AUGUST 1992 **TWO NEW VERSIONS OF PARADOX** PAGE 32

BYTE

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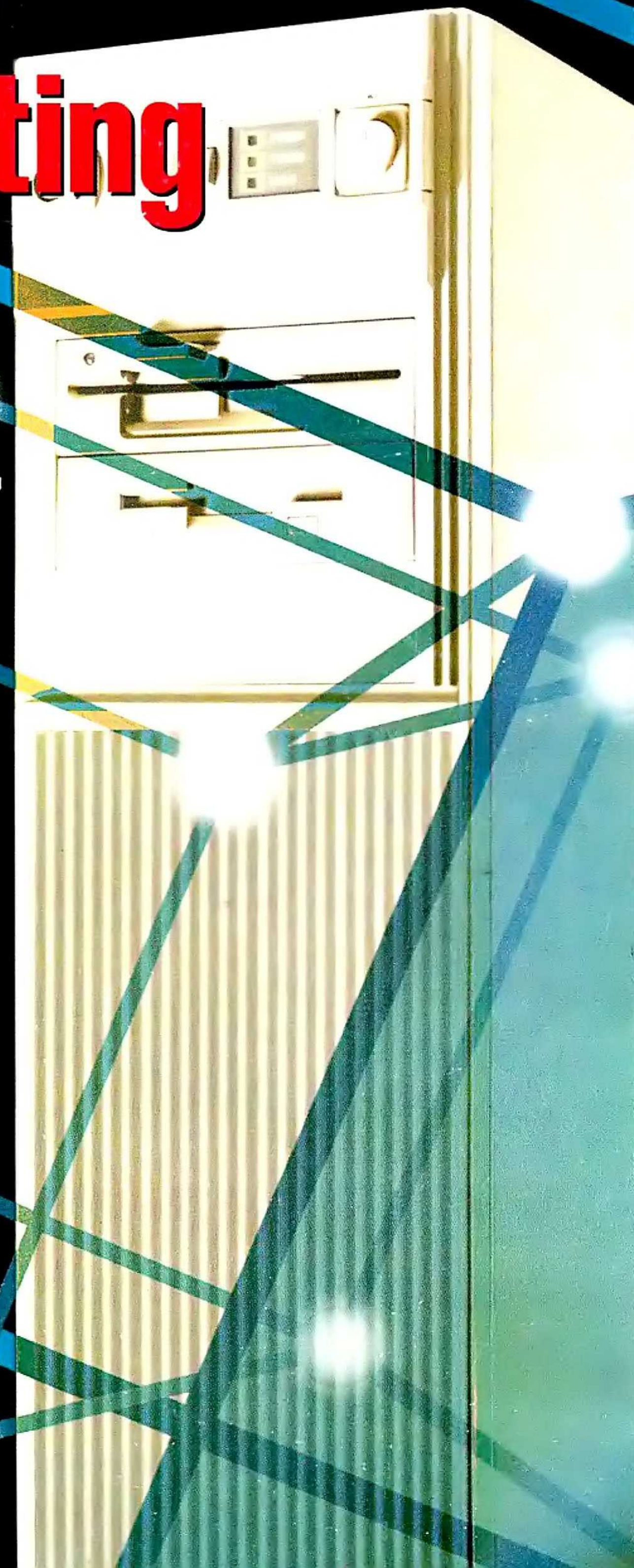

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Notebooks With High-Flying P

The paths of dashing young scientist Dakota Smith and independent journalist Lexa Kirk, drawn by seemingly mysterious forces, recently converged in South Dakota. There they made amazing discoveries: the Nomad notebooks and the astonishing little HandBook™ from Gateway 2000! Now their sworn mission is to carry the news to the far corners of the world.

"The sky's the limit!" Dakota praises the new Nomads. "These systems are every bit as powerful as their desktop counterparts! I can actually do serious computing on land, at sea or in the air!" The Nomad's patented power-management system delivers soaring battery life — over six hours from a single battery on the 25MHz 486DX system. And it has one of the biggest and brightest notebook screens in the industry.

And Lexa takes off with her HandBook, smaller than a notebook but larger and more functional than a palmtop — a real PC in miniature form! "It's a totally new category of portables, and I feel as if this little machine were designed especially for me!" she smiles, with her head in the clouds. "The HandBook is so small and feather-light; yet it has a truly usable keyboard and display, a real hard drive, and the capability to transfer files back to my editor. I can travel with it and not even know I'm carrying it!"

"Once again, Gateway is in the pilot's seat," Dakota adds. And, as he and Lexa fly off into the wild blue yonder with their message, we know in our hearts that the saga of Gateway 2000 will continue....

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Options: FieldMouse pointing device, 2,400 bps modem, alkaline battery pack, portable printer, combo unit (3.5" drive with serial port and parallel port), extra batteries

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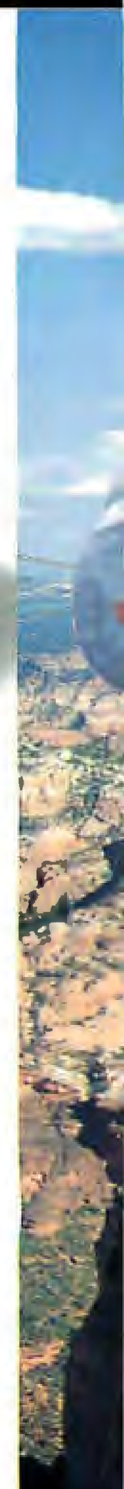
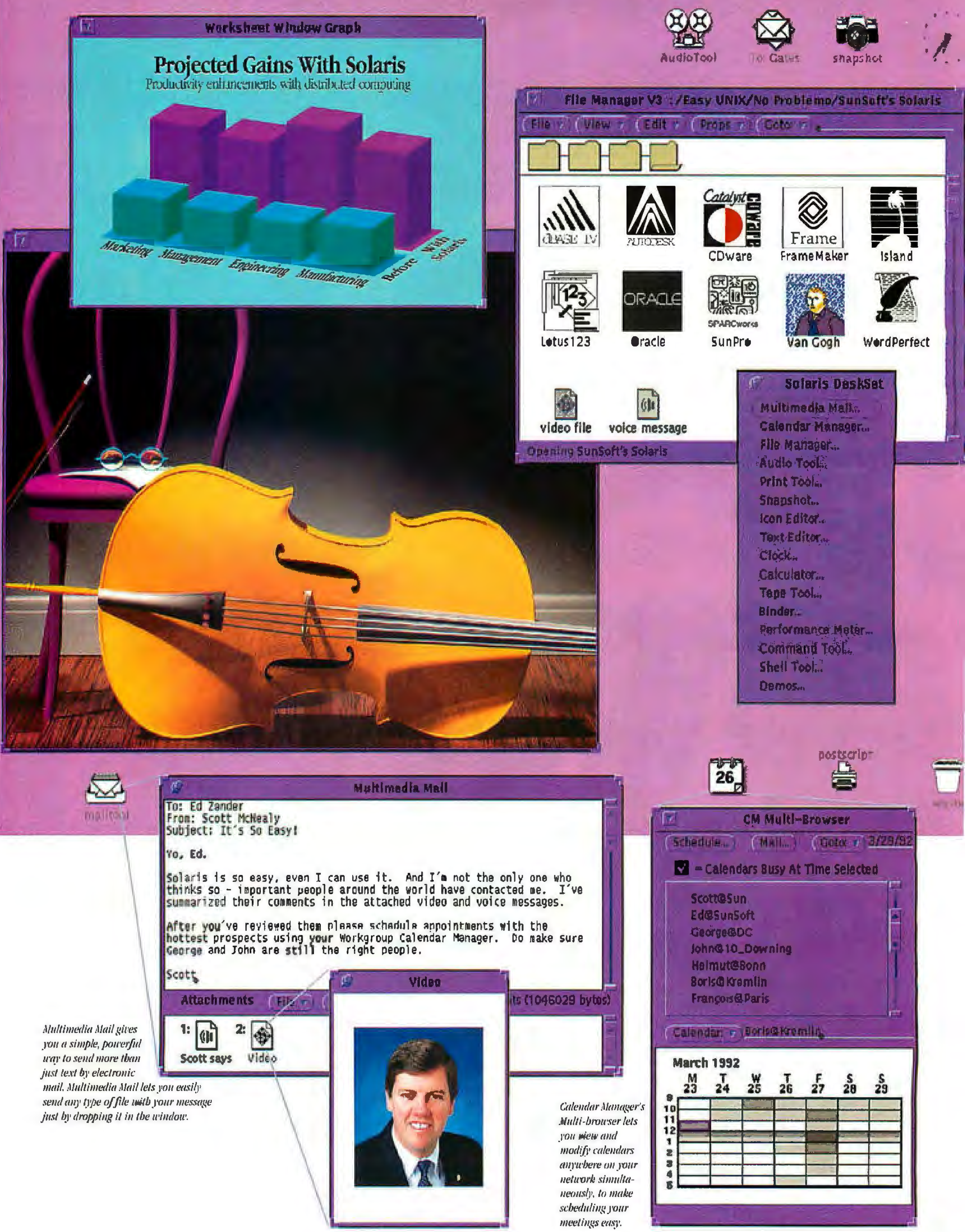
**Battery life was measured using PC Magazine's Battery Rundown Test with power management enabled. Results may vary.*





Multimedia Mail gives you a simple, powerful way to send more than just text by electronic mail. Multimedia Mail lets you easily send any type of file with your message just by dropping it in the window.

Calendar Manager's Multi-browser lets you view and modify calendars anywhere on your network simultaneously, to make scheduling your meetings easy.

Solaris: So Easy It Can't Be UNIX.

Power Made Simple.

Imagine making the power of 32-bit systems easy to use. Imagine networks that not only tie together individuals, they make groups more productive. Imagine computers united by a consistent environment. Imagine running today's favorite programs while gaining access to tomorrow's applications.

Imagine no more. Solaris® system software makes distributed computing as simple as stand-alone computing, while bringing the power of UNIX® and SVR4 to users—easily. Maybe that's why Solaris is the world's most widely used 32-bit computing solution.

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The Solaris solution starts with technology from Xerox that sparked the idea for the Macintosh® user interface, making Solaris as easy to use as any PC. But, because Solaris was created with group productivity in mind, it does much more.

Solaris breaks the isolation of personal computing by bringing network resources to the desktop. Want to send that chart to a color printer in another building? It's easy. Want to render that 3D image on a Cray in the next state? It's easy. Solaris allows objects, like files, to be dragged and dropped on function icons, such as a printer, for instant action. With Solaris, the network is at your fingertips.

Increase Personal And Workgroup Productivity.

Solaris also includes 15 tools that enhance group productivity. Among these is Multimedia Mail, which can send any type of file—applications, audio, video, graphics—in a mail message. The Workgroup Calendar Manager serves as an on-line personal and group calendar that makes scheduling meetings with people next door or on the next continent easy.

What's more, Solaris offers over 4,000 solutions including Lotus 1-2-3, Ashton-Tate dBase and WordPerfect. And SunSoft has an easy way for you to try these applications. It's Catalyst™ CDware™. With CDware, you can try more than $250,000 of software from your desktop. Solaris offers more options for productive work than any other 32-bit environment. Now, that's easy!

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BYTE

August 1992 *Volume 17, Number 8*

COVER STORY

FEATURE

All Systems Go

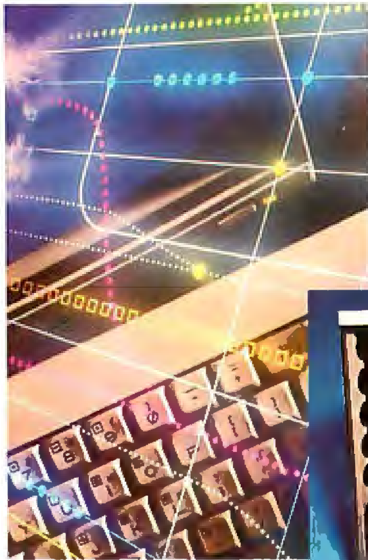
PAGE 112

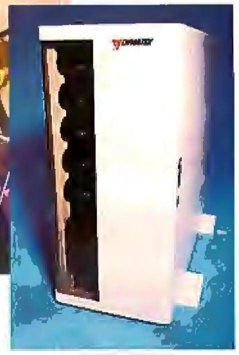
NEWS

STATE OF THE ART

REAL-TIME COMPUTING

REVIEWS





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HANDS ON

OPINIONS

PROGRAM LISTINGS
From BIX: Join "listings/frombyte92"

INSIDE BYTE

ABOUT THE COVER
A hypercube is an arrangement of parallel processors that minimizes the time required to send a message from one processor to another. Balancing communications requirements and processing power, the hypercube represents a vital step along the road to the teraFLOPS machine.

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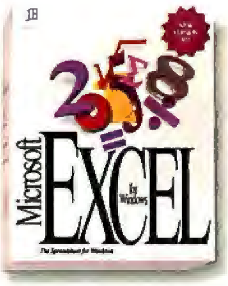
INSIDE BYTE

BYTE Topic Index and Author Guide

This index helps you find articles that contain information on each of the listed topics. (The topic list changes each month.) Combined with the table of contents (page 4) and the Editorial Index by Company (page 356), you can identify articles by type, subject, title, author, or product discussed.

Why consider a new
you can leave we



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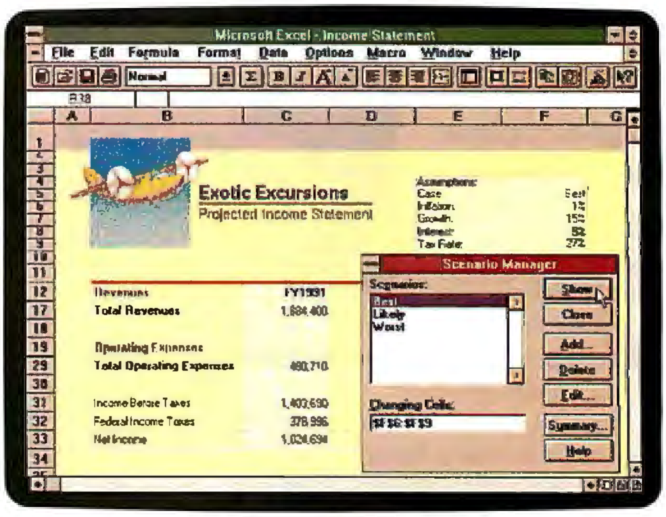
Or consider Autofill, which intelligently helps you build your worksheets. For example, when you type January in a cell, Autofill automatically enters February, March, April—as many (or as few) months ahead as you designate.

Shortcut menus are another innovation. When you click the right mouse button, a menu appears on-screen next to whatever you're doing, offering you all the options that sensibly relate to the task at hand.

Wizards are step-by-step guides that take you through complex tasks, like charting, or creat-



The Scenario Manager is a powerful analysis tool that lets you easily create and save multiple "what if" scenarios, then instantly produce nice-looking summary reports. (Which makes you look nice, too.)

ing summary tables from a database, with incredible ease.

And with new Drag and Drop, all you do is highlight the area you want to move, "grab" it with your cursor, and drag and

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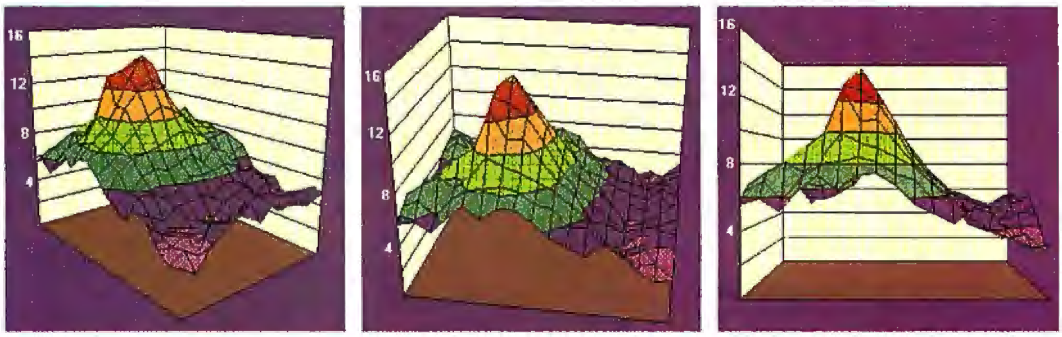
drop it to wherever you want it on your screen. It's that simple.

We've also made the Toolbar customizable. Plus, it has handy new features, such as a Spelling Checker and AutoCenter, which lets you center text over multiple columns with a single click of your mouse.



The gallery of 90 chart types includes rotating 3-D charts, along with surface, radar and picture charts. It looks great here. It's even more impressive on your screen.

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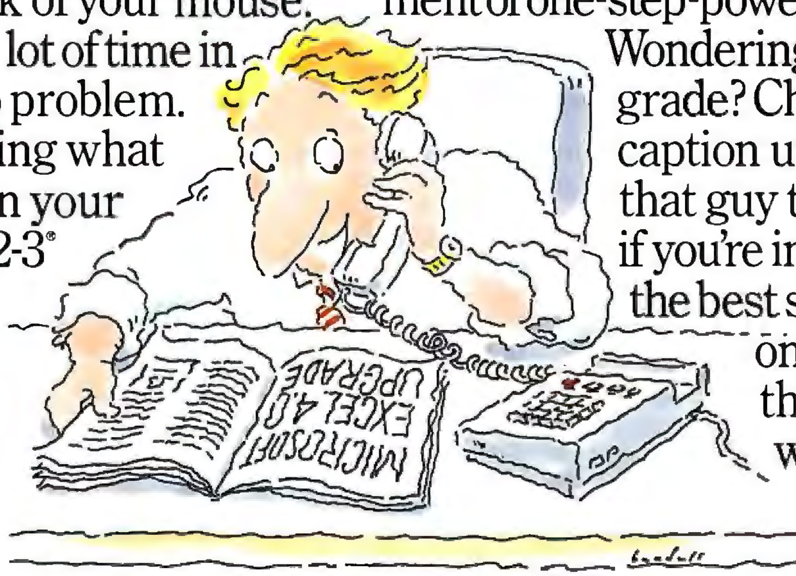

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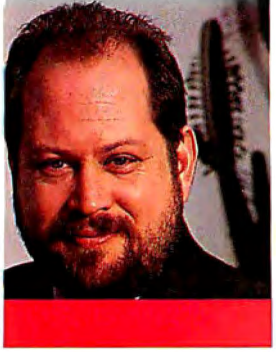

EDITORIAL

DENNIS ALLEN

ETHICS OF ELECTRONIC INFORMATION

Have you ever had information at your fingertips that you knew you shouldn't have? In case you haven't, consider this: Information that's not yours shows up on your computer—maybe from the network or the E-mail or conferencing system. Right away you recognize that the information is not yours, but you also recognize that it might be valuable to you.

New methods of transferring information still retain the attributes of privacy and ownership

For the moment, at least, you face the dilemma of whether you should use the unauthorized information in a gainful way or miss the opportunity for the sake of ethics. And don't make any armchair proclamations of virtue unless you have actually been in that situation. As with most life experiences, when it happens, even the most clear-cut solutions become suddenly complicated.

I know, because some of the people on the BYTE staff—including me—recently experienced it. Here's what happened:

Until recently, the BYTE editors in our main office and in our bureaus used a private conference on BIX (formerly known as the BYTE Information Exchange, an on-line conferencing system). We used it to communicate everything from deadlines to highly confidential information. It seemed like a good idea to use BIX since BYTE owned and maintained the BIX equipment and conferencing files. Or at least, BYTE *did* own BIX until February of this year.

We sold BIX to a company called General Videotex Corp., with an agreement that BYTE could continue using its private BIX conference—another good idea, or so it seemed. Somewhere along the way, a competing magazine started a separate private conference for its staff on BIX. We would not even have known about the other magazine's private conference had it not been for what happened.

One day, two of BYTE's editors found themselves abruptly and mysteriously "joined" to the other magazine's private conference. The two editors who found themselves in this predicament had no idea why they were suddenly privy to a competitor's confidential discussions. There they were, nonetheless, two BYTE journalists with clandestine information at their fingertips.

Now you have to keep in mind that the training of a journalist—any good journalist—includes snooping around and digging up information that most folks don't know. So it's hard to imagine any journalist who would not be curious as to what was in those conference files.

The truth is that neither editor read the files, but the story doesn't end there. To their credit, both people resisted the nearly primordial journalistic urge to uncover some tidbit of otherwise hidden information, and they promptly removed themselves from the other magazine's conference. There was one last loose end to tie up.

While everyone was enjoying a pat on the back for having successfully demonstrated their integrity, I learned that some of the covert files had been downloaded and stored on a disk (files are often downloaded from BIX automatically). Up to this point, the two staffers had made the tough decisions, and now it was my turn. I was asked quite simply, "Do you want the disk?"

I had the disk destroyed without so much as a glimpse of what the files held. But there was a moment, those fleeting seconds as my mind churned the question I had been asked, in which I considered the alternative. Probably anyone in my place would have been tempted as well, because that's the nature of humans.

Thinking of electronic information differently from, say, a personal letter at the post office is natural. The intangible character of electronic information makes the attributes of privacy and ownership somehow seem less real. So we often take for granted how, for example, we might react to someone reading private E-mail. Yet doing so is no different from opening a sealed envelope that's been stolen from the post office.

At BYTE, we learned the importance of having policies for dealing with other people's electronic information. So we're implementing clear rules as to how privacy and ownership of electronic information are to be handled at BYTE.

What would the people at your company do? Without specific policies that deal with these situations, there's no way to know for sure.

—Dennis Allen
Editor in Chief
(BIX name "dallen")

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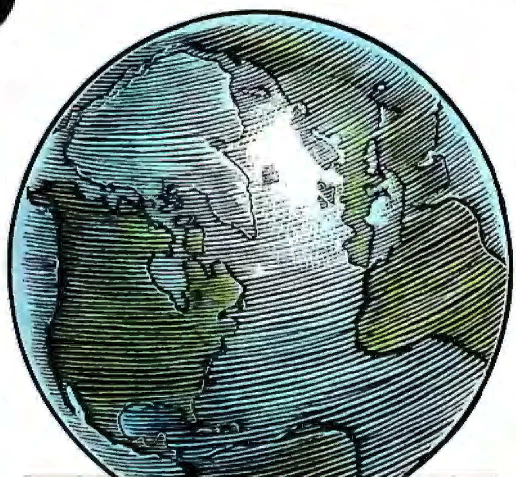

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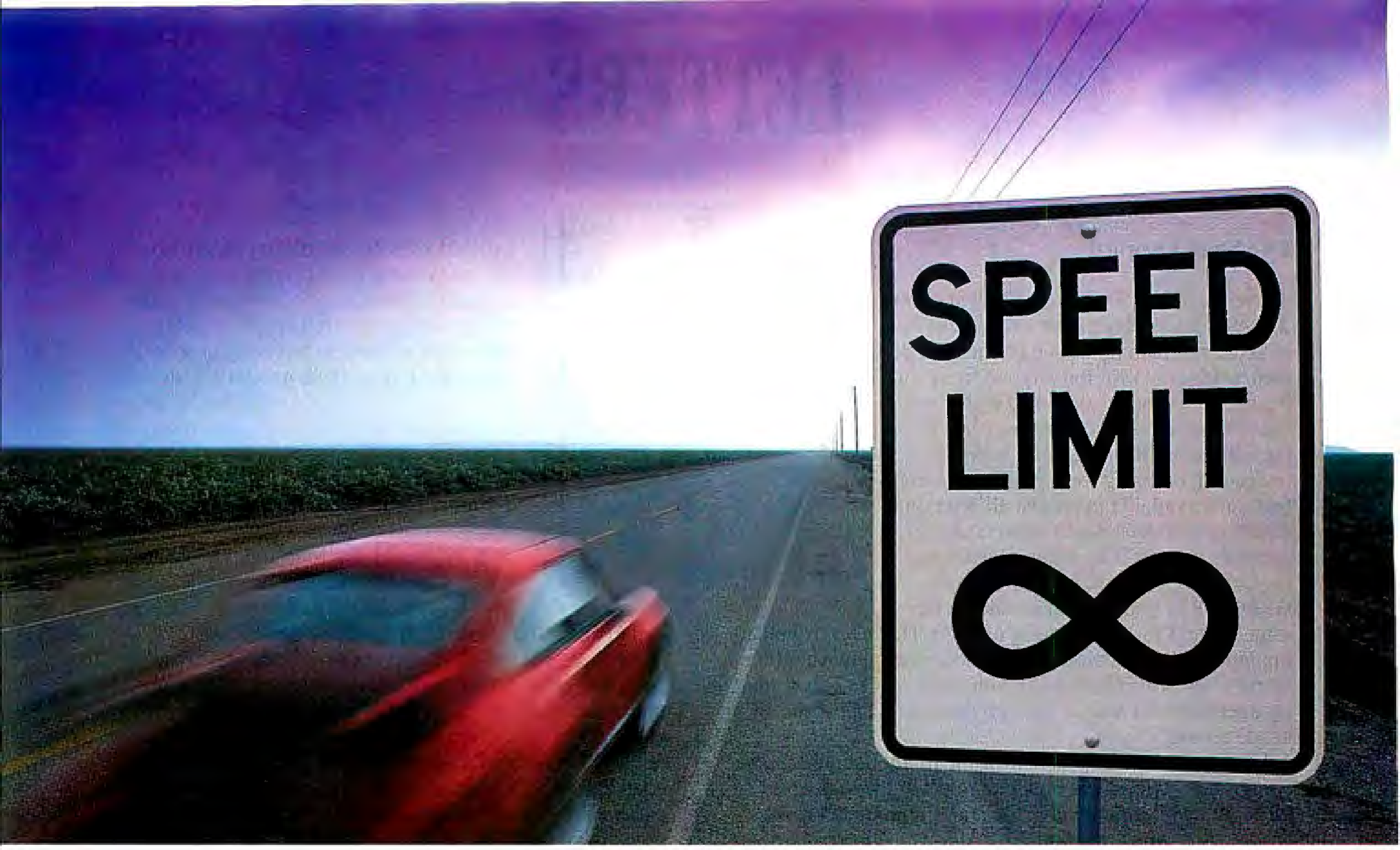

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LETTERS


Two Steps Forward, One Step Back

Two Steps Forward

In response to "Two Steps Forward, One Step Back" (May), first, ordering is not an issue for the relational data mode. The theory does not prohibit anyone from sorting the data. Rather, the issue is that ordering of rows should not have any impact on the table or on the result of a query.

Second, ordering rows as a formatting feature is available in almost all relational database products. As an analytical user, you may request it by adding ORDER BY to your query. Again, with or without ORDER BY, your output should be the same, except for the ordering of rows. However, if you are implementing a relational database system, you should worry about how to organize your data space so that your product does not search through the entire data space for a single record.

Finally, one major obstacle to the relational model's becoming user friendly is how one looks at the real world through the relational view. The relational model deals with relationships, not entities that most people are accustomed to. To tell someone that John, Mary, Loren, and Sam are members of a family is much easier than to say that <Smith, John>, <Smith, Mary>, <Smith, Loren>, and <Smith, Sam> are relationships (tuples) of the "Family Member" relation (table). However, tuples and tables give the relational model the querying capability to which no other data models have even come close.

Stanley Wang
Bellcore
Piscataway, NJ

Kudos Revealed

Kudos to Tom Thompson for "Mac Programming Revealed" (April). Now that some form of desktop environment has finally reached the masses, it is time to demystify desktop programming. Thompson's article was a good step in that direction.

Kenneth L. Kashmarek
Eldridge, IA

Windows Goes Real Time

I'm surprised that BYTE published "Windows Goes Real Time" (April). The authors suggest running DOS/Windows under iRMX and then processing several programs at once. That's four layers of code, without Windows, that the processor must go through to accomplish the end result. With Windows, it's five. I would think that only a souped-up 386 or 486 could do the job.

The reason the article mentioned iRMX is that Windows has no memory protection in any mode. Memory protection is the overriding factor in creating a real-time multitasking environment. Only OS/2 reduces the levels of code the processor has to sift through to get the processor to react in anything near real time, and it *does* have memory protection.

Michael F. Niemi
Burnsville, MN

Kinder, Gentler Computing

We would like to respond to Maureen Caudill's "Kinder, Gentler Computing" (April). Specifically, we would like to comment on the "Hearing It Talk" section of her article.

At York, we have developed a nonsegmental-based speech-synthesis system that does not rely on the more traditional methods of targeting and "gluing" together phonemes. Our system uses the *same* synthesizers as current systems (e.g., DECtalk, MITalk, DECvoice, and KlattTalk) but drives them with linguistically determined parameters. This system produces "natural-sounding" speech that cannot be differentiated from real speech under strictly controlled listening tests.

We would like to contact the author. Please advise a suitable route.

Dr. R. P. Fletcher
University of York
York, U.K.

Readers can write to Maureen Caudill c/o BYTE. See the information box below for BYTE's mail and Internet addresses.—Eds.

Pen Skeptic

For years we have been moving toward a computer interface that replaces multiple keystroke commands with a single mouse-click. Now the proponents of pen-based computers would have us replace a single click (the letter *a*, for instance) with multiple pen strokes—and there is no guarantee that the pen strokes will be interpreted correctly. It seems to me that the whole idea of pen-based input is to be able to record something that can't be input from the keyboard or selected from a menu. I know there are applications out there for pen-based computers, just as there are for voice input, but they're not for the average user.

Roger H. James
Wallingford, CT

WE WANT TO HEAR FROM YOU. *Address correspondence to Letters Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458, send BIXmail c/o "editors," or send Internet Mail to letters@bytepb.byte.com. We edit letters for length and clarity.*

FIX

We inadvertently left Digital Arts out of BYTE's May Resource Guide on 3-D rendering software. Digital Arts' address and telephone and fax numbers are: 4531 Empire Ave., Suite 229, Burbank, CA 91505, (818) 972-2112; fax (818) 972-2115. ■

NEWS

MICROBYTES

Walking the Tightrope: Apple Tends to Its Garden While Paving New Roads

Apple's strategy, which first started shaping up in late 1990, is paying dividends. At the start of the decade, Apple had many obstacles to overcome: a relatively small customer base, an overweight portable, narrow distribution channels, and computers that many users thought were too expensive. Almost a year and a half later, the company has done very well with its Mac Classic, Mac LC, and PowerBook families, and it now offers high-end 68040-based Quadras as well.

According to John Sculley, Apple's chairman and CEO, the Mac continues to gain market share, a fact that he said was largely due to the successful low-end and portable offerings. Sculley said that during the fourth quarter of 1991, 58 percent of Mac sales were to noncomputer and DOS users. Apple's unveiling of working prototypes of its PDA (Personal Digital Assistant) hand-held devices shows that the company can develop revolutionary products while tending to its existing product lines.

At Apple's World Wide Developers conference, Sculley was unusually candid about the company's future, saying that this year you can expect to see Macs with internal multimedia CD-ROM drives, more 68040-based Macs with DSPs (digital signal processors), a Mac color notebook, and more communications products for the PowerBooks. The last plan stems from positive response to the bundling of AppleTalk Remote Access software with the Mac notebooks.

By the end of 1993, Apple expects to introduce the first of the PowerPC RISC computers, which will at first run the Mac OS, not the object-oriented operating system code-named Pink. Apple is ahead of schedule on porting its system software to the PowerPC, Sculley said. For workstations in general, Apple plans to push the Mac as a standard in the Unix marketplace. Sculley also outlined the five software foundation technologies that the company will leverage as it moves into the next century:

- A new WorldScript technology will be included in a reference version (7.1) of System 7.0 and will display and process 2-byte, complex non-Roman languages, such as Chinese and Korean, as well as Arabic and Hebrew.
- QuickDraw GX, formerly the New Imaging Architecture, will supply new typography, imaging, and print capabilities to support a media and publishing industry expected to be worth $1.3 trillion by the year 2000. Printing will be simplified, and any Mac application will have the ability to display a document properly, regardless of whether the computer has the original fonts.
- The OCE (Open Collaborative Environment) will consolidate mail services and support document transactions with electronic-signature validation and improved work flow. OCE will extend Apple's reach into the telecommunications market, which the company estimates will be a $1 trillion industry by 2000.
- AppleScript, a batch-style language, will let users automate repetitive tasks and customize operations among several applications using intelligent software agents.
- QuickTime, now about a year old, will be extended to Unix systems, Windows, and OS/2, and will support MIDI and text-to-speech generation.

Sculley admitted that Apple now manages several lines of business, but he said that walking this tightrope is necessary if the company wants to remain a player in the computer industry. Apple is investing in anticipated high-growth sections of the industry. At the same time, it is working on projects to attract even more people who, to the Apple way of thinking, have never used a computer.

—Tom Thompson

NANOBYTES

A day after announcing its HyperSparc chip set, Cypress Semiconductor announced that it is moving its U.S. assembly operation offshore to streamline its manufacturing operations. The company also said it will lay off about 200 workers. Cypress president **T. J. Rodgers** attributed the workforce reduction largely to the wide gap in labor costs between U.S. manufacturing and assembly operations that are based elsewhere. He noted that when the company originally set up its U.S. assembly in 1984, it incorporated a high degree of automation to offset the difference between the U.S.'s $10-per-hour labor cost and the 50 cent–per–hour overseas cost. Since then, he said, competitors' offshore plants have become fully automated yet still pay low wages. Rodgers said the company can no longer afford the extra $8 million required per year to keep its assembly operation in Silicon Valley. □

In June, just five weeks after releasing the Windows version, Microsoft released Excel 4.0 for the Mac, the first major application to support **AppleScript**. Microsoft is reportedly working on an AppleScript-compliant version of Word for the Mac as well. □

An example of QuickTime's growing acceptance is the announcement by **Apple** and **Silicon Graphics** that QuickTime has been licensed for the Indigo workstation. This will let Iris workstations author three-dimensional animations for use on Macs. □

NEWS

MICROBYTES

High-Stakes SPARC Showdown

With the introduction of its next-generation RISC processor, Cypress Semiconductor has launched itself into a high-stakes battle with Texas Instruments to win the loyalty of SPARC workstation manufacturers and users. Because Sun Microsystems is expected to corral a large portion of the initial offering of TI's new Viking SuperSparc RISC processor for use in the modular-CPU desktop Sparcstation 10, Cypress may find an eager customer base among SPARC clone vendors.

At press time, TI said that the first Viking chips will go only to executive members of SPARC International and this drew a howl of protest from the consortium's associate members. Depending on how quickly Cypress can ramp up production of its HyperSparc chip set, Cypress may find a hungry market for its chips. Cypress expects to start sampling its chip set next month and reach volume production in the fourth quarter.

Cypress's 64-bit HyperSparc chip set, rated at 70 SPECmarks and 133 MIPS in its 66-MHz version, achieves its performance levels using a 64-bit data path and a superscalar, superpipelined architecture that supports multiprocessing. The new modules are pin- and function-compatible with Cypress's first-generation CYM6000 Sparcore uniprocessing and multiprocessing modules. In 1993, Cypress intends to start sampling 80-MHz HyperSparcs, with anticipated performance improvements reaching 85 SPECmarks and 166 MIPS. Cypress projects ratings of 101 SPECmarks and 200 MIPS for the 100-MHz version.

—Patrick Waurzyniak

Quorum Takes Legal Action Against Apple

Quorum Software Systems (Menlo Park, CA) has brought legal action against Apple to counter what it called "unsupported allegations of patent and copyright infringement." Quorum says that letters from Roger Heinen, Apple's vice president of Macintosh software architecture, accused Quorum of infringing Apple's intellectual property rights and then revoked Quorum's privileges as an Apple partner.

Quorum officials said that the company's complaint seeks redress for Apple's accusation that Quorum, in helping ISVs (independent software vendors) migrate their Mac-compatible applications to other platforms, induced those ISVs to violate licensing and confidentiality agreements with Apple.

The complaint centers on Apple's allegation that Quorum Latitude, a cross-platform compatibility tool that lets Mac-compatible applications run on other computer platforms, violates Apple patents and copyrights. Quorum says that Latitude relies solely on the use of Motif or Open Look for pull-down menus and uses Adobe Display PostScript or SunSoft News for screen rendering and thus does not infringe Apple's patents or copyrights.

Quorum has asked the U.S. District Court for the Northern District of California to rule that Quorum has not infringed any copyrights or patents of Apple.

—Larry Loeb

Tandy and Motorola Pipe Up on PDA

Mindful of the intense coverage that Apple has received on its PDA (Personal Digital Assistant), which won't be available to the public for a few months, several other companies are jumping on the vapor-hardware bandwagon.

Tandy says it will work with Casio Computer of Tokyo, Japan, to design a new family of personal information processors. Tandy and Casio will be joined by GeoWorks (Berkeley, CA), which will supply its GEOS (Graphical Environment Object System) operating environment with pen extensions, and Palm Computing (Menlo Park, CA), which will supply its applications software. Tandy officials said it's too early to talk about product details, pricing, and expected availability. But when, earlier this year, GeoWorks announced its plans to ship pen extensions by the end of the year, it said the environment would be targeted at 8088- and 8086-based systems costing less than $500.

Also, Motorola and Korea's Samsung Electronics announced plans to develop and market a pen-based palmtop computer with wireless-communications capability. Motorola will disclose further details at Comdex in November.

—Dave Andrews

NANOBYTES

Sun Microsystems is going out of its way to distance itself from the rest of the SPARC pack with its new workstation based on Texas Instruments' Viking SuperSparc CPU. In mid-May, the company announced its new desktop workstation, the Sparcstation 10, a version number that is itself quite a leap, considering that the previous model was the Sparcstation 2. "SuperSparc is an absolute breakthrough in terms of work done per megahertz," said **David R. Ditzel**, director of the advanced systems group at Sun Microsystems Laboratories. "We're getting performance that exceeds...[that of] machines outside our class." Sun officials claim that even they were surprised by the performances of the machines. □

Among the features of the Sparcstation 10 and Sun Microsystems' new SuperSparc-based servers is built-in **ISDN capabilities**, which the company says it added in response to requests from its customers in Europe and Japan. □

Long rumored to be developing a 386 clone chip, **IIT** (Integrated Information Technologies) revealed that it has set its sights even higher. Cofounder and president Chi-Shin Wang said IIT is working on a **486-class processor** that may also incorporate some of the company's multimedia technologies. With its 486 project, Wang said, "we want to integrate multimedia into the CPU. People could care less about MIPS. They care more about applications functionality." □

Apple has released the **Quadra 950**, which boasts a 33-MHz 68040 processor and a 25-MHz I/O bus. □

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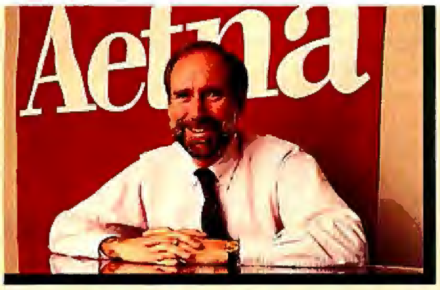

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Rolls-Royce Aerospace

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Sr. VP, Information Systems
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Director, CPC/CPPC Information Systems
SONY Corporation

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Bill Palm
President, Canadian Technology Services
Canadian Airlines

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***Application* Development Consultant**
First Federal Lincoln

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Margaret Kubaitis
Research Programmer, IS&S
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"The IEF tutorial is put together very well and quickly illustrates how to construct a system using the IEF. It gives one the basics to start getting the job done. I feel I am prepared now to build simple systems using the IEF."
K. E. Peacock
Data Administrator
City of Saskatoon, Saskatchewan

NEWS

MICROBYTES

Wireless Data Communications for Service Workers

Granite Communications (Amherst, NH) thinks that vertical markets like the hospitality, health care, and other service industries can benefit from wireless communications without having to take the Windows for Pen Computing or PenPoint route. The Granite Links system is based on the company's VP5 hand-held personal data communicator, which the company says offers two-way communications of up to 1000 feet via spread-spectrum RF signals at one-third the price and one-quarter the weight of competing wireless technologies. The company is now signing up VARs (value-added resellers), system integrators, and other developers willing to develop end-user applications that will run on the VP5.

The Granite Links system is based on a hand-held personal data communicator.

Pierre Dogan, CEO of Granite Communications, says a typical system will include many workers carrying the communicators, which transmit and receive data from a PC-connected central base station via spread-spectrum RF signals. Dogan said the Granite Links system supports data transmission of 121,000 bps and operates in the 902- to 928-MHz range. The company will probably also offer versions of the VP5 with packet-radio capabilities.

Dogan says his company is targeting niche applications—not general-purpose computing needs—with the Granite Links system. An example of a typical application Granite envisions is the one recently announced with Micros Systems (Beltsville, MD). Micros Systems will purchase VP5s and write software for the communicators so that restaurant staff can quickly beam orders into the kitchen instead of having to physically carry them.

—Chris Grierson

It's ADA Time: Have You Checked Your PCs?

The ADA (Americans with Disabilities Act), which bans discrimination against qualified persons with disabilities, goes into effect on July 26 for companies consisting of 25 or more employees. For many businesses using computers, the ADA has widespread implications, especially for companies using hardware and software that's inaccessible to persons with disabilities.

The ADA calls for businesses to provide "reasonable accommodation" for their disabled workers and applicants, which may include providing assistive technology such as speech synthesizers, braille printers, telecommunications devices, voice recognizers, and adapted keyboards and switches. Unfortunately, not all hardware and software is compatible with adaptive technology.

In the area of operating systems, access varies widely from one platform to another. DOS is one of the most accessible operating systems for persons with disabilities. The Mac also offers much in the way of accessibility. But Windows is only partially accessible, depending on the nature of the disability. Currently, Windows doesn't offer speech-access programs for blind users, although there are access systems for persons with hearing and motor impairments. Unix is also fairly inaccessible, unless you use a DOS or Mac terminal to access the system.

IBM is making Windows talk through the company's experimental Screen Reader for OS/2 and PM (Presentation Manager). By the time you read this, it should also be able to make Windows applications talk. Berkeley Systems, which already sells the Mac-based Outspoken program for blind people, hopes to have a beta-test version of a Windows screen reader by 1993.

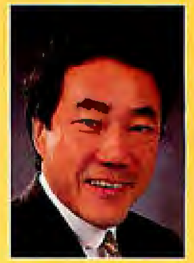
Admirable though these efforts may be, many observers believe the industry has not responded quickly enough to these problems of access. The issue has a bright side, however: As long as accessibility is considered in the design stages of a program, making software accessible to persons with disabilities is a relatively trivial task.

—Joseph J. Lazzaro

NANOBYTES

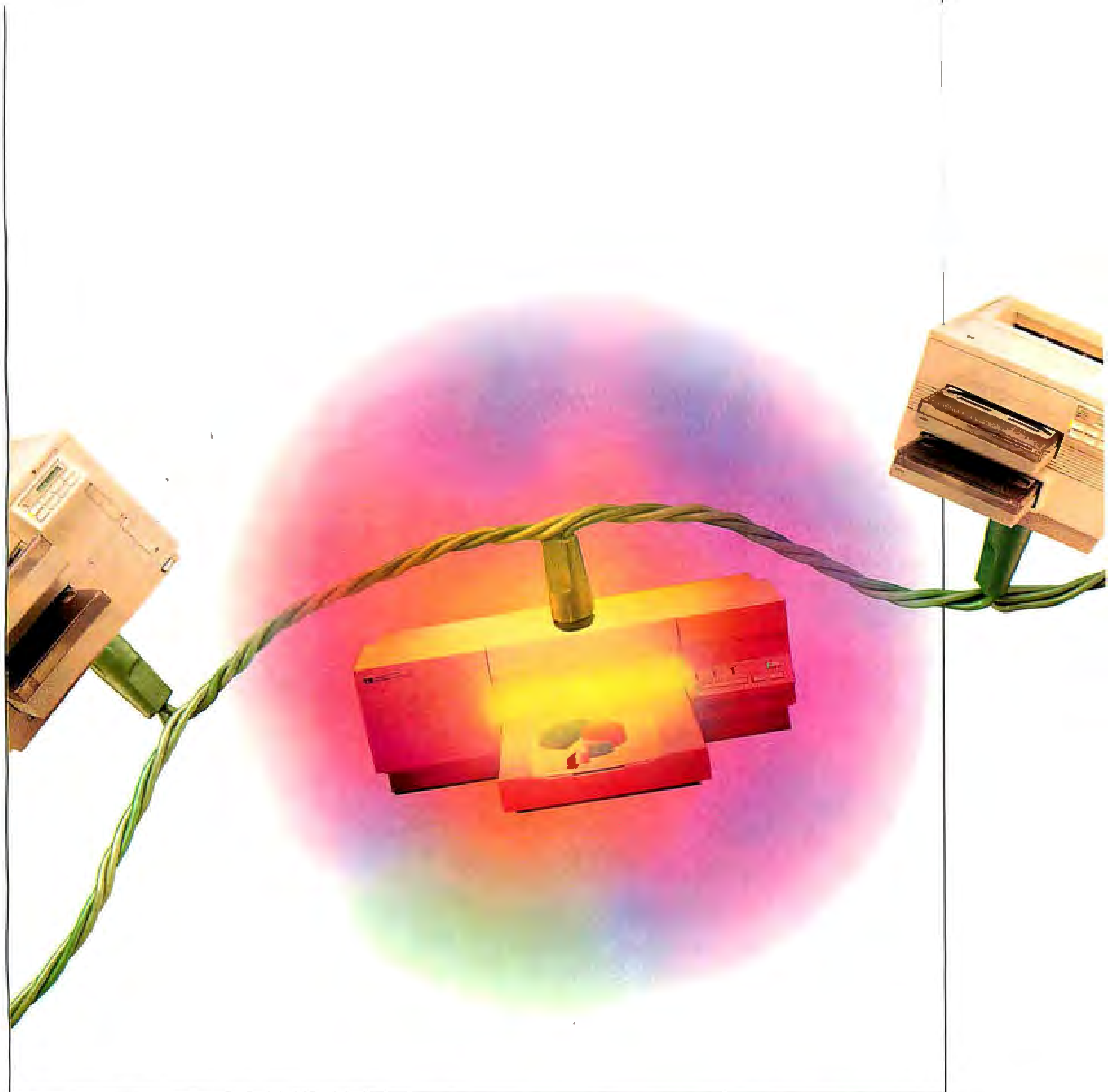
Hewlett-Packard has developed two lines of products based on its proprietary ink-jet technology that uses print heads to spray tiny dots of ink onto plain paper. The company announced affordable (under $2000) plain-paper fax machines and color printers (under $5000). HP says its new color printers are the first plain-paper ones to support 300-dpi resolution. □

Making up for lost time, CA (Computer Associates) has found Windows to be an ideal point of increased access to the millions of PC users the mammoth firm had once overlooked. With the company's recent purchase of Nantucket Software still being finalized, CA chairman and CEO **Charles B. Wang** announced in May that CA has acquired Within Technologies' Realizer, the Windows-based graphical BASIC development environment recently honored with a 1991 BYTE Award of Merit. With CA's marketing muscle, Realizer should cause more trouble for Microsoft's Visual Basic. □



Now that **IBM** has pushed OS/2 2.0 out the door, executives say the company is developing multimedia and pen extensions to the operating system. □

In response to IBM's announcement that it will preinstall OS/2 2.0 on PS/2 Models 56 and 57, **Microsoft** has developed an integrated package of Windows 3.1 and DOS 5.0 for PS/2s. Windows 3.1 & MS-DOS 5.0 for PS/2 was designed specifically for new PS/2s and will not operate on other machines. A similar package, Windows 3.1 & DOS 5.0 for customers who buy from PC manufacturers that don't preinstall Windows on their PCs, is available to PC manufacturers only. □



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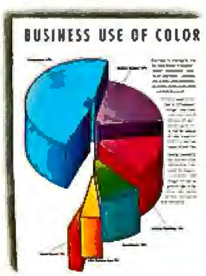

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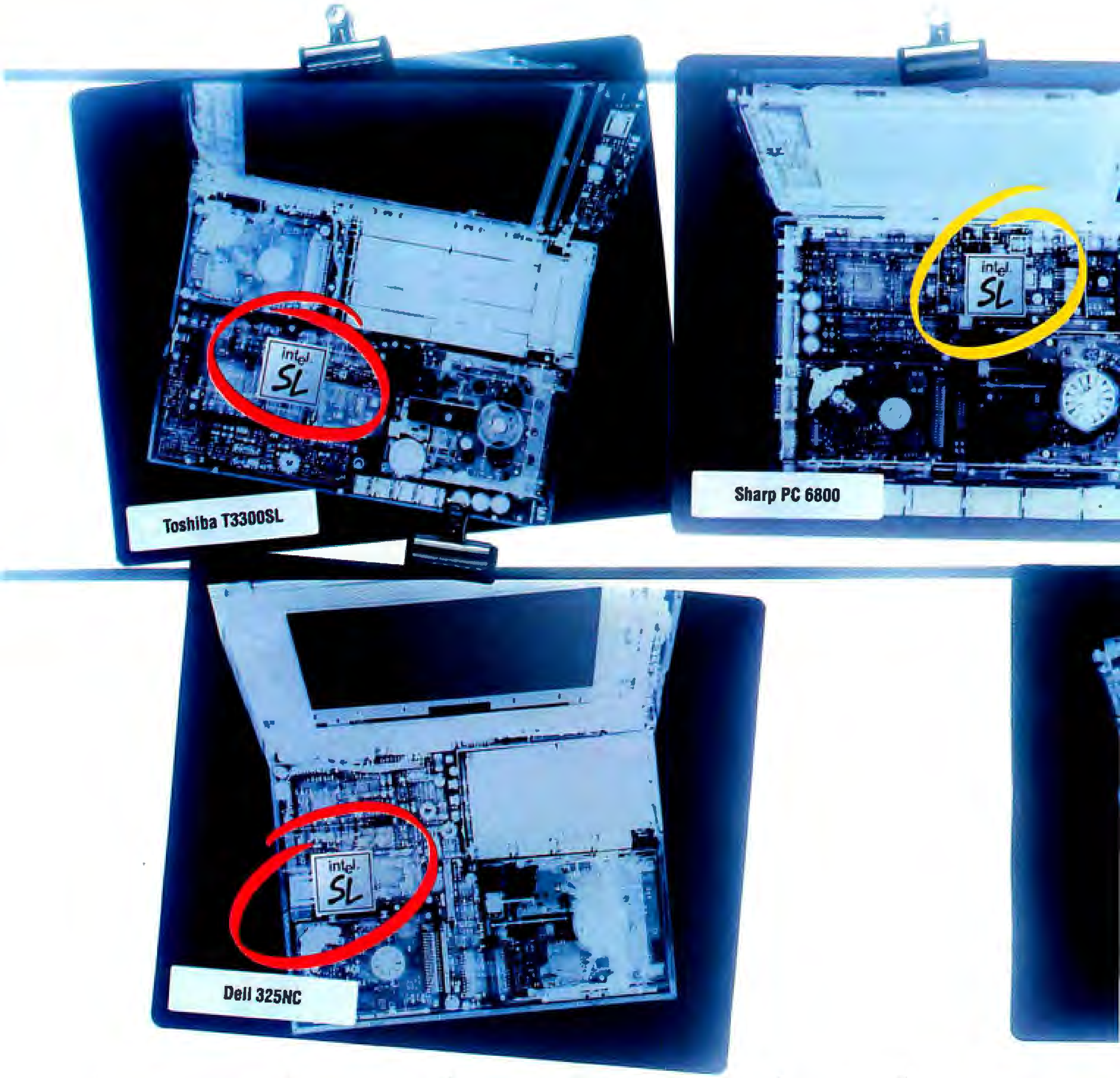

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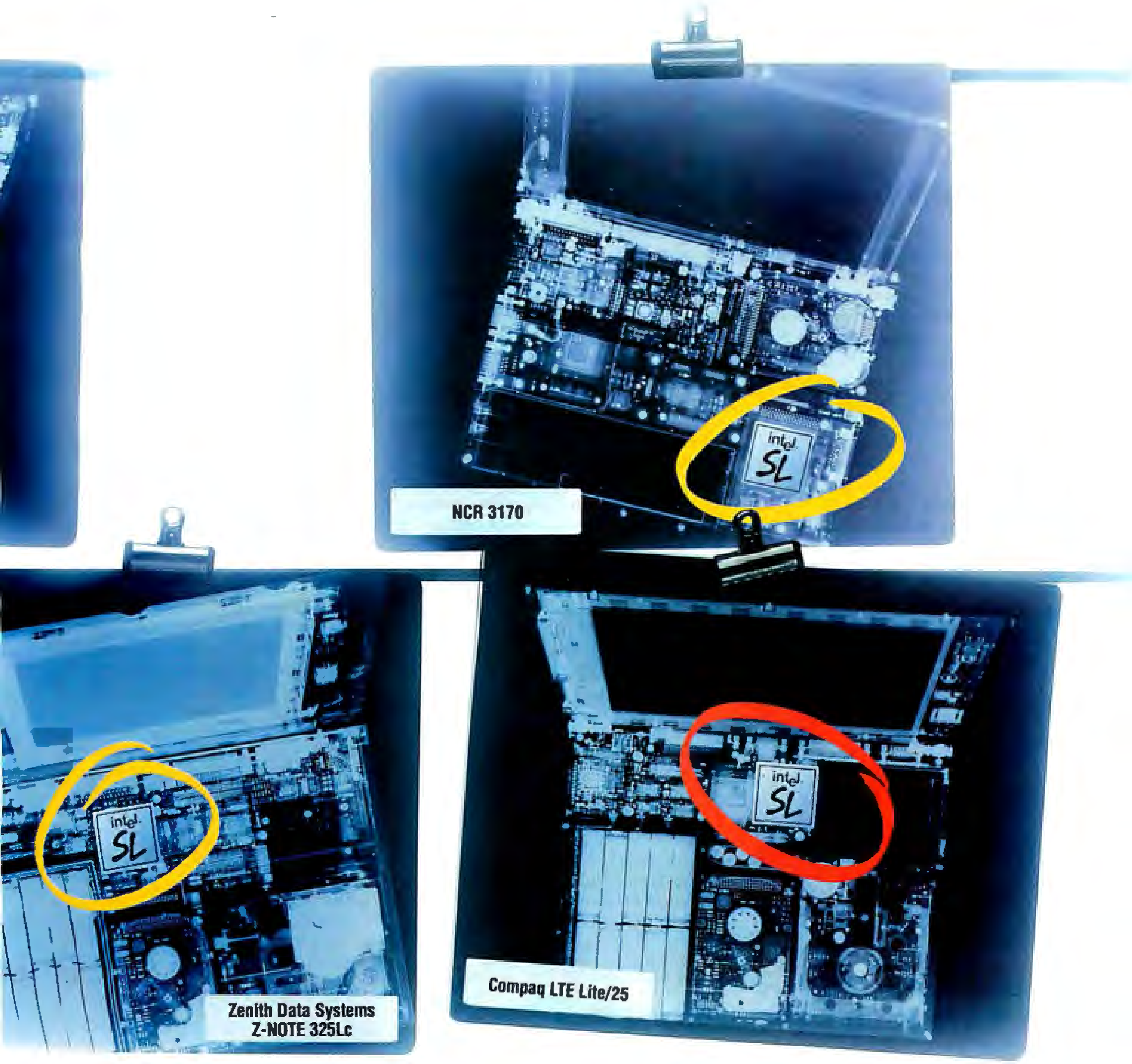

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IBM Unveils Tiny Little Transistors

In an announcement that further extends the capabilities of conventional silicon, IBM researchers say they have made the world's smallest transistors, with a size that's just 1/75,000 of the cross section of a human hair. According to Shalom Wind, research staff member at IBM's Thomas J. Watson Research Center in Yorktown Heights, New York, the tiny transistors could eventually result in the mass production of 4-Gb DRAMs.

The size of the minimum features in today's state-of-the-art processors ranges from 0.5 micron to 1 micron, but the size of the minimum features of the new device is just 0.1 micron, or 100 nanometers. The new transistors are of the size at which electronic devices in general would be expected to exhibit physical properties predicted by quantum theory, but Wind said that the new IBM devices do not exhibit these quantum effects. Researchers are exploring various ways to exploit quantum effects to develop ultradense and ultrafast devices. But for now, while research continues, the exploitation of quantum effects in real applications remains speculative.

IBM's experimental tiny transistors.

That is not to say that IBM's transistors are ready for mass use just yet. According to Wind, the electron-beam nanolithography fabrication technique used in the experimental transistor can produce about 20 to 50 chips per hour—not nearly enough for mass production needs.

"For production purposes, we'd need a tool that can make many wafers per hour, with each wafer having hundreds of chips," he said. "[The mass production solution] may occur in the electron beam tool, or not; we don't know. We anticipate x-ray lithography could be the potential manufacturing technique that may be able to produce devices like this." According to Wind, whatever the production technique that is used for mass distribution, end users should not expect to see chips that use the transistors before the first decade of the twenty-first century.

—Dave Andrews

On-Line Service Offers Electronic Information Shopping Mall

After a six-month market-building phase, AMIX (American Information Exchange), which operates as an electronic information shopping mall where customers can buy and sell information, is now actively recruiting subscribers from the public sector. An Autodesk subsidiary, AMIX (Palo Alto, CA) was founded in 1986 by the late Philip Salin, who envisioned an electronic farmer's market where buyers and sellers could meet on an equal footing to exchange information and money.

With AMIX, information sellers and software developers—anyone with a document, list, software patch, or software program that someone else can use—can post electronic bulletins that offer a brief description or excerpt of the particular file. Buyers can post comments about a product that others can view. AMIX monitors and bills each transaction, which is conducted via on-line contracts, and claims a percentage of the purchase price for each sale.

AMIX and Xanadu, the unreleased hypertext-based system for sharing unstructured information in a workgroup environment, are both part of Autodesk's Information Business Unit, so it's not surprising that AMIX offers a basic form of cross-referenced navigation and lets you post documents in multiple markets.

AMIX's form of cross-referencing is not as granular as the word-to-word type of linking promised by the Xanadu project. General manager Marc Stiegler declined to say what role Xanadu might play in AMIX. In discussing the possibility of systemwide AMIX keyword searches based on hypertext links, Stiegler said, "The real answer is to provide a better structure, and for that, I can talk about Xanadu another day." ■

—Amanda L. Waterfield

NANOBYTES

Sun Microsystems has hired away **Guy "Bud" Tribble**, one of the cofounders of Next Computer and chief developer of the NextStep object-oriented operating system. The move will place Tribble as vice president of Sunsoft, the Sun Microsystems' software subsidiary.

Before working at Next, Tribble worked at Apple with Steve Jobs, who was cofounder of the company. After Jobs was forced out of Apple, he persuaded Tribble to write the system software for a new scholar's workstation that was unveiled to the world in 1988 as the Next Cube.

According to a statement by Jobs, Tribble left after he got a "no confidence" vote in March from Next's senior executives, who didn't want him to become general manager of Next's new software division. Tribble had reportedly been on leave of absence from Next for four out of the previous nine months. Tribble said that he joined Sun for "the opportunity to work with innovative and end-user environments and get them on an awful lot of desktops." Next management appears unfazed by the move: The company says NextStep 3.0 should begin shipping by the time you read this. □

General H. Norman **Schwarzkopf** (U.S., Ret.), speaking to a group of networking professionals, asserted that "in four months we put more communications in the Gulf than was [installed] in Europe in 40 years." The problem with interoperability, Schwarzkopf told the Interop audience, "is organization, not technology. Organizations feel threatened [by interoperability]. You need to overcome the perceived threat." ■

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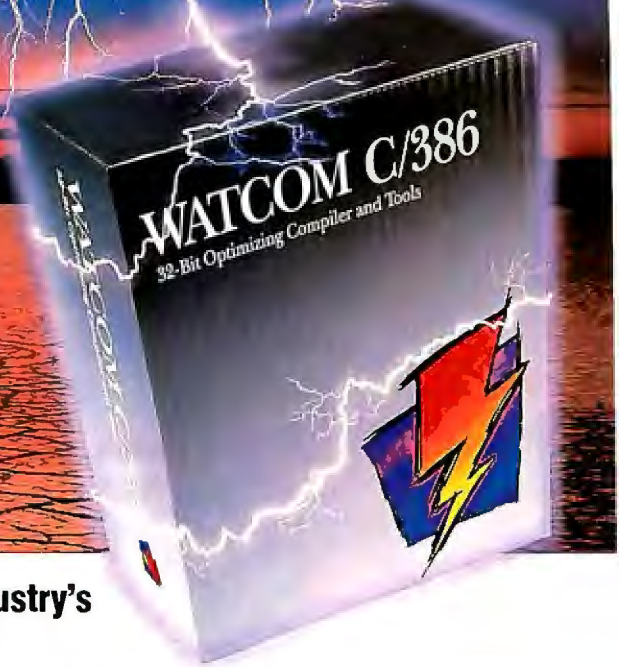

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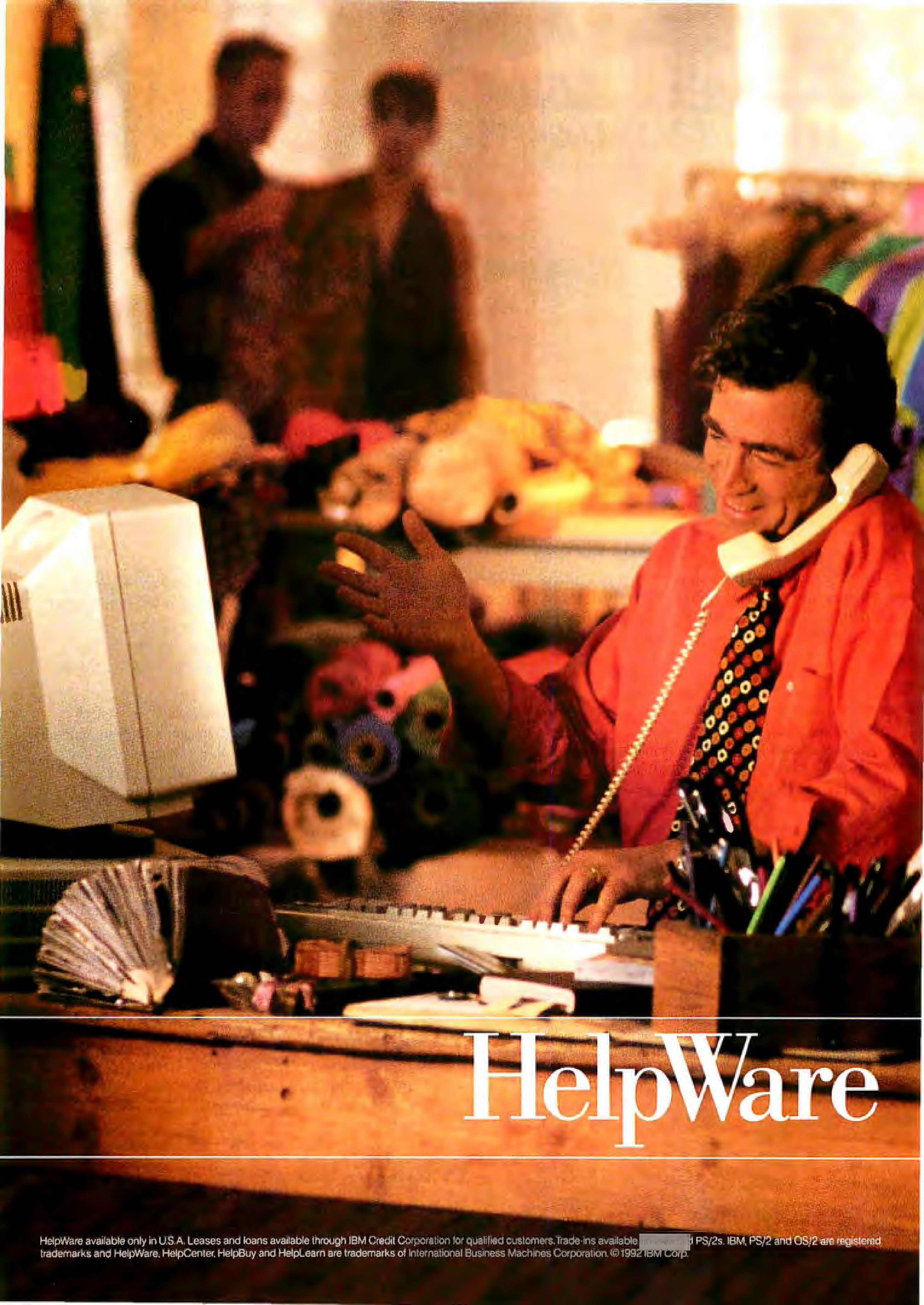
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IBM

A Pair of Paradoxes

STAN MIASTKOWSKI

Borland keeps the PC database pot boiling with Paradox 4.0 an(

It's easy to fall into a morass of mixed metaphors when you start talking about the current state of PC-based database managers. They may not be glamorous, but they are the workhorses of the computer world.

Considering what's happening to the market, an apt metaphor might be to say it's largely come down to a battle of the behemoths. Borland bought Ansa (Paradox's original developer) several years ago and last year bought Ashton-Tate, subsequently coming out with a new version of the venerable dBase IV. Earlier this year, the stakes got even higher when Microsoft announced plans to acquire Fox Software (the maker of FoxBase).

If you thought these acquisitions would calm things down in the PC database market, think again. Borland has fired a double-barreled blast at Microsoft by rolling out two new versions of Paradox. I spent a great deal of time with prerelease versions of both.

Paradox 4.0 represents an incremental evolution of the Paradox standard, albeit with a few pleasant surprises. Paradox for Windows (I'll call it ParaWin) is a new and unique animal.

A New Face

With Paradox 4.0, Borland has walked the fine line necessary when upgrading a major application with a large installed base. You must keep a large measure of compatibility with earlier versions and integrate new functionality and features without alienating current users. There was, however, a large surprise when I first started Paradox 4.0: a new interface. The long-familiar Lotus 1-2-3–style menu has been replaced with the more contemporary look and feel of drop-down menus (see screen 1). Even better, you can now use a mouse with Paradox. And there's more, including scrollable and sizable windows.

Screen 1: *Paradox 4.0 has a new user interface with drop-down menus.*

If you'd rather not eschew the old interface, there is a way out. The main drop-down menu has an Interface option that puts everything back in the familiar interface. You can't use the mouse in the old interface, however, nor can you view data in scrollable and sizable windows.

You'll find many new features and improvements in Paradox 4.0. Borland claims the biggest improvement is speed. Because the version I tested was an early beta version with embedded debugging code, it wasn't fair to run benchmarks. Borland claims that in the release version, most operations will run two to three times faster than in Paradox 3.5 because of tuned code, better memory allocation, and faster disk I/O and caching. The company also claims network performance will increase dramatically.

What else is new? PAL (Paradox Application Language) has many additions, primarily supporting event-driven programming and the new interface. PAL is indeed powerful, but the basic power of Paradox remains its ability to let you do a great deal of work without making the time-and-expertise investment to become an accomplished PAL programmer.

Making Connections

Among all the new features and improvements, it wasn't difficult to find a personal favorite. A new field type called Memo holds a virtually unlimited amount of data, either text or binary. (Normal fields are limited to 255 characters.) To keep the size of your database reasonable, Paradox 4.0 uses a unique system. Only the first 255 characters of a memo are stored within the database. The remainder is stored in a memo file with a different extension. To work in a Memo field, you enter a special memo editor that includes the ability to import data from other sources.

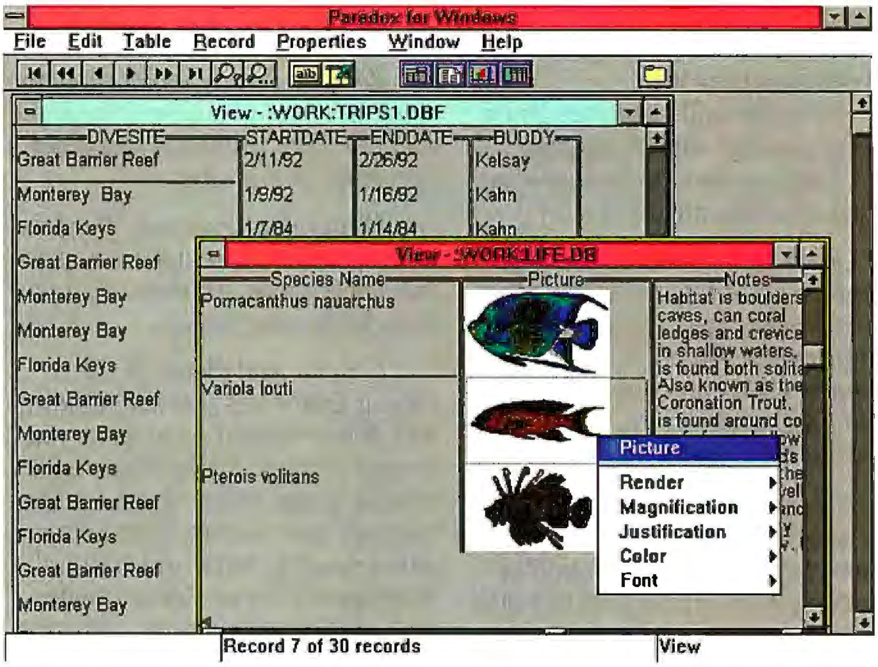
You can search the Memo field just like the rest of the database. I used it to import and store reams of material garnered from BIX. It adds a new dimension to an old database friend.

Made for Each Other

Paradox users have been waiting years for a Windows version. Now I know why it's taken so long. ParaWin is no quick-out-the-door port of the DOS version to the GUI environment. It's a from-the-ground-up rewrite that's designed to take advantage of today's graphics-oriented environment. ParaWin is an impressive piece of programming art, and it may well redefine what a graphics-oriented application should be.

Now that I've made that statement, I should explain what the big deal is. Way down deep, ParaWin is built around Borland's ILE (Interbase Local Engine), a set of core code that you can expect to see eventually in all Borland's database products. ILE is file format independent and extensible, working directly with files in a number of formats.

Here's another acronym. ILE is the key to ParaWin's OOUI (Object-Oriented User Interface), letting the package handle numerous objects beyond your garden-variety Numeric, Alphanumeric, and Date fields found in most databases. ParaWin has added Memo fields (just like those in Paradox 4.0). There's much more. Windows is, after all, a *graphical* environment, so you can link to Windows bit-map (.BMP) files and integrate graphics into your database.



Screen 2: *The Memo fields in Paradox for Windows support BLOB fields to store binary data such as graphics images.*

The BLOB

Two additional types of objects that you can include in a ParaWin database are unique indeed. The first is the BLOB (Binary Large Object) field, which links binary files to your database (see screen 2). It doesn't take long to see that the possibilities are nearly endless. Besides the mundane ability to link documents (or even executable files) to your database, you can link audio or even video if your PC is multimedia-ready. Second, the OLE (Object Linking and Embedding) field, a specialized form of a BLOB field, takes advantage of Windows 3.1's OLE capabilities.

The number of advanced features in ParaWin is simply stunning. ParaWin is designed to handle large amounts of data, make the data easily accessible, and protect the data. Borland has done extensive work on maintaining referential integrity. There are also validity checks at field and domain levels. ParaWin lets you do extremely complex data modeling with multiple complex databases. You can do something as weird as a one-to-many-to-many-to-one data relationship.

The object orientation of ParaWin extends throughout the package. The ParaWin desktop contains numerous tools for organizing files and databases as working objects and for setting up forms and reports. You pick and choose objects and graphically indicate the interrelationships.

ObjectPAL is ParaWin's object-oriented visual programming language. Unfortunately, the version that I tested didn't have it available. From the documentation, it appears to strongly resemble Borland's ObjectVision applications development system.

Keeping It Compatible

What about compatibility? ParaWin can access all existing Paradox tables. It can also run existing PAL programs from within Windows. And therein lies the, well, paradox of Paradox for Windows. Even though at first glance it looks like a completely different animal, you can get up and running with ParaWin in a matter of minutes. An experienced Paradox user can ease into the new features.

With both dBase and Paradox under its corporate wing, Borland easily takes the title of market leader in the PC database sweepstakes. But Microsoft's acquisition of FoxBase means that things will quickly become interesting. I'm forced to return to metaphors. Paradox 4.0 is the generation of a workhorse, highly tuned for handling scads of data and getting loads of work done with a minimum of fuss. ParaWin has incredible power and ability hidden under its refined exterior, setting new standards for what a GUI-oriented program should be. We now come to the ultimate paradox. Microsoft Windows has given Borland the showcase environment for the application of the future. ■

Stan Miastkowski, former BYTE senior editor for new products, is a freelance writer specializing in computer technology and news. He can be reached on BIX as "stanm."

THE FACTS

Paradox 4.0
$795

Paradox for Windows
(price not yet available)

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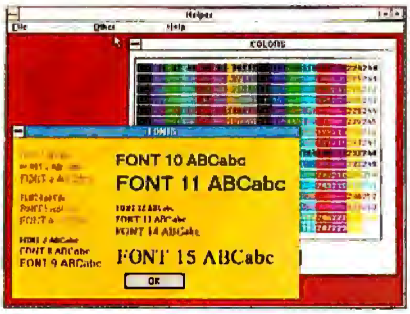

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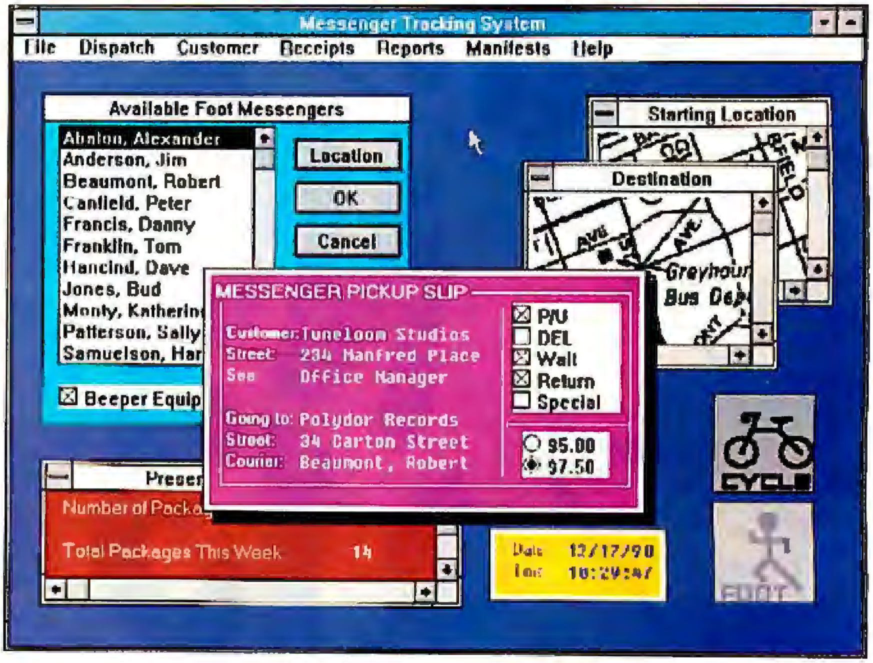

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Coherent Grows Up

BEN SMITH

The $100 Unix clone is now a 32-bit operating system that looks and feels like Unix

Even though Mark Williams Co. has been shipping its $99.95 Unix clone, the Coherent operating system, since 1990, it hasn't been more than a toy. But with the release of Coherent 4.0, you can have a real 32-bit operating system. It not only looks and feels like Unix, it also can build and run real 32-bit application programs. I found the beta version I looked at to be a very usable operating system, albeit with some drawbacks.

Big Binaries

The previous version, Coherent 3.0, could compile and run only small-model programs (i.e., instruction space of 64 KB and data space of 64 KB). Despite this limitation, Coherent 3.0 sold tens of thousands of copies. After all, all the Unix utilities worked well, it was multitasking, and it could handle several simultaneous log-ins over serial lines. If nothing else, Coherent 3.0 made a cheap UUCP E-mail server. It even had RSW's `rdb` database system available.

Coherent 4.0 breaks the memory-model barrier. Because the new version is a 32-bit operating system, the limitations of segmented memory models no longer apply. The kernel, the compiler and libraries, and some of the commands use 32-bit native mode. Also, the binary file format is COFF, which means that you can move binaries back and forth between Coherent 4.0 and other Unix systems that are both COFF- and Intel-based (e.g., SCO Unix, ESIX, and Interactive Systems). Some restrictions apply, however, because Coherent doesn't implement all the system calls.

For the User

Coherent includes over 200 commands and utilities familiar to Unix users. It has two command shells, the Bourne shell and the Korn shell. It has two screen editors, MicroEmacs (a limited and smaller version of the configurable and self-documenting programmer's editor that is very popular with computer science students and practitioners around the world) and `elvis` (a `vi` clone that is included but not supported by Mark Williams).

Also included are `bc`, the arbitrary precision calculation program, and `awk`, the report calculator and formatter. Version 4.0 even has an implementation of the text-formatting programs `nroff` and `troff`, along with the macro library `ms`. There are `tar` and `cpio` for backup and transfers with removable media and UUCP and Kermit for file transfers with other systems. And you can spawn subshells and run background processes.

Version 4.0 adds the ability to have multiscreen sessions; I toggled between several virtual terminal screens, running different applications in each. I was able to run binaries created with the old version, with recompiling. I appreciated several important new utilities, including `elm` (a modern user interface to Unix mail).

Being familiar with the genre of freely available Unix software, I couldn't help but notice that much of what I saw in Coherent was not developed by the programmers at Mark Williams. This does not mean that the programs are not sophisticated or of high quality. In the months to come, most of the GNU utilities will probably be available for Coherent, including `gcc` (GNU C compiler), `bash` (Boume Again Shell), and `perl` (Practical Extraction and Report Language, aka Pathologically Eclectic Rubbish Lister), thanks to people like Esa Ahola of Atlanta, Georgia.

For the Programmer

Coherent has library and system calls for building complex application programs, including interprocess communications with shared memory, semaphores, and message passing. For memory management, there is demand paging and virtual memory.

Coherent contains all the tools for serious application programming, not the least of which is the well-known Mark Williams C compiler, as well as `yacc` and `lex` (for lexical analysis and compiler-type program design). It also has a debugger (although it's somewhat primitive) and adds utilities for converting programs from the earlier (286) version to version 4.0. You can get BASIC, FORTRAN, COBOL, and C++ from third-party publishers.

These programming tools (and Unix-like developer's environment) are especially important to Coherent because few commercial application programs have been ported to the system. The value of an operating system begins with the value of the applications that run on it. Coherent is an extremely economical and flexible environment for building stand-alone multitasking and multiuser applications, such as those that VARs (value-added resellers) create for their customers. Because Coherent is so much like Unix, there is little that a Unix programmer will find unfamiliar in this product. A comparable Unix system with the developer's tools costs at least 10 times as much.

The Drawbacks

Coherent is not Unix. Because it isn't even Posix-compliant, it shouldn't be expected to behave exactly like Unix. Don't be surprised when your Unix Bourne shell scripts don't behave exactly as they do on a Unix system. In fact, you will find that most of the options to the commands don't exactly match those on any modem Unix system. There is a strong similarity between Coherent and Unix 7, from back in the 1970s. This is predictable, since much of the code that makes up the modern versions of Coherent dates back to the previous decade.

One further drawback is in the performance of some programs. Despite the great reputation of Mark Williams C compilers, they are optimized more for small size than for speed. The Dhrystone benchmark ran significantly better under DOS and even SCO Unix than it ran under Coherent.

There are some other problems as well. Since there is not yet any networking software for Coherent, you must use floppy disks or a file transfer utility like Kermit or UUCP to move files back and forth between different systems.

The Good, the Bad, and the Ugly

Despite the performance hit and the many inconsistencies between modern Unix and Coherent, I think that Coherent 4.0 has a lot going for it. I found that the on-line (man pages) and the 100-page printed documentation is clear and complete.

In the 386 Unix arena, it is not uncommon to pay thousands of dollars for a full system with development tools and find that something you have taken for granted as being part of any Unix system is not there. Coherent doesn't let you down this way, having just about everything.

What you won't find is networking (other than UUCP). And you won't find the X Window System. All you get is ugly, old character-based application tools. But you will find support for screen controls (the `curses` and `termcap` libraries). Mark Williams hopes to have the networking tools out by the end of this year.

Coherent's requirements are tiny compared to Intel-based Unix. You need only 640 KB of memory (compared to 4 MB) and 10 MB of disk space (compared to 40 MB). The price of $99.95 for the full system compares to over $800.

With the low cost of 386 systems and memory, you can build a very useful, multiuser, multitasking solution to an office automation problem without learning a new operating system (if you are familiar with Unix). And the environment will cost less than a PC-based video game. ■

Ben Smith is a testing editor for the BYTE Lab and the author of Unix Step-by-Step *(Howard W. Sams, 1990). You can contact him on BIX as "bensmith" or on the Internet at ben@bytepb.byte.com.*

THE FACTS

Coherent 4.0
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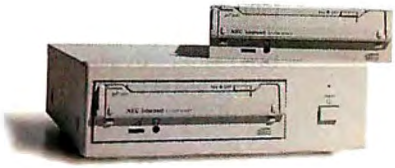

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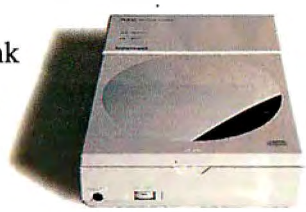

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Keeping in Step with Windows

JON UDELL AND TOM THOMPSON

CorelDraw 3.0 and Adobe Illustrator 4.0 have some impressive new features

With Windows upgraded to version 3.1, applications are also being upgraded to keep step. Two graphics packages that do so admirably are CorelDraw 3.0 and Adobe Illustrator 4.0.

CorelDraw 3.0

CorelDraw 3.0 weighs in at a whopping 23 MB. The core illustration tool gains a host of features, as well as new charting, presentation, and image-editing tools.

Longtime CorelDraw users will have a field day with version 3.0. An overhauled user interface employs free-floating "roll-up" tool palettes to manage the expanded feature set. Wherever possible, direct manipulation replaces menu or dialog-box interaction. Corel has abolished the split-window approach to editing and previewing, because version 3.0 can edit rendered objects directly.

Text handling becomes much more powerful. Text objects now sport a cursor, so you can add and delete characters directly. To change attributes—the point size or emphasis of an "artistic" text object or the justification of framed text—you can park the text roll-up on-screen and tweak the object interactively. When you fit text to a path, CorelDraw links the two objects, so if you edit either the text or the path, the two readjust dynamically.

Screen 1: *CorelDraw 3.0's blend tool works dynamically, so if you change the path, you don't need to change the blend.*

The blend tool, which interpolates a series of intermediates between two objects, can now follow a path (see screen 1). Three-dimensional extrusion now supports a movable light source; interactively adjustable depth, orientation, and perspective; and solid or gradient fills on the extruded surfaces. Complex drawings can now be divided into multiple named layers. Bit-map support improves with new import/export filters for GIF and Targa. In addition, although it wasn't available in the beta version I looked at, the toolkit will include a stand-alone image editor called CorelPhoto-Paint.

Corel has jumped headfirst into OLE (Object Linking and Embedding). CorelDraw 3.0 has client and server capabilities, and that's a happy combination. On the client side, OLE enables CorelDraw to lean on other applications that supply vector and bit-map graphics. Because its forte is graphics, the program also works well as a server. It feeds OLE clients data types they can usefully render—metafiles and bit maps.

Some interesting synergies emerged as I explored CorelDraw's OLE features. When I embedded a Paintbrush bit map in a Corel drawing, for example, I found

THE FACTS

CorelDraw 3.0
$595

System requirements:
A 386, 486, or PS/2 with a hard drive, a Windows-supported VGA monitor, and a mouse or tablet. Windows 3.1 is required for TrueType fonts.

Corel Systems Corp.
1600 Carling Ave.
Ottawa, Ontario,
Canada K1Z 8R7
(613) 728-8200
fax: (613) 761-9176
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that Corel's stretch operation left the bit map unchanged. The interplay between Paintbrush's bit editing and Corel's nondestructive effects editing hints at the sort of cooperation that OLE can support.

TrueType support is the other notable Windows 3.1 enhancement. The first beta version still used the old WFN fonts, but Corel will move to TrueType in the final release. Font-editing capabilities now encompass TrueType, letting me create my own TrueType characters by exporting Corel vector art to a font file, which I then installed and tested using Windows Write.

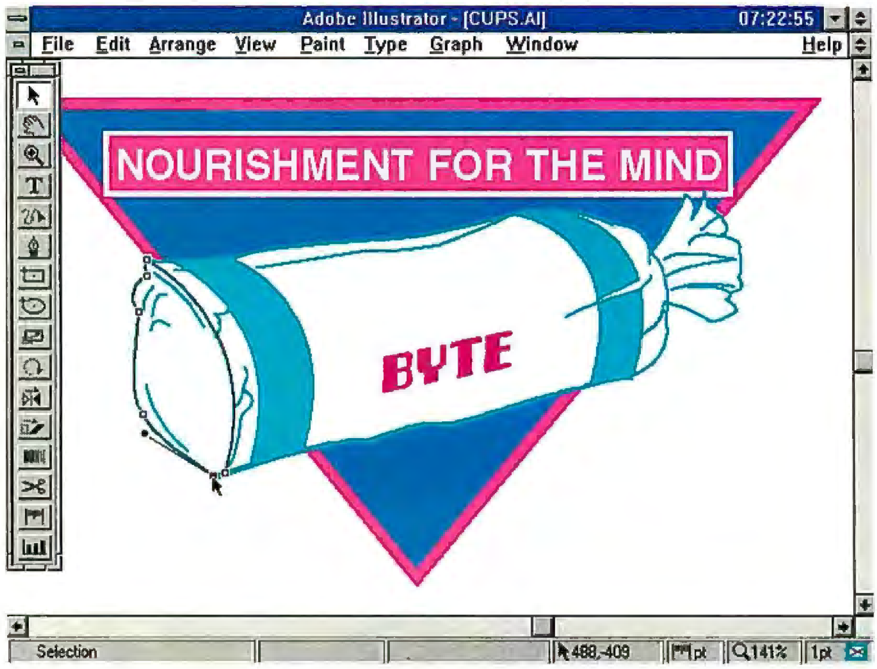
Corel's marketing message resounds with phrases like "all-in-one solution" and "value-packed," and I can't disagree with that. But I do a lot more illustration than charting or presentation, and it's the core product's vastly improved power and ease of use that really make my day.

Adobe Illustrator 4.0

An early glimpse of Illustrator 4.0 shows that Adobe plans to recapture the PC graphics market. The new version has a lot going for it in this attempt, and it starts with all the features found in the Mac and Next versions. Illustrator 4.0's color support can handle the growing number of 16- and 24-bit displays appearing for Windows, and the software is souped up for high performance on 32-bit systems. To achieve this performance boost, the code uses the flat address-space mode found on the 386 and 486 processors.

I installed copies of a beta version of Illustrator 4.0 on two 33-MHz 486-based machines with 16-bit display adapters. Illustrator 4.0 requires a new 32-bit version of Adobe Type Manager, which is included. Also bundled in are a color separator application, TypeAlign (an application that lets you manipulate text outlines for special effects), and 40 Adobe Type 1 outline fonts. Through the end of this month, Illustrator 4.0 comes bundled with StreamLine 3.0, an auto-tracing tool that traces color images to produce artwork composed of Bézier curves and color-filled objects.

Mac and Next users will feel right at home with Illustrator 4.0 for Windows. The program's layout is virtually identical across the three platforms. At the bottom of the drawing window is a status line that provides bits of important information as you proceed with your drawing. The tool-palette window can be a fixed window at the screen's left, or it can float anywhere on-screen. Mac users will like



Screen 2: *Illustrator 4.0 lets you edit your artwork in the Preview mode, modifying your work on the fly.*

the program's equivalent keystrokes: I was delighted to discover that I could edit my artwork in the Preview mode, and I could modify the artwork on the fly with all the colors and masks on-screen (see screen 2). Also new is the magnifying glass tool's "selective zoom" feature: You drag a marquee around the area of interest, and just that area appears enlarged in the window.

I was able to import BMP, PCX, and TIFF images as templates by tracing the imported image by hand with the drawing tools, with Illustrator's auto-tracing tool or StreamLine. The program also handles a variety of import/export formats (e.g., CGM, DRW, Macintosh PICT, and Windows Metafile).

To test cross-platform compatibility, I copied several illustrations I had drawn on the Mac to Illustrator 4.0. The Windows version had no difficulty working with the Mac files or files moved from the Next computer. Nor did the Mac have any problem opening and editing the files made by Illustrator 4.0.

Illustrator 4.0 lacks some features I'd like to see, such as a decent implementation of gradient fills or layer controls. I'm not saying Illustrator 4.0 is flawed, though; PC users will be glad to get their hands on its feature-rich set of tools. ■

THE FACTS

Adobe Illustrator 4.0
$695

System requirements:
A 386- or 486-based PC with 4 MB of RAM, a VGA adapter, and Windows 3.0 or higher.

Adobe Systems, Inc.
1585 Charleston Rd.
P.O. Box 7900
Mountain View, CA 94039
(800) 922-3623
(415) 961-4400
fax: (415) 961-3769
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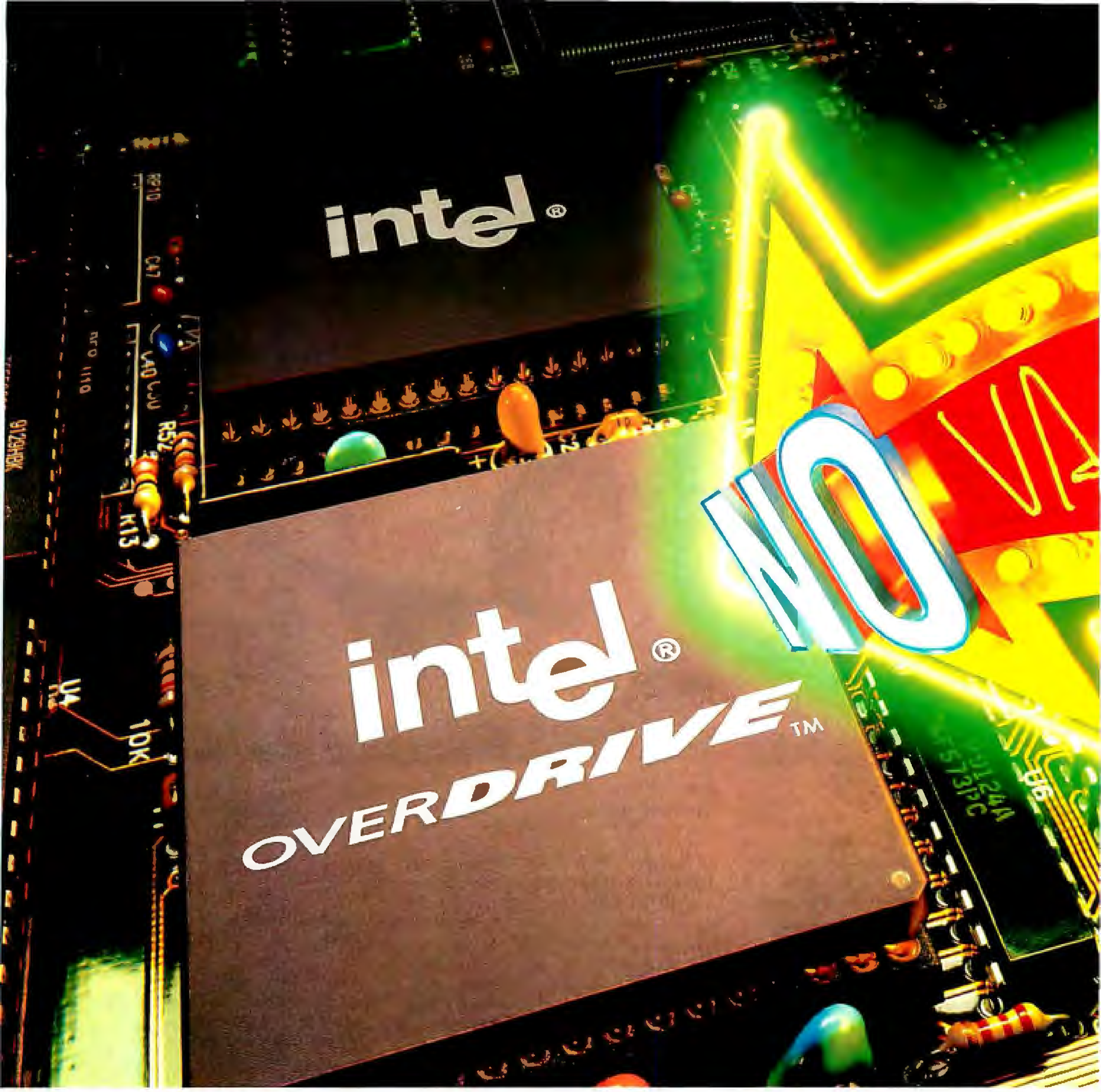

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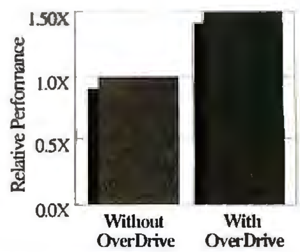

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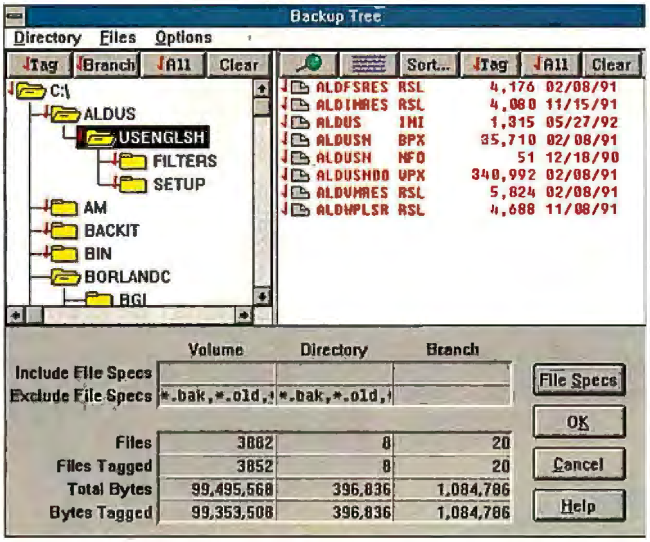
NEWS

FIRST IMPRESSIONS

Back It Up, Windows



It is ironic that one of the things every computer user should do—backing up—is among the most tedious, unpleasant tasks to complete. That's doubly true for Windows users, who typically have to enter DOS to back up their systems.

Back-It for Windows, from Gazelle Systems, aims to make backing up files so easy that you'll do it without thinking. Like Norton Backup for Windows, Back-It is a real Windows application. Nearly everything can be done with just the mouse, from setting preferences to selecting files. Back-It includes a scheduler that sits in the background and kicks off backups at times and dates you preselect.

I ran a prerelease version of Back-It. The utility's interface is classic Windows style, with a few twists. Probably the most commonly seen interface element is the file-selection dialog box, and Gazelle did a good job of designing it. For the most common backup tasks, this dialog box reduces file and directory tree selection to a few simple and obvious actions. The box is presented in the traditional split view, with the left side showing the directory structure, and the right side showing the files in the currently selected directory. Tagging can be done on either side, and an entire branch can be tagged by selecting it and clicking on the Branch button.

You can sort the file view by a number of useful criteria. In a useful twist, Back-It lets you specify inclusion and exclusion lists based on wild cards; the lists are used to automatically tag files, and separate lists can be applied at volume, branch, and directory levels. For many backups, a good set of lists is all the selection that's needed. You can, however, tag or untag individual files once Back-It applies its automatic selections. My one complaint with the file-selection dialog box is that groups of files cannot be drag-selected and tagged.

Back-It's installation adds a background task to your WIN.INI file that watches the clock and fires off backups automatically according to a schedule. Schedules are built easily enough from within Back-It, and they can be either full or "modified files only" backups. You can stack your entire backup scheme into the scheduler, directing that certain hard drives get backed up to certain floppy drives, that full backups get done every Friday, and so on. When Back-It's scheduler kicks in, it pops up a requester whenever it needs a disk or tape change. A running backup displays an icon whose title changes to reflect the percentage of the backup completed so far, and a requester pops up to let you know that the backup is finished.

Back-It's support for tape drives is much more complete than that in Norton Backup for Windows. Through a DOS device driver, Back-It supports both floppy controller-based and dedicated controller-based tape drives. Your specific drive must be directly supported. Tapes can be formatted from within Back-It, and the program includes useful tape-oriented functions like retension and security overwrite.

To save media, Back-It applies compression on demand. It also has its own verification and error-correction schemes (which can be disabled). Finally, backups can be directed to any DOS device, so you can back your system up to a network server or create an archive file that can be copied to other systems and unpacked by Back-It.

Overall, Back-It for Windows is an easy, relatively full-featured backup program for Windows. I found it much easier to use than Norton Backup for Windows, although it has fewer options for advanced users. Since backups are something you must do anyway, I figure you may as well make it as easy as possible. Back-It fills that bill better than anything I've seen yet.

