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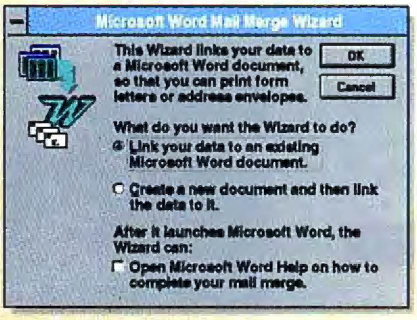

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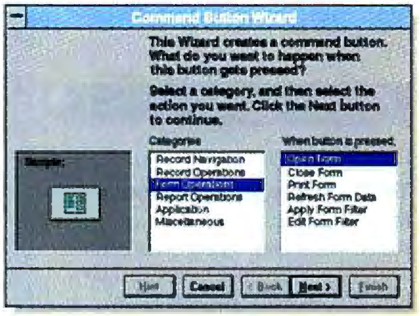

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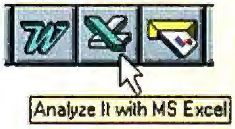

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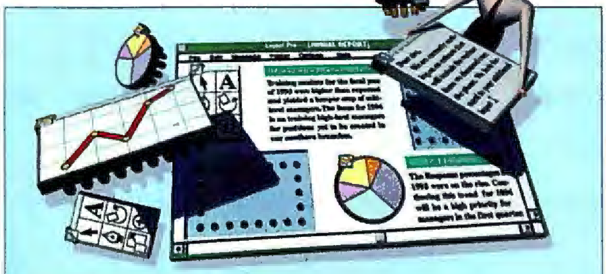

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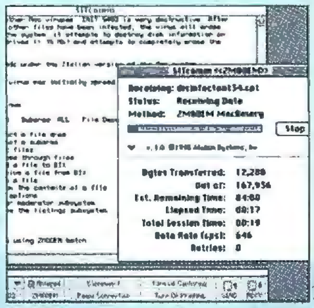

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State of the Art

Opinions

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Hands On

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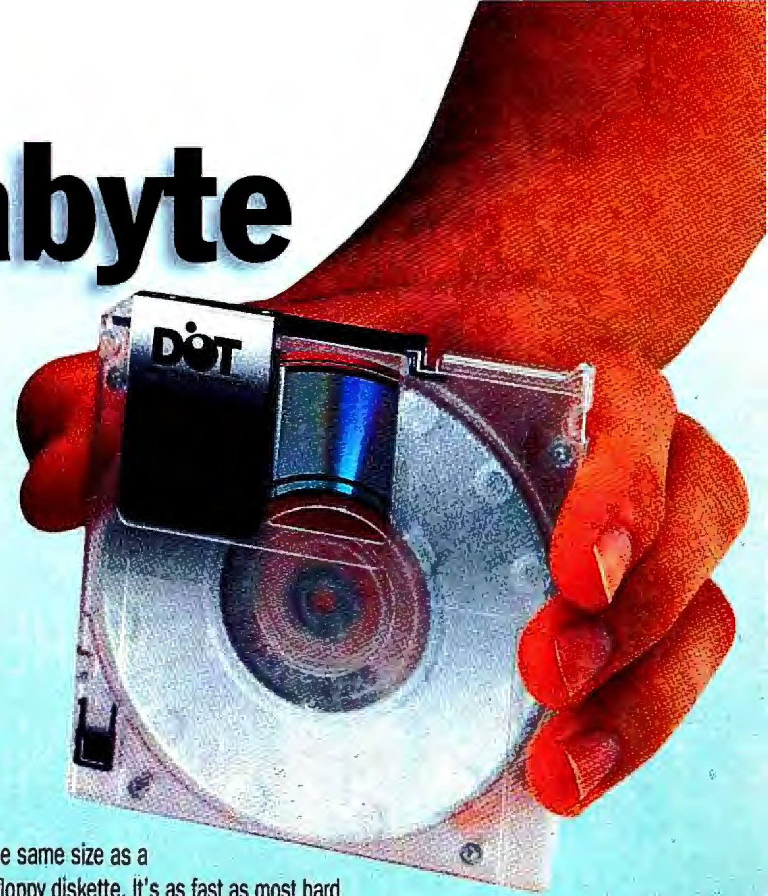

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The Entertainment Factor

Developments in the entertainment industry are strong indicators of just what lies ahead for the enterprise-computing world

Computer technology for the next 30 years will be driven by the entertainment industry. That's what Ed McCracken, the CEO of Silicon Graphics, said at the recent PC Forum—the who's who meeting of the computer industry. This was no news flash to the other computer company CEOs, presidents, vice presidents, and strategists attending the forum: Consumers in the pursuit of entertainment will spend enough money to make investments in certain technology areas worthwhile.

Sure, McCracken has a vested interest in saying what he did. After all, it was his computers that created the dinosaurs of *Jurassic Park*. It is also Silicon Graphics that is transferring its considerable graphics capabilities to build a 64-bit computer (call it a game, if you will) with Nintendo. It is also Silicon Graphics that is working with Lucas Films to move Hollywood out of the film ("linear storage," as the folks at MCA call it) business into all-digital movie productions. McCracken also spoke of virtual reality theme parks in which his company will play a major role. According to McCracken, Silicon Graphics even supplies an employee to play "video keyboard" for Grateful Dead concerts. So, yes, it's fair to say that he has a vested interest in following and promoting the entertainment industry.

That fact, however, doesn't make him any less right. Again to use McCracken's view, it's not business that has driven technology for the last 30 years—it's been the military. Had it not been for the military and its interest in the space program, would we ever have seen mass-produced microprocessors? The fact of the matter is that the arrangement hasn't been so bad. While the military subsidies paid for certain R&D of large, expensive technologies, the PC industry rolled out bits and pieces of those technologies—more often than not with notable improvements—first to individuals and later to the business enterprise.

While the PC industry likes to take credit for having invented everything, it has not invented so much as it has borrowed. Or to put it another way, it has not invented so much as it has scrounged around among the leftovers of government-subsidized research. But the net result has been good. We have more desktop and enterprise-wide computing power and functionality than ever before.

So just what does it mean that entertainment will now drive technology? In some ways, not much. New technologies will come about, and the PC industry will move them to the desktop to solve problems in the enterprise. On the other hand, it's a matter of focus. There are certain technologies that the entertainment industry seeks to exploit, and it is in those areas that we can expect rapid outgrowths to the desktop.

Clearly, the target technologies for entertainment are video, sound, user interfaces, and communications (aka, the data highway). That's not news either. But the probability that a Nintendo game or a digital set-top box running something like Prodigy TV (a proposed marriage of information and regular TV broadcasts) or even an amusement theme park will be the first to produce usable full-motion, 3-D images with beautiful sound and virtual reality interfaces is significant. You ought to be watching those developments so you can predict how those technologies will work on the desktop in the enterprise.

Consider Michael Crichton's new book, *Disclosure*, which takes place in the high-tech industry and uses virtual reality as a means for the hero to explore corporate databases in an effort to solve his problems. In the book, the characters walk on special mats and wear special glasses to wander through the corridors of networked computers to find virtual file cabinets, open virtual file drawers, and leaf through virtual file folders. An interesting way to explore a database, to be sure, but according to McCracken, that scenario in *Disclosure* (an excellent book, by the way) is a lot closer to becoming real than you might think.

But long before we can tiptoe through our databases, that kind of technology will be a staple for entertainment. Likewise, the first widespread use of videoconferencing may be on a TV set while people play games with folks in other parts of the world. None of this makes the technology any less sophisticated or less important to enterprise computing, but if we watch closely, we just might be able to predict the future. ■

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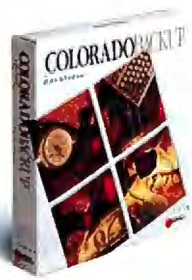

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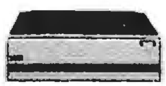

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-*PC World*, February 1994

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–PC World, Feb 94

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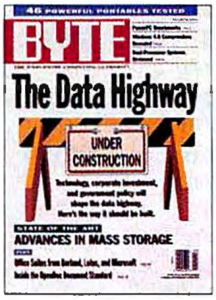
Super Highway Construction Details

Your March cover story "Building the Data Highway" was extensive and broad-based, with a good balance between background, current issues, and future potential. I am deeply involved with these issues here at the University of Montana, and all too often, folks writing about the Internet don't have a clue.

Thomas Morarre
Lolo, Montana

Our discussion of the Internet has spawned many inquiries on how to access it. O'Reilly & Associates ((707) 829-0515) sells Internet-In-A-Box. The National Center for Supercomputing (NCSA, (217) 244-3473) is the source for Mosaic. Both products provide an easy-to-access front end to the Internet.—Eds.



Overall, I thought the data-highway article was timely and useful. But I must take exception to your comment, "ATM also doesn't now support multicasting, which means that all transactions are point-to-point." Fore Systems' switches provide point-to-multipoint communication in an efficient manner, not requiring multiple point-to-point links to accomplish this task.

Tony Mason
Fore Systems, Pittsburgh, PA

The ATM Forum User Network Interface Specification (3.0) does not support multicast service addresses but does support point-to-multipoint virtual channel connections. These point-to-multipoint circuits let you transmit data and reach multiple parties, but you must know all recipients' addresses when you establish the connections. In multicasting, you only need to know a single address, and that server will know the others. The ATM Forum intends to support multicasting in its next revision.—Eds.

I must comment on the idea of supplying universal data-highway access by creating "a public trust fund into which all providers pay and from which subsidies are drawn." I cannot subscribe to, nor support, any type of arrangement where politicians have access to moneys in a public trust fund. Social Security *was* a similar type of setup until politicians squandered it, leaving us with the crippled program no one trusts or relies on.

Erik Ohmberger
Rochester Hills, MI

At the Los Alamos National Laboratory, we read your article on the data highway with great interest, as we are working on the CASA Gigabit Testbed. But CASA is not a point-to-point switchless network. The SONET (Synchronous Optical Network) lines connect to switches, with many computers on each switch. The article also implies that propagation delays are unique to the CASA network. One goal of our research is to hide these delays.

Stephen Tenbrink
Los Alamos, NM

The point we wanted to make was that adding a site to a test-bed like Nectar could be accomplished by establishing a link to an ATM switch. Adding a site to CASA involves establishing a link to one other site in the network. We did not intend to imply that the propagation delay was unique to CASA or a flaw in the test-bed, but rather that it was what CASA intended to study.—Eds.

Technical Support—We Hit a Nerve

Your report on the increase in technical-support calls (News & Views, March) ignores the real reasons: product defects and lousy or incorrect documentation. If computer firms want to know why technical support is expensive and customers are angry, they ought to look at the slop they euphemistically call *documentation.*

Joel Amkraut
Los Angeles, CA

This is an excellent point, but it doesn't contradict the findings of the Help Desk Institute. As the survey notes, major reasons for the decrease in support calls are recurring problems being solved and better customer training, both of which imply that the offending products did not work in the first place or were not intuitive.—Dave Andrews

Magic Cap: Radical or What?

General Magic's Magic Cap (News & Views, February) is hardly a "radical departure" from other point-and-click GUIs, much less original. The Home Desk by Russel Lyon, a launching pad from HyperCard to other applications, looks quite similar.

Annemarie Timmerman
Pittsburgh, PA

You aren't the only one to notice the visual similarity between General Magic's Magic Cap and Apple's HyperCard. We noticed it, too, as did Andy Herzfeld and Bill Atkinson, early Mac and HyperCard pioneers who were among the founders of General Magic and are now developers of Magic Cap. But Magic Cap is original in its elimination of the distinction (central to most other operating systems) among files, applications, and objects.—Andy Reinhardt and Tom Halfhill

Liquid-Cooled PCs...The Next Dumb Thing?

The article "Liquid-Cooled PCs: The Next Hot Thing?" (News & Views, February) leaves me totally dumbfounded. Does depletion of the ozone layer dwindle into insignificance when compared to the need to cheaply cool a Pentium chip? So much for green PCs. What's the next project—using whale oil as a lubricant?

Norm MacLeod
St. Jean-sur-Richelieu, Quebec City, Canada

The Dolch Pentium portable computer uses Fluorinert, a chemically inactive fluid, in its liquid heat sink. It does not conduct electricity or harm the earth's ozone layer.—Eds.

FIXES

Due to a printer error, the first line of the caption on page 193 in the April issue Roundup was masked. The first line should have read: "Action's time management controls are centered around its bar-style time line, where each object in a...."

In the March issue (page 66), the location for Hybrid Networks ((408) 725-3262) is incorrect. It is located in Cupertino, CA.

The February Lab Report (page 162) said the EISA bus has a 33-MHz operating speed; instead, it has a 33-MBps data transfer rate. The operating speed is the same as that of an ISA bus (8.33 MHz), but its wider bandwidth increases the data transfer rate by a factor of 4.■

News & Views

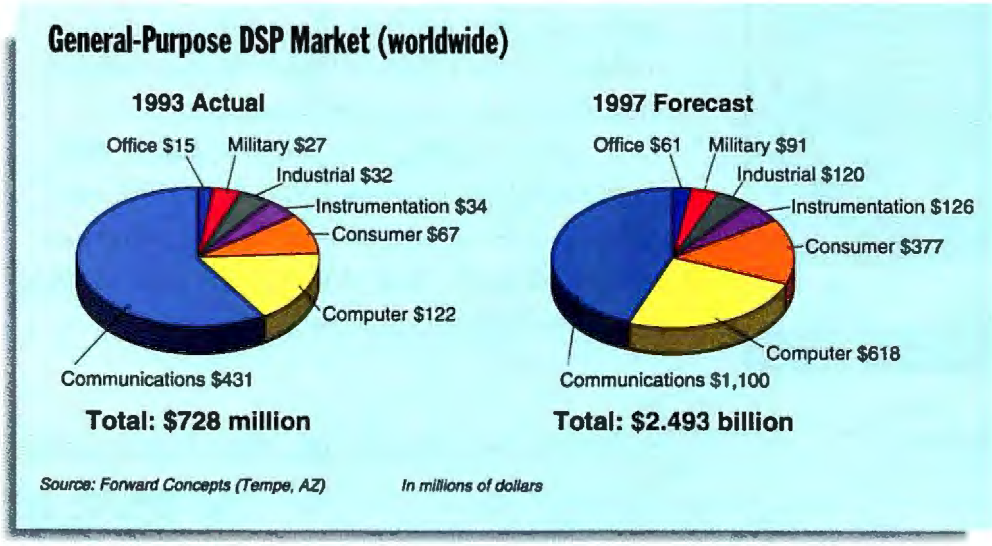
DIGITAL SIGNAL PROCESSING

The Engines to Make Multimedia Mainstream

As industry groups seek to standardize software programming interfaces, digital signal processing may hold the key to bringing voice, video, and telephony to low-cost PCs

DAVE ANDREWS

Due to their ability to rapidly process repetitive arithmetic, programmable DSPs (digital signal processors) can enable PCs to perform a variety of functions—fax and data modems to speech recognition to applying special effects to images. Because a DSP is optimized for processing certain functions related to speech recognition or digital video, it can serve as an efficient complement to a general-purpose CPU. But a lack of standards has inhibited mass acceptance of DSPs in low-end computers. Now, two efforts are under way to define software architectures that will let software developers incorporate signal computing in their applications without having to know the intricacies of different underlying DSP architectures.



One effort is being driven by Microsoft, which has defined a software architecture for Windows that will insulate hardware and software developers from having to know the nitty-gritty details of a specific DSP. A group within the IMA (Interactive Multimedia Association) is driving a second effort that hopes to establish a broad standard that encompasses Windows, the Mac, OS/2, Unix, and other platforms. The companies in this group are Apple, AT&T, IBM, Intermetrics, and Microsoft.

Motorola (Austin, TX) has already released PC Media, a development platform for hardware and software developers who want to get an early start on developing multimedia solutions for Windows that replace several single-application add-in cards. Microsoft says it will release a development kit this year that will let DSP manufacturers develop drivers that will let their chips work with applications written to the company's DSP software architecture

Microsoft also says it is developing a DSP resource manager, which will be available at about the same time as Chicago, the next version of Windows. Microsoft's DSP software architecture will interoperate with DSP kernels from AT&T, IBM, and Spectron Microsystems. The IMA was expected to release its API in April and development tools early next year. Microsoft says it is working with and will support the efforts of the IMA.

If a standard emerges that many hardware and software developers support, end users will benefit by having multimedia-capable PCs that are less expensive than those available today. Because a programmable DSP can act concurrently as a modem, sound card, or other peripheral, you don't have to buy a separate card for each function.

If DSPs become standard, software developers will be more inclined to support them in their programs. Spreadsheets that can "read" columns of numbers as you compare them to a paper backup, word processors that can send files over a modem from within a document, and databases that you can update by speaking into a microphone are just a few examples of applications that will become more prominent.

Blake Irving, product manager for Microsoft's audio product unit, agrees that developers were not shielded from the specific intricacies of individual DSP platforms offered by companies such as Analog Devices, IBM, Motorola, TI, and others. Making an application work with each platform means extra work for the developer. PC hardware vendors faced a similar problem: What if nobody writes applications for the DSP we include on our motherboard?

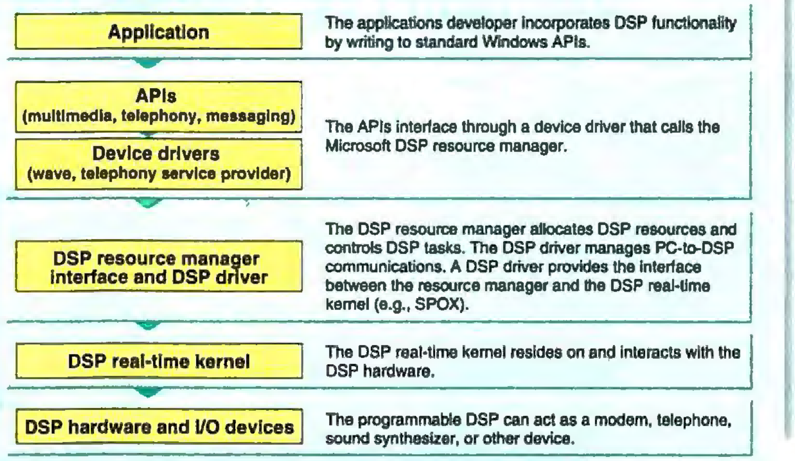
However, not everyone thinks that dedicated DSPs are required to add signal computing. For example, Apple's new Power Macs, unlike its Centris 660AV and Quadra 840AV, do not have DSPs because the PowerPC 601 chip instruction set includes the basic signal-processing multiply-accumulate operation, allowing it to operate as a DSP.

Including functionality in the CPU allows for a lower-costing system, because manufacturers don't have to add the extra DSP chip. Others are not so sure about that strategy, however, noting that today's hottest processors will be consumed by tomorrow's ambitious software. "Software DSPs I don't believe are powerful enough," Microsoft's Irving says. "History has shown that software has an infinite capacity to eat up CPU cycles."

Joe Burke, president of Spectral Innovations (San Jose, CA), which develops DSP-based products for the Mac, agrees. "People buy a PowerPC system for performance. If the first thing you do is load a [DSP] function that brings the PowerPC to its knees, you're not getting the performance."

"Software developers want the ability to run their applications on signal-processing PC platforms with or without a DSP chip," says Dave McLean, manager of Mwave product marketing and business development at IBM. "Our virtual signal-processing strategy accomplishes that." Whether it's in the DSP or in the CPU itself, however, signal computing will change the way you compute.

Microsoft's DSP Windows Interface



TI's Breakthrough DSP

Developers and analysts are raving over a new DSP (digital signal processor) that shatters speed records and brings an unprecedented level of performance to the desktop. The highly integrated chip from Texas Instruments (Dallas, TX) will begin appearing early next year in products ranging from high-end video-capture boards and image processors to videoconferencing systems. It's so fast that it leaves powerful RISC chips in the dust and opens the door to applications that weren't practical before, such as portable fingerprint recognizers and on-the-fly digital filtering of video frames.

TI says the TMS 320C80, which is better known as the MVP (multimedia video processor), executes 2 billion operations per second, about 10 times the performance of previous single-chip DSPs. "It's probably an order of magnitude faster than any other DSP," says Gerry Kaufhold, principal analyst for ThorKa Research—TRIMM ((602) 820-9112), a research and consulting firm focused on multimedia. Another ThorKa analyst, Rick Sizemore, refers to the chip as "the god of DSPs."

The MVP achieves its breakthrough performance with a combination of high integration and a unique microarchitecture. On a single chip, it integrates four 64-bit DSPs, a 32-bit RISC CPU with an FPU, dual video controllers, a DMA controller with a 64-bit DRAM interface, and 50 KB of SRAM (static RAM). Using a 0.5-micron CMOS process, it incorporates 4 million transistors—about 30 percent more than a Pentium microprocessor. The MVP is sampling now, and TI says full production will begin early next year. At an expected cost of $300 to $400 in 10,000-unit quantities, this powerful chip won't likely begin showing up on commodity PCs anytime soon, however.

Because the MVP is fully programmable and supports MIMD (multiple-instruction/multiple-data) throughput, it can be applied to industry-standard compression algorithms such as JPEG (for still images), MPEG (for motion video), and H.261 (for videoconferencing), as well as to proprietary schemes. An integrated transfer controller supports off-chip DRAM, VRAM (video RAM), and SRAM with 400 MBps of I/O bandwidth.

Developers say the MVP can do things that now require expensive workstations or multiple boards with numerous DSPs. For example, Printrak (Anaheim, CA), which makes fingerprint-recognition systems, is working on an MVP-based recognizer that replaces 28 DSP boards with a single board that's portable enough to be installed in a police cruiser.

Dr. Yongmin Kim, a professor of electrical engineering at the University of Washington (Seattle), has been working with prototypes of the chip since 1990. He is developing an MVP-based high-end multimedia board that plugs into a VL-Bus slot. Future versions will support PCI (Peripheral Component Interconnect). The board, to be sold under a nonexclusive license by Precision Digital Images (Redmond, WA), performs audio/video processing, JPEG/MPEG encoding, and P*64 compression for videoconferencing. Kim says his single MVP board replaces the equivalent of eight DSP boards costing $30,000; PDI expects to sell it for about $10,000. Kim says a convolution filter performed on a 512- by 512-pixel video frame that took four seconds to execute on a 486-based PC requires only 19 milliseconds on the MVP.

"Researchers all over the country are going to feel like they died and went to heaven when they get hold of this thing," says DSP analyst Will Strauss, president of Forward Concepts (Tempe, AZ). "Every laboratory in the country is going to want one of these for voice recognition, high-end audio/video processing, and what have you. Of course, the military is going to love it, because there's nothing else better for radar and sonar processing."

—Tom R. Halfhill

The new HP DeskJet 310 *printer.*

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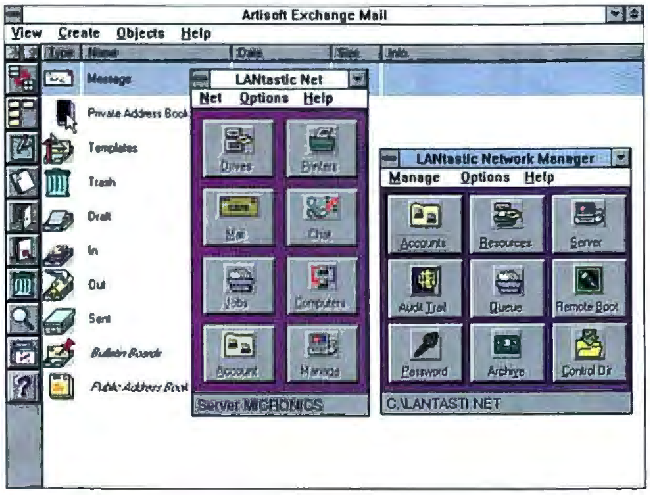
NETWORK OPERATING SYSTEMS

LANtastic 6.0 Creates Peer Pressure



Peer-to-peer LANs have evolved from limited-function packages into full-featured systems. While they offer numerous features for small and medium installations, peer-to-peer networks also easily and seamlessly integrate into existing enterprise-wide LANs. A case in point: Artisoft's LANtastic 6.0 ($119 per node; (602) 670-7100). The latest incarnation of this popular peer-to-peer LAN is packed with a raft of improvements and new features that challenge full-fledged server-based LANs on nearly everything except price. LANtastic 6.0 ups the ante, furthering intense competition in the peer-to-peer arena.