—*Tom Yager*

THE FACTS

Back-It for Windows
$99.95

Gazelle Systems, Inc.
305 North 500 West
Provo, UT 84601
(801) 377-1288
fax: (801) 373-6933
Circle 1181 on Inquiry Card.

AST's Premium Exec Offers Affordable Portable Color

The past few months have seen the introduction of several color notebooks. While portables with active-matrix screens offer brighter displays and faster cursor response than notebooks with passive-matrix screens, they also cost more. Prices for passive-matrix notebooks are now threatening the $3000 barrier. These lower-cost color notebooks are getting close attention from Windows users who want to take their WYSIWYG applications on the road. Competition is sure to get even fiercer in this notebook category.

AST Research's new **Premium Exec 386SX/25C** color notebook is a good example of this competitive trend. I had my evaluation unit for only a few weeks when the company changed its pricing strategy for the notebook and reduced the suggested retail price on all versions of the unit by 18 percent. With monochrome versions of the 60-, 80-, and 120-MB versions of the notebook just $300 less than the color versions, AST has reduced the gulf between

color and monochrome portables to a hop.

The Premium Exec weighs 7 pounds and sports a 9-inch diagonal VGA display with two backlit CCFT (cold-cathode fluorescent tube) panels. My unit had 4 MB of RAM (expandable to 8 MB) and an 80-MB hard drive. Like other passive-matrix color notebooks I've seen, it was sometimes difficult to pick up the cursor when running Windows applications, especially paint programs. However, when you use this or a similar system to generate color business presentations or spreadsheet charts, you will be loath to return to a monochrome system.

AST's notebook runs on a standard 386SX processor and nickel-cadmium batteries. The company says you can expect to run the notebook for 2½ hours when it's fully charged. But when I left the system plugged in while I worked on it and then ran it on batteries alone, the charge duration went down to about an hour.

I found the notebook's 82-key keyboard comfortable and easy to work with. I ran Windows applications using a standard mouse and Microsoft's Ballpoint miniature trackball. In spite of the difficulty I

sometimes had in picking up the cursor, both devices worked well.

The notebook has one proprietary expansion slot for adding a modem. In the back of the system, there are standard serial, parallel, external VGA monitor, and six-pin PS/2 connectors. I was disappointed to find that the system does not have sleep or suspend/resume modes.

Until screen manufacturers can improve the yields in manufacturing active-matrix screens—which may not happen for a year or more—passive-matrix technology will offer the only low-cost portable color solution. Although AST's Premium Exec doesn't offer the power-saving features that some other notebooks offer, it is a solid low-cost entrant into the expanding color notebook market.

—D. L. Andrews

THE FACTS

Premium Exec 386SX/25C
with a 60-MB hard drive, $3295;
with an 80-MB hard drive, $3595;
with a 120-MB hard drive, $4095

AST Research, Inc.
16215 Alton Pkwy.
P.O. Box 19658
Irvine, CA 92713
(800) 727-1278
(714) 727-4141
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Norton Desktop for DOS: Utilities for the Masses

The historical shortcomings of DOS have made us witness to years of watching file and disk management products leapfrog one another with every new version. But if Symantec has its way, relatively unsophisticated non-Windows users will never look elsewhere (or shop separately) for a file manager, menuing system, data-recovery program, and several other tools. They'll just buy **Norton Desktop for DOS.**

Norton Desktop for DOS is Symantec's $179 front end to the best functions of Norton Utilities, Norton AntiVirus, Norton Commander, and Norton Backup. (Version 2.0 of Norton Desktop for Windows started shipping in April.) While the just-shipped version for DOS that I saw cannot quite match the Windows product in drag-and-drop dexterity, the interface resembles that of Windows closely enough to get the job done and allow for an easy switch later if you so decide.

It's easy to guess that operating Norton Desktop centers around a Windows-like desktop of resizable windows, drive icons, pull-down menus, and dialog boxes. Symantec's expectation, of course, is that you'll auto-load Norton Desktop and double-click on your mouse on user-defined menus to launch your applications. This is nothing new. Where Norton Desktop strives to earn a permanent line in your AUTOEXEC.BAT file is in the degree of customization it offers.

Beyond installation, the program's flexibility begins with the many available options for tweaking the desktop to your liking. A choice of long versus short pull-down menus is a start; even better is the ability to take out options you or your workgroup will never use. If you're upgrading from Norton Commander, you can opt to switch the desktop interface to that of Commander—at some loss of feature accessibility. And if you'd like to change the role of the clickable buttons lining the bottom of the screen (numbered on a par with the function keys), you can replace F2 through F9 with any available command.

If you do this, however, you hamper Norton Desktop's drag-and-drop capability. This feature lets you click on a file or a directory and drag its graphical representation to another location—provided the destination is displayed in a file or a tree window—or even onto a button itself to edit, print, move, copy, or delete.

continued


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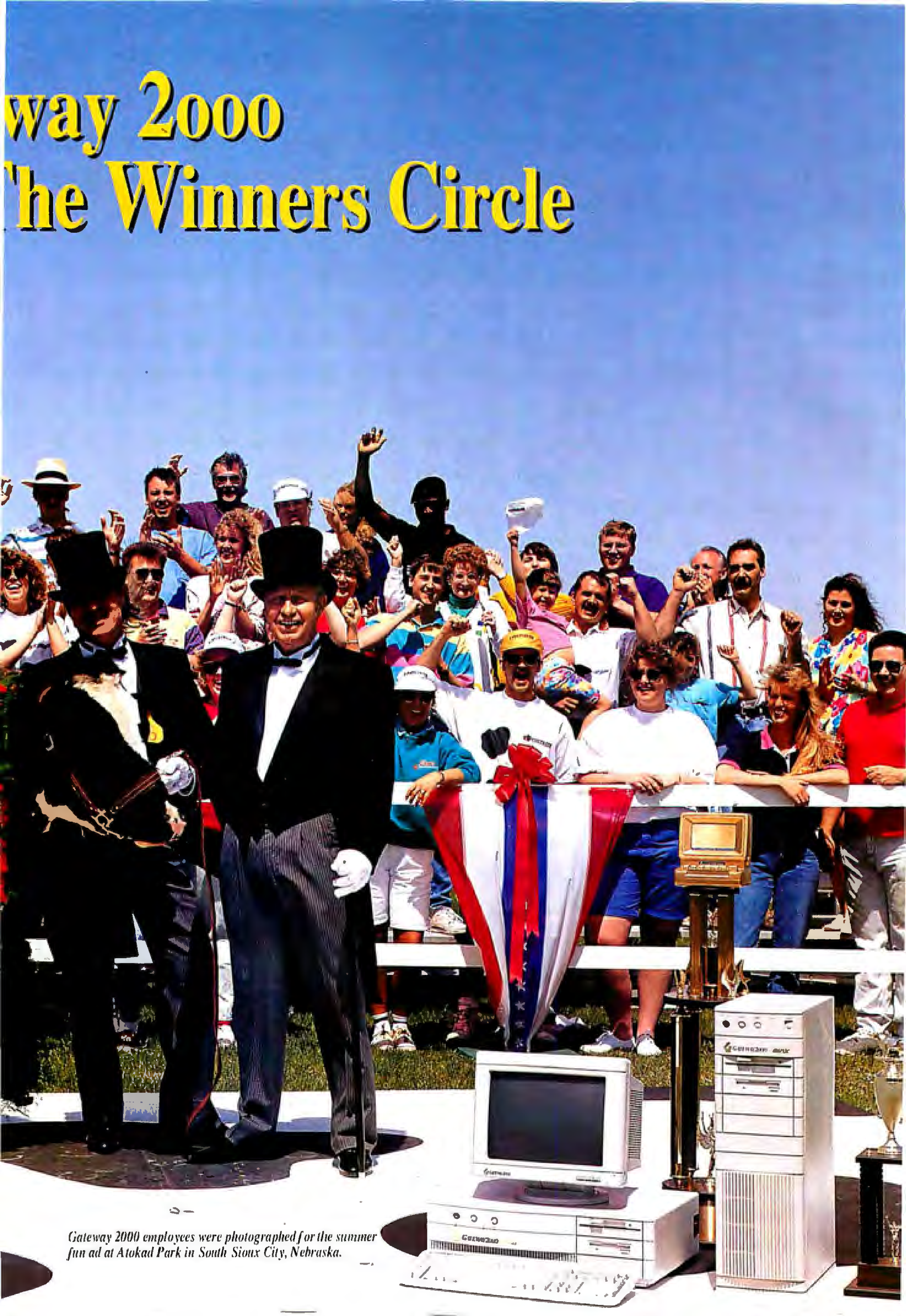
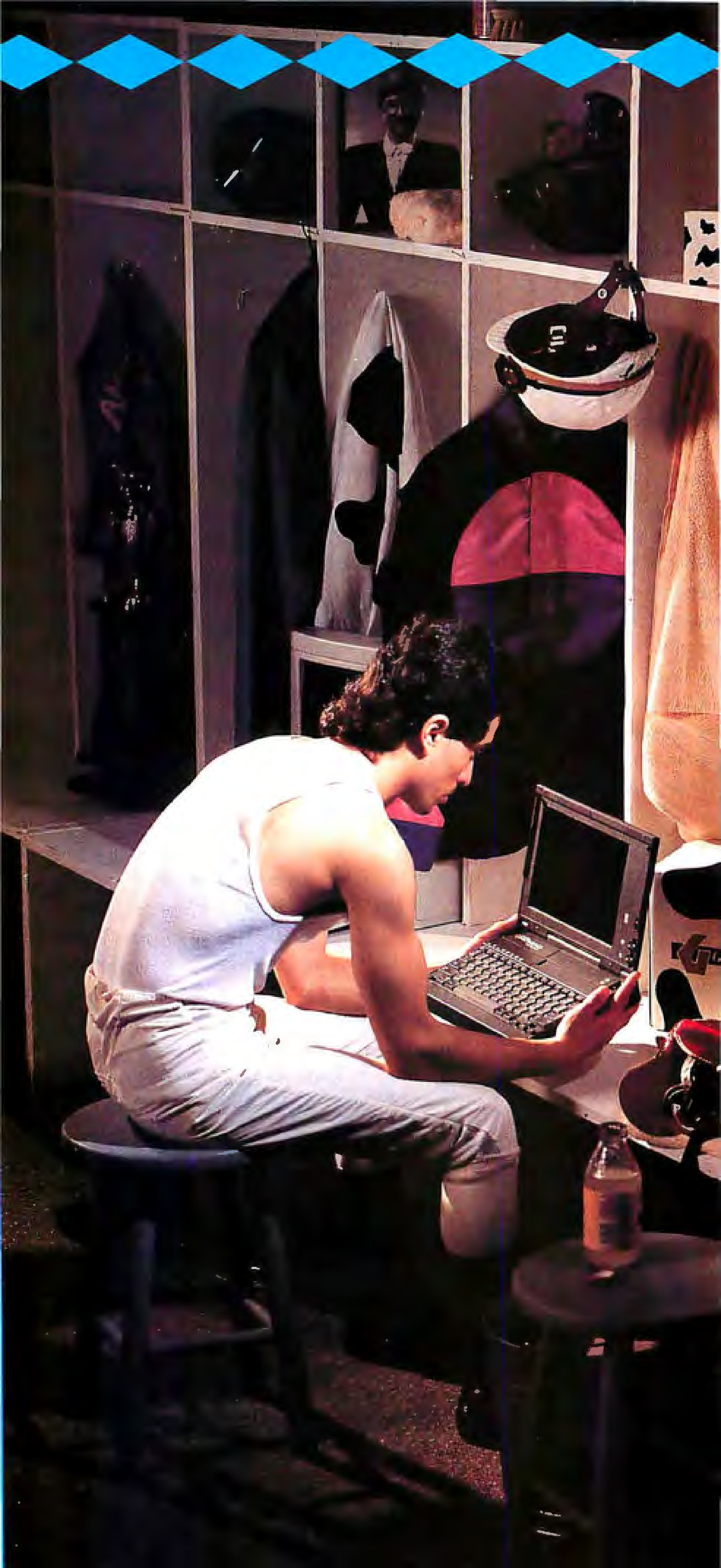


Gateway 2000 employees were photographed for the summer fun ad at Atokad Park in South Sioux City, Nebraska.



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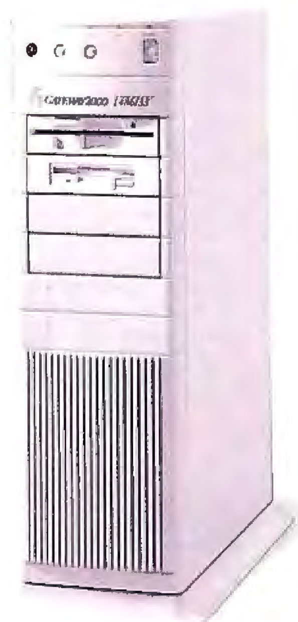

System Highlights: 64K cache RAM ■ 8MB RAM ■ 200MB Western Digital IDE hard drive with RIDE BIOS ■ ATI Graphics Ultra ■ 14" CrystalScan 1024NI VGA color monitor, up to 1024 x 768 non-interlaced resolution ■ desktop model is standard

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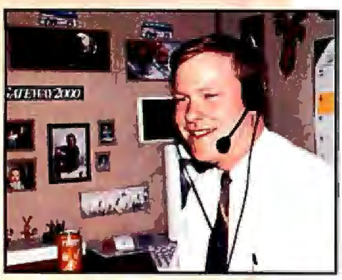

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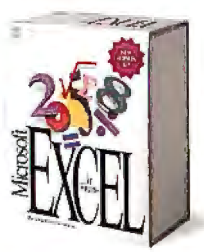

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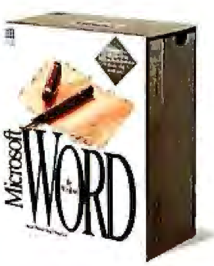

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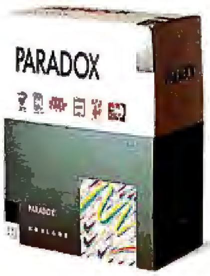
■ Easy-to-use desktop presentations program creates high-quality overheads and 35mm slides

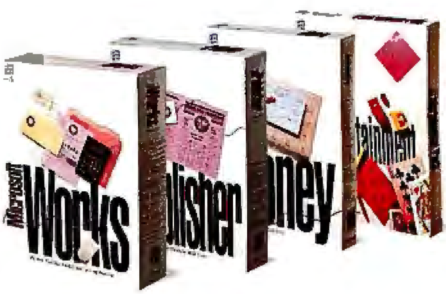
Option #4-*Borland® Paradox 3.5*



■ The award-winning database from Borland

Option #5-*The Entrepreneur Pack*

■ Includes the latest Windows versions of *Microsoft Works*,™ integrating word processing, spreadsheet, and database in one easy-to-use program; *Microsoft Publisher*,™ for creating page layouts; *Microsoft Money*,™ to help you write checks, set budgets, track expenses; PLUS an *Entertainment Pack* with eight games, including *Tetris*●



Option #6- *The Windows Programmer Pack*

■ Includes everything you need to create programs for Windows: *Microsoft QuickC for Windows*,™ *Windows Control Development Kit*,™ *Windows Help Compiler*™ and *Windows Programmers' Online Reference*.™

Option #7-*Microsoft Project for Windows*™*3.0*

■ Flexible and easy project management program

NOTE: If you would rather replace an option with *Microsoft Office*,™ it is available for $175. This package includes *Word for Windows, Excel* and *PowerPoint.*

New! Second Applications At Great Prices!

The following applications are only available with the purchase of a system, pre-installed, or to Gateway customers.

Central Point® Anti-Virus 1.2 For Windows ■ $75

Central Point Backup™ 7.2 for Windows ■ $75

The Norton Desktop™ 2.0 and Prisma YourWay 2.0 For Windows ■ $95

These offers include the identical applications contained in retail packages but will not include the retail box. You get all master diskettes and manuals, shrink-wrapped and packaged in a Gateway 2000 box.

Peripherals

The 15-Inch CrystalScan 1572FS

You'll enjoy your new Gateway 2000 computer even more if you choose the new 15-inch CrystalScan color monitor option. The CrystalScan 1572FS has a flat, square, non-glare screen to reduce distortion around the corners and provide edge-to-edge display area.
The CrystalScan 1572FS is an upgrade option only with the purchase of a 386DX or 486 system for an additional $195.

The Gateway 2000 TelePath™ Fax/Modem

The Gateway 2000 TelePath is a 14,400 bps mode, V .32bis, with 9,600 bps fax capability. The TelePath comes with WinFax Pro,™ Crosstalk™ for Windows, Qmodem™ and a free 30-day basic services CompuServe® membership — all for only $195!

■ Fax mode: V.17, V.29 and V.27ter

■ Data mode: V.32bis, V.32, V.22bis, V.22, V.21, Bell 212A and 103, V.42 and MNP 2-4 error correction, V.42 bis/MNP 5 data compression

Included With Every System:

■ One-year limited warranty ■ 30-day money-back guarantee ■ Lifetime toll-free technical support ■ Free on-site service to most locations (*factory service only for notebooks*) ■ Free bulletin board technical support ■ C.O.D. terms and major credit cards honored ■ Net 30-day credit terms and leasing options available to qualified commercial customers

Sorry — we sell peripherals only with the purchase of a Gateway 2000 system, or to people who are already Gateway 2000 customers. For fastest service, call our new direct line for the ***Component Add-On Division: 800-252-3333.*** *Please have your customer ID handy when you call.*

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- 79-Key Keyboard
- FieldMouse™ Pointing Device
- MS DOS® 5.0 & Windows™ 3.1

$1995

NOMAD 420SXL

- 20MHz, Intel® 486SXLP Processor
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- 80MB IDE Hard Drive
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- Simultaneous Video with 1MB
- Size 8.5" x 11" x 1.8", 5.8 Lbs.
- 6-Hr.* NiCad Battery & AC Pack
- 1 Parallel/1 Serial Port
- 79-Key Keyboard
- FieldMouse Pointing Device
- MS DOS 5.0 and Windows 3.1

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NOMAD 425DXL

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- Simultaneous Video with 1MB
- Size 8.5" x 11" x 1.8", 5.8 Lbs.
- 6-Hr.* NiCad Battery & AC Pack
- 1 Parallel/1 Serial Port
- 79-Key Keyboard
- FieldMouse Pointing Device
- MS DOS 5.0 and Windows 3.1

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25MHz 386SX

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- MS DOS 5.0 and Windows 3.1
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$1895

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- 64K Cache RAM
- 4MB RAM
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- 14" CrystalScan 1024NI Color VGA Monitor
- 1 Parallel/2 Serial Ports
- 124-Key AnyKey Keyboard
- Microsoft Mouse
- MS DOS 5.0 and Windows 3.1
- Choice of Application Software

$2395

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- Intel 486DX2 Processor
- 64K Cache RAM
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- 124-Key AnyKey Keyboard
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- MS DOS 5.0 and Windows 3.1
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- 124-Key AnyKey Keyboard
- Microsoft Mouse
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- Choice of Application Software
- Tower Model is Standard

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OTHER SYSTEMS

- Other systems in our product line: 16MHz 386SX, 20MHz 386SX, 25MHz 386DX, 33MHz 386DX, 33MHz 486DX EISA. Call for details and pricing.

** Battery life was measured using PC Magazine's Battery Rundown Test with power management enabled. Actual results may vary depending on configuration and applications.*

All prices and configurations are subject to change without notice. Prices do not include shipping. Components, peripherals and software are sold only with the purchase of a system, or to customers who already own Gateway 2000 systems. Some limitations apply.

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Compared with Norton Desktop for Windows, the process is understandably less smooth. (And the "Delete" button is no trashcan icon.) Nevertheless, non-Windows users should appreciate this no-nonsense alternative to clicking on the File menu.

Norton Desktop goes beyond typical DOS-shell application launching with menus you can create (or have the program auto-build), edit, and organize into workable groups. Among the network features, you can limit users' access to applications, have the computer reboot the PC upon exiting the program to prevent novices from accessing DOS, and password-protect individual menu items.

Another handy feature, which was introduced by Traveling Software's LapLink Pro, is PC-to-PC file transfer. Accomplishable via parallel or serial ports (serial only if transferring the file transfer bootstrap to a PC without it), you can connect two stand-alone PCs or have network clients access a PC connected remotely to your server.

Where the product disappoints, you can understand Symantec's logic. Printer drivers, for instance, are limited to an ASCII dump and a few variations of both Hewlett-Packard LaserJet II and PostScript. (For others, you must manually enter control codes.) However, keep in mind that you'll do most printing from the applications you launch. And while virtually all the features of Commander, Anti-Virus, and Backup are included here, anyone familiar with Norton Utilities will find much of that package's functionality lacking here. The company clearly had to draw the line somewhere.

Symantec is the first to admit that the program is not intended for the power user. But considering the integrated functionality of utilities that together would otherwise list for about $600, neither is Norton Desktop for the power spender. Think of it: over $400 less for a GUI front end that lacks the features many users will never miss. ■

—*Ed Perratore*

THE FACTS

Norton Desktop for DOS
$179

System requirements:
DOS 3.1 or higher, 640 KB of RAM, a hard drive with 7 MB of free space (2.5 MB for limited installation), and a modem if using Norton Mail.

Symantec Corp.
10201 Torre Ave.
Cupertino, CA 95014
(408) 253-9600
fax: (408) 253-4092
Circle 1183 on Inquiry Card.

Expandable Unix System

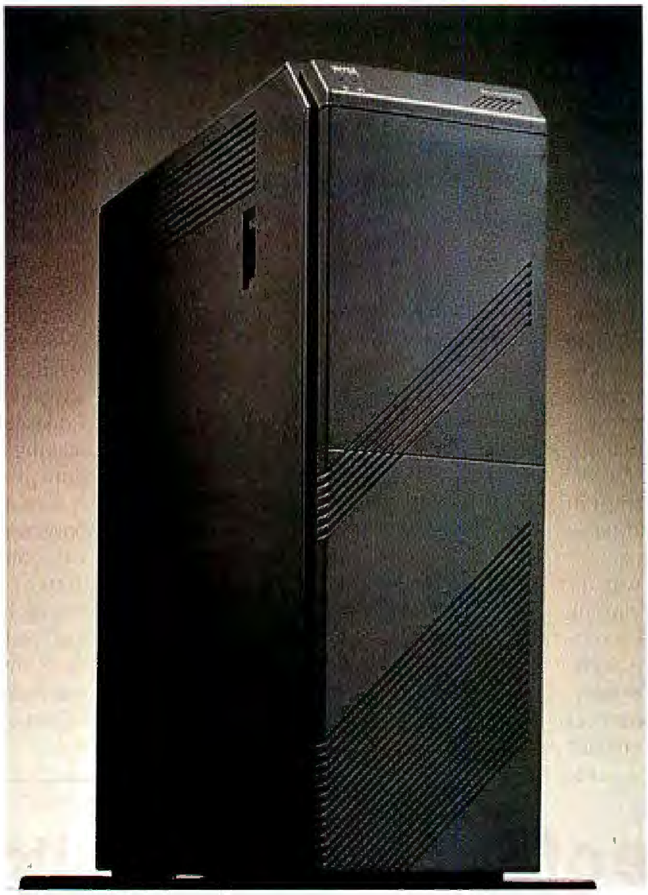
The Wyse Series 6000i Model 640 Unix multiuser system supports up to 32 users. Based on the 33-MHz 486 processor, the system includes a 387-compatible math coprocessor, 8 MB of RAM (expandable to 16 MB), 8 KB of internal cache memory, and a 128-KB external cache.

The modular tower system provides space for expansion via three mass-storage shelves for half- and full-height drives and six available ISA expansion slots. A 320-/525-MB cartridge tape drive, a 1.44-MB floppy drive, and a 420-MB SCSI hard drive are standard equipment. The unit has separate fans for the mass-storage and card areas.

Price: Base model, $9625.

Contact: Wyse Technology, Inc., 3471 North First St., San Jose, CA 95134, (800) 438-9973 or (408) 473-1200; fax (408) 473-2080.

Circle 1271 on Inquiry Card.



The Series 6000i Model 640 Unix multiuser system provides more than 2 GB of disk space.

A 486SLC in a Notebook

PC Brand's 25-MHz 486/SLC Notebook computer uses the Cyrix-based 486SLC microprocessor. Designed to handle memory-intensive applications, the unit has 2 MB of RAM, expandable to 16 MB.

Standard features of the 486/SLC Notebook include an 80-MB IDE hard drive, a 1.44-MB floppy drive, a suspend/sleep mode, and a proprietary 16-bit expansion slot for a 2400-bps data or fax modem. The unit has a nonglare, paper-white VGA screen with 640- by 480-pixel resolution that supports 32 shades of gray. Interfaces include two serial ports, a parallel port, an external VGA color monitor port, an external keyboard adapter, and an expansion connector.

Price: $1995.

Contact: PC Brand, Inc., 405 Science Dr., Moorpark, CA 93021, (800) 722-7263; fax (800) 722-7392.

Circle 1272 on Inquiry Card.

Local-Bus Logic on a Riser Card

The Anybus slim-line upgradable 486SX/20 computer removes the local-bus logic from the motherboard and puts it on a riser card. The card plugs into a CMS-patented SuperSlot, which lets you upgrade your 486 by plugging add-on and enhancement cards into the riser card, which is designed to accept as many as three cards. You can mix cards from different vendors for a customized configuration.

The Anybus system's motherboard is designed to support 169-pin and future Intel OverDrive products, and it has an optional local-bus video adapter that uses ATI's 68800 Mach-32 chip. Standard features include 4 MB of RAM, a 40-MB hard drive, five ISA expansion slots, DOS 5.0, and a 101-key keyboard. A standard-size version is also available.

Price: $1399.

Contact: CMS Enhancements, Inc., 2722 Michelson Dr., Irvine, CA 92715, (714) 222-6000; fax (714) 549-4004.

Circle 1273 on Inquiry Card.

Low Access Times Are Key

The Key486-50 and Key486-33 EISA PowerServers feature SmartCache's 68000 microprocessor and dual-bus architecture. The units allow simultaneous CPU, cache, and disk data transfer for effective access times of less than 0.5 ms.

Engineered to keep pace with growing LANs, the servers have 8 KB of built-in cache memory and a 487 math coprocessor, and they are upgradable to Intel's dual-speed CPU. You can install up to 16 MB of cache memory and 64 MB of RAM.

Each server has 10 drive bays, two cooling fans, a 14-inch Viewsonic 6 noninterlaced Super VGA color monitor, and a Super VGA card with 1 MB of RAM. The Key486-50 comes with a 700-MB tape backup unit, and the Key486-33 has a 250-MB tape backup unit.

Price: Key486-50 with a 675-MB hard drive, $6995; Key486-33 with a 340-MB hard drive, $4795.

Contact: Keydata International, Inc., 111 Corporate Blvd., South Plainfield, NJ 07080, (800) 486-4800 or (908) 755-0350.

Circle 1274 on Inquiry Card.

Optical Drive Has Hard Drive Speed

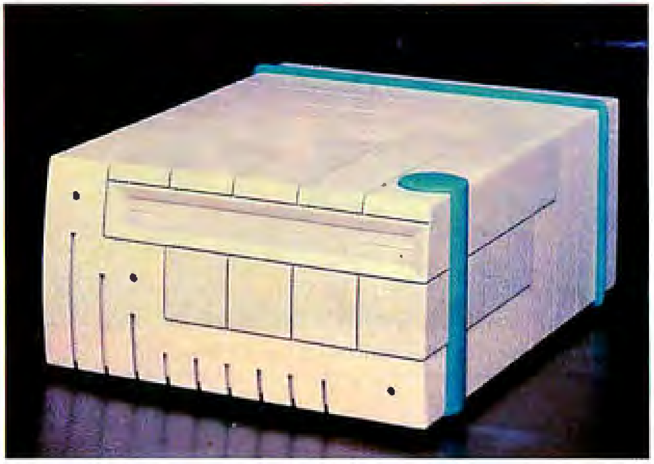
A 650-MB rewritable optical drive that runs at a hard drive speed of 3600 rpm, Pinnacle Micro's PMO-650 uses the company's newly developed optical hard drive mechanism. The advanced split optic design produces an optic head that is one-third the weight of original optic heads, for an effective access time of 19 ms. The drive's direct-seek method eliminates a step in the data-seeking process.

The PMO-650's controller has a SCSI connection, a 20-MHz data processor, and a synchronous data transfer rate of 1.4 MB in sustained mode and 4.2 MB in burst mode. The unit's dust-resistant design helps provide a mean time between failures of 30,000 hours. Unix operating systems see the plug-and-play drive as a standard removable hard drive, letting you use commands such as `mount`, `unmount`, and `format` to access it.

Price: Mac-, Sun-, and Silicon Graphics–compatible version, $3995; PC-compatible version, $4195.

Contact: Pinnacle Micro, 19 Technology, Irvine, CA 92718, (800) 553-7070 or (714) 727-3300; fax (714) 727-1913.

Circle 1275 on Inquiry Card.



The PMO-650's split optic design results in an ultralight optic head that has a fast seek time.

DAT Drives Gobble Up Data

Two DAT (digital audiotape) subsystems are now available from Tecmar. The DATaVault 4000, packaged with Tecmar's QTOS backup software, is designed for stand-alone systems and peer-to-peer networks; the ProLine DATaVault 4000 is packaged with the company's ProServe 4.0 VAP or NLM software for NetWare server–based networks.

Both drives provide an average of 4 GB and a maximum of 8 GB of storage capacity. The average backup speed of the drives is 20 MB per minute, with a maximum speed of 40 MB per minute. The drives use 4-mm DAT cassettes.

Price: DATaVault 4000, $5395; ProLine DATaVault 4000: VAP version, $5695; NLM version, $5995.

Contact: Tecmar, 6225 Cochran Rd., Solon, OH 44139, (800) 624-8560 or (216) 349-0600; fax (216) 349-0851.

Circle 1276 on Inquiry Card.

External Bernoulli Drives Use PC Power

Two 90-MB Bernoulli drives for ISA-based PCs, the Bernoulli PC Powered 90 and the Bernoulli PC Powered 90 Pro, receive power from your computer through the bus adapter card included with the drive. The 2¾- by 6¾- by 10¾-inch external drives are both fully compatible with all 90-MB Bernoulli disks and read 44-MB Bernoulli disks.

Both systems include an adapter board, a 90-MB Gold Standard disk, and software. The Pro drive's data-compression software provides a 180-MB backup mode with its data-compression software. Additionally, the Pro drive has a 32-KB on-drive cache memory and a 20-Mbps data transfer rate. Normal effective access time of the Pro drive is 18 ms; when used with the caching software, the effective access time decreases to 9 ms.

Price: Bernoulli PC Powered 90, $713; Bernoulli PC Powered 90 Pro, $855.

Contact: Iomega Corp., 1821 West 4000 South, Roy, UT 84067, (800) 777-6179 or (801) 778-1000.

Circle 1277 on Inquiry Card.

Lightweight Drives of Glass

A family of 8-ounce portable plug-in hard drives, the Vision Portable Drives are designed primarily for notebook and other portable computers. The preformatted drives transfer data at a speed of 1.25 MBps and have a typical seek time of 19 ms.

The drives use Vision Logic's IDS interface controller and Areal's 900G glass drive. Vision Logic says that the glass media technology in the drives makes them 10 times more durable than standard aluminum-based drive media. The 2- by 5- by 1-inch drives plug into the parallel port of your computer.

Price: 40-MB model, $399; 80-MB model, $599; 120-MB model, $799.

Contact: Vision Logic, Inc., 283 East Brokaw Rd., San Jose, CA 95112, (408) 437-1000; fax (408) 437-1719.

Circle 1278 on Inquiry Card.

Removable Magneto-Optical Drive

The Laserdrive LD-320 3½-inch magneto-optical drive works with both PCs and Macs. The removable, rewritable drive is available in internal and external configurations.

Designed for easy portability, the LD-320 has a capacity of 128 MB, an average seek time of less than 45 ms, an embedded SCSI connection, and ISO standard compatibility. The drive can also read ROM disks.

Price: External drive, media, and software, about $2995.

Contact: Laser Magnetic Storage International Co., 4425 ArrowsWest Dr., Colorado Springs, CO 80907, (719) 593-7900; fax (719) 599-8713.

Circle 1279 on Inquiry Card.

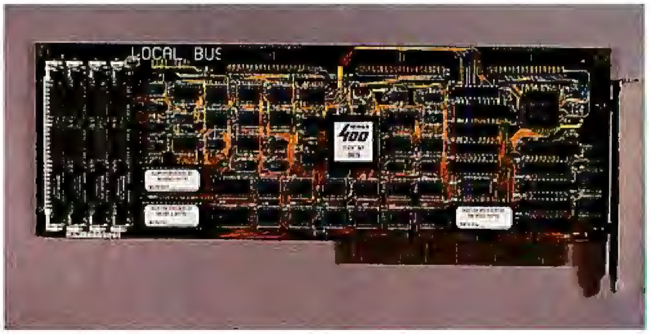
Local-Bus Data Caching

The Series 400 VL475I and VL475S caching disk controllers for the local bus comply with the Opti local-bus design and the proposed VESA specifications. The Windows 3.1-compatible controllers support up to 16 MB of RAM cache.

The VL475I supports up to four IDE hard drives and has a data transfer rate ranging from 19.5 to 33 MBps. The VL475S supports seven SCSI-2 devices for up to 12.6 MB of mass storage and is compatible with the ASPI (advanced SCSI protocol interface) support embedded in versions of the Unix operating system.

Both controllers support disk mirroring and use standard 256-KB, 1-MB, and 4-MB SIMMs for easy cache expansion. A hot-fix feature automatically tests for bad tracks that threaten data and rewrites the data to another track. Each controller also automatically identifies the disk drive to which it is attached, determining operating parameters such as size, head count, and sectors.

Price: $795 each.
Contact: Alpha Research Corp., Park North Building, Suite 120, 8200 Mopac Expy. N, Austin, TX 78759, (512) 345-6465; fax (512) 345-6496.
Circle 1280 on Inquiry Card.



The VL475 is a caching controller for the local bus.

JPEG Image Compression

The Series-H365 Accelerator Board runs Alice JPEG Image Compression software on PS/2 systems. Typical compression and decompression speed for the board is 750 KBps, which enables compressed images to be displayed faster than their originals.

The full-length expansion board uses the TMS320C51 DSP (digital signal processor) and an SGS Thomson IMSA121 discrete cosine transform processor. The board is available with from 32 to 128 KB of DSP memory and has a programmable security key and a fully JPEG-compatible bitstream.

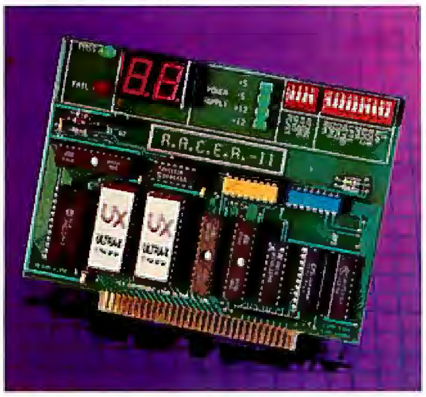
The Series-H365 is compatible with Alice JPEG Image Compression products that run under DOS, Windows, OS/2, and SunOS; thus, any image compressed with an Alice product can be retrieved by any other Alice product regardless of platform, operating system, or environment.

Price: $1595.
Contact: Telephoto Communications, Inc., 11722 Sorrento Valley Rd., Suite D, San Diego, CA 92121, (619) 452-0903.
Circle 1281 on Inquiry Card.

Portable Test Card

A second-generation half-size troubleshooting card with on-board diagnostics that relay component-level error messages, the PC-compatible Racer II comes with 512 KB of BIOS ROM for use with 386 and 486 motherboards. Additional new features on the plug-in card include a power-on self test, an improved testing methodology, support for EGA and VGA, and the ability to monitor power-supply voltages. Racer II displays the current test operation on its numeric display and a pass/fail test result on its on-board LEDs. It supports individual test selection.

Price: $649.
Contact: Ultra-X, Inc., 2005 De La Cruz Blvd., Suite 115, Santa Clara, CA 95050, (800) 722-3789 or (408) 988-4721; fax (408) 988-4849.
Circle 1282 on Inquiry Card.



Racer II shows the current test operation on a seven-segment numeric display to alleviate binary decoding.

Real-Time Images

The Eagle, a two-board real-time image-processing system, has a built-in VGA display and a frame grabber that lets you transfer multiple 640- by 480-pixel 8-bit images. The images are processed in real time at 30 frames per second. You can display the images at 60 Hz noninterlaced on a standard VGA monitor. In addition to the eight planes of VGA image storage, the display has nondestructive VGA overlay planes in either color or gray scales. Software support is provided by the Eagle Toolbox, a C or Pascal callable library.

Price: $8495.
Contact: Univision Technologies, Inc., 3 Burlington Woods, Burlington, MA 01803, (617) 221-6700; fax (617) 221-6777.
Circle 1283 on Inquiry Card.

Low-Cost Speed

The Mach 512 VGA, a Super VGA adapter with built-in accelerated functions, has a maximum expansion capability of 512 KB. Able to support resolutions of up to 1024 by 768 pixels in 16 colors, the card displays 256 colors at resolutions of 640 by 480 pixels and 800 by 600 pixels at a refresh rate of up to 72 Hz. Drivers for the card include AutoCAD releases 9, 10, and 11; Lotus 1-2-3; Windows 3.x; Word 5.0; and all VESA modes.

Price: With 512 KB, $89.
Contact: STB Systems, Inc., 1651 North Glenville, Suite 210, Richardson, TX 75081, (214) 234-8750.
Circle 1284 on Inquiry Card.

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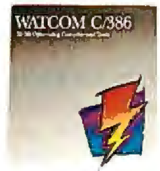

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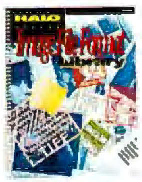

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Get a LANlord for Your Network

LANlord, an integrated software system for managing your LAN, lets you monitor and manage in real time your LAN and workstation activity, as well as workstation hardware, software, and configuration data. LANlord provides the network manager with ongoing profiles of each workstation on the LAN and prevents problems by anticipating them.

The system uses an OS/2 server to automatically collect, store, and update alert data and network statistics through a central database. An SNMP-based agent is located on each workstation to filter and transmit information defined in the object management information base. LANlord allows any network Windows workstation to serve as the management console; as many as 16 consoles can access the LANlord server at once.

Price: Starts at $999.
Contact: Microcom, Inc., 500 River Ridge Dr., Norwood, MA 02062, (800) 822-8224 or (617) 551-1000; fax (617) 551-1968.
Circle 1285 on Inquiry Card.

LANlord lets you proactively manage your LAN by alerting you when thresholds are violated.

Two Wireless LANs

The FreePort Wireless LAN has an IEEE Ethernet architecture and is SNMP compliant. Based on unlicensed spread-spectrum radio, FreePort sums the eight strongest radio signals to eliminate multipath interference.

FreePort consists of a hub with an antenna, transceivers with a multiuser interface option, and SeePort network management software. System throughput is as high as 5.7 Mbps, and transmission distance is as far as 260 feet. As many as 256 active users on as many as 62 wireless transceivers can use the system at any time, easily connecting with wired LANs. The system, transparent to existing networks, is compatible with all Ethernet LANs.

Price: Hub, starts at $4695; transceiver, $995; SeePort software, $2395.
Contact: Windata, Inc., 10 Bearfoot Rd., Northborough, MA 01532, (508) 393-3330; fax (508) 393-3694.
Circle 1286 on Inquiry Card.

FreePort operates seamlessly with existing wired LANs.

FirLAN, a 10-Mbps wireless Ethernet LAN, consists of two tranceivers and a hub. Able to run transparently across all Ethernet platforms and media, FirLAN allows seamless integration into existing wired LANs.

The ET300 transceiver has a 90-foot range and supports up to 29 Ethernet connections. An extended-range ET330 transceiver has a range of 300 feet. The EH360 hub covers a 90-degree area and supports as many as 250 transceivers.

Price: ET300, $1400; ET330, $1750; EH360, $3950.
Contact: A. T. Schindler Communications, Inc., 102–21 Antares Dr., Ottawa, Ontario, Canada K2E 7T8, (613) 723-1103; fax (613) 723-6895.
Circle 1287 on Inquiry Card.

A Single Solution for Ethernet

An EISA card that supports 10Base-2, 10Base-5, and 10Base-T Ethernet, the EISANet Model 3490E EISA Ethernet LAN adapter includes drivers for Unix, NetWare, and LAN Manager. The 10-Mbps adapter features 32 KB of shared static RAM cache packet-buffer memory. An all-surface-mount card, the EISANet 3490E uses a National DP83902 network interface controller with an integrated 10Base-T transceiver.

Price: $495.
Contact: Cache Computers, Inc., 46600 Landing Pkwy., Fremont, CA 94538, (510) 226-9922; fax (510) 226-9911.
Circle 1288 on Inquiry Card.

A Do-It-Yourself LAN

The peer-to-peer Positive NetWork System is designed to be installed by nontechnical people. The system, a NetWare Lite Pack, is fully upgradable to NetWare, with tools that let the end user configure, install, and manage the LAN.

Positive NetWork consists of a worksheet, a videotape, and an installation disk that performs basic system-analysis tasks, such as interrrogating the hardware to determine its configuration. The system's graphical screens have dialog boxes that instruct how to properly configure network cards.

Price: $399.99; add-on kit, $199.99.
Contact: Positive Corp., 9174 Deering Ave., Chatsworth, CA 91311, (818) 341-5400; fax (818) 718-2938.
Circle 1289 on Inquiry Card.

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To Hell And Back: Texas Micro Systems Are Built To Withstand The Most Demanding Environments.

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ON THE WORLD'S LARGEST ____________ ______, customized Texas Micro PCs speed transactions by functioning as two systems with two monitors, two keyboards and two operators.

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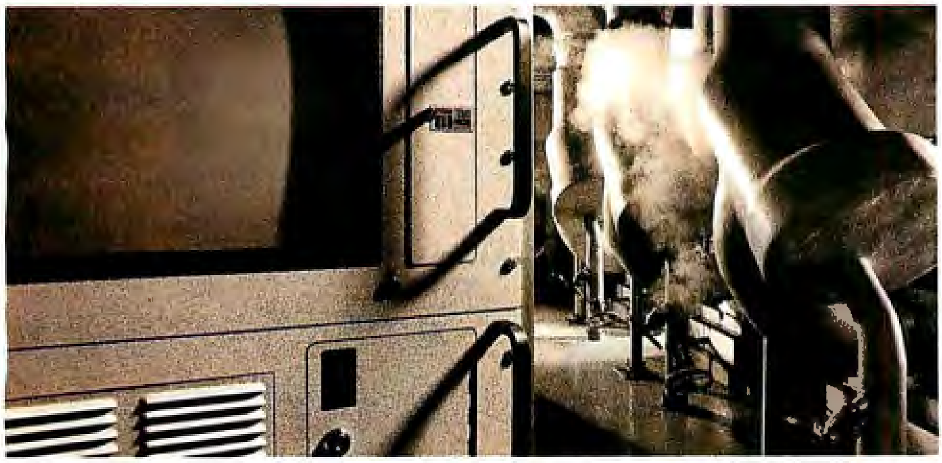

IN A HARSH ENVIRONMENT, AN ORDINARY PC IS A DEAD PC. A lot of PCs do well to survive a desktop. But on the production floor or in the field, the dust, heat, vibration and traffic can finish an ordinary PC–and your operation–in a hurry. Even if your PC has to withstand hell, your business doesn't have to. As long as you're using ruggedized PCs from Texas Micro.

OUR PCS TAKE A BEATING FROM THE FORTUNE 100. In fact, 70 of them put Texas Micro PCs through the wringer every day, in everything from industrial applications to severe office environments.

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OUR PCS ARE THE BEST BECAUSE THEY'RE BUILT FOR THE WORST. We design our 286, 386 and 486 systems using rugged design techniques that give them up to three times the life expectancy of other PCs.

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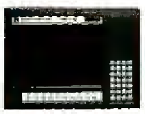

Ruggedized Workstation
- 9 option slots, 2 drive bays
- NEMA-4 compliant
- 100,000 hr. MTBF* power supply
- CRT/CPU in one unit
- VGA monitor

Ruggedized Benchtop
- 10 option slots, 2 drive bays
- Nickel-plated, steel chassis
- 100,000 hr. MTBF* power supply
- Extra small footprint

Ask A Few Tough Questions: 1-800-627-8700.

All trade names referenced are the service mark, trademark or registered trademark of the respective manufacturer. *Mean Time Between Failure.

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WordPerfect users pre
Windows no matter

Portland: 92% of WordPerfect users found Microsoft Word for Windows easier to learn.

Washington, D.C.: 72% of WordPerfect users found Microsoft Word for Windows easier to learn.

Dallas: 88% of WordPerfect users preferred Microsoft Word for Windows over WordPerfect for Windows.

Los Angeles: 72% of WordPerfect users, if given a choice, would buy Microsoft Word for Windows over WordPerfect for Windows.

The 1992 Coast-to-

The 1992 Word Challenge is over. And as you can see, the results speak for themselves. WordPerfect® for DOS users all over the country prefer Word for Windows™ for everyday word processing tasks. Over the past two months, the National Software Testing Labs visited 10 different cities to ask WordPerfect users to compare WordPerfect for Windows and Microsoft® Word for Windows side-by-side. WordPerfect users were amazed at how Word put them one step away from accomplishing everyday word processing tasks with, in many instances, one simple click of the mouse. They found it that easy.

The tour was not only fun, but it definitely confirmed two very strong hunches we've had for some time. One, WordPerfect

**Offer good for current licensees of WordPerfect, MultiMate,® WordStar,® MS® Word for MS-DOS® and DisplayWrite.® Please allow 2-4 weeks for delivery upon receipt of order by Microsoft. Offer expires 9/30/92. Limit one per customer. Reseller prices may vary. Call for syst*

fer Microsoft Word for what state they're in.

Chicago: 68% of WordPerfect users, if given a choice, would buy Microsoft Word for Windows over WordPerfect for Windows.

St. Louis: 71% of WordPerfect users preferred Microsoft Word for Windows over WordPerfect for Windows.

Salt Lake City: 76% of WordPerfect users preferred Microsoft Word for Windows over WordPerfect for Windows.

Minneapolis: 88% of WordPerfect users felt that Microsoft Word for Windows was the easiest to use.

Atlanta: 74% of WordPerfect users felt that Microsoft Word for Windows was the easiest to use.

New York: 80% of WordPerfect users think that Microsoft Word for Windows is easier to use.

Coast Word Challenge.

users prefer Word for Windows for everyday word processing tasks. And two, airports sell some very tacky souvenirs.

But you can see for yourself. Simply call us for a free "Word Challenge Kit." Included is a videocassette highlighting the actual test, and interviews with WordPerfect users who took the challenge. Also in the kit are the files you need to test Word on your own. Call (800) 323-3577, Department HA4. We think once you get a chance to judge for yourself, you'll no doubt want to take advantage of our special $129 upgrade offer.*

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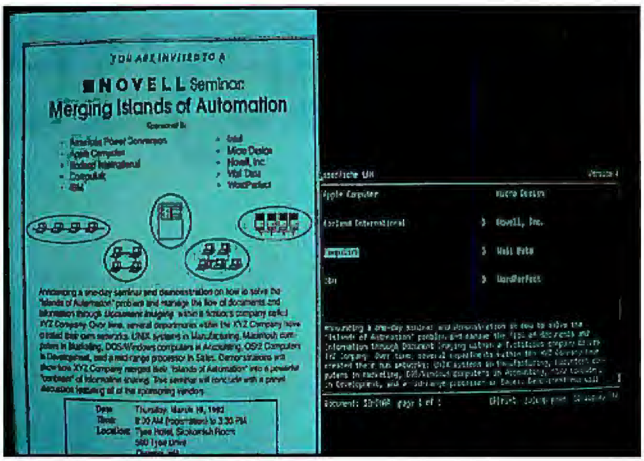
Document Imaging for Notebooks

LaserFiche Notebook, an advanced document-imaging program, lets you quickly download text, charts, graphs, forms, and photographs from your NetWare network to your notebook PC. Requiring at least a 286 computer with a minimum of 2 MB of RAM and a 40-MB hard drive, LaserFiche Notebook automatically converts scanned document images into word processing text. Able to index every word in a document via computer-assisted coding technology, the software lets you retrieve a document by searching for any word in the document.
Price: $495.
Contact: Compulink Management Center, Inc., 370 South Crenshaw Blvd., Suite E106, Torrance, CA 90503, (310) 212-5465; fax (310) 212-5064.
Circle 1290 on Inquiry Card.



LaserFiche Notebook lets you download graphs and charts from a network to your notebook PC.

Two V.32bis Modems

QuickComm's Spirit modems, available as internal half-cards and external models that connect to the serial port, support data throughput of up to 57,600 bps. The V.32bis devices feature CCITT V.42bis MNP level 5 data compression and MNP levels 2 through 4 error correction.

The modems include adaptive line speed, automatic speed negotiation at connection, and extended AT-command-set compatibility. The internal modem has a 16550 universal asynchronous receiver/transmitter for enhanced serial buffering between it and the computer and uses a single printed circuit for low power consumption.
Price: Internal modem, $299; external modem, $359.
Contact: QuickComm Co., 2290 Ringwood Ave., Suite K, San Jose, CA 95131, (408) 956-9145; fax (408) 956-1345.
Circle 1291 on Inquiry Card.

The 3220 Plus synchronous/asynchronous high-speed-dial modem from Motorola Codex supports synchronous transmission rates of from 1200 bps to 14.4 Kbps and asynchronous transmission rates of from 300 bps to 38.4 Kbps, enabling it to operate in two-wire dial applications.

The V.32bis modem has V.42 LAP-M and MNP level 4 error correction and V.42bis and MNP level 5 data compression; it works with leased- and dial-line products. A remote configuration capability lets you reconfigure the modem via AT commands at unattended remote sites. You can also automatically reset the modem to predefined configurations.
Price: $795.
Contact: Motorola Codex, 20 Cabot Blvd., Mansfield, MA 02048, (508) 261-4000; fax (508) 337-8004.
Circle 1292 on Inquiry Card.

Adapt Ethernet for LocalTalk

Connect as many as six LocalTalk devices, such as printers, to your Ethernet network with the EtherWrite hardware adapter. Available in coaxial and 10Base-T versions, the adapter has enhanced network security features that provide individual password-controlled access to the devices.

EtherWrite's auto-configure capability senses the existence of LocalTalk devices that are connected to the adapter's LocalTalk port, letting you turn on the adapter and connected devices in any order. You can upgrade the adapter's operating software—stored in a flash EPROM—by downloading it from a Mac on your network.
Price: $695.
Contact: Compatible Systems Corp., P.O. Box 17220, Boulder, CO 80308, (800) 356-0283 or (303) 444-9532; fax (303) 444-9595.
Circle 1293 on Inquiry Card.

Remote Control for Procomm Plus

Blast Remote Control for use with Procomm Plus seamlessly runs inside Procomm Plus to let you remotely control another PC. The software, which requires 640 KB of RAM, adds itself to Procomm's dialing directory by automatically editing the dialing-directory database file. The package includes the software module for the host PC that gives callers control over the remote machine. The included Blast file transfer protocol gives you PC-to-PC file transfer capability.
Price: $69.
Contact: USRobotics, Inc., 8100 North McCormick Blvd., Skokie, IL 60076, (800) 342-5877 or (708) 982-5010.
Circle 1294 on Inquiry Card.

An Ethernet Card for the Mac IIsi

TechWorks' IIsi Ethernet Card for the Mac IIsi incorporates National Semiconductor's Sonic chip set and proprietary driver software. Available for thick, thin, and 10Base-T Ethernet, the card has a pass-through slot for expandability, two LEDs that indicate network status and link integrity, and an FPU socket for advanced mathematical functions. The card uses DMA to transfer data directly into system memory.
Price: Starts at $279.
Contact: TechWorks, Inc., 4030 Braker Lane W, Suite 350, Austin, TX 78759, (800) 688-7466 or (512) 794-8533; fax (512) 794-8520.
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The KX-P2624, a 24-pin with ATM. Color option not available.*

PQ9-BY

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Use Stacks for Developing Unix Programs

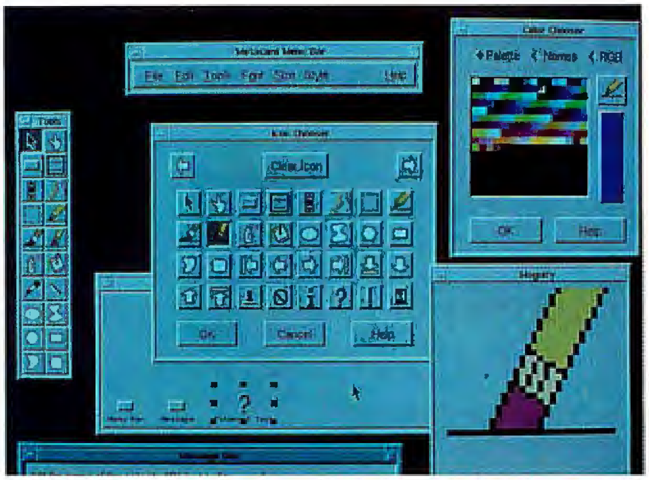
The MetaCard application developer lets you use reusable software stacks in building Motif programs and hypermedia documents. With MetaCard's simple scripting language and interactive tools, you can create GUIs, commands, or full-fledged applications.

MetaCard supports Motif interface controls such as push buttons, menus, scroll bars, and floating palettes. The system's text-editing tools let you build programs with automatic scrolling and search and sort support.

The system runs on Sparcstation, Sun-3, DECstation, HP 9000/300, and SCO Open Desktop systems.
Price: $495.
Contact: MetaCard Corp., 4710 Shoup Place, Boulder, CO 80303, (303) 447-3936.
Circle 1296 on Inquiry Card.

Gpf GUI Builder for OS/2 2.0

According to its developer, Gpf 2.0 completely supports OS/2 2.0's new (PM) Presentation Manager Workplace Shell GUI and provides improved menu-creation capabilities. Gpf uses a point-and-click approach to GUI development and then generates 16- or 32-bit C code. You can incorporate the new PM Workplace Shell user controls, including the spin button and drag and drop, within your GUI designs.
Price: $995.
Contact: Gpf Systems, Inc., P.O. Box 414, 30 Falls Rd., Moodus, CT 06469, (800) 831-0017 or (203) 873-3300; fax (203) 873-3302.
Circle 1297 on Inquiry Card.



MetaCard's Rapid Development functions let you use an object-oriented approach in building Unix programs.

OOP Tools for MIS Applications

PowerBuilder 2.0 provides an object-oriented architecture for creating mainstream business applications. The Windows-based system supports such features as inheritance, encapsulation, and user-defined objects, and also lets you program with Windows objects, functions, and events, including OLE (Object Linking and Embedding), DDE, DLL, and MDI (Multiple Document Interface) calls. PowerBuilder includes SQL (Structured Query Language) database portability and management functions and capabilities.

PowerBuilder is available in three versions for many different RDBMSes (relational database management systems). The Standard Edition supports Gupta SQLBase and XDB; the Premium Edition supports Microsoft/Sybase SQL Server, Oracle, and Hewlett-Packard's ALLBASE/SQL. There's also a Micro Decisionware DB2 edition, as well as separate versions of PowerBase that support additional database interfaces and server connections.
Price: Standard Edition, $1495; Premium Edition, $3995; DB2 Edition, $3895.
Contact: Powersoft Corp., 70 Blanchard Rd., Burlington, MA 01803, (617) 229-2200; fax (617) 273-2540.
Circle 1298 on Inquiry Card.

Genus Upgrades PCX Toolkit

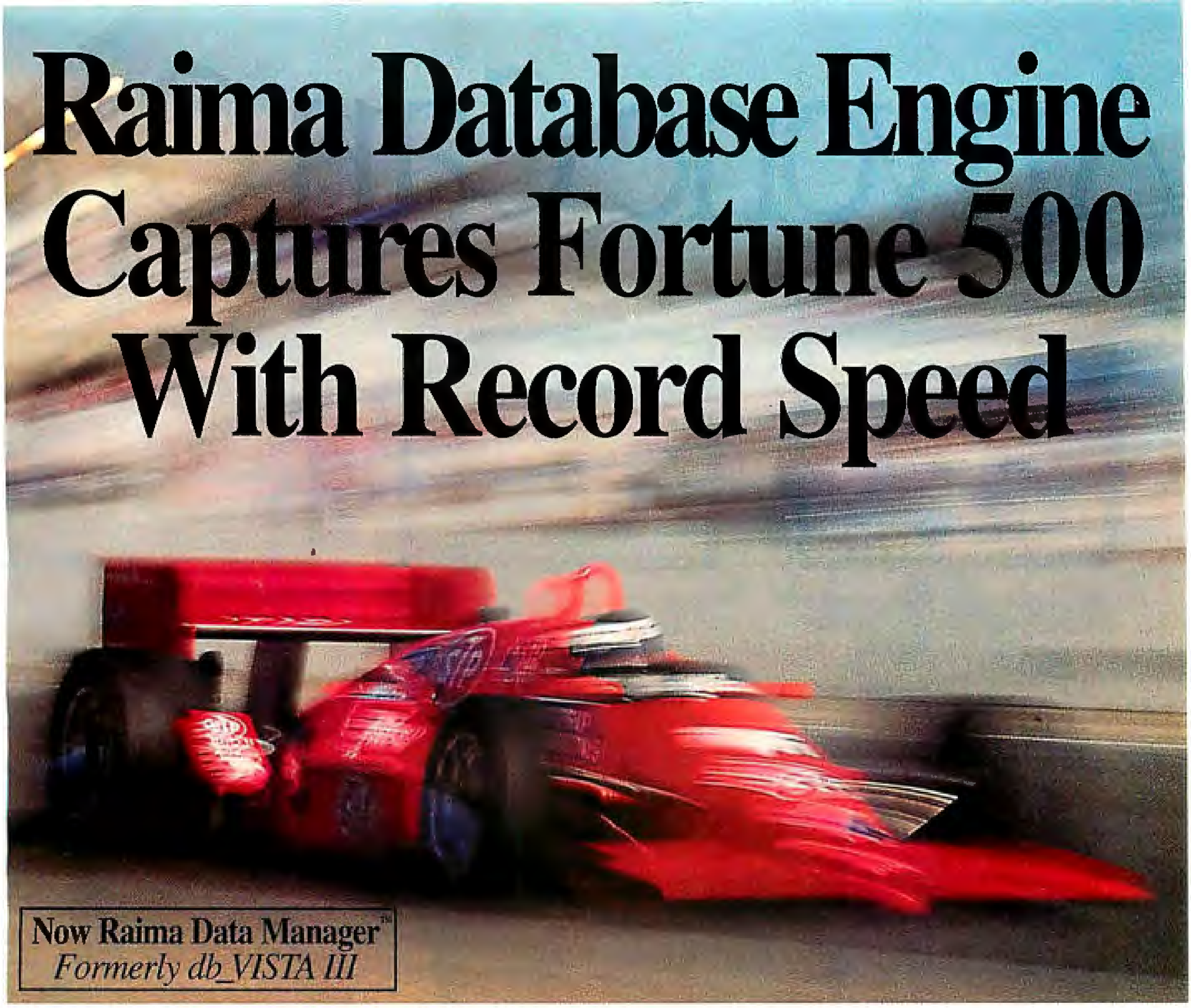
The latest release of the PCX Toolkit includes over 100 routines and 10 utilities that you can use to display, save, scale, and manipulate PCX graphics. The developer says that version 5.0 can be used with bit-mapped graphics from any program. Some functions that the program provides are slide-show creation, screen capture and conversion, image scrolling and sizing within windows, and printing of black-and-white images.

PCX Toolkit 5.0 supports all standard modes of graphics adapters (up through 1024 by 768 pixels by 256 colors) and is backward compatible with other Genus toolkits.
Price: $249; with source code, $599.
Contact: Genus Microprogramming, 2900 Wilcrest, Suite 145, Houston, TX 77042, (800) 227-0918 or (713) 870-0737; fax (713) 870-0288.
Circle 1299 on Inquiry Card.

Spiff Up Those Mac Programs

Tired of making embarrassing mistakes in your Macintosh programs? SoftPolish tests the quality of your user-interface elements to identify mistakes such as incorrect capitalization in menus, incomplete icon families, and misspelled words in dialog boxes. The program makes more than 50 tests on resources that contain visible elements of the Mac user interface. It also performs hundreds of additional tests for resource validity and comes with an English dictionary (additional spelling libraries are available).

The developer says that SoftPolish lets you add in support for new resources. The program is independent of any programming language or environment, and it lets you examine individual files, folders, or entire disks.
Price: $295; international spelling libraries, $49 each.
Contact: Language Systems Corp., 441 Carlisle Dr., Herndon, VA 22070, (800) 252-6479 or (703) 478-0181; fax (703) 689-9593.
Circle 1300 on Inquiry Card.



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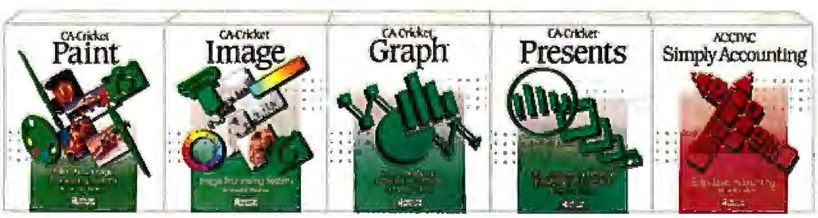

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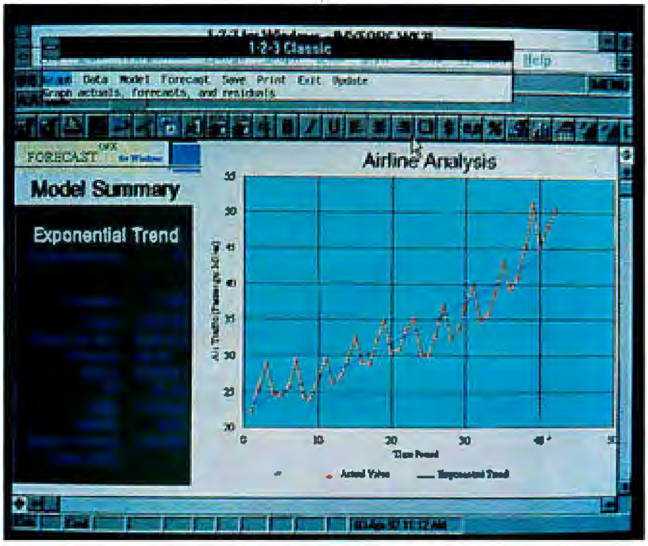
Make 1-2-3 See into the Future

ForecastGFX is a Lotus add-on that lets you use your spreadsheet data to perform time-series, multiple-regression, and descriptive statistics analyses. A full set of diagnostics, including Mean Squared Error, Mean Absolute Percentage Error, and F-statistic, provide desired levels of confidence. You can generate forecasts based on up to 300 historical observations and 10 variables.
Price: $165.
Contact: Intex Solutions, Inc., 35 Highland Cir., Needham, MA 02194, (617) 449-6222.
Circle 1301 on Inquiry Card.



ForecastGFX lets you see your forecasted data and graphs on the same screen.

One-Write Plus Gets Upgraded

Version 3.0 of OWP (One-Write Plus) Accounting Works is a bundle of programs that provide a variety of small-business accounting tools. The accounting and payroll programs are available as individual products, and most of the changes to the OWP line lie within the accounting system, OWP Accounting.

New OWP Accounting features include improved audit trails and single-report transaction histories, customized income comparison reporting, and the ability to display checking transactions across all modules. Version 3.0 of OWP Accounting lets you add general ledger accounts on the fly and provides date and time-stamped reporting, as well as a built-in screen saver.
Price: OWP Accounting, $129.95; OWP Accounting Works, $199.95.
Contact: Meca Software, Inc., 55 Walls Dr., Fairfield, CT 06430, (800) 388-8000 or (203) 256-5000; fax (203) 256-5159.
Circle 1302 on Inquiry Card.

Day-Timers Go Electronic

An agreement between Slate Corp. and Day-Timers, Inc., has resulted in an electronic version of the popular personal organizer. DTPS (Day-Timer Pen Scheduler) runs under the Go Corp. PenPoint and Microsoft Windows for Pens operating systems and provides all the functions (and then some) of the traditional Day-Timer.

In addition to the Day-Timer's calendar and to-do list features, DTPS adds a notepad and an address book. Capabilities that only electronic ink can provide include on-the-fly indexing, which lets you select part of any page, attach an index category, and later search for it in a matter of seconds. Another pencentric tool, Tiny Text, lets you save information (e.g., maps or private data) on-screen in very small text and then enlarge it as needed.

DTPS's notebook lets you jot down and annotate notes, maps, and sketches. The notebook's gallery view lets you see up to nine pages simultaneously. You can store standard address information in the address book and then copy or move that information to other sections of the organizer. The calendar lets you view your schedule in a variety of formats. The to-do list adds copy, prioritize, delete, and note-taking functions to the basic listing tool.
Price: $195.
Contact: Slate Corp., 15035 North 73rd St., Scottsdale, AZ 85260, (602) 443-7322; fax (602) 443-7325.
Circle 1303 on Inquiry Card.

Imara Lite Includes Imaging Tools

Imara Lite integrates document handling, imaging, and fax processing within a Windows-based personal productivity program. The Imara filing system lets you combine scanned files and software-generated documents (including spreadsheets) within a single file folder.

When using Imara with a fax board or modem, you can store incoming faxes in Imara folders. Imara also lets you send faxes from within the application.
Price: $295.
Contact: Imara Research Corp., 111 Peter St., Suite 804, Toronto, Ontario, Canada M5V 2H1, (416) 581-1740; fax (416) 581-1605.
Circle 1304 on Inquiry Card.

A New Take on an Old Theme

NoteTaker does exactly what its name suggests; it runs under PenPoint and turns your pen computer into an electronic notepad. NoteTaker offers tools that will be familiar even to the most inexperienced computer user. Highlighters, scissors, pens, and erasers perform the same tasks in the NoteTaker environment as they do on your desktop. NoteTaker exceeds your notepad in its ability to create space and locate keywords and documents.

The program's graphics capabilities allow you to export your free-form sketches to TIFF, BMP, WMF, and PICT formats. The Shape Expert tool converts your hand-drawn lines, circles, and squares into perfectly formed shapes.
Price: $145.
Contact: Ink Development Corp., 1300 South El Camino Real, Suite 201, San Mateo, CA 94402, (415) 573-6565; fax (415) 573-5167.
Circle 1305 on Inquiry Card.

What a racket!

$ 3,000 bucks for a CAD program? Are you kidding?

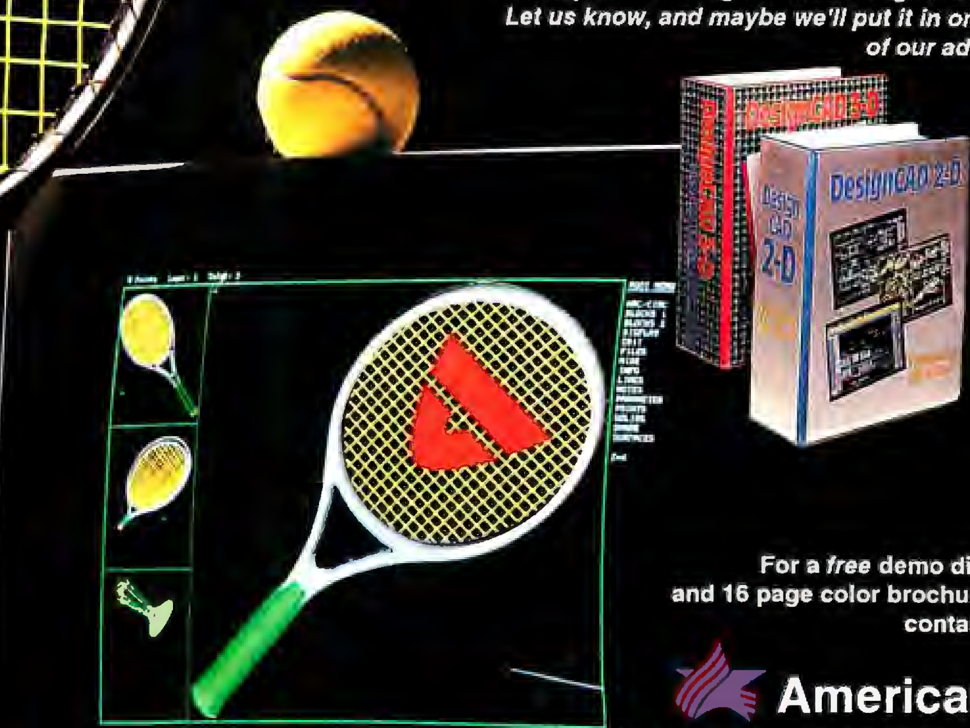
DesignCAD 2D is only $349, and it has more and better features than the other CAD programs that cost $3,000!

And, if you're ready for a three dimensional CAD program, there is the state-of-the-art DesignCAD 3D . . . for only $499!

DesignCAD is the software used in the design of Andre Agassi's tennis rackets, the Patriot missile, and scores of other high tech, low tech, and no tech products.

So what's all the racket about? It's because we believe that it's silly to spend more on a CAD system than you would on a word processor. Agree? Well, the ball's in your court.

Your product designed with DesignCAD? Let us know, and maybe we'll put it in one of our ads.



For a *free* demo disk and 16 page color brochure, contact:

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One American Way • Pryor, Oklahoma 74361
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CAD/CAM Software

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Also Available for Macintosh

There Are 174

In AutoCAD

3. Phenomenal 3D rendering. Capabilities that used to come only with AutoShade® are now built into AutoCAD® Release 12. And hidden line removal is up to 100 times faster.

4. AutoCAD SQL Extension (ASE) allows you to access data in standard database management systems via SQL. ASE provides commands for manipulating external nongraphic data and linking it to graphic entities in AutoCAD drawings.

5. Region Modeler creates intelligent 2D models. Allows you to quickly create 2D shapes with holes and complex boundaries. Automatically finds area, perimeter and inertial properties of a region.

6. Automatic timed save at user-selected intervals.

7. Now you can use PostScript® typefaces in AutoCAD drawings.

8. You can also import PostScript files into AutoCAD, and plot them.

9. New boundary polygon command surrounds an area with a closed polyline automatically.

10. New Fence or Polygon window crossing selection feature speeds selection of entities in dense and complex areas of drawings.

11. No Main Menu! You now enter directly into the AutoCAD drawing editor, where you can perform standard file handling and configuration operations, as well as work on your drawing.

12. Dramatically improved entity selection speed in large drawings.

13. Nested entity dimensioning. Entities within blocks or external references are now easily dimensioned.

14. Locked layers feature prevents accidental modification of drawing data.

15. PostScript output feature lets you enhance AutoCAD drawings by using PostScript-compatible imaging programs.

16. Release 12 and Release 11 drawings are forward and backward compatible.

17. Support for 255 individual pen widths for laser and electrostatic plotters.

18. You can plot without leaving the drawing editor. (And without losing the UNDO file.)

19. Now you can import TIFF, GIF and PCX raster images into your drawing.

20. GripEdit feature allows interactive editing of selected entities without running a command.

21. PickFirst feature lets you select entities prior to executing a command.

22. Improved external references. You can attach, reload or bind Xref files while the "master" is being edited.

23. Enhanced hatching. Automatically hatch bounded areas with a single pick.

24. New continuous polyline linetypes facilitate contour mapping and other applications.

25. Programmable dialog boxes can be customized for your particular working environment or by third-party application developers.

26. AutoCAD's new integrated calculator performs calculations based on existing geometry and includes extensive algebraic and geometric functions.

27. New ALIGN command lets you move and rotate entities in 2D or 3D.

28. 3D ROTATE command rotates entities about an arbitrary 3D axis.

29. 3D MIRROR command mirrors entities on an arbitrary 3D plane.

30. CHANGE command enhancements simplify entity property modifications, such as elevation, color, layer, linetype and thickness.

31. Advanced, multipoint tablet calibration allows compensation for map projections or stretched drawings.

32. Platform-independent menus and dialog boxes that follow operating system standards. So AutoCAD works like other programs on your computer.

33. An improved graphical interface makes the power of AutoCAD more accessible to everyone.

34. Cascading pull-down menus that put more power at your fingertips.

35. Pop-up menus at the cursor location for often-used items.

36. Screen menu is automatically updated to reflect the currently running command.

37. Shift and Control key combinations allow you to invoke more commands with your mouse and digitizer buttons.

38. Single mouse click-and-release action for selecting pull-down menus.

39. Automatic Drawing Conversion. Full support for any drawing created by any version of AutoCAD.

40. Enhanced CONFIG command allows for configuring AutoCAD from the drawing editor.

41. New dialog boxes give you control of dimension variables and styles.

42. Dimension dragging feature provides visual feedback while creating dimensions.

43. RECTANGLE command now allows you to create a rectangle with just two screen picks.

44. Enhanced Write Block command helps developers maintain "smart" drawings (entity handles).

45. Enhanced command transparency lets more commands be used inside other commands.

46. Transparent "Object Filters" dialog box allows more flexible definition of selection sets.

47. ZOOM Window is now the default.

48. DXFIX utility reads R12 DXF™ files and translates them into R10 files.

49. New COMPILE command compiles shape files, font files and Type 1 PostScript fonts.

50. Now you can fill closed polylines with PostScript patterns for extremely high-quality output.

51. Network users can view and plot AutoCAD drawings without using server authorization.

52. Database-specific drivers link AutoCAD and external nongraphic databases, such as dBase,® Paradox,® Oracle® and others.

53. Create New Drawing command now allows you to start with an unnamed

New Features Release 12.

drawing or specify a prototype drawing.

54. OPEN command presents "Open File" dialog box to simplify loading of existing drawings.

55. SAVE AS command now changes the current drawing name to new name specified.

56. END and QUIT commands prompt you for a file name when exiting an unnamed drawing, to prevent you from losing data.

57. Several AutoLISP® enhancements, including much faster loading of LISP routines.

58. A wide range of new and enhanced system variables, especially created for the power user.

59. DD Modify command allows for interactive editing of entity parameters.

60. New Units Control dialog box shows all units, angles and direction values on-screen as well as precision settings.

61. New special context-sensitive help dialog boxes allow you to browse through available help files.

62. New View Control dialog box allows selecting with a pick instead of typing in view name.

63. You can plot AutoCAD drawings as bit map files in PCF, TIFF, TGA and GIF formats. You can even automatically FAX your drawings to a subcontractor or client.

64. 24-bit, true color rendering is supported by appropriate hardware.

65. PostScript files can be brought in as outlines or fully rendered images.

66. Modify Entity dialog box enables you to edit an entity's properties directly.

67. Mirrored blocks can now be exploded.

68. List and load standard AutoCAD SHX fonts as well as Adobe Type 1 PostScript fonts from dialog box.

But Either One Of These Alone Makes It Worth The Price.

1. Something every AutoCAD® user has been waiting for: new technology that virtually eliminates regens. A new built-in 32-bit display list permits pans and zooms without regens. So you can spend your time editing your drawing, instead of waiting for regens.

2. The plot quickens. Now you get WYSIWYG plot preview, on-the-fly plot device selection and the ability to save plot configurations.

69. New option allows a box to be drawn around dimension text automatically.

70. Insert a text string before or after dimension text automatically.

71. Configuring for ADI® drivers has never been easier, with the new feature that displays all drivers in the appropriate menu when configuring AutoCAD.

72. HP LaserJet legal-size paper output is now supported by a new, improved device driver.

73. ADS applications can now be compiled by inexpensive "real mode" compilers; no need for costly development tools.

74. AutoLISP and ADS can now be used to drive the PLOT command.

75. Linetype scaling adjusts to view scale in Paper Space.

76–174. Unfortunately, we're out of space. But you get the idea. Release 12 is the most significant enhancement of AutoCAD ever. Its improved performance will pay off for every AutoCAD user. So the cost of an upgrade can pay for itself in a couple of weeks.

If you're still not convinced, call your Authorized AutoCAD Dealer. Your dealer can give you an even more complete list of the new features. And tell you what you need to do to upgrade. If you need more information or the number of your nearest dealer, call **1-800-445-5415, ext. 770.** Outside the U.S. and Canada fax 415-491-8303.

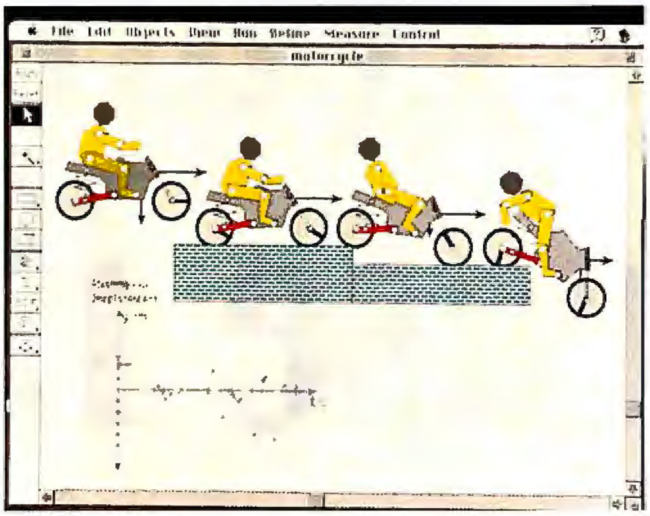
AUTODESK®

Circle 75 on Inquiry Card.

Model Motion Experiments

Interactive Physics II uses the laws of physics to guide you in designing models of objects in real motion. The Macintosh program lets you create any number of objects, define the motion parameters (e.g., mass, elasticity, and charge) for each object, apply environmental factors (e.g., gravity or air resistance), and run the experiment. You can display the resulting data in graphs, meters, or tables.

Interactive Physics II supports System 7.0 features such as Publish/Subscribe and QuickTime. You can view and save motion experiments as movies and then export the movies to other QuickTime-compatible applications. The upgrade also provides many new modeling tools, including pulleys, actuators, equation-based forces, and custom forces.
Price: $399.
Contact: Knowledge Revolution, 15 Brush Place, San Francisco, CA 94103, (415) 553-8153; fax (415) 553-8012.
Circle 1306 on Inquiry Card.

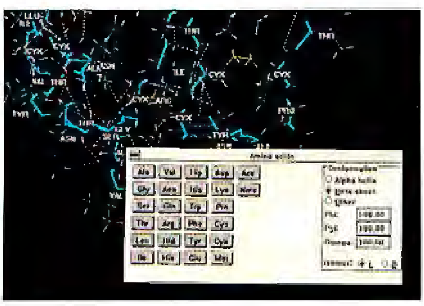


This screen from Interactive Physics II shows the effect that the mass of the rider's body and the motorcycle, friction, gravity, and speed create as the biker drives down a step. If handlebars had been added to the cycle, the rider could have compensated for the extreme bending of back, knees, and elbows.

Autodesk Ships Molecular Modeler

HyperChem is Windows-based modeling software for building, analyzing, and manipulating 3-D molecular structures. By incorporating chemical-property rules, HyperChem lets you experiment with the reactivity of molecules, evaluate chemical pathways and mechanisms, study and animate the dynamic behavior of molecules, and construct proteins and nucleic acids. The program provides amino acid and nucleotide residue libraries. Other HyperChem tools let you perform classical and semi-empirical quantum mechanical computations or calculate single-point energy values.

HyperChem's presentation options let you display your chemical structures as sticks, filled spheres, dot surfaces, or overlapping disks. Once you've built a chemical structure, you can render it, rotate it, and align it along *x*, *y*, or *z* axes.
Price: $3500.
Contact: Autodesk, Inc., 2320 Marinship Way, Sausalito, CA 94965, (415) 332-2344; fax (415) 331-8093
Circle 1307 on Inquiry Card.



HyperChem's built-in amino acid and nucleotide libraries let you build proteins and nucleic acids by sequence-based editing.

Get Instant On-Site CAD Feedback

Stylos/Markup lets CAD users make alterations to drawings and designs while in the field. The redlining application is intended for use on pen-based systems, and it runs as an add-on to existing CAD packages.

You can open your CAD files within either the PenPoint or the Windows for Pens environment, make notes or changes to the drawing as needed, and then save the new data as a file layer. When you reopen the file on your desktop computer, you can merge or eliminate the on-site changes. The program's communications capabilities let you send changes to your desktop-bound source files via modem.

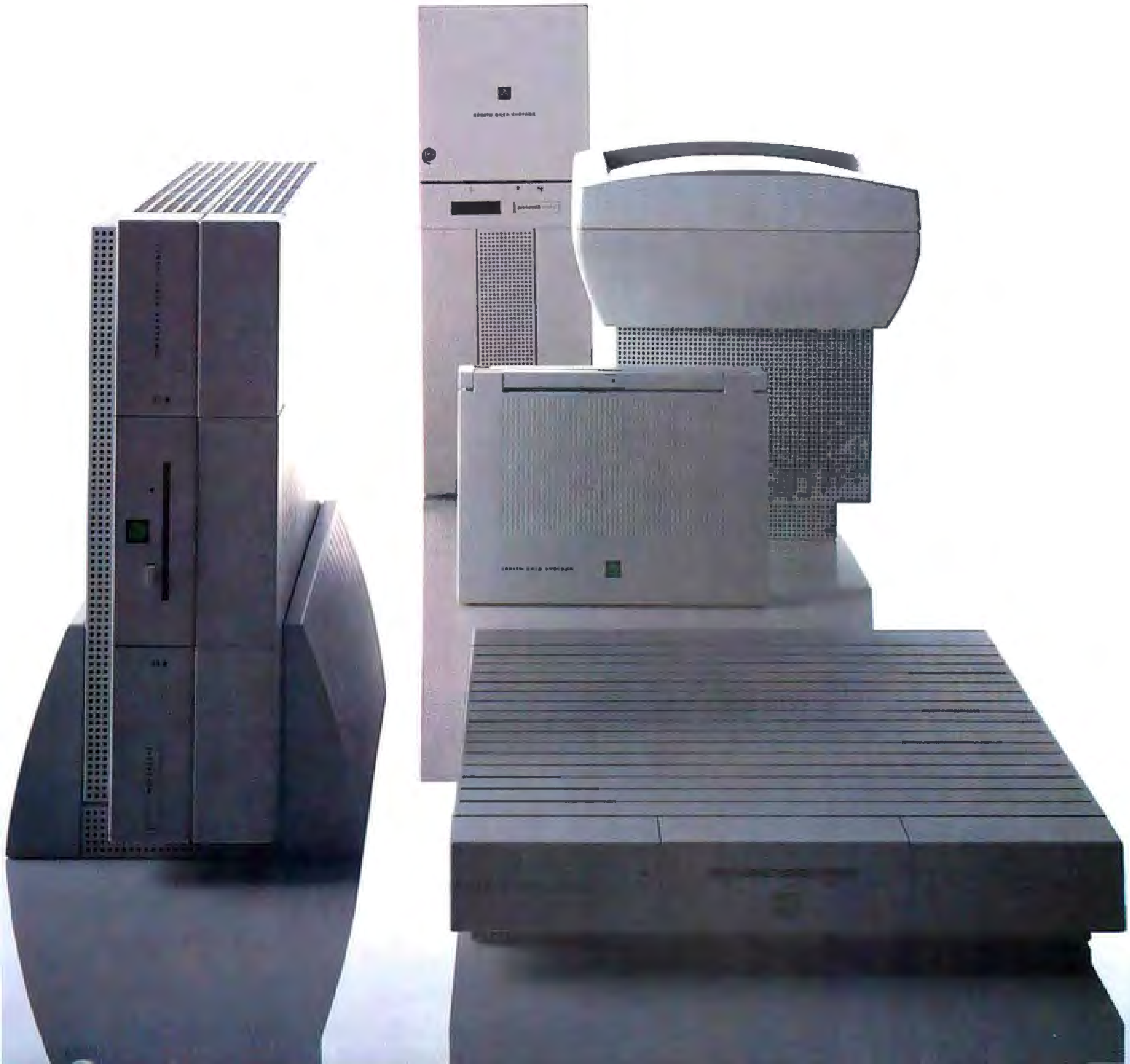
According to its developer, Stylos/Markup is compatible with any CAD format and supports many graphics file formats, including AutoCAD's DWG, TIFF, PCX, and BMP.
Price: $895.
Contact: Stylos Development Corp., 5725 Paradise Dr., Suite 160, Corte Madera, CA 94925, (415) 927-7623; fax (415) 927-0653.
Circle 1308 on Inquiry Card.

Travel the Heavens from Your Desktop

Seeing stars on your PC doesn't necessarily mean gazing at the typical celestial screen saver. With The_Sky for Windows, you can search the heavens for up to 270,000 stars and deep-sky objects.

The_Sky provides point-and-click identification of astronomical objects and, according to the developer, plots screens in less than 1 second, even without a math coprocessor. This speed lets you dynamically scroll and zoom through the sky. You can do on-screen plotting of constellation lines and boundaries or perform time skips to show planets in motion. By clicking on two known points, you can use the program as a telescope to identify unknown points.
Price: Level I (10,000 objects), $99; Level II (45,000 objects), $129; Level III (272,000 objects), $199.
Contact: Software Bisque, 912 12th St., Suite A, Golden, CO 80401, (303) 278-4478; fax (303) 278-0045.
Circle 1309 on Inquiry Card.

This way
to the future.



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consistency of component design for streamlined support and constant productivity in a changing world. Thinking Ahead means you won't have to rethink your investment. Ever.

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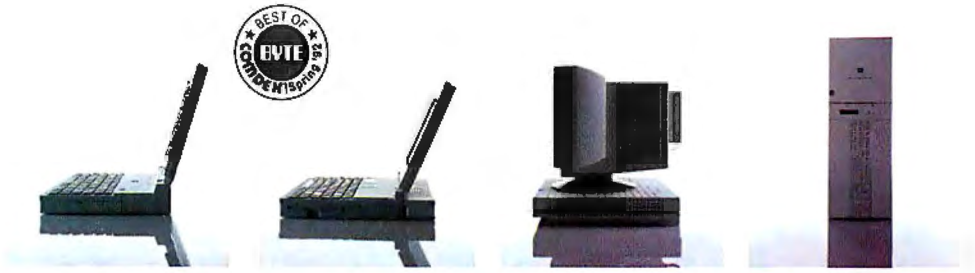

	Z•SPORT	Z•NOTE	Z•STATION ISA	Z•STATION EISA	Z•SERVER EISA
Processor/MHz	i386®SX/25 i486®SX/20 i486SX/25	i386SL/20 i386SL/25	i386SX/25 i486SX/20 i486SX/25 i486DX/33	i486SX/20 i486DX/33 i486DX2/50	i486SX/25 i486DX/33 i486DX/50
Storage	60, 85, 120MB*	60, 85, 120MB*	80, 120, 200, 400MB	120, 200, 400MB	300, 400, 500MB* (up to eight)
Memory (Standard/Max)	2/8MB* 4/12MB*	2-4*/12MB	4/64MB	4-8*/128MB	4-8*/192MB
Video	VGA display up to 64 gray scales	VGA display up to 64 gray scales or active matrix color	Integrated SVGA @ 1024x768 resolution with 16 colors. Upgradeable to 256 colors.		Integrated SVGA @ 1024x768 resolution with 16 colors. Upgradeable to 256 colors.
Pre-installed Operating Systems	MS-DOS 5.0 with APM	MS-DOS 5.0 with APM, Microsoft Windows 3.1	MS-DOS 5.0 Microsoft Windows 3.1		MS-DOS 5.0*
Integrated Connectivity	N/A	Novell NetWare, Microsoft LAN Manager, Banyan VINES client shells pre-installed	Novell NetWare, Microsoft LAN Manager, Banyan VINES client shells pre-installed		Novell NetWare, Microsoft LAN Manager, Banyan VINES, SCO™ UNIX®**
Upgrade Options	Memory, HDD, Coprocessor	Video display, Memory, BIOS, HDD, FDD, Coprocessor	CPU, Memory, BIOS, FDD, HDD, Coprocessor, OverDrive™ processor, Windows accelerator module (WAM), SCSI module, SCSI tape backup, SCSI hard drive		CPU, Cache, BIOS, HDD, FDD, Coprocessor, OverDrive processor, SCSI streamer and DAT tape drives, CD-ROM drive, LAN boards, Serial port boards
Mouse	Optional	Logitech™ TrackMan® Portable	Microsoft Two-button		Optional
Battery Life	2 or 2.5 hours under APM*	4-10 hours under Premier System Management™ (1/3 less in color)	N/A		N/A
Weight	6 or 6.2 lbs.*	5.9 or 6.5 lbs.*	N/A		N/A
Optional Peripherals	AT Docking Unit 3 slots AT compatible 2 half-height drive bays	READYDESK port replicator	N/A		N/A

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Answer questions "A" through "E" and mail or fax card to 1-413-637-4343.

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Fill out this coupon carefully. ***Please Print.***

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Title

Company

Address

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Phone Fax

A. What is your primary job function/principal area of responsibility? (Check one)

1 ❑ MIS/DP
2 ❑ Programmer/Systems Analyst
3 ❑ Administration/Management
4 ❑ Sales/Marketing
5 ❑ Engineer/Scientist
6 ❑ Other

B. What is your level of management responsibility?

7 ❑ Senior-level 9 ❑ Professional
8 ❑ Middle-level

C. Are you a reseller (VAR, VAD, Dealer, Consultant)?

10 ❑ Yes 11 ❑ No

D. What operating systems are you currently using? (Check all that apply)

12 ❑ PC/MS-DOS 15 ❑ Unix
13 ❑ DOS+ Windows 16 ❑ MacOS
14 ❑ OS/2 17 ❑ VAX/VMS

E. For how many people do you influence the purchase of hardware or software?

18 ❑ 1-25 20 ❑ 51-99
19 ❑ 26-50 21 ❑ 100 or more

❑ **Please send me one year of BYTE Magazine for $24.95 and bill me. Offer valid in U.S. and possessions only.**

August 1992 89 97 98

Product Category Information

Circle the numbers below for information on the entire category of products you're interested in.

Hardware

Accessories/Supplies 1
Add-in Boards 2
Bar Coding 3
Communications/Networking 4
Computer Systems 5
Data Acquisition 6
Disks & Optical Drives 7
Diskettes/Duplicators 8
Fax Boards/Machines 9
Graphics Tablets/Mice/Pen Input 10
Keyboards 11
LAN Hardware 12
Laptops & Notebooks 13
Mail Order 14
Memory/Chips/Upgrades 15
Miscellaneous Hardware 16
Modems/Multiplexors 17
Monitors & Terminals 18
Multimedia 19
Printers/Plotters 20
Programmable Hardware 21
Scanners/OCR/Digitizers 22
Tape Drives 23
UPS 24

Software

Business 25
CAD/CAM 26
Communications/Networking 27
Data Acquisition 28
Database 29
Educational 30
Engineering/Scientific 31
Entertainment 32
Graphics 33
Macintosh 34
Mail Order 35
Mathematical/Statistical 36
Miscellaneous Software 37
On-Line Services 38
Operating Systems 39
Programming Languages/Tools 40
Security 41
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Software Duplication 43
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Unix 45
Utilities 46
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Word Processing 48

General

Books/Publications 49
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60	86	112	138	164	190	216
61	87	113	139	165	191	217
62	88	114	140	166	192	218
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65	91	117	143	169	195	221
66	92	118	144	170	196	222
67	93	119	145	171	197	223
68	94	120	146	172	198	224
69	95	121	147	173	199	225
70	96	122	148	174	200	226
71	97	123	149	175	201	227
72	98	124	150	176	202	228
73	99	125	151	177	203	229
74	100	126	152	178	204	230
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410	436	462	488	514	540	566
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413	439	465	491	517	543	569
414	440	466	492	518	544	570
415	441	467	493	519	545	571
416	442	468	494	520	546	572
417	443	469	495	521	547	573
418	444	470	496	522	548	574
419	445	471	497	523	549	575
420	446	472	498	524	550	576
421	447	473	499	525	551	577
422	448	474	500	526	552	578
423	449	475	501	527	553	579
424	450	476	502	528	554	580
425	451	477	503	529	555	581
426	452	478	504	530	556	582
427	453	479	505	531	557	583
428	454	480	506	532	558	584
429	455	481	507	533	559	585
430	456	482	508	534	560	586
431	457	483	509	535	561	587
432	458	484	510	536	562	588
433	459	485	511	537	563	589
434	460	486	512	538	564	590

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766	792	818	844	870	896	922
767	793	819	845	871	897	923
768	794	820	846	872	898	924
769	795	821	847	873	899	925
770	796	822	848	874	900	926
771	797	823	849	875	901	927
772	798	824	850	876	902	928
773	799	825	851	877	903	929
774	800	826	852	878	904	930
775	801	827	853	879	905	931
776	802	828	854	880	906	932
777	803	829	855	881	907	933
778	804	830	856	882	908	934
779	805	831	857	883	909	935
780	806	832	858	884	910	936
781	807	833	859	885	911	937
782	808	834	860	886	912	938
783	809	835	861	887	913	939
784	810	836	862	888	914	940
785	811	837	863	889	915	941
786	812	838	864	890	916	942
787	813	839	865	891	917	943
788	814	840	866	892	918	944
789	815	841	867	893	919	945
790	816	842	868	894	920	946
791	817	843	869	895	921	947

Inquiry Numbers 1123-1304

1123	1149	1175	1201	1227	1253	1279
1124	1150	1176	1202	1228	1254	1280
1125	1151	1177	1203	1229	1255	1281
1126	1152	1178	1204	1230	1256	1282
1127	1153	1179	1205	1231	1257	1283
1128	1154	1180	1206	1232	1258	1284
1129	1155	1181	1207	1233	1259	1285
1130	1156	1182	1208	1234	1260	1286
1131	1157	1183	1209	1235	1261	1287
1132	1158	1184	1210	1236	1262	1288
1133	1159	1185	1211	1237	1263	1289
1134	1160	1186	1212	1238	1264	1290
1135	1161	1187	1213	1239	1265	1291
1136	1162	1188	1214	1240	1266	1292
1137	1163	1189	1215	1241	1267	1293
1138	1164	1190	1216	1242	1268	1294
1139	1165	1191	1217	1243	1269	1295
1140	1166	1192	1218	1244	1270	1296
1141	1167	1193	1219	1245	1271	1297
1142	1168	1194	1220	1246	1272	1298
1143	1169	1195	1221	1247	1273	1299
1144	1170	1196	1222	1248	1274	1300
1145	1171	1197	1223	1249	1275	1301
1146	1172	1198	1224	1250	1276	1302
1147	1173	1199	1225	1251	1277	1303
1148	1174	1200	1226	1252	1278	1304

Inquiry Numbers 234-408

234	259	284	309	334	359	384
235	260	285	310	335	360	385
236	261	286	311	336	361	386
237	262	287	312	337	362	387
238	263	288	313	338	363	388
239	264	289	314	339	364	389
240	265	290	315	340	365	390
241	266	291	316	341	366	391
242	267	292	317	342	367	392
243	268	293	318	343	368	393
244	269	294	319	344	369	394
245	270	295	320	345	370	395
246	271	296	321	346	371	396
247	272	297	322	347	372	397
248	273	298	323	348	373	398
249	274	299	324	349	374	399
250	275	300	325	350	375	400
251	276	301	326	351	376	401
252	277	302	327	352	377	402
253	278	303	328	353	378	403
254	279	304	329	354	379	404
255	280	305	330	355	380	405
256	281	306	331	356	381	406
257	282	307	332	357	382	407
258	283	308	333	358	383	408

Inquiry Numbers 591-765

591	616	641	666	691	716	741
592	617	642	667	692	717	742
593	618	643	668	693	718	743
594	619	644	669	694	719	744
595	620	645	670	695	720	745
596	621	646	671	696	721	746
597	622	647	672	697	722	747
598	623	648	673	698	723	748
599	624	649	674	699	724	749
600	625	650	675	700	725	750
601	626	651	676	701	726	751
602	627	652	677	702	727	752
603	628	653	678	703	728	753
604	629	654	679	704	729	754
605	630	655	680	705	730	755
606	631	656	681	706	731	756
607	632	657	682	707	732	757
608	633	658	683	708	733	758
609	634	659	684	709	734	759
610	635	660	685	710	735	760
611	636	661	686	711	736	761
612	637	662	687	712	737	762
613	638	663	688	713	738	763
614	639	664	689	714	739	764
615	640	665	690	715	740	765

Inquiry Numbers 948-1122

948	973	998	1023	1048	1073	1098
949	974	999	1024	1049	1074	1099
950	975	1000	1025	1050	1075	1100
951	976	1001	1026	1051	1076	1101
952	977	1002	1027	1052	1077	1102
953	978	1003	1028	1053	1078	1103
954	979	1004	1029	1054	1079	1104
955	980	1005	1030	1055	1080	1105
956	981	1006	1031	1056	1081	1106
957	982	1007	1032	1057	1082	1107
958	983	1008	1033	1058	1083	1108
959	984	1009	1034	1059	1084	1109
960	985	1010	1035	1060	1085	1110
961	986	1011	1036	1061	1086	1111
962	987	1012	1037	1062	1087	1112
963	988	1013	1038	1063	1088	1113
964	989	1014	1039	1064	1089	1114
965	990	1015	1040	1065	1090	1115
966	991	1016	1041	1066	1091	1116
967	992	1017	1042	1067	1092	1117
968	993	1018	1043	1068	1093	1118
969	994	1019	1044	1069	1094	1119
970	995	1020	1045	1070	1095	1120
971	996	1021	1046	1071	1096	1121
972	997	1022	1047	1072	1097	1122

Inquiry Numbers 1305-1479

1305	1330	1355	1380	1405	1430	1455
1306	1331	1356	1381	1406	1431	1456
1307	1332	1357	1382	1407	1432	1457
1308	1333	1358	1383	1408	1433	1458
1309	1334	1359	1384	1409	1434	1459
1310	1335	1360	1385	1410	1435	1460
1311	1336	1361	1386	1411	1436	1461
1312	1337	1362	1387	1412	1437	1462
1313	1338	1363	1388	1413	1438	1463
1314	1339	1364	1389	1414	1439	1464
1315	1340	1365	1390	1415	1440	1465
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1317	1342	1367	1392	1417	1442	1467
1318	1343	1368	1393	1418	1443	1468
1319	1344	1369	1394	1419	1444	1469
1320	1345	1370	1395	1420	1445	1470
1321	1346	1371	1396	1421	1446	1471
1322	1347	1372	1397	1422	1447	1472
1323	1348	1373	1398	1423	1448	1473
1324	1349	1374	1399	1424	1449	1474
1325	1350	1375	1400	1425	1450	1475
1326	1351	1376	1401	1426	1451	1476
1327	1352	1377	1402	1427	1452	1477
1328	1353	1378	1403	1428	1453	1478
1329	1354	1379	1404	1429	1454	1479

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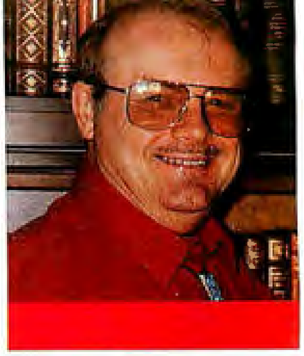

JERRY POURNELLE

MULTIMEDIA MEDLEY

Last week we went to New York City, in part to see my publishers, but mainly to take part in a Japanese-American friendship celebration. While the U.S. and Japan are to some extent trade rivals, we're both Pacific Rim nations. Whether we like it or not, we have to get along, especially now that the European Common Market is expanding into a real trade rival. We may think of Japan as a threat, but the Dutch own more of the U.S. than Japan does; meanwhile, Japan recently lost something like half their capital value in a stock-market crash. As to their investment policies, a great deal more than half of their investment in high-technology production facilities—which create high-paying jobs—has been spent in the U.S.

Certainly they do things there a bit differently from us. His Excellency the Japanese ambassador to the United Nations pointed out to Roberta that there are only 1500 lawyers in all of Japan. "We consider it dishonorable not to come to an agreement without going to court," he explains. Maybe we could learn something from them.

Meanwhile, back in Chaos Manor, the stuff has been piling up as usual.

Parallel Ports

Depend on it, if I ever get a turn as dictator, certain people will suffer. The mikado sought to let the punishment fit the crime; so will I.

At the moment, my particular candidates for poetic justice are the designers of the board-mounting mechanics for PCs. For the past half hour, I have been lying on the floor alongside my tower-configuration Cheetah 486/33.

The job seemed simple enough. A few months ago I discovered that the parallel port on Big Cheetah was output only, so I couldn't use it for LapLink Pro communications. It wasn't a fatal defect, but it was annoying. Fortunately, STB Systems sent me one of their Dual Serial/Parallel I/O boards: two serial ports and a two-way parallel port on one half-size board. It was that latter feature that snowed me: I just couldn't get that half-size board to install properly. Of course, it didn't help that the only empty slot is between two much larger boards.

The moral of the story is that I really ought to have laid the Cheetah on its side, rather than trying to work on it standing up. Oh, well. Eventually I got it done, and all the ports work just fine, but I would like to find and beat senseless the designer of that board-slot system. Its theoretical purpose is to comply with FCC "radiation standards"; the effect is to waste a lot of time and energy.

The reason I needed a two-way parallel port is that I'm setting up two new machines, and I don't want to go through installing all the software from floppy disks. It's far easier to let LapLink Pro do its thing. When you have 40 MB of stuff to transfer from one machine to another, it saves a lot of time if you can use the parallel ports.

Now, before someone writes to tell me I'm doing something illegal, remember what I do. The publishers will send me extra copies of their software to test on more than one machine, but that costs them more than just having me copy it over, so no one objects. Clearly, I am not recommending software piracy. If you're actually running two copies of the same software at the same time, you're violating both law and ethics; but we all know that.

Stepping up to multimedia can be as easy as buying an upgrade kit

Video Boards

While I was down there replacing the serial/parallel board, I removed STB's Wind/X video board. There wasn't anything wrong with it. It has worked fine for a few months now and has been fast enough and good enough. However, I just got a pair of the latest ATI Technologies Graphics Ultra boards hot off the production line, and I wanted to see if they worked in my Cheetah 486/33.

My first Graphics Ultra boards didn't. They worked fine in a Cheetah 486/25, but when they were put into the 486/33, they wouldn't even let the machine boot up. ATI dithered about that, but it turned out those were engineering samples rushed to me for testing. While they worked in some 33-MHz systems, they wouldn't work in the Cheetah with its zero wait states.

I still have the older ATI board in the Cheetah 486/25,

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which is the machine Larry Niven uses when he's here to work on our novels. The board has performed splendidly—so well that it impressed Niven. When we finished *The Gripping Hand* (the title our publishers like for the sequel to *The Mote in God's Eye*), I wearied of having 30 different chapter files in Q&A Write. Q&A Write is just great for text creation, but it's not so hot for editing, and it's plain awkward for editing and printing a complete book.

I used Word for Word to translate and ended with the entire novel in a single Microsoft Word for Windows file. (More on that later.) That has become the master file. Thus, when Roberta, and later David Stern (our editor at Simon & Schuster), made some very apt editorial suggestions, I wrote the changes into that Word file. Niven had to review those changes, and thus he saw Word for Windows on the big 21-inch Hitachi monitor driven by the Graphics Ultra board. I had the book in the CG Times Windows font, and Niven loved it.

The odd thing was that it looked much nicer on that machine than on my own. I thought this surprising because my machine has the Nanao FlexScan T560i monitor, which is newer than the Hitachi and has a higher refresh rate. In theory, it ought to produce better screen images. A puzzlement. Read on; the explanation is illuminating, or at least it was for me.

First Glitch

The Graphics Ultra board seemed to work just fine in the Cheetah 486/33, for both DOS and Windows. Whatever the problems I had with the earlier engineering models, ATI production boards have no problems with very fast no-wait-state 486 machines. Then I put in the ATI floppy disk, logged onto drive A, and typed INSTALL. The machine trundled for a moment, flashed the message "please be sure that you have the Ultra Accelerator installed," and returned me to DOS. Nothing I could do would let me run their installation program. Double-plus ungood.

It was, of course, the middle of the night. I sent a fax to ATI and went to bed. Next morning, I had a return fax: the problem is a clash between QEMM 6.02 and the ATI ROM system. Both Quarterdeck and ATI are aware of it; alas, neither has got around to documenting the problem.

The fix is to put into the QEMM386 .SYS line in CONFIG.SYS the exclusion statement X=C000-C7FF and reboot. That will take care of the conflict. Alas, it will also mess up your loads into high memory, so you should run Quarterdeck's Optimize again.

That done, all was well, and I was able to load all the ATI drivers. Their installation program has a few confusing messages—at one point it asks what subdirectory you want when in fact you don't want one at all (the proper response to that is a carriage return)—but all in all, the installation went smoothly.

Next thing was to program the Graphics Ultra board. Many video boards use jumpers to determine what the start-up mode for the board will be; the Graphics Ultra, however, uses PROM. If you have one of the few dozen monitors listed in their setup program, it's all extremely simple. Alas, the FlexScan isn't one of those, meaning that I had to do a custom setup. That required Nanao's manual, which is pretty dense. Also, the Graphics Ultra setup is reasonably complicated, and ATI's manual isn't all that clear, either. I ended up calling ATI technical support, which is very good.

Actually, though, almost everything they told me was more in the nature of confirming guesses I had already made than in telling me anything really new. On the other hand, their software warns you when you go to a custom setup that you can damage or destroy your monitor by using this program; this is sufficiently intimidating that I suspect they get a lot of calls from people who want some reassurance. The remedy for that is to put more monitors into their standard monitor list, and they're doing that.

It took about an hour, but eventually everything was set up properly, and I could bring up Windows.

Bit Maps and GUI

I have been running Windows at 640- by 480-pixel resolution. It means the desktop is pretty crowded, but that didn't seem to be a big problem, and many of the programs I was running were DOS applications (e.g., Q&A Write), which have character-based fonts rather than bit maps. Character-based fonts are the same no matter what screen resolutions you set; but that isn't true for Windows fonts.

At 640- by 480-pixel resolution, most bit-mapped fonts are thin and not very attractive on-screen. At 800 by 600 pixels, they aren't much better; but at 1024 by 768 pixels, they start looking very good indeed. That's particularly true of the CG Times font: at 640 by 480 pixels in 12-point size it looks anemic, but the same size at 1024 by 768 pixels is robust—attractive enough that Niven mentioned it.

I'm told that 1280 by 1024 pixels looks even better, but I wouldn't know: I haven't been able to get that to work. It's supposed to, but when I try to install it (with the C000–C7FF area excluded), I get odd split images when I invoke Windows. I make

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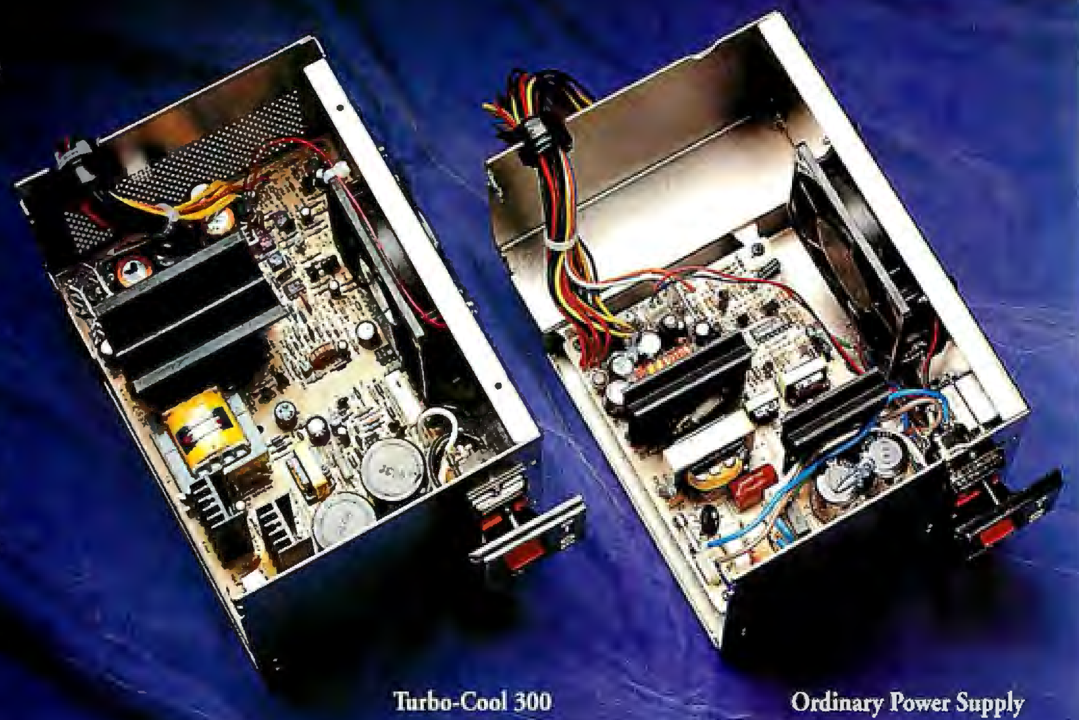

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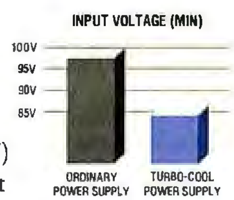

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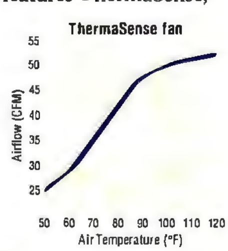

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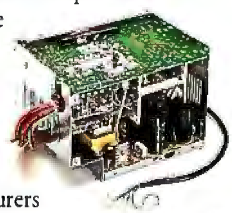

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no doubt that if I really wanted the higher resolution, I could probably get it by using the installation program to fine-tune the match between the video board and the FlexScan monitor for that resolution. But I'm happy enough with what I have.

The reason fonts look better at higher resolutions is obvious once you think about it: at 640 by 480 pixels, the fonts have a very small matrix of pixels (8 horizontal by 18 vertical) to work with. At 1024 by 768 pixels, they have enough that they can make a fair attempt to put on-screen what you will see on paper; the more pixels, the better it looks.

The Word Struggle

Clearly I've adopted Word for Windows as my editing word processor, and it's likely that after we get Niven a new 486/50 with a 20-inch FlexScan monitor and a Graphics Ultra board running Windows 3.1, we'll go to Word for creating books as well. I'm still looking for a thesaurus program as good as Word Finder and a dictionary as good as Definitions Plus that will work with Word for Windows. With Q&A Write and those, I can press Control-F10 to get the thesaurus list for any word and Alt-D to get the dictionary definition of a word—including words that pop up in Word Finder.

I don't often use those features, but when I do want them, I want them badly. I understand there are versions that work with Word for DOS. I'm told that WordStar ships an American Heritage Dictionary for Windows that works with Word, and I'll have to try it; but what I really want is the Word Finder/Definitions Plus combination I already have with DOS. Sigh.

The Word for Windows learning curve is steep. It helps if you keep the following firmly in mind: Word is object-oriented and believes each paragraph is an object. Formatting becomes easier when you understand that, as I learned in doing indentations. When we converted from Q&A Write, each paragraph had several spaces to indent the first line. As long as those spaces were there, it was *very* difficult to use Word properly. Fortunately, Word can search for a paragraph marker (^p, and it looks like that, not Control-p but caret-p) and for any white space (^w, same rule). Thus, if you tell Word to substitute ^p for ^p^w, you will, after a while, eliminate all white space at the beginning of each paragraph.

Incidentally, if you do that with a very large document, you will get a message that says you have done too many edits, and you must save your document. Unfortunately, I simply followed that instruction and did the substitution again. The third iteration of that locked the machine up so thoroughly that it required a hardware reset, crashing everything. Amazing!

After I reset and reloaded Windows, I found the file was intact as of the previous save and did the substitution again. I got the same message again, and this time it not only saved the file but closed and reloaded the file each time I got the message. On a 486/33 that doesn't take very long, even on a 130,000-word novel; and it fixed the problem. About four more iterations of substituting ^p for ^p^w did the job, and now I have pretty good control over formatting.

My next step is to learn about section markers to divide my document into chunks, particularly to divide the "front matter" (e.g., title page, instructions to the printer, dedication, and dramatis personae) from the rest of the book, yet keep the whole mess in one master file. I haven't mastered that, but I'm gaining on it. Incidentally, I find that the Windows Cardfile

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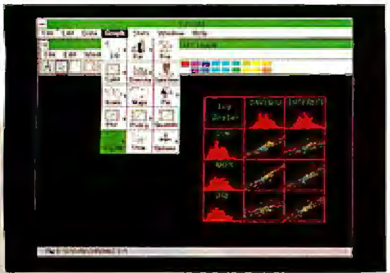

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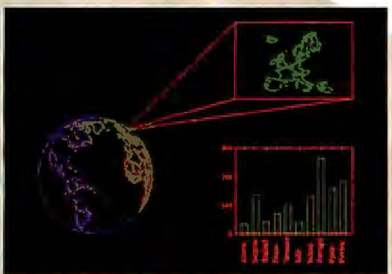
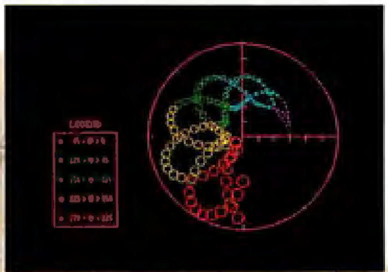
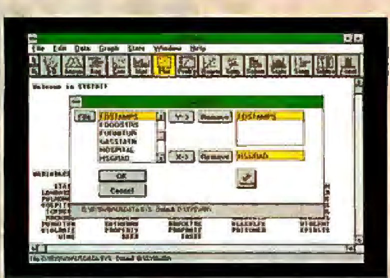






SYSTAT

program works just fine for compiling the cast of characters.

Portable Mice

One consequence of keeping *The Gripping Hand* master file in Word for Windows was needing to have Windows running on my portable machines. That's not difficult. At the moment, Roberta carries a Texas Instruments TravelMate 3000 WinSX, and I have the Zenith Mastersport 386SL. Both run Windows 3.1 nicely, although they work only in 640- by 480-pixel mode.

I used LapLink Pro to transfer the files, incidentally testing the new STB Dual Serial/Parallel board for Big Cheetah; it worked fine. LapLink Pro comes with .PIF and .ICO files, so it installs in Windows as easily as it does into DOS.

Now I had to choose mice, or rather trackball substitutes: Logitech's TrackMan Portable or Microsoft's Ballpoint Mouse. For test purposes I carried both. The Mastersport came with a Ballpoint, and Windows uses Microsoft MOUSE .SYS, so that had a head start. The Ballpoint trackball has a well-designed mounting system, with thumbscrews that will hold it onto any keyboard—laptop or desktop. It's good enough that I've been tempted to mount one on my Northgate OmniKey keyboard (if you don't have an OmniKey, you don't know what you're missing) and be done with it; the main reason I don't is that I still like the "Dove soap" mouse, which just plain looks and feels good.

The Ballpoint is well designed, with the triggers conveniently placed, and is easy to get used to. Frankly, if I didn't write this column, I wouldn't have tried another.

Then I got the TrackMan Portable.

The TrackMan installs just fine. In fact, all I did was unplug the Ballpoint, plug in the TrackMan, and turn on the Mastersport. If Windows noticed any difference, it hasn't told me yet. The TrackMan has three buttons, and MOUSE.SYS expects only two, but that's no problem. When run under MOUSE.SYS, the middle TrackMan button does nothing. If you want all three buttons active, Logitech supplies mouse drivers for that.

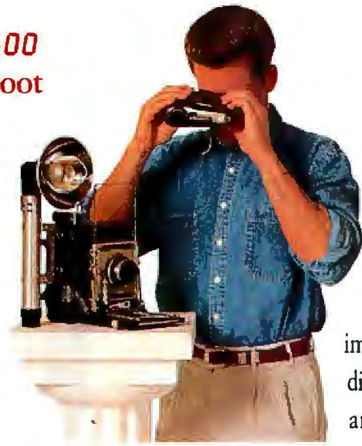
The TrackMan's action is, I think, just a little smoother than the Ballpoint's; but do notice the tentative way I put that. One thing is certain: it's *very* smooth and positive. The finger actions for left and right mouse buttons are quite different for the two devices.

With the TrackMan, you use your thumb to mash the "right" button, which is actually on the left side of the ball. That sounds confusing, but it isn't, and the action is quite natural. With the Ballpoint, you use the first two fingers, about the way you would with a regular mouse; however, because the left and right keys are pretty close together, you do have to be careful. On the gripping hand, it's easier to mash *both* buttons at once with the Ballpoint.

Finally, the mounting system for the TrackMan has the advantage of being flat, making it easier to close the top of the laptop with the mouse mount still attached. But it's not as positive as the Ballpoint's mount, and it's easier for the TrackMan to accidentally become detached from the mount (and the mount from the laptop case). The Ballpoint can be attached at several angles; the TrackMan at only one. However, I always set the Ballpoint to about the same angle the TrackMan uses, so that's hardly a big point.

My conclusion is that I don't have one.

continued



Either of these is plenty good enough, and I doubt you'd be unhappy whichever one you get. I love it when two companies fight to keep me happy.

It's a Miracle

The Miracle Piano Teaching System consists of a well-designed keyboard with speakers and headphones, a rather ingenious "footpedal," cables to connect the keyboard to your PC, and some really nifty software for teaching you how to translate musical notes into finger movements.

Now, the keyboard hasn't the musical quality of a Steinway, and the software is no substitute for a good music teacher. But anyone serious about learning to play the piano will find that The Miracle plus instructions will get you further, faster, than lessons and practice alone will ever do. Among other things, The Miracle makes piano practice a lot less painful: the software prompts you on what to do and keeps track of how well you did it.

The integration of software and hardware is amazing. You can, for instance, adjust the volume on the keyboard either with a hardware device on the keyboard itself or with the mouse on-screen. You can cause the keyboard to play notes by mousing around or by pressing the keys.

The keyboard connects to your computer through a serial port. There's also a MIDI. If you connect through the MIDI, you can get software that lets you record, edit, and play music with the keyboard. The keyboard has its own speakers, but it will also connect to external speakers or to your stereo system. I keep threatening to write an opera; this has certainly moved me closer to being able to do it.

Do understand, this is a semiprofessional system. You can certainly buy better-sounding keyboards with more complex capabilities, and if you learn to play well enough that you want to do professional concerts, you'll certainly want to get something better. Of course, the something better will cost you several times as much as The Miracle.

Serious music teachers should look into The Miracle; the system isn't going to take the music teacher's job away, just make it a great deal easier, letting the teacher concentrate on fine points. The Miracle will take care of most of the basics and provide motivation for practice to boot.

I suspect this thing is going to just fly off the shelves. The Miracle Piano Teaching System gets a User's Choice Award. Highly recommended.

Multimedia

Multimedia right now is little more than a catchphrase that doesn't stand for much,

but the concept is valid: the integration of visuals, sound, and your computer system to produce things that none of them can do alone. There isn't yet a great deal of software designed to take advantage of multimedia, but now that there's a reasonable standard, that's coming.

There are several ways to get multimedia. The least expensive way is to get the various components—a 386 or higher machine, a CD-ROM drive, and a good sound card with a MIDI—and put it all together. In fact, that's no bad way to do it. You can get inexpensive CD-ROM drives all over the place, and sound cards are easy enough to come by.

You could also get the Creative Labs Multimedia Adaptation Kit, which contains nearly everything you'll need: to wit, a Sound Blaster Pro card with a MIDI, a game port, and a SCSI port to drive a CD-ROM; a CD-ROM drive; and software. Alas, it is "nearly" everything. When we went to install the kit in our Gateway 2000 486/50, we discovered that the kit contains an internal drive. That isn't a real problem in that there is room for the drive in the Gateway; but, alas, there are neither rails nor screws with the CD-ROM drive, so it was physically impossible to install it.

I thought I might be able to find the proper screws around here somewhere, but no; they're not standard. I found one screw taken out of an older computer that matched the size and pitch of the mounting holes, but it wasn't long enough; besides, I am not going to install a CD-ROM drive with one screw.

By next month that should be fixed, and I'll be able to report on the Creative Labs CD-ROM drive.

Corel Blockbuster

I also have the Corel Blockbuster CD-ROM package. The package I have contained an external Toshiba drive, a SCSI card, cables (including a SCSI terminator), software, instructions, and the CD-ROM version of CorelDraw 2.0.

The CD-ROM installs simply enough. The instructions are clear, and the software installs itself like a miracle. There was only one problem: after everything was done, it wouldn't work. The Corel package installs the Microsoft DOS extensions known as MSCDEX, but when AUTOEXEC.BAT tried to run MSCDEX .EXE, nothing happened. Then the message "Incorrect DOS Version" appeared.

I looked for instructions on what to do. Nothing. What about a README.TXT file? None. I fired off a fax to Corel. Then, on a hunch, I looked through the software again; a file called README.CD told me what I should have remembered—that MSCDEX doesn't know about DOS 5.0. The remedy is spelled out in detail on the README.CD file and involves running SETVER. Once that was done, the CD-ROM drive came right up.

MSCDEX is very large and reduces DOS memory something awful, so I took time out to install Quarterdeck QEMM 6.02. QEMM automatically makes EMS memory available to anything that needs it. Inserting the switch /E into the MSCDEX command line causes MSCDEX to load itself up in EMS memory. The Gateway 2000 has plenty of upper memory.

Once QEMM installed itself and ran Optimize, I accessed the CD-ROM disk drive and got a pleasant surprise. That CD-ROM is *fast*! Now true, it's operating on the Gateway 2000 486/50, which is easily the fastest machine in the house; but the CD-ROM drive itself is also very fast. The result is that pictures just leap onto the screen.

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one CD-ROM drive. For the heck of it, I connected up the Pioneer Minichanger to the daisy chain. It worked just fine. The result is neat: I have seven CDs available.

Next, I put the Sound Blaster Pro board into the Gateway 2000. I did this with a little trepidation. When we first got the Gateway, we tried an older Sound Blaster Pro board in it, and that didn't work. Clearly the machine was too fast for the board, because speech came out garbled and music very fast with dead spots in it. The board I just put in came from the multimedia kit (the one that contained a CD-ROM drive but no rails), and it works just fine. The multimedia upgrade kit also contains Windows 3.1, but that came with the Gateway 2000, so I didn't need to install it.

With the Corel Blockbuster CD-ROM drive, Windows, and Sound Blaster Pro with a MIDI, I have a very fast and powerful multimedia machine.

Tandy 4033 LX

The simplest way to get multimedia is to go to your local Radio Shack and buy a Tandy 4033 LX. You get a 386/33 PC with a mouse, a 100-MB hard drive, and 4 MB of RAM; a Sound Blaster Pro/SCSI drive controller board with a MIDI and a game port; and the same CD-ROM drive you get with the Creative Labs Multimedia Adaptation Kit. My 4033 LX came with Windows 3.0, but if you get one now, you'll get version 3.1. You also get integration software and a CD-ROM with a bunch of multimedia demonstrations, some extremely impressive.

The Tandy 4033 LX is a solid machine. We've bashed it around a bit without causing any problems at all. Tandy's technical support varies in quality depending on where and how you got your system, but ultimately it's quite solid, and there are Radio Shack outlets all over the place. If you live in West Misery, Radio Shack may well be the closest high-tech shop.

There are two things you'll want to do with the 4033 LX. First, add some memory. The 4033 LX uses standard SIMMs, and the manual explains how to bring your system up to 16 MB. You may not need 16 MB, but I strongly recommend you go for 8 MB; Windows and multimedia eat memory like mad. Second, get hold of a Cyrix math chip and install that. I don't insist on the Cyrix chip, but that will certainly work. I've got Cyrix math chips in several machines, both here and at other test sites, and I've never heard a negative report. The 4033 LX manual explains the installation, and if you pay attention to what you're doing, you should have no trouble at all with it.

With a math chip and more memory, you will have a machine that is at least as good as any 386 I have here at Chaos Manor, and the multimedia integration of the Tandy 4033 LX is well worth having. You won't have as fast a CD-ROM drive as the one that comes with Corel Blockbuster; but it will be fast enough.

The manuals are a bit thin but understandable, and I didn't look for any information I didn't find. The keyboard is decent; I'm spoiled by my OmniKey, so I may not be the right judge of keyboards. The fact is, though, Tandy has produced a solid, well-integrated machine and greatly simplified the setup; it's a good way to get into multimedia without hassles. Recommended.

Gateway 2000 486/50

I don't have time for a full report on this machine; let me just say that I have reason to believe it's the fastest machine in the

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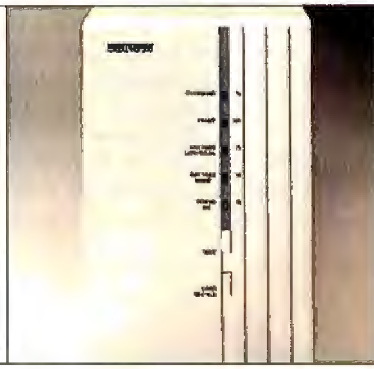

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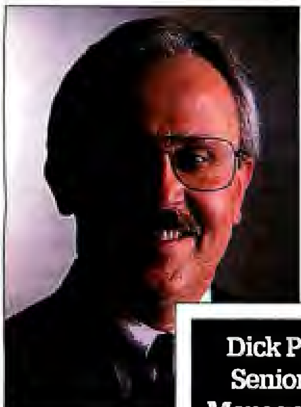

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house. I had no trouble installing Sound Blaster Pro and the Corel Blockbuster CD-ROM drive. It came with Windows 3.1; I added QEMM 6.02.

This will probably become Roberta's Windows machine. More another time, but you can be sure I won't set her up with a machine I don't have confidence in.

VisSim 1.1

There are many dynamic simulation programs for the Mac. There had been a few such programs in CP/M days, and a few of them—TutSim comes to mind—were translated to the PC. But there just weren't many nonlinear simulation programs for the PC, and those had confusing interfaces. The Mac made it a lot easier to do simulations and show results, and most of the best dynamic simulation software is still on Macs only.

Then came Windows, and I don't expect it will be long before we get a lot of good simulation programs for PCs.

VisSim is one of the first I've seen. It's pretty good, but you have to study the manual; it's not as intuitive as I'd like it to be. On the other hand, it works, and you can learn it. And once learned, it's a powerful tool.

Dynamic simulation is one of the most exciting developments in the small computer world. Anyone interested in science and engineering will learn a lot from just playing around with nonlinear simulations. They're also fun.

VisSim comes with a bunch of ready-made simulations you can use as models. I wish it came with Jay Forrester's World Dynamics built in: it's not that I'm much enamored of his model, but that model is a good starting point for world simulations, and VisSim is flexible enough to allow you to get into the equations and change things.

This is the way to learn about modeling and sensitivity to assumptions. I can't emphasize strongly enough that the best way to understand what you're modeling is to get in there and just play around with variables and initial conditions.

The professional version of VisSim is pretty expensive, although if you need it, you'll need it bad. I think there's also a student version that's more reasonably priced, for people who just want to muck around learning the simulation game.

The Virus Scene

I haven't time to do this justice, but just be warned. There's a chap calling himself Dark Avenger who is very, very good. He has released source code for generating "stealth" viruses. The upshot is that it's going to be a lot harder to detect viruses out there, since his source code makes it easier for less talented people to write them.

Get yourself a good virus-detection system and make sure you get frequent updates. I'm still recommending Dr. Solomon's Anti-Virus Tool Kit. Whatever you get, *use it*.

Winding Down

As usual, there's far more going on than I have time or space to report. Windows makes possible more and better software. Visual Basic with the Crescent Tools makes it possible to turn out incredibly sophisticated software in a very short time. I hope to have a lot more to report on that Real Soon Now.

There are some new versions of older good stuff. Bell Atlantic has Thinx 2.0; Thinx is the Windows object-oriented database I reported on last year. If you haven't seen it, try to see a demonstration; it could be just what you need. This is a

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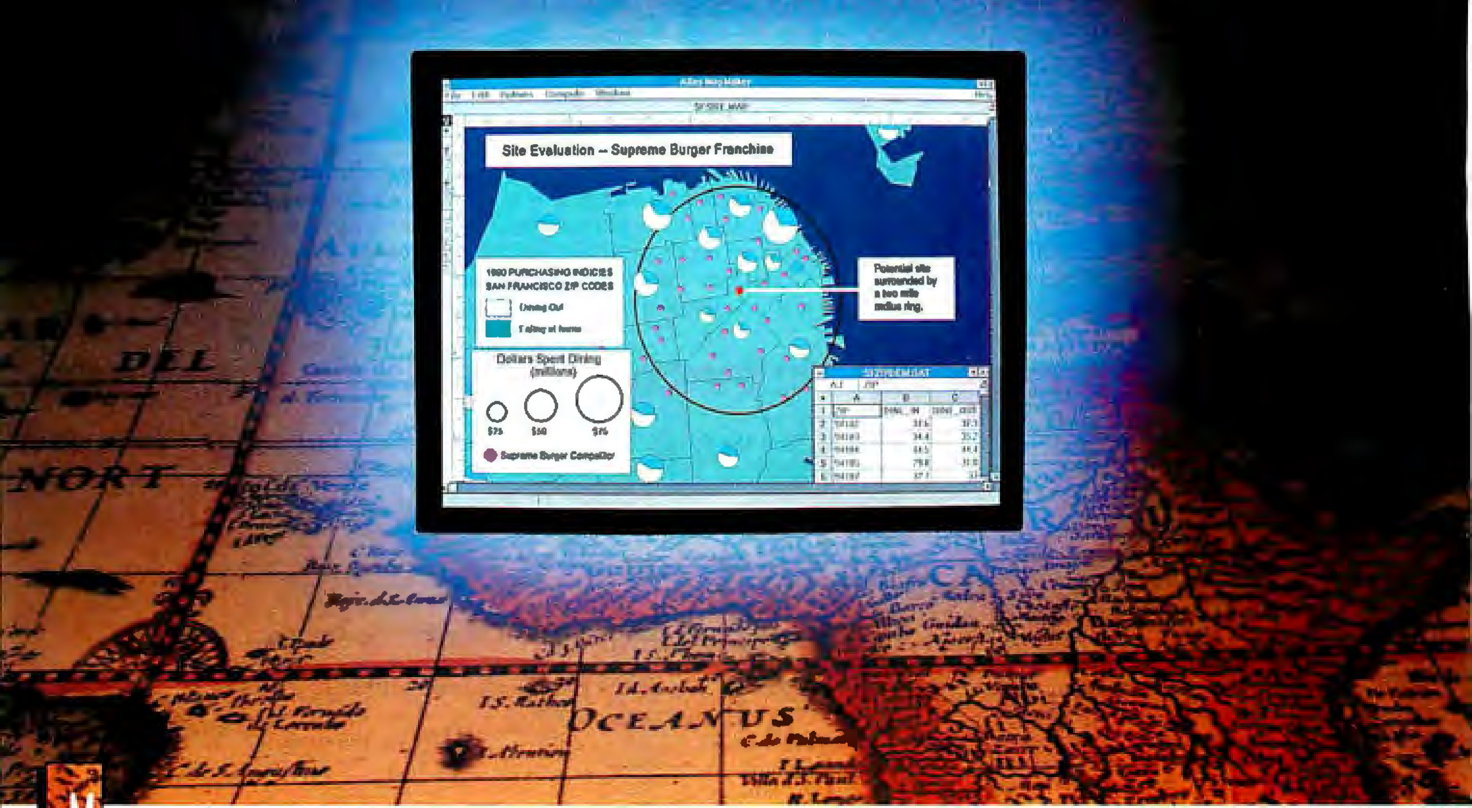

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very flexible and powerful program.

The orchid of the month goes to Symantec/Norton technical support; several readers report good experiences. I'm still looking into Norton Desktop for Windows. There's no questioning that it makes using Windows a bit neater and more convenient. If you use Windows a lot, it's likely to be worth the price; and Symantec has a reasonable upgrade policy, so when they improve that Desktop—and they will—you can get the improved version at reasonable cost.

The computer book of the month is Brian Livingston's *Windows 3 Secrets* (IDG Books, 1991) yet one more time; there's a new edition that deals with version 3.1. Reading this book may not make you an expert, but you can pretend to be one.

The book of the month is *Little Dorrit* by Charles Dickens, a novel about, among other things, government inefficiency. It's set in the nineteenth century, but the Office of Circumlocution has a strangely modern flavor, and the bureaucrats Dickens shows us could have come right out of modern Washington.

Next month, the Amiga scene: a new Amiga arrived last week. More on multimedia and a whole bunch of CD-ROMs, including CorelDraw (it's wonderful). Also, with any luck, this will be the month I really get started on networking Chaos Manor. ■

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 BIX as "jerryp."

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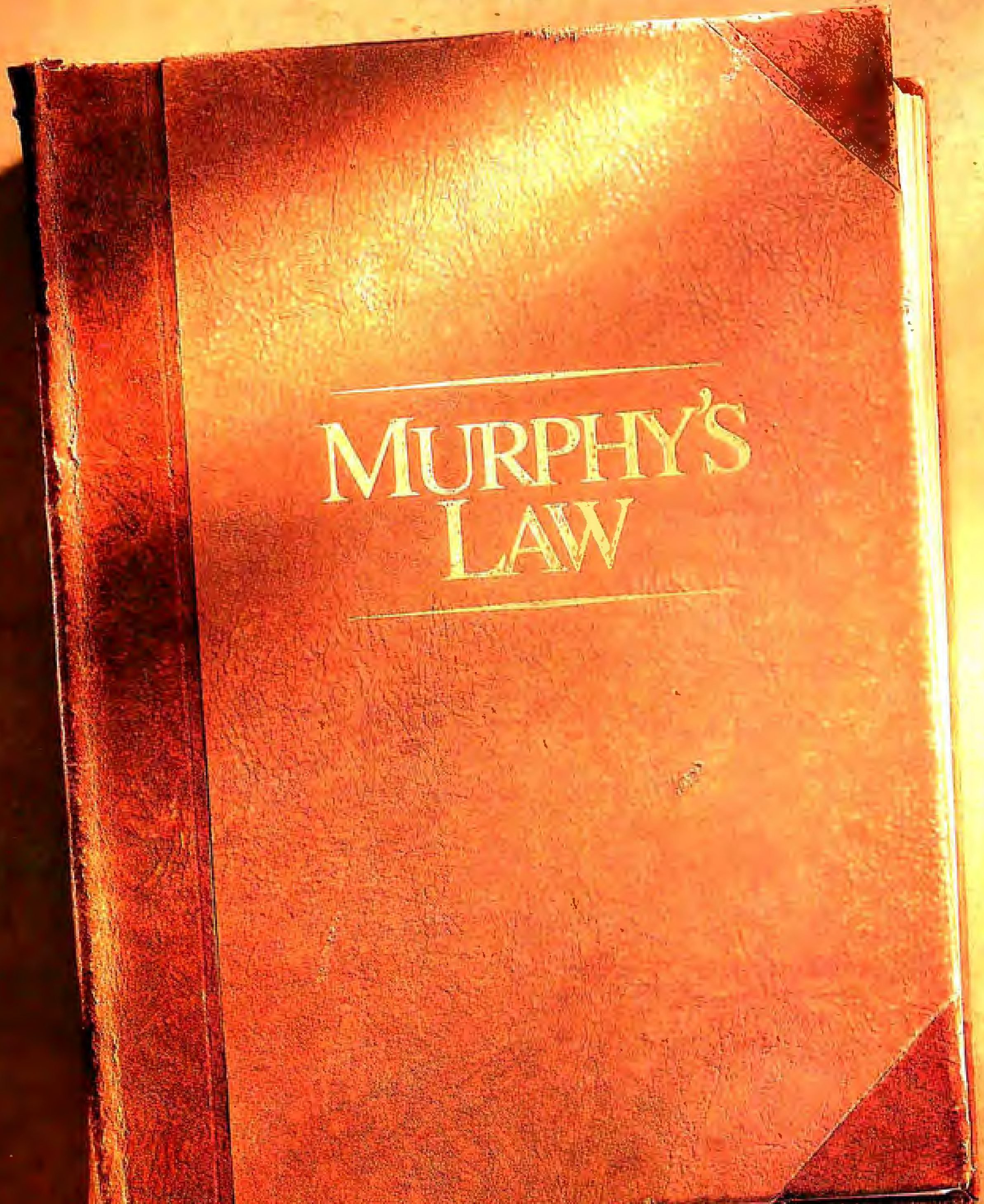

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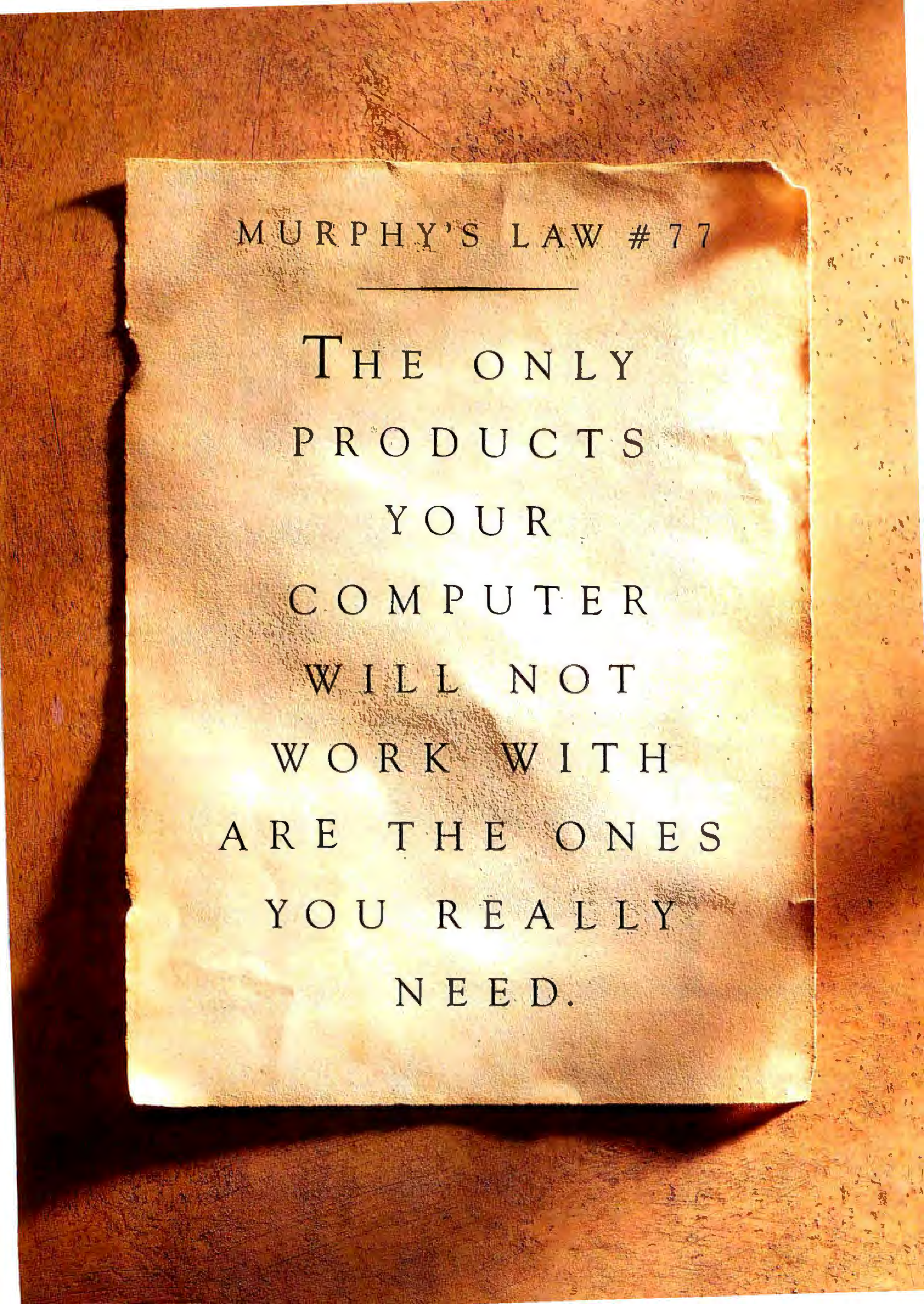
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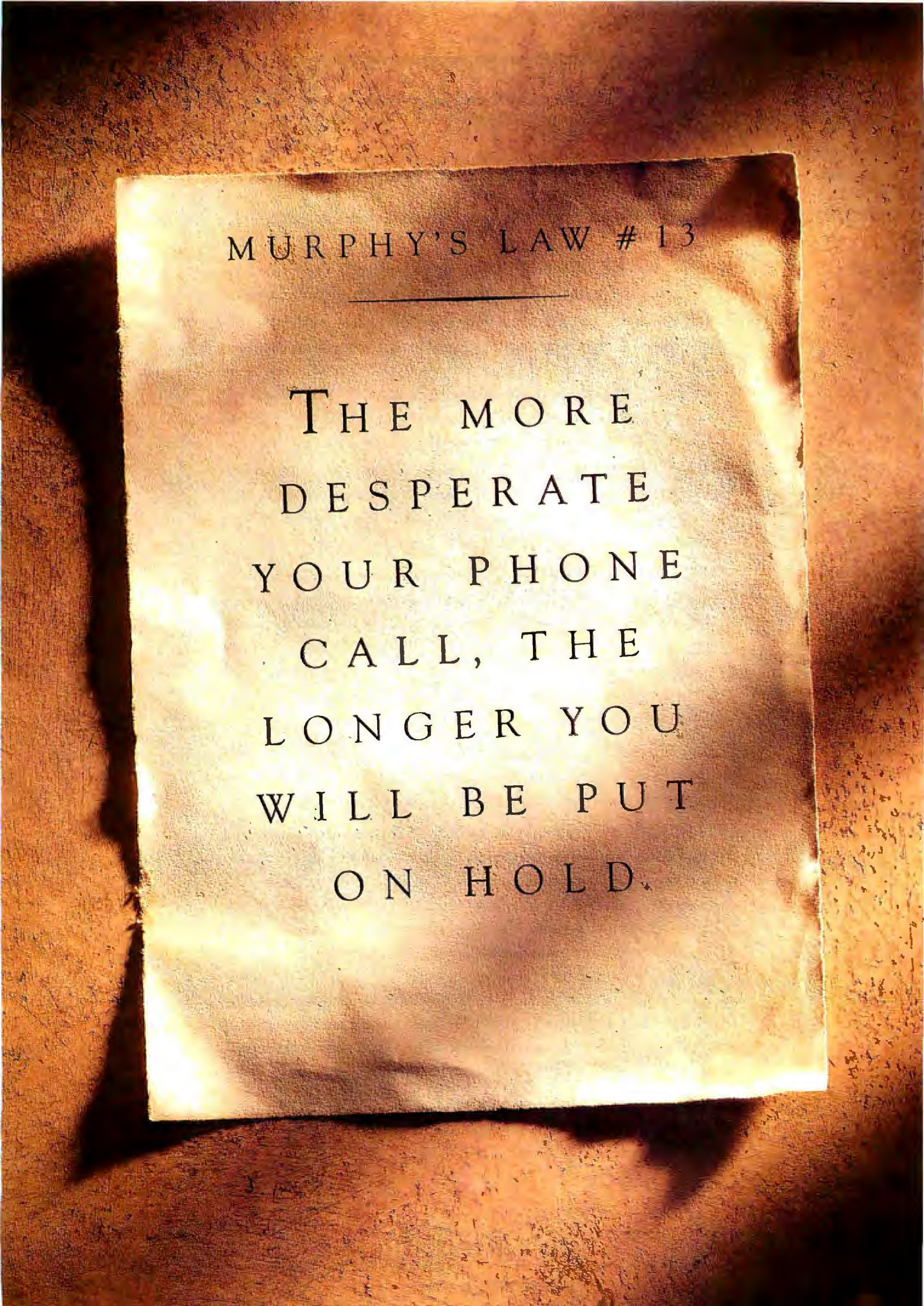
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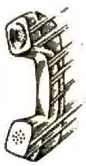

We solve most problems over the phone within 10 minutes.

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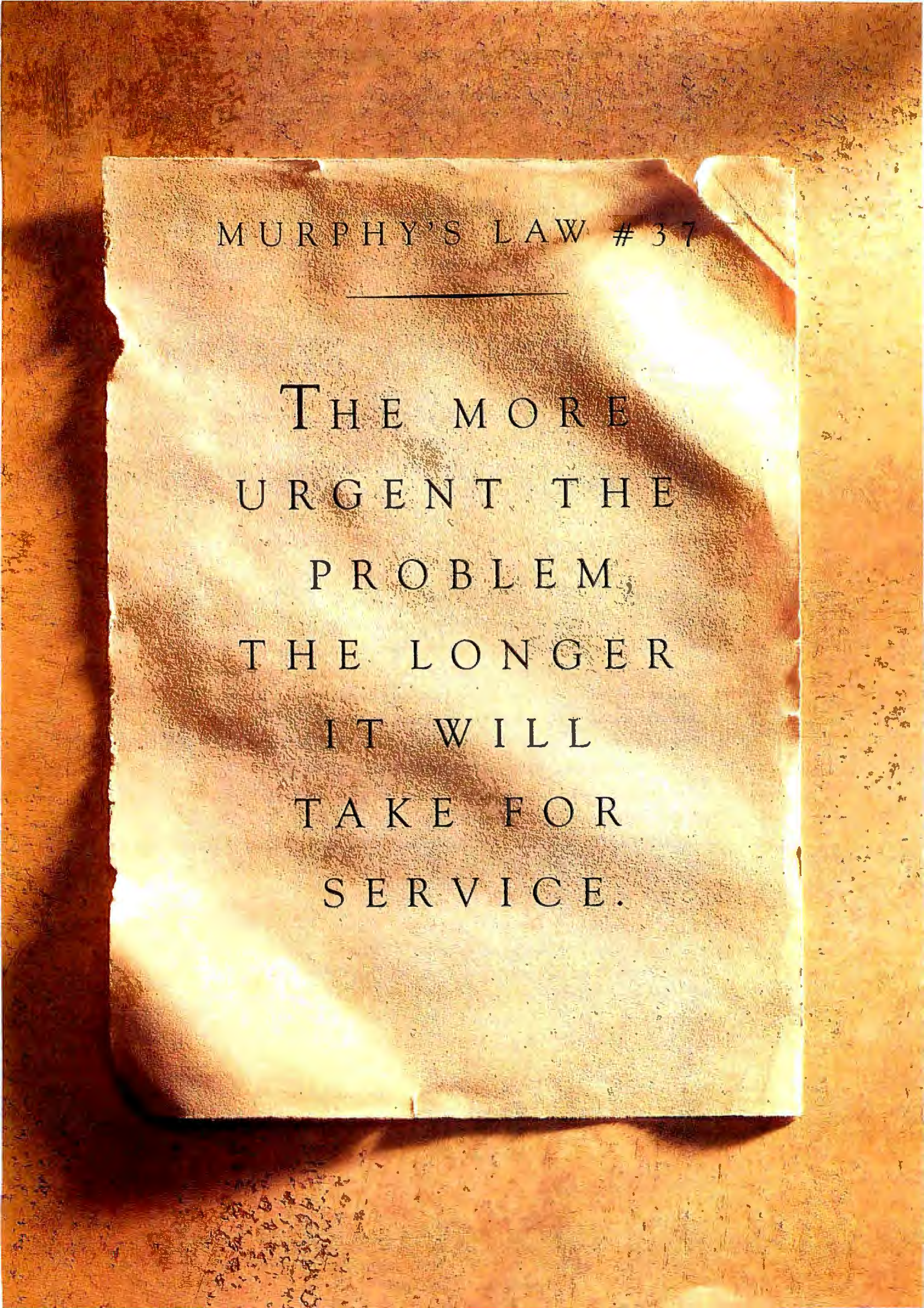
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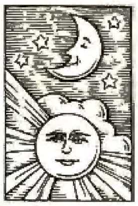

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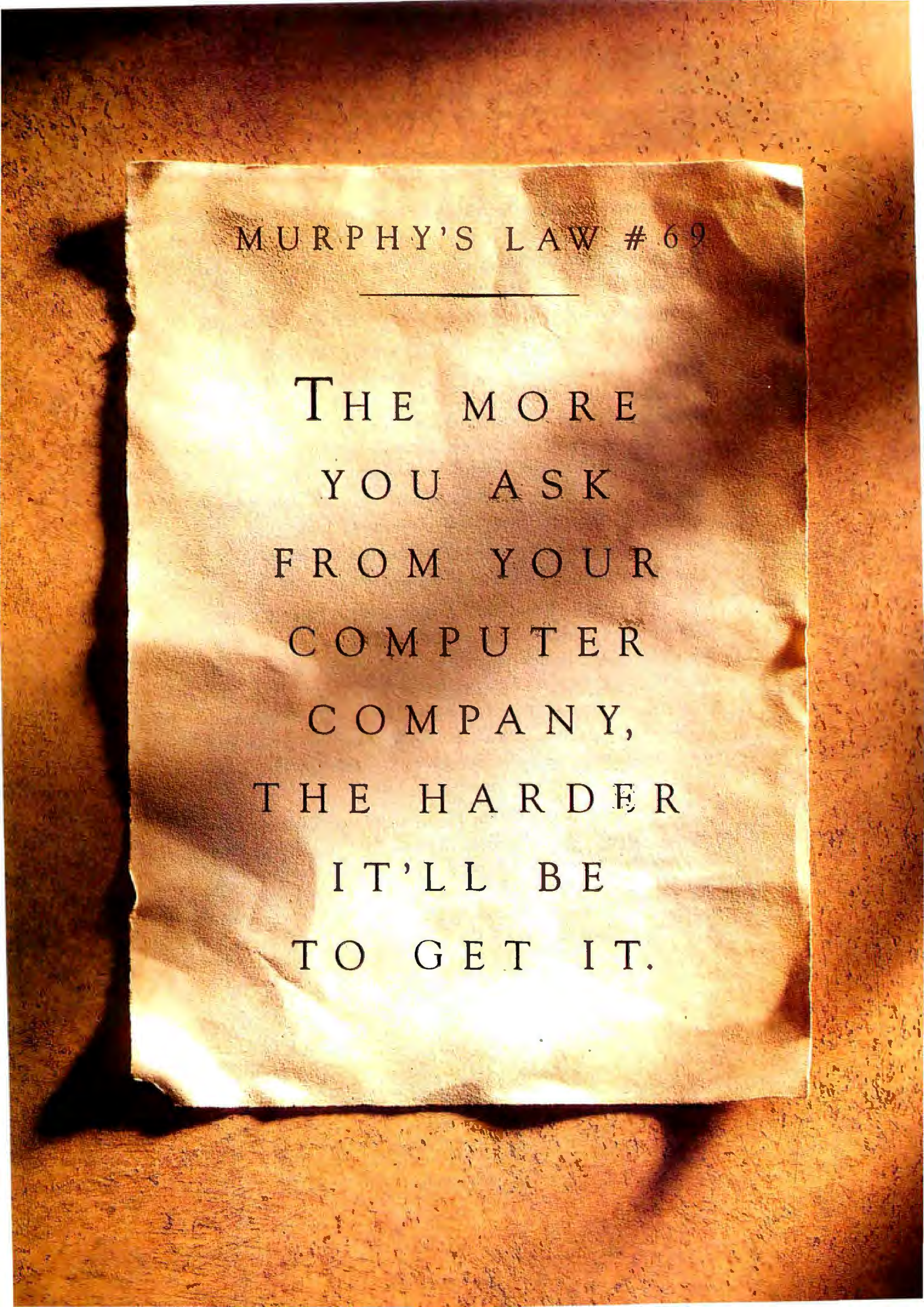
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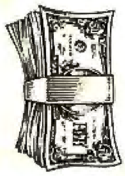

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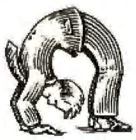

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COVER STORY

FEATURE

All Systems Go

Parallel processing is showing unparalleled performance, and computing will never be the same

DICK POUNTAIN AND JOHN BRYAN

The computing landscape is littered with can't-miss technologies, such as bubble memory and AI, that never fulfilled their promise. Until recently, parallel processing was in danger of joining that not-so exclusive club. Now, with the use of commodity RISC processors, advances in processor-to-processor communication schemes, and solid support from mainstream vendors as disparate as Sun Microsystems (Sparcstation 10/Model 52), Oracle (running on NCUBE hypercubes), IBM (reselling Parallan Computer superservers), and Microsoft (Windows NT multiprocessing support), parallel processing is breaking into the mainstream of commercial computing.

If you don't think you would ever use all the power parallel computing provides, think again. Every time computer companies deliver more power in their desktop computers, new applications come along that invariably soak it all up, and then some. A 33-MHz 486 PC is grotesquely overspecified for running a word processor under DOS, but it's only just adequate for running Windows. Next year, machines based on the P5 CPU from Intel will devour Windows displays, but they will inevitably seem slow when trying to service multimedia functions (e.g., live-action video or videophone communications) or advanced technologies (e.g., voice recognition). In the future, you'll be measuring the performance of your desktop system in BIPS (billions of instructions per second) rather than MIPS, putting your personal computer squarely into what is today considered supercomputing territory.

Today, supercomputing means parallel processing. Your future personal computer will take on many of the attributes of today's supercomputers. As Irving Wladawsky-Berger of IBM's enterprise systems division puts it, "Over time, lots of the techniques from large systems will come to smaller systems." Even Cray Research, a longtime holdout against the tide of parallelism, has announced a new parallel machine based on the DEC Alpha microprocessor (see "RISC Enters a New Generation" on page 141). Ironically, Cray Research's highly successful vector-processor machines were once regarded as an *alternative* to parallel processing.

Computers and "Real Life"

The inexorable trend in personal computing is toward closer emulation of the real world, largely because TV creates an omnipresent, if unconscious, minimum standard for the electronic representation of reality (i.e., it's in full color, and it moves). The less you know about computers, the less impressed you are likely to be by

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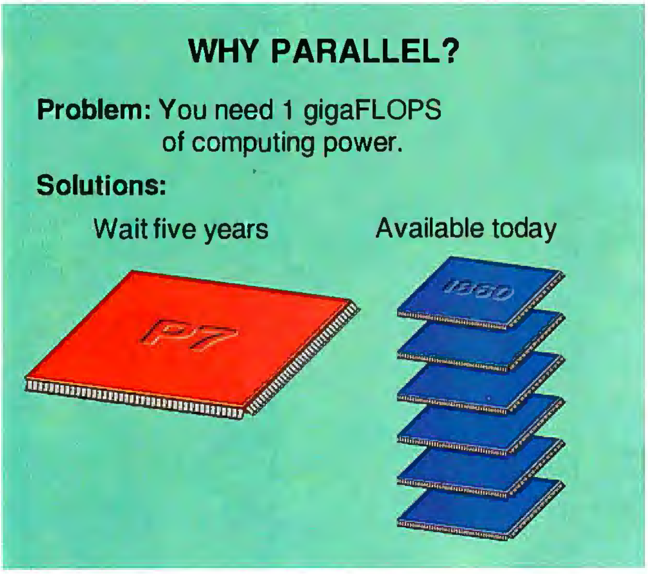

current personal computer software, and the more likely you are to ask that Emperor's-new-clothes question: "Why isn't it as good as the TV?" Experts know too much about the limits of the possible (e.g., processor-to-memory bandwidths) to fully understand what naive users expect. Making computers look simple and transparent will require more underlying computing power. In 10 years, your personal information console is likely to contain a computer with the capabilities of today's high-end scientific visualization systems, which means 24-bit color, 3-D rendering, real-time animation, hundreds of megabytes of memory, and some form of parallel architecture.

One rationale for parallel processing is based on the premise that the semiconductor industry is rapidly approaching the limits of MOS fabrication technology and that the computer designers will have to find other avenues to realize the regular performance boosts that now come from generational advances in semiconductors. If you boost clock speeds too far, you have a radar transmitter instead of a computer, and if you make the "wires" too thin, you run up against quantum effects (e.g., electron tunneling) that make transistors unpredictable. Of course, even the experts disagree on just *how* close the limits of MOS technology are. Intel, for example, is still confidently predicting that one or two more orders of magnitude in performance can be achieved with smaller feature-sizes, faster clocks, and ingenious caching schemes. Sun Microsystems is just as gung ho about the future potential of SPARC.

In fact, some observers argue that advances in fabrication technology will keep the "semiconductor wall" permanently in the future. Michael Slater, editor of the influential newsletter *Microprocessor Report*, doesn't foresee any ceiling on the number of transistors that will fit on a chip. "The most important question to ask," he says, "is what can be done economically today."

Thus, parallel processing isn't so much a replacement of current technology as it is a technology accelerator: It lets you skip computing generations for a reasonable price. If you have an application that requires 1 gigaFLOPS (1 billion floating-point operations per second) of computing power, you could wait five years for the Intel P7 (or whatever it's called by then), or you could use 20 i860s running in parallel today. For a businessperson, the answer is crystal clear. Ditto for Michael Dertouzos, director of MIT's Laboratory for Computer Science: "It's a lot easier to harness 100 horses than to grow one that's 100 times bigger." However fast a single CPU can be made to run, 20 of them, or 2000 of them, working together, will run faster.

Types of Parallelism

Defining *parallel processing* isn't easy. The term literally means executing several processing instructions at the same time rather than one after the other (*sequential* or *serial* processing), as happens in conventional systems. The problem is that parallelism is creeping into the design of single-chip microprocessors. For example, the Intel 860 can schedule four or five processor activities on each cycle and carry out a floating-point calculation simultaneously with two scalar arithmetic operations. Many new so-called superscalar RISC designs have similar architectures, which is often termed *microparallelism*.

In addition, the rise of the coprocessor introduces a parallel element into personal computer architectures. It isn't unusual to find a 32-bit display processor (e.g., the TI34020), a 68020 CPU acting as a disk-cache controller, and a Weitek RISC chip acting as a PostScript rasterizer, working concurrently with an Intel CPU in a single PC. These, however, are cases of special-purpose parallelism; you cannot, for example, use the disk-cache controller to speed up spreadsheet calculations.

This article examines general-purpose multiprocessor parallelism: the use of a number of general-purpose processors working in cooperation. This tighter definition, however, still leaves a bewildering variety of types of parallel architectures to deal with (for more details on parallel-processing classifications, see "Microprocessor Surf's Up," June 1991

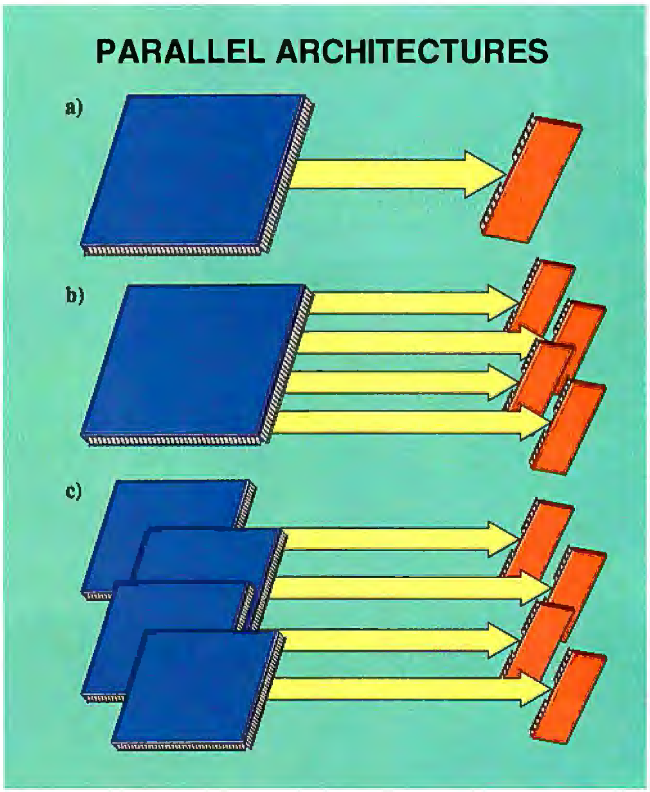

Figure 1: **(a)** *In a serial computer system, one instruction works on one data item at a time.* **(b)** *In SIMD machines, many data items are manipulated simultaneously by one instruction or by identical instructions on different processors.* **(c)** *In MIMD machines, multiple processors act independently on different data items.*

Special-Purpose Parallelism

Although SIMD architectures may not be the best solution to general-purpose computing, they are often the most cost-effective way of achieving special-purpose parallelism. The processors in a SIMD machine do not have to have the broad range of capabilities that are required by processors in a MIMD machine. They can be simple, smaller, and better targeted than the processors in a MIMD machine, making them a natural for special-purpose tasks.

Two companies, one on each coast, are among those bringing the benefits of SIMD—low cost and targeted power—to general-purpose computers. Both take advantage of VLSI technology to fabricate processors that work well on a restricted set of functions. Both see their technology eventually arriving on the desktop.

RSIC (Lincoln, MA) is working on a massively parallel data compression/decompression engine for the VME bus, designed to ameliorate the problems of transmitting and storing the enormous data sets that frequently accompany compute-intensive applications. RSIC has implemented a systolic pipe that uses over 4000 VLSI processors on one board. This level of integration is possible because each chip contains 128 of the specialized processors that the application requires.

The systolic pipe architecture, which chains the output from one processor to the input of another, is an excellent match for the textural substitution method that RSIC uses for data compression/decompression. In its current prototype design, the board can process 320 million bits per second.

Adaptive Solutions has developed the CNAPS (Connected Network of Adaptive Processors System) to solve problems that require billions of matrix-multiply operations per second. Containing 256 special-purpose VLSI processors and a 68030 control processor, the CNAPS can perform 20 billion operations per second.

Adaptive Solutions applies all this power to the pattern-recognition problems you normally encounter in character, handwriting, and voice recognition and in neural-network simulations. These applications are well-matched to a SIMD approach because they require enormous amounts of low-resolution data that is normally processed in a repetitive manner.

With "deskside" systems available today and board-level products to come in two years, Adaptive Solutions intends to provide the horsepower that will be required before applications such as continuous, speaker-independent voice recognition become a reality.

BYTE). Fortunately, the number of parallel architectures that are now having an impact in the commercial mainstream is far more manageable.

SIMD Architectures

It's traditional to divide parallel processing architectures into two broad camps: SIMD (pronounced *sim-dee*), or single instruction/multiple data, and MIMD (pronounced *mim-dee*), or multiple instruction/multiple data (see figure 1). SIMD computers execute the same instruction on many data values simultaneously. The most obvious topology for a SIMD machine is an array processor, which calculates a large two-dimensional matrix of values in parallel by applying the same operation to every element.

Perhaps the first commercial SIMD machine was the DAP (Distributed Array Processor), developed by Britain's ICL (International Computers) and now marketed by Active Memory Computing. The best known and most commercially successful SIMD machine, however, is the Connection Machine from Thinking Machines. You can buy a Connection Machine with up to 64,000 processing elements, and the machines have been used in applications as diverse as defense research and computer animation.

The most remarkable aspect of the Connection Machine is that it uses 1-bit processing elements that can perform only a Boolean combination of a 1-bit read from memory with a 1-bit internal flag. A packet-switched router built into each 16-element processor module effectively connects all the processors in the machine to one another, which is how the machine gets its name. All computations happen synchronously across the processor array, in step with the clock.

SIMD machines are also showing up on the desktop as special-purpose subsystems residing on expansion cards. Among the applications that can benefit from the SIMD paradigm are pattern recognition and data compression (see the text box "Special-Purpose Parallelism" above).

SIMD machines are well suited for speeding up the matrix calculations used by engineers in finite-element analysis, geologists in seismic modeling, weather forecasters in atmospheric modeling, and internists in image processing. They are less suitable for general computing tasks in which the data is not naturally expressible as a large uniform array.

Different Flavors of MIMD

MIMD, the alternative to SIMD, involves connecting a number of processors that run different programs or parts of a programs on different sets of data. Communication between the processors is crucial. If two processors must cooperate on different parts of the same problem, they must communicate results to each other.

Based on how the individual processors communicate, you can split the class of MIMD computers into shared-memory and distributed-memory MIMD machines (see figure 2). Each has important advantages and disadvantages.

Shared-Memory Multiprocessors

In a shared-memory MIMD computer, all the processors have access to a common pool of memory, usually via a shared high-speed bus. This makes communication between processes easy in principle—each processor leaves its answer in memory and tells another processor the address at which to find the data. In practice, things aren't quite so simple. When you have many fast CPUs vying for access to the same memory, bus contention can bring the whole system to a crawl, with most of the processors waiting for a processor to relinquish control of the bus. The solution to this problem is well known, even in the personal computer world: Add a cache. But when each processor has its own cache, the data in the caches can become inconsistent. There may be several versions of the same variable with different values (see the text box "Cache Coherency" on page 125).

The problems of bus contention and cache consistency limit the number of processors you can usefully put into a bus-based shared-memory computer (i.e., its *scalability*) to tens rather than hundreds, certainly not the thousands that supercomputing requires. Typical bus-based shared-memory computers run a multiprocessing version of Unix and use a coarse-grained parallelism, in which one Unix process is run on each processor. This makes for easy programming: The operating system takes over the responsibility for allocating processes to processors, and the machine can look like a fast sequential Unix machine to the programmer.

As you might expect, DOS is not a factor in shared-memory multiprocessing. Although there are multitasking versions of DOS about, DOS is not structured to cope with the issues specific to multiprocessing. Likewise, Apple's System 7.0 doesn't have native support for multiprocessing, although that doesn't mean that the Mac can't do multiprocessing. Radius has developed RocketShare, a multiprocessing extension to System 7.0 that lets you use multiple Radius Rocket accelerators in a single Mac (see the text box "RocketShare Boosts the Mac" on page 126).

Comparison of MIMD Machines

Shared memory

PROS
- easy to program
- lots of software
- lower cost

CONS
- limited scalability
- cache-coherency issues
- coarse-grained parallelism

Multicomputers

PROS
- linear scalability
- fine-grained parallelism

CONS
- difficult to program
- relatively expensive
- little software support

The Unix Advantage

Multiprocessing comes most naturally to multitasking operating systems that partition memory dynamically, which is why Unix variants are the most popular operating systems for commercial multiprocessing. Many systems manufacturers are betting on the Corollary-developed multiprocessing extensions from The Santa Cruz Operation, SCO Unix System V release 3.2 with MPX. Seventeen hardware-platform vendors have taken licenses with SCO, which gives them a substantial share of the 80x86 market.

What Corollary did to produce multiprocessing support in a standard Unix package was to provide what SCO calls *kernel threading*. Generally, in Unix, the process is the atomic unit of execution. A scheduler brings processes to the CPU, where they execute until finished or interrupted. Although not the same as the Posix standards committee's definition of *threads*, SCO MPX threads provide a degree of multiprocessor resource control not available in standard Unix.

Unix support for multiprocessing does not end with MPX, however. The Posix 1003.4 standard, also known as Posix.4, defines a set of extensions to Posix.1 that include many features important for both real-time applications and multiprocessing (see "Real-Time Posix" on page 177). Posix specifies an interface, not an implementation. This allows Posix-compliant operating systems (e.g., LynxOS from Lynx Real-Time Systems and TC/IX from Control Data) to provide all the benefits of Unix and multiprocessing without compromising on real-time performance. LynxOS, for example, is a real-time specific, Unix-compatible

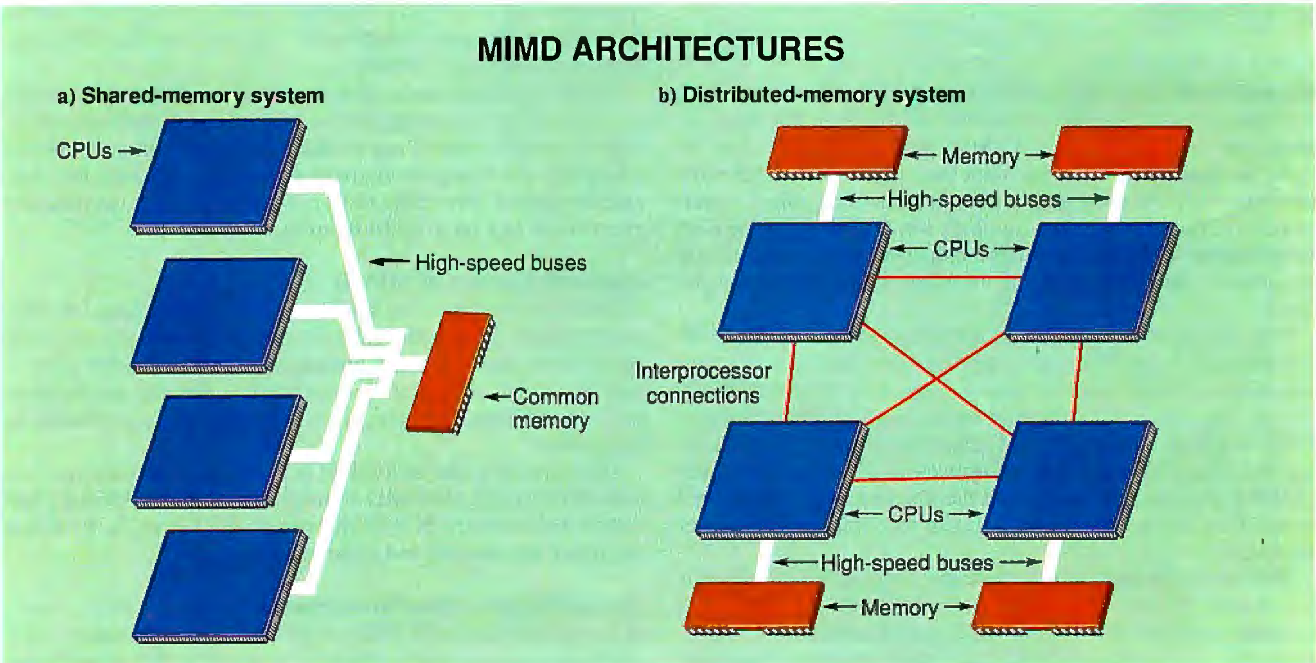

Figure 2: **(a)** *In shared-memory systems, multiple processors communicate over a common bus through a common memory store.* **(b)** *In distributed-memory systems, each processor has its own memory store and communicates via high-speed links.*

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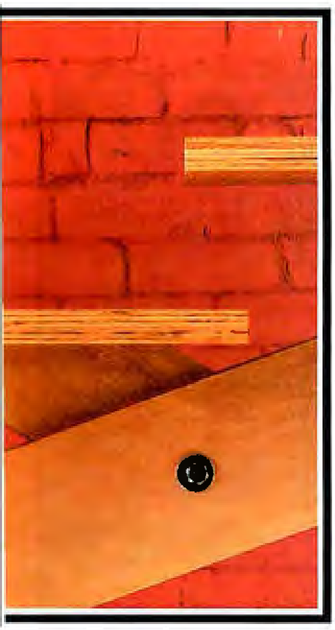

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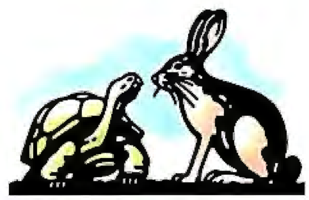

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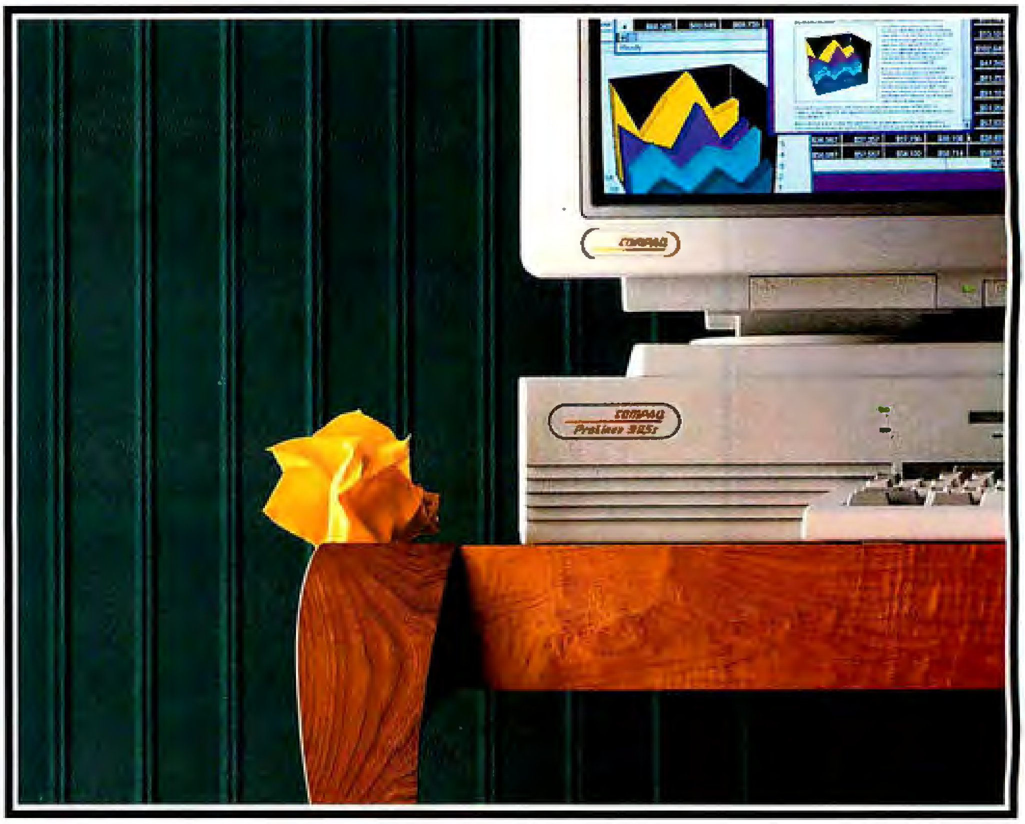

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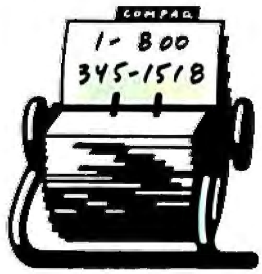

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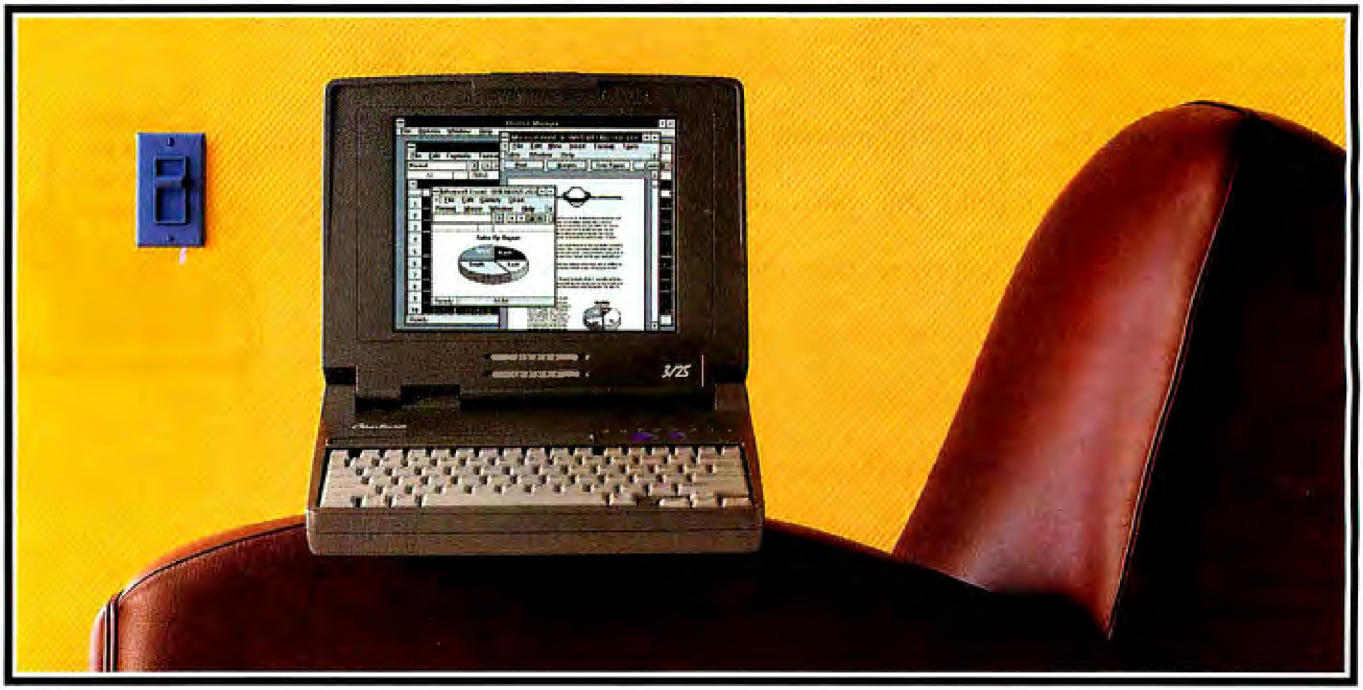

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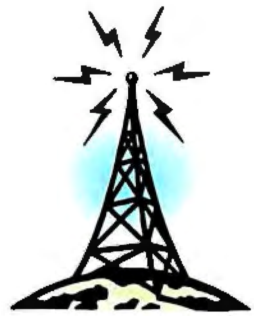

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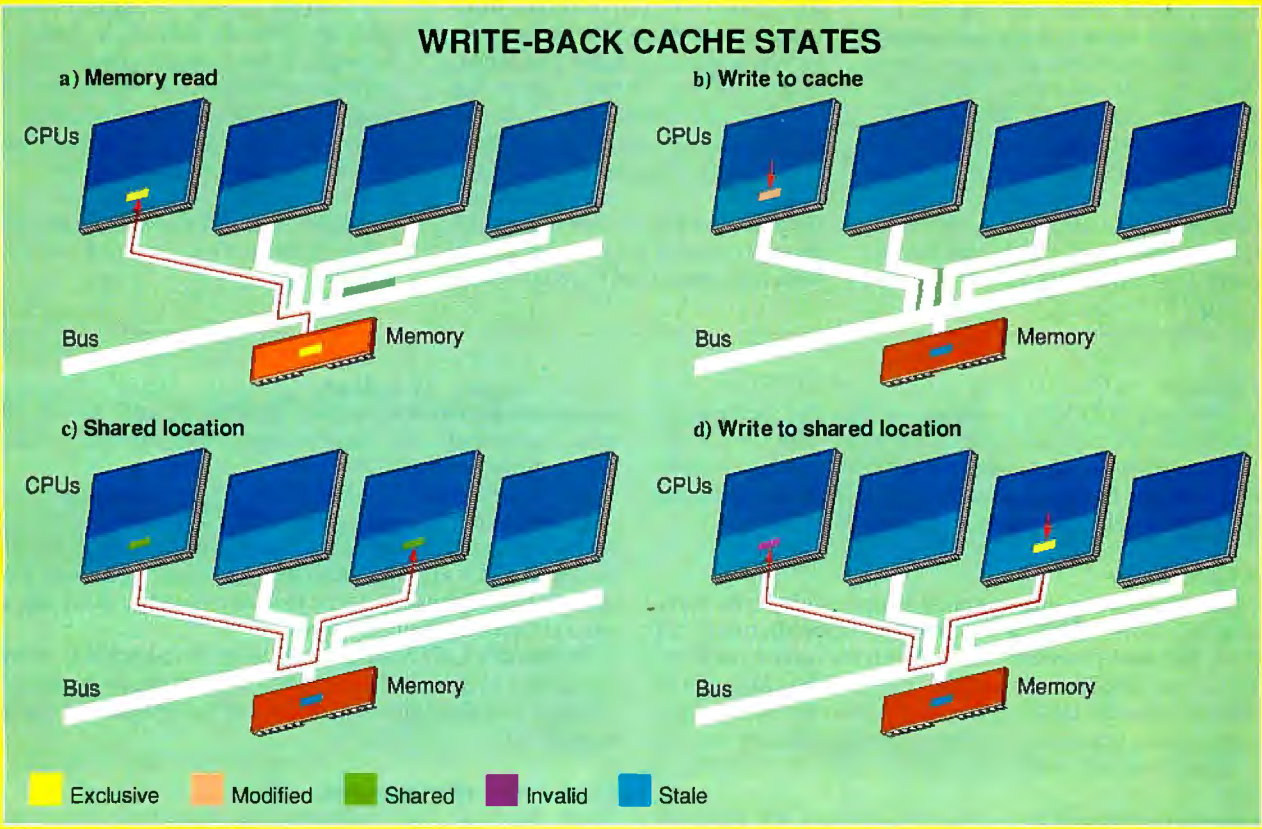
Cache Coherency

Two types of caches are typically used in shared-memory multiprocessors. In a write-through cache, all writes go to main memory, ensuring that variables there have the correct value. If other caches contain copies of the variable, they must access main memory to update their values. Write-through caches are very good for maintaining coherency, but at the cost of using a lot of bus bandwidth.

A write-back cache is more complicated and expensive to implement than a write-through cache, but it uses less bus bandwidth to maintain coherency of the values in the caches. Each line in a write-back cache is tagged with one of four states: shared, exclusive, modified, or invalid. When a processor reads a line from memory that isn't in another cache on the system, it tags the line in its cache as *exclusive* (**a**). All writes to an exclusive line are made to the cache and don't involve the system bus. When a processor writes to an exclusive line, it changes the tag to *modified* (**b**). A processor can only write to a line marked exclusive or modified.

The cache controllers on the system are constantly monitoring, or *snooping*, the memory bus. When another processor tries to read a modified line from main memory, the cache controller that owns the line intercepts the request and places the modified value on the bus to satisfy the read request (**c**). That memory line is then tagged as shared. To write to a shared line, a processor must first broadcast to all other caches and have them mark their copy of the line as invalid (**d**). It then marks its own copy as exclusive and performs the write. The stale value in main memory doesn't have to be updated until a cache is flushed. By not involving the memory bus for exclusive and modified writes, the write-back cache maximizes bus bandwidth.



operating system that supports loosely (i.e., each processor is in a separate machine and communicates over a network) and snugly (i.e., all processors are in the same machine and communicate via a backplane, such as a VME bus) coupled multiprocessing. Contrast this to MPX, which only works with tightly coupled processors that share a common processor bus.

Other Unix variants that offer multiprocessing are OSF/1 and NextStep, both based on the Mach operating-system kernel from Carnegie Mellon University and Unix SVR4 MP V2 (Unix System V release 4.0 Multiprocessing version 2) from USL (Unix System Laboratories). Developed jointly by Bell Laboratories and Pyramid Technology, Unix SVR4 MP V2 is available for Intel microprocessors.

Mary Hubley, Unix analyst for Datapro (a market research

RocketShare Boosts the Mac

JON UDELL

When Radius launched the Rocket, a 68040-based Mac accelerator card, the product was purely a CPU upgrade for Mac II, IIx, IIcx, and IIci machines. People swapped their Mac II SIMMs onto the Rocket and left the host CPU idle, riding the Rocket to stratospheric performance. With the advent of Apple's 68040-based Quadras, even dramatic price reductions—from $3495 to $1999 for the 25-MHz model—could not prevent the launch window from closing.

But Radius has an ace up its sleeve. RocketShare, a software upgrade for the Rocket, turns a Rocket-equipped Mac into a network of two or more Macs. Each Rocket gets a soft partition on the Mac's disk from which it boots a copy of System 7.0.1, and each one maintains a virtual display in its own memory. You manage multiple Mac desktops with Radius' Mission Control program. "It feels like you're using Timbuktu [Mac remote-control software]," says Gary Bringhurst, vice president of Strata, "but all the machines are nice and fast, and they're all yours."

There are two flavors of Rocket-assisted multiprocessing. The brute-force approach works with any application. Can't wait 45 minutes for Photoshop to complete the execution of a complex filter? Launch Photoshop on the Rocket, start the filter, and shove the Rocket into the "background" while you continue to use the host Mac for other tasks.

A more elegant approach works with applications that can distribute themselves across Mac networks. Examples include rendering systems (e.g., Strata's RenderPro, Ray Dream's DreamNet, and Specular International's Infini-D/BackBurner) and distributed make systems (e.g., Calliope's NetBuild and Apple's MPW 3.2 remote tool server). Because each Rocket runs System 7.0, these distributed systems can use the same Interapplication Communication and Apple event services on which they ordinarily rely.

The network-in-a-box that is a Rocket-equipped Mac operates at greater speed than a LocalTalk network because its carrier is NuBus. Its speed is largely untapped today because network-distributed applications tend to be compute-bound rather than I/O-bound. This speed, however, could become strategic as more distributed applications emerge. That, in turn, will require new software technologies that can help developers carve programs into distributable chunks. Radius says it's working on a set of APIs to simplify the process. Although Apple's licensing of key system-software components to Radius is a clear endorsement of the RocketShare concept, there's no sign of an Apple strategy for multiprocessing-software support.

Jon Udell is a BYTE senior technical editor at large. You can reach him on BIX as "judell."

firm owned by McGraw-Hill, the publishers of BYTE), sees both Unix SVR4 and SCO MPX as winners in the battle for the hearts and minds of Unix system vendors and users, with Unix SVR4 coming out on top on large systems and MPX excelling on smaller ones. "People have a high comfort level with both USL and SCO. They are solid companies," says Hubley.

New Contenders

New in the multiprocessing operating-system market is the forthcoming Windows NT (New Technology) from Microsoft. NT supports threaded processes and will run on several hardware platforms (e.g., the 386, 486, and P5 from Intel; the Mips R3000 and R4000; and the DEC Alpha). Its support for symmetrical multiprocessing lets you use the same operating system on your stand-alone machine and on a network-based shared-memory system.

Although not essential to the eventual success of NT, Karen Offermann, associate editor of Datapro, thinks the ability of NT to support multiple processors is important. "People don't plan realistically; they usually come down on the side of caution, underestimating power needs. NT's multiprocessing extensions guarantee a growth path," says Offerman. As far as NT-rival OS/2 is concerned, Offerman doesn't see its lack of multiprocessing capabilities as critical: "OS/2 is doomed, but its lack of multiprocessing extensions is only one of many reasons."

In the networking environment, several vendors have announced support for multiprocessing as a logical extension to the system markets they support. Notably absent is Novell, who, while it conceivably has plans for multiprocessing, has not yet announced anything officially.

On the other hand, Banyan Vines already has multiprocessor support in place. It's essentially a Unix system kernel that was adopted for a client/server architecture from the standard multiuser model, with PCs as nodes rather than terminals. As a result, it was easier to bring Banyan Vines up to multiprocessing speed than any other network operating system.

Microsoft's LAN Manager runs under Windows NT, where it has access to threaded device drivers and file systems. LAN Manager will also support symmetrical multiprocessing options through NT.

Chips for Multiprocessing

On the hardware side, companies are supporting shared-memory multiprocessing at all levels of integration. At the chip level, several major manufacturers have announced support for multiprocessing. Sun Microsystems and Texas Instruments produce the SuperSparc microprocessor and chip set, which has built-in support for several multiprocessing models.

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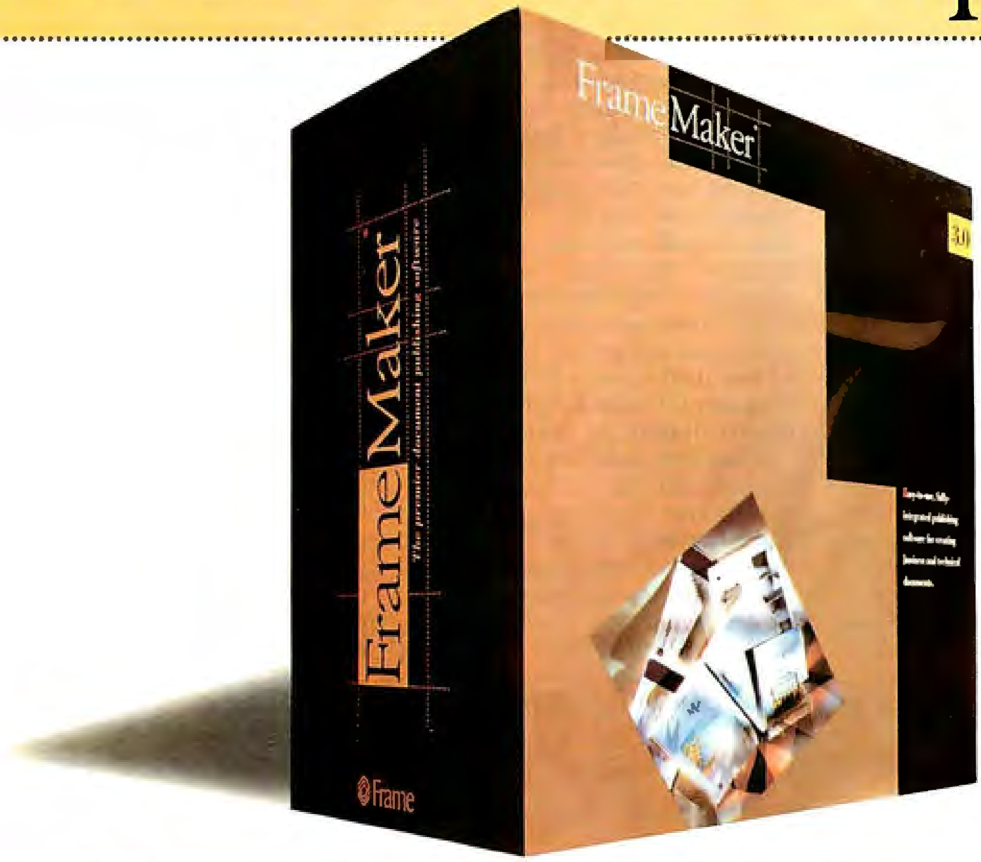

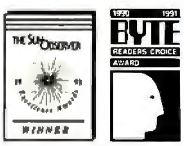

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Programming in Parallel

There has been no single dramatic breakthrough in parallel programming to match the hardware advances of the last year. Programming parallel computers is still more difficult than sequential programming. SIMD and multicomputers are more difficult than shared-memory machines, which let you use the same large global data structures that matrix-based scientific and engineering programs need rather than requiring that you partition your data between distributed memories. FORTRAN programs for a shared-memory machine can look much like their sequential equivalents. The introduction of virtual shared memory (e.g., Performance Computing Industries' shared global objects) will mean that this kind of programming can be extended to distributed-memory machines, too. This is a tack that a number of universities are pursuing in the development of High-Performance FORTRAN.

The Linda programming model, in which data packets are thrown into a memory pool called *tuple space* and retrieved after processing, is well suited for shared-memory machines and offers the advantage of hiding the reality of multiple processors from the programmer (see "Getting the Job Done," November 1988 BYTE). Torque Computer has had some success in disseminating its Opal system, which includes a portable C implementation of Linda called Tuplex and a communications architecture for Intel 860–based parallel machines running Unix. Torque Computer has opened the Opal specification to competing vendors.

Where distributed MIMD machines are concerned, the advent of routing networks has eliminated a great deal of the heartbreak from programming, because the network-operating-system layer handles low-level message routing and permits you to address message destinations using symbolic names, independent of the underlying topology. Meiko's CS-Tools C libraries typify this approach.

The implementation of switched virtual channels in the T9000 transputer will have a similar simplifying effect on the Occam language, removing the crippling restriction of four channels per processor and allowing truly topology-independent programs at last.

The irresistible rise of C has not silenced those who advocate high-level languages (e.g., Prolog) and purely functional languages as a way of achieving transparent parallelism. And these advocates are not all confined to universities either. Thinking Machines still offers Lisp as its principal programming language, and Parsytec has a commercial implementation of Parallel Prolog. The European Esprit initiative is funding research on parallel functional languages in several places. One of the results, a language developed at the University of Nijmegen in Holland called Concurrent Clean, can generate native code as efficient as that from a C compiler.

1 MB of external cache on the MBus (Sun Microsystems' industry-standard memory bus) and up to 2 MB of cache on the Xbus (developed by Xerox's Palo Alto Research Center). The Xbus was primarily designed for large-scale, massively parallel machines.

Intel also has multiprocessing in mind with the P5 chip. Significantly, it isn't necessarily the P5 as much as its support logic that will enable multiprocessing. The dedicated cache controller for the P5, a modified version of the 486DX CPU cache controller, supports the MESI (modified, exclusive, shared, invalid) cache-coherency protocol.

Although the Mips R3000 does not have any intrinsic multiprocessing capabilities, some versions of the R4000 do (e.g., the R4000SC and the MC), especially in their support for an external secondary cache. With interface logic in programmable-logic devices or application-specific ICs, the R4000 will support various bus designs. Another recently introduced microprocessor built to support multiprocessing is the DEC Alpha.

Multiprocessing Buses

The bus system in a shared-memory system is critical because it not only handles processor-memory transfers but must also support the system-cache-coherency scheme. Although some vendors use proprietary processor buses, many are turning to third-party buses, specifically the C-Bus from Corollary. An outgrowth of the NuBus designed by Corollary's founder and president, George White, the C-Bus has been licensed by several vendors of multiprocessing systems, including DEC, ALR (Advanced Logic Research), Everex, and Zenith Data Systems.

The C-Bus architecture is a dual-bus design featuring symmetrical access to processor modules and links to a separate industry-standard I/O bus (e.g., ISA, EISA, and Micro Channel architecture). It uses a write-back cache-coherency scheme to maximize memory-bus bandwidth. The target market for the resultant systems is primarily network servers.