Among the new features in LANtastic 6.0, the package's universal client will cause the most eyebrow-raising in corporate installations. A LANtastic 6.0 workstation can connect as a client to virtually any server-based network operating system. For the huge installed base of NetWare users, Artisoft has licensed Novell's NCP (NetWare Core Protocol). This lets LANtastic 6.0 access file and print services from any NetWare 2.x, 3.x, or 4.x network. LANtastic 6.0 also supports SMB technology, giving it access to Microsoft's Windows for Workgroups, Windows NT, and LAN Manager, as well as IBM's LAN Server.

Stan Schatt, LAN services director at Computer Intelligence/InfoCorp (La Jolla, CA), expects the "million users of NetWare 2.x who've been abandoned by Novell" to be the most immediate customer base for LANtastic 6.0. Artisoft has also come to the conclusion that certain users will want more. Artisoft says it will ship a 32-bit server-based network operating system later this year (see "Artisoft and Novell in Technology Partnership").

LANtastic 6.0's ace in the hole is Artisoft Exchange, what the company calls an "object-oriented groupware system." In this arena, Artisoft is going head-to-head with the groupware features of Windows for Workgroups 3.11, which include mail, scheduling, and fax support for the still-evolving Microsoft At Work standard. LANtastic 6.0 includes full-featured mail and scheduling, as well as message forwarding to pagers. Artisoft has announced that it will also offer future gateway products that allow connections to Novell MHS, MCI Mail, and server-to-server connections.

Realizing that not all LANs require all features, the product has modular server components that let system administrators pick and choose the features they need. Small installations can eschew advanced security or the extensive network management.

LANtastic 6.0 is being positioned by Artisoft as a flagship product, between the entry-level Simply LANtastic and the upcoming server-based package. With the next versions of Windows and OS/2 expected to have built-in peer-to-peer networking, InfoCorp's Schatt says that "operating-system companies will be Artisoft's biggest threat," but he adds that Artisoft has a "bright future." But in this era of parsimonious budgets, the low cost of peer-to-peer LANs is nearly irresistible.

—Stan Miastkowski

Take 2

In round 1 of the Microsoft-Stac compression lawsuit, Microsoft was ordered to pay Stac Electronics $120 million for infringing on data-compression patents in the companies' patent and trade-secret dispute. In March, Microsoft began shipping MS-DOS 6.21, a new version that does not have the DoubleSpace disk-compression feature. Stac also had to pay Microsoft $13.6 million for misappropriating trade secrets. Both companies say they will appeal.

Modular Windows, the Tandy VIS's operating system, is a product no longer, according to a spokesperson for Microsoft; it began and will end with the Tandy VIS. The representative, however, said that much of what the industry saw in the VIS-bound software may yet appear in TV cable boxes. As for the VIS, the home-based entertainment system is still available through the Tandy catalog, along with about 75 titles out of the originally promised 100. You can still buy one at a Radio Shack retail outlet, but several outlets we surveyed said the unit is a poor seller.

Artisoft and Novell in Technology Partnership

On the face of it, there's hardly a more unlikely pairing than Novell, the undisputed champion of corporate and enterprise computing, and Artisoft, which produces LANtastic, the popular SOHO (small office/home office) LAN. Nevertheless, the two companies have jointly announced that Artisoft is licensing NetWare 4.01 and NCP (NetWare Core Protocol).

Artisoft officials say the company wanted to provide its approximately 2 million users with a 32-bit, dedicated-server network operating system without having to develop that software from scratch. Artisoft will use NetWare 4.01 as the core of its 32-bit network operating system. The company hopes to release in June an integrated program that installs a version of NetWare 4.01 over a LANtastic peer-to-peer network. The server product will have the look and feel of LANtastic, Artisoft says, and will scale down certain NetWare features (e.g., the LANtastic version will not support full global directory services).

Artisoft will be selling the 32-bit server and a LANtastic NLM (NetWare loadable module) as a package deal. The package will not be bundled with LANtastic 6.0.

—Alexis Tannenbaum

75MHz.

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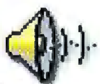

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INTERNET COMMUNICATIONS

Front Ends Ease Internet Access

Pipeline's picklists let users sift through lists and descriptions of news groups. Promising discussions can be grouped into folders. A search function helps you locate specific topics.

It seems like sacrilege, but it was just a matter of time. A number of companies are releasing software designed to make it easy to access the Internet. The flood of new Internet users are clamoring for software that simplifies connections. While on-line services like CompuServe strive to improve both their interfaces and their Internet access, several companies have rushed to fill the void. Some combine access to several on-line services, while others are designed specifically for the Internet. A few have entered the dial-up Internet market after developing front ends for dedicated (not dial-up) Internet connections.

America Online and Prodigy already provide graphical navigation programs that work with their own on-line services. Other companies have written graphical front ends. One of these is Pipeline (New York, NY, (212) 267-3636), whose Pipeline for Windows (a version for the Mac is slated to ship this month) works with the company's own Internet service. (Several other Internet providers have licensed Pipeline to front-end their Internet services.)

Pipeline offers point-and-click navigation through the complexities of news group access, as well as other advantages. Pipeline lets you multitask downloads and supports real-time chats and games and other activities through its fast PinkSlip protocol. News group subscriptions are selected from a picklist. You can combine groups in folders that you name. When you open the folder, the program automatically picks up the appropriate headers, which identify new thread topics. If you want to read the messages, you tell it to go back and get all the threads (i.e., a series of posted messages that usually relate to a particular topic).

Programs like CyberCorp's (Atlanta, GA, (404) 424-6240) Cyberdesk treat the Internet as another on-line service and function as a communications package with extremely powerful built-in scripts. The idea is that even though the various on-line services are separate, users prefer to control all their communications in one application. All mail and news group messages are retrieved for the user to read off-line. Topic headers are delivered back to the user's desktop, and the user selects the threads that should be downloaded.

WinGopher Complete, from Notis Systems ((708) 866-0159), can work through a LAN connection or dial-up connection using SLIP (Serial Line Internet Protocol) or PPP (Point-to-Point Protocol). Icons show what's available without requiring you to remember specific locations, and the interface shields users from the intricacies of `veronica`, `archie`, `gopher`, and WAIS.

The above is not a comprehensive listing of graphical front ends for the Internet. A few other products include Internet-In-A-Box (see the April BYTE, page 257), Mosaic, Cello for Windows, and Viola for X Window System. MKS ((519) 884-2251) is developing a graphical front end called Internet Anywhere.

In the past, users downloaded their Internet utilities as they became available, updating individual setups as often as new programs were uploaded. Many new users, however, will be content to treat their Internet front end like any other piece of software and wait for improvements and revisions to show up in the next version of the package.

—Angela Gunn

On-Line Access to the Internet

How much Internet access do the major on-line services offer their subscribers? Delphi and BIX led the way in providing an array of options, but the other services are starting to catch up.

America Online ((703) 448-8700) provides E-mail, Usenet, WAIS (Wide Area Information Service) and `gopher` access. No charge. (At press time, America Online was in beta testing of its Internet access services.)

BIX ((617) 491-3393) offers a range of Internet services, including E-mail, `ftp` and `archie`, `gopher`, `telnet`, and Usenet access. The first 10 MB of Internet mail each month is free; a $1 per 100 MB surcharge may be added for high-volume accounts, at BIX's discretion.

CompuServe ((614) 457-8600) has E-mail access via gateway. Standard rates to read, download, or send Internet messages are 15 cents for the first 7500 characters and 5 cents for each additional block of 2500 characters. CompuServe plans to add additional Internet access services throughout the year.

Delphi ((617) 491-3393) offers full access to Internet services, including E-mail, IRC (Internet Relay Chat), news groups, `gopher`, `telnet`, `ftp`, and gateway access to popular Internet utilities like `archie`, WAIS, WWW (World Wide Web), and `veronica`. Access is $3 per month over standard connect rates.

GEnie ((301) 251-6415) has E-mail access via gateway. No charge.

Prodigy ((914) 448-8000) has E-mail access via gateway. (It also offers access to another on-line service, the Imagination Network, through its GamePoint gateway.) Prodigy charges 10 cents for each Internet message sent or received.

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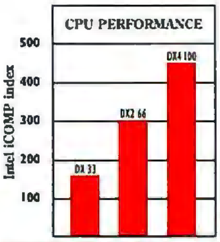

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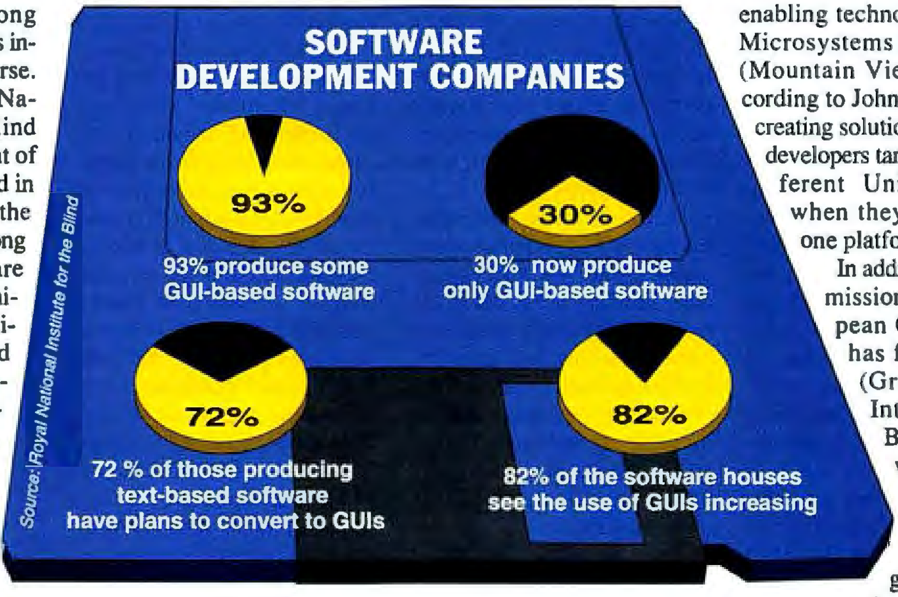
ADAPTIVE COMPUTING

Adapting GUI Software for the Blind Is No Easy Task



The use of GUIs among blind computer users is increasing, for better or worse. According to the Royal National Institute for the Blind (London, U.K.), 82 percent of the software firms surveyed in Europe and the U.S. see the use of GUIs increasing among blind users. "The blind are being guided down a graphical path as text-based applications become scarcer and scarcer," says Dave Kostyshyn, president of Syntha-Voice (Stoney Creek, Ontario, Canada), developer of the first speech program for Windows for blind users.

This widespread adoption of graphical applications adds a whole new set of challenges for applications developers and visually impaired users. The World Institute on Disability (Oakland, CA) estimates that between 400,000 and 500,000 people in the U.S. cannot see well enough to use a monitor without depending on speech synthesis or some other alternative output, such as braille.

GUI platforms rely on spatial and pictorial representations to convey information, which makes them much more difficult to use for many blind users than text-only applications, according to Kostyshyn. To make a GUI-based word processor or other type of program accessible to a blind user, developers of speech-synthesis programs must verbalize information about the interface (including buttons, menus, and text associated with graphical objects) and the application itself (including cursor position, font style and color, dialog boxes, and graphical images).

Luckily for companies that need to comply with the Americans with Disabilities Act, more GUIs are being adapted for the blind with speech, braille, and magnification systems. Although not always easy to use with all applications, this new generation of graphics-based adaptive hardware and software lets the visually impaired use Mac, OS/2, Windows, and other GUI platforms. At the 1993 Closing the Gap conference, which is often described as "the Comdex of the adaptive-computing industry," many new assistive devices were introduced.