Continuing this trend, Corollary's newest product, the C-Bus II, is also a dual-bus design, but it features fully symmetrical access across both buses. Although originally developed to support the 486 from Intel, the Mips R3000 and R4000, and other processors, the C-Bus II has taken a change in direction and will be exclusive to the P5.

Complete Solutions

Many companies have stepped into the shared-memory multiprocessing arena, focusing primarily on the network-server and technical-workstation markets. Perhaps the best known multiprocessing personal computer in the server marketplace is the Compaq Systempro. The Systempro supports two 33-MHz 386 or 486 processors. Compaq supports several operating-system options in the Systempro, each targeted at different segments of the same market. These include SCO MPX, LAN Manager, Banyan Vines, and NetWare, although Novell does not take advantage of the Systempro's multiple processors.

To keep two processors busy in a network-server environment, the Systempro comes with the Intelligent Drive Array system, which provides several network-fault-tolerant features while

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The Pioneer six-pack CD-ROM Minichanger is great. We've had it in operation for the best part of the year now, on a number of different systems.... **It has always performed flawlessly**... it changes drives a lot faster than you'd expect it to.... **It's really fast....** Accesses that used to take many seconds are now nearly instantaneous. Accesses that took over a minute now take a few seconds. **I always did like the Minichanger.... Now it's even better....** Incidentally, the Pioneer Minichanger will work just fine with a Mac. *Byte (10/91)*

The Pioneer DE-S7001 dual-purpose external optical disk drive I've written about before. Log your wordprocessor to that, save early and often, and you'll have it all.... In a word, WORM drives look like **the ultimate in backup storage.** *Byte (12/91)*

Suppose you erase a file? Overwrite one you wanted to keep? And suppose your house burned down? You don't have any off-site backup at all.... **I could remedy that by installing the DE-S7001 on the network server and archiving on that....** *Byte (11/91)*

I have the DRM-600 running not only with QEMM386.SYS, but inside DESQview windows, which has the amusing result that I can actually have several CD-ROM windows open at once.... **It's surprising** how fast you can switch back and forth among them.... The Pioneer DRM-600... **it's very convenient** to have a bunch of CD-ROMs available without swapping. *Byte (1/91)*

It's quite intuitive [the Pioneer CD-ROM Minichanger]: no instructions are required.... **Recommended.** *Byte (1/91)*

This technology is coming of age. *Byte (1/91)*"

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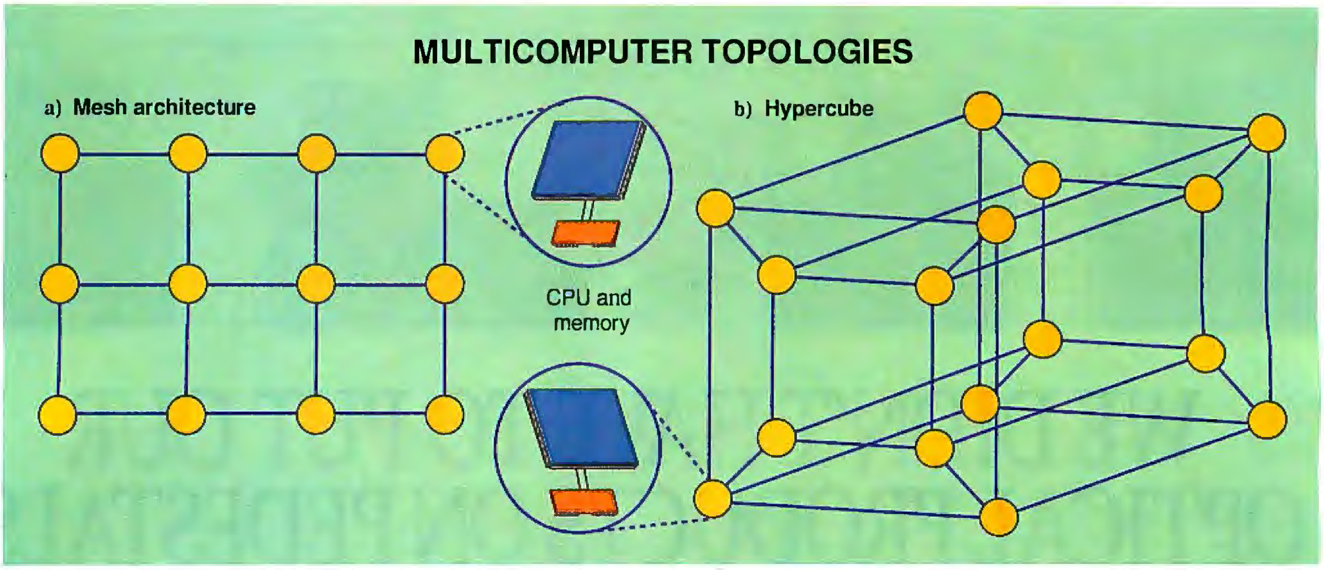


Figure 3: *The topology you use in a system depends on the nature of the application.* **(a)** *If most interprocessor communication is local—within one or two nodes—a mesh architecture is most cost efficient.* **(b)** *When communication is more widespread, a hypercube may be necessary to minimize latency.*

delivering performance limited only by the bandwidth of the EISA bus. Compaq uses an IDA controller with up to four channels to simultaneously write to and read from as many as four disk pairs. (See "Compaq's Reason to Believe in EISA," March 1990 BYTE.) Other companies staking out a claim in the multiprocessing superserver market are Parallan and NetFrame.

In the technical-workstation multiuser environment, Sun Microsystems offers several systems powered by the 40-MHz SPARC and SuperSparc CPUs. A major advantage of the SuperSparc systems is the increased size of the CPU cache; where the Sparcserver 600s with older SPARC chips can only be configured with 64 KB per CPU, the new SuperSparc servers ship with 1 MB of local cache memory. This increased cache size reduces cache misses, decreasing MBus traffic, which in turn allows for less attrition in performance scalability.

ICL, a SuperSparc licensee, bases a large part of its corporate endeavors in the multiprocessing market. A major player in the European business market, ICL produces systems targeted at the traditional minicomputer realm: upgradable business systems that specialize in transaction processing, database manipulation, and real-time financial manipulation. Other vendors supplying shared-memory multiprocessing systems include Data General (Aviion), DEC, ALR, Everex, Zenith Data Systems, and NCR.

Real-time computing is an important market in the general realm of multiprocessing, because most real-time synthesis and applications generate more data than can be acted on by one processor. Control Data Systems, the new name for the Computer Products Group of Control Data Corp. (Minneapolis, MN), has been marketing the Series 4000 in the aerospace and manufacturing-control simulation markets since the introduction of the Mips R3000 CPU. The Control Data Systems' 4336 and 4339 are the only snugly coupled multiprocessing systems available.

Control Data Systems' Series 4000 systems support various interprocessor protocols (e.g., NFS, TCP/IP, semaphores, and named and unnamed pipes) through a LynxOS TC/IX port. Each platform is a dual-bus system, with the CPUs communicating over the VSB bus. This feature allows interprocess communication to scale at a pace with I/O, which improves the bandwidth, responsiveness, and predictability of each CPU. The VME/VSB bus is capable of transfer rates of 40 MBps, and a system with eight CPUs is rated at 264 VAX MIPS and 225.2 SPECmarks.

A new company, Kendall Square Research (Cambridge, MA), is taking another tack to sharing memory on a MIMD machine: It's using virtual memory. The processors work solely with virtual addresses and are decoupled from the location of the data, which is managed dynamically by memory management hardware so that data migrates to where it's needed. This approach can be made scalable to large systems and is likely to be of growing importance in the future. Kendall Square Research's AllCache architecture is the leading example of this field of development, using 64-bit addressing, a ring topology, and advanced cache management to present the appearance of one huge memory space.

Because they share a common address space, shared-memory systems are, for the most part, transparent to application programs and application programmers. Thus, they are easier to program than other types of parallel machines (see the text box "Programming in Parallel" on page 130). On the other hand, they are limited in the number of processors they can support, due to bus saturation problems. To get much beyond the power of eight or 10 processors, you must get rid of the bus.

Shared-memory systems are used mostly as high-end graphics workstations and as file and database servers on LANs in multiuser environments, where they run nearly any type of application software. They are still considered too costly and powerful for most individual users, but the advent of power-hungry multimedia-based applications will undoubtedly see more multiprocessor systems on desktops.

Shared-Memory Applications

- file servers
- database servers
- technical workstations
- transaction processing

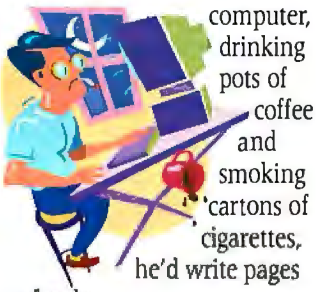
Multicomputers

In a distributed-memory MIMD machine, every computing node is a complete computer, with its own local memory. These

Why do they call it a dongle?

He wasn't famous. He didn't drive a fancy car, but dressed in his favorite Comdex T-shirt and faded blue jeans, he set out to change the course of the computer software industry. Quite a task for a lonely software developer.

Sitting in front of his computer, drinking pots of coffee and smoking cartons of cigarettes, he'd write pages of code.



It took time. Years in fact. But he did it. He wrote the most powerful computer program in the world. Now came the hard part. Selling it.

The Most Powerful Program in the World

Determined to make those long years pay off, he called on every distributor, VAR and dealer in the world. He drove from Beantown to San Diego. Flew from Dublin to Borneo. Everyone loved the program.

So he sold a few. Only a few.

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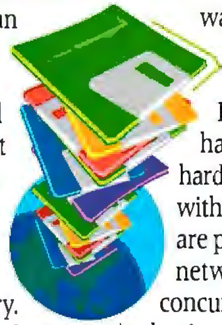
The Global Marketplace

From Paris to Prague, his program was everywhere in Europe. When he got off the plane in Hong Kong he found his program stacked to the ceiling in every computer store. Amazed in disbelief, he bought a hundred cartons of cigarettes and a hundred pounds of Indonesian coffee and flew back to Boston.



Beaten, battered and bruised he went back to the drawing board. This time he would really change the face of the software industry. He would develop a device that would prevent unauthorized distribution of software programs.

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He developed a hardware key. His peers applauded his efforts. Finally, a solid solution for revenue protection.

But he didn't know what to call it. He thought of naming it after an exotic place he visited in his travels. Madagascar was a bit too long, though.

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machines are often referred to as *multicomputers*. Because other nodes cannot see into a node's private memory space, results must be passed between nodes over a communication network. Distributed-memory MIMD architectures are also called *message-passing* architectures.

The performance of a multicomputer is as much affected by the speed of its communication network as it is by the speed of the processing elements. Perhaps it would be better to say that the balance between communication-time and computation-time in a message-passing machine varies from problem to problem, according to the algorithm used and the topology and performance of the communications network utilized. Applying more processors to a problem on a message-passing computer does not ensure improved performance because the machine may spend all its time communicating while half its processors lie idle.

There are as many ways to connect distributed processors (the topology of the multicomputer) as there are ways to use a constructor set, and most of them have been tried by someone, somewhere (see figure 3). Pipelines, arrays, meshes, cubes, hypercubes, trees, rings, and toruses all have their advocates. In fact, disputes about topology tend to take on an almost theological intensity (mingled nowadays with a shrewd commercialism, because millions of dollars of DOD acquisition funds are at stake).

Most multicomputers are built with commodity RISC chips. It's hard to justify spending your own money designing a processor when every month a semiconductor company announces the fastest-yet CPU. You can argue over whether the Intel 860, SPARC, DEC Alpha, Hewlett-Packard Precision Architecture, Inmos T9000 transputer, IBM RISC System/6000, or Texas Instruments TMS320C40 is the better chip to use, but with the odd exception, everyone now buys off the shelf. The economies of volume production speak for themselves.

Going Upscale

Scalability is the biggest advantage that multicomputers enjoy over shared-memory machines. It's the reason for their existence. In shared-memory systems, adding processors to a system can degrade performance due to bus saturation. With multicomputers, you can almost linearly increase computing power by increasing the number of processors; in the ideal case, 10 times more processors would mean 10 times more throughput. Scalability is a big issue because it doesn't just happen. You must design it in, and it's not easy to do. Simply adding processors to a distributed MIMD computer will not help if you're adding processing power without adding the equivalent communications bandwidth.

Scalability is *the* hot issue now because suddenly there's a clear winning post for high-performance parallel-computer designers: to make the first teraFLOPS computer. Why a teraFLOPS computer? Well, 1000 gigaFLOPS (i.e., 1 trillion FLOPS) is a nice round number; the sporting aspects of a race are heaven sent for publicity and marketing departments; and it corresponds to a real, if small, market demand. There are flagship applications (e.g., modeling global climate change, quantum chromodynamics, and the human genome project) that can use this much power now. Even using the fastest RISC chips likely to be available in the near future, a teraFLOPS machine will require thousands of processors, hence the obsessive interest in scalability (see the text box "The TeraFLOPS Machine" on page 135).

Topology can have an important effect on scalability. Pioneering message-passing machines like the CalTech Cosmic Cube, the Intel iPSC, and the NCUBE machines had processors that were hard-wired into a hypercube formation, a topology chosen because it gives the best trade-off between the longest path between nodes and the number of physical connections required at each node. In a system where messages have to be received and passed on by each node they pass through, the communications delay, or latency, is more or less proportional to this longest path. For example, you can connect 16 processors as a 4-D hypercube, with four connections per node and the longest path between any two processors being four nodes. For 256 processors, an 8-D hypercube topology only doubles the required connections to eight per node, and the longest path increases to eight nodes. If the connections are processor-to-processor and involve additional hardware, the hypercube is unbeatable, because it minimizes both the extra hardware and communication latency you incur as you scale the system.

The arguments about topology have become less vehement recently, because there's a definite movement away from fixed topologies and toward user-selected topology controlled by a routing network. Instead of connecting all the processors directly together, you connect them to a fast-routing network (as pioneered by the Connection Machine), which uses switches to make and break virtual connections between nodes, in much the same way a packet-switching telephone network does. The motto of this movement might be, "Switches are cheap, wire is expensive."

If the switches are designed to cause the minimum delay to messages that are just passing through, then communication latency will scale slowly as you add more nodes to the system. For example, switches that buffer each message in memory before passing it on would be quite unsuitable. Fortunately, it's relatively easy to devise switches that check the message's intended destination by reading a short address header but let the rest of the message pass unimpeded. By using multistage networks of nonbuffering switches, it's possible to get close to the theoretical ideal of a (virtual) connection from every processor to every other. Parallel computers that use switching networks usually have a software layer to handle the setting of the switches at the operating-system level (usually a version of Unix), and they present the programmer with a higher-level interface that hides the mechanics of message routing.

Multicomputer Applications

- supercomputing
- "grand challenge" problems
- database servers
- computational servers

Practical Multicomputers

The most serious impediment to the widespread commercial adoption of multicomputers is that they are notoriously difficult to program. This has prevented the creation of a commercial-multicomputer-software market, restricting multicomputers mainly to government research labs and universities. Multicomputer researchers are taking two approaches to getting these machines into the mainstream. One is to come up with better software development technologies. The other is to apply the machines to tractable problems in the commercial world.

Ron Buck, NCUBE's vice president of marketing, thinks that "the future of multicomputers in the commercial realm lies in client-server applications." In addition to its traditional niche in the supercomputing market, NCUBE wants to provide database and computational servers for LANs. In the former case, NCUBE is working actively with Oracle to port the Oracle relational DBMS to NCUBE's massively parallel architecture. The system is in beta testing and should be announced this fall.

A multicomputer as a back end makes a great deal of sense in

The TeraFLOPS Machine

Although you won't see a teraFLOPS machine on your desktop soon, you may see pieces of one. Your next desktop machine may owe a lot to one or more of the machines—all contenders for the teraFLOPS crown—described below.

The GigaCube

The GigaCube from the German firm Parsytec is a scalable, distributed MIMD design based on the Inmos T9000 transputer (see "The Transputer Strikes Back," August 1991 BYTE) and its companion chip, the C104 packet-switching router chip. The GigaCube is a cube-shaped module containing 64 transputers, whose peak performance should be about 1 gigaFLOPS, hence the name. (See the photo.)

The conceptual unit of the GigaCube is a "cluster" of 16 transputers that behaves as a single processing element. Each of the four clusters in a cube is a circuit board holding 17 transputers, 4–32 MB of DRAM, and four C104 routing chips. The extra transputer in each cluster provides fault-tolerance. A cluster is connected to each of its neighbors by eight transputer links via the C104 routers, giving a bidirectional bandwidth of 160 MBps between clusters, or about 1 gigabyte per second for the entire cluster. This is almost equal to the bandwidth available within a cluster, which suggests good scalability.

The logical topology of a network can appear anyway you like. Parsytec claims that it can implement a 10-dimensional hypercube with a sustained bandwidth of 5–12 MBps between neighboring nodes.

Thinking Machines' CM-5

Thinking Machines' CM-5 is built from tens, hundreds, or thousands of single-board nodes that contain a general-purpose SPARC processor with 8–32 MB of DRAM on a 64-bit bus. Computing nodes also have two custom 64-bit vector arithmetic accelerators capable of 128 MFLOPS. A network interface provides a 64-bit synchronous interface between nodes.

The CM-5 uses three communication networks: the Control Network, the Data Network, and an "invisible" Diagnostic Network to isolate faulty components and trace errors. The Control and Data networks are memory-mapped into the local memory space of each node so that processors can talk to each other without a costly call to the overlying operating system, which runs on each control processor.

The Control Network is responsible for synchronous operations that involve all the processors in a partition. It can, for example, broadcast a value to every processor or combine the values from all the processors into one answer in just three memory cycles.

The Data Network supports asynchronous bulk data transfers between processors, and it consumes no processing resources in transmitting messages. The Data Network topology combines features of hypercubes and "fat trees," so it provides 20 MBps of bandwidth between any group of four of the nearest neighboring processors, 10 MBps of bandwidth between any 16 neighbors, and 5 MBps of bandwidth to processors outside the nearest 16 neighbors. Processors can, however, "lend" spare bandwidth to others in their group. This networking model ensures the scalability of the CM-5.

The GigaCube's modules can be stacked to build walls with up to 16,084 processors.

Performance Computer Industries' CS-2

Another teraFLOPS contender, PCI, is a consortium of the U.K. companies Meiko and Parsys and the French firm Telmat. PCI was formed earlier this year with the intention of producing a teraFLOPS machine by next year.

PCI's CS-2 depends on two new communication chips. One chip, code-named Elan, is an MBus-compatible packet-communications controller combined with a virtual memory manager. The other chip, Elite, is a fast eight-way crossbar switch used to build a multistage network. Elan and Elite make the machine's physically distributed memory look like one shared address space to the Solaris operating system.

The computing nodes in the CS-2 are based on the 50-MHz SuperSparc chip and the Fujitsu VP2000 supercomputer on a chip. Each node has twin SCSI-2 disk controllers so that you can load data directly into a node, resulting in I/O bandwidth that can be scaled with the rest of the machine.

The CS-2 architecture promises a teraFLOPS machine from only 1000–2000 nodes. This would be far more manageable in terms of power consumption, cooling, and physical size than PCI's main competitors.

NCUBE's NC3

The latest company to jump into the teraFLOPS race is NCUBE. When released in 1994, the NC3 is expected to produce 6.5 teraFLOPS by linking over 65,000 of NCUBE's nC3 microprocessors. By giving each processor up to 640 MB of interconnect bandwidth, NCUBE expects to reduce the maximum message-passing latency in the system to 5 milliseconds. To load the enormous data sets required by such a system, NCUBE plans to significantly upgrade its distributed I/O capabilities.

To make programming easier on the NC3, NCUBE will build in the capability of letting software see the distributed memory as a single-level address space. It will offer programming tools and parallelizing compilers to simplify porting applications to the NC3.

a client-server environment. It provides more power than a uniprocessor or a shared-memory machine can, yet its greater complexity is hidden by the client-server architecture. With this architecture, the server is a black box. Applications and users don't have to know how it works; they simply send queries and get responses. In preliminary tests, NCUBE claims that its 64-node Oracle server executed a record-breaking 1073 tps (transactions per second), achieving $2500 per tps.

Computational servers are a new category of machines. They provide high-speed number crunching to client workstations attached to a network. The drawback to computational servers is that there's no standard way to format a computational query, as there is with Structured Query Language and relational databases. Further standardization is needed before computational servers become widespread.

Of course, you don't have to wait for such standardization if you develop your own applications. Companies such as MicroWay produce parallel processing subsystems that fit into ISA expansion slots and act as coprocessors to your system. The MicroWay Quadputer gives you the power of four Inmos transputers for your scientific, technical, and imaging applications.

All Systems Go

The future of parallel computing has never looked better than it does right now. It is targeted squarely at the booming network- and database-server market (which is expected to exceed $50 billion by 1995, an improvement over today's $20 billion, according to Datapro) and at the nascent computational-server market. With shared-memory machines a commercial reality and multicomputers knocking at the door, parallel technology has taken that all important first step out of the lab and into the marketplace.

For a couple of shaky years, the difficulty of parallel-software development caused widespread disillusionment and the demise of several first-generation vendors. Now the remarkable progress of commodity RISC processors is combining with advances in the understanding of communications networks to produce a technology that can solve real problems in the real world—and do it faster than any other technology on earth. ■

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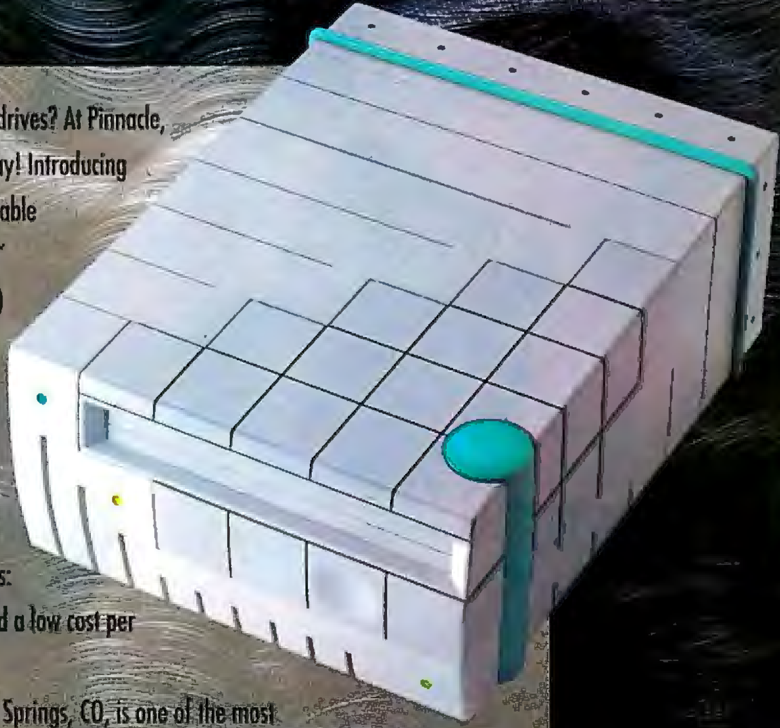

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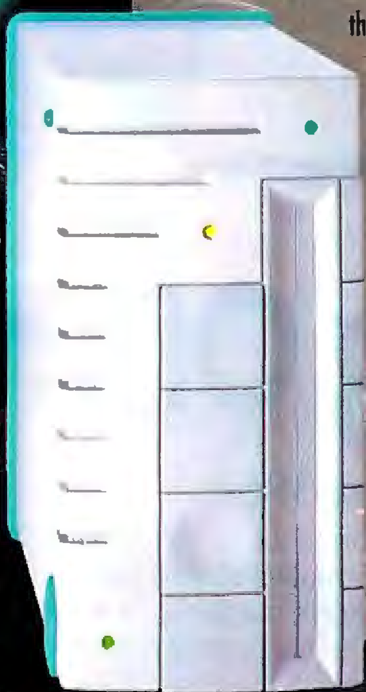

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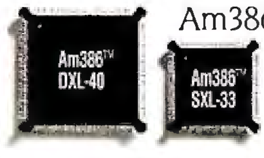

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FEATURE

RISC Enters a New Generation

An insider's look at the development of DEC's Alpha CPU

RICHARD L. SITES

RISC has emerged over the last 15 years as the model of choice for the design of general-purpose processors. Its success best indicates the degree to which it has delivered on its initial promise. The basic concept works well: Reduce the instruction set to only the most frequently used, single-stage instructions and give the language compiler greater responsibility for handling complex operations. But most processor architectures using the RISC approach were conceived several years ago and, to varying degrees, are burdened by assumptions made then.

In 1988, an engineering task force was charged with designing a new architecture to succeed DEC's VAX. The task force decided on a clean-sheet RISC design, of which I was a coarchitect. The project was code-named Alpha.

Planning for the Alpha project began in the fall of that year. We did not set out simply to build a faster VAX or just another RISC/Unix machine. And because we solved compatibility issues with existing Ultrix and VMS applications at the outset, we were free to create a kind of RISC wish list.

One factor in our decision was recognizing that the industry's 15 years of RISC use provided a valuable historical vantage point from which to examine what RISC had become and what improvements might be made in design fundamentals. As a result, Alpha embodies some new thinking in RISC development.

What Is Alpha?

Alpha is both an architecture and the start of a family of processors and systems. It is intended to be more than a proprietary solution. Its architecture, hardware, and software technologies will be licensed to third parties.

Alpha's load/store RISC architecture performs all operations between 64-bit registers. Memory is accessed through 64-bit, little-endian byte addresses, yielding an addressable memory space of 18.4 exabytes (exa is the prefix for 1018). The architecture provides 32 integer and 32 floating-point registers and supports longword (32-bit) and quadword (64-bit) integers. It also supports four floating-point data types: IEEE single (32-bit), IEEE double (64-bit), VAX F_floating (32-bit), and VAX G_floating (64-bit).

The task force decided to define a true 64-bit architecture, because Alpha was conceived as having a design life of 25 years, with the final iteration having a 1000-to-1 performance advantage over the first Alpha system. Only those who ride the very crest of the wave, using the highest of the high-end applications, need 64-bit addressing. But, like so much else in computing, user requirements for address space change with

ILLUSTRATION: RAPHAEL LOPEZ © 1992

time. Users outgrow address space at about 0.6 bit per year, so Alpha's 64-bit addressing capability should be enough for the next 25 years.

The architecture is also designed to be used in systems that will eventually range from palmtops to massively parallel supercomputers. Embedded applications are also envisaged.

The first Alpha processor (the 21064-AA) is a dual-instruction-issue, 200-MHz CMOS chip with a theoretical peak throughput of 400 MIPS. An Alpha processor optimized for embedded applications is also in development.

Chips Define the Possible

The microprocessor has had as much impact on the economics of computing as it has had on the performance of computers. As a result, any new CPU is likely to be conceived as a single-chip design. The result of this drive for chip-level implementation of RISC architectures is that advances in processor power are linked closely to advances in semiconductor technologies—processors' designs are scaled to chips, and chip technology is driven to accommodate new processors. This interdependence of technologies affects the basic strategies of RISC-chip vendors and computer systems manufacturers.

One response of large computer manufacturers to this dependence on semiconductor technologies has been to develop their own research, design, and production capabilities for chips and semiconductor processes. DEC took control of its chip-dependent destiny many years ago. As a result, it has considerable experience in semiconductor design and manufacture, currently manufacturing 80- to 100-MHz VAX processor chips in a 0.75-micron, three-metal-layer CMOS process that has a (conservatively rated) 200-MHz capability.

Like any large technology-based company, DEC has an internal base of technology that results from many research projects, past and present. Some of these projects have been aimed at exploring processor designs, including RISC designs, and their results have contributed to Alpha's knowledge base.

The State of RISC

As an approach to processor architecture, RISC has delivered on speed, economy, and, to a degree, portability of source code. But some serious shortcomings in current-generation RISC implementations limit *architectural longevity*—the ability of a processor family to evolve into greater realms of performance over time. Given Alpha's design life and performance growth targets, architectural longevity was a primary design goal.

BYTE ACTION SUMMARY

Users of desktop computers will have a new and exciting computing alternative by 1993: a true 64-bit machine, based on DEC's Alpha CPU, that runs three of the industry's leading operating systems several times faster than anything else that fits on a desktop.

Architectural longevity involves a number of key factors. The first is address-space capacity. Today, only the largest CAT scans or IC simulation applications push the limits of the virtual address space provided by a 32-bit word length. However, just 10 years ago, few applications pushed the limits of 16-bit virtual addressing. As any computer architect knows, people use up the power and space you give them and then ask for more.

The second factor is performance—not just clock-speed performance, but also MIPS-level performance. Clock speed can get only so fast—at present, a 100-MHz clock speed stretches the limits of most silicon technology (although due to some decisions made during chip layout, the first Alpha processor runs reliably at 200 MHz). Even with newer chip technologies, clock speed will probably increase by only 10 times—not enough to deliver the 1000-fold increase in performance envisioned for Alpha over 25 years.

What's needed are added dimensions for multiplying MIPS, and these must come through *multi-instruction launch*—the ability to issue more than a single instruction per clock cycle—and the ability to connect processors in parallel configurations. Few of today's RISC architectures are capable of issuing multiple instructions, and those are limited to two-way launch or, in some cases, the types of instructions they can launch simultaneously. Also, few RISC processors have the inherent communications capabilities for running in parallel-processor configurations of more than two or four processors. Some other architectures require strict read/write ordering between processors, which is difficult to achieve quickly across multipath routing networks in massively parallel-processing systems. Other architectures have only primitive atomic-update facilities that depend on holding control of a single shared-memory bus.

Last, RISC designs are optimized for Unix. For example, they provide hardware (coprocessor) instructions for manipulating a Unix view of virtual memory management. Another way architectures can be optimized for Unix is by providing register windows that depend on a low frequency of context switching. Also, some Unix design features are intended to achieve source-level compatibility among platforms. But that compatibility is also potentially limiting: Because they are optimized for Unix, they are, in effect, proprietary to Unix. Unix is certainly a key operating system, but there are sure to be other important operating systems playing on users' desktops during the next 25 years. Any RISC architecture that strives for longevity will want to accommodate them all, without a hardware bias.

Alpha: Reapplying RISC to RISC

With longevity as a guiding philosophy, we based our decisions on what to keep and change from current RISC designs. For instance, we kept the standard RISC functional concepts and dimensions: the load/store type of operation, where the only instructions that access memory are load or store instructions (no specialized instructions); the (then) standard 32 integer registers and 32 floating-point registers; and the 32-bit-wide instructions.

We reapplied the principles of RISC to processor design to get maximum clock speed. In other words, we looked as hard for what we could leave out of the design as we did for what we could put in it. As a result, we rejected any special registers, such as those for maintaining condition codes or multiplier quotients, and we worked to minimize instruction and register complexity.

The critical importance of parallel execution as a means of ensuring continued performance growth led to making the Alpha architecture capable of launching more than a single instruction with every clock cycle. The first implementation of Alpha is a dual-issue machine, capable of executing two instructions per cycle; future implementations may well be designed to launch three or more instructions in parallel.

Another crucial difference between Alpha and other contemporary RISC designs has to do with increasing performance through parallelism, but this time into multiprocessor implementations. Ready compatibility for multiprocessing carries many design implications—particularly in memory design and timing and instruction sequencing. For example, the load-

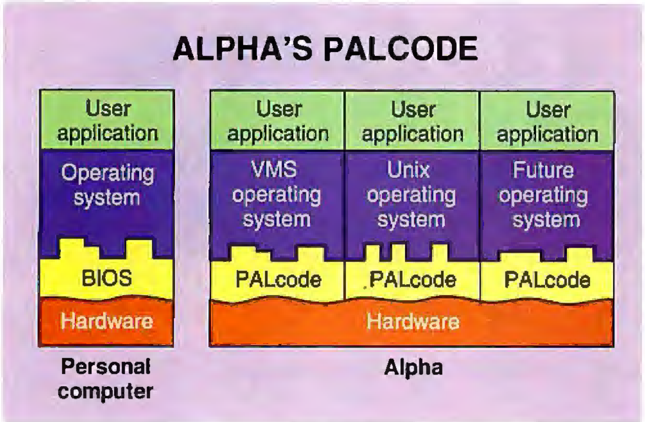

Figure 1: *Operating-system independence is the goal of Alpha's PALcode. PALcode consists of subroutines that handle context switching, memory management, and other primitives specific to each operating system. PALcode is similar conceptually to the BIOS of a personal computer.*

locked/store-conditional sequence Alpha uses for atomic updates can scale well with processor (not main-memory) speed. In the absence of actual interference, a different atomic update can be done on each processor simultaneously. And the rules for multiprocessor read/write ordering and the inclusion of the Memory Barrier instruction allow complex, high-bandwidth interconnection between processors. If these and other multiprocessing support features were not part of the architecture, the additional overhead for extra handshaking and control logic would impose severe limits on implementations of multiprocessors.

One last break with RISC tradition occurs in Alpha: The architecture is not optimized for any operating system. This independence was mandated by the immediate need to support multiple operating systems—initially, DEC's VMS, Ultrix, and OSF/1. We took the mandate to support multiple operating systems as an opportunity to give Alpha true operating-system independence—an attribute that will be even more important in the coming decade.

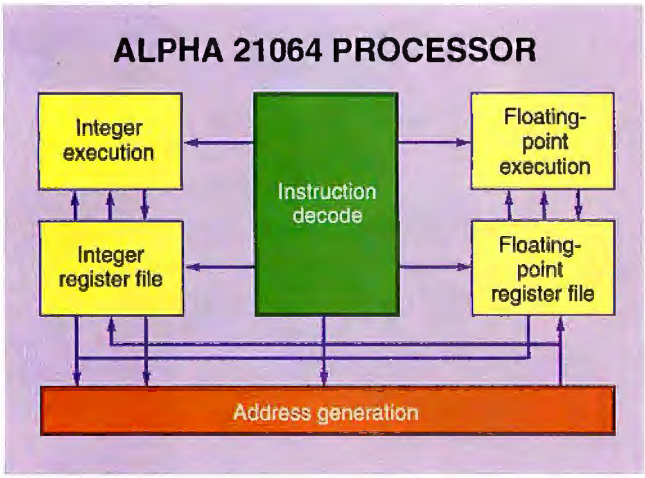

Figure 2: *Avoiding bottlenecks is the goal of the Alpha core architecture, shown here with distributed floating-point and integer register files and execution logic.*

Operating-System Independence

To accommodate existing VAX and Mips software, we came up with two sophisticated binary translators. The translators will let customers move executable programs to the new Alpha platform without having to recompile their source code.

For more complex operating-system primitives (e.g., those for context switching, memory management, and interrupt and exception delivery), we adopted from an earlier project, called Prism, the concept of an instruction library—actually regular RISC instructions but running in a privileged mode—called PALcode (Privileged Architecture Library code) (see figure 1).

PALcode consists of optimized subroutines activated by instructions, called PALcalls, that specify that certain operating-system primitives be performed. These primitive routines are then drawn from the I-cache (instruction cache) or from main memory and run in privileged (no-interrupt) mode.

In fact, PALcode is analogous to a PC's BIOS firmware: Both serve as a kind of insulation between operating system and hardware. In Alpha's case, PALcode is software, not firmware, and it permits Alpha to act (and be designed) as a single, unbiased hardware platform. The hardware can then be optimized through different PALcode implementations to run various operating systems.

Perhaps even more important, the PALcode concept opens the door to newer operating systems that are just now in development or planning stages but might predominate five, 10, or 20 years from now.

Taking Aim on Performance

Thanks to the translators and PALcode, we were free to create the fastest RISC architecture we knew how. Based on the reasons I discussed earlier, we decided on a full 64-bit architecture—one with a flat, unsegmented 64-bit virtual address capability. A 32-bit architecture would run slightly faster at first implementation, but we would pay the penalty within five or 10 years, when growing applications would demand a new—or kludged—architecture.

As for processor speed, we worked with our chip-design engineers toward a clock-speed goal of 200 MHz—that's 5 nanoseconds, or about the time that it takes a beam of light to travel 5 feet.

Additionally, we were able to call on some of the most highly respected compiler experts in the industry. This is extremely important, because compiler technology is the key to optimizing hardware-register interactions in RISC architectures and to optimizing RISC system performance in general.

Designing the Chip

Building dual-issue capability in the first Alpha processor meant making some tough decisions—notably in register organization—as well as confronting some basic RISC assumptions, particularly in functions such as instruction interaction and multi-instruction pipelining.

The first area, organization of the processor's hardware registers, was critical to getting high performance in mixed-integer/floating-point operations. By definition, RISC processors make frequent use of hardware registers for integer and floating-point calculations, and register allocation plays an important role in RISC compiler effectiveness.

One important factor in chip layout involves the physical limits of electron speed and distance across the silicon. To get optimum speed, integer registers should be placed as close as possible to integer arithmetic hardware, and floating-point registers should be placed near the floating-point adder and multiplier.

Performing simultaneous integer and floating-point operations from a single register file would require more than six read/write


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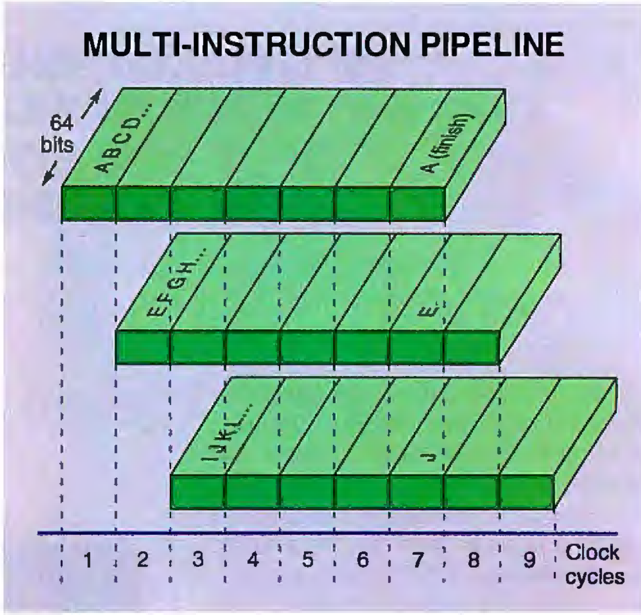

Figure 3: *Multi-instruction pipelining requires paying special attention to instruction interaction. In this example of a four-way machine, the instructions* E *and* J *cannot execute until the result of* A *has been computed. However, special bypass logic—a standard architectural attribute—sends both* E *and* J *the results of* A *at the same time the results are entered into the* A *register, so they don't have to wait an extra cycle.*

ports (e.g., for sending two numbers to the integer hardware and two to the floating-point hardware and receiving the return values, as well as accessing memory for normal load/store operations). This would create a circuit bottleneck and slow down performance.

Thus, we implemented a partitioned register file rather than a combined file and placed the integer and floating-point registers on opposite sides of the chip, close to their respective hardware and with separate paths to main memory (see figure 2). Each file contained 32 64-bit registers; thus, Alpha's performance was faster using the two small files rather than a single large file.

Compiler designers within DEC helped influence our decision. Most compiler designers would prefer a combined file, but having gained experience with partitioned files, DEC designers assured us that compiler performance would not be adversely affected.

Avoiding Speed Traps

Once the register-file design was finalized, our quest for a high-performance multiple-issue architecture dictated that we challenge some RISC assumptions. We looked for other elements or functions that might slow down (or tie up) a multi-instruction pipeline, and we then made several important secondary decisions.

Three examples of functions common to early or current-generation RISC machines and not included in Alpha are special registers or register operations, arithmetic overflow traps, and branch-delay slots. Adding functional complexity to register operations would mean adding extreme complexity—and on-chip clutter—to the decision logic that controls register usage during pipelined operations.

To keep operations as simple as possible—critical to heavily

register-oriented RISC architecture—Alpha limits instruction interaction to reads and writes of registers or memory. There are no special registers, such as condition-code registers or multiply quotient registers, and there are no complex operations (e.g., "load four registers and check for bytes of 0").

Alpha also reduces complexity in arithmetic operations. In Alpha, there are no "precise" arithmetic exceptions (there are, however, precise fault reports for memory management). An arithmetic exception can occur when the result of an arithmetic operation overflows its registers.

Some RISC architectures look ahead to see if a complex instruction (e.g., a double-precision divide) might cause an overflow. If that looks likely, they will halt all other instructions until that divide is completed. However, such an instruction can take 30 or more machine cycles, and it may not overflow after all.

By contrast, Alpha gives no special treatment to complex arithmetic instructions. Overflows, which are extremely rare, are reported only when they have occurred. This saves valuable processing cycles for those instructions not affected by the overflow, significantly speeding up multi-issue processing and pipeline operations. (However, Alpha contains a Trap Barrier instruction if you want precise reporting of arithmetic exceptions.)

Another RISC artifact eliminated from Alpha is the branch-delay slot. *Branch delay* is a means of keeping the instruction pipeline full even during branch instructions—when a natural interruption occurs in the control of sequential program execution.

In branch delay, the branch instruction is delayed and the following instruction is sent to the pipeline. In a multi-instruction-issue architectural family like Alpha—one that may span several generations of implementations—it would be impossible to maintain binary compatibility across all platforms if branch delay were used. The reason? Different platform implementations would react differently: Some would send just one instruction, another might send two, and another (future) architecture might send four, six, or more instructions into the pipeline.

In place of branch delay, Alpha uses several mechanisms that avoid the delay time caused by branch instructions (see figure 3). These include adding predictive logic that anticipates branch direction many cycles before the branch is resolved. When used with an optimizing compiler, this results in fast prefetching, in the right direction. Also, Alpha can use some bits in a branch instruction to provide a hint of the jump target—another way to prepare the instruction logic to handle the branch.

Alpha as an Open Architecture

DEC has embarked on a program to license the Alpha technology in chip, board, or box form, and with varying degrees of additional software, to third-party vendors and developers. Already, DEC has announced some Alpha license agreements, and we anticipate more in the near future.

In addition to large-system vendors, the company expects that some PC makers will adopt the Alpha engine.Thus, you may see it in desktop- or even notebook-size packaging in the not-so-distant future. ■

Richard L. Sites is a senior consultant engineer for DEC's Semiconductor Engineering group in Littleton, Massachusetts. Prior to joining DEC in 1980, he worked at IBM, Hewlett-Packard, and Burroughs. At IBM, he worked on software for the precursor to the first RISC machine (the 801). Sites holds a Ph.D. in computer science from Stanford and a B.S. in mathematics from MIT. He can be reached on BIX c/o "editors."

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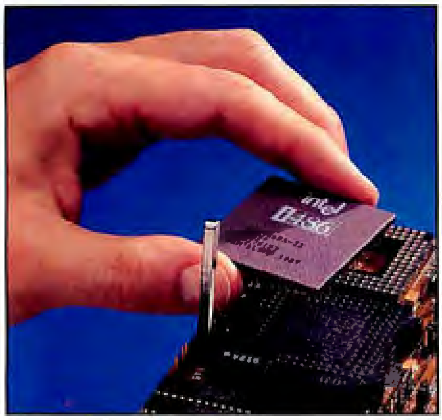

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REAL-TIME COMPUTING

Real-time technologies are widening the scope of what we can control with computers

JOHN A. STANKOVIC

Real-time systems are those in which the correctness of the system depends not only on the logical results of computation but also on the time at which the results are produced. Real-time systems range from simple microcontrollers to highly sophisticated, complex, distributed systems. They directly control much of what we depend on in our world. A cursory survey of familiar real-time systems might include the microcomputer controlling your automobile's engine; the process-control systems that refine gasoline, manufacture medicines, bake bread, and generate electric power; and the flight-control systems in a modem airliner, the ATC (air traffic control) systems that guide it safely on its way, and the ticketing system that reserves your seat. All these systems depend on real-time control.

Real-time applications are growing in number, and so is our dependence on them. Because of this, it is important to understand the current technology and its limitations and to devote significant effort toward improving the technology.

Real-Time Systems

Typically, a real-time system consists of a *controlling* system and a *controlled* system. For example, in an automated factory, the controlling system is the computer and human interfaces that manage and coordinate activities on the factory floor. The controlled system is the factory floor itself, with its robots, assembly stations, and assembled parts.

A controlling system interacts with its environment based on the information from various sensors and inputs. The real-world environment with which a computer interacts can be viewed as a controlled system. The information presented to the computer must be consistent with the actual state of the environment, or the actions of the controlling system can be disastrous. This makes periodic monitoring of the environment and timely processing of sensed information a must.

Timing Is Critical

The timing-correctness requirements of a real-time system arise from the system's role as a controller. For example, if the computer controlling a robot does not command it to stop on time, the robot might collide with something. In many real-time systems, severe consequences result if the timing and logical-correctness requirements of the system are not satisfied.

The most common timing constraints for tasks are either *periodic* or *aperiodic*. An aperiodic task has a deadline by which it must finish or start, or it may have a constraint on both start and finish times. With a periodic task, a period might mean "once per period T" or "exactly T time units apart."

Low-level application tasks, such as those that process information obtained from sensors or that activate elements in the environment (through actuators), typically have stringent timing constraints dictated by the physical characteristics of the environment. Most sensory processing is periodic. For example, a temperature monitor of a nuclear reactor core should be read periodically so that any changes can be detected promptly.

Some of these periodic tasks may exist from the point of system initialization, while others may come into existence dynamically. The temperature example is an instance of a permanent task. An example of a dynamically created periodic task is a new flight entering an ATC region. The periodic task of monitoring a flight begins when the aircraft enters the ATC region and ends when the aircraft leaves the region.

continued

More complex types of timing constraints can also occur. For example, spray painting a car on a moving conveyer must be started after time T1 and completed before time T2. Aperiodic requirements can arise from dynamic events such as an object falling in front of a moving robot or a human operator pushing a button on a console.

Time-related requirements can also be specified in indirect terms. For example, the value of completing a task can be specified to increase or decrease with time. Similarly, an inexact but fast answer might be more valuable than a slow but accurate answer. In other situations, missing x deadlines might be admissible, but missing $x+1$ deadlines might be unacceptable.

What happens when timing constraints are not met? The answer largely depends on the application. A real-time system that, say, controls a nuclear power plant or a missile cannot afford to miss timing constraints on critical tasks. Resources needed for critical tasks in such systems have to be preallocated so that the tasks can execute without delay. In many situations, however, some leeway does exist. For example, on an automated factory floor, if it is estimated that the correct command to a robot can't be generated on time, it may be appropriate to command the robot to stop or slow down (allowing more time to produce a correct command).

In a real-time system, the characteristics of the various application tasks are usually known at the outset and might be scheduled statically or dynamically. Typically, periodic tasks are specified statically, and aperiodic tasks are specified dynamically. When the periodic temperature monitor of the aforementioned nuclear reactor senses a problem in the core, it can invoke another aperiodic task to activate the appropriate elements of the reactor to correct the problem (e.g., to force more coolant into the reactor core). In this case, the deadline for the aperiodic task can be statically determined as a function of the physical characteristics of the reactions within the core. On the other hand, the deadline of a task that controls a robot on a factory floor can be determined dynamically depending on the robot's characteristics, such as its speed and direction.

BYTE ACTION SUMMARY

Real-time applications bring the power of computers to bear in controlling much of the modern world. The optimized technologies developed for these applications are advancing and entering the mainstream.

Accommodating Change

In a statically scheduled real-time system, the characteristics of the controlled system are assumed to be known before the system is designed. Thus, the nature and sequence of the system's activities can be determined off-line before the system begins operation. Static systems are quite inflexible but are likely to achieve low run-time overheads. In practice, most applications involve a number of components that can be statically specified along with many dynamic components.

Most currently implemented real-time systems are static in nature, but next-generation systems will have to adopt solutions that are more dynamic and flexible. This is because these systems will be large, complex, and physically distributed among different sites and will function in uncertain environments. More important, they will have to be maintainable and extensible due to their likely need to evolve and their projected long lifetimes. Because of these characteristics, real-time systems in general need to be fast, predictable, reliable, and adaptable.

Real-Time Means Predictable

One long-held misconception about real-time computing systems is that fast operation is their only requirement. Speed is usually a necessary attribute, but a real-time system must also be able to meet explicit deadlines. Being fast on average does not guarantee that a deadline will be met. If a real-time system can be shown to be able to meet its deadlines (using a worst-case rather than an average-case analysis), it is said to be predictable.

Predictability has many meanings; for the purpose of this article, it means that when a task or set of tasks is activated, it should be possible to determine its completion time, subject to failure assumptions. This must be done taking into account the state of the system (including the state of the operating system and the state of the resources controlled by it) and the tasks' resource needs.

Characterizing Real-Time Systems

Building a real-time system is a task that can range from simple to extremely complex. The difficulty depends on the system's characteristics. Five of the most important characteristics are discussed below.

Granularity of deadline and computation time of tasks. In a real-time system, some tasks have deadlines or periodic timing constraints. If the time that elapses between the point when a task is activated (i.e., required to be executed) and the point when it must complete execution is short, then the deadline is tight and the granularity of the deadline is small. This implies that the operating system's reaction time has to be short and the scheduling algorithm to be executed must be fast and very simple.

Tight time constraints may also arise when the deadline granularity is large but the amount of computation required is also great. In many real-time systems, tight timing constraints predominate; therefore, designers must focus on developing fast and simple techniques to react to this type of task activation. In general, the tighter the deadline, the more difficult the design task will be.

Strictness of deadline. This refers to the value of executing a task after its deadline. There is no value in executing a hard real-time task after its deadline has passed. A soft real-time task retains some diminished value after its deadline, so it should still be executed after that point. Different techniques are usually used for hard and soft real-time tasks. In many cases, hard real-time tasks are preallocated and prescheduled to ensure that all of them make their deadlines. Soft real-time tasks are often scheduled with non-real-time scheduling algorithms, with algorithms that explicitly address the timing constraints but aim only at achieving a good average-case performance, or with algorithms that combine importance and timing requirements. Hard real-time tasks are more difficult to deal with than soft real-time tasks, and dealing with both types simultaneously is even more difficult.

Reliability. Many real-time systems operate under severe reliability requirements; that is, if certain tasks, called *critical tasks*, miss their deadlines, a catastrophe may occur. These tasks are usually guaranteed to make their deadlines by an off-line analysis and by schemes that reserve resources for critical tasks, even if it means that those resources are idle most of the time.

The requirement for critical tasks is that all of them should always make their deadline (a 100 percent guarantee), subject to certain failure and workload assumptions. However, too many systems treat all tasks that have hard timing constraints as critical tasks when in fact only some are truly critical. This can result in erroneous requirements and an overdesigned and inflexible system. It is also common to see hard real-time tasks defined as those of critical

Safety by Formal Design

RICHARD MARLON STEIN

Software safety has become a paramount concern for many real-time applications, especially those that depend on computers to control their processes or products. Medical instruments have become substantially more capable—and expensive—because of the flexible diagnostic power enabled by embedded computers and software. But these machines that are intended to preserve life could go awry and end it (see "Computers Out of Control," February BYTE). In one tragic example, a radiation therapy machine, the Therac 25, fatally overdosed two people and seriously disabled several others because there was a bug in the dosage-editor-control software.

To prevent mishaps like this, new techniques in software engineering must be developed. Formal methods of specification pioneered by the Programming Researeh Group at Oxford University present an attractive approach to better software safety.

A formal method is basically a mathematical proof of design. The Programming Research Group devised the *Z notation*, a specification language based on set theory and first-order predicate logic to express a system's functionality. The specification's schemata embody mathematical descriptions of the individual requirements imposed on the system. A schema enumerates a precise mathematical proof of functionality that eliminates the ambiguities of the English language or graphically based CASE tool--design philosophies. The rigors of mathematical logic and set theory are used to specify the detailed operation of the system, which can be proven right or wrong with the laws and axioms of mathematics.

Formal specification methods are extraordinarily popular in the U.K. Many projects, including IBM's CICS (an online transaction processing program) and the Inmos transputer, were designed with formal methods; this approach resulted in substantial savings during the testing and integration phases of each product's life cycle. Formal methods have also been used to specify digital oscilloscopes and real-time operating-system kernels.

Formal methods represent the antithesis of the ad hoc school of software engineering. One must undergo a multiweek training process to develop the skills needed to produce probably correct schemata and acquire the ability to transliterate a specification into software. Industrial concerns are reluctant to switch to formal methods because of this training expense. Universities that adopt formal methods as part of their computer science curriculum could offset this cost, however.

Industry can gain from formal methods in several ways: Product quality will improve; and software development costs will drop, since less time is spent patching software that is proven correct before the latter phases of the life cycle (e.g., code, integration, and testing)—where mistakes become progressively more expensive to correct—are reached. Product liability and insurance premium costs account for a substantial part of business decisions to build a system in the first place. A formal specification can be used to establish proof of product correctness—that it behaves precisely as it should and thus absolves its developer from liability if it should fail under circumstances outside the scope of its intended use.

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importance with strict deadlines. It's important to keep a clear separation between these notions because they are not always related.

Size of system and degree of coordination. Real-time systems vary considerably in size and complexity. In most of today's real-time systems, the entire system is loaded into memory, or, if there are well-defined phases, each phase is loaded prior to its beginning. In many applications, subsystems are highly independent of each other and there is limited cooperation among tasks. The ability to load entire systems into memory and limit task interactions simplifies many aspects of building and analyzing real-time systems.

But for large and complex next-generation systems, having completely resident code and highly independent tasks is not always practical. Moreover, solutions can't be based on virtual memory because of the substantial unpredictability it causes. Increased system size and greater coordination requirements give rise to many new problems and complicate the notion of predictability.

Environment. The environment in which a real-time system is to operate plays an important role in the system's design. Many environments (e.g., an automobile engine or an assembly line) are very well defined. Designers think of these as deterministic environments. Even though they may not be intrinsically deterministic, they are controlled. These environments give rise to small, static real-time systems where all deadlines can be guaranteed at the outset.

Even in these simple environments, restrictions on the inputs are needed. For example, if an assembly line that can cope with only five items per minute is given more than five, the system will fail. Taking this approach enables an off-line quantitative analysis of the timing properties. Since you know exactly what to expect given the assumptions about the environment, you can usually design and build these systems to be predictable.

The problem is that the approaches taken in relatively small, static systems do not work for larger, more complicated, and less controllable environments. Consider a next-generation real-time system such as a team of cooperating mobile robots on Mars. This system is large, complex, distributed, and adaptive. It contains many types of timing constraints and needs to operate in a highly nondeterministic environment and evolve over a long period of time. It is not possible to assume that this environment is deterministic or to control it well enough to make it look deterministic. This type of dynamic real-time system operating in a nondeterministic environment is required for many applications. But many new answers are required before reliable and safe systems of this type can be built.

Real-Time Operating Systems

The operating system is the focal point for next-generation real-time systems (see "The RTOS Difference" on page 161). It must provide basic support for predictably satisfying real-time constraints, fault tolerance and distribution, and integrating time-constrained resource allocations and scheduling across a spectrum of resource types. These resource types include sensor processing, communications, CPU, memory, and other forms of I/O.

Future developments in real-time operating systems and kernels could simplify applications design, especially through more direct support for developing predictable and fault-tolerant real-time applications. One aspect of this support will be in the form of scheduling algorithms. For example, the design and analysis of real-time applications is simplified if the operating system can perform integrated CPU scheduling and resource allocation in a planning mode so that collections of cooperating tasks can obtain the resources they need at the right time to meet timing constraints.

Further, if the operating system retains information about the importance of a task and what actions to take if the task is determined to be unable to meet its deadline, then a more intelligent decision can be made about alternative actions. In turn, graceful degradation of the performance of the system can be better supported rather than resulting in a possible catastrophic collapse of the system. Kernels that support retaining and using semantic information about the application are sometimes referred to as *reflective kernels*.

A distributed real-time operating system must use an open-system approach.

Real-time kernels are also being extended to operate in highly cooperative multiprocessor and distributed-system environments. This means that there is an end-to-end timing requirement that includes all processing and communications tasks. The distributed system must complete this set of tasks before a deadline (possibly with complicated precedence constraints).

Directions for Distributed Systems

Much research is being done on developing time-constrained communication protocols to serve as a platform for supporting user-level end-to-end timing requirements. The Mars project (see reference 1), the Spring project (see reference 2), and a project currently under way at the University of Michigan (see reference 3) are all attempting to develop such protocols.

The Mars project uses an a priori analysis and then statically schedules and reserves resources so that distributed execution can be guaranteed to make its deadline. The Spring project's approach supports dynamic requests for real-time virtual circuits (which have a guaranteed delivery time) and real-time datagrams (i.e., packets of data that have a best-effort delivery) integrated with CPU scheduling to guarantee the application-level end-to-end timing requirements. The Spring project uses a distributed replicated memory based on a fiber-optic ring to achieve the lower-level predictable communications properties. The work at the University of Michigan also supports dynamic real-time virtual circuits and datagrams, but this project is based on a general multi-hop communication subnetwork (i.e., one that goes from one network to another).

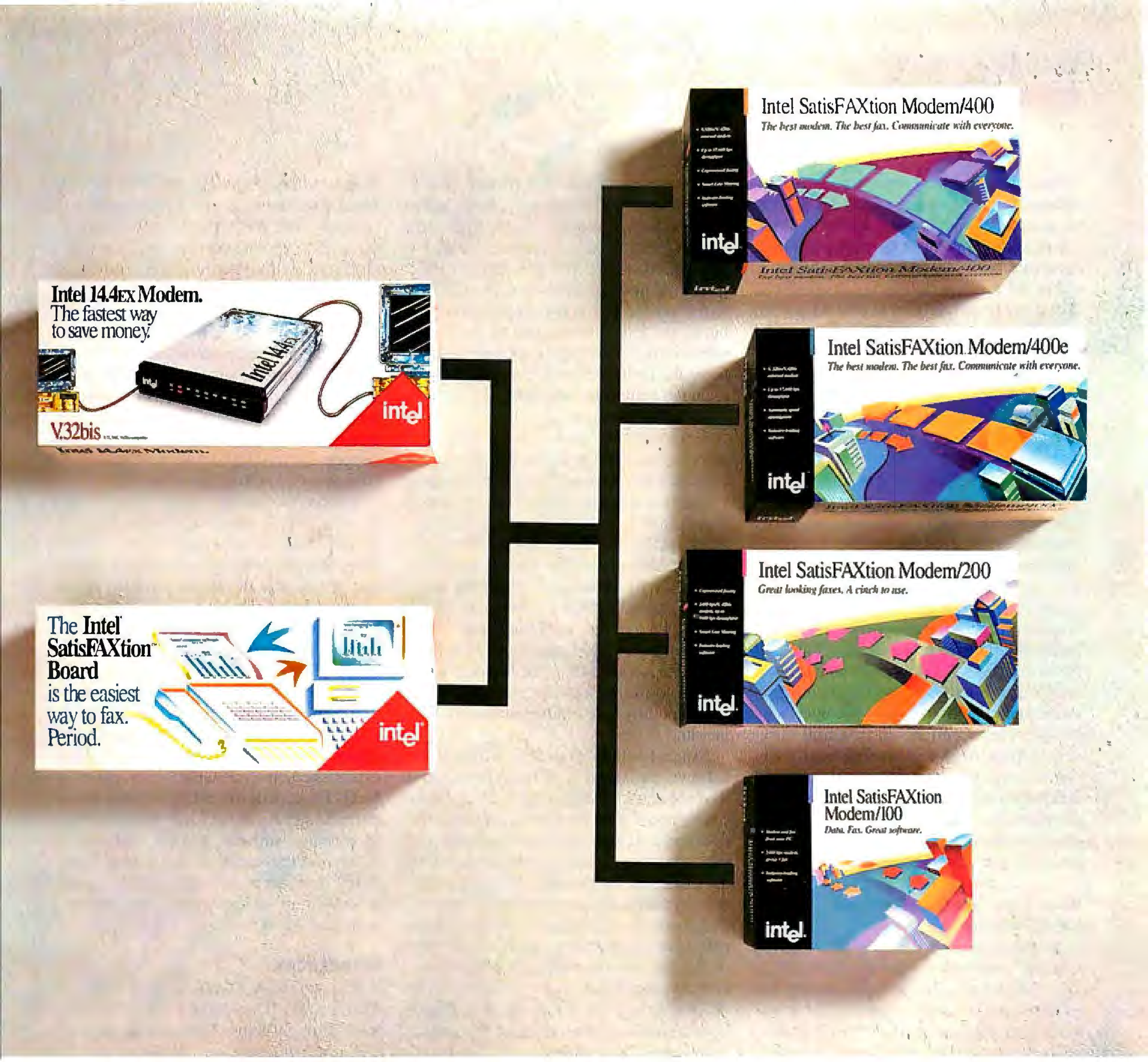
Research is also being done on developing real-time object-oriented kernels to support the structuring of distributed real-time applications. Although no commercial products of this type are yet available, one company has developed this technology as a foundation for its distributed real-time control systems (see "Objects in Real Time" on page 187).

Applications requiring predictable distributed-systems technology differ widely. To handle this diversity, a distributed real-time operating system must use an open-system approach. It is also important to avoid having to rewrite the operating system for each application area with different timing and fault-tolerance requirements. A library of real-time operating-system objects might provide the level of functionality, performance, predictability, and portability required. For example, a library of real-time scheduling algorithms should be available that can be selected depending on the run-time task model being used and the load, timing, and fault-tolerance requirements of the system.

Directions in Scheduling

Recent research into real-time scheduling has been fruitful. Theoretical results have identified worst-case boundaries for dynamic on-line algorithms, and complexity results have been produced for various types of assumed task-set characteristics. Queuing-theory analysis has been applied to soft real-time systems covering algorithms based on real-time variations of FCFS (first come, first served), earliest deadline, and greatest computation time. We have seen the development of scheduling results for imprecise computation, a situation where tasks obtain a greater value the longer they execute up to some maximum value. More applied scheduling results have been produced with an extensive set of improvements to the rate-monotonic (i.e., deterministic) algorithm; these include the deferrable-server and sporadic-server algorithms, techniques to address the problem of priority inversion, and a set of algorithms that perform dynamic on-line planning.

We have also seen practical application of a priori calculation of static schedules to provide 100 percent guarantees for critical tasks. These guarantees are based on many



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(oftentimes unrealistic) assumptions. If the assumptions are a poor match for the environment (which is more likely in a distributed environment), the system will miss deadlines with 100 percent guarantees.

For all the scheduling results outlined above, the trend has been to deal with more complicated task sets and environmental characteristics. While many interesting scheduling results have been produced, there are only piecemeal solutions. Still required are analyzable scheduling approaches that are comprehensive and integrated. For example, an overall approach must be comprehensive enough to handle preemptable, nonpreemptable, periodic, and aperiodic tasks; tasks with multiple levels of importance (or a value function); and groups of tasks with a single deadline. The approach must also accommodate end-to-end timing, precedence, and placement constraints; communications, resource, and fault-tolerance requirements; tight and loose deadlines; and normal and overload conditions. Finally, the approach must be integrated enough to handle the interfaces between resource allocation and CPU scheduling, I/O scheduling and CPU scheduling, real-time communications scheduling and CPU scheduling, local and distributed scheduling, static scheduling of critical tasks, and dynamic scheduling of essential and nonessential tasks.

Real-Time Architecture and Fault Tolerance

Real-time systems are usually intended for specific purposes. In the past, architectures that supported such applications tended to be special-purpose, too. The current trend is to use more off-the-shelf components to produce more generic architectures. For this article, I'll consider how architecture affects the computation of worst-case execution time and supports fault tolerance.

A program's worst-case execution time is dependent on the system hardware, the operating system, the compiler, and the programming language. Many hardware features that speed up the average-case behavior of programs pose problems with regard to worst-case behavior. For instance, caches, pipelining, DRAMs, and virtual memory lead to highly nondeterministic hardware behavior. Similarly, compiler optimizations tailored to make better use of these architectural enhancements contribute to poor predictability of code-execution times. Additional complications include system interferences due to interrupt handling, shared memory references, and preemptions.

Many real-time system architectures consist of multiprocessors, networks of uniprocessors, or networks of both uniprocessors and multiprocessors. Such architectures have the potential for high fault tolerance but are also difficult to manage so that deadlines are met predictably. Fault tolerance must be designed into the system from the beginning, encompass both hardware and software, and be integrated with timing constraints. In many situations, the fault-tolerant design must be static due to extremely high data rates and severe timing constraints.

Ultrareliable systems need to use proof-of-correctness techniques to ensure fault-tolerance properties. Primary and backup schedules computed off-line are often found in hard real-time systems. New approaches are also being taken in which online schedulers predict when timing constraints will be missed, enabling early action on such faults. Dynamic reconfigurability is needed, but little progress has been reported in this area. Also, while considerable advances have been made in the area of software fault tolerance, techniques that explicitly take timing into account are lacking.

Since fault tolerance is difficult to achieve, the trend is to let experts build the proper underlying support for it. Some examples of primitives that support fault tolerance include the implementation of checkpointing, reliable atomic broadcasts, data logging, lightweight network protocols, synchronization support for replicas, and recovery techniques. Making these primitives available to applications simplifies the creation of fault-tolerant applications. However, many of these techniques do not carefully address timing considerations or the need to be predictable in the event of a failure.

The integration of fault tolerance and real-time scheduling can make a system more flexible. For example, the use of an imprecise computation model or a planning scheduler gives rise to a more flexible approach to fault tolerance than static schedules and fixed backup schemes.

New Trends and Technologies

Building complex next-generation real-time systems will be difficult and require research advances in many aspects of system design and implementation. For example, good design methodologies and tools (see the text box "Safety by Formal Design" on page 157) that include programming rules and constraints must be used to guide real-time system developers through subsequent implementation and analysis. This includes proper decomposition of an application into subsystems and allocation of those subsystems within distributed architectures. The programming language used must provide features tailored to these rules and constraints, limit its features to enhance predictability, and provide the ability to specify timing, fault tolerance, and other information for subsequent use at run time.

The execution time of each primitive of the kernel must be bounded and predictable, and the operating system should provide explicit support for all the requirements, including real-time requirements. New trends in the operating-system area include the use of microkernels, support for multiprocessors and distributed systems, and real-time threads.

The architecture and hardware must also be designed to support predictability, facilitate analysis, and provide for growth. For example, hardware should be simple enough so that predictable timing information can be obtained. And the resulting system must be scalable so it can meet additional computing needs as the system evolves.

Research is required to address all these issues in an integrated fashion. To satisfy this need for systems integration, various centers for real-time computing have been established, such as CRICCS (Center for Real-Time, Intelligent, Complex Computer Systems) at the University of Massachusetts–Amherst. Finally, although it is beyond the scope of this article, additional research is currently focused on the development of real-time databases and real-time AI. ■

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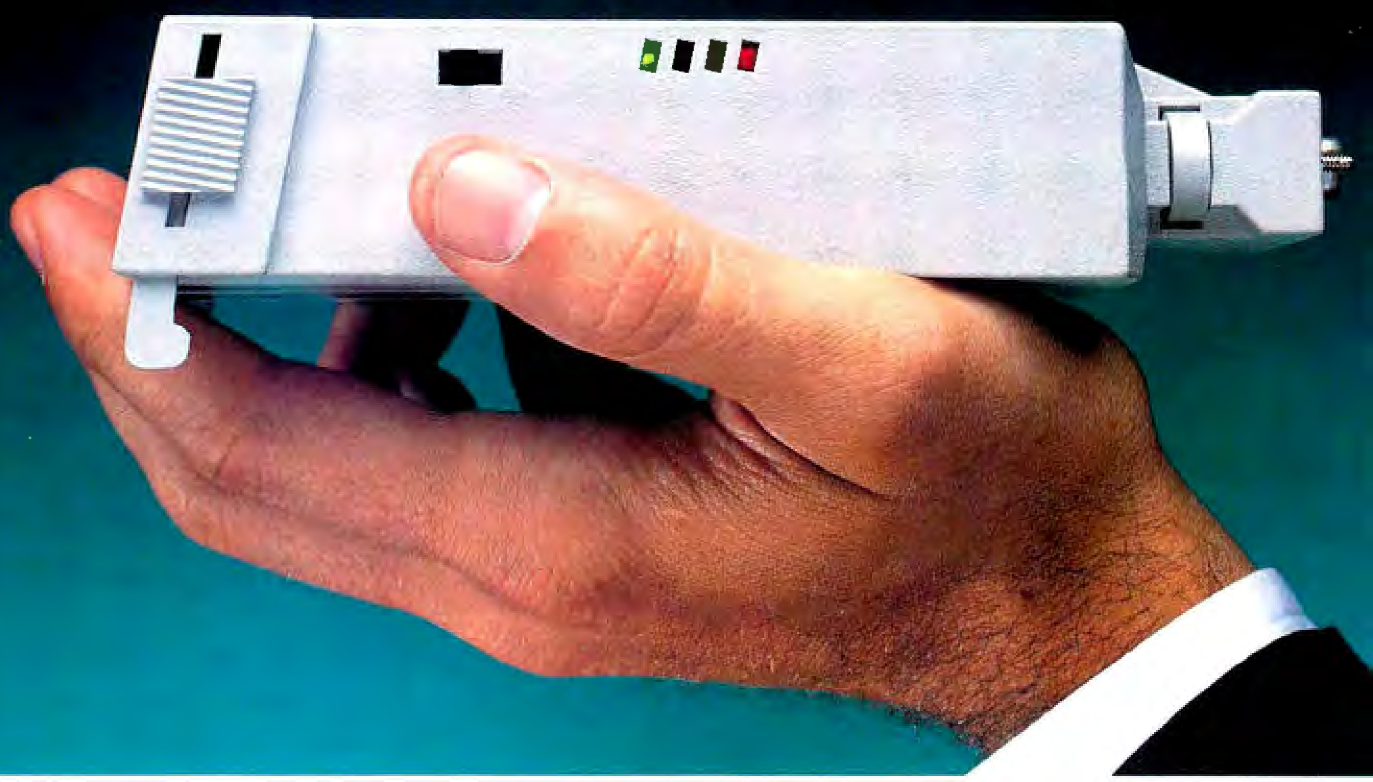

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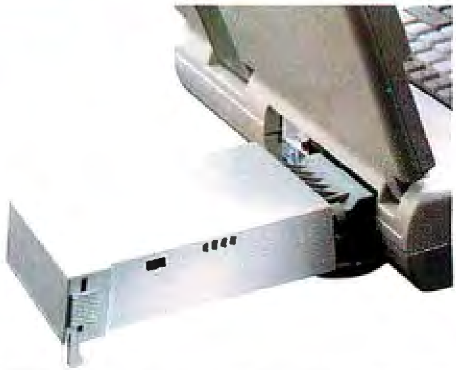

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THE RTOS DIFFERENCE

Real-time applications make unyielding demands on an operating system, but proper design can deliver an operating system that's up to the challenge

KEVIN D. MORGAN

Many features found in today's operating systems are intended to improve a computer's average throughput rate. But by definition, a real-time application's performance isn't measured by average execution rates; many literally pass or fail based on the time required for each execution of an algorithm or kernel service call. For example, consider a temperature-control algorithm that's overseeing a sensitive chemical process. If the algorithm executes within its predefined time limit every instance but once, and that one delayed execution allows the process to go exothermal (i.e., run away uncontrollably), is the control system a successful design?

Common operating-system features that spell high performance for general-purpose applications can spell failure for real-time applications. Factors that are key to understanding real-time operations include an understanding of RTOSes (real-time operating systems), how they differ from standard operating systems, how they're affected by common computer features, and how they're advancing.

RTOSes

Real-time computing applications require operations to complete in a fixed time period. The types of time-limited operations vary greatly, as does the degree of difficulty that a computer system may have in meeting its timing limits. And the consequences for failing to meet timing limits range from mere inconvenience, to significant financial losses, to the loss of human life.

Because of the broad scope of real-time computing, the attributes and design alternatives of RTOSes are very broad. In this article, I'll examine these attributes and design alternatives, take a detailed look at some of the unique and technologically advanced aspects of RTOSes, and explore the interplay of real-time requirements with state-of-the-art hardware designs.

Attributes of RTOSes

RTOSes can usually be characterized as having unique requirements in five general attribute areas: determinism, responsiveness, user control, reliability, and fail-soft operation.

Determinism is the tendency of a system to perform an operation in a well-defined, or "determined," time period. A fully deterministic system performs operations in the same amount of time, every time, independent of surrounding conditions. Conversely, a fully nondeterministic system is one for which operation times have no guaranteed upper boundary.

BYTE

A computer must have an optimized operating system to perform real-time applications. Knowing how these operating systems affect real-time performance is critical to understanding such applications.

All operating systems, including RTOSes, exhibit behavior that is less than fully deterministic; one of the key characteristics of RTOSes is their degree of deterministic behavior. The maximum amount of time a high-priority device interrupt is delayed from interrupting the computer system is called the IACKL (interrupt acknowledgment latency). A non-real-time operating system may have a long IACKL—in the range of tens or even hundreds of milliseconds—while an RTOS's IACKL will typically have an upper boundary of anywhere from a few microseconds to a millisecond. Note how the difference in determinism between an RTOS and a non-real-time operating system is largely a matter of degree. This is true of every characteristic of real-time systems.

Responsiveness is the ability of a system to respond quickly to an event. Because a synchronous event (e.g., a process sending a message to another process) induces a well-defined series of operations whose speed is important to the performance of any computer system, responsiveness to synchronous events is usually not a key difference between real-time and non-real-time systems. Asynchronous events—in particular I/O interrupts—are the area in which real-time systems have more stringent requirements.

Interrupt response times have several important components. The first is the maximum amount of time the acknowledgment of an interrupt can be delayed; this attribute is more properly considered a component of determinism. The second component is the amount of time required to initially handle the interrupt and begin execution of the ISR (interrupt service routine). This time is dependent on the type of the ISR; if the ISR involves a user task, and hence a context switch, then the maximum delay time to initiate and then perform the context switch becomes a significant response factor. The third component is the amount of time needed to actually service the interrupt. The fourth component is the effect of nested interrupts on the system's response time. Interrupt nesting occurs when one interrupt occurs, followed by further interrupts, prior to completion of the first. The degree to which a system allows and handles interrupt nesting affects deterministic behavior and responsiveness.

Response time—I/O interrupt response time in particular—is critical for real-time systems because they must meet real clock-time requirements imposed by individuals, devices, and data flows that are external to the computer system. The RTOS interacts with and/or controls external systems via I/O. Hence, I/O responsiveness and determinacy of I/O operations are key characteristics of real-time computing systems.

User control in a general-purpose time-sharing operating system is limited so that the operating system can be designed to provide specific services with their own attributes of fairness and response times. Such operating systems include some degree of user control, such as which classes of users are to be given preferential treatment. But the operating system makes the final decisions about which processes to run now or later, which I/O to perform now or later, and so forth. The operating system makes these decisions to balance individual service requests with attainment of overall performance objectives, which are usually measured in terms of throughput (i.e., jobs completed per unit time) and interactive responsiveness.

An RTOS gives ultimate control of the system's behavior to the user. The user may actually be a restricted set of the system's total user community, but that "user" has a broad set of capabilities for controlling system behavior.

This user controllability starts with the concept of fixed, user-specified priorities for task execution. This is not the only scheduling policy that a real-time system may provide, but it's the most common. The system's letting the user specify the relative priorities of tasks allows the user to specify throughput and/or responsiveness goals for the system on a much finer basis than a "do the best you can overall" request. For example, the tasks that acquire data from a jet engine test system can be given high priority to avoid the loss of incoming data, while the processing of that data can be given a lower priority.

User controllability does not stop with task prioritization; it extends to every area of the system. A real-time system will allow the user to specify such characteristics as the use of paging or process swapping, what processes must always be memory resident, what disk transfer algorithms are to be used, what rights the processes in various priority bands have, and so on.

Frequently, real-time systems give users *privileged capability*—that is, the right for a user process to switch into privileged mode, the mode that's strictly forbidden to any process in a time-sharing system except the kernel itself. This allows a user process to do such things as turn off the entire interrupt system to ensure that a time-critical operation executes without losing control of the CPU and violate memory-protection mechanisms in order to do high-performance data transfers directly to a memory-mapped I/O device or some other process. The right of a user process to switch into privileged mode is one of the few attributes that do not exist in a non-real-time system; it provides the ultimate in user control.

Reliability in an RTOS means that the system can run continuously for extended periods—frequently years—without failure. Almost all personal computer users have had their computers hang up on them; after a quick reboot to solve the problem, they simply grumble and go on working. But a real-time system failure that requires a reboot is likely to be catastrophic, because real-time systems frequently control real-world systems. Losing control of processes in a manufacturing plant can cost millions of dollars; losing control of processes in a fly-by-wire airplane can cause loss of human life.

Reliability in an RTOS also means ensuring that critical real-time processes are able to execute by letting them preallocate all required resources. Resource depletion by non-real-time processes cannot be allowed to cause the application's real-time requirements to go unmet.

Fail-soft operation is a concept that results from applying fallible computer systems to mission-critical applications. All computer systems, even those with redundancy and failproof software, sometimes fail. A modern operating system, such as a standard Unix system, will perform a panic operation when it detects a corruption of data within the kernel. The panic operation causes a failure message to print out on the system console, may dump the memory contents to disk for later failure analysis, and terminates execution of the system.

An ideal real-time system, on the other hand, will never perform a panic operation. Instead, when a kernel data corruption is detected, steps are taken to either correct or minimize the problem. The user (or a user surrogate, such as a specific user process) is notified of the failure. The system continues executing, possibly with some degradation of performance or degree of overall service. The notified user process can then take appropriate steps at an application level. These can range from immediate shutdown of the entire system in a graceful manner to bringing a backup system on-line or sounding an alarm. This type of behavior is referred to as *fail-soft operation*.

Another characteristic fail-soft requirement for RTOSes is file system consistency and data integrity during a system failure, crash, or power-down. The Unix method of write-back disk caching is frequently incompatible with the requirements of a real-time system, because it makes it difficult to guarantee that no data will be lost if system operations terminate for any reason; data written to the cache but not transferred to disk will be lost if the system crashes.

These five attributes are the key areas of difference between a real-time system and a non-real-time system. The actual attribute values of an RTOS are determined by the design choice made by its developers; I'll explore these choices next.

Design Alternatives for Real Time

RTOSes vary widely in their organization, models of computation, feature sets, and algorithms. They range from single-task, dedicated control systems in which all I/O is performed via polling and the kernel size is only a few hundred bytes to large Unix-style systems that claim to provide time-sharing services, transaction-processing capabilities, and real-time operation. In this section I'll break down the key implementation alternatives for real-time systems so you can better understand, compare, and contrast the plethora of systems that are branded "real-time."

Design alternatives that significantly affect the unique attributes of RTOSes can be classified into six broad areas: memory model, tasking model, binding model,

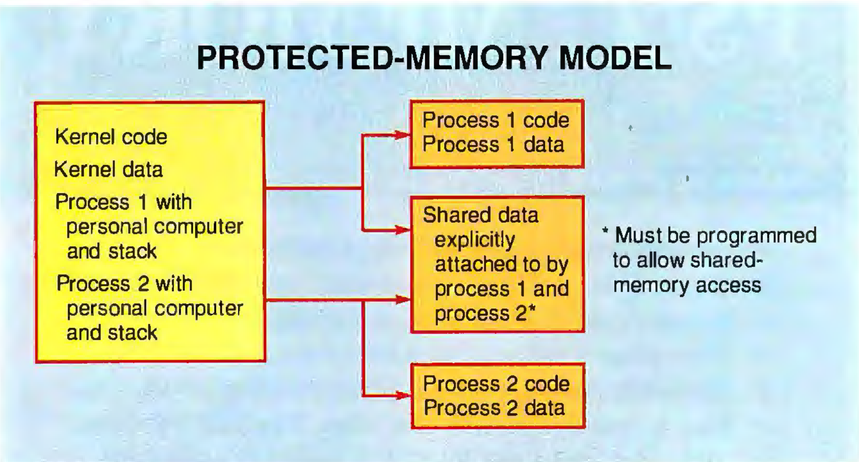

Figure 1: *The protected-memory model reserves protected data and code areas for each process. Provisions for sharing data between processes must be specially programmed.*

reentrancy model, interruptibility model, and degree of modularity. I'll look at each and also consider the most common combinations of design choices.

Memory Model

There are two fundamental types of memory model that can be used for an RTOS: a global address space with no protection between tasks, and separate address spaces with some form of protection between tasks. A global memory model is your only choice when the target CPU provides no protection facilities. Such processors are simple and inexpensive. But using a global memory model with a processor that has extensive address space–protection facilities is a mismatch of software and hardware.

Multitasking operating environments are frequently implemented using a global address space with no protection. The advantage of this design is that task switching can be performed more quickly due to the smaller amount of process state that must be saved and restored for each context switch (since there is no per-task address and protection information). And since all memory is equally accessible by all tasks, data sharing requires no special programming. In a task-protected environment, the use of shared memory between tasks requires special requests to the operating system to create such shared areas.

A drawback of the global memory model is that it offers no protection between tasks. Errant reads or writes from a task are not trapped by protection hardware and may not appear as an overt defect until they are exposed by a change in the operating environment after system deployment. Additionally, the operating-system kernel itself is exposed to possible corruption by the user tasks; a dynamic failure of a user task can cause complete system failure. But in a protected environment, the failing task alone would suffer a protection violation and be signaled (and possibly terminated) without affecting the entire system operation.

Current commercial RTOSes usually fall clearly into one of these two models of memory management; a few offer a choice of either model.

Tasking Model

A real-time system design may utilize only a single thread of execution; in such a design, there is no concept of multiple tasks or context switching between tasks. Such nontasking systems come in two flavors: one that allows interrupts and the execution of an ISR asynchronously from the execution of the main system task, and one that does not allow for interrupts. The latter performs all I/O on a polled, rather than an interrupt-driven, basis.

A single-task, polled I/O system is highly specialized and usually developed from scratch for a specific repetitive operation. It has the advantage of being highly deterministic and responsive. It is naturally coupled to a global-memory-model design.

DOS is a single-task operating system that allows asynchronous ISR execution. Asynchronous ISRs are used to simulate true multitasking in such systems. However, most modern RTOSes provide for true multitasking, if only because typical applications with real-time attribute requirements involve multiple parallel operations that are most easily mapped onto a multitask design. A feature related to the tasking model and the memory model for an RTOS is the provision of user-process-level threads, which I'll discuss later.

Binding Model

Multitasking RTOSes may be initially built by a user with a fixed number of tasks and a specific set of code for them to execute. Such a system is said to provide *static binding*. A system that allows a new task with new code to be created and loaded while the system is running provides *dynamic binding*.

Some RTOSes don't directly address the question of static versus dynamic binding; in fact, they don't address the question of building a complete system environment at all. These real-time kernels provide a service for creating a new task, but what code that task executes and how it gets into memory is completely up to the system designer using the real-time kernel product. Other systems provide flexibility by allowing a static system to be prebuilt so that no dynamic loading need occur and by providing operating-system services that allow a new task, complete with task-specific code, to be loaded from an I/O device (e.g., a ROM or a disk) or from across a LAN.

Statically bound systems are closely coupled with a ROM-based real-time application, such as an automobile engine controller. Dynamic binding is needed for more dynamic environments, such as a work-cell controller in a manufacturing environment where the specific jobs to be performed change over time.

Reentrancy Model

An operating system provides services for user tasks. Some of these services are in the form of code that's bound with the task itself; these are called *libraries*. Others are provided by the operating-system kernel and are invoked by a system call. The system-call operation changes the global system state from user mode to kernel mode.

In a multitasking environment, a task can generally be stopped at any time and a different task executed instead. A kernel may or may not allow a task switch to occur at any arbitrary time that a task is executing in kernel mode. If the system does allow this, then the newly executing task may in turn make a system call and execute in kernel mode (or it may stop while in kernel mode and start up again). A system that generally allows task switching out of a task executing anywhere in kernel mode is called a *generally reentrant kernel*.

A system that only allows task switching out of a task executing at specific points in kernel mode is known as a *limited reentrancy kernel*. Reentrancy into a kernel must be controlled because a kernel

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scans and manipulates global data structures. These operations can fail—with catastrophic consequences—if two such operations are allowed to intermix due to context switching and kernel reentrance.

A generally reentrant kernel still performs nonreentrant operations that must be protected from reentrancy. One of two techniques is used to accomplish this: Either context switching is temporarily disabled, or a semaphore is used to protect access to the data structure or critical code region by another process.

Kernel reentrancy control is the primary driver of a key real-time system performance metric known as CSL (context switch latency). CSL is the longest amount of time that the system can delay the initiation of a context switch to a new ready-to-execute task that is of higher priority than the currently executing task. If the currently executing task is in kernel mode in a limited reentrancy kernel, then the current task must continue executing until a preemption point is reached—that is, a point where it is safe for the system to context-switch and allow the kernel to be reentered. The longest path between preemption points then determines the CSL.

In a generally reentrant kernel, the longest code path for which context switching is disabled determines the CSL. However, if semaphores are used for controlling critical region or data-structure access during critical operations, then a context switch may be allowed, but the newly activated process may make a system call that will end up blocking (i.e., delaying execution or going to sleep) because it needs access to the critical region. Thus, the CSL is reduced, but a possible delay of the high-priority task is created; this, in turn, decreases overall system determinacy. I'll explore this use of semaphores for critical section management in a kernel more thoroughly later on.

CSL is an important responsiveness characteristic any time that processing of I/O involves the execution of user tasks. Since I/O is normally bound for user tasks, which in turn process the data in some way and then do further I/O, CSL is an important characteristic of an RTOS.

The original implementation of Unix and its evolutionary successors use a preemption-point approach toward managing kernel reentrancy and have a limited number of preemption points (i.e., any time a process is blocked waiting for an event, the system allows a context switch to occur). This approach means that the CSL can be extremely large, since kernel operations in standard Unix systems can take a long time. Early "real-time Unix" systems addressed this problem by incorporating more preemption points. More modern Unix approaches include revamping the entire kernel to make it generally preemptible. These modern approaches are often coupled with making the Unix kernel suitable for symmetric multiprocessors, as general kernel reentrancy is also needed for high performance in these environments. Most real-time kernels designed from the ground up for real-time operations use a generally reentrant approach.

Interruptibility Model

A kernel might also be reentered due to the occurrence of an I/O interrupt. If an interrupt is handled by some form of task that requires a context switch in order to execute, then reentrancy due to an interrupt is generally no different from kernel reentrancy by tasks. If, as is frequently the case, I/O interrupts are handled by special ISRs that run not as tasks but as special handlers in an interrupt mode, then reentrancy due to interrupts becomes a second type of reentrancy that the kernel must handle.

Nothing is free; every optimization in one area imposes a cost in another area.

One approach to interrupt-handler reentrancy into the kernel is to simply shut off I/O interrupts any time the kernel is executing. This approach can work for kernels that are small or that have short paths of execution. However, most modern real-time kernels provide extensive services (e.g., LAN operations) that preclude using such an approach.

The typical approach to interrupt-handler reentrancy is two-pronged. First, the set of operations that can be performed by an ISR running in interrupt mode is limited to a specific set. The kernel designer understands exactly what data structures will be scanned and/or manipulated by that set of services. Then, all scans or manipulations of those data structures by code in the kernel in ways that cause simultaneous access problems are protected by the CPU hardware's disabling of acknowledgment of I/O interrupts for the period of the operation. The maximum time that I/O interrupts are disabled is the IACKL, which, like the CSL, is a key performance characteristic of an RTOS.

Modularity

RTOSes serve in a wide variety of applications and take many different forms to meet the specific needs of these applications. As a result, an RTOS must have a high degree of modularity.

While an RTOS may be designed to provide a fixed set of services, such a structure limits its flexibility. For example, if a kernel must have a complete disk-based file system, then it is not suitable for a ROM-based application that requires no I/O other than, say, RS-232 interactions. A diskless workcell application that requires dynamic process loading requires an operating system that can have a LAN manager and a process loader structured into it.

Determinacy and Caching

Both RISC and CISC processor architectures make extensive use of data caching (which, for the purpose of this article, will refer to data and instructions) and caching of address translations to improve average system performance. But in computer science, nothing is free; every optimization in one area imposes a cost in another area. Caching imposes a significant increase in the nondeterminism of CPU operations, an area of particular sensitivity for real-time applications.

The general concept of a data cache is that of a small, high-speed (and costly) memory area that lies between a fast processor and the slower main-memory subsystem. When a byte or word of data in main memory is accessed by the processor, a contiguous memory area holding the data item is transferred into the cache. This contiguous memory area is called a *cache line*; the typical size of a cache line is 16 to 64 bytes. The cache line is preserved in the data cache in the likely event that further data from the same area of memory will be accessed soon. Typically, data cache accesses can be performed in a single processor cycle, whereas a main-memory access causes delays in the range of two to 10 cycles.

An address-translation cache (frequently called a translation look-aside buffer, or TLB) has the same function as the data cache, but instead of holding actual data, it holds information on how to translate a virtual address to a physical memory address. A large block of such translation information is held in main memory; only a small portion of this information is held in the address-translation cache at any one

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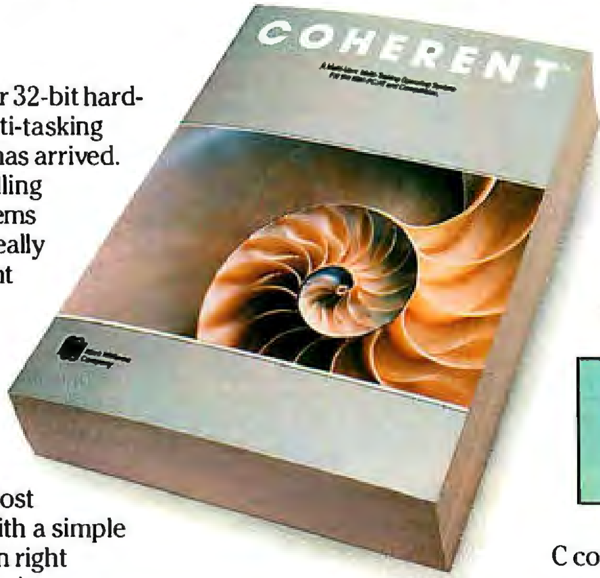

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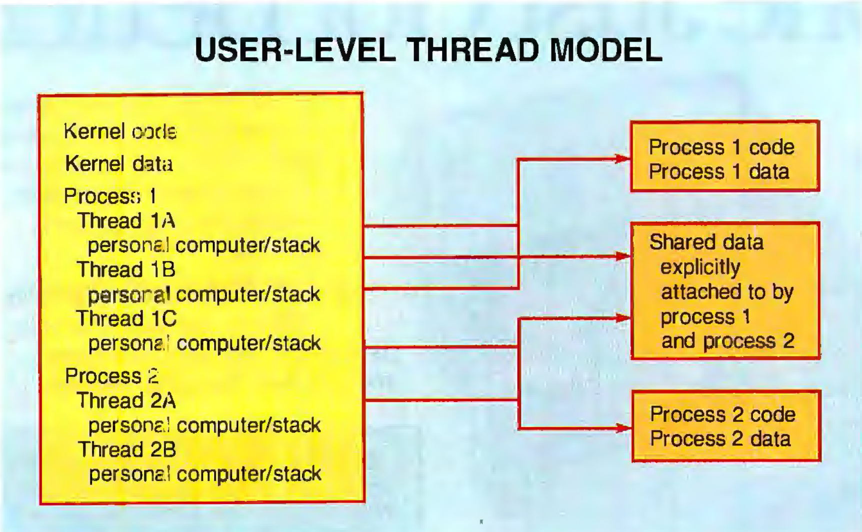

Figure 2: *A system providing user-level threads is a protected-memory system in that it protects each process and the kernel, but it allows a process to contain multiple threads of execution. The threads executing within a process have immediate shared access to all global data within the process.*

time. TLB misses can be far more costly than cache misses and can require many CPU cycles to look up and fetch the required data from memory.

The data- and address-translation caches dramatically improve average CPU execution rates by reducing the number of times the CPU must wait for a main-memory access. But, as discussed earlier, the performance of a real-time application is frequently measured not by average execution rates but by the time of each instance of the execution of an algorithm or kernel service call. Data and address cache misses may cause the execution time to vary by as much as a factor of 20.

Block TLBs

The processor implementations of today, such as the Mips R4000 and the Hewlett-Packard 7100, provide block-translation facilities to allow the operating-system designer to minimize nondeterminism due to address-translation cache misses. TLB entries usually translate on a page basis (typically 2-KB to 16-KB pages); the high bits of an address select the virtual page and are translated to a physical page, while the low bits select the bytes or words within the page. The CPU assumes that individual pages are contiguous in physical memory, but the virtual-address-translation function allows contiguous virtual pages to be scattered in physical memory. Shifting contiguous page location from physical to virtual memory simplifies memory management for the operating-system designer.

With a block-translation facility, units of contiguous physical memory larger than a single page are translated by a single block TLB entry. The first and most important use of such a facility is to map all the code in the kernel using a single block entry, thereby eliminating all data-address-translation cache misses for kernel code. Doing this requires that the kernel code be physically contiguous in memory, but since RTOSes always have fully memory-resident kernels, this requirement is easily fulfilled during system boot-up. The next logical use of block TLBs is for mapping as much of the kernel data areas as possible to minimize address-translation cache misses on kernel data accesses. Since kernel data can be dynamically allocated and deallocated, managing this data becomes more difficult and is exacerbated by the frequent restrictions on the placement and size of the contiguous memory block to be mapped by the block TLBs.

Finally, a real-time system can provide a program-execution mode wherein the program is loaded contiguously into main memory and mapped with block TLBs. Again, memory management complexity is increased due to the need to find or create contiguous free memory areas for program loading, but the benefit in increased execution determinism more than outweighs this cost. Real-time kernels that use block TLB services and provide these services to programs will be very popular in the 1990s.

User-Level Threads

All modern RTOSes provide multitasking; they differ in the type of memory model used. Some provide a *global-memory model*, where all processes have immediate and implicit access to all loaded code and data. In this model, data and code sharing is automatic, programming is simplified, and task-switching times may be reduced. The operating-system kernel in such a system is usually not protected from user tasks.

Other RTOSes provide a *protected-memory model* that defines for each process its own data and code areas that are protected from other processes (see figure 1). In this model, the operating-system kernel is similarly protected from user processes, and system calls occur only through controlled gateways, usually using special instructions that either cause a trap or change privilege levels and possibly jump.

Modern systems can provide the best of both worlds via *user-level threads*. Such a system is first and foremost a protected-memory-model system; each process is protected, as is the kernel itself (see figure 2). But in a system with user-level threads, a process may contain multiple threads of execution; each thread has its own private program counter and stack, and hence its own flow of execution through the process code and its own state. The multiple threads executing within a process have the advantage of immediate shared access to all global data within the process. This eliminates the need for special programming for shared-memory access, which is a drawback of protected-memory-model systems. At the same time, different processes can be used where data protection is needed for security or reliability reasons. Thus, the user-level thread programming model allows an application to be partitioned into discrete sets of data and threads that act on the data, with protection between the sets.

The tasking facility in Ada is based on a thread concept. In the past, Ada was implemented on multitasking systems such as standard Unix by having an Ada run-time module at the process level that, within the single-threaded-process model supported by the Unix kernel, would create multiple threads of execution to support multiple Ada tasks. The kernel itself would view the entire Ada module as a single process with a single program counter and stack; the Ada run-time module would effectively create multiple program counters, stacks, and threads of execution within the process. The big drawback of this implementation was that any time a single Ada task initiated a blocking I/O operation (e.g., a disk read), the Unix kernel would block the process, which in turn would block every Ada task.

Real-time systems (and some non-real-

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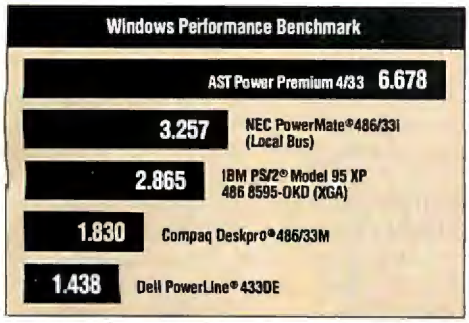

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time systems) are increasingly supporting user-level threads within the kernel itself. In such systems, a thread—not a process—is the object that the kernel schedules and switches to, as well as the object that can block I/O or an interprocess communication facility (e.g., a semaphore or a message-queue read).

This type of system has substantial benefits for real-time applications. Since the kernel deals with threads directly, each thread can have its own independently definable user priority and can independently block without affecting the continued execution of other threads. The concept of user-level threads presents a significant new application-programming model in which a global-memory model and a protected-memory model are blended together to allow the best of both worlds.