The Mac was the first GUI-based platform to become accessible for the blind, thanks to Berkeley Systems' Outspoken speech software. (For information on other adaptive products, see "Computers for the Disabled," June 1993 BYTE.) Due to the overall success of Windows 3.1, users can pick from a wide variety of Windows-based adaptive hardware and software products. The newest Windows speech package to enter the market, WinVision from Artic Technologies (Troy, MI, (313) 588-7370) joins Windows screen readers like Window Bridge from Syntha-Voice ((905) 662-0565) and ProTalk from Biolink Computer Research and Development (North Vancouver, British Columbia, Canada, (604) 984-4099). IBM has developed Screen Reader/2, a speech-access program for OS/2 that lets the blind use DOS, OS/2, and Windows applications with the aid of speech and braille output.

A previously inaccessible platform for the disabled, Unix and its GUIs, is starting to attract developers. Several are working on a suite of adaptive products for Unix, ranging from speech programs for the blind to keyboard-enhancement utilities for persons with motor disabilities. The Disability Access Committee for X, or DACX, is creating operating-system-level hooks to make it easier to develop speech- and braille-access systems for visually impaired users.

"We want to make the workstation environment friendly to adaptive developers by creating device-independent tools," says Earl Johnson, manager of enabling technologies at Sun Microsystems Laboratories (Mountain View, CA). According to Johnson, DACX is creating solutions that will let developers target several different Unix platforms when they develop for one platform.

In addition, the Commission of the European Communities has funded GUIB (Graphical User Interfaces for Blind People), which is exploring the following output technologies: speech, braille, and audio. Those involved in the GUIB project are working to ensure that new platforms are developed with the needs of disabled people in mind.

Although GUI-based platforms are becoming more accessible, Syntha-Voice's Kostyshyn notes that the next wave of operating systems will offer a new set of challenges. For example, when Microsoft unveils its new version of Windows with its overhauled interface, speech-reader programs will have to be modified as well.

The process of adapting GUI platforms will be further complicated by the expected increase in the number of 3-D applications. Ronald Morford, a blind programmer and president of Automated Functions (Arlington, VA), says, "The translation of 3-D graphics screens into braille or speech output is a formidable task for the programmer and a sometimes steep learning curve for the blind user." Challenges like these add a whole new set of dimensions for developers of adaptive products.

—Joe Lazzaro

PDAS

Motorola's Envoy First to Run Magic Cap

In announcing the hand-held Envoy, Motorola is the first company to release details about a hand-held computer designed specifically to run General Magic's Magic Cap operating system. With built-in modems for wired and wireless communications, bundled clients for on-line services, and a software environment built around communications, Motorola aims to correct one of the most commonly cited failings of Apple's Newton MessagePad, its lack of communications capabilities.

However, in other key areas the Envoy, which is expected to ship this summer, is still an early iteration of the ideal portable communicator. At 7.25 by 5.75 by 1.2 inches, it's bigger than a MessagePad, making it too large to put in a coat pocket. It weighs 1.6 pounds (725 grams)—25 percent more than the 580-g MessagePad 110 and nearly two-and-a-half times more than a Hewlett-Packard HP 100LX. It's intended for data, not voice communications, so it doesn't substitute for a cellular phone. But the biggest problem is its $1500 list price.

In relative terms, of course, the Envoy's $1500 price is impressively low for what you get (see summary box). But given the MessagePad's mediocre sales at less than half the price, the Envoy may remain a niche product for the foreseeable future. Small volumes lead to tepid developer response, which constrains availability of applications.

Andy Seybold, editor of the *Mobile Computing Report* and an analyst of the mobile-computing market, praises the Envoy for what it has achieved, especially the integration of communications into applications. Seybold also likes the Magic Cap user interface, especially the fact that it doesn't use handwriting recognition.

But, he adds, without an optional external keyboard, the Envoy has limited usefulness for E-mail and document creation, which he believes are the key applications for customers most likely to buy it. "To me, the Envoy is a device not for creating data but for manipulating it," he says. This poses a marketing dilemma. Whereas the Simon from IBM and BellSouth, which combines a cellular phone with basic address book and scheduling functions, is not meant as a desktop replacement, the Envoy has to compete against subnotebooks, yet in text-processing applications it suffers by comparison.

As for the price, Seybold offers the classic analysis: "If something is very, very useful to people, price is a nonissue. But I'm not sure this version [of the Envoy] is useful enough to make price irrelevant."

—Andy Reinhardt

Motorola Envoy

Unlike the Newton MessagePad, Motorola's $1500 Envoy includes a built-in fax modem and a wireless modem. It also has two PCMCIA slots.

- $1500 price
- 16-MHz 32-bit 68349 "Dragon" processor
- 1 MB of RAM, 4 MB of ROM
- 9600/2400-bps fax modem
- 19.2-Kbps Ardis wireless data modem
- Two PCMCIA Type II slots
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- IRDA-compatible infrared transceiver
- Bundled applications: America Online, eShop, AT&T PersonaLink, RadioMail, Intuit, PenWare

PDA Companies: We've Only Just Begun

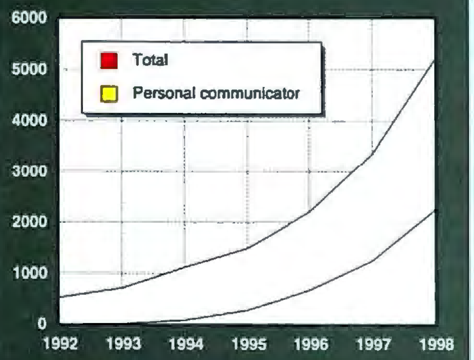
Apple has released a slimmer, less expensive, and more capable Newton PDA, the MessagePad 110. The MessagePad 110, which sells for $599, is a half-inch narrower than the MessagePad 100 and supports deferred handwriting recognition, letting you scribble notes for later conversion. Apple also beefed up the system RAM to 1 MB. "I think this new version reinforces Apple's commitment to this technology," says Barry Owen, editor in chief of *Intelligent Newton* (San Francisco, CA). "There will be many more manifestations of this platform." Apple also plans to beef up the Newton's communications abilities by supporting two-way wireless data-communications services.

More PDA competitors will soon enter the field. Hewlett-Packard and Novell have invested in Geoworks (Berkeley, CA). The three companies say they will collaborate on low-cost (under $500) consumer-computing devices designed for anywhere, anytime network access. And Compaq, Motorola, and Toshiba have announced their intentions to develop products for Microsoft's WinPad, which is the code name for a future operating system for hand-held devices. Other companies are reevaluating strategies—Eo's next PDA will likely more closely resemble a smart cellular phone.

Mike French, project director at Link Resources, estimates that Apple's sales of the MessagePad in the product's second four months were only 25 percent of its first four months (20,000 versus 80,000 units). But his company forecasts an upbeat market, as new PDAs reach the market and as large corporations complete pilot projects for specialized applications.

—D. A.

Forecasts of Personal-Productivity Devices
(Units in thousands, U.S. only.)



Source: Link Resources (New York, NY)

Link Resources (a New York City–based consulting and research firm) forecasts a 45.7 percent compound annual growth rate for personal-productivity devices, including organizers, personal agents, personal communicators, intelligent electronic books, electronic notepads, and entertainment products. Personal communicators will account for nearly half these sales by 1998.

HANDWRITER VERSION ALSO AVAILABLE FOR MACINTOSH

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Gestures are special pen strokes that perform specific editing functions,|

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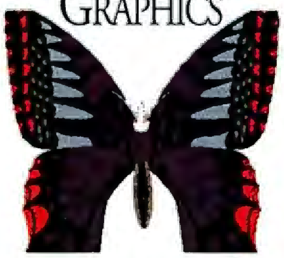

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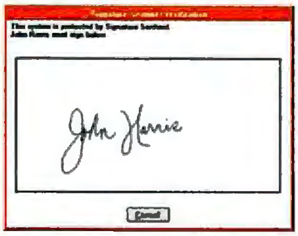

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March 1994, *PC COMPUTING*

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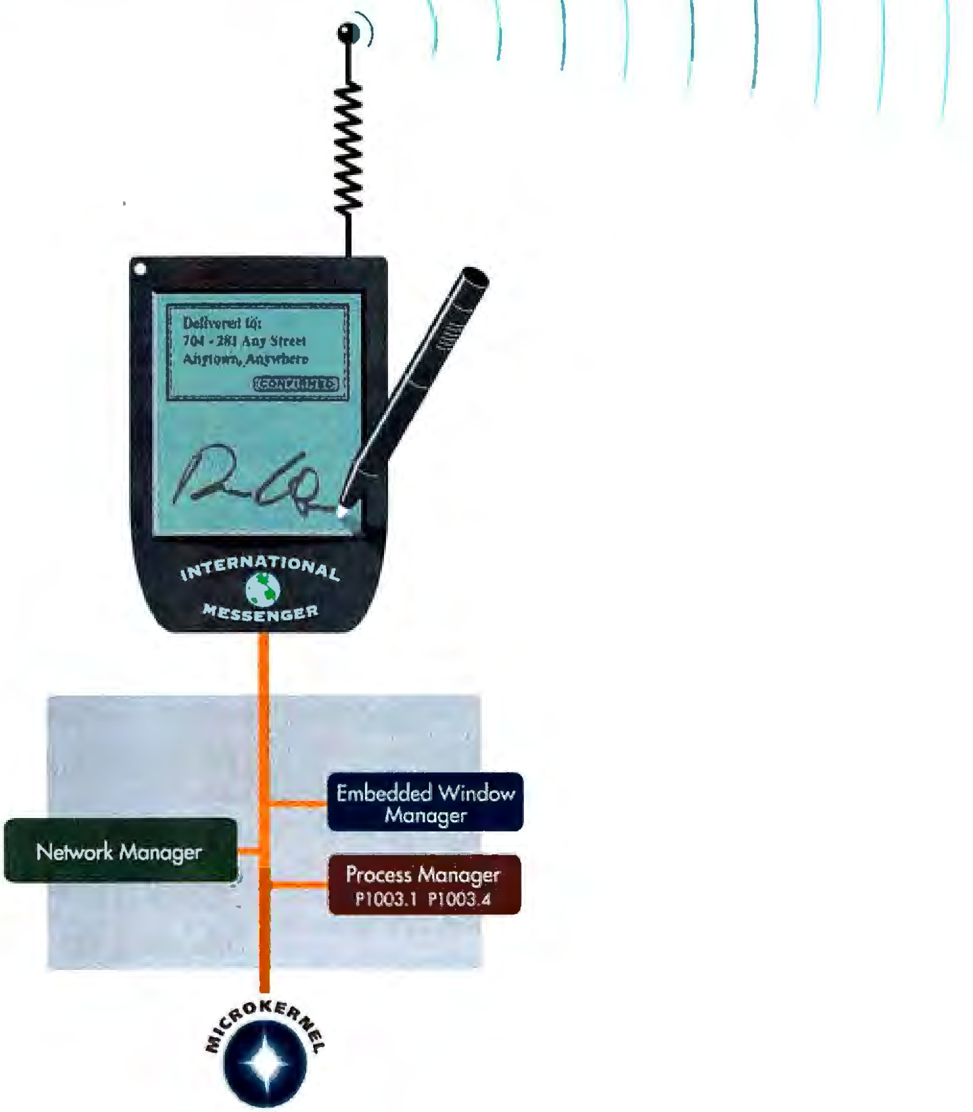

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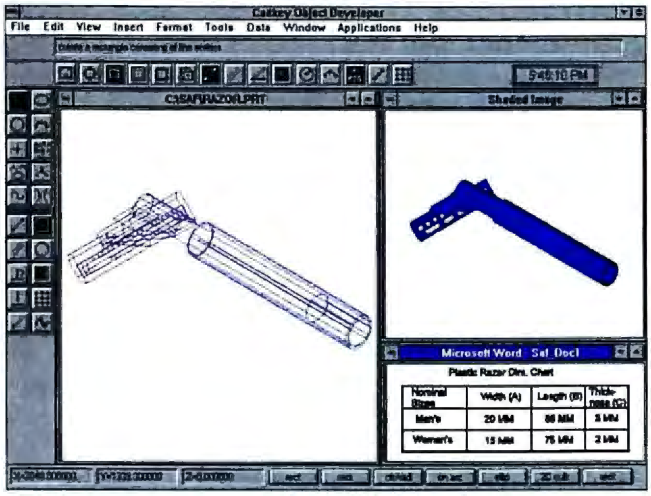
PROGRAMMING TRENDS

CAD Gets Objective



Cadkey's Object Developer lets you develop CAD applications that integrate with other Windows programs via customizable interfaces, OLE 2.0, and multiple documents.

Rather than overloading their programs with new features, a few CAD software vendors are looking at the underlying architecture of CAD and exploiting new technologies, such as OOP (object-oriented programming) and OLE 2.0.

Cadkey (Windsor, CT, (203) 298-8888), best known for its namesake mechanical CAD program, has developed the Cadkey Object Developer (CODe), which is a fully object-oriented framework for developing CAD applications. Other CAD vendors are embarking on similar development paths: Autodesk will make AutoCAD more modular over the next several releases of that program, and Visual CADD (Seattle, WA) is developing a 2-D CAD program that will support visual programming languages and OLE 2.0 for release sometime this summer.

CODe is designed and optimized for Microsoft Windows, including the Win32s, NT, and Chicago versions. CODe's architects took full advantage of Windows. They used visual programming languages and incorporated MFC (Microsoft Foundation Classes) and OLE 2.0 in the product.

An essential feature of CODe, which starts at $495, is that it is modular in nature. The program includes a geometric modeler, a solids modeler, math libraries, and a graphics pipeline. Each component is a module that can be plugged in or unplugged, as the developer wishes.

Similarly, developers who require more than the simple file-based storage included with the first version of CODe can opt to use Object Design's ObjectStore client/server database.

It may seem odd that a traditional CAD vendor would want to sell a development tool rather than an end-user program. But in many cases, AutoCAD serves only as a CAD engine that supports specialized applications ranging from process piping to apparel design. CODe offers the developers of these applications a powerful, modular engine.

—Evan Yares

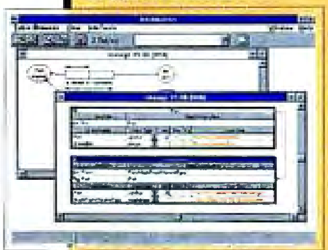
CODE TALK

RICK GREHAN

InfoModeler Gets the Message to the Customer

If you've ever been involved in the construction of a large-scale database system, you know the hazards. In my experience, such hazards always revolved around properly determining what should go into the database, figuring out how it all hooked together, and making sure you didn't miss a relationship or data item. Usually, I could avoid these hazards if I could show the client the database structure and get verification that my proposal not only captured all the data, but that the tables were correctly related. Of course, this worked only if I could keep the client from falling asleep as I outlined the database structure. Things would have gone more smoothly had InfoModeler been available then.

The data-modeling methodology of InfoModeler (prices range from $795 to $1495) is based on the object-role-modeling paradigm rather than the more well-known entity-relationship paradigm. The latter captures database information at a lower level (the logical level), where you have to create entities (members of a database), assign attributes, determine which tables those entities inhabit, and build relationships between the tables.



Asymetrix's InfoModeler lets you describe your database application using everyday business terminology.

In object-role modeling, much of this work occurs naturally as you construct facts about the information in your database (it's automatic with InfoModeler). You determine what objects will be in your database (e.g., employees, dates, and addresses) and what roles those objects play (e.g., employees live at addresses and are hired on certain dates). You collect these facts and hand them to InfoModeler. It passes back a recipe for your database, complete with which items are in what tables, descriptions of constraints, relationships via foreign keys, and even the code necessary to build the tables.

InfoModeler's structure for implementing object-role modeling is Asymetrix's FORML (Formal Object Role Modeling Language), which incorporates both graphical and text "languages" for describing a database. The graphical notation is composed primarily of object types (represented by ellipses) connected to one another through predicates (represented by rectangles). Graphical models easily map to sentences in FORML's text language, and although the syntax is necessarily strict, you can nevertheless build natural English sentences such as: "Employee lives in city." A database neophyte can therefore examine a database definition written in this language and stand a reasonable chance of being able to understand it and to spot an error in the design.

—Rick Grehan

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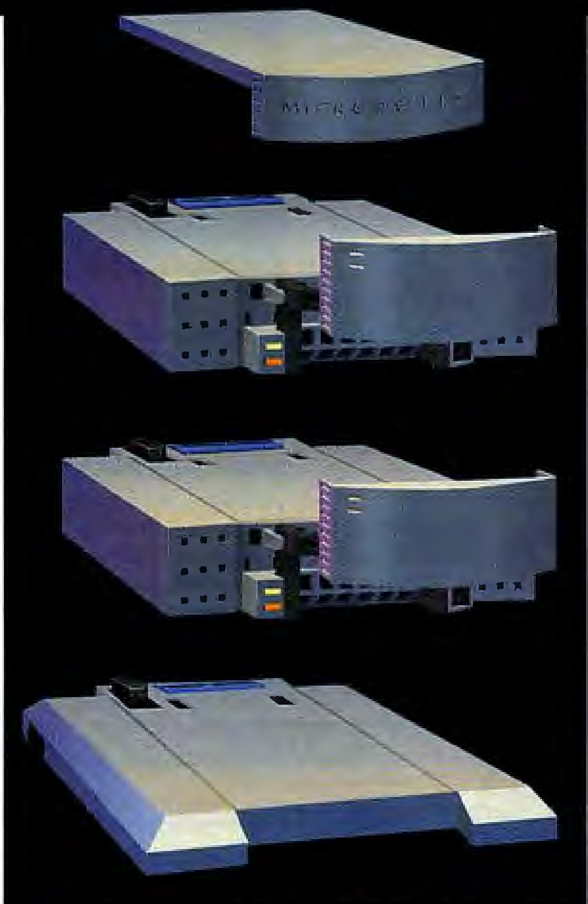

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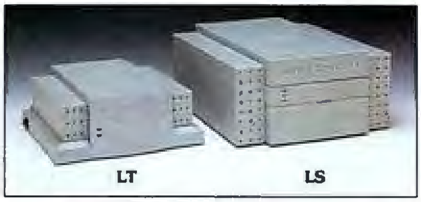

MICRODISK subsystem storage modules can be stacked four to seven modules high depending on model.

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* AV models have slightly lower formatted capacities. Specify for MAC or PC compatible.

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DATABASES

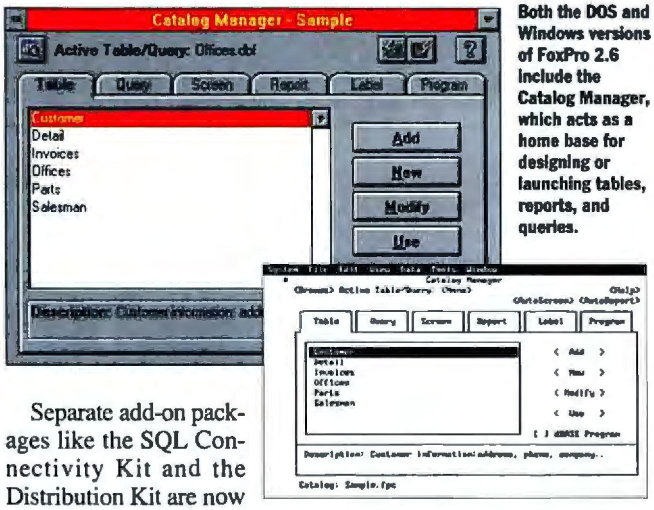
FoxPro 2.6 Targets dBase IV Market

For several years, each new version of Microsoft's FoxPro has set new standards for speed among PC databases. At the same time, FoxPro has been quietly leading the way in terms of cross-platform interoperability. It was one of the first DOS databases to offer a fully mouse-driven windowing interface, along with some innovative enhancements to the stalwart "when" and "valid" operators to make applications event-driven. The Windows version was fully compatible with the DOS version. And FoxPro 2.5 for the Mac is providing serious competition to ACI US's 4th Dimension and Blyth Software's Omnis 7.

Nevertheless, Borland's dBase IV dominates the installed base for Xbase databases. With FoxPro 2.6, Microsoft hopes to lure dBase users with a combination of dBase compatibility, usability features, and packaging. Unix and Mac 680x0 and PowerPC versions should follow this summer. (Borland says it will release dBase for Windows in June.)

New dBase IV–like extensions to the FoxPro language should make most dBase applications run as is. Last year's Migration Kit is replaced with AutoMigrate, which converts forms and reports to FoxPro format automatically when applications run.

FoxPro 2.6 offers wizards, which help you quickly do common tasks, to users who might be intimidated by the complexities of creating applications. Technically advanced users can bypass wizards and work with the sophisticated Power Tools (e.g., Screen Builder and Project Manager).



Both the DOS and Windows versions of FoxPro 2.6 include the Catalog Manager, which acts as a home base for designing or launching tables, reports, and queries.

Separate add-on packages like the SQL Connectivity Kit and the Distribution Kit are now packaged together as FoxPro Professional for $695. The base package ($495) will sell for $99 through June 30.

Many of FoxPro's persistent annoyances are still present in the preliminary version I used. It's still difficult to put record navigation into forms or build one-to-many forms without special utilities, and applications produced by those utilities are still hard to customize. But the price of FoxPro's speed and power has always meant some sacrifice in accessibility by less sophisticated users.

—Mark Hettler

APPLE'S AND MICROSOFT'S SYSTEM SOFTWARE ROAD MAP

Apple recently divulged new details of its system software strategy for the next few years. This summer, System 7.5 will introduce such features as multithreading; drag-and-drop editing; QuickDraw GX (an improved graphics engine for both screen rendering and printing); MacTCP (the first in a series of Open Transport network protocols to be integrated into the Mac OS as AppleTalk is); a scriptable Finder, which allows macros and applications to automate file management tasks on the Mac Desktop; automatic file synchronization between mobile and desktop systems; built-in DOS file compatibility; and context-sensitive help.

Conspicuously missing from System 7.5 are preemptive multitasking (System 7 is limited to cooperative multitasking) and memory protection (which keeps programs from interfering with each other in a multitasking environment). In contrast, both of those features and multithreading are expected to appear in Chicago, the next release of Windows 3.x. According to Apple's road map, Mac users must wait until the release of an operating system code-named Gershwin in 1996 to get true preemptive multitasking (OS/2 2.1 already provides preemptive multitasking, multithreading, and memory protection).

Gershwin will also introduce a hardware-abstraction layer. This layer abstracts upper-level operating-system services from the underlying hardware, allowing easier cross-platform portability. Another notable feature of Gershwin will be an entirely new GUI, but Apple is tight-lipped on details. Copland is Apple's intermediate step to Gershwin. Among other things, Copland will offer memory protection and a microkernel architecture. Until the hardware-abstraction layer is added in Gershwin, however, the microkernel will contribute little to Copland's portability.

—T. R. H.

	1993	1994	1995	1996
Apple	System 7 Pro	System 7.5	"Copland"	"Gershwin"
	• PowerTalk (Apple Open Collaborative Environment) • AppleScript • PlainTalk (voice recognition) • QuickTime 1.6 • DOS file I/O	• Multithreading • Drag and drop • QuickDraw GX • MacTCP • Intelligent help • Scriptable Finder • File synchronization • 680x0 and PowerPC	• Microkernel • Memory protection • New I/O architecture • OpenDoc • Active assistance • More networking	• Preemptive multitasking • HAL (hardware-adaption layer) • Intelligent assistance • Advanced graphics • New GUI
Microsoft Windows NT	3.1 (Portable Windows)	"Daytona"	"Cairo"	
	• Preemptive multitasking • Multithreading • Memory protection • Symmetric multiprocessing • C2-level security • NT file System • HAL • 80x86, R4000, Alpha	• Smaller memory footprint • New TCP/IP, IPX/SPX stacks • PowerPC • OpenGL support	• Distributed OS • Object File System • New GUI	?
Microsoft Windows for Workgroups 3.11	(80x86 Windows)	"Chicago"		
	• Peer networking • 32-bit network drivers and file system • Remote access • Built-in fax • Improved NetWare integration	• Preemptive multitasking • Multithreading • 32-bit components • New GUI • OLE 2.0 support • Plug and play • Platform-independent networking	?	?