Reentrancy Control with Semaphores

Reentrant kernels frequently use kernel-level semaphores to control access to critical code regions. An example of a critical code region is code that is doing an insert operation on a linked list that is itself a global data structure used by many areas of the kernel. An attempt to delete a list item for which the delete operations become interleaved with the insert operations due to process preemption (based on priorities) and kernel reentrancy can be disastrous. A typical approach to this access-control problem is to attach a semaphore to the linked-list data structure and require any code that performs list operations to first lock the semaphore and then unlock it when complete. In this way, each list operation is guaranteed to complete before the start of a new operation.

In a real-time system, such an approach can lead to subtle but significant response-guarantee problems. Consider a case in which process A, running at priority 10, has locked a list semaphore and is performing a list insert when a disk I/O–completion interrupt occurs. The disk driver ISR wakes up the waiting process B, which is at priority 20 (in this case, 20 is more important than 10). The kernel, being preemptible, instead of returning to the interrupted process A, switches immediately to the more important and now executable process B, which then executes a system call.

During the course of performing this system service for process B, the kernel needs to perform an operation on the list that process A was using. An attempt to lock the semaphore fails because A has it locked. B is put to sleep until the list semaphore is unlocked. The system now switches back to process A, which continues its list operations. Under ideal conditions, it will complete its operation and unlock the semaphore, which will awaken process B. The system will switch back to B, which can then lock the semaphore and continue its operation.

In this scenario, the highest-priority process, process B, is context-switched to immediately by the kernel. However, it is unable to accomplish its task due to resource locking by a lower-priority process. Hence, a first-order concern for an RTOS designer using a preemptive kernel model must be the number and length of times for which resources are locked in order to perform any system service. Note that a system may have excellent response characteristics in terms of starting the execution of a newly awakened highest-priority process, but it may frequently allow that process to be delayed in a busy environment.

The frequency of use of data structures is highly application-dependent.

RTOS designers must consider an even more subtle and dangerous condition that can occur in the above scenario. Consider what happens if, after A starts execution again after B has blocked on the semaphore, another I/O completion interrupt occurs, this time waking process C at priority 15. Because A is less important than C, a switch to C occurs immediately. Process B (which has priority 20) is now effectively waiting for process C (which has a lower priority) and will continue to wait until process C gives up the CPU of its own accord.

This problem is called *priority inversion*; its solution is known as *priority inheritance*. With priority inheritance, the owner of a locked resource temporarily inherits the priority of any requester of the resource. It is easy to see why from the above scenario. Process B, at priority 20, needs process A, at priority 10, to complete its operation involving a locked resource that process B needs. Hence, by having process A inherit B's priority of 20, the system doesn't allow an intermediate-level priority process (e.g., C at 15) to preempt A and hence delay B.

The priority-inversion solution presented here is simple, but the implementation can be quite complex when requirements for nested locked resources are considered. A semaphore-lock alternative that avoids this complexity is to disable context switching for the duration of a critical (i.e., nonreentrant) operation. One trade-off involved is that a context switch-off period can delay any switch, regardless of whether the target process will use the data structure undergoing a nonreentrant operation. The proper design approach will use a context-switch disabler for frequently used data structures, and semaphore locks for infrequently used data structures. But before you assume this to be a simple answer, remember that the frequency of use of data structures is highly application-dependent.

Alternative Scheduling Policies

Real-time systems generally present to the application designer a programming model involving fixed, application-specific priorities. The only semantic content of these priorities is a specification of how the CPU should be allocated, assuming that more than one process can be executed.

Application designers must map the time-behavior requirements of their applications into this programming model, when in fact the real world is not organized into such definite terms as "A is more important than B, which is more important than C." A may actually be more important than B unless A cannot be performed in time, in which case B becomes more important and A should not be performed at all.

The classic example of this is when there are two alternatives to solving a problem of significance—for example, maintaining control of a half-ton steel rod traveling at 50 mph in an automated steel mill. Data on its position and velocity must be computed and outputs generated to keep the rod on the proper track. If the overall algorithm can be accomplished on time, it is the most important task. If it cannot, a shutdown program must take precedence to prevent complete loss of control.

Problems described in terms of time needed to complete requirements lie in the realm of *deadline scheduling*, a scheduling policy for multiple processes in which each process is described in terms of value function over time, and the value of a result increases over time to a maximum and then decreases. A problem in which the value of the result goes to zero abruptly at a certain point is referred to as a *hard real-time problem*, while one in which the

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value of a result goes to zero gradually over time is referred to as a *soft real-time problem*. The role of the deadline scheduler is to schedule processes so that no process completes with a zero-value result and the overall set of values is maximized.

To perform deadline scheduling, the scheduler must know the completion value over time and the resource (i.e., CPU and I/O) load and execution time requirements for every process in the system. Deadline scheduling is a reality in the world of the real-time-application developer. The classic approach to ensuring that a task with a serious deadline (e.g., loss of the steel rod in the example above) is accomplished within the time budget is to overdesign the system, usually through the use of dedicated computational power. The problem of monitoring whether the system is going to complete on time, along with the problem of specifying exactly what the value of completion over time is to the operating system, is avoided.

Deadline scheduling is proving to be a useful technology in the world of human interfaces and multimedia systems. Such systems have limited computational power, because users are willing to spend only limited amounts of money on specialized multimedia-processing hardware. But these systems are asked to perform a large number of tasks, regardless of whether they can accomplish all of them effectively. As a result, multimedia systems require that the system designer either make a priori judgments of the values of solutions over time or provide the user with a method to specify these time/value functions. For example, is receiving an incoming fax message without error more or less important than responding quickly to a user request for the display of a graphical image? At what point does minimizing further delay of an image display outweigh handling the incoming fax? A simple relative task-priority specification mechanism will probably not suffice (i.e., "always do displays before handling incoming data, regardless of loss of transmitted data"), unless failures due to overloading are uncommon.

Multimedia systems, an increasingly popular type of real-time system, are likely to drive deadline schedulers into the mainstream in the 1990s. Deadline schedulers will ensure that multimedia systems meet their users' needs based on what these users define as the value functions for their systems' tasks. ■

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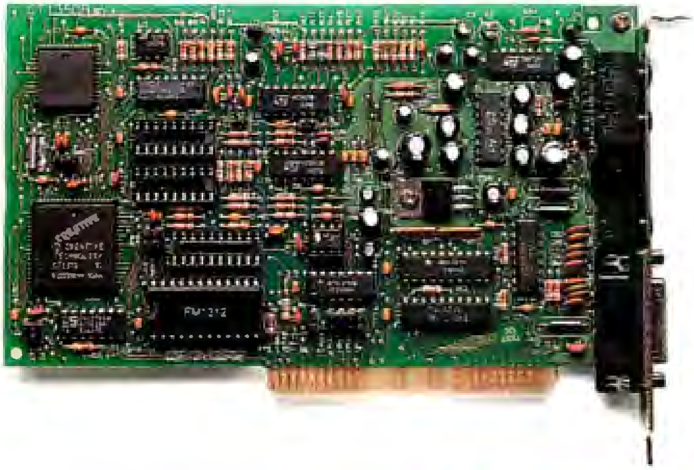

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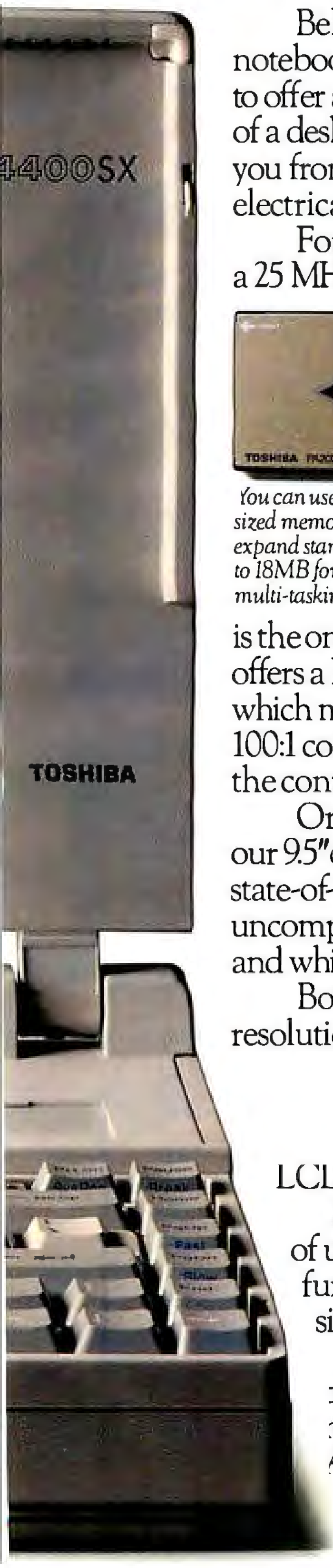

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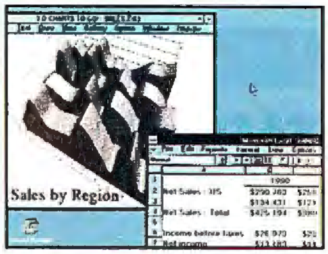

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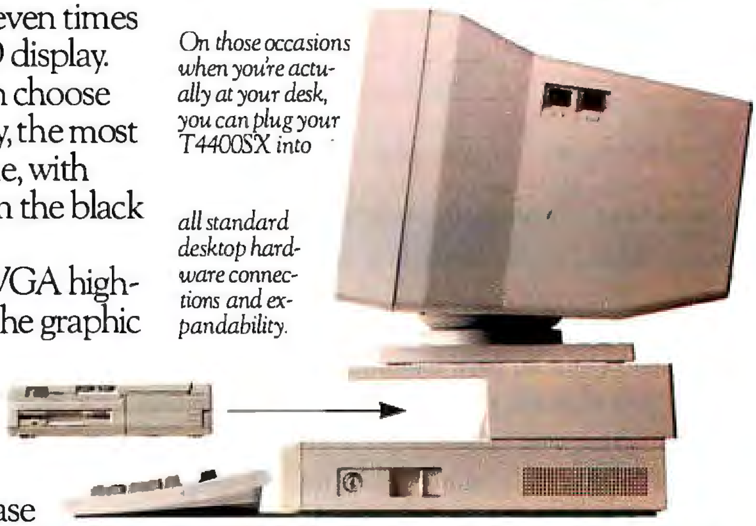

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PRODUCT SUPPORT						
Documentation	9.0	8.2	8.6	5.7	6.2	7.3
Vendor Training	8.7	7.9	8.0	7.2	7.6	8.0
Problem Response Time	8.8	7.5	7.2	6.1	6.4	6.7
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Software integration capabilities	8.34	7.26	7.24	6.27	6.10
Ease of data retrieval	9.08	7.68	7.66	6.61	6.11
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Product Features Average	8.64	7.10	6.61	6.14	5.60
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Charges for training time	6.88	4.49	4.59	5.64	4.56
Provision for technical support	7.81	5.76	5.72	5.87	5.22
Provision for marketing support	6.89	5.88	6.09	6.13	3.80
Documentation & product information	8.74	6.73	6.56	6.45	5.56
Frequency of updates & revisions	8.35	5.88	6.34	5.57	5.00
Support Features Average	7.73	5.79	5.84	5.90	4.94
Overall Average	8.34	6.66	6.35	6.06	5.38

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REAL-TIME POSIX

Posix is bringing the benefits of portability and openness to real-time applications

RICHARD MARLON STEIN

Real-time systems are everywhere: in cars, VCRs, microwave ovens, supermarket checkout counters, video games, telephones—the list is almost endless. For example, the improvement in the fuel efficiency of automobiles is partially due to EFI (electronic fuel injection). EFI uses an embedded computer system that controls the engine's fuel supply virtually instantaneously in response to changing commands from the accelerator pedal. Like all computer applications, real-time applications derive many of their capabilities from the characteristics of their operating systems.

Below the surface of a real-time application sits the operating-system kernel. Since it is the core of the application, it must be extraordinarily robust and stable. Rather than attempting to provide equal access to all processes, as does a timeshare system that runs batch or interactive jobs, an RTOS (real-time operating system) is tuned and sculpted by the application, much as an athlete is trained for a specific event.

A real-time computer system is actually a simulation that generates a predictable result within a predetermined amount of time. The application exploits an RTOS to achieve a specified level of fidelity in the simulation—no more or less than required. Using system calls, the application constructs a tightly orchestrated simulation that may consist of many separate processes, each designed to contribute in a unique capacity.

The RTOS kernel insulates the application from the host silicon by abstracting the bare state machine into a usable interface. This abstraction mechanism allows software engineers to design portable

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IEEE POSIX

The IEEE Posix standards committee comprises 16 distinct working groups. Each focuses on a specific aspect of open-systems computing.

Group	Charter
1003.0	Open-system architecture
1003.1	Posix application interface
1003.2	Shell and command utilities
1003.3	Testing and verification methods
1003.4	Real-time extensions to Posix
1003.5	Ada language bindings
1003.6	System security extensions
1003.7	System administration
1003.8	Transparent file access
1003.9	FORTRAN language bindings
1003.10	Supercomputing profile
1003.11	Transaction processing
1003.12	Protocol-independent network access
1003.13	Application environment profiles
1003.14	Multiprocessing application environment profiles
1003.15	Batch services

software. Until recently, Unix was the focus of portability and open-system initiatives; real-time applications were not as aggressively courted by operating-system vendors. But although real time has long been the province of specialized operating-system products, it's finally entering the age of open systems through the efforts of the working groups of the IEEE's Posix standards committee.

Portable Applications Through Posix

In 1988, the IEEE adopted its standard 1003.1, called Posix.1, which defines a set of system calls, interface definitions (including arguments), and ranges (which must be supported by a vendor's Posix implementation). Unix has been promulgated as the baseline for the Posix standard since the early 1980s, and it is endorsed by government agencies like NASA and NIST (National Institute of Standards and Technology) and commercial groups like Unix International and OSF (Open Software Foundation). Unix supports the OSI (Open Systems Interconnection) reference model, where one application can be easily moved between different platforms.

The OSI model serves as the vehicle for application mobility across a range of platform hardware, from workstations to supercomputers. Vendors of mainframes were slow to endorse this model at first, but workstation manufacturers, including Hewlett-Packard and Sun, quickly embraced this standard. Software publishers support it because it means that they no longer have to invest in creating and supporting many platform-specific versions of their products; they can write an application on one platform and simply recompile it on another platform with little difficulty.

The Posix class of standards embraces far more than standard operating-system-interface definitions; the table lists the Posix working groups and their charters. The Posix standards committee recognized that real-time applications have specific needs, and IEEE standard 1003.4 (on real-time extensions) and standard 1003.4a (on threads extensions) and its companion standard 1003.13 (on application environment profiles for real-time applications support) supply a solid foundation for addressing the real-time computing domain.

Since they are mature (albeit draft) standard documents, these three official Posix standards (collectively called the Posix.4 standard) will provide software publishers with a unified and versatile set of system services that cover the complete spectrum of RTOS capabilities and applications. Some vendors are currently developing implementations based on these mature drafts. At least two companies have announced Posix.4-compliant products: DEC (Maynard, MA) has introduced its OSF/1 operating system, and Lynx Real-Time Systems (Los Gatos, CA) has announced LynxOS.

The standard does not specify implementation mechanisms, but it does mandate that Posix.4-compliant vendors must state performance data for all the extensions under a variety of timing and machine conditions. Such performance metrics are essential for applications publishers who use the Posix.4 extensions in their simulations and products. For end users, comparison shopping is simplified by the publication of performance metrics. Verification of Posix vendor performance metrics will be accomplished through standard testing laboratories licensed by NIST.

BYTE ACTION SUMMARY

Real-time applications are built as custom systems, which greatly increases the cost and complexity of developing them. The efforts of the working groups of the IEEE's Posix standards committee are bringing the benefits of portability and openness to real-time systems.

Beyond 1003.1

The Posix extensions are grouped into categories and include *binary semaphores*, a synchronization mechanism useful for guarding access to a device or memory region shared between competing processes. A semaphore helps protect a simulation's critical functions by controlling which processes can alter specific devices, files, or memory regions. When properly used, semaphores ensure determinism.

Process-memory locking prevents an operating system from swapping out blocks of data from virtual memory to disk. Most real-time simulations cannot afford to wait for a machine to fetch swapped data and executable instructions from a slow mass-storage device; the Posix extensions provide system calls that lock data and instructions in RAM.

The Posix extensions also provide shared-memory facilities. Multiple processes can efficiently exchange information (or pointers to information) through a common physical location. The Posix.4 extensions allow the file-system naming conventions to be used for creating and operating on shared-memory segments. Shared-memory attributes (e.g., write and read permissions on a per-process basis) can be specified, and this feature can add security to an application. Multiprocessor platforms are also able to take advantage

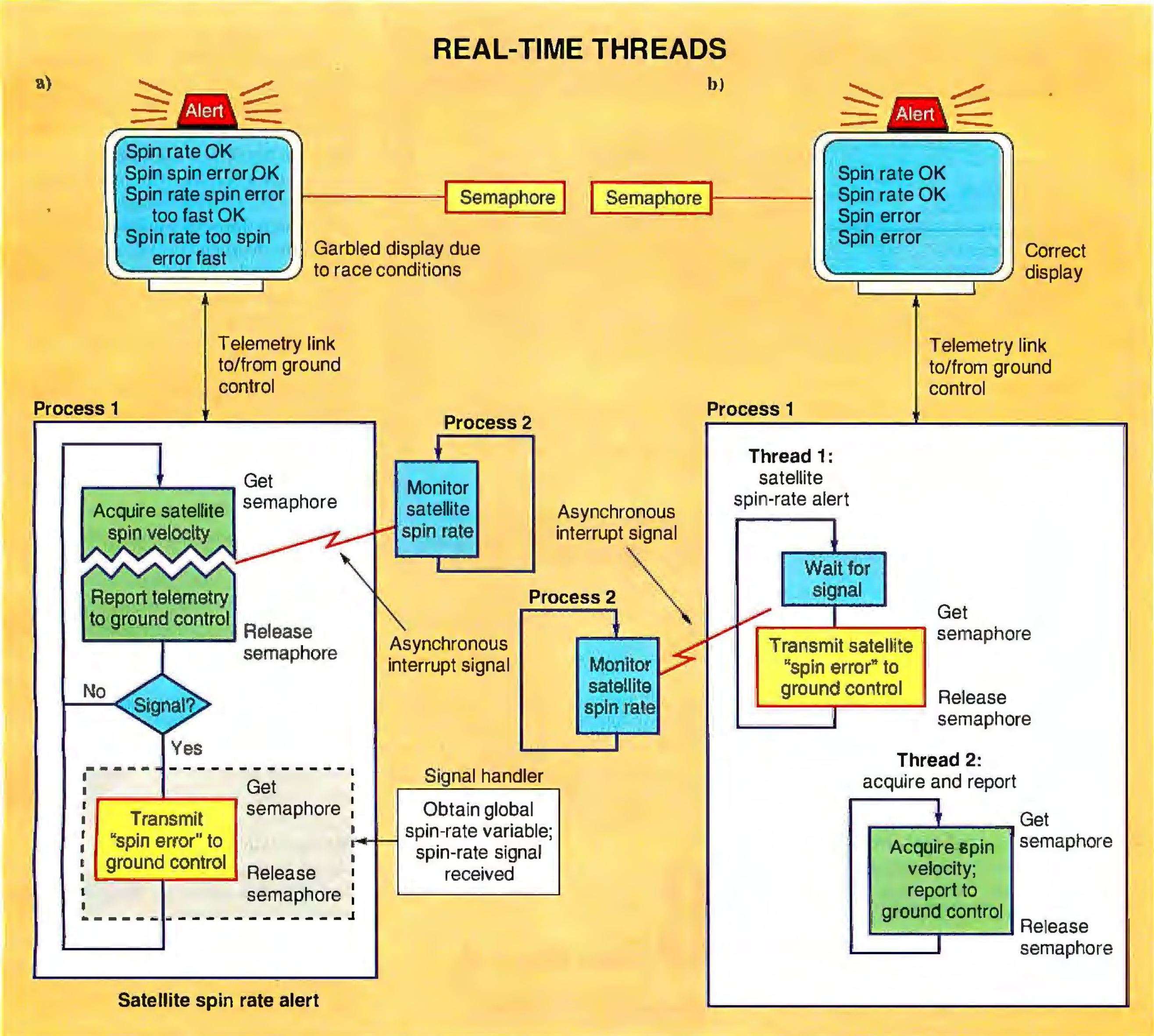

Figure 1: *(a) Process 1 uses a standard Unix signal handler to report satellite spin-rate data. This implementation leads to a race condition, where the display output may become garbled due to the asynchronous interrupt condition overriding the normal output instruction stream. (b) When the process is implemented as a thread that runs concurrently with another peer, the race condition is eliminated; the output will appear normal under all circumstances. This implementation uses a thread to perform the warning-message output. It blocks until the signal is received; then the peer thread blocks, the warning message is displayed, and the other peer resumes.*

of this facility.

Priority scheduling and the capability to specify either round-robin or priority-based policies, like FIFO (first-in/first-out), are also specified by the Posix extensions. In round-robin scheduling, processes with the same priority are given equal time slices of the processor, and the process dispatcher cycles each one in a continuous loop. With a FIFO policy, multiple processes are permitted to execute, and the first one that is available at a given priority level runs. If the process is preempted by a higher-priority process or blocked because of an I/O operation, it is then moved to the end of the priority queue.

Asynchronous event notification allows an important mechanism to report when operations that are independent of the currently running process are complete. I/O to a disk file is slow, and a process may choose to perform this operation asynchronously and continue running the body of its context. At some later time, the asynchronous activity may complete; the calling process receives notification of this and can judge whether it was completed successfully. A timer's expiring or an external process's sending a message are additional examples of asynchronous events; since the context of the executing process may not reach the part of the code body that tests for these conditions, an asynchronous event handler processes these events. The Posix.4 extension establishes timer resolution with a fine granularity. Control of the temporal state can be specified in nanoseconds, and both absolute

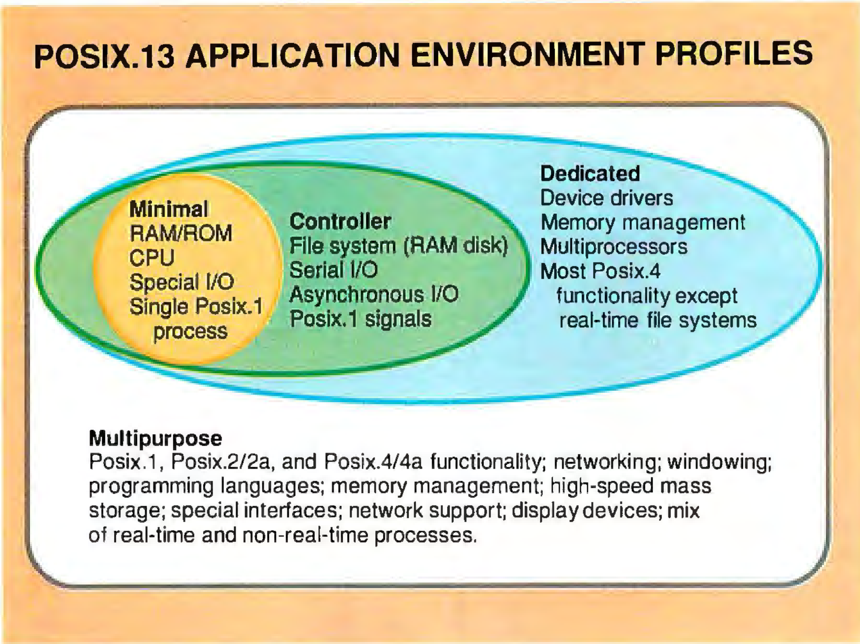

Figure 2: *The application environment profile core of Posix.13 is the minimal profile. Successively larger and more robust application environment profiles build on this core.*

and relative timing is permitted.

The Posix.4 standard enumerates other services that are important to real-time computing, such as support for asynchronous I/O, extended and reliable interprocess communication for the proper ordering of messages, and real-time files for use by transaction processing and databases. A real-time file system permits direct I/O transfers (in which buffering systems are bypassed), preallocation of file sizes, the organization of contiguous files, and aligned transfers of data from memory to the I/O device. Synchronized I/O is also supported by real-time file systems, affording a reliable mechanism for data transfers by verifying that the data stream has been received and written by the I/O device. Transaction-processing and database-commit operations can make use of this function.

All these services have been agreed to by the Posix.4 working group as substantial and important enhancements to the original Posix.1 interface. Header files that define constants and symbols for accessing real-time functions are also specified by the standard. Special processing privileges are not necessary to use these functions.

Following a Slender Thread

One area of standards activity that remains to be hammered out is that of thread extensions. A *thread* is a lightweight process that exists within the context of a parent process. A thread differs substantially from a child process created via the Unix `fork()` call, which causes the entire process space to be replicated—a heavy and expensive operation. A thread uses the address space of its parent and thus requires far less overhead to create, manage, and execute than a child process does. A machine must maintain far less state information for a thread, and it runs within the confines of the parent, but it can be scheduled with different scheduling-policy and signal-handling capabilities (see figure 1).

The Posix 1003.4a working group is trying to agree on how much context a thread must carry and how asynchronous event notification (i.e., signals) will be dealt with by a thread. Until these issues are resolved, Posix.4a will not become part of the full Posix.4-standard release.

Threads are useful in shared-memory multiprocessing environments, where idle processors can pick up the slack by running threads spawned from larger contexts. Threads become trivial to manage when simulations run on silicon that supports microcoded process schedulers with context-switch times of 1 microsecond or less. Software overhead is nonexistent on these CPUs. Standard CISC and RISC components do not support this microcode mechanism, although at least one processor, the SGS-Thomson/Inmos transputer, does.

Before Posix.4, operating-system vendors carved niche markets for their products.

Mapping a Real-Time Hierarchy

Before Posix.4, operating-system vendors carved niche markets for their products. The Posix 1003.13 working group committee (on application environment profiles) examined these commercially successful products to discern the scope of RTOS support for real-time application domains. The committee identified the four real-time profiles: minimal, controller, dedicated, and multipurpose. Each more complex profile requires substantially more operating-system services and resources than its simpler siblings (see figure 2).

The minimal application profile is used in embedded systems that are largely autonomous and drive few I/O devices; no mass storage is used. A single Posix.1 process is used with interrupt handlers for all computation in such systems. An example of a minimal-profile product is the firmware that controls a VCR, video game, or microwave oven.

The controller real-time profile adds structured device I/O and memory management and accommodates RAM disk storage and Posix.1 signals. Mass storage can be used but is not required.

The dedicated real-time profile adds multiple processes and processors. Most of the Posix.4 extensions are needed except for a real-time file system.

The multipurpose profile consists of the entire Posix.1 and Posix.4 functionality and includes the capability for interactive use, as in a flight simulator. Networking can be used, as can threads, window management systems, and high-speed I/O devices for mass storage.

These standard profiles can be implemented simply with a Posix.1- and Posix.4-compliant product through the configuration of a system with the minimal Posix.13-standard kernel symbol definitions. A system administrator can enable or disable any range of Posix.1 or Posix.4 functionality and thus tailor the kernel to meet the needs of a particular installation or application.

continued

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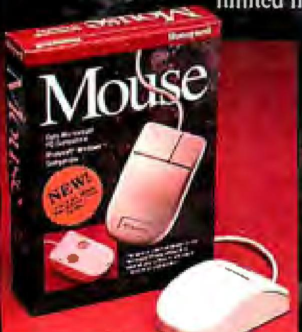

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Posix must eventually be able to provide support for massively parallel computers.

Short Memory

The Posix-standard effort has so far avoided attempts to unify memory models among processor and machine architectures. While support for uniprocessor and shared-memory multiprocessor systems is intrinsic, no mention of scalable parallel-processing architectures has been made. Posix must eventually be able to support massively parallel computers (also called *multicomputers*), which are the acknowledged future of the computer world.

The memory model associated with a distributed system stands as a great barrier that unnecessarily complicates software engineering for multicomputers. A Posix-based memory model like that supplied by Linda (see the bibliography) can make distributed memory transparent to an application programmer and greatly simplify his or her chore. Until this occurs, multicomputer software will remain expensive, since no portable standard memory model exists. The sooner this standard arrives, the sooner these powerful machines can be applied to the complex environmental, engineering, and scientific challenges that await solutions. ■

Richard Marlon Stein is a freelance writer residing in Santa Clara, California. He can be reached on Internet at rms@well.sf.ca.us or on BIX c/o "editors."

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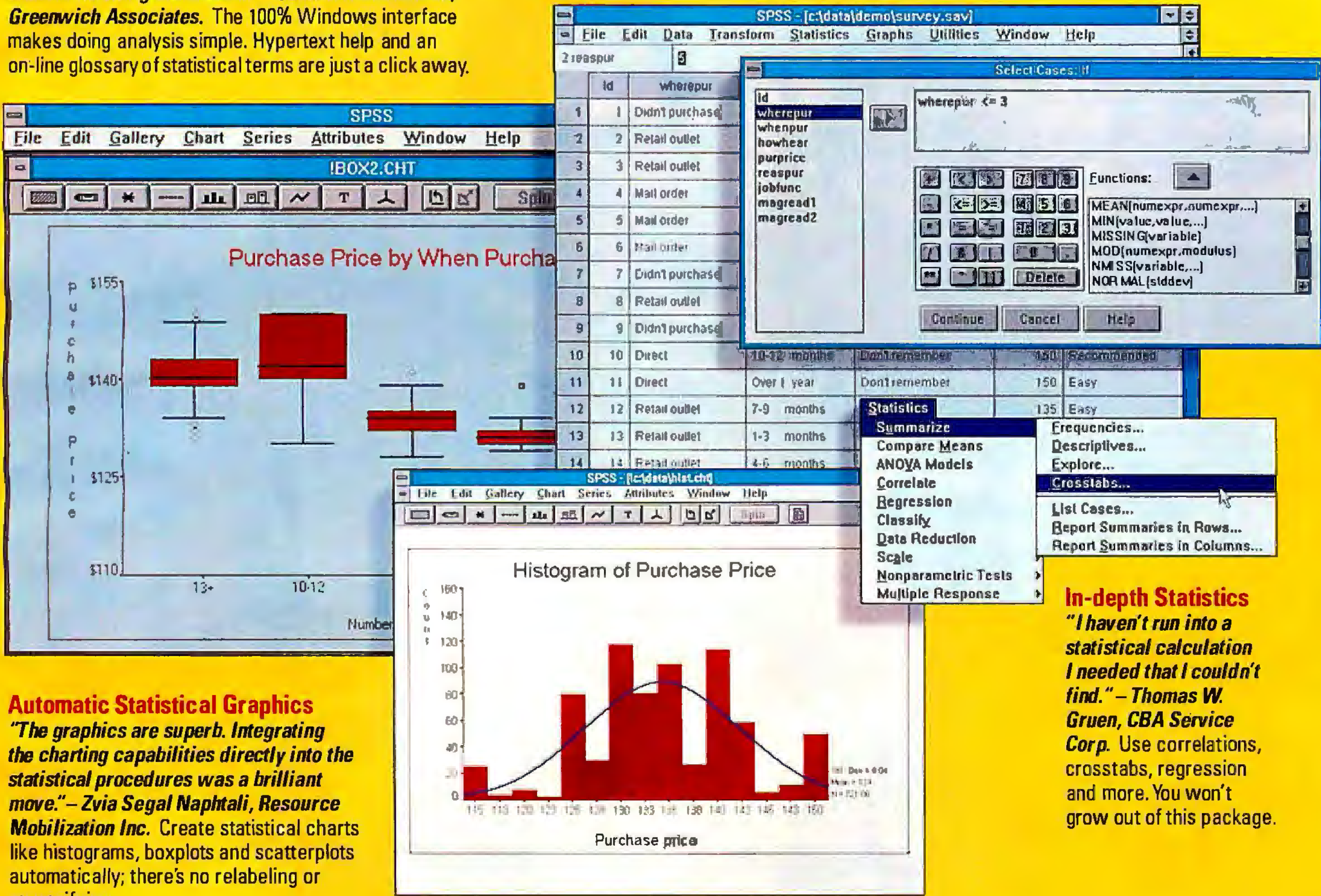

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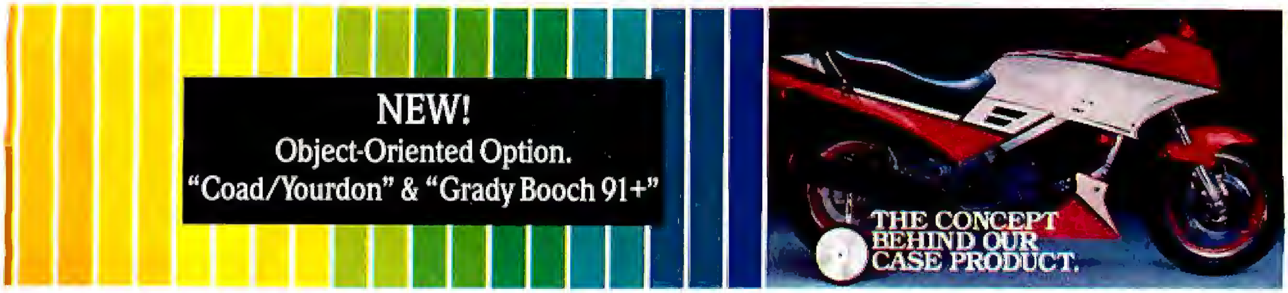

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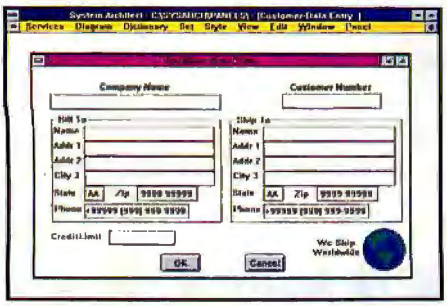

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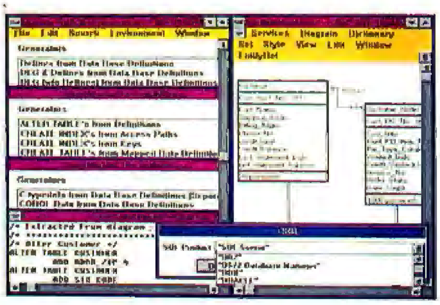

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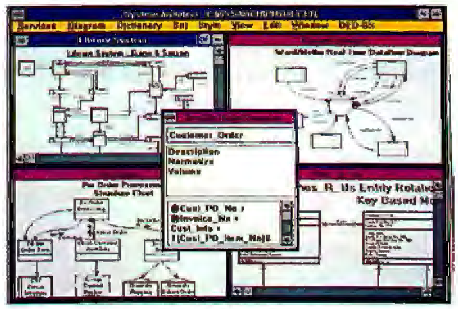

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OBJECTS IN REAL TIME

Object-oriented technologies and optimized real-time systems are enabling the next generation of control

HARRIS KAGAN

Object management, distributed computing, and open systems are driving profound advances in computer technology. They are also being reinterpreted and augmented, with some equally profound results, for a whole range of applications that may not be instantly familiar to some people. However, recent developments in support of these applications will have instantly recognizable benefits.

Distributed systems can have an overwhelming degree of complexity. Add to that the unforgiving requirements of real-time performance and the nonstop reliability that is required for distributed control, and these systems become too much for a general-purpose computer to handle. Yet users of DCSes (distributed-control systems) demand to have the ability to use them on standard computers and to have them interoperate seamlessly with the rest of their corporate information systems (see the text box "The Process-Control System" on page 189).

Object Orientation

Using the right type of object orientation can be the key to making real-time distributed systems work. I'll review the basics of object orientation, provide examples of how it can be applied within a specific area, and discuss how it can be adapted to systems in general. While DCSes represent a segment of computing that's usually neglected in general discussions about computing, they offer some surprising answers to the challenges of distributed real-time systems.

In distributed real-time computer systems, *objects* are meaningful data constructs that have a dynamic quality and a

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unique identity (so they can be easily identified and communicated with). A DCS can be viewed as an integrated collection of many different objects working in concert (although the total system is greater than the sum of its parts). In their simplest form, objects can be such things as printers, ports, and logical devices. As objects become more complex, they have inherent and implied hierarchical structures and many attributes. An object can also be a user with certain privileges and attributes (e.g., passwords, user/group/world, and read/write/execute).

It's easy to relate to an object such as a printer—a physical device usually referenced as a logical device—whose dynamic attributes are simple things like off-line or out of paper. Complex objects become more abstract as their number of attributes and internal hierarchical construction increase. An object in a DCS is traditionally a portion of the process under control, such as a valve in a pipe or a distillation column in a refinery. The attribute of interest in a valve is its flow, and its parameter is its rate of flow or percentage of opening. A distillation column has many attributes addressing temperature, flow, density, and pressure, along with many associated parameters.

The object types commonly found in DCSes today are control objects (e.g., tags); simple variables created by applications for sharing data; complex variables of arrays, strings, data structures, and nested or hierarchical control objects; and logical and physical devices. Working with objects requires a valuable system resource known as *object management*.

Object Management

Object management can be viewed as a specific set of functions supporting change or event-driven data between various applications and stations on a network. What makes it so valuable is that it has the ability to define objects by type, allowing a convenient way to organize and arrange data. A sampling of common object types might include control objects, shared variables (e.g., data created by applications), logical devices (e.g., alarm loggers and applications), and physical devices.

Object management supports the notification of a change within an object greater than a defined change limit. There are two benefits here. The first is that this notification is change driven, essentially providing data by exception. This negates the need for software polling. Whenever the point of interest changes, it triggers a notification to the client from the server that the change occurred and that new data is available. Data-by-exception models greatly reduce the network load under normal conditions, because if a value doesn't change, there is no communication.

The second benefit of change notification is the ability to specify a change limit or dead band (i.e., a range in which changes have little interest). If the point of interest is a measurement of temperature, you might only want to know about changes that exceed 1 percent of the range of your measuring device. Setting change deltas provides a noise filter within a real-time system.

Object management also fully supports a client/server model, providing a high degree of security. This includes the ability to automatically logically reconnect a communications path that physically gets broken and is restored.

The final benefit of object management is its support for unique object names. This provides an unprecedented level of validity security. An object on a network that you share data with must be the object you expect it to be. There can be no ambiguity about whether you're working with the correct data or object.

All DCSes place a supreme value on security.

BYTE ACTION SUMMARY

Object-oriented technologies are the focus of concentrated research. Developers of control systems are putting results of this research to work in real-time applications and systems.

The Client/Server Model

A client/server model for object management is, pragmatically speaking, an extension of the operating system in a multitasking environment. The applications that must share data and objects need to do so in a timely and secure way, and the physical locations of the parties involved must be transparent to the applications.

Using the client/server model for object management, you can think of the application that needs the data object as the *server* and the application that sends the data as the *client*. In a distributed-control environment, objects must be shared in real time between peer stations on a network. The extent of peer-to-peer communications depends on the capabilities of the station doing the actual control, the deterministic nature of the peer-to-peer communications, and the requirements of the application.

Real-Time Control and Objects

Objects can form the basis for real-time control in a DCS. The basic unit of a control object is a *block*, an algorithm that performs some common function. For example, a PID block is a proportional/integral/derivative algorithm with standard parameters that can be manipulated. A block's parameters (e.g., set point, output, measurement, high alarm level, and low alarm level) are modified through the configuration processes and by software connections to and from other blocks. The set of available control blocks form the building blocks for the desired control scheme. From the template of an analog input block, a user can set the specific attributes of the various parameters and create a uniquely named analog input block for a specific set of input points.

In a hierarchical structure, it is convenient to group a set of blocks together as a *compound*. The primary attributes of a compound are that its set of blocks can be alarmed, displayed, and manipulated together. Thus, the compound itself becomes an object. The compound can then be nested into other higher-level objects; each higher-level object may have its own parameters as well as all the information embedded within its subobjects. The information is simply referenced so the data flow is clean and fast. This hierarchical structure allows a change to some aspect of a parameter within a block to become immediately available to the highest-level object (i.e., a compound) associated with that block, as well as to any other client in the distributed system with a logical connection to that block.

Security

All DCSes place a supreme value on security. There is often the risk of loss of human life or tremendous liability due to lost production should a DCS fail. Many process plants and their control systems are expected to run for years without ever

The Process-Control System

Unless you grow your own food, spin your own cloth, hunt with a bow and arrow, never drive, and never get sick, you depend on process control in many ways that you probably don't recognize. Process control is the technical and economic enabler of chemical, oil, and gas refineries; textile and paper mills; food and drug manufacturing; mining industries; municipal water and sewage treatment; and, of course, power generation.

The processes and end products of all these industries are obviously different. Yet from the standpoint of a control system, they offer many similarities. Each has data to be acquired, control decisions to be processed, communications to perform, reports to generate, and more. But these similarities are of type, not detail. The challenge is to develop a control system that addresses the tremendous but unique complexity of each application without reinventing a thousand new wheels each time.

These control systems are usually called distributed process-control systems, or DCSes. A modern DCS has three points of view: the control system, the computer system, and the information management system. The primary attribute of a DCS is its ability to control a process via the execution of various algorithms in real time. The very nature of process plants is such that this control needs to occur over large physical areas and must be supervised by many individuals. This profile leads to a major feature of the computer system view—that the system must be distributed.

The information management system view grows naturally from the role of the DCS as the heart of a process plant. The DCS is a key source of information for the whole organization. In addition to controlling the process, information from the DCS is central to inventory control, shipping, receiving, engineering, management, training, maintenance, analysis, and even marketing and sales forecasting. The DCS must process lots of information quickly, communicate among many stations and nodes securely, and make data available in a clear, understandable way across many boundaries, stations, applications, and networks. Any user of data in the system should have the ability to get any data anywhere, and get it in time enough to take effective action based on it.

These requirements dictate that a system from one vendor must be open to other vendors' systems, networks, software, and instrumentation. In fact, today's DCS can be described as an open, industrial, real-time, object-oriented, hierarchical, change-driven, fault-tolerant, redundant, distributed process-control system.

shutting down; the phrase "7×24" (for seven days a week and 24 hours a day) is often used to modify terms like *operation*, *reliability*, *security*, and *performance* when discussing DCSes. Software upgrades to existing systems must be made while the systems remain running.

Security in the DCS world means reliability (i.e., robustness), validity (i.e., getting the data you expect to get every time), availability of system resources, authentication, and encryption. Objects help provide security in an open and distributed system. Of the five above-listed concepts of DCS security, the most important ones are validity and availability.

Validity means data integrity—in other words, getting good data. This is a security issue, because anything that adversely affects the quality or integrity of the data poses a security risk. Availability is the probability that the system resources required for operation are available at any time they are needed. Availability can be addressed as a subset of authentication services.

Authentication

Authentication is simply the verification of a user's identity. The object in this case is the user of the system, and the authentication mechanism is the password-protected accounts that he or she uses. Objects as data constructs must have names, and object management requires a facility to guarantee that those names are unique. Any entities in the system that need to share data first need to find each other and validate that they are sharing data with whom (or what) they expect to share it. Finally, the entities need to evaluate the extent to which the data will be shared or modified (i.e., the privilege level of the interaction).

The fundamental way in which objects are guaranteed to be unique is through a declarations process. When an object is created within a running system, it needs to announce its arrival. This is broadcast via a systemwide communications service that all members of the system need to address. Should a duplicate name exist, the manager of the object with the original name responds; the new object with the duplicate name is not entered within the local object manager's name lists. DCSes require an attachment service so that when running networks are merged they can share and resolve naming conflicts.

Environments, Objects, and Security

Each of an object's attributes defines a constraint, quality, or special ability of the object or its behavior. For example, you could define the security attributes of an object such that its data is available only to other objects of a certain class.

When operational environments are managed as objects, the flexibility of the system increases significantly. Typical operational environments within DCSes are provided for process operators, who manage the process; process engineers, who define the process and its constraints; plant management users, and maintenance personnel.

In a DCS, an operating environment may be further specified for an individual operator. Such an operator's environment gives him or her access to a subset of applications and process displays. For example, an individual operator may be allowed to set values to controllers via the display but may be blocked from canceling an alarm or altering a data log. One display may behave differently in different circumstances, depending on the environment from which it is invoked. An environment object defines the degree of security from the client side, while the security attributes of a control object enforce security compliance.

Connection Management

Distributed computing obviously depends on communications and connections. But the relationships between communications services and objects in a real-time system are not so obvious. The nature of a distributed system requires that data be shared via some message protocol. For a DCS, however, facilities for message identification, delivery, security, and portability are of the most importance. Both one-time communications and change-driven communications are critical to the correct functioning of a real-time system. In a DCS, a one-time message is generally thought of as a get or a set, either of which needs to be performed in a timely way. A *get* is a reading of a single data value; a *set* is the writing of a value. Control objects always have attributes and parameters that are gettable and settable. These parameters have their own attributes regarding who has the privilege of performing these operations.

Other communications are best served when messages are delivered over a secure connection. A secure connection provides a notification to both ends if it should break, and it guarantees the order of delivery of message traffic. Because an object manager requests communication services and is notified of the status of communications, it has the ability to automatically reconnect the client and server logically should a connection be physically broken and rejoined. This auto-reconnect function has the advantage of allowing objects to migrate. A unique object (whether it's software, hardware, or logical) can move from one place to another in a way that is relatively transparent to the applications tracking it. In the DCS world, these capabilities are key to providing security.

The network objects and process objects in large systems are subject to frequent change due to periodic maintenance of the system and process plant. But the overall functioning of the system and the plant must continue during maintenance, and users must have the ability to control, redirect, and compensate should certain areas of the plant get into trouble.

Configuration Management

System configuration encompasses the layout of hardware and software as well as the definition of physical, logical, and application relationships, including licensing, hosting relationships (for stations that aren't self-hosting), logical device declaration, device backup designations, I/O port assignments, configurations, and more. Modifications to a system's configuration can be complex, especially in a global system where all system attributes need to be known by all the elements in the system. The strict operational requirements of real-time control applications further add to the complexity. For the DCS designer, the challenge is to develop an architecture that allows systems to become intelligently adaptable to change. DCSes must be modifiable on-line in a way that is transparent to the system's applications and to the process it's controlling.

Much of the complexity of system modification can be reduced by combining an object-oriented system with intelligent object-oriented applications. In terms of system configuration, any application can be trained to know enough about objects to be able to handle new ones with ease. For example, consider the addition of a new control station to a running DCS (a common occurrence). In this case, the new control station is non-self-hosting; it requires boot services from another station. There are two different methods that can be used for this common modification—a traditional approach and an object-oriented approach.

In the traditional approach, the system configuration must be modified to identify the new station by a logical name, place it within a node, and assign it to a station management group and to a host file server. After the configuration decisions are made, the process is completed by the execution of an installation program that creates whatever files and database changes are needed. In some cases, this information needs to be made available to every other station or file server on the network. The new station is then physically installed in the system and booted up. If the new station is of a completely new type or is a device previously unknown to the system, upgrades must be made to the system-configuration, system management, and software-installation software.

The object-oriented approach is very different. The new control station is simply plugged into the running system. The new station, which in this case is a non-self-hosting control station, starts putting out boot requests. Since all host stations are aware of all the other stations in the object-oriented network, some simple tasks can be performed: The system management program can alert the system administrator that there is an unfulfilled boot request occurring on the network, and a human system administrator can invoke the system-configuration application. This application can determine that the unsolicited boot request is from a control station by looking at the semantics of the boot-station message object. The configuration software has enough information at this point to know where the station is located (via node addressing), what image and base applications are required, which file server is best suited to be the host file server, and what the minimal configuration questions that require human input are.

This example illustrates what happens to simply add a new station to the network; completing its integration to the DCS requires additional work. The information management requirements depend on the applications involved. The database for physical objects usually requires some reconfiguration to deal with the new data associated with this new station. The application requirements are addressed by additional applications or reconfiguration of existing applications to deal with the added functions and capability brought on-line by the new station. This means new control algorithms must be added to the station, new control objects must be created for the control database, and new hardware must be added to the system for the control station's connection to sensors and actuators.

The information and application aspects of reconfiguration are managed by smart objects that are cloned from object libraries and modified for their new roles. Often the only thing needing change is the top-level name of the objects. Library objects can include displays and their display objects, control objects, application objects, environments, and individual operators.

The Future of Real-Time Systems

The purpose of working with any system is to manage data and to be in control of all the information that is important for the completion of your work. Real-time systems have special needs, but if you can design a real-time system, you can use it to run non-real-time applications as well.

Object management research needs to continue to provide higher-level constructs that are simple and easy to use. Standards need to be developed, and applications need to take advantage of them. Correct object management will create the foundation for dissimilar systems' sharing data in a relatively seamless way.

While objects have the ability to provide a framework for organizing and sharing data, they must be managed in a way that provides correct access and security. Combining objects with distributed real-time systems is a natural evolution. ■

Harris Kagan is an architect for systems development and engineering with The Foxboro Co. (Foxboro, MA). You can contact him on Internet at hkagan@foxboro.com or on BIX c/o "editors."

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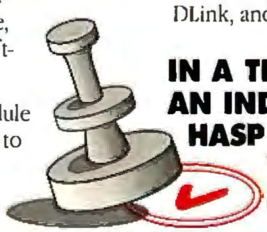

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BYTE May 1992

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REAL TIME GOES HOME

Home information appliances are coming, with multimedia features and a real-time operating system

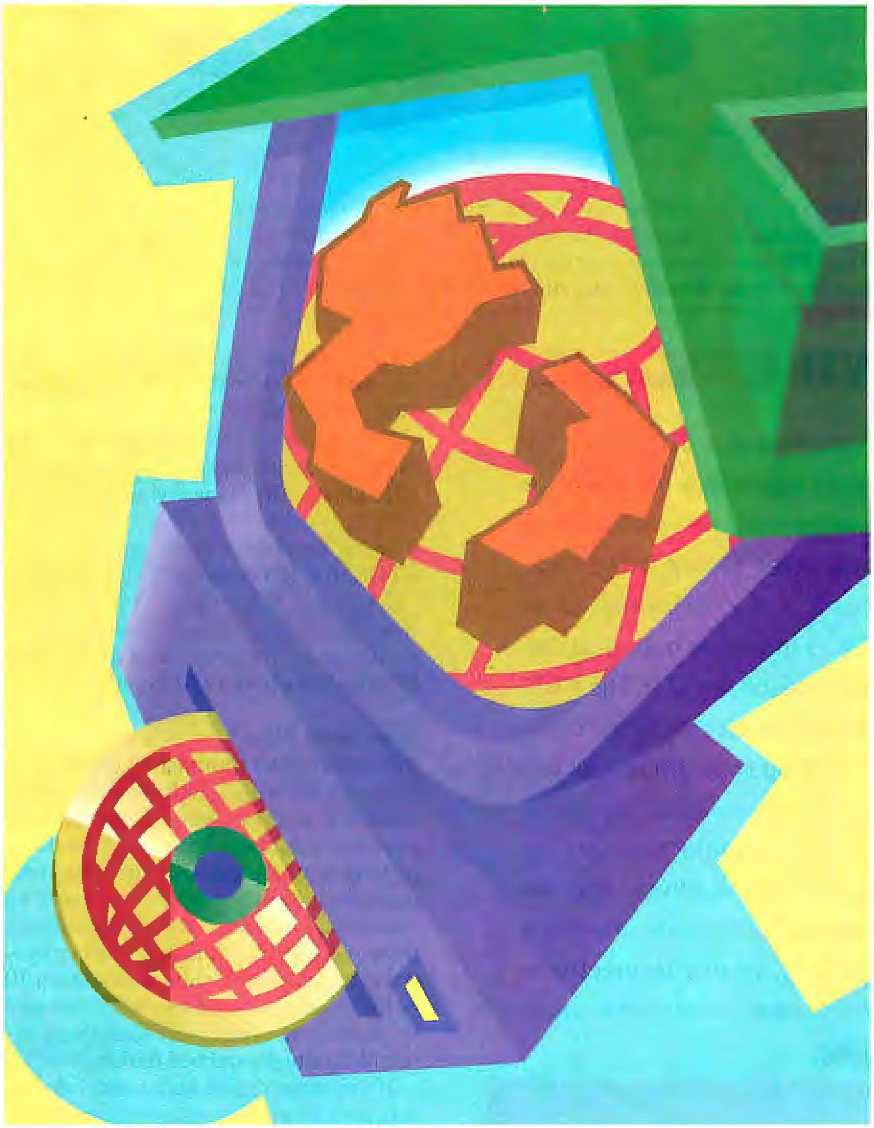
KEN KAPLAN

A fusion of computers, TV, and telephones will soon bring new kinds of entertainment and information services into the home, to an extent almost unimaginable today. Technologies to deliver these services are now emerging; some are already available. The "home information appliance" of the future is beginning to take shape.

It is probably a small box atop or built into your TV. It contains the equivalent of a Mac Classic plus powerful audio and video decompression and signal-processing engines (see figure 1). It has a CD drive and a telephone/cable TV wideband digital-network interface. It has no keyboard—just the usual wireless remote control with a small joystick or trackball added. And it costs about $200.

The software foundation will be based on RTOSes (real-time operating systems) and specialized, consumer-friendly graphical interfaces that look more like network news graphics than Windows or Motif. Today, you find real-time software in a wide variety of intelligent products and in systems used mostly in industrial, military, and scientific applications. The development of these new interactive multimedia products will spread real-time software far beyond its traditional niche.

The first example of this new genre is the CD-I (Compact Disc Interactive) system introduced to the consumer market in October 1991. It looks like a CD player and hooks up to a TV like a VCR. In addition to playing normal audio CDs, interactive multimedia CD-I offers high-quality natural images, high-fidelity sound, and complete interactivity. For instance, you can take a self-directed tour through the Smithsonian. Children can watch a



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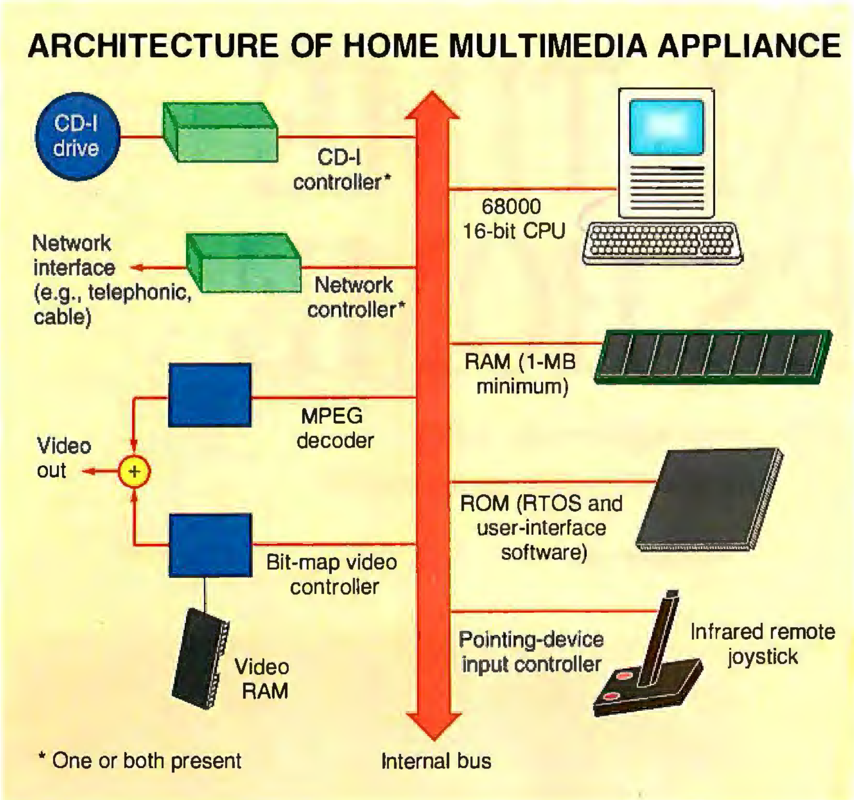

Figure 1: *The architecture of a home multimedia appliance has most of the same components as a low-end PC, with digital video and audio decoders added. The CPU and RTOS manage the flow of data from the optical disk or network interface to the decoders and run the GUI.*

BYTE ACTION SUMMARY

Your TV and a CD-I device will soon become a means of receiving multimedia information and other services. The backbone of the technology is an RTOS (real-time operating system) based on OS-9. The RTOS allows for precise synchronization of audio and video, as well as for the multitasking necessary to handle multiple requests for the service. The new services will include interactive games, access to electronic databases, and home shopping.

cartoon, recolor its characters, and even change the soundtrack, and then play back "their own" version.

Researchers at Philips Electronics and Sony, the developers of CD-I, quickly realized that an RTOS was essential for use with their technology. They chose the OS-9 operating system as the basis for CD-RTOS, the ROM-based RTOS in every CD-I player. A key factor in the decision was OS-9's open-ended reconfigurability, necessary for supporting multimedia I/O and other future extensions.

Why Real Time?

Video and audio information coded digitally can be stored and communicated much like any other kind of data. There is a critical difference, however: Sound and pictures have a temporal (time-based) dependency. Simply stated, they must be played back at exactly the same speed they were recorded, with nearly perfect synchronization. A time shift of more than 10 milliseconds between motion video and its audio track results in something resembling a badly dubbed movie.

If you want digital audio and video as part of an interactive multimedia program, the applications software must be able to both control and sense the current playback point of the audio and video material. This also involves precision timing. For example, a delay in the delivery of a block of audio data can produce a noticeable click or pop in the sound.

The source of the multimedia data is an input stream typically delivered from an optical disk, a high-speed telecommunications interface, or any other medium capable of delivering data at a real-time rate. For full-screen, full-motion video with high-fidelity stereo sound, the minimum data rate is about 1.5 Mbps (or about 150 KBps). The processor and operating system need to accept and manage this high-speed input stream while simultaneously performing other tasks, such as accepting input from the pointing device, updating the user-interface display, and running the application program.

An RTOS provides an excellent software foundation for multimedia applications. The multitasking capability provides a concurrent programming paradigm that is well suited for multimedia programming. The RTOS also provides other essential services, such as real-time synchronization, interprocess communications, and fast interrupt handling. Popular operating systems such as MS-DOS and Unix can't handle applications with real-time attributes easily (if at all).

The fact that many applications must go around DOS has caused headaches for designers of DOS emulators that run on other hardware (e.g., Mac and Unix workstations). It also has had more insidious effects. Because DOS fails to provide a usable, hardware-independent application environment, PC programmers have to write code to support nine or more different video display modes, several kinds of pointing devices, and perhaps a half-dozen brands of sound processor boards. The user is often forced to run elaborate installation and setup programs. DOS is definitely not consumer-friendly.

A good RTOS avoids these problems because it provides a fast, versatile, expandable, and hardware-independent I/O system. The system using it can be expanded or improved in the future without affecting existing application programs.

You Should Be in Motion Pictures

MPEG (Motion Picture Experts Group), an industry standards committee, has devised a standard for digital compression and decompression of full-screen, full-motion video. It is likely to be the ubiquitous standard for digital video for many years to come. In all probability, TVs of the future will have MPEG input jacks.

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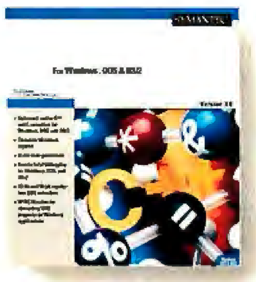

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Real Time and Digital Motion Video on LANs

JIM LONG

Multimedia and digital motion video are finally becoming practical for commercial desktop computing. Digital video will first appear in applications such as training, education, factory-floor reference, retail point-of-sale, and video databases. It will then expand into general office environments as video annotation, video mail, teleconferencing, and fancy presentations become commonplace.

For these applications to become a reality, cost-effective multimedia-capable systems need to be available. The keys to creating these systems are video compression technology, real-time synchronization subsystems, and real-time networking.

Networks are important because the characteristics of multimedia data, especially audio and video components, require sharing data among many users. Most multimedia applications (e.g., training and documentation systems) support workgroup or enterprise-wide organizations. In addition, future applications such as desktop video conferencing will mandate networked solutions.

To be effective, popular compression technologies must be integrated into desktop operating systems and networks in a real-time fashion. But most desktop systems, networks, and servers are designed to handle transaction-oriented applications in a time-sharing fashion. Local and network operating systems share scarce resources (e.g., CPU, bus, memory, and network bandwidth) democratically among many users. Too many requests spread out resources and slow everything down. This is a nuisance for transactional activities like word processing, databases, or spreadsheets. For video, the delays can be disastrous.

Audiovisual streams demand a Federal Express attitude: They absolutely, positively have to arrive at the client computer on time, regardless of network traffic flow. Video is not either slow or fast: Either it works, or it doesn't. Therefore, managing data flow is key to all multimedia computing, especially on networks. The important network function for audiovisual media isn't fair allocation of resources or error-checking; it is making sure that data flows at the proper rate between the server and client, or between client and client, and guaranteeing that data arrives on time. Ensuring proper data flow is particularly difficult for normal networks because of the many bottlenecks that exist in the client/server environment.

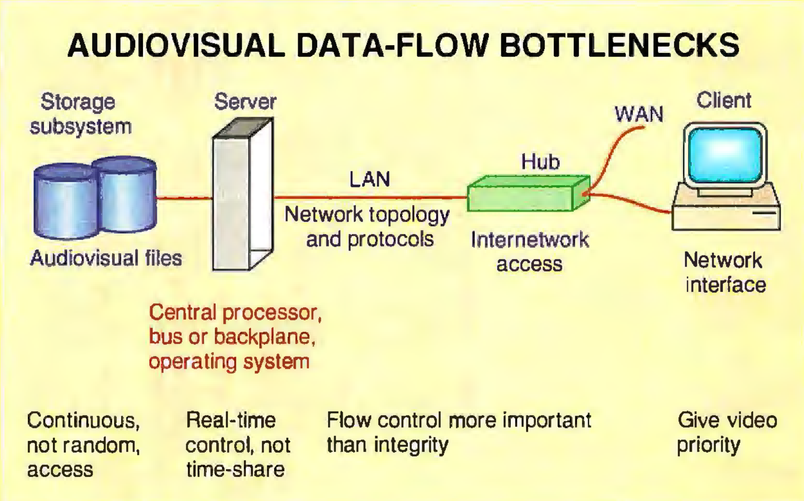

Figure A: *Because most networks are not designed to allow a consistent, continuous flow of data, they present several bottlenecks to the smooth control of audiovisual data. Each network component pictured here presents an opportunity for delay or interruption. Access from the storage subsystem needs to be continuous, not random. Control over the CPU, bus, and operating system must be in real time, not time-shared. Flow control through the network is more important than integrity. And video data must have priority over textual data in getting to the client.*

Bottlenecks for Digital Video

Along the digital path that connects the disk drive on a server to a client computer, these bottlenecks slow or interrupt the audiovisual stream. The bottlenecks occur in the disk drive, the system bus, the processor, the network, and the various interfaces and buffers between the parts of the system (see figure A).

The trick is to make an asynchronous system (i.e., computers and packet networks) behave in a synchronous fashion (like a telephone call). To accomplish this, buffers are usually placed throughout a system to even data flow. While they are useful, buffers are not a panacea. For either live or stored video, keeping buffers filled requires a real-time approach. If a buffer is almost empty, you cannot wait for another application's printing request to finish before filling it.

Making the buffers large reduces their real-time demand. But this can introduce *latency* and, even worse, it can introduce *jitter* if the system designer relies more on probability effects than on deterministic management. (Latency is the delay between a signal being sent and received; jitter is a breakup of the video stream caused by underrunning buffers.)

Latency and jitter issues are particularly demanding when supporting multiple, live, full-duplex teleconferences. Buffers can also require significant memory and CPU resources if the operating system manages them by means of many memory-to-memory copies of the same data, as is common in most systems.

Add the fact that a server or a network is dealing with dozens of video streams, sometimes several needing synchronization to one desktop, and the real-time buffer management issues become extremely complex. Normal server file systems do not have the deterministic scheduling ability that is necessary to handle this complicated problem efficiently.

Buffer management is one part of an overall, end-to-end, flow-control function. For the network, this means that instead of normal asynchronous request/receive communication between two computers, streams should be initiated and then paced via communication designed to tune the stream flow depending on whether it is arriving too fast or too slow. Pacing also requires real-time scheduling.

Most of today's network protocols have little regard for timely delivery. They are usually so concerned with error control and acknowledgments that they can't keep up with a high-speed continuous stream. Special lightweight pacing protocols are needed to handle video streams and also to coexist transparently with other protocols. Such protocols can be designed to be more efficient for streaming data by eliminating some of the functionality found in protocols such as TCP, which is meant to cover many other applications and types of networks (e.g., error control for 9600-bps voice lines).

Finally, because video streams have to be handled differently than other data, network devices and computers must be able to distinguish between the two. In fact, video should be given priority—another real-time feature. For example, if, over a short period of time, a network device capable of handling 10 Mbps is flooded with 7 Mbps of video and 7 Mbps of other data, it must be able to ensure that the video information gets through while delaying the other data.

Potential Solution

The good news is that cost-effective solutions are at hand that coexist with traditional systems and add real-time network and server functions. The real-time functions ensure that the video streams are managed in a timely and reliable fashion. In fact, by adding real-time elements, you can meet the challenges of networked video applications without installing expensive new networks or specialized client platforms. Large multimedia network solutions (i.e., 40 to 60 simultaneous video streams) can use common 10Base-T Ethernet networks and new switched Ethernet hubs, preserving the existing client network interface hardware.

The video streams in such a network can be managed by a real-time streaming data application server tuned for the demands of video by efficiently managing disk arrays and real-time video network protocols. Video protocols can operate in parallel with traditional network servers on the same network to ensure timely delivery of real-time multimedia streams.

Such a configuration will allow users to access both their current networked applications as well as new video applications. This solution provides the foundation for the integration of video into current and future desktop applications. The solution also brings video to the desktop in an easily installed, cost-effective manner and offers a powerful user interface.

Jim Long is president of Starlight Networks, Inc. (Mountain View, CA), which is developing a real-time digital networking environment. You can contact him on BIX c/o "editors."

MPEG combines a number of compression and coding techniques to squeeze motion video into a digital data stream. The highest compression is achieved with a DCT (Discrete Cosine Transform), which effectively codes interframe differences. The quality, size, and resolution of the decoded picture depend on the data rate used, which is adjustable. At 1.5 Mb, the picture is slightly better than what you would get with VHS videotape. At 2 Mb, laser-disc quality is achieved. And from 5 to 10 Mb is HDTV territory.

An MPEG decoder IC requires parallel processing with a combined effective throughput on the order of 100 MIPS. It also has to be economically mass-produced, at a price of a few tens of dollars at most. Several companies claim to have working silicon now, and Philips has promised to ship CD-I players with MPEG before the end of this year.

MPEG needs a real-time software environment. Once compressed, video data cannot be manipulated by an application program. So, many MPEG-based systems will have a second video "plane" that will appear "on top" of the motion video. VCRs and TV receivers with on-screen controls usually use this technique so that control graphics (e.g., channel and volume graphics) do not completely cover the TV program. Multimedia applications will use the overlay graphics plane for several things, including menus, captioning, and controls.

Take a movie player application as an example. An application program (or *task*, in real-time jargon) is playing continuously running MPEG motion video. A second task (the user interface) draws VCR-type control icons (e.g., pause and fast forward) on the graphics overlay plane, covering only a small area at the bottom of the screen. Now the viewer uses the pointing device to move the cursor to an icon. The user-interface task continuously receives pointing-device input coordinates and correspondingly updates the overlay graphics plane to redraw the cursor as it moves. When the viewer pushes the select button, the user-interface task signals the motion video task, which then commands the MPEG decoder and the input media controller hardware to execute the requested function.

Real multitasking is necessary to run the motion video application and the user-interface programs simultaneously. Some precise timing may also be needed to give smooth, clean cursor motion. Often, the user-interface task will be synchronized to the video-display timing (using interrupts), so graphics updates are done only during the vertical retrace time.

continued

And Now Answer the Phone

Another big step is connecting the multimedia box to wideband telecommunications networks (e.g., telephone networks, cable TV systems, and direct-broadcast satellite systems). Some of the potential services that can be provided are quite interesting. You will be able to rent a movie without visiting a video rental shop—you'd just dial it up. You could tune into almost any sports event being played anywhere, perhaps even choosing the camera angle and controlling your own instant replays. You can have instant access to almost any home-shopping catalog (with minicommercials and product demos).

The information sources will be "consumer-oriented," so they may include access to libraries around the world; financial services such as banking, investments, and insurance; perhaps even in-depth reviews of that new car you've been dreaming about.

The network is basically a data pipe between your home and a server at a remote information warehouse. It delivers standard-format packets of multimedia data at a constant rate. The technical requirements are eased since the high-speed data stream need flow in only one direction. It's easier to send high-speed data in one direction than in both directions concurrently.

To communicate back to the remote server, only a relatively low data-rate "reverse channel" for control is needed—even a few thousand bps is adequate in most cases. The reverse channel may be a completely different medium; the use of cellular phone–like radio transmitters has even been proposed. It is generally better to have the reverse channel be an integral part of the network interface, because the high-speed incoming channel and the reverse channel can be routed together through the network. Also, the reverse channel may be used to communicate with the network itself (e.g., to dial a number).

Network interfaces are a traditional application for RTOS software. Most data communications equipment depends on embedded RTOSes. Fast interrupt response, synchronous and asynchronous I/O capabilities, and the ability to rapidly respond to events (e.g., in flow control and error correction) are all essential for data communications.

The server providing the multimedia data must have multitasking capabilities to handle many callers simultaneously. It must also retrieve and transmit data with precision timing.

So When Will It Happen?

It's starting now. CD-I is here. Philips announced it will ship a CD-I player with full MPEG by year's end. Several telephone and cable TV companies say they'll have small-scale trials or demos of "video-on-demand" services early next year.

Based on the current status of the technology and some assumptions about the amount of money consumers are willing to pay for these magic boxes, it will probably be three to five years before there is significant widespread deployment of network-connected multimedia. This can be extrapolated from the historical price curves of the key semiconductor components. So it is probable that CD-I will be the first widely used consumer multimedia product. CD-I players with network interfaces may even become universal home multimedia decoders/controllers. ■

Ken Kaplan is president of Microware Systems (Des Moines, IA), which developed and sells OS-9. You can contact him on BIX c/o "editors."

Real-Time Operating Systems

Although all real-time applications are in some sense unique, common ground for many of them begins with a real-time operating system. These operating systems form the core of a growing number of real-time applications.

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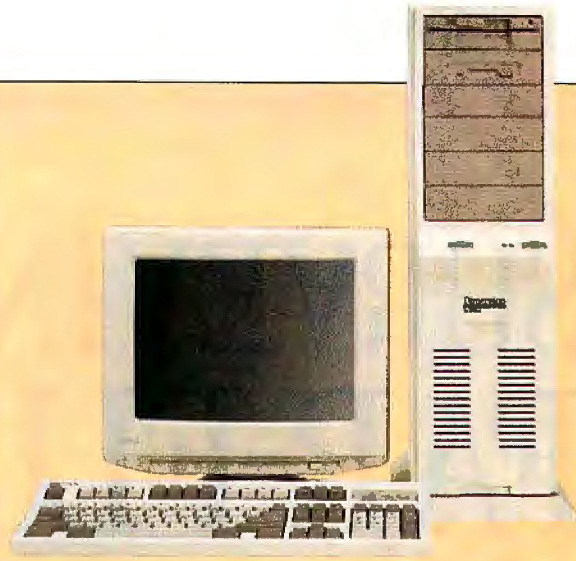
4 MB RAM, 80 MB Hard Drive, Dual Floppy Drives (3.5" and 5.25"), SuperVGA 1024I Monitor (14", 1024 x 768, .28mm), MS-DOS® 5.0/Microsoft® Windows™ 3.1/Mouse

$1,549
Lease: $57/MO.

Dimension 386DX/33 i386DX 33 MHz System
4 MB RAM, 80 MB Hard Drive, Dual Floppy Drives (3.5" and 5.25"), Super VGA 1024I Monitor (14", 1024 x 768, .28mm), MS-DOS 5.0/Microsoft Windows 3.1/Mouse



$2,199
Lease: $81/MO.

Dimension 486SX/25s i486SX 25 MHz System
4 MB RAM, 212 MB Hard Drive, Dual Floppy Drives (3.5" and 5.25"), Ultra VGA 1024NI Monitor (14", 1024 x 768, .28mm), MS-DOS 5.0/Microsoft Windows 3.1/Mouse

$2,699
Lease: $100/MO.

Dimension 486DX/33s i486DX 33 MHz System
8 MB RAM, 212 MB Hard Drive, Dual Floppy Drives (3.5" and 5.25"), Ultra VGA 1024NI Monitor (14", 1024 x 768, .28mm), MS-DOS 5.0/Microsoft Windows 3.1/Mouse

$1,799
Lease: $67/MO.

Dimension 486SX/25 i486™SX 25 MHz System
4 MB RAM, 120 MB Hard Drive, Dual Floppy Drives (3.5" and 5.25"), Ultra VGA 1024NI Monitor (14", 1024 x 768, .28mm), MS-DOS 5.0/Microsoft Windows 3.1/Mouse

$2,299
Lease: $85/MO.

Dimension 486DX/33 i486DX 33 MHz System
4 MB RAM, 212 MB Hard Drive, Dual Floppy Drives (3.5" and 5.25"), Ultra VGA 1024NI Monitor (14", 1024 x 768, .28mm), MS-DOS 5.0/Microsoft Windows 3.1/Mouse

$1,499
Lease: $55/MO.

Dimension NL20 i386SL 20 MHz System
2 MB RAM, 40 MB Hard Drive, Weight: 6.3lbs. including battery, Minimum battery life: 2.5 hours, Edgelit VGA LCD (8.5" Diagonal, 640 x 480), MS-DOS 5.0/Microsoft Windows 3.1/Mouse

$1,799
Lease: $67/MO.

Dimension NL25 i386SL 25 MHz System
2 MB RAM, 60 MB Hard Drive, Weight: 6.3 lbs. including battery, Minimum battery life: 2.5 hours, Edgelit VGA LCD (9.5" Diagonal, 640 x 480), MS-DOS 5.0/Microsoft Windows 3.1/Mouse

intel inside

SURVEYING FAR-FLUNG NETWORKS

Distributed monitoring and analysis tools give you a bird's-eye view of network activity—even if your network spans the globe

BRUCE H. HUNTER, TOM MAHONEY, MICHAEL HURWICZ, STEVE LARSON, AND BARRY NANCE

In the weedlike growth that typifies network development, there's usually little time for central planning or analysis. Network administrators hurry instead to deliver solutions, mixing systems from different vendors, bridging remote segments developed to match different needs, and tweaking whatever needs tweaking to keep the network running. But where a hastily concocted LAN can be unwieldy, a far-flung, multisegment network can simply grow too big to manage with the usual black magic. Worse, it can develop problems that you can't solve without gaining a networkwide perspective.

Fortunately, as networks have grown in size and complexity, management and analysis tools have grown in sophistication. Among the most powerful of the new generation of tools is the distributed network monitor. Distributed monitors constantly gather information on network behavior, allowing savvy administrators to solve problems, tune for performance, and plan for growth even on WANs (wide-area networks).

This month, we review six distributed monitoring and analysis systems: Concord Communications' Trakker; Hewlett-Packard's LanProbe System; Network General's DSS (Distributed Sniffer System); Novell's LANtern; ProTools' NCS (Network Control Series); and TTC's (Telecommunications Techniques Corp.'s) NetLens Analyzer and NetLens Probe. Because large networks are so incredibly complex and the tools required for their analysis so demanding, this month's Solutions Focus takes a different tack than usual. Instead of presenting our customary head-to-head, BYTE Lab–based analysis, we took the six products to be reviewed out into the field and asked five experts familiar with real-life, large-scale network problems to install, run, and evaluate them.

With a distributed monitoring or analysis system, you get a picture of the activity on your entire corporate network, no matter the size. Generally, these products are not tools for emergency repair or diagnostics, although you can use them to track

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BYTE ACTION SUMMARY

- **WHAT NETWORK MONITORS DO**
  These sophisticated network management tools let you monitor, and often analyze, network activity across multisegment networks.

- **LIKES**
  Analyzing traffic across an entire WAN presents an excellent perspective on network use and can help in design and expansion; centralized access means less travel for network gurus; good analysis tools can aid network management novices.

- **DISLIKES**
  Each of these systems is expensive; some don't allow monitoring of diverse networks.

- **RECOMMENDATIONS**
  Direct comparisons are not possible, because each system ran in a separate environment. However, each product has qualities to recommend it: Trakker for all-around excellence on Unix-based networks; Network Control Series for superior analysis tools; LANtern for a usable, useful interface; LanProbe System for low-cost distributed monitoring; and Distributed Sniffer System and NetLens Analyzer for administrators already familiar with stand-alone versions.

down faults. Instead, they play a daily role on your network, providing invaluable constant tracking data.

Vendors tout their systems as tools for "proactive" network management. You must decide up front whether you can afford this powerful, elegant—and expensive—approach. Most of these systems run to tens of thousands of dollars for monitoring several segments. Of course, for enterprise-critical networks, these costs pale beside the cost of downtime.

A Closer Look

All the systems share a basic architecture: a central monitoring console and remote data-collection units residing on individual network segments. The data-collection devices capture packets from different protocol families at multiple protocol layers. Depending on the sophistication of a system's analysis tools, this raw data can be

FEATURES OF DISTRIBUTED NETWORK MONITORING SYSTEMS

Distributed monitoring and analysis systems allow you to keep close tabs on multisegment networks. All divide the work between remote data-collection devices and a centralized console, but similarities end there; protocol support, price, and sophistication of analysis tools set each product apart. (• = yes; o = no; N/A = not applicable.)

	Concord Communications Trakker	Hewlett-Packard LanProbe System	Network General Distributed Sniffer System	Novell LANtern	ProTools Network Control Series	TTC NetLens Analyzer and NetLens Probe
Monitor	Segment monitor: stand-alone, 25-MHz MIPS R3000-based unit	HP 4991A LanProbe segment monitor: stand-alone monitor unit, includes internal modem	Sniffer Server: stand-alone monitor unit	LANtern Network Monitor: stand-alone monitor unit	Cornerstone Agent: software monitor and analyzer requires PC running OS/2 1.3 or 2.0 with network card	NetLens Probe: stand-alone monitor unit
Console	Trakker console: software only (Includes SunNet Manager); requires SPARC workstation	HP 4993A ProbeView console: HP Vectra 386/25 running ProbeView manager software	SniffMaster Console: 386/25 PC running SniffMaster software; kit version (requires 386 PC) available	LANtern Services Manager software console; requires 386 PC running Windows 3.0 with network card	Foundation Manager: software console analyzer; requires OS/2 1.3 or 2.0 with network card	NetLens Analyzer: PC with network card, software; kit version (requires PC) available
Pricing	Segment monitor: $6000; Trakker console: $18,000	HP 4991A LanProbe: $2995; HP 4993A ProbeView console: $10,730; ProbeView manager software: $5000	Sniffer Server (Ethernet): $8995; SniffMaster Console: $16,995	LANtern Network Monitor: $4495; LANtern Services Manager: $4995	Cornerstone Agent: $1295; Foundation Manager: $8995	NetLens Probe: $3995; NetLens Analyzer: $15,990
Topology support						
Ethernet	•	•	•	•	•	•
Thin-wire Ethernet	•	•	•	•	•	•
10Base-T	•	o	•	•	•	•
Token Ring	o	o	•	o	•	•
ARCnet	o	o	o	o	o	o
LocalTalk	o	o	o	o	o	o
Mixed-segment topologies	N/A	o	•	N/A	•	o
Protocol support						
Seven-layer decodes	TCP/IP, NFS, DECnet, LAT	TCP/IP, AppleTalk, NetWare, Banyan Vines, DECnet, OSI, 3Com, XNS	TCP/IP, NetWare, Sun NFS, PC-LAN, DECnet, AppleTalk, XNS, X.25, ISO, Banyan Vines	None	TCP/IP, NetWare, LAN Manager, AppleTalk, PC-LAN, DECnet, 3Com	TCP/IP, NetWare, AppleTalk, 3Com, PC-LAN, DECnet
Decodes	TCP/IP, DECnet, AppleTalk, IPX, OSI, Banyan Vines, SNA	TCP/IP, AppleTalk, NetWare, Banyan Vines, DECnet, OSI, 3Com, XNS	TCP/IP, NetWare, Sun NFS, PC-LAN, DECnet, AppleTalk, XNS, X.25, ISO, Banyan Vines	None	TCP/IP, NetWare, LAN Manager, AppleTalk, PC-LAN, Banyan Vines, DECnet, 3Com, SNA, XNS	TCP/IP, NetWare, AppleTalk, PC-LAN, ISO, DECnet, 3Com
Link-layer monitoring	All link-level protocols	All link-level protocols	All link-level protocols	All link-level protocols	All link-level protocols	Banyan Vines, SNA, XNS
Management protocols						
SNMP alarms	•	•	•	•	•	•
SNMP MIB support	MIB I	MIB I, MIB II	MIB I	MIB I, MIB II	MIB I, MIB II, RMON	MIB I, MIB II, RMON
Monitoring and alarms						
Node statistics	•	•	•	•	•	•
Segment statistics	•	•	•	•	•	•
Networkwide statistics	•	•	•	•	•	•
Network load	•	•	•	•	•	•
Broadcast rate	•	•	•	•	o	•
Short-packet rate	•	•	•	•	o	•
Collision rate	•	•	•	•	o	•
Unknown station	•	•	•	•	o	•
Duplicate address	•	•	•	•	o	•
Cable break	o	o	•	o	o	•
Display capabilities						
Network map	•	•	o	•	•	o
Filtered packets	•	•	•	•	•	•
Network usage	•	•	•	•	•	•
Packet statistics	•	•	•	•	•	•
Error statistics	•	•	•	•	•	•
Miscellaneous						
Out-of-band communication	o	•	•	•	o	•
Remote monitor configuration	o	•	•	•	•	o

processed to present network administrators, sitting at central consoles, with a variety of information about their networks. The most sophisticated systems can provide an analysis that decodes packets at all seven layers, covering much more than network hardware.

Network General's DSS takes a somewhat different approach from the other monitoring systems. Most of them simply capture data on the distributed probes and communicate packets or filtered packets back to the console monitor, where all analysis takes place. DSS, on the other hand, conducts both capture and analysis on the remote devices; the central console is simply a viewer that enables you to electronically visit remote monitors on the network.

Concord Communications' Trakker is a hybrid of the architecture of the DSS and probe-based systems. Trakker conducts much of its high-level analysis at its remote segment monitors.

All these systems work alongside SNMP consoles and manageable devices. Many of these devices support the common MIB (management information base) databases of SNMP, including MIB I and MIB II. In theory, at least, that means you should be able to share network tracking data among probes from different vendors. However, only ProTools' Network Control Series and TTC's NetLens Analyzer support SNMP's remote network monitor MIB, RMON, which will probably be the first practical vendor-independent platform for sharing data among probes. (HP's recently announced LANProbe II, not included in this review, also supports RMON.)

In a comparison of distributed monitoring systems, at least two factors are absolutely critical. First, the system must support your physical network topology and be able to decode the protocols you use. The systems support a wide range of protocol families, so the protocol requirement is usually easily met. However, many systems are limited to one of a few types of physical topologies, and only a few systems will let you monitor various network types simultaneously.

Second, consider the cost of each system and the related costs of its requirements. Most have both a hardware and a software component, and support requirements can range from a 386SX-based PC to a Sun Microsystems workstation.

In the following sections, each reviewer presents his perspective on a distributed monitoring system based on personal experience. You will find the details of protocol support, prices, and configuration summed up in the features table.

Concord Communications' Trakker

Bruce H. Hunter

Here's what Unix network people really need: a mechanism that makes it possible to watch each network segment, in real time, without interfering with the network. Indigenous Unix tools like `etherfind`, `netstat`, and `ping` don't cut it, as most of them are limited in scope and operate on a single protocol layer. Other tools are available, but these often require network polling, adding to network traffic—something that administrators are constantly trying to minimize in the first place. And even if you have the most comprehensive tool set, you won't have all the information you need, because these independent tools were not designed to work together. Sun Microsystems' SunNet Manager was a step in the right direction, but it requires agents to interface network elements with SunNet Manager, and such agents may be hard to come by.

Concord Communications' Trakker is, finally, the realization of an ideal Unix network tool. It monitors the network at all times without slowing it with constant polling. It operates at all internetwork protocol layers, decoding most protocol families. And most important, it ties all its capabilities together under the capable orchestration of a single monitoring console.

Architecture

Trakker uses dedicated microcomputers (called *segment monitors*) to monitor each segment. Each of these small (12- by 12- by 3½-inch) 20-MIPS machines attaches to a network segment or subnetwork through a standard MAU (multistation access unit). Segment monitors don't require a video monitor or keyboard except during setup.

Segment monitors work with Trakker software that runs on a central SPARC system under SunNet Manager. As system administrator, you monitor all network activity through this central Trakker console.

Segment monitors analyze network transmissions, storing the results in Trakker's MIB. The Trakker console gathers information from the MIBs stored by each segment monitor. There are literally thousands of data objects in Trakker's MIB; these objects are further divided into sections based on protocol suites. Trakker monitors can also detect alarm conditions and send a notice to the console through an SNMP agent. Trakker coordinates all its information through intelligent analysis software, using its knowledge of each protocol to map communications from several protocol layers into dialogues between nodes on the multisegment network.

Real-Life Trakker

Installing any system this far-reaching is bound to take time and effort. Installing the segment monitors takes very little time, but preparing the console monitor is nontrivial. You will have to regenerate some kernel options, enabling semaphores and using a generous setting for `maxusers`. Concord Communications recommends 24 MB of real memory, along with 10 MB of disk space for the product and 72 MB of swap space.

Trakker's segment monitors run $6000 each, and you'll need one for each segment. The Trakker software will run you an additional $18,000, but if you already own SunNet Manager, you may be able to talk a deal.

Trakker ran error-free as I evaluated its capabilities on my company's Unix network, which consists of a large number of workstations. Trakker never hung or got confused, and it never did anything untidy. Even more amazing, it blessed me with error-free operation in spite of my inexperience with the tool.

I was surprised at how many minor problems I picked up on our well-designed and well-tuned network. I found time daemons taking much too much CPU time, persistent error messages from an NFS (Network File System) client trying to access a file that was no longer there, and similar errors that would have gone undetected without Trakker. Most valuable of all, I was able to track my NFS traffic day by day; I got a look at the real work habits of my users, noting how constantly and predictably they loaded each segment. It was clear that if we used Trakker over a prolonged period, we could postpone the expense of another network redesign by fixing the errors Trakker showed us and redistributing the workload accordingly.

What struck home for me was Trakker's convenience. Once it's set up, it's permanent. Analysis tools like protocol analyzers, in contrast, are clumsy, because you have to lug them around and plug them into whatever network segments you need to analyze.

One thing I appreciated most as a Unix system administrator was that I could use Trakker from the Unix side of the network. The monitor program we use for our concentrators is a fine tool, but because it runs on DOS, it's not readily available to anyone but the network administrator. However, on today's networked sites, Unix system administrators also need access to network tools, since about 70 percent of their work is network-related.

Documentation and Help

Trakker's voluminous documentation is thorough and excellent. You get separate guides to installing the segment monitor, monitoring TCP/IP and NFS, and tracing; there are also individual guides to LAT, DECnet, and the data-link layer.

Some guides (e.g., the Internet monitor guide) are so thorough they provide a review of the basics of network protocols, encapsulation, and network layering for both the TCP/IP and OSI stacks. I was able to cover all the documentation in just two evenings, including a quick review of the console user's guide, which I needed after using the tool for the first time. Besides the printed manuals, Trakker also includes an excellent, hypertext-based help tool built on FrameMaker.

Dazzling Scope

Trakker's most important feature is its ability to work at all network layers and with all protocols. Early network analyzers could not easily format protocol layers above the data-link layer. Later analyzers and monitors improved, but none of them can compare with Trakker, which tracks down the TCP/IP family, the UDP family (including NFS), DECnet, and LAT. Trakker also offers link-level monitoring of NetWare, AppleTalk, and PC-Net protocols. In addition, Trakker formats protocol information before presenting it to the administrator, so you don't have to be intimately familiar with the details of each protocol.

The dazzling scope of Trakker's abilities is, in the long run, its most impressive attribute. Monitoring all protocols at all layers, Trakker offers the functions of most basic Unix network tools, as well as the capability of a protocol analyzer and network monitor. Trakker is easy to use, and once installed, it stays installed; it's a clean solution. It requires little maintenance and takes no toll on the network it's entrusted to watch. And while not inexpensive, Trakker costs less than the tools and software needed to duplicate its functions piecemeal.

Bruce H. Hunter of Folsom, California, has been a Unix systems administrator for over 12 years. He is the author of seven books, the latest of which is Unix Systems: Advanced Administration and Management *(Macmillan, 1991). You can reach him on BIX c/o "editors" or on Internet at editors@bytepb.byte.com.*

Hewlett-Packard's LanProbe System

Tom Mahoney

Comprehensive network management strategies require three main components: instrumentation to collect performance data, an integrated network management platform, and integrated database applications. HP's LanProbe distributed analysis system provides instrumentation for Ethernet networks. It also sets the framework for an integrated management platform.

LanProbe System consists of one or more Ethernet monitors, or LanProbes, that attach directly to thin or thick coaxial cable or, via an external transceiver, to fiber-optic or unshielded twisted-pair cabling. Each LanProbe monitors one Ethernet segment. LanProbes report network activity to a central console, an IBM AT or PS/2 workstation running ProbeView, HP's Windows-based monitor program. (HP also offers a fully configured HP Vectra PC as a console option.)

Using LanProbe

Installing and configuring the LanProbes is a cumbersome and time-consuming procedure; you need to determine and configure an IP address for each one. You must also configure each LanProbe for the specific medium, setting each for twisted-pair, coaxial, or fiber-optic cabling. As I set up LanProbe on Connect Computer's corporate LAN, I had a few problems with these requirements. Dealing with media incompatibility required assistance from HP technical support, which provided helpful advice.

Once past the messy setup, LanProbe performed well and was very easy to use. ProbeView runs as a Windows application and makes good use of its GUI. ProbeView provides basic and detailed information about Ethernet LAN performance. It monitors vital LAN parameters and gathers useful statistics, such as valid packets, collisions, errors, and broadcasts. ProbeView displays current activity levels of individual nodes as well as overall performance trends.

LanProbes can communicate with the ProbeView console through either the network or remote (out-of-band) connections. Remote probes connect through a dial-up connection or a data switch. A program called ProbeView Alert Manager handles remote control of each probe, allowing the network administrator to configure each monitor and set access passwords.

Each LanProbe comes with an internal 2400-bps modem. As an alternative, you can attach a faster external modem to the RS-232 serial connection. HP's built-in modem provides data compression to speed up data transfer; still, LanProbe's remote operation is intended for downloading accumulated statistics at periodic intervals, not for continuous reporting. To make collecting data easier, the ProbeView console can initiate an automatic download from each probe at predefined times.

There is no real limit to the number of probes that can report to a single console; the probes-per-console limit is more an issue of network management philosophy. For example, in a decentralized environment, a company division may want to monitor its own networks using a small number of LanProbes. In a highly centralized company, on the other hand, all network information can be forwarded to a single group. HP claims that one of its customers runs 75 LanProbes reporting to a single ProbeView console.

Protocol Support

LanProbe monitors a wide array of protocols in many different families, including TCP/IP, OSI (Open Systems Interconnection), NetWare, Banyan Vines, DECnet, AppleTalk, and XNS stacks. The LanProbe monitor is limited to Ethernet networks at the data-link layer, however, handling 802.2, 802.3, and SNAP protocols.

If you want to decode packets, you'll

need to purchase the ProbeView Protocol Analysis option from HP. The analysis software allows you to decode and examine packets; it includes a library of 28 filters to enable searching for specific types of packets.

LanProbe System also provides information about network utilization, valid packets per second, valid bytes per second, broadcast packets per second, errors per second, and collisions per second. It maintains trend data about various network parameters, such as valid packets, multicasts, broadcasts, CRC (cyclic redundancy check) and alignment errors, collisions, and jabber.

LanProbes can deliver alerts (HP jargon for alarms) to the ProbeView console when a significant network event occurs. An alert might signal, for example, that network collisions exceeded a threshold or that a log buffer reached maximum capacity. Alerts include the type, date, and time of the triggering event and the segment and network where the alert occurred. When an alert has been received, the Alert Manager icon pulses red, with an accompanying beep; you can read the alert message by simply clicking on the icon. All alerts are automatically logged.

LanProbe includes solid SNMP support. The ProbeView Alert Manager will forward alerts to SNMP management stations on the network regarding cable test alerts, relevant echo alerts, duplicate IP alerts, and statistics alerts. ProbeView will also forward the SNMP MIB data maintained by agent devices when polled by an SNMP management console and send SNMP traps when alert thresholds are exceeded.

Pluses and Minuses

The most useful feature of the LanProbe System is its ability to present current or daily trend data in a clear, concise graphical format. The daily trend option enables you to view trends over a 30-hour period. Another strength is ProbeView's Windows orientation; an export option from ProbeView lets you easily transfer monitor data to other Windows applications.

The LanProbe System has its limitations. The initial setup takes a considerable amount of time. Also, LanProbe does not support Token Ring LANs, at a time when most large corporate environments have heterogeneous networks that require an integrated approach to network management.

LanProbe isn't cheap, but compared to some of the more full-featured analysis systems like Trakker and the Network Control Series, it's an economical alternative. Each LanProbe sells for $2995, and the ProbeView software costs $5000. The optional Protocol Analysis capability is another $2000. HP will supply a turnkey Vectra 386 system ($10,730) as the console, or you can buy a compatible 386-based system.

LanProbe has a role to play as a key data-gathering subsystem in a comprehensive network management system. Its SNMP support and forwarding of SNMP alerts are important attributes. But for sophisticated protocol debugging and troubleshooting, systems such as Network General's Sniffer or HP's own Network Advisor are probably better tools. LanProbe lets you capture data on monitoring activity, save it, and export it to Network Advisor.

Tom Mahoney is a senior consultant with Connect Computer Co. in Eden Prairie, Minnesota. He's had over 10 years' direct experience with LANs and extensive experience in the areas of strategic systems planning, internetwork design and implementation, systems integration, and network management. You can contact him on BIX c/o "editors."

Network General's Distributed Sniffer System

Michael Hurwicz

Somewhere, deep in the heart of the mathematical chaos that rules the universe, it is written that network problems will always multiply faster than network gurus. Budgets for guru artillery, such as protocol analyzers, follow equally perverse laws. The result is the familiar sight of the lone network troubleshooter racing from glitch to glitch with protocol analyzer in hand.

Network General's DSS permits the breathless guru to run less and work more. The DSS is a remote-control protocol-analysis system from the maker of the popular Sniffer protocol analyzer. It combines reliability and high performance with low impact on the network. And for those who currently use Sniffer, the fact that DSS is a Sniffer work-alike is, of course, a major advantage.

Not a Probe

What is the DSS? First, it is not a probe-based system. True, both types of systems capture packets, and both consist of remote units and central consoles. Beneath these surface similarities, however, lies a world of difference.

A probe captures packets and sends summary information or filtered data, or both, back to a central console. The central console then analyzes the data. The DSS also has remote boxes (called Sniffer Servers) that communicate with central consoles (called SniffMaster Consoles). Like probes, Sniffer Servers capture packets. However, in contrast to probes, Sniffer Servers also analyze. The central consoles just act as screens for "movies" generated on Sniffer Servers. No packet-capture data or summary information changes hands.

There is one exception to this rule: Sniffer Servers send SNMP alarms to SniffMaster Consoles, which then consolidate them. SNMP alarm consolidation is a "by-the-way" function for most users, however. It's hardly a sufficient reason for laying out the bucks for a DSS.

Sniffer Servers cost between $5000 and $11,000, depending on configuration. The SniffMaster Console PC board and software cost $7995, and Network General will provide a turnkey system for $16,995. A DSS with two or more Sniffer Servers is always cheaper than the same number of stand-alone Sniffers.

Troubleshooters familiar with the Sniffer will see only minor differences in the DSS. Monitoring functions, which Network General has brought into the Sniffer from its Watchdog Network Monitor product, are also in the DSS. The monitoring function provides statistical summaries of traffic for individual stations and the network as a whole, and it generates alerts when selected variables exceed user-defined limits.