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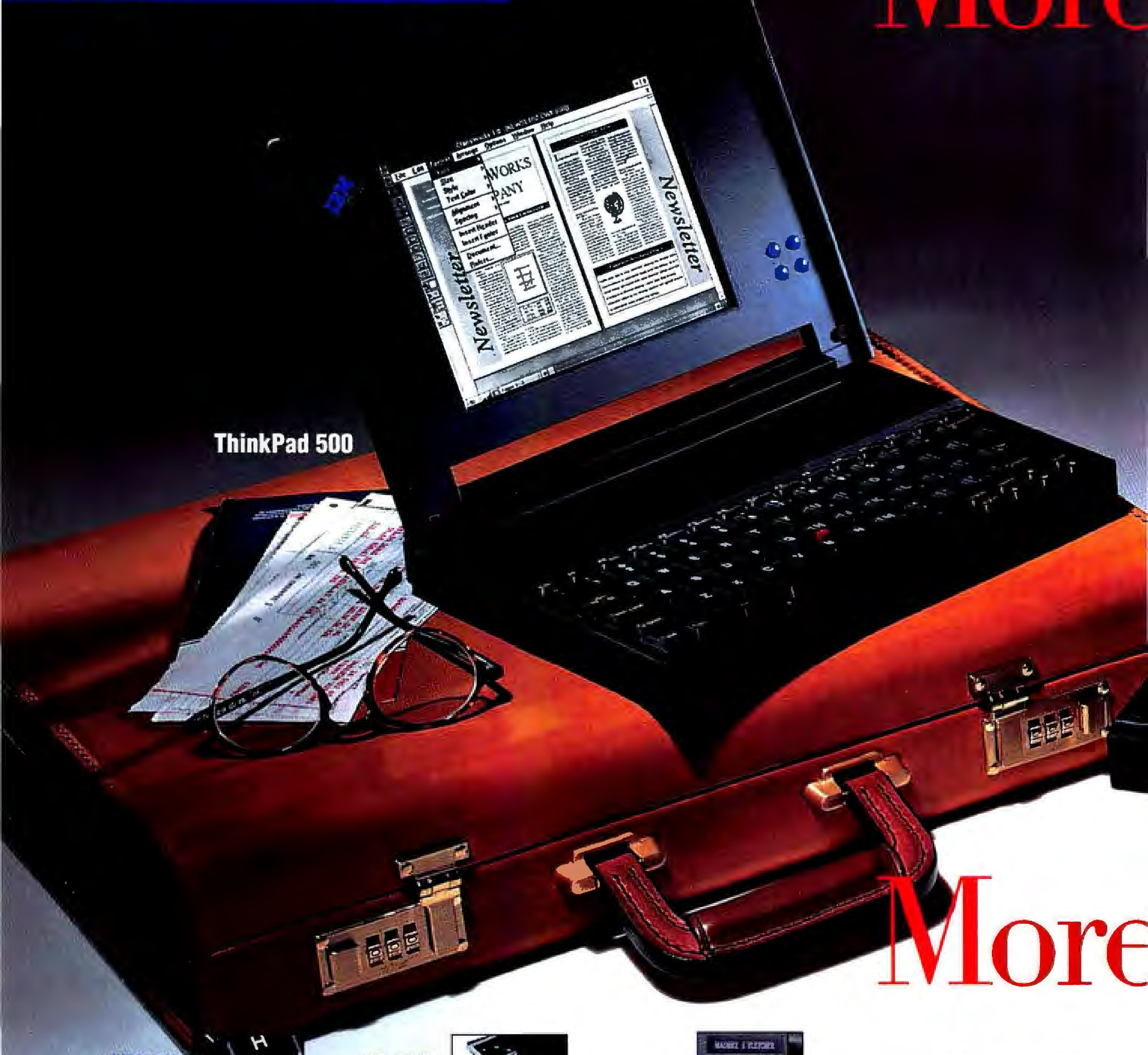

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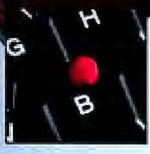

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- BYTE Magazine, January 1994 -

PC Digest RATINGS REPORT

☆☆☆☆ Recommendation

"The KFC CA 1507, recipient of the EPA's Energy Star, offers a full range of image adjustment controls. This monitor complies with the DPMS power management standards suggested by the VESA and will work with any VESA-compliant computer."

- PC Digest, November 1993 -

KFC's new green monitors consume less than 1.5 Watts when inactive, and less than 20 Watts when on stand-by. Compared to the average of 85~100 Watts for an ordinary monitor, each KFC monitor contributes substantially to a greener environment. And you're not just sharing the contribution, you're also saving money.

CA1718 was the Best Value Runner-up for Spreadsheet & Graphics Color Monitor in BYTE Magazine's January 1994 BYTE/NSTL Lab Report. CA1507 (picture not shown) was awarded the "Best Value: General Business Color Monitor" by BYTE Magazine in January 1994 BYTE/NSTL Lab Report.

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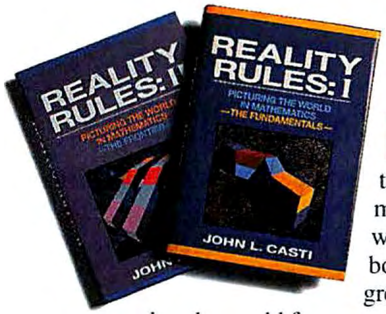
Entertaining Math Models



RICK COOK

If the two-volume *Reality Rules* sounds like gang graffiti, the content is an entertaining but useful graduate-level course in mathematical models—how they work and why they fail. Like all good teaching, these books are lucid and thought-provoking. Like great teaching, they also entertain while showing the world from a new perspective.

Perhaps the most off-putting thing about this work is the table of contents. John Casti includes every trendy topic, from catastrophe theory and cellular automata to genetic programming and sociobiology. And, just to keep modelers humble, he tops it off with a chapter on the theories of knowledge, citing Kuhn, Sapir-Whorf, Godel, and other members of the currently fashionable pantheon.

In spite of the apparent grab-bag contents, *Reality Rules* is not another "fluff 'n stuff" popularization. All these fields relate very directly to the business of building good models. Catastrophe theory, Casti says, is useful "in giving us a deeper understanding of what does and doesn't count in the analysis of a particular system."

That statement comes after a solid introduction to catastrophe theory, an examination of how to use it in constructing models, and several pages of a case study showing its use to analyze the growth and collapse of budworm populations. Casti may take you on the scenic route, but he never loses sight of his destination.

For Casti, models are dynamic systems, and model making is the process of mapping reality (or the interesting parts thereof) onto a dynamic system. Ultimately, he says, the success of the model depends on the appropriateness of the dynamic system chosen and the fidelity of the mapping. Casti assumes his readers understand vector notation and have a working knowledge of calculus and matrices. Even without that, most of the work is comprehensible, although the more of the math you understand, the more you will profit from the books.

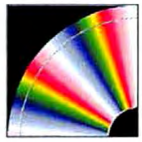
The style, like the math, is easy and informal. Casti is never afraid to substitute a paraphrase where a formal definition or complete proof is unnecessary. If you do computer modeling, these books will save your bacon one day. Meanwhile, they will make you think and entertain you to boot. ■

REALITY RULES: PICTURING THE WORLD IN MATHEMATICS, VOL. 1: THE FUNDAMENTALS, VOL. 2: THE FRONTIER

John L. Casti
Wiley-Interscience
ISBN 0-471-57021-4 and 0-471-57798-7

$35 each

Rick Cook uses computer models to help him write science fiction. You can contact him on BIX as "rcook."



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At your fingertips (well, actually on four CD-ROMs), you can have 72 million U.S. residential listings and 8 million business listings. SelectPhone from Pro CD is available for $299. The residential listings give the full address and phone number, and you can search by name, city, state, ZIP code, street address, and phone number. The business listings include the SIC (standard industrial code) classification and business heading and number of employees. You're not limited to what you can print or export. Searching and sorting is rapid. (For $149, Pro CD also has DirectPhone, which can be searched by name only.)

The database is created by shipping all 10,000 phone books printed in the U.S. to Beijing, where 250 clerks keyboard in the names, with updates produced quarterly. The results can be a little spotty. Major firms were missing. In the case of Egghead Software, there were only 62 entries, and the "number of employees" field rarely seemed reliable. And I wondered what those Chinese clerks thought about the "pet cemetery" business heading, especially as several West Virginia exterminators were included.

The main competitor is Business America on Disc from American Business Information. It lists businesses only, but it additionally includes the name of the boss and credit information. But you lease the disc, and for $7500 a year, you're limited to retrieving 20,000 business profiles. For the budget-conscious, the firm also offers The Eleven Million Businesses Phone Directory for $79. You can search by name, city, state, ZIP code, and phone number, but you can retrieve only the name and phone number. Keyboarding and verification, however, are done in-house.

—*Lamont Wood*

Lamont Wood is a freelance writer living in San Antonio, Texas. You can contact him on BIX as "lwood."

ETHICS AND COMPUTERS

COMPUTER ETHICS: CAUTIONARY TALES AND ETHICAL DILEMMAS IN COMPUTING, 2d ed., by Tom Forester and Perry Morrison **MIT Press, ISBN 0-262-56073-9, $14.95**

Is it OK to copy your friend's game onto your machine? Is it just a funny prank when someone has infiltrated a company's computer system leaving a smiley face on every screen? Obvious questions like these, and some not-so-obvious computer dilemmas, are not answered, but rather discussed in the revised edition of *Computer Ethics*.

Perhaps by becoming aware of the often negative results caused by computer hacking, invasion of private E-mail messages, viruses, software theft, and computer failures, society will no longer tolerate such abuse and misuse of computer systems. As the authors contend, "this book is a modest contribution to this task."

—Dave Vislosky

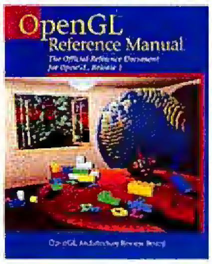
BATTLE OF 3-D SPACE LIBRARIES

OPENGL REFERENCE MANUAL by the OpenGL Architecture Review Board Addison-Wesley, ISBN 0-201-63276-4, $32.95

OPENGL PROGRAMMING GUIDE by the OpenGL Architecture Review Board Addison-Wesley, ISBN 0-201-63274-8, $34.95

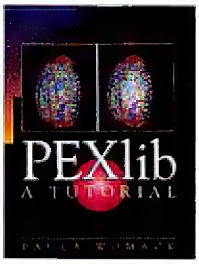
PEXLIB: A REFERENCE MANUAL by Mark Graff PTR Prentice-Hall, ISBN 0-13-176066-1, $34

PEXLIB: A TUTORIAL by Paula Womack PTR Prentice-Hall, ISBN 0-13-15843-7, $42



Two of the leading 3-D graphics libraries are PEX and OpenGL. PEX, as Paula Womack describes it, is a 3-D extension to the X Window System. OpenGL is not quite the equivalent; it is less focused on client/server communications than on graphics effects. OpenGL comes from Silicon Graphics and, like PEX, is freely available as a set of libraries. (What isn't free is the hardware that is optimized for either of these libraries or implementations of these libraries for specific hardware. But that's another story.)

These books don't provide a comparison with any other 3-D graphics libraries or how they might or might not functionally overlap and perhaps interplay between applications and systems (a radical idea!). What you get is a tunnel view of 3-D graphics. But then, by the time you buy any of these texts, you will already have decided which 3-D graphics direction you will concentrate on. Be it PEX or OpenGL, these books are essential. You will need both the tutorial/guide and the reference manual.



The tutorial/guides are loaded with programming examples that show the concepts of their respective graphics library. Both include a small portfolio of art that was created using the library, as well as diagrams of the visual concepts that are related to the program's functional concepts. The *OpenGL Programming Guide* spends more pages discussing the concepts than does *PEXlib: A Tutorial*, which is more restricted to the view of a specialist programmer.

What is amazing in all these volumes is how little graphics is used to illustrate the information. When you consider that the subject is graphics, you'd expect that every concept—whether it be 3-D rendering attributes, or even the rationale behind various data structures, data-object binding, and client/server protocols—would be illustrated by a dynamic image. This is not so. The reason is that the subject matter is geared to the applications-programming level, not to the applications-using level. One thing is clear: Programming 3-D graphics is far more complex and time-consuming than taking a piece of paper and a pencil and rendering the image that is in your mind. ■

—Ben Smith

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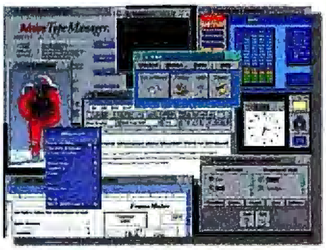

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MetaWare High C/C++
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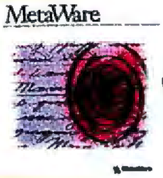

NEW RELEASE! High C/C++ version 3.1, MetaWare's 32-bit compiler, is shipping. Includes a 32-bit source-level debugger, and a 32-bit Application Developer's Kit for Windows. The "Incremental Strengths" feature enables gradual migration from C to C++ one block at a time. High C/C++ provides optional ANSI conformance, eight levels of global optimization and a full implementation of C++ templates.

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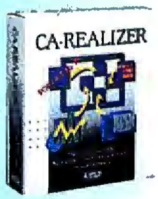

Defines a new generation of development tools that handles the mechanics of event-driven programming, message passing, process sharing and other complexities behind the scenes. Combines a structured superset of BASIC extended to access Windows and OS/2 objects and resources, a visual development tool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

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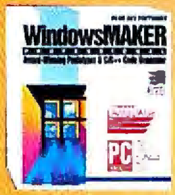

This award-winning product offers more functionality & ease-of-use than any other tool. Create full-featured Windows Applications: MDI, Toolbars, Status bars, Templates, On-line Help, Graphical 3D buttons, Edit During Preview & much more. TrueCode™ technology ensures that user code is 100% preserved during code regeneration. Supports ANSI C, MFC C++, OWL C++ & more. Uses Switch-It™ Code Generation Modules for generating code for specific platforms, allowing migration between languages, C++ libraries & platforms. Highly recommended!

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PRODUCT OF THE MONTH

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object-Menu
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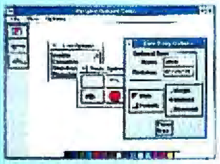

object-Menu is *the* way to quickly create powerful object-oriented applications. Built-in aesthetics make it easy to create interface styling such as Windows, Motif, or your own custom design. Portability to DOS, Windows/NT and OS/2 enables you to offer your product to multiple target markets with a single engineering effort. And, object-Menu's intuitive architecture, straightforward methodology and Visual Design tool actually speed GUI development to allow you more time to focus on your application.

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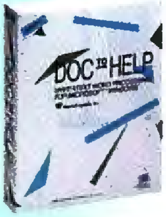

The world's best documentation and help-authoring tool just got better, and now supports all Windows 3.1 features. New features of version 1.5 include an interactive help window editor, an interactive help macro editor, support for segmented hypergraphics and the ability to import existing help source files and convert them into documentation.

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Distinct TCP/IP for Windows
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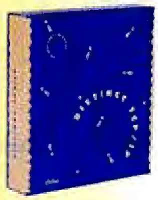

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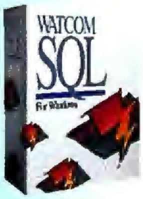

WATCOM™ SQL for Windows is a complete client/server DBMS including a standalone single-user SQL database server. WATCOM SQL for Windows allows you to develop and deploy single-user standalone applications, and to develop applications for use within the WATCOM SQL Network Server Edition. WATCOM SQL for Windows includes support for the Microsoft Open Database Connectivity (ODBC) standard for database applications.

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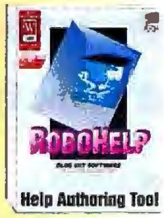

RoboHELP® 2.6, the best-selling Help Authoring Tool for Windows & Windows NT, offers full document to Help system conversion & vice versa. Turns Word for Windows into a fully functional hypertext authoring system capable of producing Windows Help files as easily as it does plain text. Fill in the actual Help text when prompted. RoboHELP takes care of generating the RTF, HPJ & H files. Link tester allows you to simulate your design before you compile. Full support of Word 2.0 & Word 6.0, & all features in the Windows Help Engine, such as macros, secondary windows, & multiple hotspot graphics.

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NEW THIS MONTH

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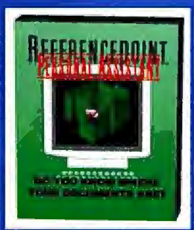

ReferencePoint Personal Assistant automatically makes an index of any information that you create or modify anywhere on your computer system, so that you can find any file, instantly, whether from a word processor, database or spreadsheet. So, type what you want to find, and Personal Assistant will locate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

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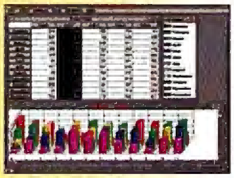
GFA-BASIC Compiler for Windows
by GFA Software Technologies, Inc.



GFA SOFTWARE announces the release of the first BASIC compiler for Windows. For the first time ever, BASIC programmers can create a true Windows EXE, DLL, or VBX. The GFA-BASIC Compiler paves the way for BASIC and "C" programmers to start writing fast, robust Windows applications quickly. Benchmarks place the new Compiler at 25-50% faster than C or C++. The GFA-Basic Compiler ships with OPTLINK from SLR.

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Mwave™ Developers Toolkit with IBM WindSurfer™ Bundle
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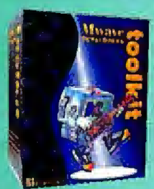

What once was multiple products and toolsets is now bundled in one multimedia PC add-in card and Toolkit. The Mwave WindSurfer Communications Adapter is a "works out of the box" data/FAX modem, sound, voice messaging & telephone answering card with application software. It is bundled with the Mwave Developers Toolkit so you can build software that takes advantage of the Mwave digital signal processing (DSP) platform that drives WindSurfer. Try out the magic of a software upgradeable and programmable Mwave PC solution. You'll be developing for the future and using it today! And you can do it for an incredibly low price!

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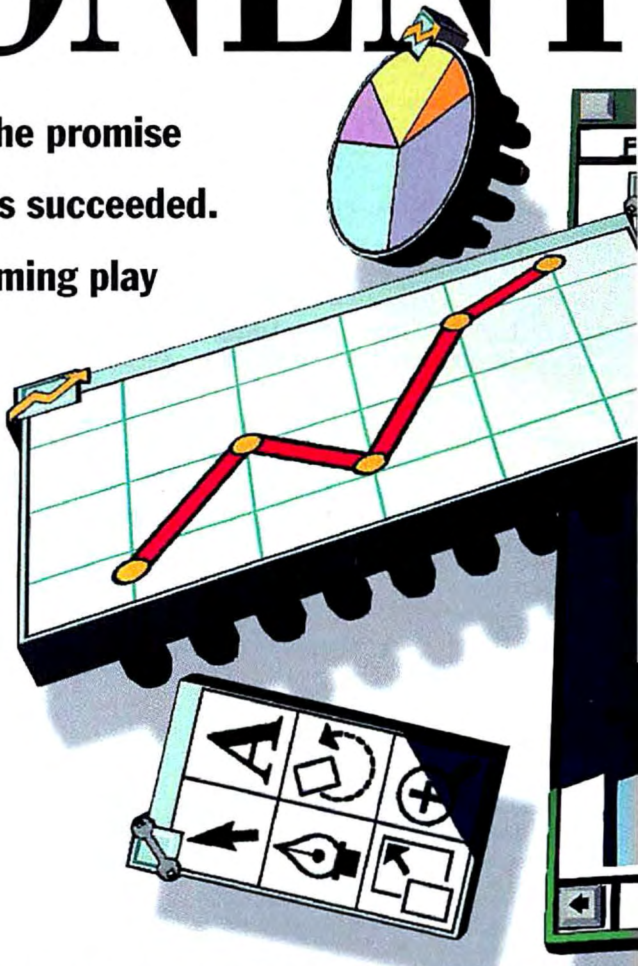
COMPONENT

Object technology failed to deliver on the promise of reuse. Visual Basic's custom controls succeeded. What role will object-oriented programming play in the component-software revolution that's now finally under way?



JON UDELL

Tom Button, Microsoft's Visual Basic czar, loves to show how Visual Basic's custom controls have galvanized the component-software business. "Here are the 16 controls we shipped with Visual Basic for Windows 1.0," he says, positioning the Toolbox window in the lower left corner of the screen. "When we shipped version 2.0, third-party custom controls were already becoming common." He sweeps the Toolbox upward to reveal several dozen controls. "And here's the situation today." Now the Toolbox fills the screen with a dense mosaic of all the custom controls the machine's memory and disk can hold.

The fact that VBXes (Visual Basic custom controls) today best exemplify the decades-old notion of reusable software has been a surprise for everyone, including Microsoft. VBXes aren't just for 3-D buttons, gauges, and scrollable grids. National Instruments (Austin, TX) will sell you a VBX that controls GPIB (general-purpose interface bus) instruments. Cimflex Teknowledge (Palo Alto, CA) offers a VBX-based expert system. Distinct (Saratoga, CA) packages its TCP/IP programming kit into a VBX. Diamond Head Software (Honolulu, HI) offers a suite of image-handling VBXes. Stylus Innovation (Cambridge, MA) sells one that you use to build voice-response and fax-on-demand applications.

These are all actual "off-the-shelf" components that you can use to build real applications in a hurry. They are not, however, objects—at least, not the sort of objects that aficionados of C++, Smalltalk, or Objective-C embrace.

Real objects, as OOP (object-oriented programming) experts rightly point out, rest on the tripod of inheritance, polymorphism, and encapsulation, while VBXes stand only on the single leg of encapsulation. But if that's a crippling limitation, why has VBX—rather than OOP—ignited the component revolution? Why have C++ vendors such as Microsoft and Borland had to reverse-engineer Visual Basic so that programmers, lacking reusable C++ objects, can tap the rich VBX component market?

These ironies have spurred all the major players in the software industry to rethink the role of object technology vis-à-vis reusable components. What has emerged is a new, more realistic understanding of how a component-software industry can work.