Network Load and Performance

Network General helps ensure reliable communications by allowing users to route DSS communications out of band. There are two ways to do this. First, SniffMaster Consoles can connect to Sniffer Servers via telephone, using modems (at rates of up to 9600 bps). Although screen updates are rather slow in this mode, the phone lines are guaranteed to be 100 percent independent of the LAN. In addition, each Sniffer Server has two LAN adapters: a monitoring adapter and a transport adapter. The transport adapter is used for communicating with the SniffMaster Console, and the

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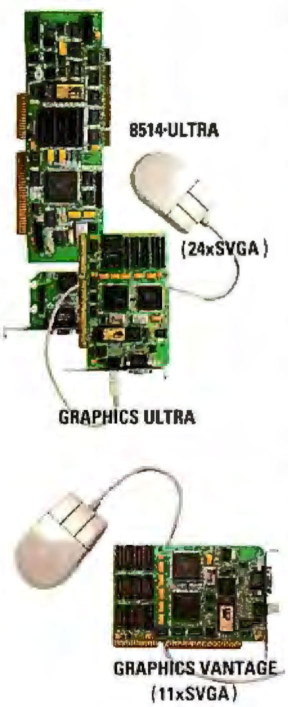

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Perfecting the PC

monitoring adapter is used for monitoring. These two adapters can be on two different networks.

In my tests, I had both the transport adapter and the monitoring adapter on the same network. In this configuration, if the transport adapter put a lot of traffic on the network, it could cause problems. Fortunately, the DSS, by its own count, peaked at less than 0.2 percent network utilization on the 10-Mbps Ethernet network. For comparison, a single IBM PC doing word processing peaked at about 1 percent when saving a file.

Network loading, by the way, is one area where the DSS is preferable to probes. Probes often don't put a tremendous load on the network, because they're configured to capture only packet headers and to filter out all but a few specific types of packets. However, if the console needs to look at a lot of data, a probe can load the network to an unacceptable degree. The DSS, in contrast, uses almost no network bandwidth, no matter how many packets it captures.

Limitations

The DSS is a solid, high-performance, full-function tool that can save you money. However, it does have some limitations.

For one, communication between Sniffer Servers and SniffMaster Consoles depends on particular protocols. Token Ring servers support NetBEUI and NetBIOS over IPX. The Ethernet server supports TCP/IP and NetBIOS over IPX. Network devices such as routers often block NetBIOS packets. If a device, such as a router or bridge, prevents the selected protocol from operating between the DSS server and the console, the troubleshooter will be reduced to using a slow serial connection.

Another limitation is that a single Sniffer Server can provide just one view of the network at any given time. Even though two different consoles can access the same server simultaneously, they'll see the same thing. (Both their keyboards will also control the server.) With probes, on the other hand, each console can request and receive different data or summaries. Those consoles can be configured to display that data in a number of different ways, too. In addition, there's generally no problem with having three, four, or half a dozen consoles controlling and getting information from the same probe, in comparison with the DSS's limit of two consoles per Sniffer Server.

The DSS's segment-by-segment or ring-by-ring view of the network is also a drawback. Since each Sniffer Server sends screen information, not captured packets or summary information, the DSS console is not in a position to consolidate data from multiple segments or rings. (The one exception to this rule is SNMP alarms.) If a router or bridge malfunctions, it's likely to affect all the networks to which it's connected. In a probe-based system, the console could potentially create a list of all rings or segments in which a particular type of error packet exceeds a certain rate. The console could list devices, such as routers, that appear on more than one of those rings or segments. With the DSS, you would have to flip from screen to screen and perform those correlations manually.

Let Gurus Guru

The DSS should have great attractions for current Sniffer users who have multiple geographically dispersed networks and not enough protocol-analysis gurus to go around. It will enable gurus to respond to problems from a central console, making

responses quicker, avoiding travel expenses, and allowing gurus to concentrate on guruing rather than sprinting.

On the other hand, if you're not committed to a particular protocol-analysis tool, consider a probe-based system as an alternative. Probe-based systems are likely to be less expensive, and in some ways they're more flexible than the DSS.

Michael Hurwicz, a consultant and writer in Eastsound, Washington, specializes in LANs and E-mail. You can contact him via MCI Mail, SprintMail, or AT&T Mail as "mhurwicz" and on BIX c/o "editors."

Novell's LANtern

Steve Larson

Novell's offering for centralized network management for large Ethernet internetworks is LANtern, a sophisticated tool made easy to use by a well-designed user interface. It provides network managers with information for everyday maintenance and also offers diagnostic functions for the "everyday" emergency. There are two components to LANtern: the LANtern Network Monitor, a rack-mountable data-collection device that connects to an Ethernet segment, and the LANtern Services Manager, the companion management software that gathers and interprets network data.

Lighting Up LANtern

Installation of the LANtern Network Monitor is simple plug-and-play: Just connect a transceiver from the port on the back of the device to your Ethernet segment. Once the connection is made, the data light on the monitor begins to flash immediately, indicating data collection. The network monitor runs on thick, thin, or twisted-pair Ethernet networks.

The LANtern Services Manager requires a powerful hardware platform: a 386-based PC running Windows 3.0 or higher and a network card with an ODI (Open Data-link Interface) driver. The ODI requirement is where some users may have problems. If you're lucky enough to be using one of the cards that the Services Manager supports out of the box (i.e., Novell and 3Com cards), the software automatically sets up the drivers for you. If you use any other kind of card, you'll have to acquire a driver and obtain configuration information from the manufacturer.

The LANtern Services Manager can communicate with the network monitors by various methods: serially via a null modem cable from a PC to a network monitor, via dial-up by attaching a modem to the monitor's serial port, or over the LAN using IP. Clearly, IP is the preferred option for performance.

When communicating on the LAN, the Services Manager automatically detects any LANtern Network Monitors that are connected to a local Ethernet segment. For the Services Manager to detect monitors connected to other Ethernet segments, your LAN must be bridged or have a router that will pass IP packets.

I tested LANtern on the twisted-pair network of Connect Computer, using a third-party network card in a 20-MHz 386SX-based Services Manager console workstation. I recommend a faster machine, as system response time was slow when LANtern displayed several graphs simultaneously. I configured two Network Monitors on Connect's home-office LAN, one on each of our bridged Ethernet segments. Once problems with the setup of the ODI drivers were rectified, the Services Manager was able to automatically detect both Network Monitors on our network. For testing purposes, I also hooked up one Network Monitor via a null modem cable. Serial communication was slow but acceptable on an isolated basis; you wouldn't want to use serial communications as an everyday option.

Tracking Statistics

LANtern can track several protocols, including IP, IPX, and DECnet. I used a Novell LANalyzer to place packets of various protocols on our test network with varying levels of traffic. The LANtern Network Monitor detected and tracked everything I sent to it, which included IPX, XNS, DECnet, SNA, and other protocols. For the advanced administrator, the ability to track these different protocols on a large Ethernet internetwork is essential for maintaining proper network performance levels. Particularly impressive is the Services Manager's real-time utilization tracking of a segment.

LANtern's statistics tracking is very good; the system stores statistics records in Btrieve databases on the Services Manager console. Novell has made it easy for less experienced administrators, as well as seasoned network pros, to scan LANtern's vast databases. The Services Manager includes a long list of preset statistics combinations, which you can view as a real-time graph. These combinations allow even a relative novice to find trends in what might otherwise be a heap of obscure statistics.

One particularly useful feature is LANtern's ability to make customized real-time graphs based on statistics you select. There is also an option to generate a list of Ethernet devices describing protocol, packet destination, MAC (media access control) address, and many other statistics. This feature lets you track the activity of a single network device. One useful option that LANtern unfortunately lacks is a way to display information graphically on stations specified by protocol.

LANtern includes alarm support for parameters that exceed user-defined thresholds. This allows the manager of a large internetwork to receive alarms of network conditions before they reach a critical stage, as well as receive alarms that indicate current problems. A bar graph provides an easy way to set thresholds for visual, audio, and logged alarms. LANtern can generate an alarm on utilization thresholds, CRC (cyclic redundancy check) errors, local collisions, remote collisions, short and long packets, jabber, and other typical transmission errors.

There are no preset limits on the number of Network Monitors that the Services Manager can track; it's purely a function of the amount of available disk space on the console. If you track a lot of data, LANtern's Btrieve databases can quickly outgrow available disk space.

Check It Out

Overall, LANtern's statistics tracking and diagnostic features are very good. Anticipating that some users may be intimidated by the wide range of data that LANtern collects, Novell has created a Services Manager interface that's easy to use. Basic statistics analysis is well documented in the user's guide for the Services Manager, so anyone can use this system after spending a couple of hours with the system manuals.

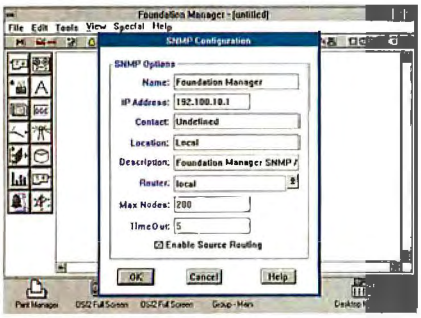
The documentation has some shortcomings. The system manuals should offer more troubleshooting documentation for dealing with installation problems. Further, although LANtern was able to pick up all the protocols we used for testing, the system documentation on all the protocols supported is sparse. More details on protocol support would be useful.

LANtern Network Monitors cost $4495. Novell also offers an entry-level version called the LANtern Network Monitor LTD, which is limited to monitoring a

maximum of 32 stations, for $2495. LANtern Services Manager software sells for $4995.

All in all, LANtern Network Monitor and LANtern Services Manager constitute an excellent product for proactive Ethernet internetwork management. It's easy to use, and it ran without problems.

Steve Larson is a systems engineer at Connect Computer Co. in Eden Prairie, Minnesota. He has more than five years of internetwork design, implementation, and troubleshooting experience, and specializes in WANs, network-to-mainframe communications, and applications integration. You can contact him on BIX c/o "editors."



ProTools' Network Control Series

Barry Nance

The growth of my company, PRC, has forced us to move 18 people, along with a file server, into a new office across the street. Novell's Async Remote Router created a WAN link between our old and new LANs, and ProTools' NCS (Network Control Series) let me monitor the two networks from my desk. I wanted to make sure both the LANs and the link between them stayed healthy during the reconfiguration of PRC's networks. BYTE asked me to review NCS at just the right time.

NCS is a software-only product, consisting of two modules: FM (Foundation Manager) and CA (Cornerstone Agent). FM sells for $8995; each CA (one per segment) will run you $1295. You use FM as a master console and CA as a remote slave on each outlying network. Both components require a 25-MHz 386-based computer running OS/2 1.3 or 2.0. You must also use a Token Ring adapter that offers a "promiscuous" mode of operation. This mode lets applications software see all the frames that circulate the LAN; Proteon, Olicom, Ungermann-Bass, IBM, and Compaq all make such devices. You can also use NCS on Ethernet LANs with a wide variety of Ethernet network adapters.

Multiple FMs can share data; for example, one FM node running Token Ring and another running Ethernet can share and report statistical data from each LAN. You'd need to set up a Token Ring/Ethernet bridge in this situation to let NCS process the network management packets from the other LAN.

Each CA gathers statistics on its LAN and reports results, on request, to the central FM. FM and CA use SNMP to exchange statistics. The components did not appear to slow our router's performance, but you can configure FM and CA to exchange data less frequently if you find that NCS's internal communications are putting a significant load on your network.

CA can operate by itself on the local console. You can monitor network loads, set alarms, or generate a map of the nodes on CA's segment. According to ProTools, CA can also report its findings to any SNMP console that uses RMON, MIB I, or MIB II.

Up and Running

You use your own PCs, copies of OS/2, and network adapters to run NCS. You'll want to plan ahead to make sure all the pieces are ready at the right time. Installation itself is a snap. The documentation includes a Customer Information Guide for obtaining technical support, a Getting Started Guide with installation steps and tutorials, and a thorough User's Guide.

NCS decodes MAC control frames, SNMP, TCP/IP, XNS/IPX, NetBIOS, NetWare NCP, IBM/Microsoft SMBs, Banyan Vines, IBM SNA, and DECnet protocols. You can associate a different name with each network node (ProTools says that future versions of NCS will be able to obtain these names automatically from the network operating system), and NCS uses DDE to exchange data with products like Microsoft Excel. NCS can also import frame-capture files from Network General's Sniffer.

NCS's menu options are SAA/CUA (Systems Application Architecture/Common User Access) compliant, but the toolbar of icons gives you the quickest access to NCS functions. The Acquire icon tells NCS to begin capturing frames. The Playback icon sends previously acquired frames across the LAN. The Remote icon connects FM to one of up to 256 remote agents (e.g., a CA). The DDE icon lets you export NCS statistics. The Transmit icon lets you generate network traffic; it's password-protected.

You use the Alarm icon to set up thresholds to tell NCS to notify you when MAC-layer error frames, high network load, or unusually large or small frames occur. The Filter icon lets you categorize and see frames between specific nodes or categories of nodes on the LAN.

The Map icon shows a graphical display of the nodes on the LAN. You can see total traffic or, with filtering, traffic between specific nodes or kinds of nodes. The Statistics icon lets you see up to 16 simultaneous summaries of network and workstation activity, including frame-size distribution, errors, and network load.

One of NCS's nicest qualities is its strong graphical orientation. For example, you set up filtering by graphically attaching filters through a visual programming tool.

NCS in Action

The first thing you should do with a network analyzer is baseline your LAN, to establish what's normal for your network. NCS offers automatic baselining—a nice feature. After you let NCS observe your LAN, it automatically sets up alarm thresholds for you.

The next most handy feature of NCS is GeoGraph. When you drag the Map icon to the main window, NCS draws a map of your LAN (local or remote). You see the message traffic between nodes on the LAN in real time; you can instantly see who is hogging the network.

If you're not an expert LAN troubleshooter, don't worry—NCS's Network Consultant screens, in OS/2 hypertext (.INF) format, offer a range of helpful advice. For each of about 35 typical problems, you see symptoms, a problem description, and a proposed solution. NCS ships with a list of solution files, and ProTools says that it will continually expand the list of typical problems and solutions in the database. A partial list of problems ("B" through "C" in the NCS help file) shows entries for broadcast storm, buffer overflow, cable fault, cache problems, and connector fault.

Problem descriptions are detailed and comprehensive, and they are obviously written for a general audience. A typical description for cable fault suggests that the faulty cable may be lying next to vibrating equipment or may be too near a device that generates electrical noise.

ProTools designed FM and CA to help you proactively prevent network problems. Both modules do a good job of decoding and analyzing LAN packets at all levels. The statistical reporting functions enable you to view bar graphs and tables depicting your network's workload in a very useful fashion.

continued

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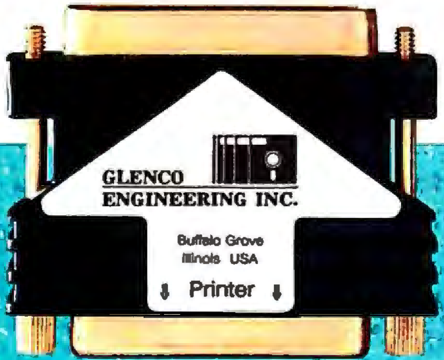

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TTC's NetLens Analyzer and NetLens Probe

Barry Nance

TTC's distributed LAN-monitoring tools allowed me to watch over the same process I analyzed with ProTools' NCS: the creation of another segment in PRC's LAN. As with NCS, it was an ideal time to review a distributed monitoring system.

Two NetLens Probes accompanied the NetLens Analyzer. The NetLens Analyzer is a Compaq Portable III running Compaq DOS 3.31 with 640 KB of RAM and a Token Ring board. The NetLens Probes are self-contained devices (not PCs) that you attach to each remote LAN. The NetLens Analyzer acts as a central console from which you can see activity from each of the network segments. The NetLens Analyzer queries the NetLens Probes on each segment to gather LAN traffic data. A proprietary TTC protocol carries data between the analyzer and the probes. TTC offers both Token Ring and Ethernet versions; however, a single analyzer and its probes can monitor only one type of physical network.

Although the NetLens Probes must send captured packets back to the NetLens Analyzer for analysis and decoding, I didn't notice any performance problems. Communication between Probes and Analyzer using the TTC communication protocol on our Token Ring LANs didn't hamper the passage of normal NetWare traffic through the router.

Token Ring NetLens Probes cost $3995 each, and you'll need one for each ring. The NetLens Analyzer, including the host console, costs $15,990. The company also sells a NetLens Analyzer kit, consisting of a network adapter and software you install in one of your own PCs, for $12,450. TTC's network adapter, built into the NetLens Analyzer I reviewed, contains an on-board 80186 CPU running at 16 MHz, as well as a Texas Instruments TMS380 Token Ring controller chip.

Installation and Configuration

Installing the TTC products is a simple matter of attaching them to your LAN. If you need to reconfigure a NetLens Probe, you connect an asynchronous terminal, or a PC running communications software, to the Probe's serial port. To install the NetLens Analyzer computer, you connect a LAN cable to its network adapter.

The TTC documentation doesn't assume that you're a networking expert. The user's guide clearly spells out how to run the different tests, and the Packets and Protocols booklet helpfully explains the underlying theory on which NetLens Analyzer works.

The NetLens Analyzer can decode TCP/IP and UDP, MAC frames, LLC, ISO, CONS/CLNS, Banyan Vines, IPX, NetBIOS, and NFS protocols. The NetLens Analyzer model that I evaluated also decodes the higher-level NetWare NCP, IBM/Microsoft SMBs, and IBM SNA protocols. You use the TADDMOD utility to associate names with the individual node addresses on your LANs. The TMAKE123 utility does a good job of converting test results into files that you can import into Lotus 1-2-3.

Living with NetLens

The menu options for NetLens Analyzer are traffic-display modes. You can choose alarms, development, performance, statistics, summary, test, traffic generation, open, and errors. You use the alarms mode to warn you about error conditions on the local or remote network, selecting from a variety of conditions. You can set an alarm to tell you when network traffic gets above a certain level, the rate of MAC error frames exceeds a certain threshold, a new station joins the ring, a station has not transmitted anything for a long time, the ring is beaconing, a station has lost contact with a neighbor, or the active monitor has failed.

The development mode lets you debug a new protocol or IPX/NetBIOS application if you're writing software that sends and receives packets. Performance mode can show either packets per second or network load. Summary mode shows average load, peak load, and error rate. The other modes offer similar summary-level information. NetLens Analyzer has a facility to log all frames to a disk file so that you can look at them later. NetLens Analyzer implements password protection to prevent unauthorized use of the traffic generator or the development-mode analyzer function.

To activate remote probes, you choose one or more (by name if you've configured it that way; otherwise, by network address) from a list of up to 50 remote devices. Except for the open test, which you can't run remotely, all the NetLens Analyzer modes operate the same way whether you are monitoring a remote probe or

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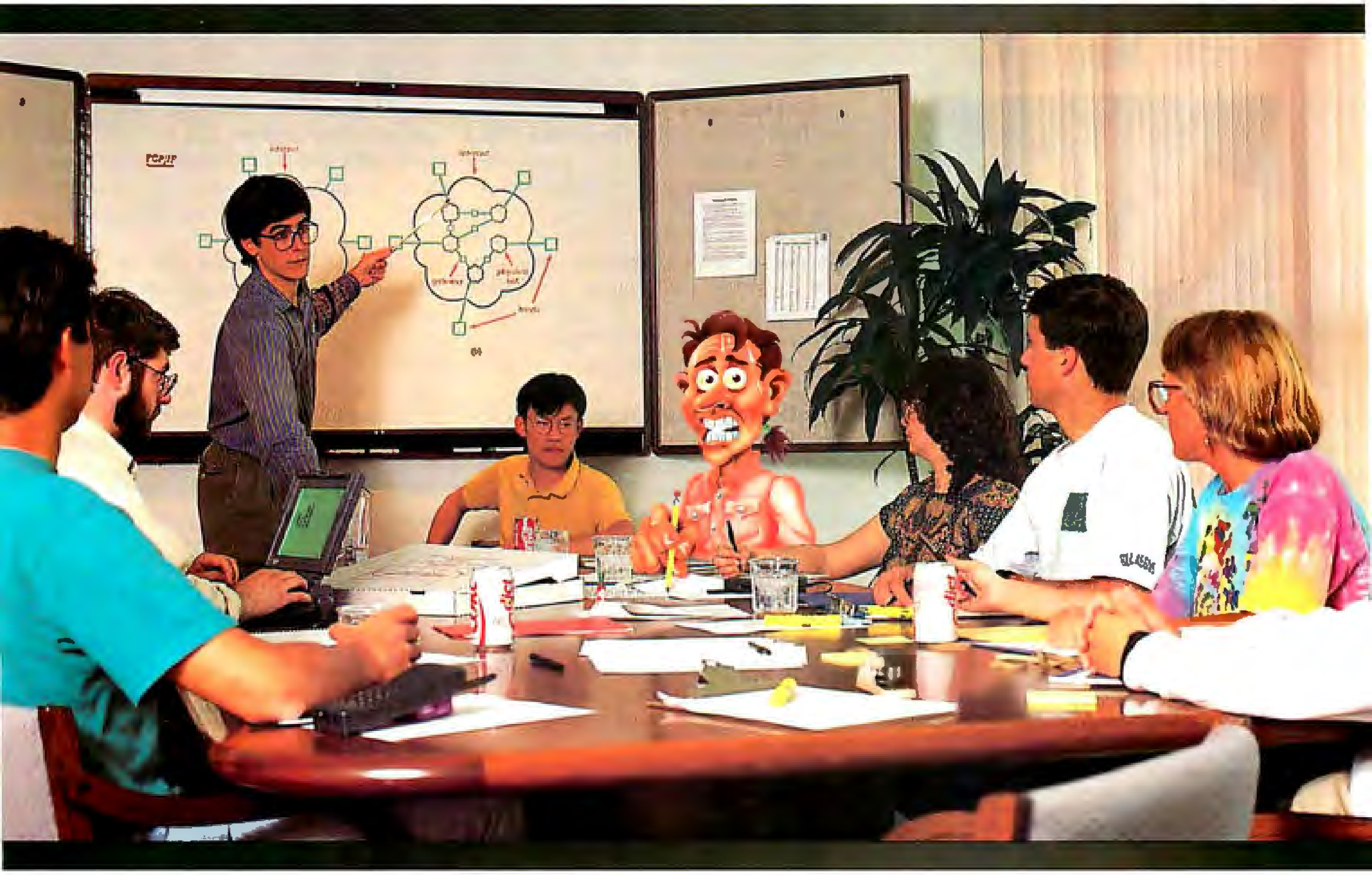

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running locally on the analyzer. When you're connected to a remote probe, the NetLens Analyzer screen shows a happy face that blinks to indicate that the connection is still active.

Protocol analyzers show LAN traffic; it's up to you to figure out how the traffic relates to the work you do in your office. The first step is to baseline your LAN. I used the NetLens Analyzer's statistics mode to baseline both the local and remote networks. After a half-day of monitoring, I used the figures from the full-statistics screen to set alarm thresholds for both networks. From my desk, I could watch the critical link between the routers, as well as the file server on the remote network. I could monitor traffic at other nodes, too.

NetLens Analyzer's detection and display of Token Ring faults is its strongest feature in a Token Ring network. The analyzer maintained an accurate log of all the errors that occurred on each LAN—receiver congestion, line errors, burst errors, and things like that. For example, NetLens Analyzer showed a pattern of receiver congestion errors at one of the remote workstations. I then installed a better-performing network adapter in the office across the street. The next time I fired up NetLens Analyzer, it told me I had cured the problem.

A Useful Tool

In standard configuration, the NetLens Analyzer and NetLens Probes decode four layers of protocol, up through the transport layer of the Open Systems Interconnection reference model. Decoding all seven layers, which you'd want if, for example, you need to see file-redirection packets, is an option. The protocol support in the standard configuration is more than adequate for diagnosing and isolating hardware problems and for analyzing network traffic loads.

With the TTC system, you have to do the work of associating names with network nodes and determining what's normal for your network. You also have to spend the time and effort to understand and analyze the network message traffic. Overall, though, I found NetLens Analyzer a reliable, useful tool. And the well-written documentation helped me make sense of the LAN activity, both locally and remotely. ■

Barry Nance, a programmer for the past 20 years and a BYTE contributing editor, is the author of Using OS/2 2 *(Que, 1992),* Network Programming in C *(Que, 1990), and* Introduction to Networking *(Que, 1992). Barry is the Exchange Editor for the IBM Exchange on BIX, where you can reach him as "barryn."*

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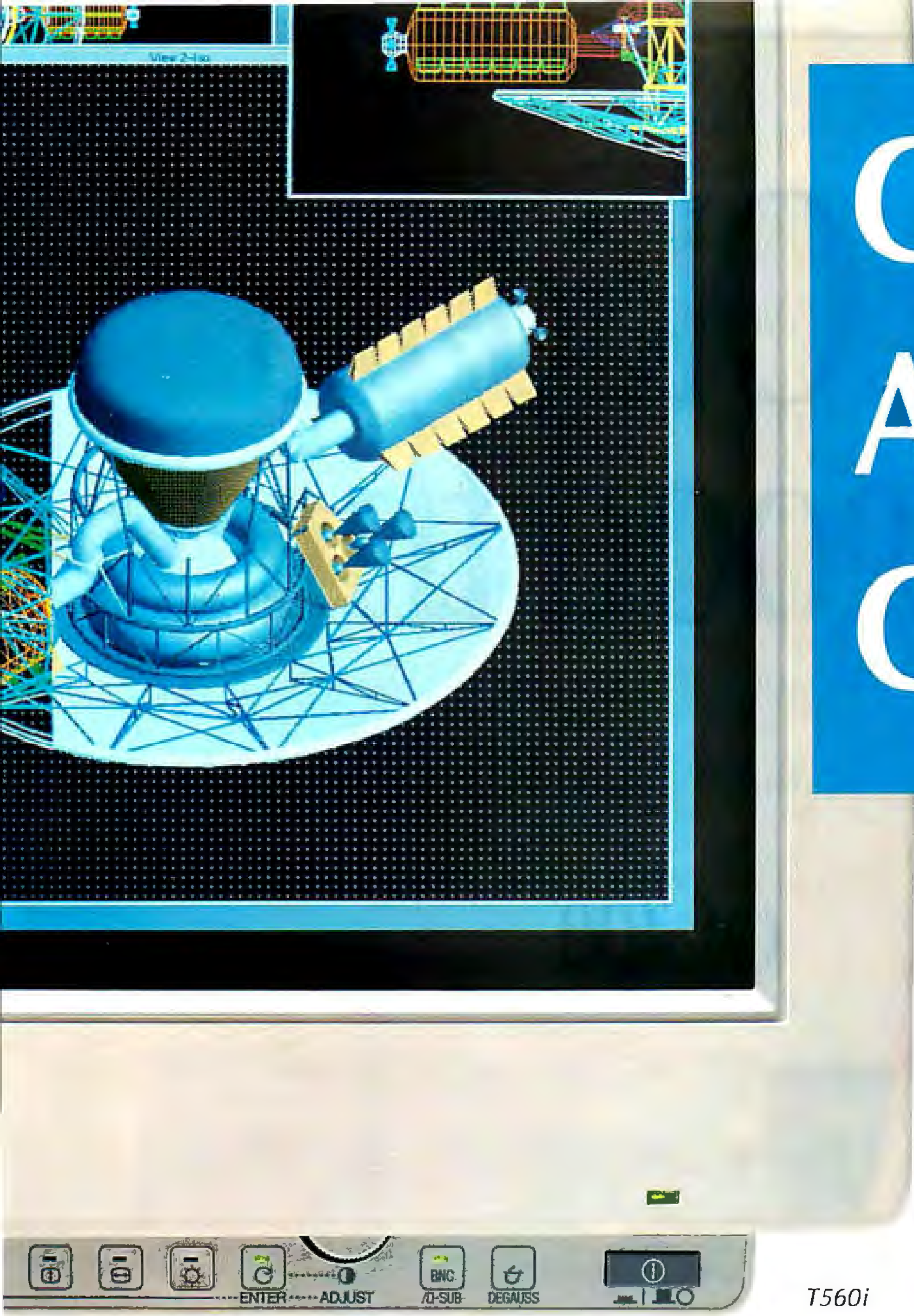

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PostScript's Middle Class

The BYTE Lab tests printers that raise the bar without breaking the bank

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Price, speed, and resolution. These features are at the top of the list when BYTE readers go shopping for a printer. If you need a model capable of handling the PostScript page-description language, price no longer is the obstacle it once was. You can get a good PostScript printer for less than $1500 (see "Penny-Wise PostScript" in the October 1991 BYTE). But what if you're less concerned about price and more interested in getting sharp output at a relatively brisk clip? Then, you need to take a look at the middle class of PostScript printers.

The good news is the list of machines that fall into this category is growing. More manufacturers are adding technology for enhancing the look of printed text, particularly text in small point sizes, without raising prices exorbitantly. They're also incorporating faster processors to boost output rates. While these midrange printers cost more than basic "white bread" PostScript models, prices have fallen to a level that most companies can afford.

In this month's BYTE Lab Product Report, we compare 11 midrange printers that offer PostScript capability with a bit of icing on top: Apple's LaserWriter IIg, Dataproducts' LZR-960, Epson America's EPL-8000, GCC Technologies' BLP IIS, IBM's LaserPrinter 10, LaserMaster's TrueTech 1000/4, Mannesmann Tally's MT-908, NEC Technologies' Silentwriter2 990, NewGen Systems' Turbo PS/400p, Texas Instruments' microLaser Plus PS 17, and XANTE's Accel-a-Writer 8000. For those willing and able to go a step above, we also look at the QMS-PS 1700, a more expensive, high-resolution printer designed for use on a network (see the text box "High Speed, Sharp Graphics, and Lots of Connections" on page 234).

In general, midrange PostScript printers distinguish themselves from penny-wise models by offering print speeds of at least six pages per minute and resolutions of at least 400 dots per inch. (Our list includes a couple of exceptions, but units that don't meet these criteria compensate by providing either enhanced resolution or considerable processing speed.) We chose the current group of printers to give you an idea of the depth and breadth of capabilities covered by the term *PostScript compatible*—and to see just how little or how much you must spend to get better-than-basic PostScript quality.

Our selections present a wide range of features and capabilities: engines from several manufacturers (including one for the GCC Technologies BLP IIS that is based on LED-array technology rather than on laser technology), engine speeds ranging from 4 to 17 ppm, and resolutions from 300 to 1000 dpi. Support for PostScript versions also varies (see the text box "PostScript: Level 2 and Clones" on page 227). List prices start at $1399 for the microLaser Plus PS 17 and climb to $7995 for the QMS-PS 1700, but base price doesn't always provide a good point of comparison. Some manufacturers sell printers ready to run PostScript; others offer PostScript capability or sufficient memory to run PostScript as options that can add several hundred dollars to the price tag.

Drivin' the Toner

At the heart of every printer is an engine. The Canon engine, in its various versions, turns up in half of the review units: the Apple LaserWriter IIg, LaserMaster TrueTech 1000/4, NEC Silentwriter2 990, NewGen Turbo PS/400p, QMS-PS 1700, and XANTE Accel-a-Writer 8000. There's good reason for this engine's popularity. It's easy to maintain, and the toner and drum share a single cartridge that slides easily into the printer. When the toner runs out, you simply replace the entire cartridge. The integration makes the cost of a new cartridge relatively high—replacements retail for around $100—but Canon cartridges are widely available, so you can shop around for the best price. Cartridges also may be recycled, which means you can sell depleted ones to a "remanufacturing" operation and purchase recycled, replenished cartridges for considerably less than the cost of a new one.

Other printers that follow this all-in-one design include the Epson EPL-8000, built around a 10-ppm Minolta engine, and the Lexmark IBM LaserPrinter 10, based on IBM's own 10-ppm engine. Epson and IBM cartridges are not as

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BYTE
Subscription Department
P.O. Box 558
Hightstown, N.J. 08520-9409

widely available as the Canon cartridges, and the prices may run a little higher because they can be used only in printers with those engines. You also will have a harder time selling a used cartridge from one of these printers, because many remanufacturers deal exclusively with Canon cartridges.

The Texas Instruments microLaser Plus PS 17 and the Dataproducts LZR-960 use Sharp engines rated at 9 ppm. Installing these units' separate toner and drum cartridges is a little more difficult than with the simple Canon engine, but it can be more economical because you may replace just the toner or the drum. Further, what you lose in convenience you make up for in efficiency, because printers built around Sharp engines offer a more compact design.

The Mannesmann Tally printer, which has a Konica engine running at 8 ppm, also uses separate drum and toner cartridges, which fit into a lift-out tray. You must work quickly when servicing this machine, however. The photosensitive drum lacks a cover, and prolonged exposure to bright light could damage it.

The Okielectric engine in the GCC BLP IIS uses an alternative technology: an LED array that produces very nice output. This design means that the Okielectric engine is somewhat simpler mechanically and therefore has fewer moving parts that may break. Unfortunately, it is also our least-favorite engine to set up and replenish. The toner comes in a metallic cylinder. To add toner, you remove the old cylinder and pop in a new one, rotating it a half-turn to release the powder into the toner well. The cylinder remains in place, but you may get a bit dirty during refills, because there is no protective case between you and the cylinder.

You Need More Than a Fast Engine

Engine design and ppm ratings are important but, when it comes to PostScript printers, they tell only part of the story. Fast engine speed simply won't be that beneficial if the printer's controller spends a lot of time interpreting the PostScript code before sending it along to the print engine.

To give you the full picture, our suite of benchmarks included start-to-finish printing tests (see the text box "Testing PostScript Speed and Compatibility" on page 232). The fastest printer in the BYTE Lab tests proved to be the QMS-PS 1700, with its 17-ppm engine and 25-MHz Intel 80960CA RISC microprocessor. A laser printer that packs such pure brute force is just what you need for a networked printer. Of course, you pay for this level of performance. The QMS is in a class above the other units

BYTE ACTION SUMMARY

- **WHAT MIDRANGE POSTSCRIPT PRINTERS DO**
  These printers deliver the industry-standard PostScript language (or compatible alternative), relatively fast printing speed, scalable fonts, and high resolution.

- **LIKES**
  Good output, especially crisp text; PostScript compatibility; falling prices.

- **DISLIKES**
  PostScript still is slow. It requires a fast microprocessor and plenty of RAM to keep up with a fast computer. Replacing toner and drums can be expensive.

- **RECOMMENDATIONS**
  Most economical is the TI microLaser Plus PS 17. However, the more expensive Epson EPL-8000 beats the TI at speed and quality of output. Our champion for sharpest output is the 1000-dpi LaserMaster TrueTech 1000/4. If you're shopping for a fast network printer, check out the QMS-PS 1700.

reviewed here and is included as an index of sorts that shows what's available when you go beyond the midrange of PostScript printers.

The fastest truly middle-class printers---candidates more likely to end up on a desktop—are the NEC Silentwriter2 990, the NewGen Turbo PS/400p, and the Dataproducts LZR-960. All use a Weitek RISC processor; the NEC and the Dataproducts use the 8200 running at 16 MHz, while the NewGen has an 8220 running at 16 MHz. All also have reasonably fast engines. The lone printer to use the 16-MHz AMD 29000 RISC processor is the 8-ppm XANTE Accel-a-Writer.

Rounding out the field are the printers that use a variety of Motorola 68000 microprocessors. The fastest of this bunch is the Apple LaserWriter IIg, with a 25-MHz 68030. Behind it are the Texas Instruments microLaser Plus, with a 68000 running at 12.5 MHz, and the IBM, with a 68020 running at 16.7 MHz. Our speed benchmarks clearly illustrate the benefits of coupling RISC processors with reasonably fast print engines.

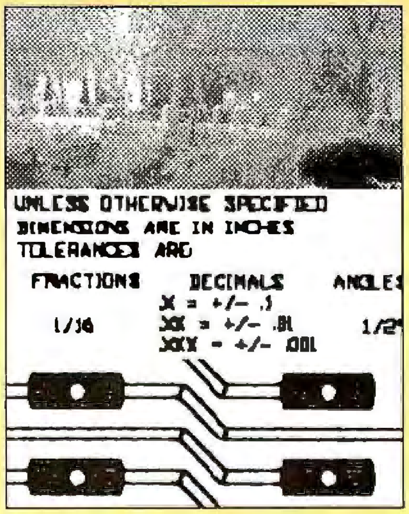
Of course, the final product matters as much as processing time, and all the printers we tested produced good-looking pages of text and graphics. Only after looking intently at the fine details under a magnifying glass were we satisfied that we had singled out the printers capable of producing the highest quality output. (See the text box "Do You Really Need All Those Dots?" on page 230 for guidelines on choosing the printer with the right resolution.)

Eleven midrange printers with such varied capabilities, designs, and features offer a lot to talk about—too much, in fact. In the discussions that follow, we focus on the five midrange models that, in our estimation, are the cream of this middle-class PostScript crop. To see how the remaining six stack up against the top five and our "token" high-end PostScript model—feature for feature and benchmark for benchmark—see the table on page 228 and the figure on page 232.

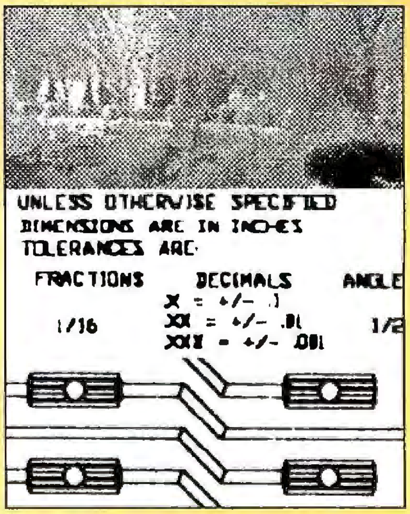
The printers that didn't make the cut certainly aren't slouches. They simply fall short in one respect or another,

HOW THE OUTPUT LOOKS

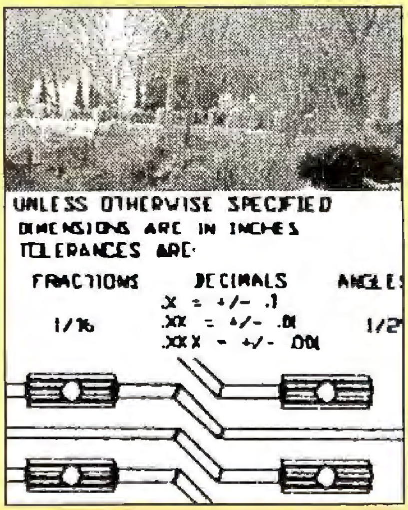
These enlarged output samples show how each printer handles different types of printing jobs. The top row of samples, extracted from the background of a black-and-white photograph, demonstrates each printer's control of contrast and resolution when working with halftone images. The middle row of samples shows how each printer does when dealing with very fine detail; the trick is to print tiny text without filling in the holes of letters such as o *and* e. *The bottom row of samples, a closeup of a diagram of a printed circuit board, shows each printer's ability to produce thin, curved lines and angles. Good toner distribution is one of the keys to successfully printing small text and fine lines; if toner spatters, output suffers. You be the judge.*



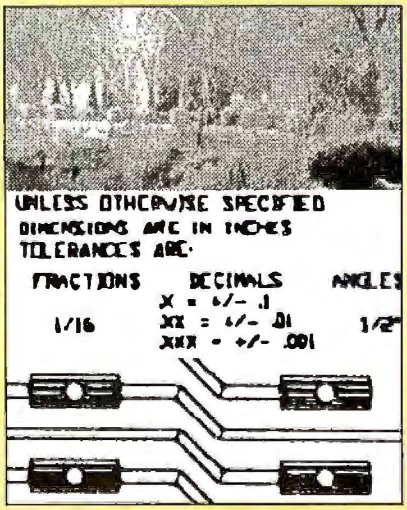
Epson EPL-8000



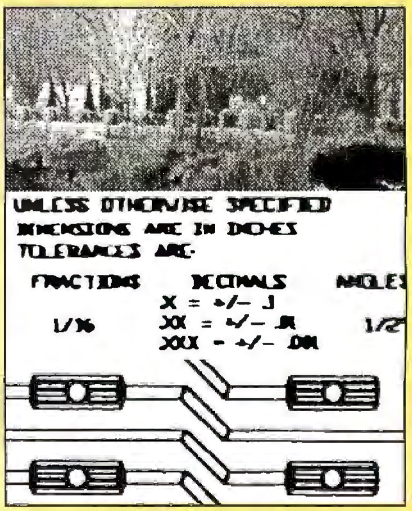
IBM/Lexmark LaserPrinter 10



LaserMaster TrueTech 1000/4



NewGen Turbo PS/400P



QMS-PS 1700

PostScript: Level 2 and Clones

PostScript Level 2 clears up the confusion over the many different PostScript revisions, unifying them under one release. Level 2 offers support for CMYK (cyan, magenta, yellow, black) color images, composite fonts, support for extended character sets with special positioning requirements, and optimized text and graphics operators currently used in Display PostScript systems. The new release also includes language additions, such as file-system extensions to support hard disks and cartridges. The Level 2 language also addresses a major complaint about PostScript: its slow performance. Level 2 caches predefined forms and patterns, compresses data, and handles memory and resources more efficiently.

Although printer makers are moving to Level 2, and several manufac-turers have started shipping Level 2 printers (see the features table "Midrange PostScript Printers Compared"), the move to provide Level 2 compatibility is only beginning to gather steam. For most users, Level 2 won't make a significant difference except for work involving color images.

Nearly every printer manufacturer offers a PostScript-compatible device, but PostScript compatibility no longer is the exclusive province of Adobe. Its success has spawned a host of PostScript "clones." The Mannesmann Tally MT-908, for example, uses a non-Adobe interpreter: PageStyler from Destiny Technologies, and the LaserMaster TrueTech 1000/4 relies on Microsoft's TrueImage PostScript. During benchmark testing, we turned up a few problems with the Mannesmann Tally implementation that prevented us from printing several test pages. The TrueTech 1000/4, on the other hand, did just fine.

In general, PostScript clones do the job, especially if you look for a version written by a respected software developer such as Microsoft.

perhaps providing print quality that is less than exceptional or print speed that is below average.

One printer that didn't make our top five but that definitely deserves careful consideration is Apple's LaserWriter IIg. With its Canon engine and Motorola 68030 processor, the IIg did well in our speed tests. It also offers something Apple calls PhotoGrade technology, which permits it to print 65 shades of gray—a helpful capability if you work with a lot of scanned images. In addition, the LaserWriter IIg incorporates Apple's FinePrint technology, which smooths the edges of text. To our eyes, however, the print samples from the IIg did not look significantly better than pages from other printers in this report. While this is a good printer, and one that networked Mac users will likely scarf up, the $4599 asking price gives us pause. The 1000-dpi LaserMaster TrueTech 1000/4 costs over $100 less than that.

EPSON EPL-8000

Epson's EPL-8000 resides on the outskirts of the midrange PostScript neighborhood. It has a resolution of merely 300 dpi but, with help from Epson's resolution-improvement technology, manages to produce sharp output. Its rated 10-ppm engine speed is among the highest of the printers we reviewed. With a base price of $1995, it stands out as a real bargain. But, beware; you need to spend a little more to bring it into the PostScript class.

First, count on installing the PostScript Identity Card, which costs $649; then, you'll need to boost RAM from the standard 1 MB to at least 1.5 MB. You can add memory: by adding a 0.5-MB chip set or by installing a 2-MB expansion board. Setting up the Epson and adding PostScript and memory is easy.

The EPL-8000's Minolta engine finished second only to the high-speed QMS in our page-printing test, taking just 22 seconds to complete the task. Its performance in the Genoa tests for CAD and precision-drawing applications and in the tests for word-processor graphics, however, was below average.

Epson's Resolution Improvement Technology produces smooth and sharp lines, graphics, and text. You can change the quality of the printout from the control panel, simply by adjusting the degree of enhancement from light to heavy and printing out a test pattern to check the results. The unit's print resolution for text is among the highest of the printers we tested (see "How the Output Looks" on page 226).

The EPL-8000's printer emulations include the Hewlett-Packard LaserJet III and Epson ESC/P modes, which cover applications written for Epson 9-pin and 24-pin printers. The printer has two built-in interfaces, one Centronics parallel port and one RS-232C/RS-422 serial port; you can install optional interface cards if you need a third channel for input. You may connect as many as three computers to the Epson EPL-8000, which can switch automatically to the channel receiving the data.

A printer offering PostScript compatibility and enhanced resolution at a relatively good price, the Epson EPL-8000 is an excellent choice if you produce primarily text documents and need fast printouts.

IBM LASERPRINTER 10

The IBM LaserPrinter 10 Model 4029-030 is based on the Lexmark 4029 printer engine, a standard engine for Lexmark's entire LaserPrinter line. But unlike less expensive LaserPrinter models, which use a Motorola 68000, this LaserPrinter uses a Motorola 68020 running at 16.7 MHz. It also uses a high-capacity toner cartridge rated to produce 15,000 printouts.

Like most of the other units in this report, the IBM LaserPrinter 10 has a one-line, 16-character LCD, three LEDs, and eight buttons on the front panel for setting up the printer and displaying printer status. Navigating through a multiline menu tree using a one-line display is annoying, but at least the user's guide is well written and provides detailed instructions on how to configure the printer.

The LaserPrinter 10 comes standard with 1 MB of RAM (expandable to 9 MB) and three emulations: HPGL, HP PCL4 (with 12 bit-mapped fonts), and IBM Personal Printer Data Stream (with 10 bit-mapped fonts and 26 scalable Adobe Type 1 fonts). If that's not enough variety, you can plug IBM's proprietary font card into the unit's two slots.

Adding PostScript to the LaserPrinter 10 requires installing a circuit board on the printer controller board. The Adobe PostScript option costs $499; the HP

continued

MIDRANGE POSTSCRIPT PRINTERS COMPARED

Engine life, microprocessor, memory, and typefaces are some of the features that distinguish one PostScript printer from another. (● = yes; ○ = no; N/A = not available).

Company	Apple Computer, Inc.	Dataproducts	Epson America, Inc.	GCC Technologies, Inc.	IBM/Lexmark
Model	LaserWriter IIg	LZR-960	EPL-8000	BLP IIS	IBM LaserPrinter 10
Price	$4599	$2195	$2648**	$2599	$2395
Standard Features					
Engine manufacturer	Canon	Sharp	Minolta	Okielectric	Lexmark
Print resolution (dpi)	300	300	300	300	300 or 600
Integrated/separate drum and toner	Integrated	Separate	Integrated	Separate	Integrated
Rated speed (pages per minute)	8	9	10	8	10
Operating noise level (dBA)	50	50	50	53	50
Engine life (no. pages)	300,000	180,000	300,000	300,000	N/A
Monthly duty cycle (no. pages)	6000	10,000	5000	5000	20,000
Standard memory (MB)	8	2	1	4	1
Maximum memory (MB)	32	10	7.5	4	9
Microprocessor/speed (MHz)	68030/25	Weitek 8200 RISC/16	68000/16.67	68000/16.67	68020/16.7
Interface*	A, R, SCSI, Ethernet	A, P, R, SCSI	P, R	A, P, R	P, R
Dimensions (H x W x D in inches)	8.6 x 20 x 18.5	10.5 x 13.6 x 15	10.5 x 18.8 x 15.1	5.24 x 17.7 x 17.7	10.2 x 14.2 x 20.6
Weight (lbs.)	45	33.5	40	24.2	33.6
Power consumption (watts)	900	700	850	800	750
Warranty	1 year	1 year	2 years	1 year	1 year
Paper Handling Features					
Standard capacity tray (no. pages)	200	250	250	200	200
Maximum capacity with optional trays	400	500	500	400	700
Paper sizes handled	Letter, legal, A4, B5	Letter, legal, A4, B5	Letter, legal, A4, A5, B4	Letter, legal, A4, B5, C5	Letter, legal, A4, A5, B5
Prints envelopes	●	●	●	●	●
Output orientation	Face up or down	Face up or down	Face up or down	Face up or down	Face down
Optional equipment	Envelope tray, paper trays, external hard drive	Paper trays, envelope feeder	Paper trays, PostScript Identity Card	Printer emulation cartridge, interface adapters	Paper trays, font cards, envelope feeder
Typographic Features:					
No. resident typefaces	35	35	27	35	26
Has font cartridge slots	○	2	2	1	2
Accepts HP font cartridges	○	○	○	○	○
Offers PostScript Level 2	●	●	○	○	○
HP-PCL 5 compatible	○	○	●	○	Optional
Autoswitching Standard mode/PostScript	●	○	●	○	●
Provides Windows print driver	○	○	●	●	●
Printer Emulation	LaserJet Series II	LaserJet Series II	LaserJet Series II, Epson printers	LaserJet Series II, Diablo 630	IBM PPDS, HPGL, HP PCL4

*A = AppleTalk, P = parallel, R = RS-232C

**$1999 without PostScript card

LaserMaster Corp.	Mannesmann Tally	NEC Technologies, Inc.	NewGen Systems Corp.	QMS, Inc.	Texas Instruments, Inc.	XANTE Corp.
TrueTech 1000/4	MT-908	Silentwriter2 990	Turbo PS/400p	QMS-PS 1700	microLaser Plus PS 17	Accel-a-Writer 8000
$4495	$1995	$2999	$2995	$7995	$1399	$3995
Canon	TEC	Canon	Canon	Canon	Sharp	Canon
400 or 1000	300	300	400	300 or 600	300	300 or 600
Integrated	Separate	Integrated	Integrated	Integrated	Separate	Integrated
8	8	8	4	17	9	8
53	47	50	53	50	50	53
150,000	300,000	300,000	150,000	1.5 million	180,000	750,000
6000	5000	5000	3500	50,000	10,000	25,000
9	1	2	4	8	1.5	2
9	5	4	16	32	4.5	16
Proprietary RISC/16	Intel 80960 RISC/16	Weitek 8200 RISC/16	Weitek XL-8220/16	Intel 80960CA RISC/25	68000/12.5	AMD 29000 RISC/16
N/A	P, R	A, P, R, SCSI	A, P, R	A, P, R	A, P, R	A, P, R
9.1 x 17.9 x 19	8.6 x 15.5 x 15.9	11 x 25 x 17	7.5 x 16 x 13.5	19 x 21.6 x 22.4	10.9 x 13.4 x 14.2	9.1 x 8 x 19.5
38	31.9	49	23	106	33	50
870	600	870	550	650	700	870
90 days	1 year	1 year	1 year	2 years	1 year or 120,000 pages	1 year
200	250	200	50	1000	250	200
450	550	200	250	N/A	750	N/A
Letter, legal, A4, B5	Letter, legal, A4, B5	Letter, legal, A4, B5	Letter, legal, A4	Letter, legal, A4, exec.	Letter, legal, A4, B5	Letter, legal, A4, B5
●	●	●	●	●	●	●
Face up or down	Face up or down	Face up or down	Face up or down	Face up or down	Face up or down	Face up or down
Paper trays, sheet feeder	300-sheet feeder, PageStyler PostScript-compatible PDL	Letter or legal paper cassettes, Envelope cassette	SCSI interface, 250-sheet page tray, font cards	Envelope feeder, duplexing unit, SCSI and Ethernet interfaces	Turbo upgrade , (PostScript Level 2) 500-sheet feeder, envelope feeder	Paper tray
135	35	35	35	58	17	35
N/A	2	○	2	2	2	○
○	○	○	●	○	○	○
●	○	○	○	○	●	○
○	●	○	○	○	●	○
●	○	●	●	●	●	○
●	○	●	●	●	●	●
Microsoft's TrueImage	LaserJet Series III, Epson FX-850, IBM Proprinter XL24e, PageStyler PDL	LaserJet IIP	LaserJet Series II, MPGL	LaserJet Series II, HPGL, CCITT Group 4, DEC LND3	LaserJet Series II	LaserJet Series II

Do You Really Need All Those Dots?

For most computer users, a 1000-dpi laser printer is overkill. Few applications require a resolution that fine. But if your work involves printing technical drawings, scanning in sophisticated images, or doing anything else that requires reproducing shading or minute details, then you can justify such an extravagance.

Printers that fall within the 600- to 800-dpi range offer plenty of resolution for fine detail. Generally, you can use these printers to produce good-looking newsletters, brochures, and proposals.

Practically everybody can benefit from using a laser printer that offers 300- to 400-dpi resolution. The real workhorses of the breed, these printers are designed to produce readable output for letters, reports, contracts, memos, and the like.

PCL5 option costs $199. You can install both options if you wish, but keep in mind that you'll need at least 2 MB of RAM to run PostScript, which means you will need a $199 1-MB memory upgrade or the $799 4-MB memory upgrade. The PostScript board provides only the basic 17 PostScript fonts; however, you can add 22 scalable fonts with a $399 font card.

But you may need even more memory than that if you want to take advantage of another special feature: the option of boosting standard 300-dpi output to 600-dpi output. Running in 600-dpi mode with PostScript installed requires 5 MB of RAM.

The 600-dpi resolution of the LaserPrinter 10 produces excellent quality output, thanks to IBM's Print Quality Enhancement Technology. Like Epson's Resolution Technology, PQET enhances the appearance of characters by smoothing the edges through controlling the size of the dots. Smaller dots reduce the jagged edges of characters.

Although the printouts look great, the LaserPrinter takes its time producing them. Despite having a 68020 running at 16.67 MHz, the unit scored a disappointing 0.73 in the BYTE Lab printer test suite, one of the slowest times we recorded.

Another, more minor, flaw concerns the ports. Both of the printer's parallel and serial ports share the same Centronics connector; you configure the appropriate port through the printer's front panel switches. If you plan on sending data to the printer via a serial port, however, you'll need to purchase a special Centronics-to-DB25 adapter or cable.

The IBM LaserPrinter 10 is a good solid printer that produces excellent output at 600 dpi. Outfitted with the PostScript card, it ranks as one of our favorite laser printers.

LASERMASTER TRUETECH 1000/4

LaserMaster's TrueTech 1000/4 printer is very different from the other printers covered in this report. Not only does it surpass the others in resolution, producing printouts at 400 by 1000 dpi and 1000 by 1000 dpi, it comes with a controller designed to fit inside the host computer. The card acts like any other high-speed print controller. Because the controller has its own on-board processor, a proprietary RISC design, this setup places a minimal load on the host PC's resources.

The controller board can vary the density of individual dots, and LaserMaster claims the printer can achieve resolutions as high as 1000 by 1000 dpi in its so-called TurboRes mode. To support both resolution levels, the company offers two types of toner cartridges. One contains a fine-grained toner formulated for the thin lines required for text; the other is designed to handle the large dark areas typical of graphics images.

With the TurboRes mode turned on, curved lines and text characters appear much smoother. The print quality in both the 400- and 1000-dpi modes places the TrueTech 1000/4 near the top of its class. In terms of speed, however, it is only adequate.

The TrueTech 1000/4 is not based on Adobe PostScript. Instead, it comes with Microsoft's TrueImage PostScript-compatible interpreter, which makes the printer compatible with Windows 3.1 TrueType fonts. Despite its use of a PostScript "clone," the TrueTech sailed through our compatibility benchmarks.

The only sticking point with this printer is the installation procedure. You have to install the controller card in your computer, sacrificing a free 16-bit slot in the process. In addition, you must assign the card to a specific port, either LPT 1, 2, or 3, and set two DIP switches. Finally, you have to run a program to configure the controller for a base I/O address and IRQ setting. During testing, we had no difficulty using the default address of 100 hexadecimal and IRQ10, but you may use other addresses and IRQs to avoid conflicts with existing hardware.

The setup program also lets you select printer emulation modes (PostScript, HP PCL, or both), install the font manager software, and install the 135 TrueType-compatible fonts that come with the printer. A complete installation requires approximately 3 MB of hard disk space. The separate manuals for the controller and the printer cover installation and operation, but this is not a plug-and-play printer.

Although the TrueTech's high resolution is exceptional, it isn't a printer for the average office. Unless you do a lot of desktop publishing and precision printing, you probably don't need to pay for resolution this impressive. But if crisp text and images are what you want most, check out the LaserMaster TrueTech 1000/4.

NEWGEN TURBO PS/400P

At only 23 pounds, NewGen's Turbo PS/400p is a featherweight compared to the other printers we tested, but it's a heavyweight in terms of performance. This compact marvel uses a 16-MHz Weitek XL-8220 RISC processor with a Canon engine, a combination that won't keep you waiting long for printouts.

Its results on the Genoa test suite are outstanding. An overall index of 1.93 places the PS/400p third from the top in speed, right behind NEC's Silentwriter2 990. With another 2 MB of RAM added to the standard 4 MB offering, you can do double page buffering and increase printing speed by 75 percent.

Although it prints at just 400- by 400-dpi resolution, the Turbo PS/400p comes with IET (Image Enhancement Technology) that smooths out curves, sharpens line art and text, and enhances gray scales—all without noticeably affecting output speed. According to NewGen, IET increases resolution to an effective 600 dpi for line art and text. Results in the text-resolution tests were excellent.

Font support for the Turbo PS/400 is top-notch. You get 35 LaserWriter IINT/NTX-compatible resident fonts and some HP LaserJet Series II-compatible fonts. NewGen also provides additional

Both products give LaserJet® owners 100% PostScript® compatible output. But one is built to do it a lot faster.

Let's face it. Some things in this world were designed for speed. And other things, well, just weren't.

Take Pacific Data Products' PacificPage PE/XL™ and Hewlett-Packard's PostScript Cartridge. Both give you 100% PostScript compatible output, but only one delivers it with blazing speed. To be precise, PacificPage PE/XL performs up to 8 times faster than HP or any other standalone cartridge in Windows as well as DOS.

You're probably thinking that to get speed like this, you'll sacrifice print quality or pay a lot more. Nope. When we say 100% PostScript compatible output, we mean it. You'll get exactly the same output as you would from HP or Adobe. We're so sure of it, that we back PacificPage PE/XL with a 60-day money back guarantee of satisfaction.

As for price, just compare. PacificPage PE/XL includes a cartridge, an accelerator board with 2 MB of memory and, of course, its impressive speed for only $14 more than HP's cartridge and 2 MB of memory.

PacificPage PE/XL is easy to install. Just slip the cartridge in any LaserJet IIP, IIP Plus, III, IIID, or IIIP, and slide the accelerator board into the memory slot. It's compatible with all software applications that support PostScript output.

Why wait? Call Pacific Data Products at (619) 597-3200 ext.1212, Fax (619) 552-0889.

HP PostScript Cartridge	PacificPage XL
3:37	:35

Time to print average graphics page

Courier Swiss 721 (Helv) Swiss 721 Narrow (Helv Narrow)
Dutch 801 (Tms Rmn) Zapf Calligraphic 801 (Palatino) ITC Avant Garde®
ITC Bookman® Century Schoolbook ITC Zapf Chancery®
ITC Zapf Dingbats® Symbol αβχδεφγηιφκλπ

Each typestyle comes in normal, bold, italic and bold italic treatments except for Chancery, Zapf Dingbats, and Symbol.

PACIFIC DATA PRODUCTS

FAST WINDOWS® PRINTING WITH i960™ PROCESSOR

PhoenixPage

Testing PostScript Speed and Compatibility

For PostScript printers, it's not enough to produce good-looking pages. You want a model that works fast and can handle all sorts of software, too. To evaluate these printers' overall speed and compatibility, we relied heavily on tests derived from the industry-standard Genoa Technology test suite, which involves printing over 700 pages of text and graphics using 48 popular Mac and PC applications. If a printer can successfully make its way through the tests, it's compatible for most business applications.

The first speed benchmark, the Single-Page Test Index, suggests how efficiently a printer handles short memos or business letters (see the figure, part a). We used Lotus Development's Ami Pro to generate a single-page business letter, timing each printer from the time it began processing the PostScript code to the moment the printer dropped the paper into the output tray.

Next, we took 50 pages from the Genoa suite and broke them into three groups by application category: spreadsheets, drawing programs, and word processors (see the figure, part b). The times in these three categories suggest the level of performance you might expect if you use the printer for these types of applications. The spreadsheet component of the Application Tests Index includes pages from different versions of Lotus 1-2-3 and Microsoft Excel. The spreadsheet images have a lot of heavily formatted text and a number of three-dimensional graphs.

The drawing component involved working with AutoCAD, PageMaker, Ventura Publisher, and several illustration packages. The CAD images we printed contain thousands of thin, closely spaced lines and shapes, while the DTP and illustration pages focus on larger areas, intricate shapes, and complicated fill patterns.

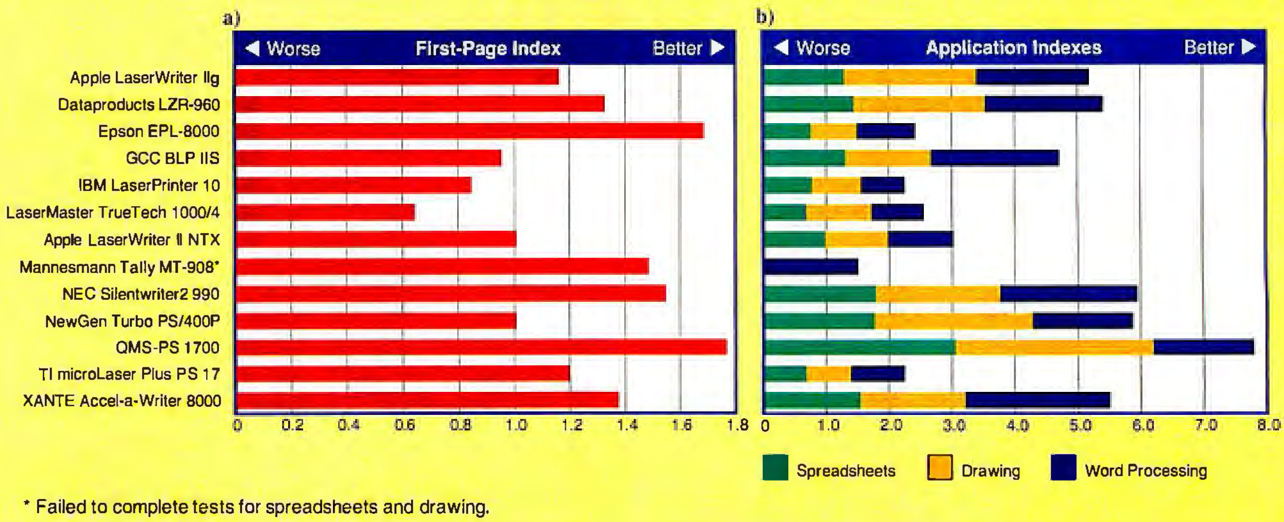
The word-processing component of the Application Tests Index evaluated how well the printers handle pages of text containing a variety of fonts. Printers that have trouble rendering complicated curves usually do better in this area of the test.

The results of both the First-Page Test and Application Tests are indexed to the Apple LaserWriter II NTX, a $5000 high-end PostScript printer rated at 8 ppm that BYTE typically uses as a baseline printer for tests such as these.

To round out the testing, we ran a series of other benchmarks, the results of which you won't see reflected in the graphs below. That's because they emphasize compatibility rather than performance.

PostScript is a complex language, and most applications—even groups of different applications—don't fully exercise its capabilities. To check out how each of the review printers handles the complete range of PostScript capabilities, BYTE ran each machine through Genoa test pages designed to exercise every PostScript operator. Of the 12 printers tested, only the Mannesmann Tally, which uses the PageStyler page-description language instead of Adobe PostScript, choked during testing. Company representatives acknowledge the problem and promise an update that will fix it.

BYTE BENCHMARK RESULTS



(a) *The first-page index tracks each printer's performance on a single page of text, comparing completion time against that of the Apple LaserWriter II NTX. We started timing when the print command was entered and stopped timing when the page fell into the output tray. This test evaluates how efficiently a printer can handle memos and simple business correspondence.*

(b) *The application index rates the printers' performance when processing and printing spreadsheets, drawings, and pages of text. All results are indexed to the Apple LaserWriter II NTX. Longer bars indicate better performance. Results for the Mannesmann Tally printer do not appear because it failed to complete the tests.*

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MacUser
\$\$\$\$1/2

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1-800-527-3500.

The microLaser PS17 has earned the 1990 *PC World* Best Buy award; microLaser PS35 has earned the 1990 *InfoWorld* Excellent Value award and 4½ mice from *MacUser*, October 1990.

Features	microLaser Plus Basic	microLaser Plus PS17/PS35	microLaser Turbo	microLaser XL Turbo
PPM	9 ppm	9 ppm	9 ppm	16 ppm
Emulation	HP LaserJet II	HPLJII/PostScript	HPLJII/PostScript II	HPLJII/PostScript II
Processor	68000	68000	RISC/8220	RISC/8220
Fonts	14 HP Fonts	17 or 35 Scalable	35 Scalable	35 Scalable
List Price	\$999	\$1,399/\$1,749	\$2,249	\$3,649

TEXAS INSTRUMENTS

*Based on estimated typical usage. **For more information on service upgrade options, call 1-800-847-5757 in the U.S. and 1-800-268-6314 in Canada. †Suggested retail price—dealer prices may vary. ‡Based on suggested retail price of consumables and approximate page coverage rating for each consumable at 4% black (toner, developer and OPC). microLaser is a trademark of Texas Instruments Incorporated. Microsoft and DOS are registered trademarks, and Windows is a trademark of Microsoft Corporation. Adobe, PostScript and the PostScript logo are registered trademarks of Adobe Systems Incorporated which may be registered in certain jurisdictions. LaserJet is a registered trademark of Hewlett-Packard, Inc. Apple and Macintosh are registered trademarks of Apple Computer, Inc. OS/2 is a registered trademark of International Business Machines Corporation. UNIX is a registered trademark of AT&T.

Circle 64 on Inquiry Card.

support for Bitstream Fontware, Adobe and PostScript downloadable Type 1 and 3 fonts, and HP Soft Fonts. An optional SCSI connection is available, which makes it feasible to store even more fonts on a hard disk.

Another bonus is the PS/400p's ability to work not only with the Macintosh and the PC but also with Sun workstations. Automatic Recognition Technology recognizes and switches interfaces and emulations so that the printer does not need to be reconfigured when moved among the three platforms.

Documentation is refreshingly well organized and comprehensive, detailing everything you need to know to get maximum use from this machine. With the manual in hand, you can't go wrong setting up the PS/400p. It provides sections on software applications and emulations, PostScript, maintenance, and troubleshooting. Hats off to NewGen for well-written documentation.

In its class, the Turbo PS/400p is a sterling performer in speed, resolution, and font support.

XANTE ACCEL-A-WRITER 8000

XANTE Corp.'s Accel-a-Writer 8000 printer gives you speedy output and true 600- by 600-dpi resolution. This $3995 unit's printing speed and output resolution push it near the top of the midrange PostScript ladder.

The Accel-a-Writer lacks some common features, such as font cartridge slots and optional paper trays, but it compensates for this with the way it handles gray-scale printing, font storage, and memory management. XANTE claims that, when the Accel-a-Writer 8000 is set to 600- by 600-dpi resolution, it automatically enhances gray-scale images, printing them at an *equivalent* resolution of 850 by 850 dpi, with as many as 197 gray levels. If you don't need resolution this high, you can select a 300- by 300-dpi setting from the printer's control panel.

XANTE's Virtual Disk Technology, an external hard drive emulator, lets you permanently store as many as 30 downloadable fonts in the printer's controller—in addition to the 35 fonts already resident. You also can hook up a hard drive to store 30 more fonts. To allocate more virtual memory for downloading fonts or increase printer resolution or processing speed, you simply change the settings from the front panel, telling the Advanced Memory Management system to take charge.

The Accel-a-Writer 8000 gets its horsepower by combining the Canon engine with a 16-MHz AMD RISC processor. On our PostScript benchmark tests, the Accel-a-Writer outpaced even the LaserWriter IIg in the First-Page Test, the spreadsheets tests, and the word processing tests. Dual-page processing, a technique that permits one page to be printed while another is being built in the background, improves speed further.

Setting up the Accel-a-Writer should be a breeze: You install the toner cartridge and fusing pad, quickly configure

High Speed, Sharp Graphics, and Lots of Connections

If you're part of a workgroup that generates thousands upon thousands of printouts a month, you should consider buying a network printer. If those printouts often contain graphics and itty-bitty text, think about getting a network printer offering resolutions higher than 300 dpi. If the workgroup uses a combination of PCs, Macs, and Unix machines, you ought to buy a network printer with multiple interfaces.

You can get all these features in the QMS-PS 1700 printer, a workhorse built around a 17-ppm Canon NX engine and a controller equipped with Intel's 25-MHz i960 RISC processor. This power translates into time savings. In our benchmark tests, the QMS-PS 1700 shot out the first page in 21 seconds. More significant for people who generate complex drawings or images, the printer scored well in CAD test, cranking out a page in about half the time required by the fastest midrange printers. Of course, the QMS-PS 1700 costs a good deal more than a typical middle-class PostScript model.

Another feature that makes the QMS-PS 1700 valuable to people who print a lot of graphic images is that it permits you to switch from 300-dpi resolution to 600-dpi resolution by pressing a button on the front panel. Output at 600 dpi looks very sharp. Images that involve thin lines—engineering drawings or architectural plans—look particularly crisp when printed out in the QMS-PS 1700's 600-dpi mode. With some printers, closely spaced intersecting lines are difficult to reproduce; where lines converge, the printer lays down a blob of toner. There's none of that with this unit; thin, closely spaced lines are clear and distinct. QMS says that the machine's 600-dpi resolution is only part of the reason. The use of microfine toner, it claims, helps make thin lines distinguishable and tiny text legible.

Besides speed and high resolution, the QMS-PS 1700 has one other laudable characteristic: You can hook it up to just about anything. The machine comes equipped with serial, parallel, and LocalTalk connections, all of which can be active simultaneously. If that doesn't fit your situation, you can buy Ethernet (NetWare, TCP/IP, EtherTalk, or DECnet) or Token Ring (NetWare) interfaces.

The QMS-PS 1700 also is multilingual. It can understand PostScript, HP PCL (LaserJet II emulation), and HP-GL (LN03 Plus also is available for DECnet users). Employing what QMS calls Emulation Sensing Processor technology, the printer looks at the incoming data stream and automatically switches to the appropriate language. The user simply has to invoke the print command.

At $7995, the QMS-PS 1700 isn't cheap. It runs about a thousand dollars more than the competing HP LaserJet IIISi. But it does have several things the IIISi lacks, including higher resolution, a LocalTalk connector, automatic emulation switching, 8 MB of memory (compared with the IIISi's standard 2 MB), and 10 more Adobe fonts. For some users, these features make the extra cash outlay worthwhile.

COMPANY INFORMATION

Apple Computer, Inc.
20525 Mariani Ave.
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(408) 996-1010
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Dataproducts
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(818) 887-8000
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Epson America, Inc.
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(310) 782-0770
fax: (310) 782-5220
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GCC Technologies, Inc.
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(617) 890-0880
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LaserMaster Corp.
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fax: (612) 944-0522
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Lexmark International, Inc.
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(606) 232-3000
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NEC Technologies, Inc.
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(508) 264-8000
fax: (508) 264-8488
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NewGen Systems Corp.
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Fountain Valley, CA 92708
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fax: (714) 641-2800
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QMS, Inc.
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(205) 633-4300
fax: (205) 633-4866
Circle 1114 on Inquiry Card.

Texas Instruments, Inc.
P.O. Box 202230
Austin, TX 78720-2230
(800) 527-3500
Circle 1115 on Inquiry Card.

XANTE Corp.
2559 Emogene St.
Mobile, AL 36606
(800) 926-8839
(205) 476-8189
fax: (205) 476-9421
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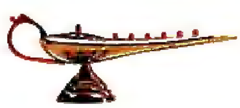
the printer, and connect the printer cable to the serial, parallel, or AppleTalk port. But in the real world, things aren't always so straightforward and you might need to do some twiddling from the control panel. Unfortunately, the documentation that came with the review unit lacked instructions on using the control panel keys to configure the printer—a major omission.

Hopefully, the company will rectify this; in the meantime, XANTE is making



other improvements. As this review goes to press, it announced plans to introduce a new firmware release for the Accel-a-Writer, which reportedly will enable autoswitching between various printer languages. By this fall, the printer should support PostScript Level 2.

XANTE has a very competitive PostScript printer in the Accel-a-Writer 8000, a machine that certainly lives up to its name for resolution, performance, and font-storage capabilities. But as with many good things in life, you'll have to pay for this excellence.

Picks of the Pack

With such a wide range of printers to choose from, we simply couldn't narrow the field to just one printer. Instead, we grouped the printers into three categories and picked the best printer from each.

In the "living with reality" category, we chose the NewGen Turbo PS/400p. It offers 400-dpi resolution, a 4-ppm Canon engine, a Weitek 8220 microprocessor, and built-in PostScript capability. The quality of its output is excellent, even when examined under magnification.

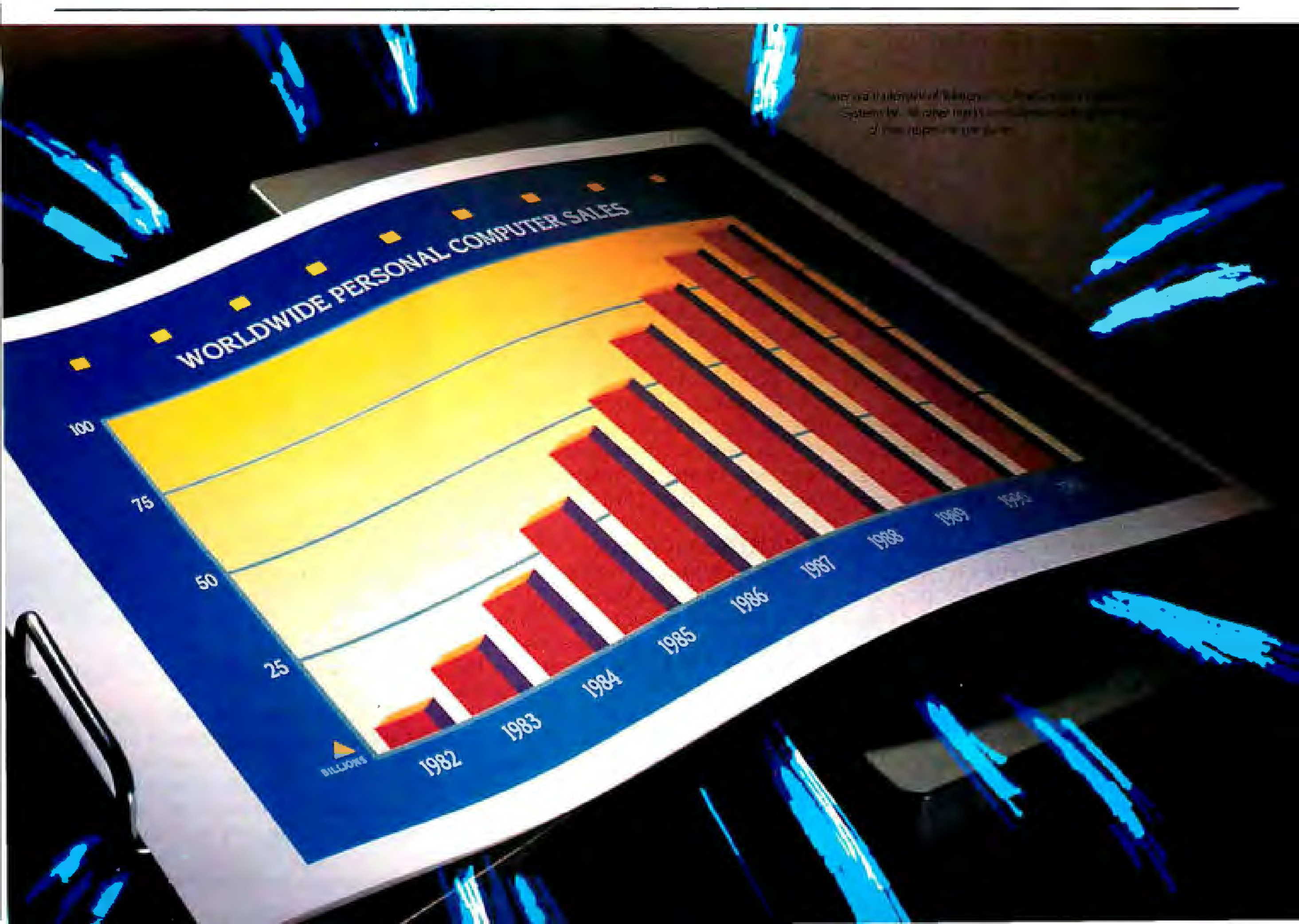
In the "speed at a good price" category, we went for the Epson EPL-8000. It has a 300-dpi, 10-ppm Minolta engine, a 68000 microprocessor, and a list price of only $1995. Fortunately, the EPL-8000's relatively low resolution doesn't translate to poor-quality output; in fact, its print quality rivals that of some 400- and 600-dpi printers. The Epson also is quick at printing out pages of text. There's a catch, though: The PostScript Identity Card, without which the printer can't handle PostScript, costs extra. If price is your top concern, you can't beat the TI microLaser Plus. But to our eyes, its output isn't as sharp as the top five.

In the "price is no object" group, our choice is the QMS-PS 1700, a higher-priced and more capable model than the other printers tested for this report. Its 600-dpi resolution, fast 17-ppm engine, Intel microprocessor, ample paper trays, and network capabilities, show what $7995 can buy.

Whichever level of printer appeals to you, your money may buy a lot more soon. Most printer manufacturers already offer or soon plan to offer middle-class PostScript machines. Increased competition promises to bring prices down, so last fall's penny-wise models may soon become, in terms of price, the dot-matrix printers of the PostScript world. Today's midrange models then will become tomorrow's standard fare.

Still, not everyone needs a PostScript printer. If most of your printing involves memos and letters, you have no reason to invest in one of these middle-class machines. But if you want better resolution and speed, any of the printers we looked at is worth the investment. Just a $1399 outlay is enough to get you started, or you can join the upper middle class and get the 1000-dpi output of the LaserMaster TrueTech 1000/4 for $4495. Between those two price ranges lies a variety of PostScript machines that will fill the bill for people who need good output and don't like to linger around the printer. The models spotlighted prove that, in the PostScript world, middle class doesn't have to mean dull and boring. ■

Stan Wszola is a BYTE Lab testing editor. David L. Edwards is a consultant to the BYTE Lab. They can be reached on BIX as "stan" and "dedwards," respectively.



HARDWARE

No More Data Loss:
The BYTE Lab Tests Six Disk-Array Subsystems

BILL LAWRENCE

Hard disks are the weak links in most systems. As the only mechanical members of an otherwise all-electronic environment, they boast data transfer rates that are at least an order of magnitude less than the systems they are connected to. And because a hard disk is a mass of mechanical parts moving at high speed, the question is not whether failure will occur, but when.

With the failure of any other component in a system, the road back to normal operation is simple replacement of the failed item. When a hard disk crashes, replacement is just the beginning. The data also has to be restored, and whatever data was created between the crash and your last backup is lost forever.

The tactic traditionally used by most systems managers to minimize the disruption of hard disk failure is disk mirroring. Disk mirroring is high-priced insurance; it requires that you buy double the disk space that you actually use. Because every disk and its data is duplicated, your system can operate when a disk fails.

Another way to achieve nonstop operation is with a disk-array subsystem. Basically, a disk array is created when you join two or more hard disks to make one logical disk volume. An array configuration can leverage disk I/O performance by dividing disk reads and writes more or less evenly among the drives in the array. To further enhance performance, drive controllers are often also duplicated.

In "File Servers Face Off" (February BYTE), the BYTE Lab reviewed high-performance file servers that use disk arrays to improve disk throughput and in some cases provide data redundancy. The systems discussed here take data protection a step further. Five of the six systems I tested provide the ability to replace and rebuild a failed drive without interrupting access to your system, and some extend this "hot-swapping" capability to controllers and power supplies as well. You can add any of the stand-alone arrays discussed here to the 386 or 486 CPU of your choice, and some work with any SCSI-compatible host.

I tested four systems that implement RAID (redundant arrays of inexpensive disks) level 3 or 5. (See the text box "A RAID Primer" on page 241 for an explanation of the different levels of RAID.) The four systems were the NetArray from Ciprico, the Intelligent Array Subsystem from Core, the Raider from Dynatek, and the Raidion from Micropolis. Only one of these systems had been on the market for more than a year when my testing began, and the remaining three had been released within the preceding six months.

To see how RAID 3 and 5 technology compares to more traditional solutions, I tested two more common configurations, NetSpan from Legacy Storage Systems and RapidAccess from MicroNet Technology, that use mirroring (i.e., RAID level 1) to achieve redundancy (see the text box "Disk Mirroring: Protection Plus Performance" on page 244).

A RAID Reality Check

I tested each system on an Ethernet network running Novell NetWare 3.11. Each array was connected to an AcerFrame 3000MP, a 33-MHz 486 EISA tower with 24 MB of RAM. Two workstations, a 16-MHz 386DX and a 10-MHz 286, rounded out the test environment.

With each array, I ran a series of performance tests under normal conditions and then disabled one drive and repeated the tests. As a final step, I replaced the failed disk and exercised the array's ability to dynamically rebuild a replaced hard drive.

My performance tests were designed to keep the server's disk channels saturated with a varied mix of read and write activity. From the 386 workstation, 15,000 random reads of 4 KB each were performed on a 128-MB file. On the 286 worksta-

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BYTE ACTION SUMMARY

- **WHAT RAID DISK ARRAYS DO**
  Disk arrays that implement the RAID 3 or 5 specification provide protection from disk failure without the 100 percent disk space overhead of a traditional disk-mirroring configuration. The equivalent capacity of one disk in the array is set aside for data redundancy.

- **LIKES**
  Protection from data loss without paying for double the disk capacity; the ability to replace failed drives, power supplies, and controllers without turning off the system.

- **DISLIKES**
  Implementing data redundancy comes at the expense of performance. Many systems new to the market have incomplete or inaccurate documentation.

- **RECOMMENDATIONS**
  For the best mix of RAID benefits, choose Dynatek's Raider. If fault tolerance is your main concern, choose Core's Intelligent Array Subsystem.

tion, 12 image files ranging from 2 to 3 MB in size were read sequentially in 512-byte increments. On the server, NetWare's Btrieve and Butil NLMs (NetWare loadable modules) were used to read 68,000 lines from a flat file and to write them as records to a Btrieve database. All activities were run concurrently and created a load on the server's disk channel that you'll hopefully never encounter in reality, at least on a sustained basis.

The arrays showed a wide range of performance results, but some consistent patterns emerged. The redundancy provided by the RAID 3 and 5 units extracts a significant performance penalty. Only one of the four RAID 3 and 5 units provided performance equal to that encountered in a similar single-drive configuration. On the other hand, turning off redundancy and running in a RAID 0 configuration on the two units that supported this capability improved performance by almost 100 percent. The bottom line: With today's implementations of RAID 3 or 5, you trade performance for redundancy.

That's the bad news. The good news is that all units flawlessly recovered from the failure of a drive. With each system, access to the server and its data was not interrupted. A rerun of the performance tests with one drive disabled showed that performance degraded a bit on most units but not enough to be unworkable. With the Ciprico NetArray, performance actually improved slightly. Every unit accepted and rebuilt a replacement drive, again without interruption of access to the server and its data. Not once during any drive replacement and rebuild did the power switch have to go to the off position.

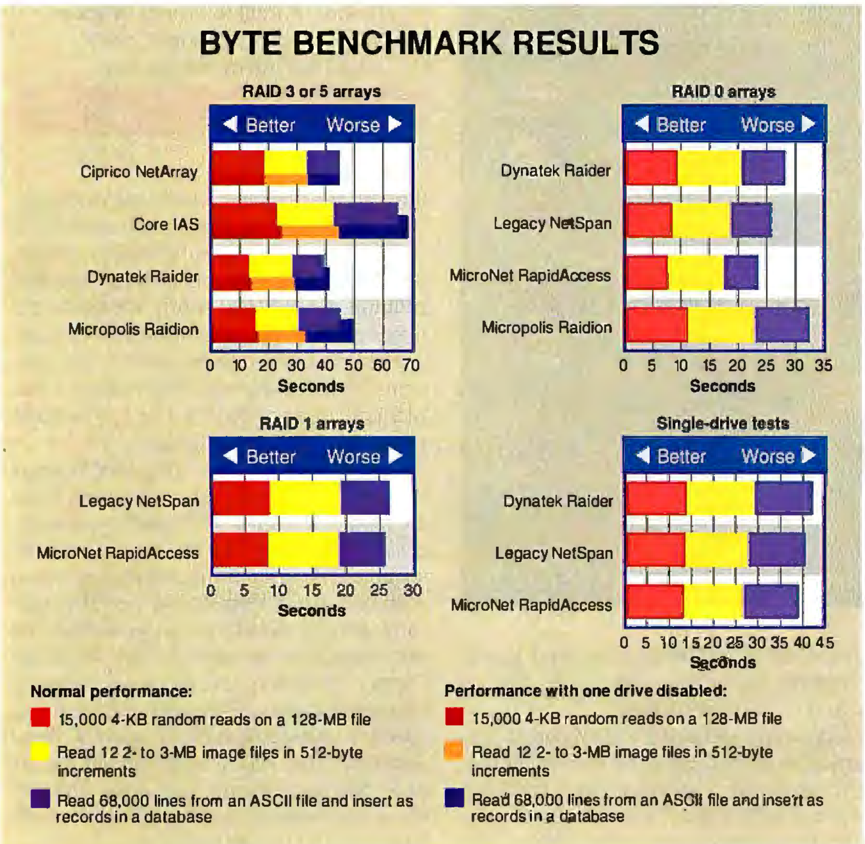
continued

DISK-ARRAY SUBSYSTEMS COMPARED

Prices of disk arrays vary greatly based on RAID level and operating-system support and capacities. (● = yes; ○ = no.)

	Ciprico NetArray	Core Intelligent Array Subsystem	Dynatek Raider	Micropolis Raidion	Legacy NetSpan[1]	MicroNet RapidAccess[1]
RAID levels						
0	○	○	●	●	●	●
1	○	○	○	○	●	●
3	●	●	○	○	○	○
5	○	○	●	●	●[2]	○
Redundant components						
Disks	●	●	●	●	●	●
Power supply	○	●	●	●	●	●
Controllers	○	●	●	●	●	●
Hot-swappable components						
Disks	●	●	●	●	●	○
Power supply	○	●	○	●	○	○
Controllers	○	●	○	●	○	○
Operating systems supported						
NetWare 3.1x	●	●	●	●	●	●
NetWare 2.x	●	●	○	○	●	●
Unix	●	●	●	○	●	●
OS/2	●	●	●	○	●	○
DOS	●	●	●	○	●	●
Array sizes available						
Minimum	2 GB	1.3 GB	660 MB	680 MB	400 MB	660 MB
Maximum	3.4 GB	5.2 GB	4 GB	47 GB	7.8 GB	5.2 GB
Price of tested array	$33,495	$64,600	$32,320	$20,711	$34,900	$29,280

[1] Provides only disk mirroring under NetWare.
[2] Supports RAID 5 under OS/2 and Unix.



Comparing disk-array performance: In every case, lower numbers indicate better performance. The 15,000 random-read test was performed on a 128-MB file, and disk reads were in units of 4096 bytes. The sequential-read test was performed by opening and reading sequentially (in 512-byte increments) 12 image files ranging in size from 2 to 3 MB. The database load test was performed using NetWare 3.11's Btrieve and Butil NLMs to read 68,000 lines of an ASCII file and to insert each line as a record into a Btrieve database. All three tests were run concurrently. Some arrays could be configured to more than one RAID level and as a single drive. In these cases, the array was tested in each configuration available, and all results are shown here.

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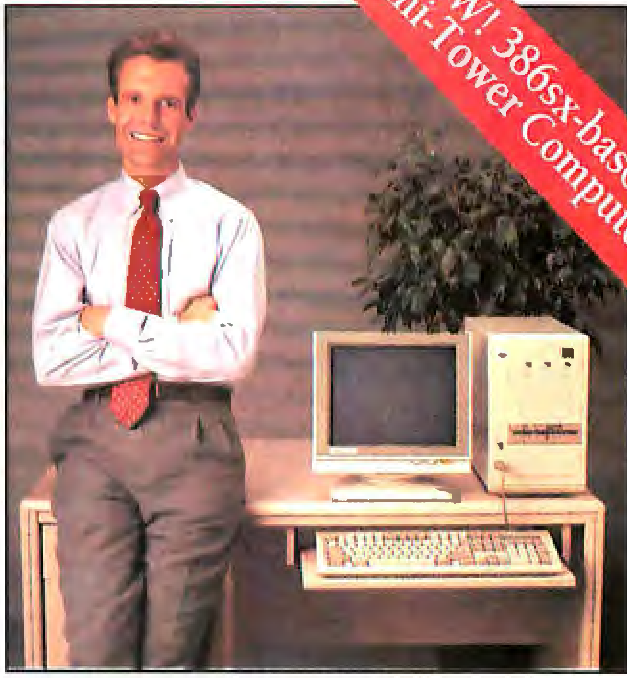

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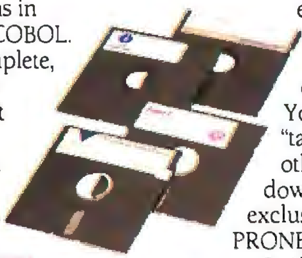

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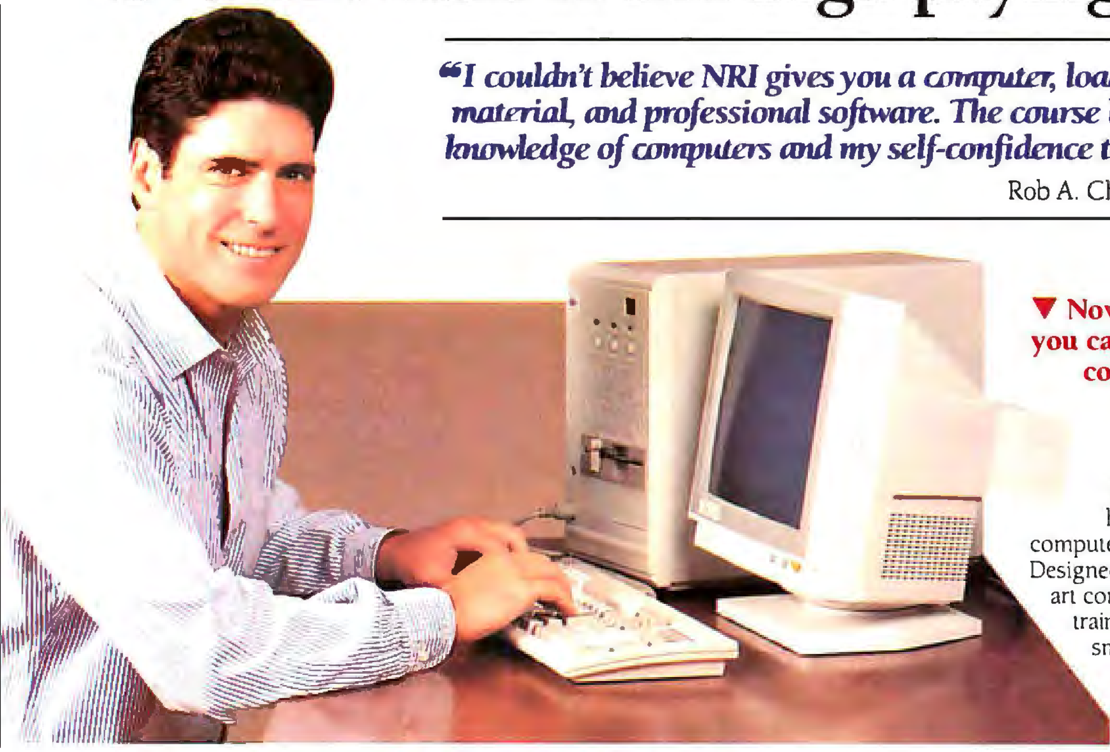

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A RAID Primer

Using arrays of three or more disks to form a RAID (redundant arrays of inexpensive disks) offers two benefits. The first is performance. In a RAID implementation, data is scattered evenly across every disk in the array using a technique called striping. Overall throughput improves because each disk in the array can more or less evenly divide the load of system disk reads and writes.

The second benefit is data redundancy. Every RAID level but one specifies a method whereby data is stored redundantly on the array so that the failure of one disk does not result in data loss. Six RAID levels have been defined. They differ in how they implement striping and redundancy.

RAID level 0: A RAID 0 array consists of a series of disks where striping is the only RAID feature implemented. No provision is made for data redundancy. Because a RAID 0 array provides all the performance benefits of striping and none of the overhead entailed by writing redundant failure-recovery data, it is the configuration to choose when performance is important and failure protection is not.

RAID level 1: RAID 1 arrays implement disk mirroring along with data striping. Each disk in the array is mirrored by another; the second disk in the mirrored pair stores an exact copy of the first disk's information. In a four-disk RAID 1 array, you have two mirrored pairs and the equivalent capacity of two disks to use for data storage.

If all disks can perform reads and writes simultaneously, disk mirroring will probably subtly improve disk-read performance, since a read request will be satisfied by the first drive in the pair to seek the information. Write requests slow down because they have to be completed for both disks in the pair.

RAID level 2: RAID level 2 is the first to set aside the capacity of one disk to perform data recovery for the remaining ones. Striping is implemented at the bit level: The first bit for a unit of information is written to the first disk, the second to the second disk, and so on. Because multiple error-correcting disks are required in an array, RAID 2 is not commercially implemented for microcomputer systems.

RAID level 3: In a RAID 3 array, striping is typically implemented at the byte level, and one disk (often called the parity drive) is set aside to store error-correcting information. The error-correcting code stored by the parity drive is calculated by performing bit-wise arithmetic on the bytes on the data drives. In a process not unlike finding the value of a variable in a simple algebraic equation, the missing byte on a failed disk is calculated by using a bit-wise operation to combine the byte values on the remaining disks and comparing that value with the value on the parity drive. Commercial RAID 3 implementations often optimize disk-read performance by synchronizing the spindle rotation of each drive so that parallel reads of a range of bytes can be readily performed. For this reason, RAID 3 units should be particularly fast when doing sequential reads of large files. RAID 3 performance suffers when doing heavy disk writes because the parity drive must be written to in every write operation.

RAID level 4: A RAID 4 array sets aside a single disk in the array as the parity drive. RAID 4 stripes in units of disk blocks rather than bytes, a disk block being the amount of data transferred to or from the disk in one write or read operation.

RAID level 5: A RAID 5 array spreads the error-correction data evenly across the drives in the array. The data is striped in units of blocks. RAID 5 arrays should handle multiple simultaneous disk writes more quickly than RAID 3 or 4 arrays, because no single disk must be written to during every write operation. Because they stripe in block increments, RAID 5 arrays should handle multiple simultaneous random reads well, because each disk can independently retrieve an entire disk block. Error-correction data on a RAID 5 array is spread evenly among the drives in the array.

Dynatek's Raider

Dynatek's Raider is the unit of choice if you need the best overall mix of redundancy, performance, flexibility, and economy. It can be configured as a RAID 5 or RAID 0 array and provides hot-swappable drives. The Raider consists of a compact tower (called the Mountable Module Depot) that can accommodate up to five half-height drive/power-supply combination modules. Since each disk module includes its own power supply, there is no master power supply to become a single point of failure.

I tested a unit that consisted of five 1-gigabyte drives, which resulted in a total capacity of 3.8 GB when configured as a five-drive RAID 5 array. Disk modules ranging in size from 330 MB to 1.2 GB are available. Dynatek packages an Adaptec SCSI host controller and uses Adaptec's NetWare disk drivers.

In addition to turning in the fastest performance results of any of the RAID 3 or 5 units tested, the Raider provided the most flexibility. If you need to start small, you can configure the Raider with a single drive and add modules as your budget permits (although you'll have to reformat to include an additional module).

The Raider's flexibility extends to the failure recovery process as well. On a NetWare 3.1x server, the Raider displays a notice on the server screen when a drive fails and creates an entry in its own log file. An NLM and a DOS utility are provided to enable you to perform the drive replacement and rebuilding process. While the interfaces for both utilities are cryptic (you frequently have to use a 13-character code to identify the drive you're working with), they afford you better-than-average control over the rebuilding process. You can monitor the progress of the rebuild and can even change the rate at which the rebuild occurs during the process (with all the other units, the rebuild rate is set before you start or is not tunable at all).

The documentation had no index and was often inaccurate, and I had to call Dynatek's technical support several times to get information that the documentation should have covered. Dynatek reports that new manuals are in the works that may be available by the time you read this.

The Raider configuration that I tested had a retail price of $32,320, putting it in the average range for the units discussed here. The system can be used with NetWare 3.1x, OS/2, or AIX 3.2.

Core's Intelligent Array Subsystem

Core's Intelligent Array Subsystem (IAS) claimed several distinctions during my array evaluation. It was the slowest and most expensive but also the most fault-tolerant. Apparently, its engineers stressed reliability and maintainability over performance.

The IAS, a modified RAID 3 implementation, is the unit to choose if cost and speed take a backseat to nonstop availability. The unit sports three power supplies, any one of which can fail without stopping the system. Drives, controllers, and power supplies can be hot-swapped independently of each other. Even the power cord has been engineered for reliability: It clips securely in its socket to prevent accidental removal. The unit comes with a good manual and toll-free technical support.

The IAS has a small LCD panel that can be used to monitor and configure the unit. The panel can be used to display the status of the array's components and can also be set to provide an activity gauge. You can carry monitoring and control a big step further by connecting a PC running OS/2 to the IAS's serial port. With this PC running Core's IAS Monitor program, you can monitor and collect information on the performance and status of the array and completely control the array's operation. You can also dial in to the monitoring PC and control the array via modem if required.

Notification of disk or other component failures is handled via an audible alarm and with a message on the LCD panel (and via the IAS Monitor program if you are using it). The rebuild rate is fixed, but you can monitor the progress of the rebuild process. No failure or rebuild information is available from the server console.

The unit I tested, the CPR-400, is housed in a large tower and provides a usable capacity of 4 GB. It costs $64,600 as configured, which is about twice the cost of the other arrays tested. Units ranging from 1.3 to 5.2 GB (and costing from $24,000 to $74,600) are available.

The IAS is designed to be operating-system neutral. It performs all configuration and monitoring functions on its own LCD panel or with a dedicated monitoring PC, so it can be used with virtually any SCSI-compatible host controller and operating system. The downside of this neutrality is that no failure or rebuild information is reported back to the operating system. I tested the IAS using an Adaptec 1740 and Adaptec's NetWare drivers.

Ciprico's NetArray

The NetArray from Ciprico is a RAID 3 array with five drives. It provides a good balance of economy and performance, but it comes up a little short on hot-swapping capability. Its disks are the only components that are hot-swappable.

I tested a unit with 3.4 GB of usable capacity, which costs $33,495 as configured. Units with capacities ranging from 2 GB to 3.4 GB and prices ranging from $24,495 to $33,495 are available. You can also buy the Ciprico tower cabinet and RAID 3 firmware without drives for $14,495.

The NetArray has several unique characteristics. In addition to providing the second-fastest performance when operating in normal mode, it offered even better performance when operating with a failed drive. All other RAID 3 or 5 units showed a performance decrease when running with a failed drive. The NetArray's manual also includes instructions for connecting two server CPUs, a primary and a backup, to the same array. In the event that the first CPU fails, you can quickly put users back to work by using the second CPU.

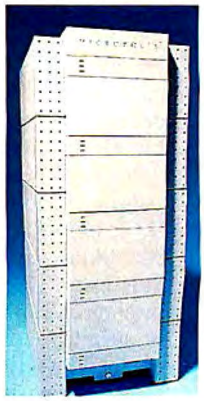
Drive failures trigger an audible alarm and a light on the array and are reported to the NetWare server error log. Rebuilding takes place at a rate that you set when you load Ciprico's NetWare driver. You cannot monitor the progress of the rebuild.

I tested the NetArray using Ciprico's RimFire SCSI host controller and NetWare driver, which the company recommends for use on NetWare servers. The RimFire is available in ISA, EISA, and Micro Channel configurations.

Micropolis's Raidion

If this were a beauty contest instead of a disk-array evaluation, the Raidion from Micropolis would win hands down. With the Raidion, a RAID 5 array, each disk is housed in a separate module that includes a power supply and controller. The modules can be fitted together to build an attractive tower that can be up to four units tall.

The Raidion's low price alone makes it worth considering. My test configuration, a five-disk array with a usable capacity of almost 4 GB, costs $20,711, about $12,000 less than similarly sized arrays from Ciprico and Dynatek. With its fully modular approach, the Raidion can be expanded as needed. Micropolis claims that configurations including up to 28 modules are possible. Modules are available in 340-, 670-, 1030-, 1340-, and 1750-MB sizes.



The Raidion works only with NetWare 3.1x, and it is the Raidion NetWare disk driver that implements RAID 5 error correction and striping. You can optionally configure the array to be a RAID 0 implementation. Configured as a RAID 5 array, the Raidion was the second-slowest system that I tested.

The Raidion's documentation has some serious omissions. You probably won't be able to install the array without calling Micropolis's technical-support department (which fortunately can be reached with a toll-free number 12 hours a day). A special setting required when your file server has more than 16 MB of RAM is not documented, and if you use NetWare's normal procedure to automatically create the start-up batch file that calls the Raidion disk driver, the driver is started improperly and will not initialize the array. A manual that describes how to operate the utility used to rebuild replaced drives wasn't finished in time to be shipped with my unit (even though the array has been on the market for six months).

Once you get past these hurdles, the unit works well. Raidion provides an on-screen notice when a drive module fails. This notice is not written to the server error log, which means that the on-screen information could scroll out of view before you have a chance to see it. The other aspects of failure recovery are handled well: You can set a rebuild rate before starting, and the progress of the rebuild is displayed

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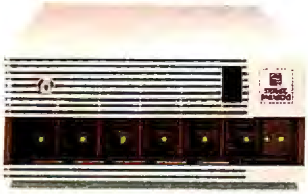

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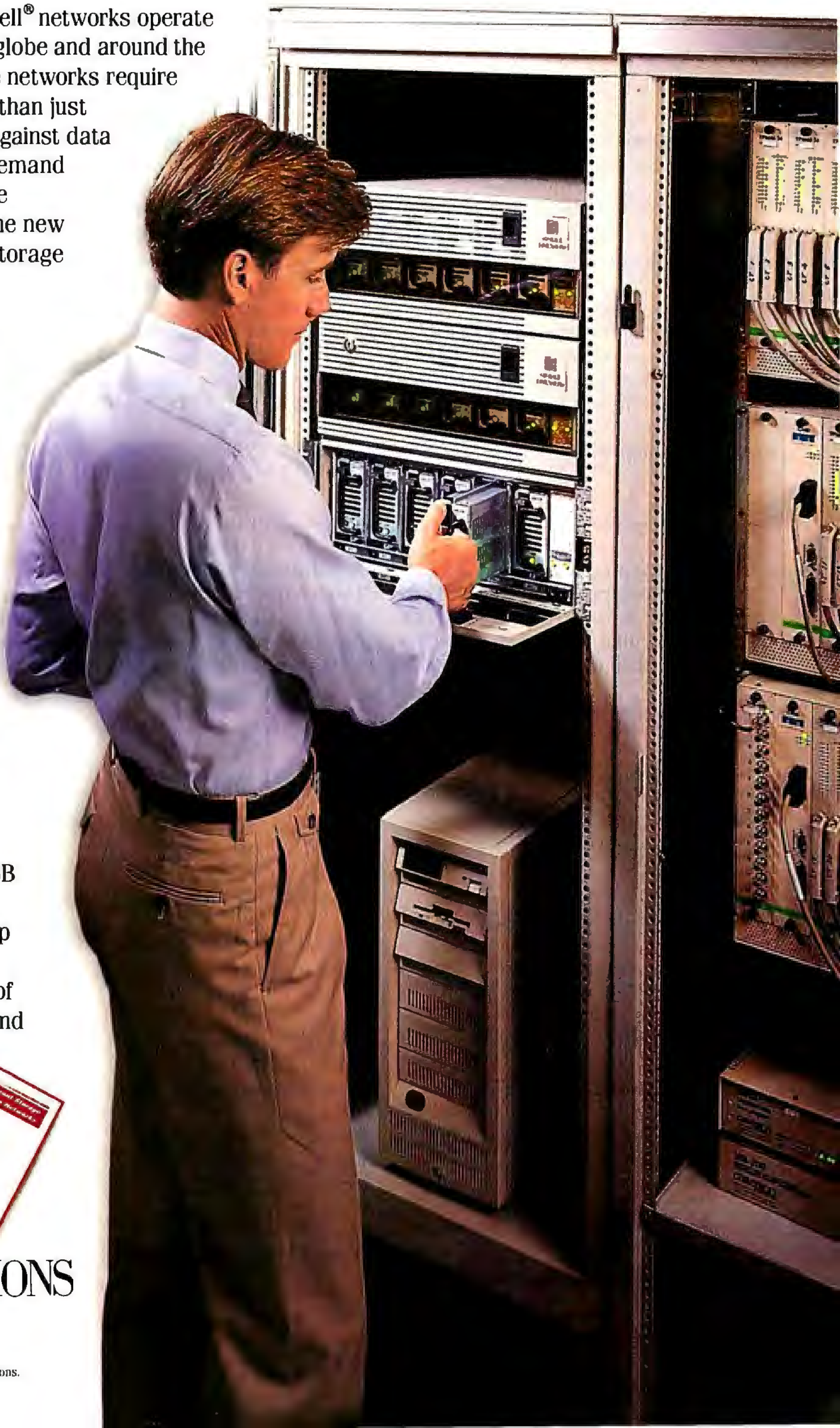

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Disk Mirroring: Protection Plus Performance

To see how the new RAID 3 and RAID 5 disk arrays stack up against the traditional disk-mirroring approach, I tested two systems that use disk mirroring to protect against data loss. The first, the NetSpan from Legacy Storage Systems, is a six-drive array housed in a tower enclosure. The NetSpan provides redundant power supplies and hot-swappable disks. My configuration consisted of six 1.3-gigabyte drives and sells for $34,900. Drive sizes of 249 MB, 420 MB, and 760 MB are also available. Legacy provides two Adaptec host controllers and uses Adaptec's NetWare drivers.

With OS/2 and Unix, the NetSpan can be configured as a RAID 5 array. Legacy has announced that it will release RAID 5 support for NetWare in the third quarter of this year.

I also tested an array comprising four 1.3-GB RapidAccess drives from MicroNet Technology. MicroNet supplies its own host SCSI controllers and NetWare drivers, and each drive is housed in a separate cabinet with a power supply and controller. There are no hot-swappable components. MicroNet also supplies drivers for DOS, NetWare 286, Unix, and Xenix. The array I tested is priced at $29,280. Drives of 330 MB and 670 MB are also available.

On both the Legacy and MicroNet arrays, I ran my suite of performance tests with and without disk mirroring implemented (or in RAID terms, the arrays were configured to level 0 and level 1). I also tested a single drive from each array to compare array throughput to that of a single drive.

For both systems, RAID 0 performance was almost twice as good as the single-drive configuration. With mirroring implemented, performance was only slightly degraded. The bottom line: If you need protection from disk failure but want to make the minimum performance sacrifice, use a RAID 1 disk-mirroring configuration.

throughout the process.

Micropolis supplies Adaptec SCSI host controllers for the server PC. You can connect one controller per module if you like to maximize redundancy.

A Solution That Works

The RAID 3 and 5 units discussed here deliver what they promise. With only 20 percent of the total array capacity devoted to data redundancy, they provide full protection from the failure of one disk. Since all the units provide the ability to replace and rebuild a drive without turning off the system, nonstop operation becomes a realistic possibility.

With prices for a 4-GB array ranging from about $25,000 to $65,000, the benefits of RAID technology obviously do not come cheap. However, if downtime is expensive—for example, if your array is part of the system that controls a manufacturing line or is used to store data for a nonstop emergency medical application—then the costs for these arrays are probably easy to justify.

Only one question remains. Is disk failure so prevalent and devastating that it is worth the elaborate precautions entailed by a RAID 3 or 5 solution? Only you can make that decision, but my own testing experience served as a reminder of how fragile hard drives can be. I tested six disk arrays, which all together included 31 separate drives. In three weeks of testing, two drives failed. ■

Bill Lawrence is part of the team that manages a 2300-node, 70-server network for a major Western utility. He also writes extensively about various computing issues and is the author of Using Novell NetWare, *2d ed. (Que, 1991). You can contact him on BIX c/o "editors."*

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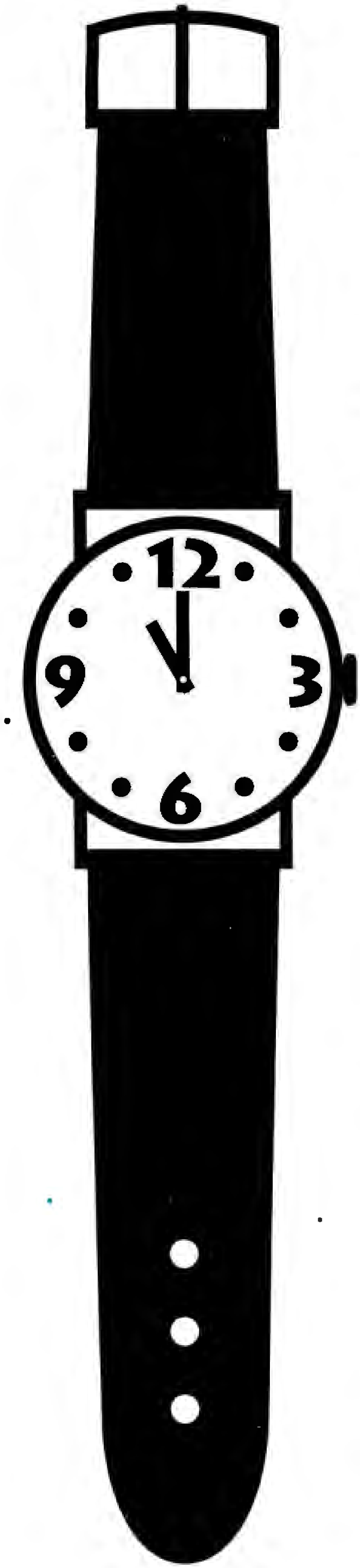
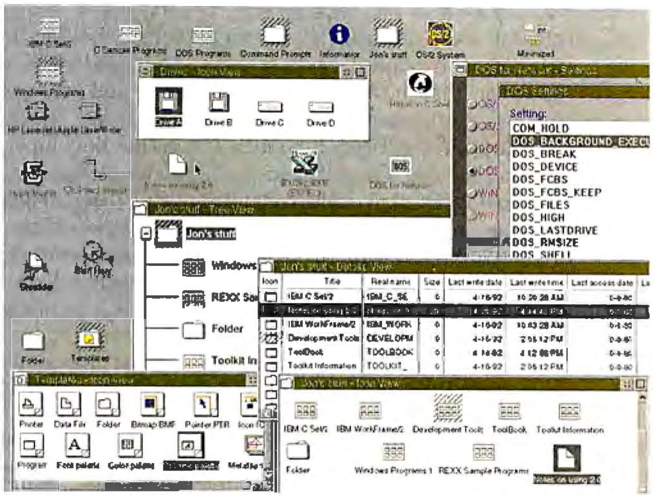


SOFTWARE

OS/2 2.0: A Mixed Blessing

JON UDELL



The Workplace Shell at 1024 by 768 pixels. Shell objects include printers, drives, folders, data files, programs, and the shredder (trash-can). Objects support settings dialogs appropriate to their type. Folders can show multiple views of their contents in separate windows.

OS/2 2.0 does just what IBM said it would. It runs multiple DOS programs. It runs Windows 3.0 programs in a full-screen DOS session or "seamlessly" alongside PM (Presentation Manager) programs. It runs 16- and 32-bit PM software. And it controls the whole show with the unconventional new Workplace Shell. To jam in all these features, IBM had to code right down to the wire, with varying results. Your satisfaction with 2.0 will be a function of how well its strengths meet your needs.

What are its strengths? These include excellent DOS multitasking, reasonable support for Windows 3.0 software, and of course the native OS/2 environment, which features robust protection, a 32-bit flat memory model, demand-paged virtual memory, and threaded multitasking. Its weaknesses? Performance, stability, and ease of use don't yet meet the high standards IBM set with OS/2 1.3. I'll focus here on what's new in the final release of 2.0. For details on the complete feature set, see "OS/2 2.0: It's a Family Affair," April 1990 BYTE, and "OS/2 2.0: A Pilgrim's Journey," December 1991 BYTE.

Meet the Workplace Shell

The most dramatic change since the last version I reviewed is the Workplace Shell (WPS). It was then incomplete and barely functional. In its place I used the old 1.3 shell, which is not an option in the final release. All of 2.0's eggs are now in the WPS's basket. (There is a "1.3 look-alike shell," but it is just the WPS in disguise.)

The WPS has inspired much passionate debate in its short life, so let me be careful to explain why I think it is unfortunate that IBM mandates its use. I don't mind that the WPS is non-Windows-like and fully object-oriented—indeed, I find these qualities refreshing. I do mind that it is maddeningly slow and eminently crashable. These problems probably will be fixed. Until they are, though, I wish IBM would give me back the old shell.

The new OS/2 desktop as implemented by the WPS bears superficial resemblance to the Macintosh and to alternative Windows shells such as NewWave and WinTools. Folders nest within folders to arbitrary depth and contain icons that represent programs, documents, drives, or printers. To open, copy, move, delete, or print a document, you drag it to and drop it on an appropriate icon. As with any system that relies heavily on drag-and-drop, effective use requires the ability to easily search and navigate the folder tree.

The WPS, however, is way too sluggish. When I opened a folder containing just a few icons, the disk light blinked and the task took a full 3 seconds to complete. To reopen the same folder still took about 2 seconds—this on a PS/2 Model 70 25-MHz 386 with 6 MB of memory, using HPFS (High Performance File System) with its default 256-KB disk cache. When I upped the cache to a megabyte, nothing changed. Why? Partly because the shell always rereads from disk, in case the contents of a network-resident folder have changed, and partly because of the overhead of processing icons. On a Compaq Systempro 33-MHz 486 with 16 MB of memory, things sped up quite a bit, of course, but you shouldn't need a screaming machine to make the shell feel snappy. Note that 16-bit PM applications such as PageMaker, Wingz, and DeScribe run quite well, so this isn't an indictment of the underlying system but only of its most visible application, the shell.

Even more discouraging was the search performance. To find all .EXE files on a 200-MB FAT (file allocation table) partition took 3½ minutes on the Systempro using the WPS's integral Find utility. Contrast that with 30 seconds using 2.0's own Seek and Scan applet (miniature application), or just 10 seconds for the Windows 3.1 File Manager (on the same machine booted under DOS). This is because the WPS reads extended attributes so that it can satisfy abstract queries like "find all text files," and also because its Find tool dumps search results into a top-level folder in the form of *shadows*. Shadows are special WPS objects that serve as aliases for program or data files. They're among 2.0's niftiest innovations. You can create a shadow manually by pressing Control-Shift while dragging a shell object. Identified visually by a grayed title, shadows help you form logical groupings of objects without moving their physical referents. But to create hundreds of shadow icons in response to a search seems costly.

Desktop vs. File-System Hierarchies

There's another, more subtle, problem. The first time I searched for .EXE files, I couldn't find a file I knew I'd copied to the disk. The reason was that the WPS's Find tool, by default, searches the desktop tree, not the file-system tree. The former is, in fact, part of the latter, since the desktop takes physical form as a directory tree rooted in C:\OS!2_2.0_D. Within that tree, WPS folders appear as subdirectories, and WPS program and document objects appear as files—but only if you use the shell to create or move those folders, programs, and documents. I had used an XCOPY command to download test software from the network, which meant my desktop-oriented search had gone down the wrong path.

Next, I reran the migration tool that captures DOS, Windows, and OS/2 applications as WPS objects and searched again for .EXE files. Still no luck. Now the desktop tree contained program icons, but no program files. The WPS stores program icons not as files, but as extended attributes. Only a WPS drag-and-drop (or its programmatic equivalent) can actually place files in WPS folders. Finally, I found the right approach. Although the Find tool defaults to a search of the desktop tree, you can also tell it to search the file-system tree starting at, for example, C:\. This means, however, that the WPS does not resolve the awkward structure clash that plagues Windows in the form of the infamous Program Manager/File Manager dichotomy. Existing DOS, Windows, and PM applications create files, not WPS objects. Alternatively, you can create WPS objects that contain data and launch applications. But once launched, these applications typically present File Save As dialog boxes that invite you to create new files outside the WPS's purview.

There may be a better way. Internally, the WPS uses an elegant OOP (object-oriented programming) technology called the System Object Model. With the System Object Model toolkit, which ships with IBM's WorkSet/2, you can convert an abstract description of a class hierarchy, along with its methods and instance data, into C header files. Programs that include these header files use the system services OS/2 provides in SOM.DLL to create and interact with objects belonging to the class. The WPS is such a hierarchy, and the developer's toolkit supplies the header files programs need to interact with WPS objects. The shell API exposed here is far richer than that available to Windows programmers. Moreover, the toolkit includes the abstract descriptions of the WPS objects and the translators that turn those descriptions into header files.

What does all this mean? PM programmers can readily create WPS-aware programs that do not violate WPS's logical storage model. Even better, they can create specialized WPS objects. Imagine, for example, a "backup folder" that inherits all standard folder behaviors but also copies its contents to tape periodically. However, only specially written PM applications can exploit the shell API.

BYTE

- **WHAT OS/2 2.0 IS**
  An all-in-one PC operating system that runs multiple DOS and Windows applications along with 16- and 32-bit PM software.
- **LIKES**
  Great DOS multitasking; reasonably good support for Windows 3.0 software; and the best platform for PM software.
- **DISLIKES**
  The Workplace Shell, though laudable, currently creates more problems than it solves.
- **RECOMMENDATIONS**
  OS/2 2.0 will meet the needs of many OS/2 1.x users, as well as some power users of DOS/Windows. Not recommended for average DOS/Windows users.
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DOS, Windows, and OS/2

OS/2 2.0's virtual DOS machines work quite well. Virtual DOS machines come in two flavors. The default DOS box uses a DOS kernel that OS/2 supplies. Alternatively, you can boot a "specific" version of DOS—such as DOS 5.0—from a floppy disk or a boot image built with OS/2's VMDISK command. It's preferable to use the default DOS box, which has a host of settings that you can twiddle: EMS, DPMI (DOS Protected Mode Interface), UMB (upper memory block), and video memory settings, idle detection, printer time-out, and many others.

If you want to run DOS block device drivers, though, you will need to boot a real DOS into the virtual DOS machine and adjust settings by way of its CONFIG.SYS. I've run network and CD-ROM drivers in a DOS 5.0 virtual DOS machine under OS/2 2.0, although, as I reported last time, some network adapters (i.e., Tiara and Interlan) worked in this configuration while others (i.e., Novell and Xircom) did not.

Windows support also comes in two flavors: full-screen and "seamless." Both use the same basic technology. A Windows 3.0 standard-mode kernel, adapted by IBM to act as a DPMI client with respect to the virtual DOS machine in which it runs, in turn provides DPMI services to Windows applications. In the full-screen mode, Windows applications multitask on a normal Windows desktop under the control of Program Manager; in the seamless mode, they occupy PM windows and obey the WPS, which is a neat trick.

OS/2 2.0 includes both clipboard and DDE transfer agents to carry these two protocols across the Windows/PM boundary. The clipboard works well for standard formats such as text, bit maps, and spreadsheet ranges. However, while I've seen the Windows-to-PM DDE transfer working in IBM demonstrations, my own tests failed to create DDE links between PM DeScribe and Windows Excel or between PM Wingz and Word for Windows.

IBM does not include the Windows 3.0 applets, but if you already own them, you can move them into 2.0. You can't use the Windows 3.1 applets, for the same reason you can't use them under Windows 3.0—they require the 3.1 kernel.

Along with 3.0 applets such as Write and Paintbrush, I've run PageMaker 4, Word for Windows, Excel, and Turbo Pascal for Windows under OS/2 in both full-screen and seamless modes. Either way, the virtual-DOS-machine overhead clearly takes its toll on Windows' performance under 2.0. In a full-screen Windows session, BYTE's disk- and screen-intensive PageMaker benchmark was more than twice as slow on the Systempro, but only a little slower on the PS/2 (relative to Windows 3.1 on the same hardware). The compute-intensive Excel benchmark, however, ran just slightly behind native Windows 3.1 on both machines. Results for the seamless mode were also split: PageMaker did better (relative to full-screen mode); Excel did worse. In no case did OS/2's Windows performance outpace that of Windows 3.1 on the same hardware, and I doubt IBM will continue to claim that 2.0 is a "better Windows than Windows." It is, however, a pretty good Windows for OS/2 users who want to run Windows software under OS/2.

Dig for the Gold

In the final analysis, OS/2 2.0 just isn't quite finished yet. At times, when I'm running multiple network-attached DOS sessions along with Windows and PM software, it lives up to its potential. But I have to work harder than I should to get things going, and the WPS detracts from both performance and stability.

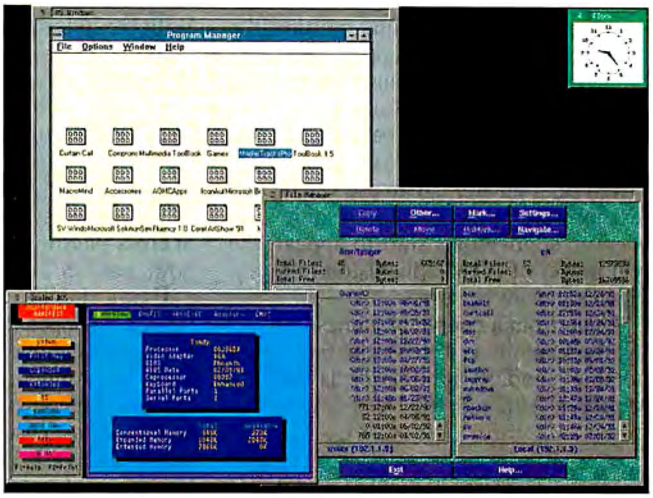
There's gold in 2.0, and power users will mine it as we always have. But the job requires more digging than most folks will want to do. ■

Jon Udell is a BYTE senior technical editor at large. You can reach him on BIX as "judell."

APPLICATION

Was Desqview/X Worth the Wait?

TOM YAGER



The Desqview/X desktop with a few applications. Desqview/X allows multiple text-mode DOS and X Window System graphical applications to share the screen with a standard-mode Windows session.

There's little argument: Almost every DOS user would like to run multiple programs at the same time. Users have been looking to Windows, Desqview, OS/2, and a host of other means of making DOS multitask. Windows has been getting all the attention lately, however, because it also provides a popular base for graphical applications.

Not to be left behind, Quarterdeck has put a new set of teeth in its old standard DOS multitasker, Desqview. Desqview/X brings industry-standard graphics, networking, and distributed computing to the time-worn DOS multitasking problem and lights a fire under the competition by adding support for extended DOS and Windows applications.

Standing Alone

Installing Desqview/X is a bit of an adventure, but not because it's difficult. The package includes two other Quarterdeck products: the QEMM-386 memory manager and Manifest, a program that reports on your system's configuration. These two work in concert to manage your extended memory. QEMM-386's Optimize utility sniffs out every last nook where memory can be remapped to expand the standard DOS space. This is the tedious part. In my case, it rebooted my PC (a Tandy 4033 LX) several times to find the most effective configuration. I can't fault Quarterdeck—there's no other way to find every last bit of available memory space—but this makes installing Desqview/X more work than installing Windows or OS/2. If you change your system's configuration, you'll probably have to run Optimize again.

Out of the box, a single copy of Desqview/X does pretty much what Desqview did—but with graphics. The *X* in the name refers to the manner with which Quarterdeck chose to do the graphics: using MIT's X Window System. What sets Desqview apart from its competitors is that in addition to being a good DOS multitasker, it is also a fully functional X environment. It's even possible, through the use of libraries available from Quarterdeck, to port native X applications to Desqview/X.

Since there aren't yet any Desqview/X-specific applications (except for the handful of utilities and games provided with the package), you'll probably run the DOS, extended DOS, and Windows applications you're running now. Home base for Desqview/X is the desktop, the X root window. The default desktop is blank; you launch applications by popping up a menu with a mouse button. You can easily reconfigure Desqview/X to start the Application Manager or any number of other programs automatically on start-up. The screen shows a loaded desktop.

You can run DOS and extended-DOS text-mode applications in either fixed-size or resizable windows. The scalability comes from the inclusion of ATM (Adobe Type Manager). No matter how you reshape the DOS window, every character remains visible. Thanks to Adobe's skill with fonts, the characters remain readable down to an impressively small size. Colors and line-drawing characters are reproduced perfectly in the window, as well.

You may also choose to run standard-mode Windows (not included with Desqview/X), which appears in an X window of a size you specify. What you see in that window is the full Windows desktop; you cannot launch Windows applications directly from Desqview/X. Running standard mode costs you Windows' virtual memory support and prevents you from running some applications and drivers that require 386 enhanced mode.

Desqview/X lets you run graphical DOS applications, giving them the full screen. You don't lose control when a DOS program takes over the screen; just tap the hot key and the Desqview/X main menu will appear. Switching away from a DOS graphics program will suspend it.

Standard Features

Doing a full X implementation is ambitious enough in itself (Desqview/X occupies seven high-density 3½-inch disks), so Quarterdeck doesn't lose points for failing to include lots of standard applications. I was a little surprised to find that there was no equivalent to the Windows notepad or Write, especially with ATM included in the bundle. The included applications are split among administrative, demonstration, and game programs.

The administrative programs give you lots of control over your system. One utility reports on memory usage, checks the status of running applications, brings up a copy of an application's window, and kills a specified task. You also get a print manager of sorts—a spooler that intercepts printed output from multiple applications and feeds them to your system's printer. Both programs have full-screen, mouse-sensitive text interfaces that give you quick access to information and changes.

Desqview/X adapts itself to individual applications through DVP files, the equivalent of Windows PIF files. Created by the graphical DVP Manager application, DVP files contain information about memory requirements, COM port usage, text mode (fixed or scalable), starting window size and position, and other program-specific items. Everything you plan to run should have an associated DVP file, and these are kept in a reserved directory. DVP files are first in the search path when you request to run a program by name.

The included ATM shows itself most obviously in its support for scalable DOS windows. It is plugged into Desqview/X's

X server, so smooth Times, Helvetica, Courier, and Symbol fonts are available to Desqview/X-specific applications. These programs also use ATM's print support, which brings scalable fonts to a variety of popular dot-matrix and laser printers. For DOS applications, neither the fancy fonts nor the print support mean anything. DOS programs cannot use ATM to spruce up reports. This was an oversight; the Print Manager should have at least permitted the assignment of a standard ATM PostScript font and size to use when DOS text jobs are printed. Until Desqview/X-specific applications start to appear, the real power of ATM's inclusion in Desqview/X cannot be seen.

Aside from a couple of games (including the ubiquitous Tetris), the only other notable standard application is the File Manager. Although the Desqview/X File Manager is Spartan compared to the Windows version, I quickly grew to like its LapLink-style two-view interface (shown as part of the screen).

TCP/IP Support

With Desqview/X, you can run any text-mode DOS program or standard-mode Windows session on a remote system. It includes support for NetBIOS and NetWare SPX/IPX connections between Desqview/X systems. With an optional module, it will also support connections with TCP/IP-based systems, opening up a world of cross-platform compatibility that Windows and OS/2 can't yet touch.

Using the TCP/IP module, a Desqview/X-equipped PC can join a network of Unix workstations, X terminals, and even Macs and Amigas; practically everything can run X these days. Its best link is with Unix systems. I used FTP Software's venerable PC/TCP DOS TCP/IP module. Unix X programs will run over a network connection to your Desqview/X-equipped PC, and your PC can provide DOS and Windows applications to every X-capable system on the network.

I tested Desqview/X in a Unix lab environment. I set up connections between Desqview/X on the Tandy 4033 LX, an Opus SPARC system running SunOS/Solaris, and an Altos System 5000 33-MHz 486 running SCO Unix with Open Desktop (SCO's X implementation). Desqview/X's X server proved stable and even fast, once I moved off the Tandy's standard Paradise VGA card and onto an 8514/A card (which also gave me the extra resolution many X applications expect). The only serious performance problem involved the cursor; it lagged considerably behind mouse movements and grew more sluggish as more windows were displayed. Aside from that, I ran several Unix applications, including FrameMaker; Island Write, Draw & Paint; and an assortment of standard and homebrew X programs, with only minor difficulties.

Desqview/X's standard-issue window manager (the program that lets you resize, move, iconify, and otherwise manipulate your application windows) apparently lacks the color-palette management that some X programs expect. If you run an application that sets up its own palette, that palette is imposed on everything you run until the application is terminated.

My other complaint is also window manager–related: Resize operations are extremely awkward. You must place the mouse pointer precisely on the corners of the window border to resize it, and in my tests, the window manager often failed to listen when I dragged the window to a new size. In addition, the windows lack border icons for common operations like maximize, close, and iconify. Quarterdeck defends this by claiming to support a "Desqview look and feel." I'd have to say that, as good as Desqview is at what it does, it hardly makes a good model for a windowing system.

On the plus side, I was able to sit at the Opus SPARC system (running either Sun's Open Windows or Integrated Computer Solutions' X server) and call up a host of DOS applications. Desqview/X happily served them up, delivering them to the Opus screen within seconds of my request. Remote DOS sessions can't use ATM-scalable fonts, but Desqview/X includes a set of prescaled fonts that you can copy to and compile on most X implementations. DOS text applications come up looking great—and in color. DOS graphics applications cannot be run remotely, and after running Windows remotely, I can understand why.

Quarterdeck deserves credit for its work to make Windows 3.0 or 3.1 run as a Desqview/X subtask. It is standard-mode only, and you can't just double-click on a Windows program and have it run directly, but Windows will run remotely. The trouble with remote Windows is that, unlike X, it wasn't built to run efficiently over a network. Performance is just bearable and at times unacceptably slow. It does work; I was able to run several Windows programs remotely without incident. But performance is slow enough that I can't recommend Desqview/X's remote Windows capability except as an occasional convenience.

Technical Achievement

There's much more to be said about Desqview/X. Technically, it's quite an achievement. How it will figure in the fast-changing desktop environment struggle remains to be seen. Much depends on how quickly software vendors set about creating native Desqview/X applications, because the DOS text-mode program is becoming a rarity.

Like it or not, the graphical interface rules the day, and Desqview/X's ability to run Windows programs isn't enough. What it offers is an alternative to proprietary, comparatively isolated PC graphical environments. None of them can match Desqview/X's networking muscle or its strength in mixed-platform settings. ■

Tom Yager is a BYTE technical editor and author of UNIX Program Development for IBM PCs *(Addison-Wesley, 1991). He can be reached on BIX as "tyager" and on Internet at tyager@byteph.byte.com.*

BYTE

■ **WHAT DESQVIEW/X IS**
It's an implementation of the X Window System that allows you to run multiple DOS, extended DOS, X, and Windows programs locally or remotely.

■ **LIKES**
Industry-standard (not proprietary) system; strong support for distributed computing; standard scalable fonts.

■ **DISLIKES**
Weak support for DOS graphics programs; poor remote Windows performance; no third-party application support (as of this writing).

■ **RECOMMENDATIONS**
Desqview/X is a stable, standards-based system that fits well into mixed-platform settings.

■ **PRICE**
$275; optional TCP/IP module, $200

■ **FOR MORE INFORMATION**
Quarterdeck Office Systems
150 Pico Blvd.
Santa Monica, CA 90405
(800) 354-3222
(310) 392-9851
fax: (310) 314-4217
Circle 1131 on Inquiry Card.

HARDWARE

NEC's Notebook Compromises for Color

WAYNE RASH JR.

NEC Technologies' UltraLite SL/25C is one of the first active-matrix color notebooks to hit dealers' shelves. The UltraLite is built around the Intel 25-MHz 386SL microprocessor, so it's fast.

Its backlit TFT (thin-film transistor) LCD provides good color and delivers full VGA resolution, yet it uses relatively little power compared to earlier portable color screens. More important, the UltraLite's screen is fast enough to avoid the problem of trails behind moving objects, such as the mouse pointer.

Color Compromises

Portable-computer color screens are a compromise. They can't soak up the power that a CRT uses, or there wouldn't be a prayer of running them on batteries. But TFT displays still demand a lot of power to drive the backlighting, which must shine through the color LCD panel. That means there will always be a trade-off between battery life and the brightness and brilliance of a portable TFT display.

NEC has obviously chosen to favor battery life in this equation; the backlighting is somewhat dim (see the photo). You can't use the UltraLite outside or in a brightly lit office. Even under normal office fluorescent lighting, the screen washes out to the point of being difficult to see, and in sunlight, it's unusable. However, if you have an office optimized for computer use, with indirect, subdued lighting, you'll probably be able to see the screen just fine.

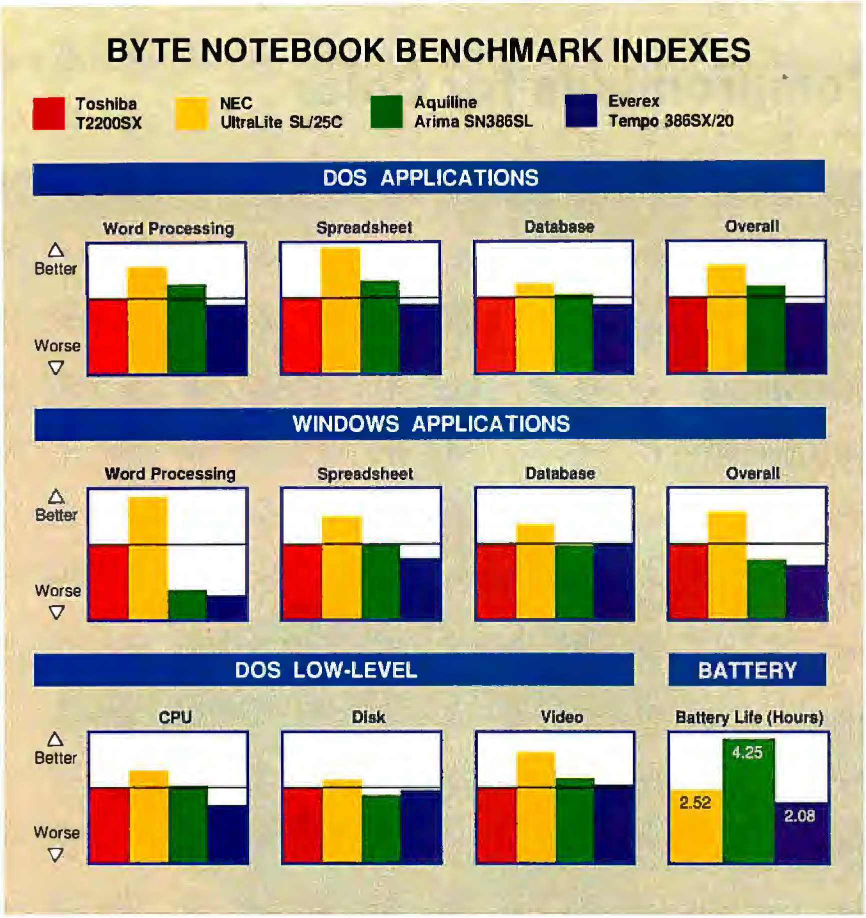
Even with relatively low-powered backlighting, the UltraLite demands considerably more power than comparable monochrome devices. NEC says that the normal battery life between charges is 1 hour, 18 minutes if you use the machine constantly during that time. This closely matches the 1 hour, 20 minutes I measured in actual use. BYTE's battery-life tests (see the figure) pegged the UltraLite's life at just over 2½ hours in typical conditions—far below the times of monochrome SL machines that BYTE has tested, but above those of some SX-based monochrome notebooks.

NEC has made good use of the 386SL's power management features to extend life. If you don't press a key, and if there isn't anything happening on the screen for over a second, the CPU clock drops to 6.25 MHz. After a preset time, all power-consuming

NEC's UltraLite SL/25C has a colorful, high-contrast display, but the machine is bulky, and the display can fade in bright light.

BYTE

- **WHAT THE ULTRALITE SL/25C IS**
  NEC Technologies' low-power high-speed notebook with an active-matrix color display.
- **LIKES**
  The UltraLite is fast, and power management features provide good battery life.
- **DISLIKES**
  The UltraLite is big and heavy by current notebook standards, and it's hard to work with the display in bright light.
- **RECOMMENDATIONS**
  Considering the premium you pay for color and the added bulk required for the display, the monochrome version of the UltraLite is probably a better choice.
- **PRICE**
  $6268 (as tested)
- **FOR MORE INFORMATION**
  NEC Technologies, Inc.
  1414 Massachusetts Ave.
  Boxborough, MA 01719
  (508) 264-8000
  fax: (508) 264-8673
  Circle 1133 on Inquiry Card.



All results are indexed, and higher numbers indicate better performance. For each index in the DOS and Windows tests, a Toshiba T2200SX running DOS 5.0 and Windows 3.0 = 1.

The BYTE low-level benchmark suite identifies relative performance at the hardware level, breaking down performance by system component. The results of these tests can help you to identify the relative performance of a given subsystem and to determine where performance bottlenecks may lie. For a complete description of these tests, see "BYTE's New Benchmarks: New Looks, New Numbers," August 1990 BYTE. The BYTE low-level benchmarks, version 2.2, are available in the byte.bmarks conference on BIX, or you can contact BYTE directly.

BYTE's application performance suite measures the performance you can expect to see running a given application category under a given operating environment. We test under two environments: DOS 5.0 and Windows 3.0. We test three application categories for each environment, running test scripts using the following programs: Word Processing: WordPerfect 5.1 and Lotus Ami Pro 2.0; Spreadsheet: Lotus 1-2-3 release 2.3 and Microsoft Excel 3.0a; Database: Software Publishing Superbase 4 version 1.3 and Borland dBase IV. The data files and test scripts are available from BYTE.

Benchmark results place NEC's UltraLite SL/25C among the faster notebooks BYTE has tested. Its battery life compares favorably to that of some monochrome machines.

devices shut down as the computer enters rest mode. Finally, after another configurable interval, the machine shifts to standby mode, where the processor completely stops. Standby mode requires only about 4 percent of the power required during full operation.

Replacing the battery is easy even while you are using the UltraLite. The battery is located beneath a panel in front of the screen. If the computer is in use, you shift it into standby mode by pressing a button that is adjacent to the power switch, swap the old battery for a new one (the UltraLite will run for about 5 minutes with the battery removed), and shift the computer back into normal operation.

High-Speed Cruise

The UltraLite runs at a full 25-MHz clock speed when it's plugged in, but you can set the battery-power clock speed to 25 or 12.5 MHz. The lower rate extends battery life. BYTE ran performance tests on a 4-MB version of the UltraLite (the standard complement is 2 MB) running at 25 MHz. As you can see from the benchmark graph, that performance is respectable. In real-world use, the UltraLite is fast enough to run Windows comfortably while at full speed.

I was surprised that switching to half-speed battery operation didn't give me much of a perception that the UltraLite was slowing down. Of course, CPU-intensive operations, such as reformatting a large Word for Windows document or recalculating a big spreadsheet, would make the slowdown obvious, but most people don't run those operations on notebooks very often. The only obvious delays happen when you bring the computer back to life after it's been in the standby mode. That can take a few seconds.

Big

No matter how you look at it, the UltraLite is hefty for a notebook computer. At 9 by 11½ inches, it stretches the upper end of the category boundaries. Its 2½-inch thickness is probably too much for your briefcase, and it weighs 7½ pounds. When you carry the UltraLite around for a while, you begin to wonder where the name came from.

Thickness also makes the UltraLite harder to use. The front edge of the keyboard rises 1½ inches above the surface on which it rests. This is high enough to make typing uncomfortable.

Otherwise, the UltraLite is well arranged. The floppy drive is on the left side near the front, leaving plenty of room on the right side for a clip-on trackball like the Ballpoint mouse. The 80-MB hard drive is just behind the floppy drive. The controls are easy to find: The power switch is on the flat surface above the keyboard, and the standby switch is next to it. The brightness control is just below the screen's lower-right corner. Serial, parallel, mouse, keyboard, external floppy drive, and VGA connectors are behind covers on the backpanel. The backpanel also holds a power jack (concealed by a plug that's hard to remove but easy to lose) and a docking-station connector.

At just under $6000, the UltraLite is reasonably priced—as these things go. Toshiba charges, and Zenith plans to charge, a lot more for its color notebook computers (close to $8000). If, however, you can live without a color screen, you can save a lot of weight and thousands of dollars and get longer battery life. If the UltraLite's color screen were as bright and clear as those of some of its competition, it might be worth the cost; but the display is just not that good. NEC's UltraLite SL/25C is a good machine, but for six grand, you should expect a great one. ■

Wayne Rash Jr. is a consulting editor for BYTE and director of the Network Integration Group of American Management Systems, Inc. (Arlington, VA). He is coauthor of two books for business network users: The Executive Guide to Local Area Networks *and* The Novell Connection. *You can contact him on BIX as "waynerash" or in the to.wayne conference.*

APPLICATION

A Fresh Approach to Databases

RICK SCOTT

Database programs are an invaluable tool for keeping track of information, but they can be difficult to learn and use. Approach Software is trying to change that with its new Approach for Windows, which takes advantage of a graphical environment to remove some of the fear and loathing from setting up a database system. Approach is not only simple to set up, but it also offers some unique features, such as being able to easily access and blend information from other databases.

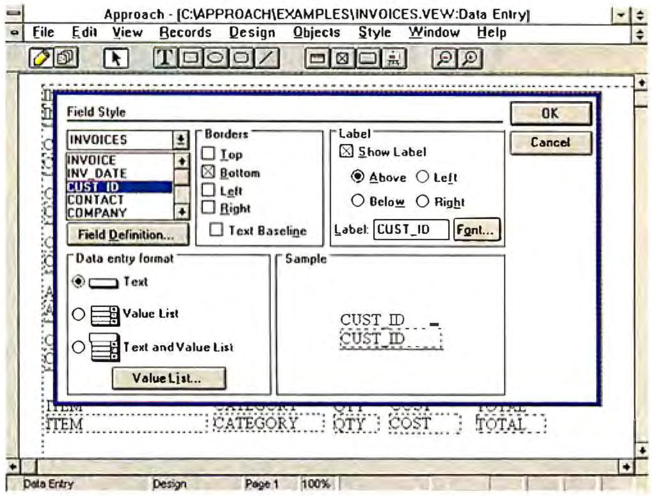
Approach is a stand-alone relational database. But it can also serve as a front end to databases created in dBase III Plus, dBase IV, Paradox, or Oracle SQL. It is equally suitable for creating files you can use with those programs. Approach can mix data from any of these three databases in the same form or report, to a limit of 10 databases per application.

The program can import and export information in popular formats, such as Lotus 1-2-3, Microsoft Excel, and ASCII. Approach can also store graphics in PCX, TIFF, EPSF, BMP, and Windows metafile formats. This is handy if you want to set up a pictorial database, such as a personnel directory. Besides text and pictures, the program offers six other field types: Numeric, Boolean, Date, Time, Memo, and Calculated. Approach is function-rich: A calculation can use any of 81 predefined functions, including trigonometric, statistical, date, conversion (i.e., numeric to text), and string functions.

When you want Approach to sort a file, just click on the fields you want to sort on, in the order you want, and select ascending (e.g., A to Z) or descending. Multiple-field sorts are also possible. Approach creates an index (which it calls a *smart index*) on any field on which you do a find or a sort. After a field is indexed, Approach maintains the index for that field so that subsequent fields and sorts are performed faster. You can also define a field as an Index field during data entry. Boolean, Picture, and Memo fields cannot be indexed.

Approach comes with a macro feature to record and play back a sequence of operations. You can set macros to move to different screens, switch a view, find a particular record, execute a menu option, move to the current record, or set a field to a particular value. As with everything else in Approach, you define your macro's action from a list of options. Macros are the closest thing to programming you'll find in Approach, since it has no programming language.

Making a database with Approach is a point-and-click process. After naming a new database and choosing its type (e.g., dBase, Paradox, or Oracle SQL), you enter the field name, field type, and field length. Approach extends the standard types. For example, in dBase mode, which is the default, you can have Text, Numeric, Date, and Boolean fields, as well as Calculated fields. Building a formula for a Calculated field is as simple as picking the fields to be included in the calculation and selecting the operators and functions. Operators include standard math, such as



To design a data-entry field with Approach for Windows, you pick fields from a pull-down list and then select border and label options. The program lets you preview the results in a window in the lower right corner. The toolbar at the top provides push-button access to commonly used operations.

BYTE

WHAT APPROACH FOR WINDOWS IS
A relational database for Windows.

LIKES
It's easy to use and has the ability to access and use files from dBase, Paradox, and Oracle SQL. It also has good documentation.

DISLIKES
It's awkward to change lists when conditions change or you make a mistake, and it lacks mail merge.

REQUIREMENTS
Microsoft Windows with 2 MB of RAM and an EGA or better monitor. To use Oracle SQL databases, you need software from Oracle.

RECOMMENDATIONS
Approach is perfect for novices and intermediate users, for those who don't want or need a database programming language, and for people who need to tap into data in dBase, Paradox, and Oracle SQL formats.

PRICE
$399

FOR MORE INFORMATION
Approach Software Corp.
311 Penobscot Dr.
Redwood City, CA 94063
(415) 306-7890
fax: (415) 368-5182
Circle 978 on Inquiry Card.

The Key to Other Databases

D. BARKER

One of the significant and unique components of Approach for Windows is the company's PowerKey technology. The program uses this technology to access and work with files from dBase, Paradox, and Oracle SQL databases. "With a PowerKey, we can give someone access to a data type without them having to learn a new database," says Approach Software president Kevin Harvey. PowerKeys are basically DLLs. But they are not filters, Harvey says: "They are full-blown database engines that allow Approach to act like a native database." Approach doesn't build an intermediate data file. It operates directly on each native data type.

PowerKeys bring several advantages. As Jaleh Bisharat, Approach Software's vice president of marketing, points out, corporations can give Approach to their novice or intermediate computer users, while their programmers or database honchos can continue using dBase, Paradox, or Oracle SQL. "This allows corporations the flexibility to provide appropriate database solutions to a range of users," she says.

New PowerKeys will give Approach the ability to tap into more databases, such as SQL Server.

D. Barker is a BYTE Lab technical editor. You can contact him on BIX as "dbarker."

+, -, and so on, as well as < >, =, and ( ).

In design mode, you not only add and position fields on the screen, you define data-entry options as well (see the screen). One option lets you define the value of a field on a new record. You can force a default value or the current date and time, or you can select the value from the previous record. A field can also be serialized, which is perfect for invoices or customer numbers. You can determine the beginning and incremental values, too.

The database builder can set up parameters to force you to fill in a field, in essence making the field required. Another option lets you pick from a list of values you define. Approach creates a drop-down scrollable list for you during data entry. The only limitation to this procedure is that if you add an entry to the list, it appears at the bottom of the list. You cannot reorder elements in the list unless you delete all elements and rebuild the list from scratch. This is a serious limitation and inconsistent with the flexible options that Approach uses in the rest of the design process.

The database designer can specify that you match the value you enter to one that is already in the specified field in another record in the same database or in a joined database. For example, you might want to verify that a customer number in an order form exists in the customer's database. Approach makes this procedure extremely simple—you just specify the database and the field in that joined database by selecting files and fields from a list.

Joining database files is easy, too. You open a database and select the field to be used as the key to the second database. When you select the second database, you pick the corresponding field and click on the Join button. That's all there is to it.

Designing Forms and Reports

Approach uses an object-based method for designing a form. Basically, you start out by choosing database fields from a list, and then you click on the Add button to put them in the adjacent Form Fields list. Approach builds a default form, which includes field prompts and room for each field you've selected. You move and resize these fields to make the form look the way you want. In design mode, you work with objects such as field prompts, the fields themselves, graphics, and titles. For example, if you want to move a field, you click on it and drag it to a new position.

Putting together a report that presents the data from a set of records or a whole database is similar to designing a form with Approach. Reporting comes in three flavors: standard, in which each field sits on a separate line; columnar, where each record appears as a row; and summary, which shows only the calculated results of specified records.

On a Network

Approach will work with several LANs: Novell Advanced NetWare 2.0A or higher, NetWare 386, NetWare Lite, LANtastic, Microsoft LAN, IBM PC LAN 1.12 or higher, 3Com 3+Open 1.0 or higher, or Banyan Vines 2.1 or higher.

If someone else on the network has made a change to the file you're working on, Approach will show you that change if you use the Refresh command. If a fellow user modifies a record after your last refresh, the program alerts you to that and asks if you want to override the modification. The program will lock a record if you want to temporarily keep another person from making a change to it. After you have made changes, Approach automatically locks the record while writing those changes. When working with dBase or Paradox files, you can specify "no database sharing" if you don't want anyone working with a file while you've got it. Furthermore, you can guard files with passwords so that other people can view them but can't change them.

As Easy as It Gets

Approach makes the design and use of databases almost effortless. It takes advantage of point-and-click operation, the hallmark of a good Windows (or any GUI) application. Novices should have no problem getting up to speed.

Approach still has some rough edges, especially when it's building validation lists. If you make a mistake or want to make an addition later, you have to start from scratch. Mail merge also needs to be implemented.

As a stand-alone relational database program that can double as an easy-to-use front end to dBase, Paradox, and Oracle SQL databases, Approach is unique. If your database requirements are straightforward and you don't want or need a programming language, you can't go wrong with Approach. ■

Rick Scott is a technical writer and consultant based in Seattle, Washington. You can reach him on BIX c/o "editors."

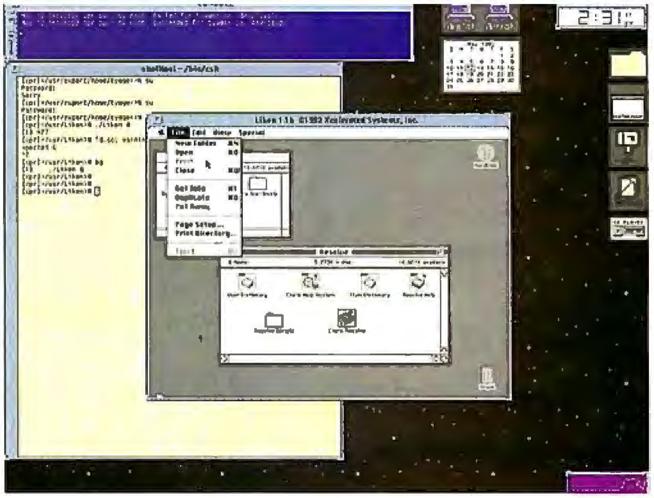
APPLICATION

Macintosh Impersonator

TOM YAGER

Life would be easier if everyone in your company used the same kind of computer. In reality, however, most businesses operate networks that include many kinds of systems. Sharing data among those various system types is hard enough. Sharing applications among them is almost impossible.

With Liken, Xcelerated Systems offers a partial solution to the cross-platform applications compatibility problem. Liken is software that emulates a Mac, from its 68000 CPU to its system ROMs. Once you install Liken on your SPARC-based workstation, you suddenly can run a wide assortment of Mac programs; no special hardware or software (other than Liken and the Mac system software) is needed.



Liken running under OpenWindows with the pop-up menu activated.

Preparing the Imaginary Mac

I installed Liken on a Sun Microsystems Sparcstation IPC with 16 MB of memory that was running SunOS 4.1 and OpenWindows 2.0. It installs using Sun's automated `extract_unbundled` facility, and a vendor-supplied script takes it from there. Take note: Each copy of Liken is serialized, so before you can use it, you have to call Xcelerated Systems to collect an authorization key.

Liken's minimum requirements are meager: 5 MB of disk space and an unspecified amount of memory. It ran well within my Sparcstation IPC's 16 MB of memory. To complete the installation, you'll need a set of Mac system software disks; the procedure and documentation call specifically for version 6.0.7, and the software must be on 1.44-MB floppy disks. Even at BYTE, where there are lots of Macs of various ages, I had trouble tracking down the needed version and format. Since newer Macs ship with System 7.0, finding the older version to accommodate Liken could be a challenge for some users.

The faux Mac that Liken creates is no Quadra. Rather, you get a 68000-based system with 4 MB of memory and a monochrome display, with no math coprocessor. It won't run System 7.0, it has no networking support, it can't read 800-KB Mac disks, and it can't run MultiFinder. These points are immutable (for now). While all that seems mighty limiting to many modern-day Mac users, there are still a lot of systems out there with most of these limitations, so you'll find plenty of commercial software that runs in this environment.

While Liken's primary job is to emulate a Mac, it takes advantage of some perks found only in a workstation environment. For one, the monochrome display is configurable to a variety of sizes, from the standard 512- by 342-pixel resolution "cute-little-Mac" display to an 1152- by 900-pixel resolution window that fills a Sun monitor. Since Liken runs under OpenWindows, you can run it across a network. The monochrome-only display emulation performs reasonably well over a wire. Also, Xcelerated Systems applied some imagination to storing Mac files on the workstation's hard drive. More on that shortly.

Feels Like a Mac

Liken loads and launches quickly, opening a display window that dumps the typical "happy Mac" boot icon in favor of a less inspiring Xcelerated Systems logo. That's quickly replaced by the familiar, cozy Mac Desktop, and the similarity is more than just skin-deep. Whenever you select the Liken window and place the mouse pointer inside it, the virtual Mac owns your mouse and keyboard. Mouse movement, at least on the Sparcstation IPC, is only a little sluggish compared to the mouse movement in the root window. Performance of other common Desktop activities—pull-down menus, resizing and moving windows, dragging items to the Trashcan, and so on—varies in relative speed, but I always found them bearable.

Liken has a pop-up menu (see the screen) (activated by the Mac-superfluous

BYTE ACTION SUMMARY

- **WHAT LIKEN 1.0 IS**
  Software for SPARC-based Unix workstations that emulates a Mac.
- **LIKES**
  Variable-size display, flexible file system support, and simple pop-up menu control.
- **DISLIKES**
  Configuration and compatibility limitations, no networking, and no System 7.0 support.
- **RECOMMENDATIONS**
  A good start on what promises to be an effective bridge between Mac and Unix environments. Version 1.0 is a little wobbly yet, but it offers the neediest users some early relief.
- **PRICE**
  $695 for a single-user license.
- **FOR MORE INFORMATION**
  Xcelerated Systems, Inc.
  3944 Murphy Canyon Rd.,
  Suite C201
  San Diego, CA 92123
  (619) 576-3080
  fax: (619) 576-2504
  Circle 977 on Inquiry Card.

right mouse button) that lets you mount a floppy disk, CD-ROM, or hard disk volume; change the display resolution; bring up the on-line manual; or force an exit from Liken. The menu is always available, regardless of what the virtual Mac is running.

The pop-up menu's volume-mounting options point out some interesting traits of Liken. It doesn't monitor the floppy drive, checking for media the way the Mac does. Instead, the drive is available to other Unix applications until you insert a floppy disk and ask Liken to mount it. Liken can deal only with 1.44-MB floppy disks, and it can't format them. Once they're mounted, though, they can be handled just like regular Mac floppy disks, and you'll have no trouble exchanging disks with any 1.44-MB-capable Mac. And while Liken can't automatically mount an inserted floppy disk, it can eject one in the normal Mac way. If your Sun workstation has a CD-ROM drive, Liken will let you read any Mac-compatible CD-ROM. Again, Liken doesn't seize control of the device until you explicitly ask it to. On a multiuser system, that's the right way to handle device usage.

Liken supports two flavors of hard disk access: HFS (Hierarchical File System) and UFS (Unix File System). HFS is the format used on native Mac hard disks. A Liken HFS volume is a preallocated Unix file that looks to the Mac system software like a formatted and initialized hard disk. The UFS volume uses its own hierarchical structure to store Mac files. While Mac files stored on an HFS volume can be seen only by Liken, UFS files are ordinary Unix files that Unix applications can read and modify.

Feet to the Flames

Running a handful of popular Mac applications turned out to be a challenge thanks to Liken's lack of network support. Despite the fact that BYTE's Mac and Unix networks are linked with the venerable Cayman Systems' GatorBox, I was unable to get files copied from a Mac to the Sparcstation IPC (through Cayman's GatorShare) to read correctly under Liken. I finally resorted to floppy disks, finding that the latest version of Aladdin Systems' Stuffit archiving utility crashed Liken. When I used an older copy of the utility things ran smoothly.

Claris Resolve ran mostly without problems, and the display performance was pretty good. Sometimes, though, Liken would forget to refresh parts of the screen during a scroll. The data was still there, but I had to kick in another scroll to get the screen refreshed. MacWrite II ran well without any of Resolve's display anomalies. Beyond that, compatibility, as evidenced by Xcelerated Systems' own manual, is a mixed bag. Many of the big names (e.g., Microsoft's Word and Excel) make Liken's compatibility list, while others (e.g., Frame Technology's FrameMaker and Apple's ResEdit) do not.

Liken supports an Apple LaserWriter as an output device, routing Mac applications' printed output through the Unix line-printer daemon. Since Xcelerated Systems doesn't offer a LocalTalk card or adapter, you need to use one of your SPARC system's I/O ports (serial or, in some cases, parallel) or connect to a LaserWriter through a network. Either way, your application must use the system's printer driver that intercepts and reroutes the output through Unix. Programs that want to use proprietary drivers must be persuaded otherwise or made to save their output to a file that you can then print manually.

A Real Conclusion

On my Sun Sparcstation IPC, the BYTE low-level Mac benchmarks showed Liken's performance to be about half that of Apple's low-end PowerBook (a 16-MHz 68000). There were both bright (transcendental floating-point operations) and bleak (text-output) spots, but on a 25-MHz SPARC system, Liken seems to pull the weight of an 8-MHz 68000.

Once again, compatibility became an issue as the graphics benchmark test froze up. Liken didn't freeze, though, and I was able to use the pop-up menu's Abort command to shut down Liken.

Liken earned my respect for doing most of what it promised and for not promising to do more than it could. Both the documentation and the company that created it are honest about what Liken can and can't do, so when the firm talks about the product's future, I'm inclined to take it seriously. This first release of Liken will be followed by a series of intermediate updates, rolling in color, networking, System 7.0 compatibility, and a host of other things that Mac users have come to expect.

Today, Liken is a convenience that can help smooth out some sticky integration issues for mixed-platform shops. Soon, if Xcelerated Systems' plan works out, Liken will grow into a product that even the most dedicated Macophile will happily use. Given what I've seen so far, I'm looking forward to the Likens to come. ■

Tom Yager is director of the BYTE Multimedia Lab and author of the forthcoming book The Multimedia Producer's Handbook *(Academic Press). He can be reached on BIX as "tyager" or on the Internet at "tyager@byteph.byte.com."*

SOFTWARE

Power Tools for Visual Basic

JON UDELL

Visual Basic was born to be extended. Once you see the wonders you can work with its native controls—menus, buttons, list boxes, and text fields—you lust for even more leverage. Visual Basic can't really extend itself, however. An interpreted language that lacks pointer support, it just isn't the right tool for building high-performance objects that reach deep into the Windows API. Instead, it relies on custom controls called VBXes (Visual Basic Extensions). Written in C, these extensions appear in the Toolbox and act just like native Visual Basic controls. You draw them on forms, modify their properties interactively at design time or programmatically at run time, and write code to define how they respond to events.

Microsoft's new Professional Toolkit for Visual Basic supplies a set of useful custom controls and the development tools you need to write your own VBXes. The new custom controls (see the table) are a mixed bag. Some merely add visual or functional pizzazz to standard Visual Basic controls. You can use three-dimensional versions of buttons and frames to achieve a chiseled Motif-like look, or instant-change scroll bars that trigger change events while the scroll indicator is moving. Others take Visual Basic into new areas—graphing, common dialog boxes, OLE (Object Linking and Embedding), multiple-document interfaces, pen input, and multimedia.

Experimenting with these building blocks proved entertaining, productive, and sometimes frustrating. Why frustrating? Because I achieved so much so quickly with the Visual Basic power tools, I raised my expectations impossibly high. Then reality set in. Also, I discovered that some of the Toolkit's controls don't encapsulate all the behaviors they should to rate as fully general-purpose objects.

Building a Database Browser

My central example is the database browser (see the screen). This program uses five Toolkit controls: Common Dialogs, Grid, Graph, MDI Child, and (gratuitously) OLE Client. It displays a FoxPro 2.0 database in one MDI Child window, graphs selected data in a second, and inserts an embedded object into a third. For the database support, I enlisted the help of Sequiter Software's CodeBasic (the CodeBase 4.5 DLL with Visual Basic bindings).

The Grid control serves as a database browser. The Graph control renders the selected column of data as a 3-D bar chart. Both the Grid and the Graph controls occupy the MDI Child control, as does the OLE Client (minimized), which contains an embedded Paintbrush image.

Using the Common Dialogs control to put up a Windows 3.1 standard File Open dialog box (in response to my program's File/Open command) was a delightfully trivial exercise. At design time, I set the control's `Filter` property to "*.dbf" so that the dialog box would show only database files. Then, to handle the event triggered by the File/Open command, I wrote one line of Visual Basic code (e.g., `CMDialog.Action = 1`) to select and activate the File Open dialog box. (The control polymorphically handles all five common dialogs—File Open, File Save, Color, ChooseFont, and Printer. The index of File Open is 1.) When my program ran, the file selector displayed only .DBF files. When I picked one, its name became the value of the property `CMDialog.Filename`. Nothing could be simpler.

At the heart of my application was the Grid control. I easily converted it into a naive database browser. Using CodeBasic functions to step through the rows and, within each row, the fields of the database named in `CMDialog.Filename`, I filled each cell by updating the properties `Grid.Row` and `Grid.Col` (with the row/field counters) and `Grid.Text` (with the contents of the current database field).

Once loaded in this manner, the browser scrolled horizontally and vertically, needing no lines of code to tell it what to do. But this naive approach fell apart when I switched from a toy-size database to a real one. When I let the Grid control try to swallow the whole database, Windows promptly ran out of memory. Clearly, I

BYTE

- **WHAT PROFESSIONAL TOOLKIT FOR VISUAL BASIC IS**
  A collection of Visual Basic extensions (custom controls) and a toolkit for building VBXes.
- **LIKES**
  It extends the Visual Basic programmer's reach enormously with plug-and-play support for MDI Child, OLE Client, Common Dialogs, and graphing.
- **DISLIKES**
  Some controls, notably the grid and pen controls, lack full generality or sufficient access to the underlying Windows API.
- **RECOMMENDATIONS**
  No serious Visual Basic programmer will want to be without it.
- **PRICE**
  $299
- **FOR MORE INFORMATION**
  Microsoft Corp.
  1 Microsoft Way
  Redmond, WA 98052
  (800) 426-9400
  (206) 882-8080
  fax: (206) 936-7329
  Circle 976 on Inquiry Card.

THE PROFESSIONAL TOOLKIT'S CUSTOM CONTROLS

Some of the new controls are prettier or more useful versions of existing Visual Basic controls. Others break significant new ground.

3-D Check Box	Instant Change Scroll Bars
3-D Command Button	Key Status
3-D Frame	MDI Child
3-D Group Push Button	OLE Client
3-D Option Button	Pen Edit Controls
3-D Panel	Picture Clip
Animated Button	Spin Button
Common Dialogs	Multimedia Device Control
Gauge	
Graph	
Grid	

needed to make the grid act as a window onto a portion of the database.

To make this happen, I added a row pointer and had the load routine fetch only as many rows as needed to fill the grid. But then the vertical scroll bar broke. The Grid control's automatic scrolling works only relative to in-memory grid data. To let a programmer do a manual override, the grid's scroll bars would have to support the `Change` event and the `Value` property, which they don't. Thus, there is no way to write a scroll handler that fetches, say, rows 3500 to 3525 when you scroll to the middle of a 7000-row database.

To work around this limitation, I had to make the Grid control's vertical scroll bar invisible and superimpose on it a standard Visual Basic vertical scroll bar. This approach worked, but it was awkward. When I moved or resized the grid, I had to adjust the extra scroll bar to match; doing that programmatically so the grid could size itself to a containing MDI Child window was tricky.

A general-purpose object that can wield tabular information is so enormously useful that I chafed at the Grid control's implicit restriction to in-memory data. It also annoyed me that you can't edit the grid's cells directly. Again, there's a way to work around the problem. You can put up a text box elsewhere on the screen and link it to the current cell. But why not let the cell itself implement a `Change` event, as text boxes do, and cut out the middleman?

Adding Bells and Whistles

The Graph control launches a server process that supports a variety of graph styles. I added a list of these to my program's Graph menu so that, once the Graph control received the contents of the Grid control's selected range, it could redisplay the data as 3-D pie or bar charts or an area chart. The Graph control probably should support the AddItem method, though, as does the Grid control. That way, the client code's inner loop could send whole data sets rather than individual data points.

I used the MDI Child control to create containers for the Grid and Graph controls. The MDI Child control remedies what had been a deficiency in Visual Basic. It has a couple of restrictions, however. First, you have to create all your MDI Child windows at design time. If your application needs to conjure up windows on the fly, you'll have to reveal ones you've previously created and hidden. Second, you can't draw directly on a child window; you have to place a picture control in the window and draw on that instead.

However, MDI Child windows work nicely as containers for other controls. I drew my Graph control on the surface of an MDI Child window, so the window owned the graph. The MDIChild control's `ClientWidth` and `ClientHeight` properties gave me the numbers I needed to resize the graph in response to the window's `Resize` event.

The OLE Client control can do a huge amount of work very tersely. By setting its properties, you can query the registration database for the list of available OLE servers, activate a server in embedding or linking mode, copy linked or embedded objects to the clipboard, and write objects to or read them from binary files. Although my application didn't need OLE, I put it in just for fun. Four lines of code sufficed to put an embedded Paintbrush object into my third MDI Child window.

Separately, I tested the Professional Toolkit's pen and multimedia support. For the pen, you get HEdit (handwriting edit) and BEdit (boxed edit) controls. These will suffice for simple pen applications but probably not for advanced projects. The central Windows for Pens data structure, the RC (recognition context), doesn't appear as a Visual Basic property. Even if it did, you'd be hard put to use it directly, since an RC contains nested pointer-based structures that Visual Basic can't mimic. As a result, some key parts of the pen API, notably dictionaries, aren't open to the Visual Basic programmer.

The pen control does expose one piece of the RC: the "alphabet codes" that tell the recognizer what kinds of characters to look for. For example, you can set the `CharSet` property by ORing the constants ALC_LCALPHA and ALC_NUMERIC in order to recognize lowercase letters and digits. But you can't use ALC_BITMAP to specify an arbitrary set of characters, as in the regular pen Software Development Kit, since Visual Basic can't handle the 32-byte bit-addressable data structure that recognition mode requires.

I used the multimedia control to build a simplified version of Visual Basic's media player. The control has a row of nine buttons—Prev, Next, Play, Pause, Back, Step, Stop, Record, and Eject—to which you can attach MCI (media control interface) commands. Somewhat strangely, the control's `Command` property won't accept a complete MCI command string such as "play CDAudio from 1 to 4." To play the first four tracks of a CD, you have to use the following code:

```
MMControl.DeviceType =
"CDAudio"
MMControl.From = 1
MMControl.To = 4
MMControl.Command = "play"
```

Easy enough once you get the hang of it, but why not just send the MCI engine entire command strings at one crack?

The Bottom Line

I don't know of a quicker way to achieve the result you see in the screen shot. At the same time, I found myself wanting many of the custom controls to be more powerful and more general than they are.

Of course, you can write your own controls with the tools provided. The documentation that comes with the Control Development Kit does a good job of describing the intricate dance that a VBX must perform. And, of course, there's a thriving third-party market for Visual Basic add-ons. Still, I'd like to see some of the Professional Toolkit's idiosyncrasies ironed out in a future version. ■

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SYSTEM

Mac LC II: The Sequel

ROB MITCHELL

The Mac LC II packs a 68030 CPU, 4 MB of RAM, and 32-Bit QuickDraw capability into a compact box.

BYTE ACTION SUMMARY

WHAT THE MAC LC II IS
Apple's latest entry-level color Macintosh.

LIKES
This modular Mac offers 8-bit color and 68030 performance for $1200 less than the Mac IIsi.

DISLIKES
Single 68030 Direct Slot limits expandability; no room for NuBus boards or a second internal hard drive.

RECOMMENDATIONS
If you are choosing between entry-level Macs, buy the Mac LC II over the Mac Classic II if you want a bigger screen or color. Buy the IIsi if you want additional power and the ability to add a NuBus board or an internal hard drive.

PRICE
$2298

FOR MORE INFORMATION
Apple Computer, Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010
Circle 1132 on Inquiry Card.

On the face of it, Apple's Mac LC successor, the Mac LC II, doesn't look like a great leap forward. The tiny, 12- by 15-inch pizza box (see the photo) still includes on-board 8-bit color video, a Superdrive, and a 40-MB hard drive. But LC users longing for more-capable memory handling will notice some major changes: Apple has boosted system RAM to 4 MB and replaced the 16-bit 68020 CPU with a 68030—the same 32-bit chip that powers the Mac Classic II and the Mac IIsi.

Thanks to the 68030's integrated MMU (memory management unit), LC II users can use virtual memory, and they'll be able to take advantage of memory protection when Apple system software supports it. The LC II still clocks its CPU at 16 MHz, however, and Apple strapped the new 32-bit 68030 to a 16-bit data bus. That should put the LC II in the same performance class as the LC and at about the level as the similarly designed Classic II. In contrast, the IIsi, which runs the 68030 at 20 MHz and sports a 32-bit data bus, will remain a noticeably faster machine.

Little Faster, Lots Cheaper

The LC II held a slight edge over the Classic II in both the low-level and the application benchmarks (see the table). The small performance differential was consistent across all tests but isn't likely to produce a noticeable improvement during everyday use. The IIsi hasn't yet been tested under the BYTE Lab's new Macintosh benchmark suite, so I've included test results for the Mac SE/30 (16-MHz 68030 CPU; 32-bit data bus). The SE/30 outperformed the LC II by a wide margin. Word processing and database tests ran about 1½ times faster, while scientific and spreadsheet applications ran two to three times faster—thanks to the SE/30's FPU. The IIsi sells for about 1½ times the cost of a comparably equipped LC II.

Except for the processor and memory subsystem, the LC II's configuration details haven't changed from those of the original LC, although the cost has dropped considerably. Apple prices an LC II with 40 MB of RAM, 256 KB of VRAM (video RAM), a 40-MB hard drive, a keyboard, System 7.0, and a microphone and mouse for $1699. BYTE's base-model test system included a 12-inch 512- by 384-pixel color monitor ($599). At the bottom line, you can put a complete 12-inch color Mac system on your desk for just under $2300.

The LC II's ROM supports 32-Bit QuickDraw, although you can't use it without a 16-bit video upgrade or a 24-bit color board for the LC II from companies such as RasterOps and Radius.

Inside, the LC II is extremely compact.

continued

Despite slightly faster disk times, the Mac LC II performed about on par with the Mac Classic II in the application tests. The Mac SE/30, which has a CPU architecture that's similar to that of the Mac IIsi, was 20 percent to 35 percent faster in the low-level tests and up to three times faster in the application tests. The SE/30 included a math coprocessor, which boosted some application test results.

	Mac Classic II	Mac SE/30	Mac LC II
Low-level performance			
CPU	1.00	1.39	1.03
FPU	1.00	1.27	1.02
Disk	1.00	1.24	1.12
Video	1.00	1.23	1.07
Application performance			
Word Processing	1.00	1.47	1.01
DTP	1.00	1.27	0.92
Database	1.00	1.59	1.03
Development	1.00	1.47	1.02
Graphics	1.00	1.79	1.18
Scientific	1.00	2.37	1.08
Spreadsheet	1.00	3.01	1.00
Overall	1.00	1.85	1.03

All machines were tested running System 7.0.1. Except for the conventional benchmarks, all results are indexed; for each test, a Mac Classic II = 1, and higher numbers indicate faster performance. The floating-point benchmarks use the SANE library. Comprehensive test results and detailed configurations are available for all machines upon request.

The system board, which measures a mere 8¾ by 7 inches, includes the 68030 CPU, four ROM chips, 256 KB of SIMM-mounted VRAM, 4 MB of 80-nanosecond system RAM soldered onto the motherboard, and a few support chips. Two empty SIMM sockets let you expand system memory to 6, 8, or 10 MB. To get to 10 MB, you add two 4-MB SIMMs to the 4 MB on the system board, which gives you a total of 12 MB. However, the LC II uses the same memory controller ASIC (application-specific IC) that's in the LC, and that device can only address 10 MB.

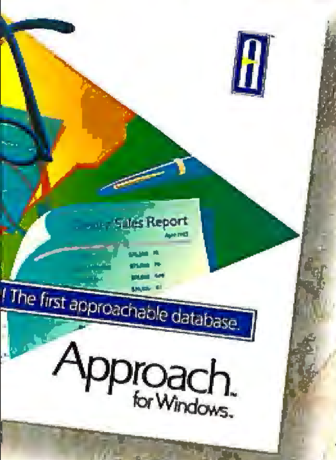
68030 or Better

With the introduction of the modular LC II and the compact Classic II, Apple is clearly migrating toward the 68030 as its entry-level platform. The two machines are similar in both price and performance.

The LC II's Direct Slot makes it the more flexible machine, but the deciding factor for most users will be color. If color is what you want, the LC II is the place to start. ■

Rob Mitchell is a senior technical editor at BYTE. You can reach him on BIX as "rob_mitchell."

This Approach Eliminates All Barriers To Databases.



"Approach for Windows is an amazing product with features galore…No other Windows database to date is as powerful or easy to use…You'll be as wowed by it as we were," says PC Computing.

For many of us, running a database is like running an obstacle course. If it has any relational power at all, you'll get snagged on programming. If you want to share information with other databases, you'll hit a wall. And, of course, there's the hurdle of using a database over a network.

Now someone's figured out a way around all this. Fittingly, it's called Approach™ for Windows™—a remarkable new Windows database. The first truly *approachable* one. And the only one that's both a stand-alone database—with its own relational engine—and a front-end to other data.

Approach is so easy anyone can use it. It takes just minutes to build a new database or produce a professional report. You'd expect that from a database with this much speed. One that includes a tightly integrated, built-in forms design package with extensive graphics tools, a slew of turnkey business templates, and a report generator. Everything you need to harness relational power. Even the power to link up to 10 databases simultaneously.

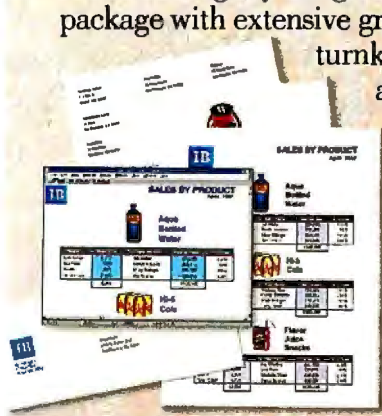
BEST OF BYTE COMDEX/Spring '92
Best Software Winner

Something else you can harness is existing data. Approach is built for superb client/server performance from the ground up. Using our exclusive PowerKey™ technology, you get something previously unheard of: 100% compatibility with dBase®, Paradox®, or Oracle® SQL data.

Break through the barriers of Windows databases. "Approach proves you can deliver a high performance relational database anyone can use," lauds Technical Director J. Diamond of the Windows User Group.

Since Approach is also 100% network compatible (no set-up required), you can access, manipulate, mix, update, and report on information while others work on the same file, in either Approach or the native application.

So call us at 1-800-Approach or see your local dealer. Because if you want the database path of least resistance, there's only one Approach.



We've bottled all the graphics and layout tools you'll need. So even a first-time user can produce professional reports in minutes.

APPROACH
SOFTWARE CORPORATION

Circle 190 on Inquiry Card.

REVIEWER'S NOTEBOOK

LANtastic Gets Faster

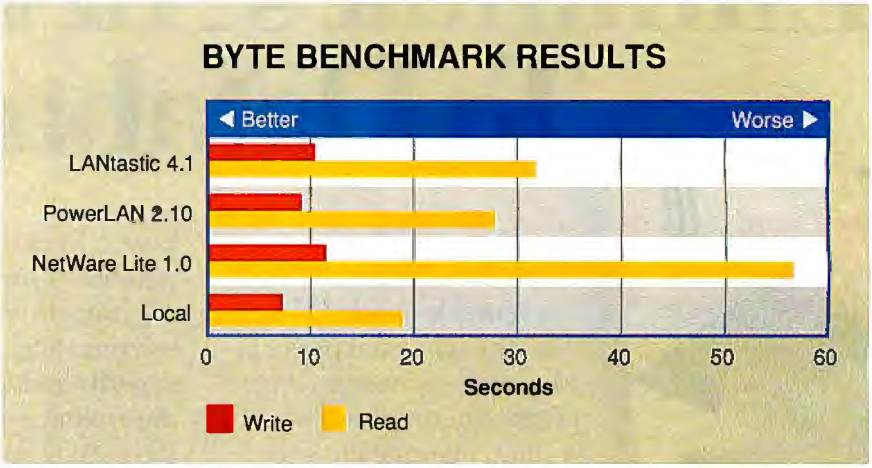
Artisoft's peer-to-peer LAN grew faster this spring with the release of LANtastic 4.1. Like LANtastic 4.0, which we compared with four other peer-LAN systems in last November's product roundup ("Peer LANs Offer a Low-Cost Network Alternative"), LANtastic 4.1 is an easy-to-install, inexpensive, and RAM-stingy alternative to a full-blown network operating system.

LANtastic 4.1 cranks performance a few notches beyond that of LANtastic 4.0 and is easier to use. The figure shows the results of our peer-LAN benchmarks comparing LANtastic 4.1 and some competitors. In our previous roundup, Performance Technology's PowerLAN 2.10 smoked the rest of the peer-LAN pack, including LANtastic 4.0. But with Artisoft's latest release, the gap has narrowed considerably; although PowerLAN is still the fastest, LANtastic 4.1 comes in a very near second. It shows especially dramatic improvement in file-read speeds.

LANtastic 4.1 offers several performance enhancements over its predecessor, including a faster NetBIOS, caching of network resources, and improved record locking. While record locking was not a factor in our tests, the enhancements in file-access time and transmission time clearly make version 4.1 a quicker, more responsive system.

Beyond performance, Artisoft has added utilities that make the network easier to use and manage. These include automatic log-in, improved print handling and new print commands, and several new System Manager features. Artisoft has also updated LANtastic for Windows (its Windows interface) for the new release.

LANtastic has always been easy to run and undemanding of system resources. Adding *fast* to that list of attributes can't help but bolster its popularity.



LANtastic 4.1 comes close to toppling PowerLAN 2.10, the fastest peer LAN we've tested. The newest LANtastic also easily outguns Novell's NetWare Lite. Local tests (timed directly on the host machine) are included for comparison.

QueryDOS: A Good File Utility with One Flaw

Combine a DOS command-line interface, a dBase-style syntax, and an innovative view of your hard drive, and what do you get? QueryDOS, a file-manipulation program from Backus-Naur. Upon running QueryDOS 1.0, you are greeted with a dBase-style dot prompt. Each file and directory is treated like a database record. If you are familiar with dBase commands, you will immediately be able to start using QueryDOS without referring to the manual. For example, the Browse command shows a familiar columnar report that you can scroll through. One difference from dBase is that pressing Return on a directory entry moves you through the directory tree. As with dBase, you can mark entries for deletion without actually deleting them; marked entries can be restored or deleted at a later time.

Although QueryDOS can be used as a command-line shell, it is best used as a tool to quickly manipulate files. You can set selection filters to restrict the displayed files by date, time, size, name, file extension, and file attributes. To copy all files in a directory tree that are less than one week old and greater than 2 KB long (and don't have .BAK, .TMP, or .PRN as an extension), you simply set a single-line filter and then perform a recursive copy. When copying to floppy disks, QueryDOS will automatically prompt for as many disks as it will take to copy the files. It cannot, however, copy a single file that is larger than a disk.

Unfortunately, QueryDOS exhibits an anomaly with Novell networks that severely cripples the product: It cannot access a subdirectory on a network drive unless the user has full access to all directories leading to that directory, including the root directory. This is unreasonable. In a typical installation, the supervisor will not allow common access to root directories. Without read access to the root directory, QueryDOS users cannot access any subdirectories.

Backus-Naur has said that this was a conscious design decision to allow only the supervisor access to directories. During follow-up discussions, the company told us it intends to immediately change this function to allow proper access.

Given this design change, QueryDOS will be a very flexible tool for manipulating files. As it is right now, however, it is unusable in a network environment. ■

—The BYTE Lab

Reviewer's Notebook provides new information—including version updates, new test data, long-term usage reports, and reader feedback—on products and product categories.

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BOOK
AND CD-ROM REVIEWS

FROM AI TO PUZZLES

Bright Air, Brilliant Fire
Gerald M. Edelman

Codes, Puzzles, and Conspiracy
Dennis Shasha

HUGH KENNER

We'll be debating AI well into the twenty-first century, while the AI mavens keep refining their packages. The Turing test ("if you can't feel sure it's artificial, then stop complaining") gets shakier the more one thinks about it. Headlines last November were affirming that the Turing test had been passed by a program written—to the amazement of the *New York Times*—in Queens; half the jury thought it was maybe a person. The program, PC Therapist, proved to be a pretty flaky mix of stolid Eliza and zany Racter. Having played with it, I can only assume that some jurors were going stir-crazy. (Play with it yourself. The PC version of PC Therapist is $59.95 [plus $5 shipping] from Thinking Software, 46-16 65th Place, Woodside, NY 11377.)

Its rationale is disarmingly naive. I have a zillion phrases floating around in my head, and so has it. When I talk, I fish up phrases and connect them, and so does it. So what's the difference?

Well, the best explanation of the difference so far written is Gerald M. Edelman's *Bright Air, Brilliant Fire*. If you want, you can skip to the 40-page "Critical Postscript," which goes deep into the fallacies of what Nobel laureate Edelman calls "mind without biology," one phrase for software-simulated mind.

The Turing argument began by noting that wildly different hardware configurations can get the same answer from a well-structured algorithm. So the algorithm is what matters; the hardware may as well be neural tissue. Thus, the brain/machine difference vanishes. Something else that vanishes, Edelman observes, is any distinction between consciousness and logic. *Experience* becomes a meaningless word. "The transitions of Turing machines between states are entirely deterministic, while those of humans give ample appearance of indeterminacy. Human experience is not based on so simple an abstraction as a Turing machine; to get our 'meanings' we have to grow and communicate in a society."

That leads to a discussion of human language, something radically different from FORTRAN or C. A clinching anecdote has two tourists in a Tel Aviv nightclub, where a performer rattles off one-liners in Hebrew. One tourist falls off his chair in uncontrollable laughter. "What are you laughing at?" scoffs his friend. "You don't even understand Hebrew." The man on the floor manages to gasp, "I trust these people."

Ponder that long enough, and you perceive a language existing as a purely social phenomenon. In an extreme case, it need not even be comprehended. (My French may go blank, but I can tell this Frenchman is friendly.) But AI languages are purely instrumental; either they link concepts without ambiguity, or else they do nothing at all.

That's a sample, merely, of a rich and lucid discussion. No one denies that AI has useful artifacts to offer. Expert systems, for instance, have repeatedly proved their merit. As a general model, though, of human cognition—well, it's doubtful if we'll get much beyond PC Therapist.

Meanwhile, if reality makes your head ache, Dennis Shasha's new book offers just the cure: a zany narrative studded with well-formed puzzles, all with attainable answers. His sequel to *The Puzzling Adventures of Dr. Ecco* is called *Codes, Puzzles, and Conspiracy*, and even if you settle for just staring at the puzzles, it makes an enjoyable read. A sample puzzle? Most are pretty intricate, but here's a fast one. Sixteen 4-bit words are possible: 0000, 0001, 0010, and so forth. You can pack them into a string and tell the recipient where to start counting; thus, 0010110 contains 0010, 0101, 1011, and 0110. Quick now: On that principle, pack all 16 into one 19-bit string. Easy, wasn't it? Or was it?

Five contest puzzles (solutions due by 9-1-93) can win you round-trip tickets to London and a visit to the Hampton Court maze. ■

Bright Air, Brilliant Fire, Gerald M. Edelman, Basic Books, 1992, $25, 280 pp., ISBN 0-465-05245-2.

Codes, Puzzles, and Conspiracy, Dennis Shasha, W. H. Freeman, 1992, $17.95, 242 pp., ISBN 0-7167-2275-5.

Hugh Kenner is Franklin and Callaway Professor of English at the University of Georgia. His recent books include Mazes *and* Historical Fictions. *You can contact him on BIX as "hkenner."*

THE USER INTERFACE

TOG on Interface, Bruce Tognazzini, Addison-Wesley, 1992, $26.95, 352 pp., ISBN 0-201-60842-1.

Designing the User Interface, 2nd ed., Ben Shneiderman, Addison-Wesley, 1992, $43.95, 550 pp., ISBN 0-201-57286-9.

When Apple introduced the Mac, it also introduced a set of interface style guidelines to which the developer community was to adhere. At first, this produced more criticism than praise, particularly since the earliest Apple-produced software broke many of these guidelines. However, this approach of insisting on a consistent interface has been profitable in the long run. Users now speak of a proper "feel" for a Mac application. Developers who want to break with the stated interface now spend more time considering this move. Quick fixes are out of fashion; long-term solutions are more acceptable.

For years, a primary keeper of the interface flame at Apple was Bruce Tognazzini. For the last three years, he has interacted with developers by a column in the *Apple Direct*

ILLUSTRATION: MARK STEARNEY © 1992

newsletter. This column explores the problems and perils of implementing new functions. Tognazzini also helped clarify the baseline styles and operations of the Mac interface.

Along the way, he has compiled a set of principles and guidelines that are important to anyone creating a program that interacts with people. Although *TOG on Interface* is based on his years of Mac experience, none of the guidelines are specific to the Mac environment. Tognazzini presents guidelines for interface development and user testing. His principles cover the gamut from minimizing impact of new releases on current users to affecting user behavior. For personal, hands-on experience, this is the book to read.

Designing the User Interface is a completely different type of book. More than just a discussion of how to create usable interfaces, this book delves into the known state of the art in human factors, nonmainstream users, text versus graphics, keyboards versus mice, knowledge versus memory, and other areas of vital importance to today's interface designer. From guidelines for creating data-entry applications to natural languages and virtual reality, *Designing the User Interface* spans the technology from the mundane to the esoteric. Shneiderman's book is a compact reference to a rapidly changing field.

—Raymond GA Côté

METHODICAL NUMBERS

Numerical Methods/Real-Time and Embedded Systems Programming, Don Morgan, M&T Books, 1992, $36.95, 496 pp., ISBN 1-55851-232-2.

Numerical Methods by Don Morgan is a slow, cautious, methodical tour of the world of arithmetic calculation by computer. A book with chapter titles like "Numbers, Integers, and Real Numbers" sounds tedious. Yet Morgan has presented this potentially boring and frequently intimidating subject in a professional and readable manner.

He starts with an overview of the basics (number representations, bases, and arithmetic principles) and immediately relates them to the processor environment (bus width, flags, rounding, and shifting). Although he gears the book toward Intel 8086 architectures, the algorithms and discussions are suitable to any processor.

Morgan next moves boldly into integers: addition and subtraction, signed and unsigned, multiprecision arithmetic, decimal arithmetic, and four different multiplication algorithms. Fixed-point (real) and floating-point representations receive similar treatment. He next moves to reading and writing numbers and converting among various formats. The closing chapter deals with elementary functions: algebraic, trigonometric, and transcendental.

Numerical Methods presents the theory and reasoning behind each algorithm. Multiple algorithms used to solve identical problems are compared and evaluated in terms of execution time, system resources, and rounding, precision, and error differences. *Numerical Methods* provides sufficient information for you to decide on the most appropriate algorithm for your application. Each algorithm listing consists of a plain-English description followed by a well-commented 8086 assembly language implementation. The book includes all listings on disk, with a simple shell from which you can exercise the code.

—Raymond GA Côté

THE ARMCHAIR TOURIST

Great Cities of the World, $79.95 per volume

Slip on your headphones, pop in a CD, and travel around the world on your desktop. Great Cities of the World is available from InterOptica Publishing, Ltd. (300 Montgomery St., Second Floor, San Francisco, CA 94104, (415) 788-8788; fax (415) 788-8886.

InterOptica bills this series as a multimedia travel guide. I looked at volume 1, which includes Bombay, Cairo, London, Los Angeles, Moscow, New York, Paris, Rio de Janeiro, Sydney, and Tokyo. A second volume covers Berlin, Buenos Aires, Chicago, Jerusalem, Johannesburg, Rome, San Francisco, Seoul, Singapore, and Toronto. Great Cities doesn't provide encyclopedic references, as Countries of the World and the World Factbook do, but that's not the point. Instead of exhaustive information on a city's history or politics, you get a taste of the city by learning its basic customs and viewing its most distinctive sights.

InterOptica has done an admirable job relaying the intangibles—the distinctive "feel" of a city and its heritage. A slide show flips through photographs of important places while a narrator describes the sights. Native music plays in the background. These slides range from the obvious (the traditional view of Moscow's Red Square) to the poignant (Bombay's poor huddled in tents against a backdrop of splendid skyscrapers and apartment buildings). An essay on each city conveys a general impression of the city's culture and spirit.

Great Cities includes plenty of practical information for the traveler: hotel and restaurant listings, popular sights, transportation facilities, nightlife, the arts, and recreational retreats. To plan your lodging, click on the icon for hotels and make a selection from grand, deluxe, moderate, economy, or airport. A map shows the location of the hotels in each category. Click on the text icon, and you get phone numbers, addresses, and hotel rates.

The "Fast Facts" section offers information on visas, communications, climate, and currency. It also gives important addresses (e.g., police, postal, immigration, and tourist information). You can view a list of foreign phrases or listen to the correct pronunciation on your headphones by clicking on each entry.

The program runs under Windows, but it does not have the feel of a Windows application. It has no menu bar, nor any way to minimize the screen (i.e., turn the screen into a Windows icon). Great Cities is nonetheless very graphical and highly entertaining. It's not, however, very useful as a research tool.

Once you've hit the road, you'll need a good hard-copy guidebook to carry with you. Until then, you can slip on your headphones and travel the world from your armchair.

—Stanford Diehl

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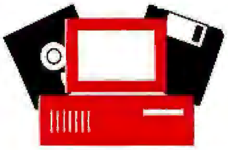

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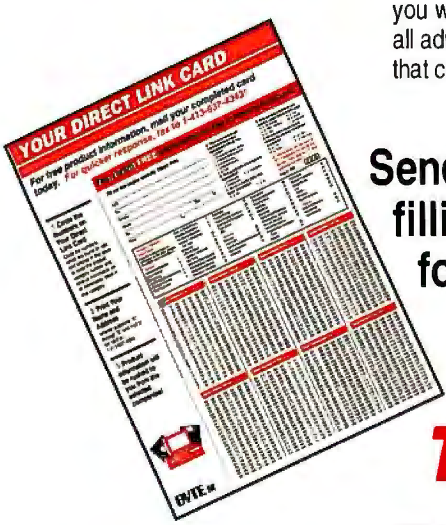

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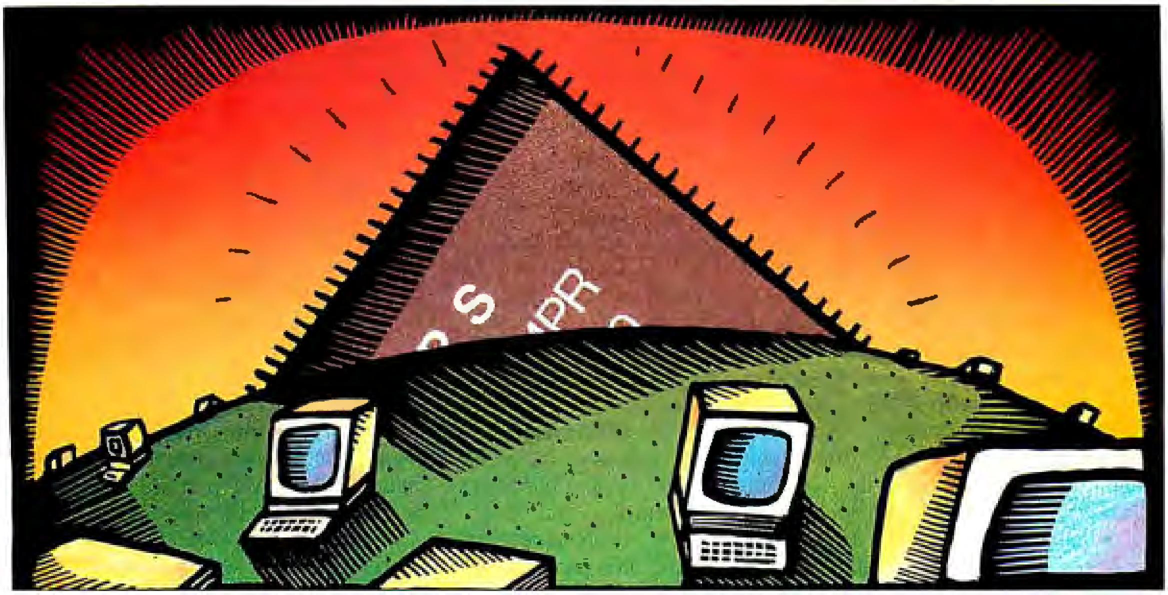
Digital Signal Processing



A new breed of DSPs looms on the personal computing horizon

DSPs (digital signal processors) have been around for nearly a decade. They're responsible for the sound clarity of CD players, the enhanced graphics of many laser printers, the high-speed head positioning of hard drives, the increased functionality and speed of digital phones and modems, and the imaging clarity and performance of many radar, sonar, and medical-imaging systems.

Now, as multimedia applications enter the mainstream of personal computing, DSPs are being positioned as the engines that will make it all happen. They can enable personal computers to handle high-performance video and stereo-quality sound as well as perform a variety of telephony and communications functions, including faxing, modem use, speech recognition, and speech synthesis. In this article, we'll survey the current crop of DSPs from Analog Devices, AT&T, Motorola, and TI (Texas Instruments); consider how DSPs work; and discuss how they'll affect personal computing in the next few years.

In the 1960s, a group of researchers at AT&T Bell Labs invented the set of techniques now known as digital signal processing. The researchers were looking for ways to recover information from signals that were distorted, noisy, or incomplete after transmission over long-distance phone lines and satellite links. The algorithms they developed are used today in a variety of applications, including audio, imaging communications, and control.

DSP algorithms tend to swamp unassisted personal computers. For any application requiring real-time response or a high level of operator interactivity, DSP hardware is required. Such hardware is typically available for personal computers in the form of specialized coprocessor boards that can speed up DSP operations by 10 to 500 times.

Anatomy of a DSP Chip

A DSP chip is a microprocessor dedicated to the rapid execution of complex DSP algorithms in real time. The classic DSP processing model involves inputting continuous A/D serial data to DSP memory, fast DSP processing, and D/A serial data outputs.

DSP chips aren't inherently faster than general-purpose microprocessors, but they are organized for repetitive arithmetic on orderly data. A DSP chip typically features high-speed MAC (multiply and accumulate) hardware that facilitates iterative algorithmic processing by enabling the chip to perform single-instruction-cycle floating-point multiplication with no accumulation overhead.

DSP chips use 16-, 24-, or 32-bit words and are designed for either fixed-point or floating-point arithmetic. The *word length* of a DSP chip refers to the size of its instruction and data paths and varies by application (see table 1). Adding two 16-bit data points will likely produce a 17-bit result; multiplying the two inputs will produce a

DSP APPLICATIONS AND THEIR PROCESSING REQUIREMENTS

Table 1: *The word length of the DSP chip refers to the size of the instruction and data paths. Requirements vary by application.*

Application	Word length (bits)	Fixed/floating-point
Dedicated drive controller	16	Fixed
Computer graphics	16	Floating-point
Process control	16	Fixed
PBX	16	Fixed
Modem	16	Fixed
High-quality audio	24	Fixed
Graphics rendering	32	Floating-point
Robotic image processing	32	Floating-point
Instrumentation	32	Floating-point
Sonar/radar/missile guidance	32	Floating-point
Speech recognition	32	Floating-point
Multimedia	32	Floating-point

32-bit result. If the native internal architecture of the chip will not handle the required length, then extra scaling operations must be done in software.

It's important to note that a 32-bit floating-point chip often includes 40-bit accumulators for added precision during accumulation. Each 32-bit floating-point DSP in a high-end multiprocessing imaging application might cost as much as $600. By contrast, the 16-bit fixed-point DSP in a speaking toy might cost less than $3.

Most DSP-based designs that use 16-bit processors are implemented using assembly languages. These applications require tight code that will fit into the limited address space of 16-bit processors. The newer 32-bit DSP chips have larger address spaces and high-level-language support and offer libraries of preprogrammed signal-processing routines. Developers can use tested and documented filters, communications protocols, and multimedia algorithms with these chips.

A 32-bit DSP delivers up to 25 MIPS and 40 MFLOPS of computing power. In addition to large address spaces, these chips feature multiple register files, general addressing modes, bit-manipulation instructions, and integrated on-chip peripherals such as DMA hardware, timers, and serial ports. TI alone markets two dozen different DSP chips divided into five families. There are nearly a dozen 32-bit floating-point chips available today, and an even larger number of fixed-point devices. Table 2 summarizes the five 32-bit DSPs discussed in this article.

32-bit DSP Architectures

TI's TMS320C40 has separate 32-bit address and data buses for external access and five internal buses for data, DMA, and peripheral support. Most notably, however, it features six on-chip communications ports that run at 20 MBps. These ports support multiprocessor designs with minimum glue logic.

With two processors, the standard subsystem architecture employs shared memory; with more than two, the hardware becomes far more complex, and the accompanying software problems are legendary. TI is working on a parallel DSP development environment to support a four-TMS320C40 product for military and other high-end applications. A key challenge will be to develop a C compiler that will partition tasks and an operating system that can manage multiple processors.

The AT&T DSP3210 is intended for personal computer applications. AT&T wants to make the chip attractive to designers of motherboards and is openly targeting the multimedia market with its VCOS operating system and multimedia function library (see "Signal Processing for Multimedia," February BYTE). Whereas the TMS320C40 is intended to multiprocess with other TMS320C40s, AT&T's DSP3210 is intended to multiprocess with either an Intel 80x86 or a Motorola 680x0. The DSP3210 maintains a 32-bit bus-master interface to the system memory. This makes it easy to add one or more DSPs in parallel to the host CPU. The DSP3210 supports both big- and little-endian byte ordering, so it can share both data and pointer values with Intel and Motorola hosts. For real-time signal processing, the DSP3210's on-chip SRAM (static RAM) is loaded with code and data from system memory before execution.

The Motorola DSP96002, like the TMS320C40, was designed for multiprocessing. But whereas the TI chip is optimized for a loosely coupled architecture using communications ports, the technology of the DSP96002 has a bus-oriented, tightly coupled architecture.

The DSP96002 is arguably one of the most powerful DSP chips available. It has five on-chip buses and bus-arbitration logic, plus instruction cache and data memories. In a single cycle (i.e., 2 ticks), the chip can do a floating-point multiply, add, and subtract while loading two registers and doing a DMA transfer and four address calculations.

With a 40-MHz clock rate, the 96002 provides a performance of 60 MFLOPS and 20 MIPS. It has two 32-bit memory ports, each of which can access local or shared memory. Each port also includes a complete system bus that can be used to access a slave processor's internal memory. Originally touted as a multimedia engine, the DSP96002 has found a fit with less cost-sensitive, floating-point-intensive image-processing applications in which repetitive operations are easily split among multiple chips.

The Motorola DSP56001/2 is the only 24-bit fixed-point DSP chip currently available. The 24-bit architecture provides higher accuracy and performance than basic 16-bit DSPs without the larger memory of a 32-bit fixed or floating-point DSP. Next and Silicon Graphics workstations use it for high-quality audio support. The 56002, which has a 20 percent faster clock rate than the 56001, is the second generation of this architecture. With a 40-MHz clock rate and two clock cycles per instruction, the new chip can perform 20 MIPS.

Analog Devices has taken a novel approach with its latest floating-point DSP, the ADSP-21020, by providing it with a modified Harvard architecture: separate data and instruction memories and buses, and an on-chip cache memory for instructions. But since most DSP algorithms require two pieces of data as well as an instruction to execute, a Harvard architecture alone doesn't quite go far enough in many instances.

The ADSP-21020 is optimized for high-speed execution of algorithms that contain tight inner loops in which the cache can be loaded with the instructions while both on-chip buses are used for data. This results in single-cycle execution of multiply accumulates and an extremely fast 75-MFLOPS rating at 25-MHz clock speeds.

The ADSP-21020 is designed to provide unconstrained data flow to and from the computation units. In every instruction cycle, two operands can be read or written off-chip to or from the register file,

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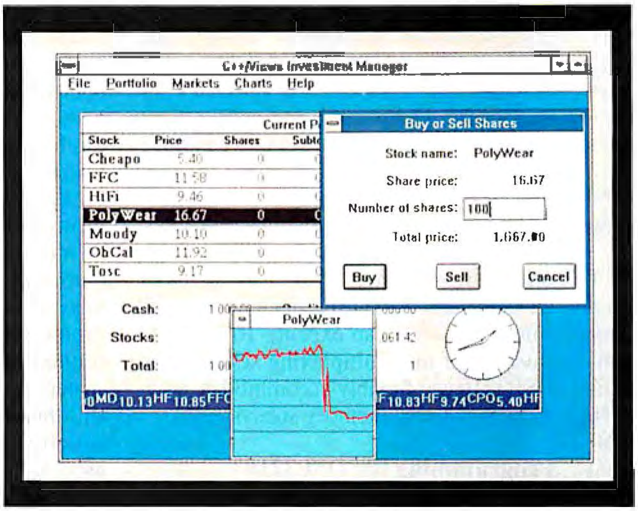

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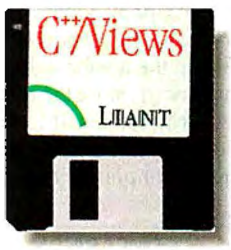

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two operands can be supplied to the ALU, two operands can be supplied to the multiplier, and two results can be received from the ALU and the multiplier. Like other DSPs, the ADSP-21020 executes all instructions in a single cycle.

A Closer Look at the DSP3210

Because DSP chips can do multiple operations per instruction, they enable you to do a lot of processing with very little program code. DSP operations include built-in looping and addressing, so the chips can race through two data memories and a result matrix at the same time. Doing multiple operations simultaneously eliminates much of the algorithm bookkeeping that makes many DSP algorithms so slow and complicated on a general-purpose chip such as the Motorola 68030.

For example, take a look at the AT&T DSP3210. The instruction set of this chip is well suited for image-processing applications in a personal computer environment. To support direct interfaces to standard CPU data structures, the DSP3210 contains instructions to directly manipulate byte, integer, and IEEE floating-point formats. This arrangement allows data to be transferred directly into the DSP memory space for processing and then returned to the host processor.

Like other 32-bit floating-point chips, the DSP3210 provides extended logic instructions that make the branching utilized by high-level-language compilers much more efficient. Logic functions are new to DSP devices. In the past, their instruction sets were limited mainly to math functions. The DSP3210 instruction set also provides data acquisition functions to control the collection and output of data samples.

Instead of multiple buses and a Harvard architecture, the DSP3210 uses a time-division multiplex scheme to perform four operations per instruction cycle. The chip has seven functional units: a CAU (control arithmetic unit), a DAU (data arithmetic unit), memory (which is divided into two banks), a bus interface, serial I/O, a DMA controller, and a timer. The CAU and DAU are the execution units and are the heart of the chip. The CAU is a 32-bit integer controller that handles address calculations, branching control, and integer and logic operations. It also generates addresses for the operands of floating-point instructions. DAU instructions can have up to four memory accesses per instruction, and the CAU is responsible for generating these addresses using the post-modified, register-indirect addressing mode—one address in each of the four states of an instruction cycle. At a clock rate of 66.7 MHz, the CAU can execute 16.7 MIPS. Because of the multiplexing scheme, the DSP3210 can flexibly accommodate a variety of external memory subsystems.

Programming the DSP3210

DSP3210 assembly language instructions are patterned after the C programming language. For example,

```
*r1++ = a0 = a1 + *r2++ *
*r3++
```

is a single instruction to multiply the two floating-point values stored in the memory locations pointed to by registers r2 and r3, add the results to the contents of accumulator a1, store the result in accumulator a0, write the result to the 32-bit memory location pointed to by register r1, and post-increment pointer registers r1, r2, and r3.

The single DSP3210 instruction, which can have up to four memory accesses, has many of the attributes of a pipeline. If several multiply-accumulates execute in succession, then the DSP3210 automatically pipelines the instructions so that one instruction completes every cycle. The DSP3210 pipeline can extend to four stages, so the contents of an accumulator, multiplier input, or adder input can be written to memory without requiring an additional instruction. This is a key feature for performing adaptive filtering and matrix operations.

A typical signal-processing problem might require the multiplication of a 1x4 matrix by a 4x4 matrix. This is also a common algorithm used in 3-D graphics transforms involving a 4x4 by 4x1 transform on *n* points. Each point requires 16 multiplies and 12 additions. On the DSP3210, this can be accomplished in 22 instruction cycles: six for initialization and 16 for execution (see listing 1). The first three instructions define the two input matrices and the output matrix; the next three instructions initialize three registers to be used in the remaining post-modification addressing instructions.

Each cycle takes advantage of the four separate memory accesses allowed for the calculation of one dot product: Fetch two operands, fetch the next instruction, and write the previous result to memory. To perform 1000 vector transforms with a 66.7-MHz DSP3210 would require just 0.96 millisecond (16 x 60 nanoseconds) after initialization if all the code and data fit in on-chip memory. Otherwise, performance could degrade by one-half as the single on-chip bus is used to access external data and program instructions. Of course, clever DSP programmers modify

A COMPARISON OF 32-BIT DSPS

Table 2: *Key specifications for five popular DSPs. (N/A = not applicable.)*

	TI TMS320C40	AT&T DSP3210	Motorola DSP96002	Motorola DSP56002	Analog Devices ADSP-21020
Clock speed (MHz)	50	66.7	40	40	25
Instruction cycle (ns)	40	60	50	50	40
Instructions	135	63	133	N/A	63
1024-point FFT (ms)	1.025	1.9	1.047	N/A	0.77
Pins	325	132	223	132	223
DMA channels	6	2	2	1	None
32-bit timers	2	1	None	None	1
Serial ports	None	2	None	2	None
Price	$560	$60	$440	$80	$275
MFLOPS	50	33	60	N/A	75 peak; 50 sustained
MIPS	25	16.5	20	20	25

algorithm code to account for the peculiarities of any given chip's architecture; for example, with the DSP3210, the trick is to try to keep off-chip accesses to just one or two per instruction cycle and pay no performance penalty.

Listing 1: *Matrix multiplication on the DSP3210. The chip's concise assembly language syntax resembles that of C.*

```
r1 = matA
r2 = matB
r3 = matC
r15 = -12        /post modify by 4*(n-1)/
r16 = 16         /post modify by 4*(n)/
r17 = -44        /post modify by 4*((n-2)n+(n-1))/

a0 = *r1++**r2++r16
a0 = a0 + *r1++**r2++r16
a0 = a0 + *r1++**r2++r16
*r3++ = a0 = a0+*r1++r15**r2++r17
{repeat for rows 2, 3, and 4}
```

Programming the Motorola and Analog Devices DSPs

With the Motorola DSP96002, the 1x4 by 4x4 vector-transformation algorithm takes three instructions for setup and 19 instructions for kernel execution. Each of the assembly-level code instructions has up to six fields of the form

```
fmpy.s d7,d5,d1  fadd.s d1,d0
x:(r0)+,d6.s y:(r4)+n4,d7.s
```

The first field, called the op-code field, tells the data ALU, address-generation unit, bit-manipulation unit, or program controller which instruction to perform. The second field specifies the operands to be used. The sample code above calls for a single-precision multiply of d7 and d5 and storing the result to d1.

The third field, another op-code field, specifies a floating-point add/subtract operation in the data ALU, and the fourth field contains the operands for that operation. The sample instruction calls for a floating-point add of d1 and d0 and storing the result in d0.

The fifth field specifies an optional data transfer over the *x* data bus (and the addressing mode for the transfer); the last field provides similar information for the *y* data bus. (The DSP96002's five separate bidirectional 32-bit buses are the *x* data bus, the *y* data bus, the global data bus, the DMA data bus, and the program data bus.) Performing 1000 vector transforms with a 40-MHz DSP96002 would require 0.95 ms after initialization was complete.

The FFT (fast Fourier transform) "butterfly" operation is another key signal-processing algorithm. It uses a complex input comprising real and imaginary parts along with a complex coefficient with sine and cosine components. The DSP3210 requires six instructions to encode the inner loop; the Analog Devices ADSP-21020 can encode the inner loop in just four instructions (in a total time of 160 ns). Setup takes up only one line of code that sets a loop counter to the value in register 15 and says to run until the loop counter (LCE) expires (see listing 2).

The second line of the core loop shows the power of the complex chip architecture. A single instruction cycle accomplishes a floating-point multiplication, addition, and subtraction together with a data memory (dm) write and a program memory (pm) read. The fourth term in the instruction tells the DSP to get the data in floating-point register f13, write it to data memory in location i2, and then modify pointer value i2 by the value of m0, a modify register. This is similar to the post-increment capability of the DSP3210.

The ADSP-21020 has a program memory for the storage of op codes and data values and a separate data memory for operands. Each memory has its own bus.

Listing 2: *The FFT butterfly operation on the ADSP-21020. The chip's instruction format includes optional fields for multiplication, addition, and subtraction, as well as fields for manipulating data and program memories.*

```
LCNTR=r15, Do end_bfly until LCE;
f8 =f1*f6,              f14=f11-f14,  dm(i2,m0)=f10, f9=pm(i11,m8);
f11=f1*f7, f3 =f9+f14, f9 =f9-f14,   dm(i2,m0)=f13, f7=pm(i8,m8);
f14=f0*f6, f12=f8+f12,               f8=dm(i0,m0),  pm(i10,m10)=f0;
end_bfly:
f12=f0*f7, f13=f8+f12, f10=f8-f12,   f6=dm(i0,m0),  pm(i10,m10)=f3;
```

The on-chip cache is used only for instructions that require the program bus for a data fetch. In the butterfly operation, the first line of code, which sets the loop counter, would never be cached, but the four lines making up the loop would all be cached, since they all have program-memory data fetches (reads or writes) as part of the instruction. Since the instruction is in a cache, the program-memory bus is free for a data transfer, and two operands can be accessed in a single cycle.

DSP Applications for Personal Computing

The success of multimedia applications for personal computers will require the ability to compress and decompress large sound and video files to store them, transport them across networks and bus interfaces, and play them back at normal full-motion-video speeds. DSPs can help. In JPEG (Joint Photographic Experts Group) encoding, for example, a picture is broken up into 8- by 8-pixel blocks that serve as the input to a DCT (discrete cosine transform); this reduces data redundancy. The DCT coefficients are then quantized using weighting functions optimized for the human visual system, which is insensitive to some color and spatial frequencies, and the resulting data is encoded using a Huffman variable-word-length scheme. To decompress an image, this process is done in reverse. All these operations are multiply-accumulate intensive and require accelerator hardware to meet current performance demands.

Traditional software support for personal computer DSP boards comes in two flavors. If you need to roll your own DSP application for filtering, noise suppression, fax/modem/communications, image processing, or spectral analysis, you can get an appropriate toolkit—an assembler, a linker, a C compiler, and possibly a packaged library of DSP algorithms. Or you can buy one of the DSP applications that require or support personal DSP peripherals. Examples of these DSP programs include FDAS from Momenta Data Systems, Hypersignal from Hyperception, Signal Processing WorkSystem from Comdisco Systems, SpeechStation from Ariel, and Spectrum Analyzer from Spectral Innovations. These applications typically target speech or audio research, filter design for electronics applications, emulation of spectrum analyzers or oscilloscopes, and radar/sonar research.

New this year is support for DSP hardware from within non-DSP applications. For example, several new products that were announced recently allow users of National Instruments' LabView program, a leading data acquisition and analysis package for the Mac, to boost performance by adding a DSP board and LabView DSP extensions to their systems. No reprogramming is required, since the DSP-enhanced modules use the same inputs and outputs as standard modules. LabView is supported in this fashion by both Spectral Innovations, which makes Mac DSP boards based on the AT&T chip set, and National Instruments, which makes a NuBus board that is based on the TI TMS320C30.

Spectral Innovations' Lightning Effects uses the same approach to beef up Adobe Photoshop. Lightning Effects enables Photoshop to export a variety of operations (e.g., filtering, blurring, scanning enhancement, and image resizing) to a DSP chip. These imaging operations, which make heavy use of multiply/accumulate operations, run up to 20 times faster with Lightning Effects than they do on an unaccelerated Mac. However, other Photoshop operations, such as screen redrawing and individual pixel-editing functions, obtain no benefit at all from a DSP accelerator.

In the future, DSPs will be incorporated directly onto system motherboards rather than taking the form of board-level add-ins. The state of the art is advancing quickly. In March, IBM, TI, and Intermetrics announced an alliance to promote the MWave subsystem, a fixed-point DSP technology for multimedia computing that will allow a single subsystem to handle the processing that is done today by multiple add-in boards. In April, AT&T formally announced its VCOS operating system, multimedia extensions, and DSP3210 chip, as well as strategic alliances with several board companies and systems vendors.

Whether you are a radar/sonar researcher, a developer interested in multimedia education and entertainment software, or an end user who wants to be able to talk to a computer and have it talk back, there's a DSP-enabled personal computer in your future. ■

Andrew W. Davis is an independent marketing consultant who focuses on data acquisition and image processing. Joe Burke is president and a founder of Spectral Innovations (Santa Clara, CA), which specializes in DSP solutions for Mac users. You can contact them on BIX c/o "editors."

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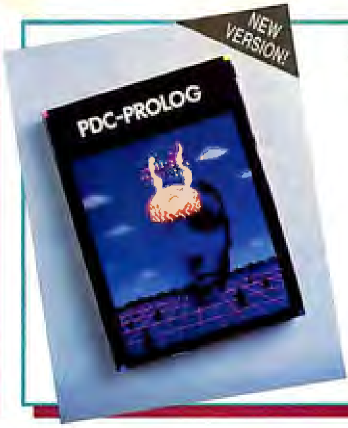

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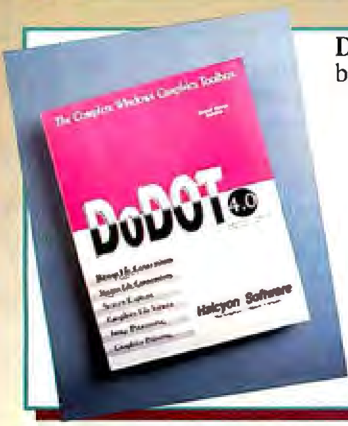

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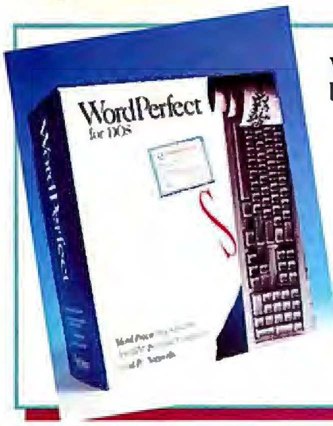

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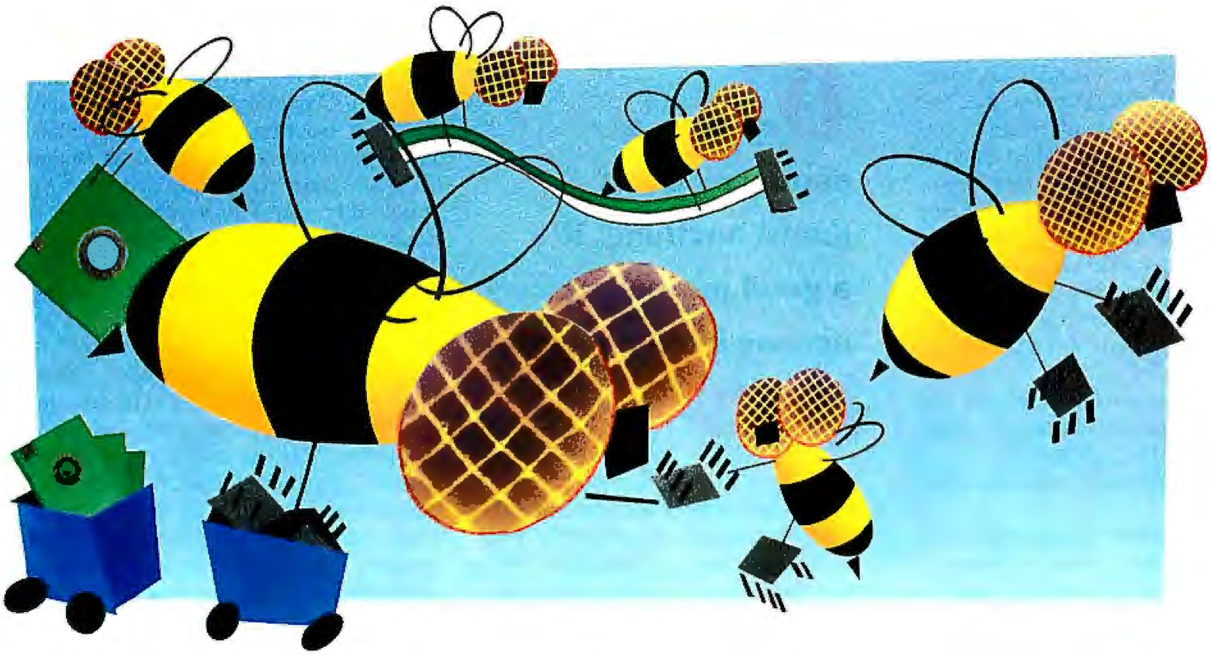

Here's how to manage access to shared resources in a multiuser environment

The world of multitasking and multiuser systems is a world of careful coordination. Like aircraft jockeying for a runway, programs vie for drives, printers, and other shared entities. When two or more airplanes attempt to land on the same runway at the same time, or when two or more programs try to access the same disk file simultaneously, a crash often results.

The task of adequately managing access to shared resources is not a simple one. Before tackling that, I should define just what constitutes a "resource"; the advent of the Mac and Windows has given a new definition to the term. I use it broadly to mean system assets that programs use in either a multiuser or multitasking environment (since the problem of resource management in a single-user, single-tasking environment is trivial). Because the resources are shared, they are often in limited supply. This is the crux of access management: providing a means of making these limited supplies available to multiple programs.

Resources might include processors, memory, disk space, printers, or virtually any peripheral device. For the purposes of this article, I refer to such resources as *physical* resources. A network printer is the quintessential shared resource. Proper access management for the network printer is an obvious requirement: It won't do to have someone else's word processing document come out of the printer intermixed with yours.

Entities other than physical devices can also be shared resources. These *logical* resources include printer queues, files within databases, records within database tables, and even fields within records. In a shared-memory system, you might impose some segmentation scheme as a means of handling memory allocation. These memory segments are another good example of a logical resource.

Logical resources are not physical entities in the same sense as a printer or a plotter, but they always have a physical component. Files exist as magnetic domains on a hard disk platter, for example.

Logical resources are just as real as physical resources, and mishandling access to them can result in problems that are just as severe as those that occur when two programs attempt to send data to a single printer. If two processes insert a row into a database table with no access coordination in effect, the result is a tangle of data. Whichever process's write operations execute last overwrite the information laid down by the other process. This situation—where more than one program writes to the same data and where the outcome depends on which program gets scheduled last—is called a *race condition.*

Semaphores

The simplest way to provide access management is via an active data structure known as a *semaphore.* Notice that

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I've coined a new term here: *active data structure*. I wanted to distinguish semaphores from traditional data structures such as bit fields, lists, and the like. Even though internally a semaphore is just an integer value, the semaphore's behavior depends on how that value is manipulated.

Semaphores are most often used to control access to *critical sections* of code in a multitasking environment. A critical section is a portion of a program that only one process can execute at a time—for example, that portion of an operating system's BIOS that seeks to and reads a sector from the hard disk. Suppose that one process begins to execute this section, gets past the seek part, and is switched out to be replaced by another process that begins executing the same code. When the first process switches back in again, the interrupting process has moved the disk head to a different location on the platter. The first process completes the critical section and ends up reading a sector from the wrong place.

As you'll see, a semaphore placed as a guard to the critical section would allow only one process through at a time. Each task can issue a seek-and-read without being interrupted.

Because a semaphore can literally guard anything, it's a good, simple method of access management. Semaphores come in two forms: *binary* and *counted*. The binary semaphore is the simpler of the two forms, and you can visualize it as a toggle switch governed by a few special rules. If you pretend that the switch guards access to some resource, then the properties and rules are as follows:

- Only one process has access to the switch at a given time.
- If the process finds the switch set to the off position, it can turn the switch on and proceed to access the resource.
- If the process finds the switch on, some other process is using the resource. The process blocked at the switch must try again later.
- Once a process has finished with the guarded resource, it must turn the switch off.

The first property guarantees that operations are *atomic*. This means that a process in the midst of manipulating the semaphore is not interrupted; it keeps one process from changing the switch behind the back of another process. The second and third properties describe the mechanics of the semaphore. The last guarantees that a forgetful process won't leave the switch on, stranding everyone following it as they wait forever for the switch to return to the off position.

The switch might simply be a bit somewhere in memory. Usually, operating systems that support semaphores guarantee the semaphore's atomic behavior by disabling interrupts while the semaphore is being tested and modified.

A counted semaphore, as its name suggests, increases the possible states of a semaphore beyond simply on and off.

Because a semaphore can guard anything, it's a good method of access management.

(Counted semaphores are sometimes referred to as *general semaphores*.) Imagine a bowl of tickets, and imagine that a process must be carrying a ticket to be permitted access to the guarded resource. The new rules are as follows:

- Only one process can have its hand in the bowl at a given time.
- If a process gets a ticket, it is allowed access to the resource.
- If a process does not get a ticket, it must try again later.
- Once a process has finished with the guarded resource, it must return its ticket to the bowl.

These rules parallel those of the binary semaphore. A counted semaphore, however, allows more than one process at a time to access the resource. It's up to the system to "initialize the bowl" so that it holds an appropriate number of tickets at start-up. An operating system creates a counted semaphore using an integer value rather than a single bit.

A counted semaphore would be handy if you had attached four modems to one of your systems on your network and designated that machine as a modem server. In this case, you would initialize the semaphore with a count of four.

State Your Rights

A semaphore does not recognize different *types* of access; a process is either admitted or denied access to whatever the semaphore guards. In many cases, it's worthwhile to provide different access rights that identify what operations the requesting process is allowed to perform.

There are two fundamental access rights: *exclusive* and *shared*. All other forms are elaborations on these two basic types. You've probably encountered access rights in one manual or another, usually in the section describing file access. If you read the passages in the MS-DOS documentation on file access rights, it's easy to get out-and-out frightened. The same applies to AppleShare documentation for the Mac. Both texts present scary matrices of allowed and disallowed interactions for a program attempting access of one type while access of another type is already in place. For now, I'll keep it simple.

A process acquiring exclusive access to a resource has unrestricted and uncontested access privileges to that resource: The rest of the world is excluded. Exclusive access is usually applied when a process must make global changes to the resource in question. Also, most physical resources that permit only one user at a time—a networked printer or modem, for example—can only be accessed exclusively. Returning to the example of a networked printer, suppose your program and some other user's program are both vying for access to that printer. Whoever gets control of the printer must obtain exclusive access to the printer for the duration of the print job—not just on a page-by-page basis.

Under shared access, a program has restricted access to the resource, as does the rest of the world. Restricted access means that the process is limited as to what type of operations it can perform on the resource. Most often, a process with shared access performs read operations only. This is simply called *read-only access*; it is frequently used in file management and database systems.

Lock Your Valuables

The topic of access rights leads naturally to the subject of file locking. After all, opening a file with exclusive access is often referred to as *locking* the file. One variation on the access rights discussed above is *multilevel locking*. Multilevel locking means establishing a variety of shared access levels—exclusive access is still exclusive access. Furthermore, you have to define how different lock levels interact with one another. The following example illustrates why this is important.

A B-tree is a data structure that programmers often use to manage database indexes. B-trees consist of nodes, or pages, that are fixed-length physical records. Each

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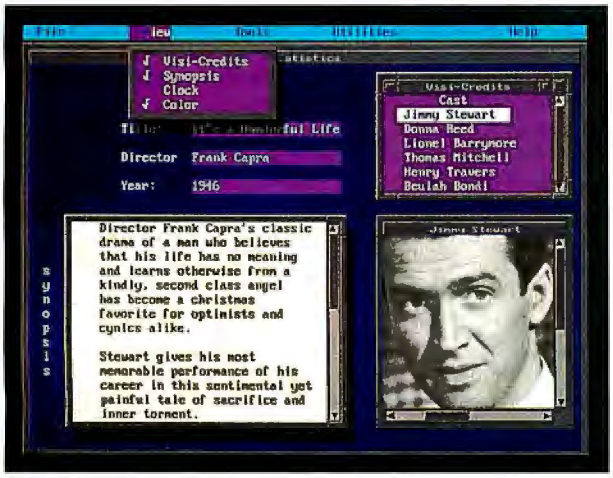

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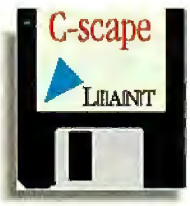

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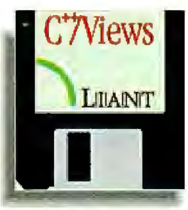

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record is usually stored in its own disk sector. Nodes carry key and pointer tuples so that the logical structure looks something like the diagram in the figure. Note the relationship among nodes. Each node (except the root) has exactly one parent node. Every nonleaf node has one or more child nodes. I won't distract you with the formal details of B-trees here; instead, I suggest you take any questions about those details to "Trees 'n Keys," parts 1–3, January–March 1989 BYTE.

What's important is how a database system manages access to a B-tree in the presence of multiple users—some who might be simply reading the index, and others who might be in the process of updating it by inserting or deleting keys. You want users to conflict with one another as little as possible, and you don't want one user locking others out for no good reason.

One multiuser management technique for B-trees uses three kinds of locks: *read locks*, *intent-to-update locks*, and *update locks*. A read lock is just what it says: The program issuing the lock simply reads the tree. Read locks assure the program that no other program will modify the locked node, putting the reader's local copy of the node out of sync with the version on disk. A read lock permits shared access; any number of programs can hold a read lock on the same node.

An update lock is an exclusive lock on the node and indicates that the lock holder is in the process of modifying that node. A program would issue an update lock while inserting or deleting a key on a particular node. Since an update lock is exclusive, it ensures that only one task can alter the node at any moment and that no task can read a copy of a node that's about to be altered.

The intent-to-update lock is tricky. It's issued by a program that is about to perform an update but is currently only gathering information about the structure of the tree in the vicinity of the node or nodes to be updated. For example, a program in the process of inserting a key must first execute a search operation to locate where the key is to be placed in the B-tree. To perform that search, the program must snake its way down into the tree from the root, collecting information about the holding capacity of the nodes it visits (i.e., how much free space is on those nodes?).

Why collect holding capacities? Because insert operations always begin on a leaf node of a B-tree, and those nodes the program is visiting on its way to the leaf include the great-grandparent, grandparent, and parent nodes of that leaf. Some of these ancestor nodes will be modified if the effects of the insert propagate back up the tree. Such propagation happens if the insert causes a node to become overfilled. In that case, the node splits, and a selected key from the node is moved up the tree to be inserted into the parent node. The program can calculate how far the effects will propagate using the capacity information it collected on the way down, but this information is valid only as long as someone else doesn't modify those nodes. The ancestor nodes must remain unchanged until the program completes the insert operation.

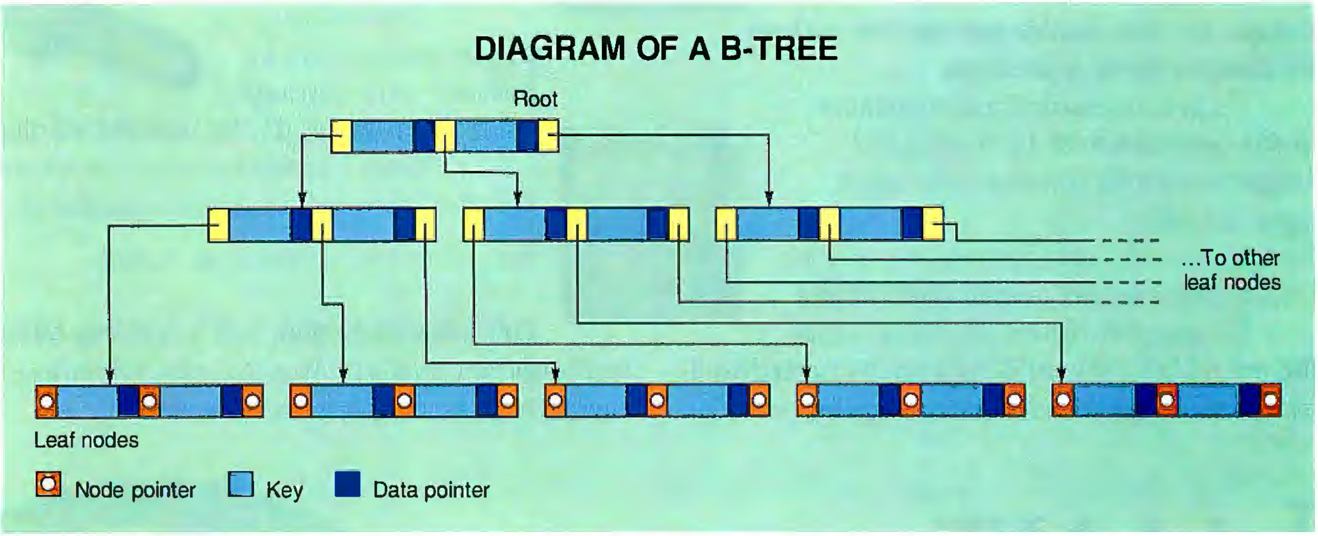
That's where the intent-to-update lock comes in. It allows a program to assure itself of the local integrity of the B-tree throughout an update operation. An intent-to-update lock excludes update locks and other intent-to-update locks, but it does not exclude read locks, since a task that is only reading the node will not modify it. This allows good concurrent access to the B-tree; many programs can continue reading in the vicinity of an update operation. Before the actual updating begins, however, the program must convert the intent-to-update locks into update locks on those nodes it intends to modify. This will serve to drive away any reading processes before the program modifies the B-tree.

The above method uses three locking levels. Furthermore, the interaction among these levels is complex: Update locks exclude everyone, intent-to-update locks exclude update and intent-to-update locks, and read locks don't exclude anyone.

Access Control as a Service

Thus far, I've introduced a smorgasbord of access management techniques. Now I'll examine how to bring all the ideas together and build an access manager (sometimes referred to as a *lock manager*) that can act as a central switching station in a multiuser or multitasking environment. Such a manager might run as a background task on a Unix system or as an NLM (NetWare loadable module) on a NetWare server.

In the discussion that follows, assume that I've created a server process that acts as an access coordinator. Processes using systemwide resources must first petition this server for permission to access those resources. (I refer to the tasks as *clients* to



The search for a particular key always begins at the root. If the key is not found, the search concludes in a leaf node where the key would be if it were in the tree. If the search is in preparation for an insert operation, the location where the search ends is where the insert begins.

make the client/server relationship clearer.) The server either grants or denies permission. For now, I'll leave out the detail of how the petition-grant/deny conversation takes place; it could be any method of interprocess communication—a message queue, sockets, or whatever.

The simplest model for access coordination is a gate, with the server process acting as gatekeeper. Any client lucky enough to arrive at the gate when it's open passes through. A client that arrives at the gate when it's closed is turned away and must try again later. It's up to the server to monitor clients passing through the gate and—based on the number of clients, the kinds of access they're requesting, and the kinds of access the resource will permit—determine whether to close the gate behind a client that has just passed through. (This gate analogy bears a close resemblance to the switch analogy I described in my discussion of semaphores.)

A piece of p-code (from the client's perspective) that follows this model would look something like this:

```
while
  (pass_thru_gate(
    server_id, resource_id)
{ <...spin your wheels...> }
<...access permitted...>
```

Here, the function `pass_thru_gate()` returns a TRUE value if the server allows passage through the gate controlling the resource identified by `resource_id`.

As short as it is, this scrap of p-code reveals one of the limitations of this model. Requests for access occur within a tight polling loop. If the above client task is running in a multitasking environment, it could consume considerable CPU time as it makes the same attempt over and over again. You could eliminate some of the overhead by writing the "wheel-spinning" portion of the loop so that the current task is descheduled for several time slices, giving other tasks in the system a chance to get some work done. You can do this easily in a cooperative multitasking system. It's not so easy in a preemptive multitasking system if descheduling calls are not available to the application programmer.

Even so, if you're running on a network so that the server is executing on a machine separate from the client, then each call to `pass_thru_gate()` translates to traffic on the network. If the resource is tied up, then any client's attempt to access it will result in a series of exchanges with the server that looks like a child nagging its parent: "Can I go through yet?" "Not yet." "How about now?" "No." "Now?" "No." And so on. This creates a great deal of unnecessary network chatter.

Worst of all, no fairness is built into the scheme. There's no guarantee that a coincident series of requests won't result in one client getting turned away repeatedly. Suppose client A has access to the resource. Client B makes a request and gets turned away. While B is waiting, A releases the resource but client C immediately requests and acquires it. B tries again and is turned away again, and while B waits, C releases the resource and client D gets it. The computer science technical jargon for B's situation is *starvation*.

The simplest model for access coordination is a gate, with the server process acting as gatekeeper.

What's needed is a queue—a waiting list. When a client requests a resource that is currently in use, that client is not simply turned away, but is placed on a waiting list for access to that resource.

In a simple waiting list, every task enters at the bottom of the list. Access is granted on a first-come/first-served basis. In the scenario above, client B requests access and is placed on the waiting list. When client C requests access, it enters the queue behind B. So, when client A finally gives up the resource, B gains access. (In fairness to the lowly semaphore, most operating systems that have built-in semaphore functions provide a waiting list as part of semaphore management.) Network traffic is considerably reduced, since a client no longer repeatedly nags the server. One transmission goes out from the client, saying, in essence: "Let me know when I can have access to this resource." The only other transmission would come from the server: "OK, you've got it."

There are several improvements to this idea that let it work even more smoothly. First, it's a good plan to put a cap on the amount of time a client has to wait on a resource. The client's transmission would then become, "Let me know if I can have access to this resource within the next 10 seconds." Now the server has two responses: "You've got it," or "Sorry, your waiting time is up." This prevents a client application from freezing when a resource is tied up for an inordinately long period of time.

You may also want to allow clients to attach a priority to themselves that controls where they enter the waiting list. This involves imposing rules such as, "A client shall enter the list behind all clients of higher priority and before all clients of lower priority. Clients of equal priority are serviced on a first-come/first-served basis." With such a prioritization scheme, a client task running in background could be given a low priority, and high-priority clients would tend to acquire access before the background client.

Wheel-spinning still occurs, but it now consumes fewer network and CPU resources and is relegated to lower-level routines where the application programmer doesn't have to contend with it. P-code for a request might now look like this:

```
result=get_resource(
  server_id,resource_id,
  priority, timeout );
if( result==ERR_TIMEOUT )
{
  <...code to handle time-out...>
} else
{
  <...access allowed or some
   other error...}
```

I've added the arguments `priority`, which specifies the client's priority level, and `timeout`, which specifies the number of seconds the client is willing to wait for the resource. I'm assuming that the program blocks at `get_resource()` until access is granted or the request times out. I also assume that if you're in a multitasking environment, `get_resource()` does smart wheel-spinning. In other words, while `get_resource()` waits, it should allow other tasks some CPU time slices.

At Your Service

I've written an access-managing server that provides the capabilities described above for Unix. I've tried to keep the low-level network communications routines layered away from the higher-level code so the intrepid programmer can more easily move it to other operating environments (e.g., NetWare). The access manager acts as a systemwide librarian. Not only does it provide a central repository where client tasks can look up information on resources (e.g., name, availability, and access rights

permitted), it also manages access to the resources under its control. If a client task wants access to a resource, it must check out that resource with the access manager. Tasks awaiting an unavailable resource are placed on a waiting list.

The access manager supports up to four levels of locking and allows you to define lock-level interactions on a per-resource basis. You can define some resources to have only one lock level (e.g., exclusive only) and others to have multiple levels, in case you want to implement the B-tree multilevel locking scheme that I described earlier.

I will describe the access manager's services in detail next month, but a few of the most significant commands that a client process can issue to the server follow:

- *Register a resource*, which lets the client define a resource and log it with the server. The client must supply descriptive details of the resource: its name, how many clients can use the resource simultaneously, how many lock levels the resource supports, and so on. Furthermore, the manager provides resource *templates*, a kind of object-oriented feature. This relieves clients from having to transfer often-used resource details: Once a resource template is defined, a client can request the equivalent of "Register a resource of name so-and-so and use template such-and-such." The template carries all the necessary initialization details.
- *Apply lock*, which lets the client issue a resource-lock request. The client specifies the lock level and the maximum time it's willing to wait for the resource. The server compares the requested lock level with any locks currently applied to the resource and determines whether to place the client on a waiting list or grant access.
- *Remove lock*, which is the reverse of the apply lock command.
- *Change lock*, which lets the client change the current lock level. For example, if you were implementing the multilevel locking scheme I described for B-trees, you could use this call to change an intent-to-update lock to an update lock.

Next month, I'll conclude with a close look at the data structures and inner workings of the access manager. Since this is a client-server arrangement, I'll also go into the details of the client side and provide a few programming examples. ■

Rick Grehan is technical director of the BYTE Lab. He holds a B.S. in physics and applied mathematics and an M.S. in mathematics/computer science. You can reach him on BIX as "rick_g."

BARRY NANCE

THE RIGHT PROFILE

Profiling DOS file access to hunt down bottlenecks

For a certain development project, I needed to know the exact times an application opened and closed its files. I also needed to know the file-handle values and if the file operations were successful. So I wrote IOPROF (I/O Profiler) and PTRACE (Profile Trace reporter), two utilities that can help you keep track of file access.

IOPROF is a TSR program. You run it once to load and activate the program. Then you run the application you need to profile. When you run IOPROF a second time, the program writes its statistics to a file and removes itself from memory. IOPROF can record up to 1000 file operations; it tracks file-open, file-close, and file-creation events.

If you're trying to optimize the performance of an I/O-oriented DOS program, you can use the information IOPROF provides to tell you how much time your program spends doing file I/O operations, either on a local disk or on a network drive.

Tracking File Access

IOPROF intercepts INT 21h and recognizes certain file operations as they occur. Each of these operations is a DOS function call: open, close, or create a file. Written in assembly language, most of IOPROF is a table in which the program stores data about each event. IOPROF time-stamps each record by calling DOS function 2Ch (Get System Time), with the time the function call started and ended. IOPROF also records whether DOS reported an error (carry flag set) as it tried to do the operation. I used MASM (Microsoft Macro Assembler) 5.1 to assemble IOPROF. You'll need the BIOS.INC and DOS.INC files that come with MASM if you want to modify the program. IOPROF takes about 25 KB of RAM, but most of that is the aforementioned table.

PTRACE is the reporting program. It reads IOPROF's record file and displays a formatted listing of filenames, operation codes, file handles, and start and stop times. PTRACE is a simple (56-line) Turbo C program that understands the layout of IOPROF's table.

Listing 1 shows a sample report. In the EVENT column, 3D is an open, and 3E is a close. The ERR column shows whether each operation succeeded or failed. You can find out most of what you need to know from this report by keeping track of file handles. For example, to find out which file was closed in a 3E operation, you note the handle and look back through the list of operations until you see a corresponding 3C or 3D. ■

Listing 1: *A sample report from PTRACE.*

EVENT	FILE	HANDLE	ERR	START	STOP
3D	cl.exe		Y	11:54:31.53	11:54:31.65
3E		0005		11:54:31.97	11:54:31.97

MAC/Tom Thompson

Keep on Schedule with Notify

I wish I owned stock in 3M, because the bottom of my SuperMac monitor is festooned with Post-it notes that act as reminders for schedules and deadlines. If all you need are some simple reminders, Steve Stockman's Notify 2.2 fits the bill.

Notify is a Control Panel that posts reminder messages onscreen through the Mac's own Notification Manager (i.e., the part of the Mac OS that lets background processes send messages to users). To set up Notify, you open the Control Panel and enter up to 64 messages, each up to 240 characters long. Then you schedule the time and date of each message's arrival. Messages can be repeating (e.g., indicate a meeting every Friday at 2:00 p.m.), or they can time out (i.e., after a certain time or date, the message clears itself). You can easily add, edit, or remove messages to keep your reminder list current. Notify is free, and it works perfectly. Thanks, Steve.

UNIX/Ben Smith

A GNU Debugger

Of all the products available through the FSF (Free Software Foundation), among the best known are the GNU development tools: GNU's compilers and its sophisticated debugger, gdb. Richard Stallman was the author of gdb, but many other programmers have performed work on this multilanguage, multiplatform source code debugger.

Among gdb's features in the current release (i.e., edition 4) are command history, watchpoints, dynamic switching between object-file formats (including COFF, .o object files, and archive libraries), and support for SunOS shared libraries.

The GNU debugger has been ported to most operating systems, but it's particularly well known to Unix and DOS programmers. Source code for gdb and the GNU's compilers can be found on BIX, on most Internet anonymous FTP sites, and on floppy disks from FSF.

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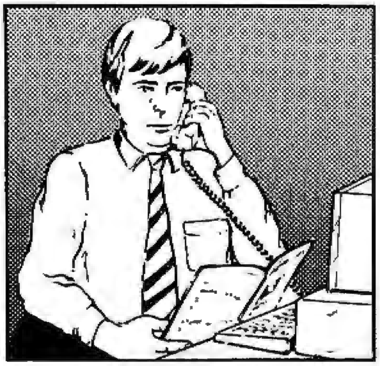

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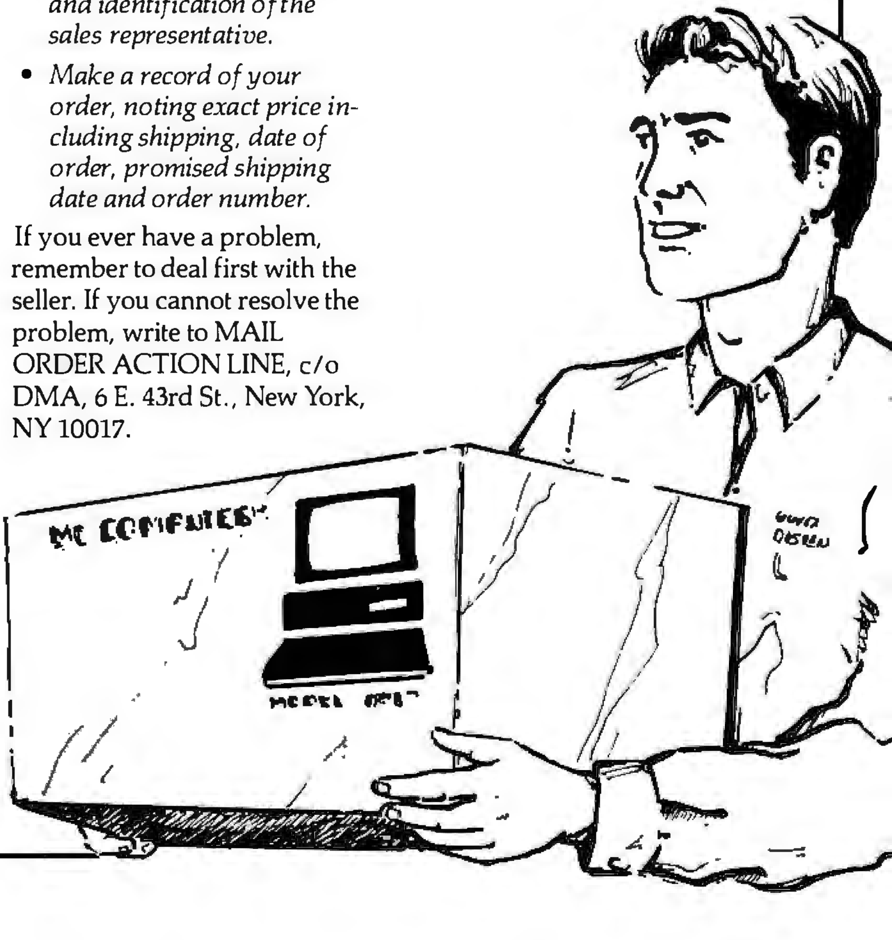


MARK J. MINASI

EXORCISING THE A20 POLTERGEIST

What to do about those random characters that sometimes appear in DOS 5.0 and Windows applications

Have you ever seen a word processor display odd keystrokes under DOS 5.0 or Windows? It happened to me while upgrading the machines in my office. My marketing person, Donna, claimed that WordPerfect for Windows wouldn't work with DOS 5.0. I didn't have time to look into it, so I uninstalled DOS 5.0 and put the matter in the "things I will do eventually" pile. But I kept hearing scattered reports of keyboard problems with DOS 5.0.

Then Kris, a technical instructor, reinstalled 5.0 on Donna's machine, "causing WordPerfect and other programs to display random characters." "Random characters?" I asked. "Will it do it right now—before our very eyes?" Kris said that there seemed to be no way to make it *stop* doing it. Grabbing my deerstalker cap and calabash pipe, I cried, "Quick, Kristina! The game is afoot!" Along the way, I learned that, believe it or not, you need the keyboard's permission to address extended memory. And thereby hangs a tale.

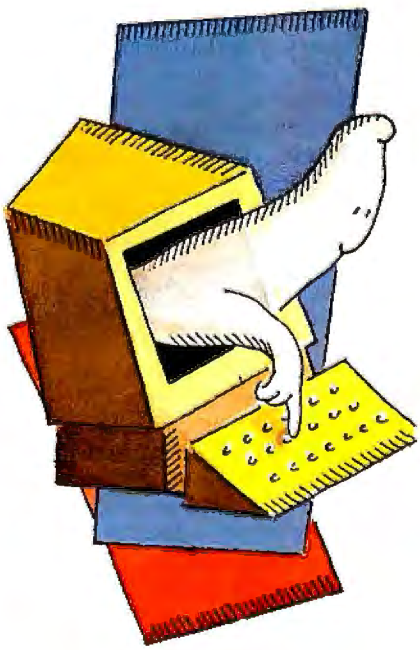
Address-Line Issues

A peek or two at the symptoms showed that the characters weren't random at all. Intermittently, the keyboard added a Shift key to the keystroke, almost as if there were a ghostly finger on the keyboard. Like all good troubleshooters, I started by emptying the CONFIG.SYS and AUTOEXEC.BAT files. The problem went away. While adding back the lines one by one, I found the problem in `DOS=HIGH`.

This surprised me. Of all the nifty features of the memory managers that come with DOS 5.0 and Windows 3.1, the one that seems to have the least trouble is loading DOS into the HMA (high memory area). This is the memory space between 1024 KB and 1088 KB. (For you purists, it's not exactly from 1024 KB to 1088 KB; it's between 1024 KB and a point 16 bytes below 1088 KB.)

The HMA is an artifact of a bug in 286 and higher CPUs. These "286+" chips have several processing modes designed mainly to accommodate multitasking and handle large amounts of memory. Protected mode is the keystone of Windows, OS/2, and other advanced PC operating platforms. To maintain backward compatibility with existing 8088 programs, Intel included the 8088 compatibility mode, or real mode. DOS was written to live in real mode, but Windows and OS/2 are changing that.

The original 8088 could address 1024 KB of memory, so you'd think that 1024 KB would be the limit for 286+ chips in real mode. But for reasons that are too convoluted to describe here, 286+ chips address just under 1088 KB of RAM in real mode.



Suppose an 8088 program has its instruction counter at the very top of memory at location 1024 KB − 1. (The addresses start at 0, so the top address is 1024 KB - 1). When the processor tries to increment the instruction pointer, it rolls over to location 0, just as an automobile's odometer does when it passes 99,999 miles. It does this because the 8088 processor is built to support 1024 KB of RAM, which requires 20 wires, or address lines, on the address bus (2^{20} equals 1024). These line numbers go from A0 to A19. An 8088-based computer has no A20 address line and can't communicate with memory beyond 1024 KB. A 286+ computer, on the other hand, has more address lines: 24 for a 286, 386SX, or 386SL; and 32 for a 386DX, 486SX, or 486DX.

What happens when a program sets the instruction pointer for a 286+ CPU running in real mode at 1024 KB − 1 and then tries to increment the pointer? Instead of rolling over, it moves up to 1024 KB and continues to move up to nearly 1088 KB. That's partly because there are address lines above A19. When your program first rises above 1024 KB − 1, it energizes the A20 address line.

The Infamous A20 Gate

The presence of the A20 line troubled the designers of the IBM AT, who sought compatibility with the IBM XT. They responded with the A20 gate, an electronic switch on the A20 line between the processor and memory. When the AT (and all subsequent PCs) powered up, the gate opened, keeping A20 signals from reaching memory. This lets a 286+ more fully emulate an 8088: The addresses wrap around, and the top of real-mode memory becomes truly 1024 KB − 1 on a 286+ computer.

Then along came Windows. The A20

ILLUSTRATION: ROBIN JAREAUX © 1992

gate must close before protected-mode programs like Windows can address extended memory, and the keyboard controller controls the A20 gate. This controller, which is an 8042 chip on most 286+ motherboards, is a microcomputer in itself. It has a CPU, RAM, and ROM all built into a single 40-pin DIP. This design explains why resetting the computer with the Ctrl-Alt-Del keys doesn't do the same thing as turning the power off and on again. Pressing Ctrl-Alt-Del just resets the CPU. That doesn't do any good when the *keyboard* processor crashes.

Microsoft addressed the problem with DOS 5.0 and Windows 3.0 with HIMEM.SYS and the WINA20.386 driver, respectively. Windows 3.0 came first. Then DOS 5.0 arrived, with its ability to load DOS high by twiddling the A20 line. Windows' 386 enhanced mode creates virtual DOS machines, but the standard DOS machine that WIN386.EXE creates—the virtual machine manager under Windows 3.0—doesn't know anything about the HMA or the A20 gate.

The WINA20.386 driver solved that. WIN386.EXE in Windows 3.1 knows about the HMA, but the installation program doesn't remove the now-irrelevant `device=WINA20.386` line from your SYSTEM.INI file; you should remove it yourself after upgrading. And if you're not loading DOS high, you don't need WINA20.386 at all.

The Poltergeist Problem

If you use OS/2, you don't have to worry about the A20 line; the software closes the gate (connects the A20 line) and goes on. DOS is a different story. Prior to version 5.0, DOS just opened the gate and left it open. Now you can load programs into the HMA. But when you put any program—particularly DOS—into the HMA, the A20 gate swings open and closed as though in a windstorm. That causes a problem on some PCs when the keyboard controller can't open and close the gate quickly enough. Bombarding the keyboard controller with A20 requests can make it behave erratically in its primary duties, leading to the Shift-key specter I described earlier.

What do you do if you have this problem? Start by checking your CMOS settings. Many motherboards, particularly those built with the Chips & Technologies chip set and the AMI BIOS, feature a "fast A20" option. If you've got such a motherboard, make sure it's enabled in your computer's Setup program. Also, look for this feature the next time you're buying a PC clone.

Next, check the keyboard controller. Just as BIOSes sometimes require updates, so does the keyboard controller. If you have an AMI BIOS, you'll see the words *American Megatrends, Inc.* on-screen when you turn on your computer. At the bottom of the screen, you'll see what look like serial numbers, followed by -K*x*. The *x* will be the version number of your keyboard controller. I've seen -KA, -K8, -KD, and -KF. You want the KF version to avoid A20 problems.

Don't think that just because you've got a new computer you have version KF. I recently did work for a large defense agency that had just received a pile of new Everex computers equipped with the K9 controller. Keyboard controllers sell for under $75 and aren't too hard to find; just check the ads in the back of computer magazines for BIOS upgrade vendors. Donna now has a new keyboard controller, and all is well. There may, however, be a cheaper way out.

Under DOS 5.0, HIMEM.SYS manipulates the A20 gate. You've probably noticed the "A20 handler enabled" message when HIMEM loads. And you now know that the keyboard controller is the control point for the A20 gate. But that's not the whole story. PS/2 computers use an entirely different approach, as do the AT&T 6300 Plus, Philips computers, the Acer 1100, and many others. To address this problem, HIMEM has a `/machine:` switch. You invoke HIMEM.SYS with the `/m:n` parameter, where `n` is a number from 1 to 16.

If your PC misbehaves with HIMEM, try all the machine types—but make sure that you've got a bootable floppy disk on hand first. QEMM owners can use the IGNOREA20 and UNUSUAL8042 options. I find that if you've got a problem PC, QEMM is better at handling A20 troubles than HIMEM. However, before you go out and buy QEMM or a new keyboard controller, try all the HIMEM machine parameters.

Here's a final suggestion: The DOS version of WordPerfect is more sensitive to this type of problem than are other programs, because it programs the keyboard controller directly. Invoking WordPerfect with the `/nk` option may alleviate the problem. ■

Mark J. Minasi runs seminars around the world on OS/2, Windows, and PC troubleshooting. He is based in Arlington, Virginia. You can contact him on BIX as "mjminasi."

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

ASK BYTE

Missing Megabytes

I recently bought a 130-MB Seagate ST1144A IDE hard drive for my Vendex/VTI Turbo 55 computer, which is a 12-MHz 286 machine. When the retailer formatted the drive, he could get only 124.7 MB. He claims my machine's BIOS is outdated and won't support the higher-capacity drive, but my local service center insists that the ST1144A has a formatted capacity of 124.7 MB.

The drive installation instructions state that "if you have a system BIOS that offers a user-defined drive type, select from the following drive configurations." When I go into Setup and attempt to enter 1001 cyls, 15 heads, 17 sectors, 130.7 formatted MB, it's not accepted.

Is there a BIOS upgrade for my machine? I would like to get all I can from my new hard drive.

Jeffrey A. Sawyer
Woonsocket, RI

I can understand your frustration knowing that 6 MB of hard disk space in your computer is inaccessible. Unfortunately, there are no replacement BIOS source codes for your machine.

You could run an installation and management utility like SpeedStor or replace the motherboard. SpeedStor takes the place of your missing "user-defined drive type" and lets you configure your drive any way you want. It sells for $100 from Storage Dimensions, Inc. (1656 McCarthy Blvd., Milpitas, CA 95035, (408) 954-0710; fax (408) 954-0517). A new motherboard will cost anywhere from $100 to $500, but you should be able to reuse all your internal expansion boards.

Your best option, however, may be to do nothing. The missing 6 MB is slightly less than 5 percent of the total disk space. Run your system with only 124 MB. When you finally do bump up against the hard drive's storage limits, motherboard prices will probably have dropped somewhat, and you can pick up a bargain.—Stan Wszola

Lifesavers

How long should I keep my computer turned on—on a day-to-day basis—to minimize wear and tear and maximize its life? I have a Leading Edge D/LT386SX Plus laptop with a 40-MB hard drive, 2 MB of RAM, and a VGA screen.

Except for mechanical wear and tear on the keyboard, screen hinges, and so forth, what are the main factors in the wear and tear leading to the breakdown of a computer? I've heard that "thermal variations" are the main cause.

André Pilon
Toronto, Ontario, Canada

When you turn on a computer, the sudden rush of current stresses the system's electronic components. The same thing happens when you turn on a light. That's why most light-bulb failures occur at this time.

With older desktop computers, leaving them on was the best practice. This left all the internal components at a steady temperature, and they experienced no stresses from powering on. Current laptop computers use smaller components and generate less heat, so thermal variations aren't a serious problem. Computers like yours also use power management circuits that turn off unused subsystems or put the entire machine into a sleep mode when not in use. This conserves battery power and lengthens the computer's life. Spinning down the hard drive limits wear on the drive spindle and motor. Shutting off the backlighting on the display increases the life of the fluorescent tubes.

My suggestion is that you leave your computer on for most of your workday and shut it off at night. I also suggest investing in a good surge suppressor/power conditioner.—Stan Wszola

A Capital Offense

I need to check the spelling of 300 MB of ASCII text data, but all the spelling checkers I have seen tag every proper noun. This has tripled the time it takes to check my data. Is there a spelling checker that will not tag words that begin with a capital letter?

S. Spencer
Levittown, NY

None of the spelling checkers I know about ignore capitalized words. Indeed, ignoring capitalized words presents its own problems since the first word of each sentence will not be checked.

Your problem lies in generating a list of valid names for your spelling checker. A product called Moby Words contains, among other things, a list of over 15,000 names culled nationwide from telephone books. You could feed this list into your spelling checker and create a private dictionary. Moby Words is available from Illumind (571 Belden St., Suite A, Monterey, CA 93940, (408) 373-1491).

Another possibility is to create your own list of valid names. A rather tedious yet straightforward method is presented in the Unix environment. Running the `spell` *utility on your file creates an output file containing one unrecognized word per line. The* `sort` *and* `uniq` *(i.e., unique) utilities can then create a sorted list of unspelled words. The sorted list groups all the capitalized words together. You manually proof these words by removing the incorrectly spelled items and feed the list back into your spelling checker.*

Many such Unix-style utilities are available for DOS, both commercially and in the public domain. For information on commercial utilities, contact Austin Code Works (11100 Leafwood Lane, Austin, TX 78750, (512) 258-0785) or Mortice Kern Systems, Inc. (35 King St. N, Waterloo, Ontario, Canada N2J 2W9, (800) 265-2797 or (519) 884-2251; fax (519) 886-8619). ■

—Raymond GA Côté

The BYTE Lab welcomes your questions. Address correspondence to Ask BYTE, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. You can also send BIX mail c/o "editors."

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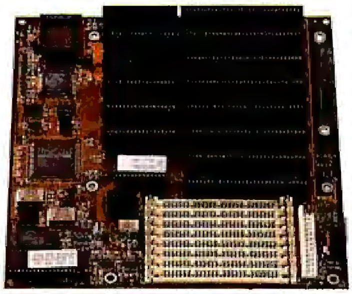

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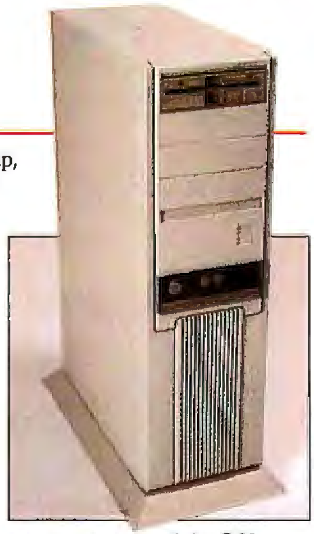

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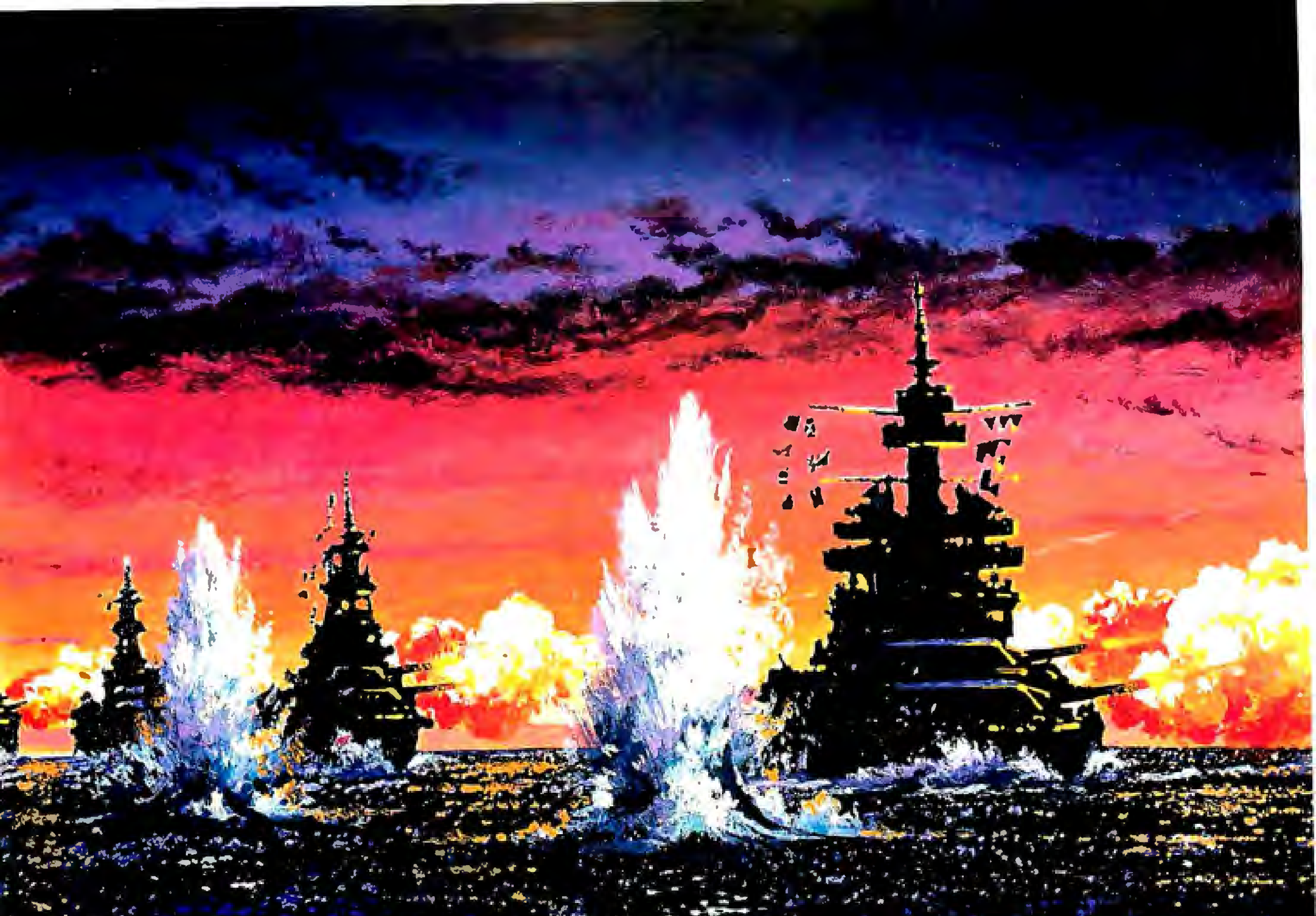

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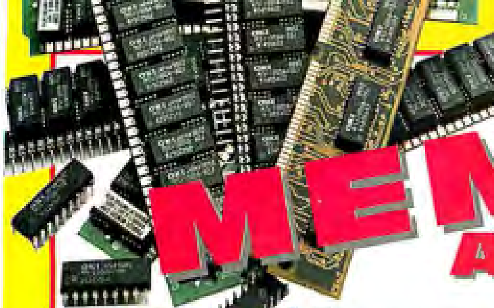

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- ✓ IBM PS/2 25/286, 30/286, 50, 50Z, 60

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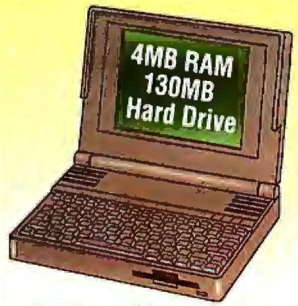

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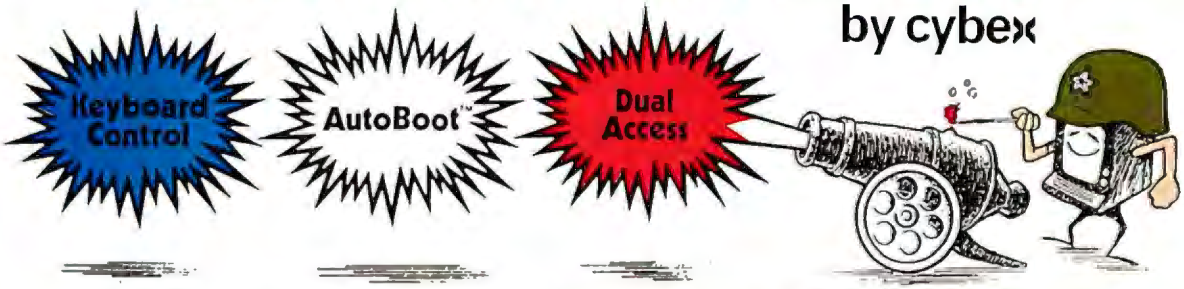

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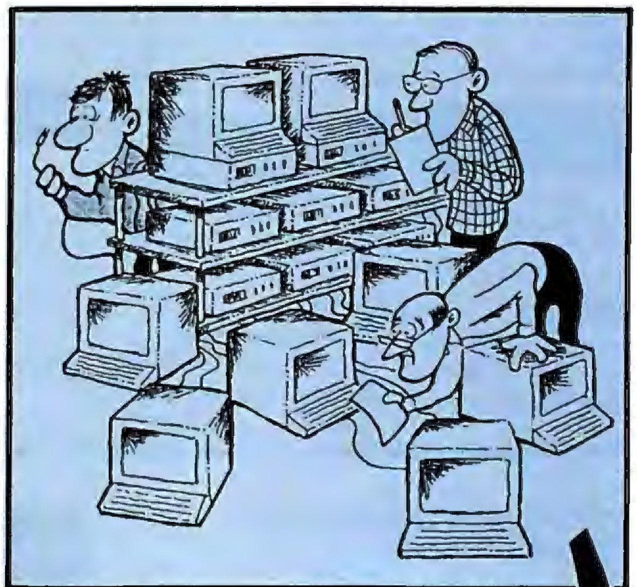

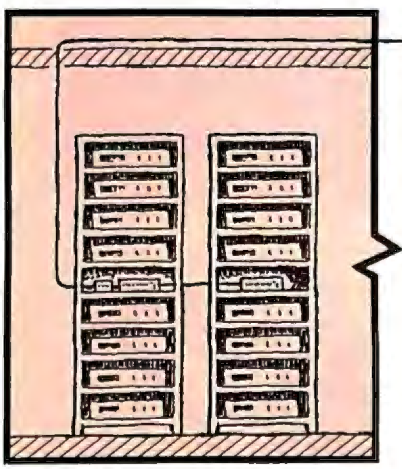

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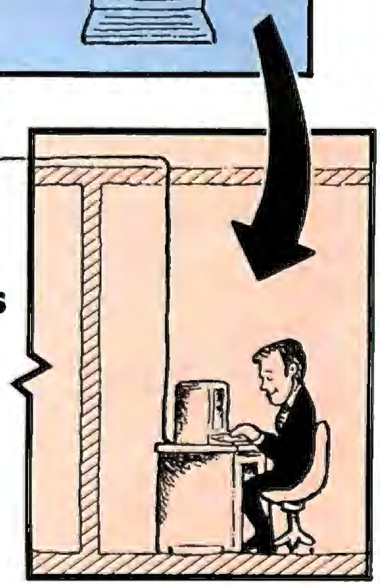

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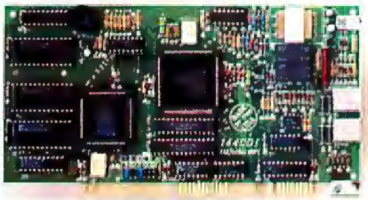

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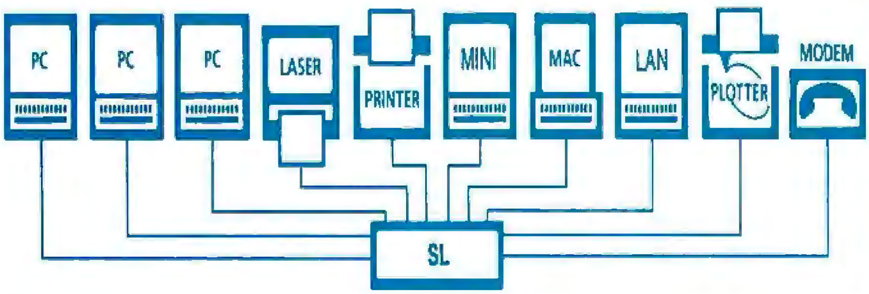

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HXP	4 Parallel	2/2, 3/1	256KB-16MB	$245
HCP	2 Parallel	1/1	256KB-16MB	$225
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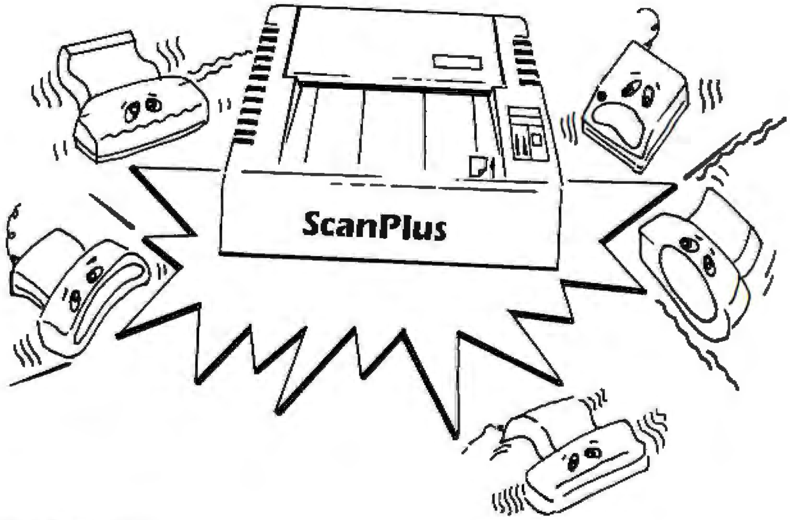

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Communication:
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SPEC.

Type : Desktop, Sheet-fed

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up to 8.5"x14" longer if S/W allow

Scanning Speed:
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Scanning Mode:
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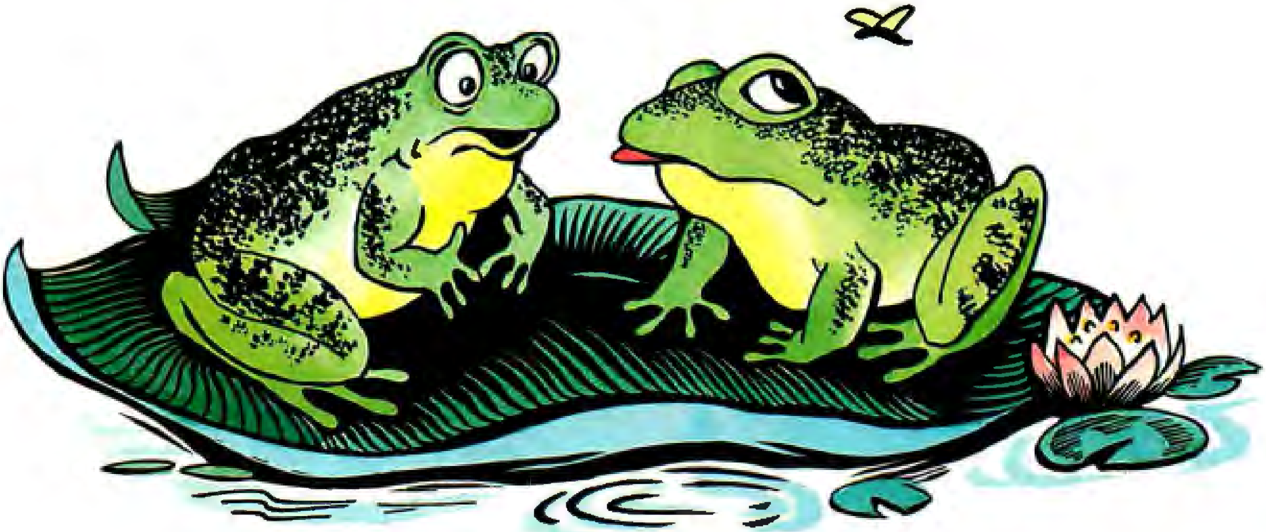

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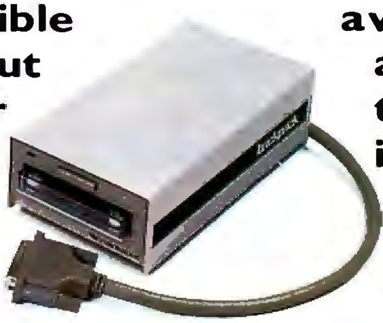

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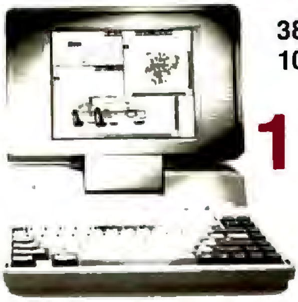

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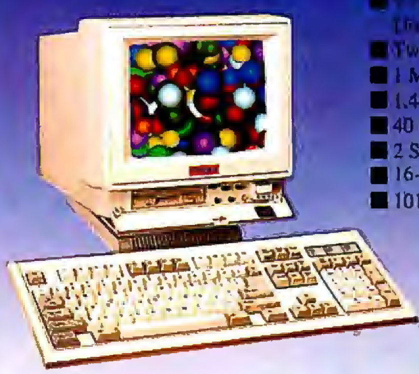

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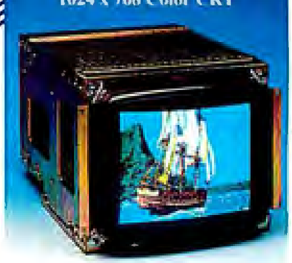

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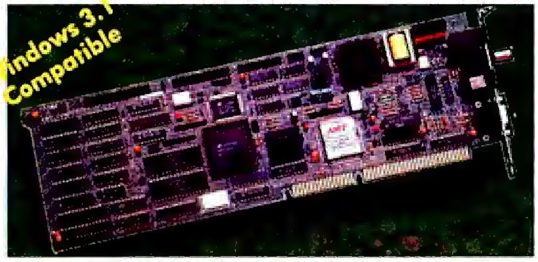

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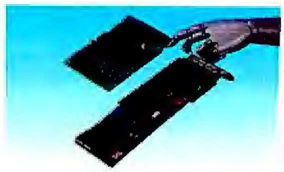

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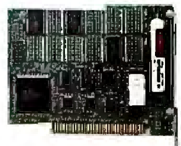

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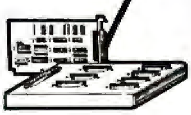

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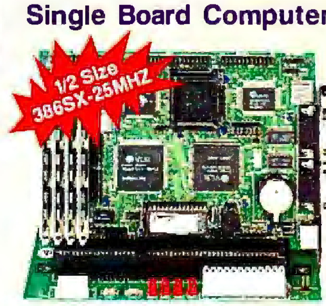

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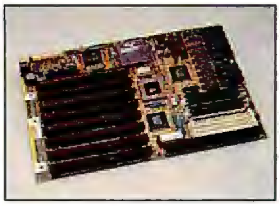

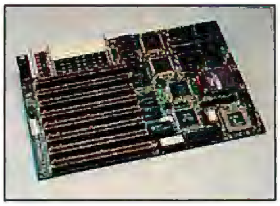

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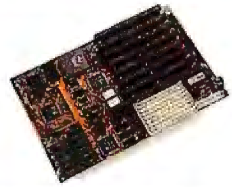

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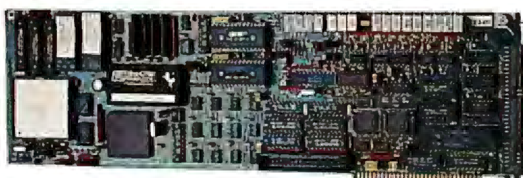

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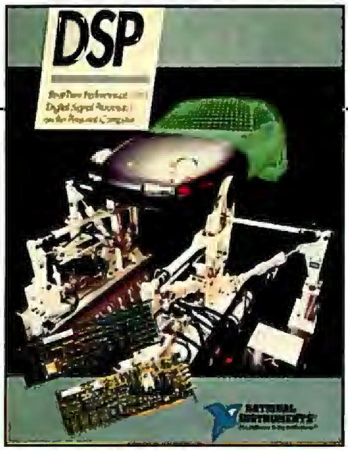

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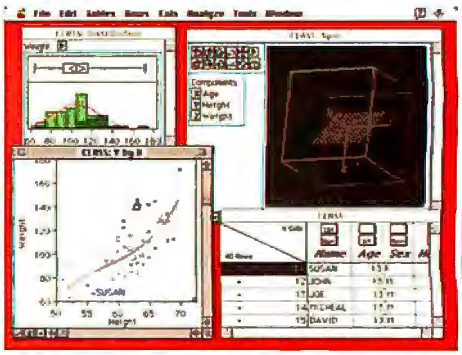

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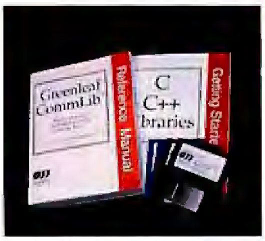

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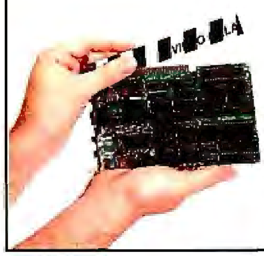

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YOUR DIRECT LINK

PRODUCT CATEGORY INDEX

For FREE product information from individual advertisers, circle the corresponding inquiry numbers on Your Direct Link Card!

To receive information for an entire product category, circle the category number on Your Direct Link Card!

YOUR DIRECT LINK CARD

For free product information, mail your completed card today. *For quicker response, fax to 1-413-637-4343!*

1. Circle the Numbers on Your Direct Link Card

Circle the numbers which are found on ads and articles in this issue or circle the product category number and receive information on all advertisers listed in that category.

2. Print Your Name and Address

Answer questions "A" through "E" and mail or fax card to 1-413-637-4343.

3. Product information will be rushed to you from the selected companies!

BYTE

Yes, I want FREE information on the following products!

Fill out this coupon carefully. *Please Print.*

Name

Title

City State Zip

Phone Fax

A. What is your primary job function/principal area of responsibility? (Check one)
- 1 ☐ MIS/DP
- 2 ☐ Programmer/Systems Analyst
- 3 ☐ Administration/Management
- 4 ☐ Sales/Marketing
- 5 ☐ Engineer/Scientist
- 6 ☐ Other

B. What is your level of management responsibility?
- 7 ☐ Senior-level
- 9 ☐ Professional
- 8 ☐ Middle-level

C. Are you a reseller (VAR, VAD, Dealer, Consultant)?
- 10 ☐ Yes
- 11 ☐ No

D. What operating systems are you currently using? (Check all that apply)
- 12 ☐ PC/MS-DOS
- 15 ☐ Unix
- 13 ☐ DOS+ Windows
- 16 ☐ MacOS
- 14 ☐ OS/2
- 17 ☐ VAX/VMS

E. For how many people do you influence the purchase of hardware or software?
- 18 ☐ 1-25
- 20 ☐ 51-99
- 19 ☐ 26-50
- 21 ☐ 100 or more

☐ **Please send me one year of BYTE Magazine for $24.95 and bill me. Offer valid in U.S. and possessions only.**

August 1992 89

Product Category Information

Circle the numbers below for information on the entire category of products you're interested in.

Hardware

Accessories/Supplies	1
Add-in Boards	2
Bar Coding	3
Communications/Networking	4
Computer Systems	5
Data Acquisition	6
Disks & Optical Drives	7
Diskettes/Duplicators	8
Fax Boards/Machines	9
Graphics Tablets/Mice/Pen Input	10
Keyboards	11
LAN Hardware	12
Laptops & Notebooks	13
Mail Order	14
Memory/Chips/Upgrades	15
Miscellaneous Hardware	16
Modems/Multiplexors	17
Monitors & Terminals	18
Multimedia	19
Printers/Plotters	20
Programmable Hardware	21
Scanners/OCR/Digitizers	22
Tape Drives	23
UPS	24

Software

Business	25
CAD/CAM	26
Communications/Networking	27
Data Acquisition	28
Database	29
Educational	30
Engineering/Scientific	31
Entertainment	32
Graphics	33
Macintosh	34
Mail Order	35
Mathematical/Statistical	36
Miscellaneous Software	37
On-Line Services	38
Operating Systems	39
Programming Languages/Tools	40
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General

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417	443	469	495	521	547	573
418	444	470	496	522	548	574
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420	446	472	498	524	550	576
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422	448	474	500	526	552	578
423	449	475	501	527	553	579
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1328	1353	1378	1403	1428	1453	1478
1329	1354	1379	1404	1429	1454	1479

YOUR DIRECT LINK CARD

For free product information, mail your completed card today. For quicker response, fax to 1-413-637-4343!

See reverse side for card.

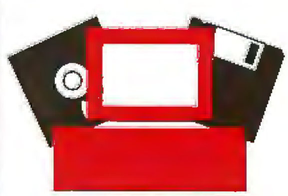
1. Circle the Numbers on Your Direct Link Card

Circle the numbers which are found on ads and articles in this issue or circle the product category number and receive information on all advertisers listed in that category.

2. Print Your Name and Address

Answer questions "A" through "E" and mail or fax card to 1-413-637-4343.

3. Product information will be rushed to you from the selected companies!



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FIRST CLASS MAIL PERMIT NO. 176 PITTSFIELD, MA

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BYTE

Yes, I want FREE information on the following products!

Fill out this coupon carefully. ***Please Print.***

____

____

____

____

____

____

A. What is your primary job function/principal area of responsibility? (Check one)
1 ❑ MIS/DIP
2 ❑ Programmer/Systems Analyst
3 ❑ Adminstration/Management
4 ❑ Sales/Marketing
5 ❑ Engineer/Scientist
6 ❑ Other

B. What is your level of management responsibility?
7 ❑ Senior-level
9 ❑ Professional
8 ❑ Middle-level

C. Are you a reseller (VAR, VAD, Dealer, Consultant)?
10 ❑ Yes
11 ❑ No

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12 ❑ PC/MS-DOS
15 ❑ Unix
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14 ❑ OS/2
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E. For how many people do you influence the purchase of hardware or software?
18 ❑ 1-25
20 ❑ 51-99
19 ❑ 26-50
21 ❑ 100 or more

❑ **Please send me one year of BYTE Magazine for $24.95 and bill me. Offer valid in U.S. and possessions only.**

August 199[illegible]

89 99

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Fax Boards/Machines	9
Graphics Tablets/Mice/Pen Input	10
Keyboards	11
LAN Hardware	12
Laptops & Notebooks	13
Mail Order	14
Memory/Chips/Upgrades	15
Miscellaneous Hardware	16
Modems/Multiplexors	17
Monitors & Terminals	18
	19
Printers/Plotters	20
Programmable Hardware	21
Scanners/OCR/Digitizers	22
Tape Drives	23
UPS	24

Software

Business	25
CAD/CAM	26
Communications/Networking	27
Data Acquisition	28
Database	29
Educational	30
Engineering/Scientific	31
Entertainment	32
Graphics	33
Macintosh	34
Mail Order	35
Mathematical/Statistical	36
Miscellaneous Software	37
On-Line Services	38
Operating Systems	39
Programming Languages/Tools	40
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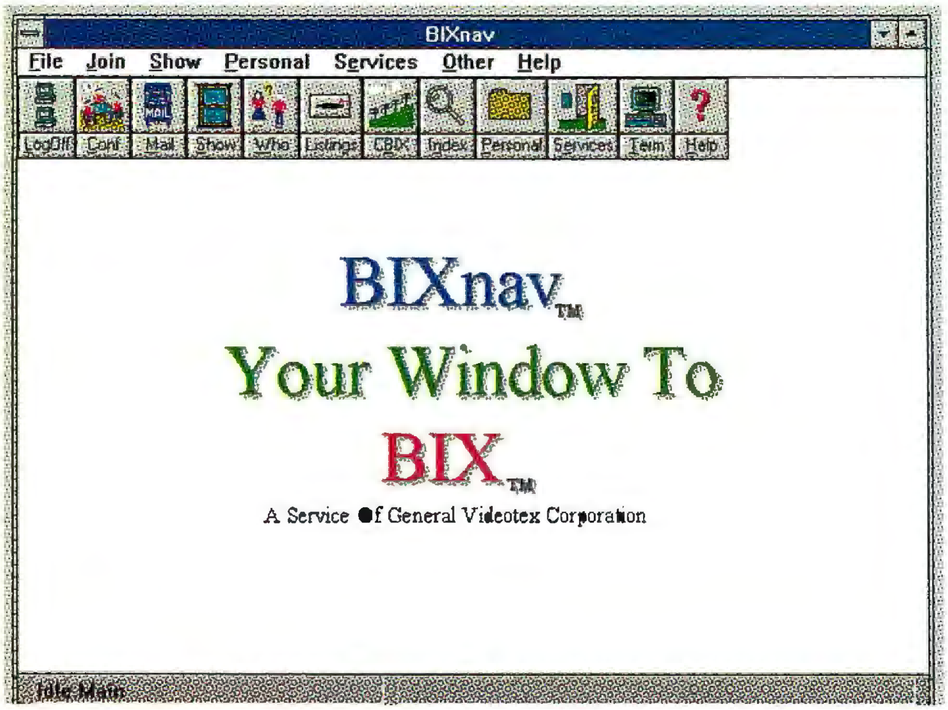

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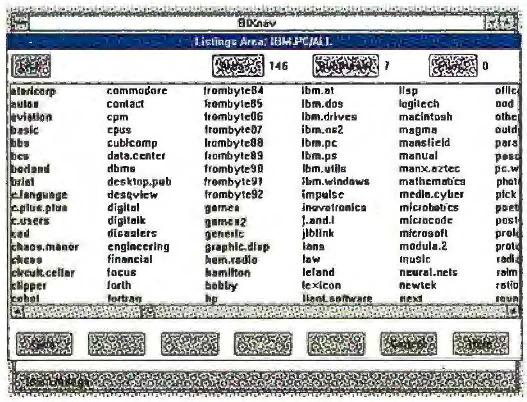

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STOP BIT

JIM MANZI

THE PRODUCTIVITY MACGUFFIN

Organizational productivity hasn't benefited from the PC revolution. Here's why.

During the last presidential election year, while most Americans focused on flags and furloughs, I went out on the hustings to speak on the subject of computers and white-collar productivity. Following this ordeal, I vowed never to address the issue publicly again. But that's proven to be impossible. The subject keeps cropping up, and no one in our industry can afford to ignore it.

Alfred Hitchcock invented a term to describe the object in his films around which all the action revolves. He called it the MacGuffin. It could be a missing body, a bottle of wine that is not really a bottle of wine, or whatever.

Organizational productivity is the MacGuffin of the computer industry. It is the missing return on investment after more than a decade of heavy spending on information technology. During the 1980s, companies spent almost a trillion dollars on new information technology, but productivity in the services sector actually declined.

The situation has grown more serious since my lonely lecture tour. Global competition has intensified, and most companies regard increased productivity—measured in terms of lower cost structures, reduced cycle time, and speed to market—as absolutely essential for survival.

The situation is even more serious for companies in the computer industry. If our customers are focusing with renewed vengeance on productivity, and if we still can't show how our products help deliver it, there is some question about our own survival.

Fortunately, some good news is at hand. *Fortune* recently carried a story about workgroup applications entitled "Here Comes the Payoff from PCs." It talks about time savings of up to 90 percent from groupware. Of course, one story in *Fortune* does not constitute a trend—especially when it's hot on the heels of still another article by Peter Drucker in *Harvard Business Review* on the new productivity challenge. Some may even take the combination of the two as a negative indicator.

But clearly something is happening on the white-collar productivity front. In fact, two things are happening: networks and mobile computing. With growth rates of about 40 percent a year, they have become the twin engines for growth in the computer industry. Both trends are related directly to the quest for improved productivity.

Over the last 10 years, many companies have fallen into the trap of technology for technology's sake. This has not been entirely their own doing. They have had ample encouragement from members of our industry, who have never hesitated to trumpet their latest product release with no thought to customers' business goals. In all the excitement, people lost sight of a few simple economic truths.

The first is that real value in an organization is generated not by machines, but by people. It applies not just to computers, but to the steam engine, the printing press, and the pencil. The second principle is that the greatest value is generated not by individuals, but by teams.

Given these two principles, there was no reason to think that PCs, by themselves, would increase productivity. The PC revolution may have even made things worse. As Arno Penzias, the Bell Lab's Nobel prize winner, points out, there is a net loss in productivity when individuals must run errands between isolated machines.

It is no coincidence that networks and portable computers are booming at a time when companies are at long last realizing gains from their computing investments. Networks and portables—and the applications that both need—address the basic organizational need for coordination and collaboration. Networked applications enable people to share information and work. Correctly designed applications enable people to work together even though they are not always connected (it is another fundamental truth that people are not always in their offices).

Industrywide numbers on productivity gains are still not in, but there is mounting evidence of tangible gains. One of Lotus's customers, a worldwide consulting firm, has connected its entire organization and uses networked applications to leverage expertise. Knowledge throughout the firm, regardless of location, can be applied to every customer account. As a result, it is winning new accounts.

Another customer, a computer company, uses networked applications to capture and preserve the "intellectual capital" in its product development process, enabling people to move from project to project without the costly start-up time.

These are the sort of real, tangible gains our customers have been looking for all along. We are clearly getting closer to the elusive MacGuffin. ■

Jim Manzi is president and CEO of Lotus Development Corp., a developer of applications software and information services in Cambridge, Massachusetts. You can reach him on BIX c/o "editors."

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Why not give us a call?

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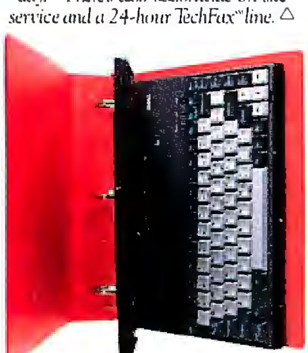

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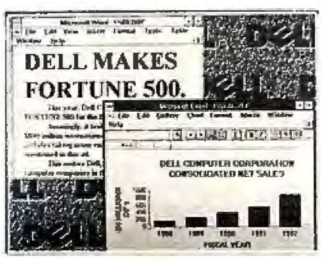

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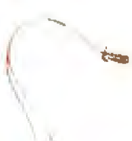

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