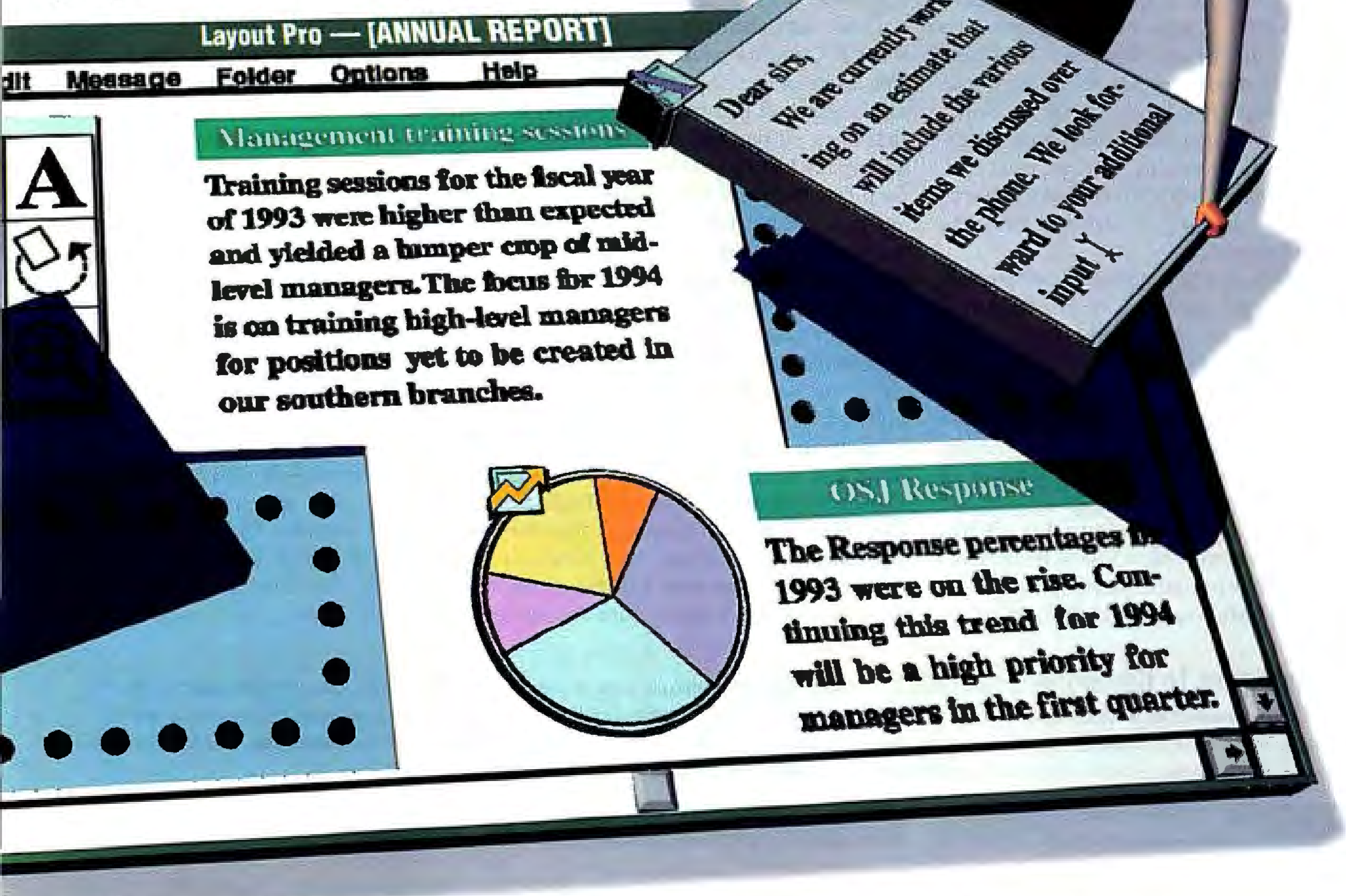
Rethinking Reuse

The traditional OOP vision was, at best, vague on the subject of reuse: Objects would appear as by-products of software development, a market would emerge, and programmers would become producers and consumers of objects. Why didn't this happen? There were two major roadblocks. Most OOP language systems, including C++, lack the means to package and distribute objects effectively in binary form. More subtly, the skills and disciplines needed to build components are often quite different from those needed to use them.

Apple, DEC, IBM, Microsoft, Novell, Sun, and others are busily revamping their system software and tools in an effort to break through these roadblocks. Despite incessant bickering, they're all headed down the same path.

An alphabet soup of standards, including Microsoft's COM (Common Object Model), IBM's DSOM (Distributed Sys-

WARE



tem Object Model), Sun's DOE (Distributed Objects Everywhere), Hewlett-Packard's DOMF (Distributed Object Management Facility), Next's PDO (Portable Distributed Objects), Novell's AppWare Bus, and the Object Management Group's all-embracing CORBA (Common Object Request Broker Architecture), will provide the mechanisms for component exchange that pure OOP failed to deliver. Meanwhile, a restructuring of the software industry will define niches and appropriate technologies for the component builders who create reusable packages, as well as for the solution builders who assemble components into end-user applications.

At the end of the day, applications are all that really matters. Thirty years ago, we began hearing about a software crisis. The crisis was, simply, an applications backlog—too few programmers, too little time, and too much demand. Since then, every new paradigm for the construction of software—structured programming, CASE, OOP—has been billed as the way out of the software crisis. Yet we've hardly made a dent in the backlog. True, we're far better served by commercial software than in the past, but it remains horribly expensive to build custom software that automates processes unique to particular industries or individual companies.

To drive down the cost of custom software development, you have to apply a principle that software theorists have known for years. The best programmers aren't just a little better than average programmers; they're shockingly better—10 times, maybe 100 times more productive. And yet, says Richard Probst, SunSoft's manager of business development for project DOE, today we see virtually no division of labor in the software industry. "The way you work is about the same no matter what kind of software you work on," he says, "and that's a sure sign of an immature industry."

The VBX phenomenon is an important first step toward maturity. VBX-enabled programming differs markedly from conventional programming. You create applications by arranging controls on forms, editing the controls' properties, and writing a few—often surprisingly few—lines of event-handling code in Visual Basic, or C++, or whatever language is native to the environment that hosts the VBX.

This simple discipline, which is standard across all domains served by VBX controls, enables average programmers (like me) to build custom applications in hours or days. It took me just two days to put together a useful client/server database application using Coromandel's Integra VDB. And while I haven't yet tried Stylus Innovation's Visual Voice, I'm certain that I could leverage the programming expertise it encapsulates to build the fax-on-demand system our editorial assistants have been asking for, and do the job in the day or two I could justify spending on it.

The Dark Side of VBX

Despite its success, VBX is a flawed component architecture. Most glaringly, it's tied to Windows and (less tightly) to Visual Basic. That puts the cart before the horse. As a prospective buyer, notes SunSoft's Probst, "you should ask first about a component's functionality, quality, and price, and its supplier's track record, not about its required operating system and language environments."

Moreover, a rich supply of components cannot erase the inherent limitations of Windows 3.x—segmentation, cooperative multitasking, and fragility. "Some of our customers want to build T1 voice-response systems that handle 24 lines," says Mike Cassidy, president of Stylus Innovation, "but Windows can handle only about 15 connections."

In the realm of Windows 3.x, VBXes are further restricted to Visual Basic and a small number of other development tools, including Microsoft's and Borland's C++ compilers, Powersoft's PowerBuilder, and Gupta's SQLWindows. These tools jump through hoops to emulate the Visual Basic run-time environment—with varying degrees of success. "Hosting VBXes was not the most pleasant engineering task we've undertaken," says Bill Rabkin, senior technical evangelist with Powersoft (Burlington, MA), "and we got no cooperation from Microsoft."

Other critics find the boundary between the VBX and its environment too rigid. The allure of real object technology, after all, is that you can modify a component that does 90 percent of what you need, adding the last 10 percent yourself. NextStep programmers find it ridiculous that you can't extend VBXes in this way. Their equivalent to a VBX is the palettized object, which other objects can freely inherit from and specialize.

In NextStep, component builders and component users share the same Objective-C messaging and inheritance mechanisms. Doesn't that violate the principle of division of labor? Not when programmers use their own components. Alex Cone, president of Objective Technologies (New York, NY), markets NextStep components and also uses them in his consulting work. "The power of NextStep," he says, "is that I always use the same messaging model, I always build objects and systems the same way, and I never have to shift paradigms."

From VBX to OCX

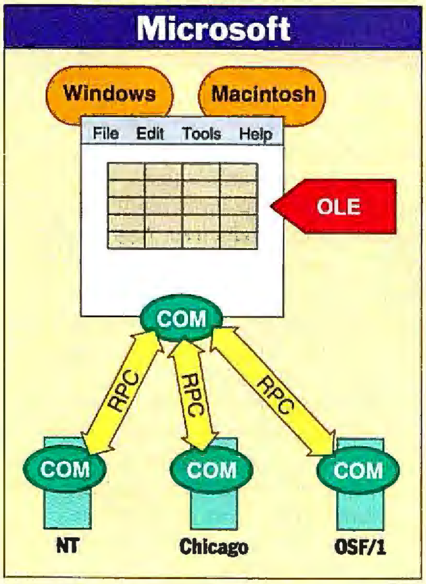
Recognizing these limitations, Microsoft has created a new component model based on OLE. When Visual C++ 2.0 ships, probably this summer, developers will gain access to the tools needed to build a new generation of VBX—the OLE custom control, or OCX. OLE controls won't silence all the criticisms of VBXes, but they will move the Windows component market onto a much firmer foundation.

Some of the infrastructure for OLE controls is already visible in Visual C++ 1.5 and MFC (Microsoft Foundation Classes) 2.5. That tool set radically simplified the creation of OLE 2.0 in-process servers that can embed themselves in container documents and export their internal methods to callers by means of the OLE automation interface, IDispatch.

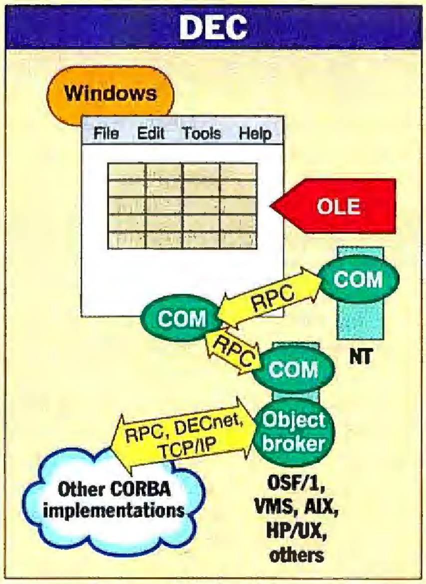
Note that Visual Basic—or its embeddable variant, VBA (Visual Basic, Applications Edition)—is only the first of potentially many languages that will be optimized to control OLE automation servers. Lisp, Smalltalk, and other interpretive languages, once they are retrofitted with IDispatch support, will be able to wield

Approaches to Component Software

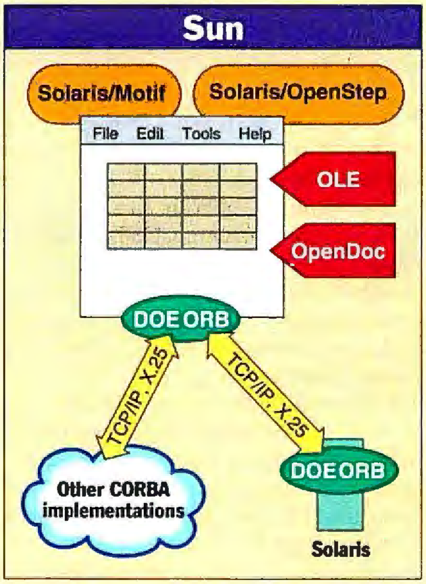
Document, object, and communication models for six leading component architectures. A document model, such as OLE or OpenDoc, defines how a component fits into the GUI application environment. An object model, such as COM, DSOM, or DOE, defines at a high level how components talk to other components that may be local or remote. A communication model supports conversations between components across a network. The object models shown connecting to a CORBA "cloud"—DOE and DSOM—are CORBA-compliant. There is interoperability within a given CORBA implementation, such as DSOM, but not yet across implementations—for example, from DSOM to DOE.



Today, OLE 2.0 and COM support Windows (and soon, Macintosh) components. A distributed version of OLE 2.0 that will support networked components is also in the works, and it has been demonstrated using a version of COM licensed to DEC.



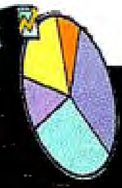
DEC plans to bridge the worlds of OLE/COM and CORBA. ObjectBroker, acting as a gateway, will enable OLE components to communicate with CORBA components running on a variety of platforms, including OSF/1, VMS, AIX, and HP/UX.



OpenStep brings to the Solaris platform the rich application environment of NextStep and its wealth of object-oriented components. Sun plans to support OLE and OpenDoc. DOE components will communicate with each other and with other CORBA implementations.

OLE controls just as they can now call DLLs.

Visual C++ 2.0, with MFC 3.0 and the OLE Custom Control Developer's Kit, will enable such automation-aware in-process servers to mutate into full-blown OLE controls that maintain editable properties, generate events, and can bind to data the way VBXes do today. The redistributable run-time DLL containing support for these extensions will be available in 16- and 32-bit versions; unlike VBXes, OCXes will run natively on Windows 3.x, NT, and their successors. They will not initially exploit multithreading, however, even though the enabling substrate—MFC 3.0—will itself finally be thread-aware and thread-safe.



"The way you work is about the same no matter what kind of software you work on, and that's a sure sign of an immature industry."

Richard Probst, manager of business development, SunSoft

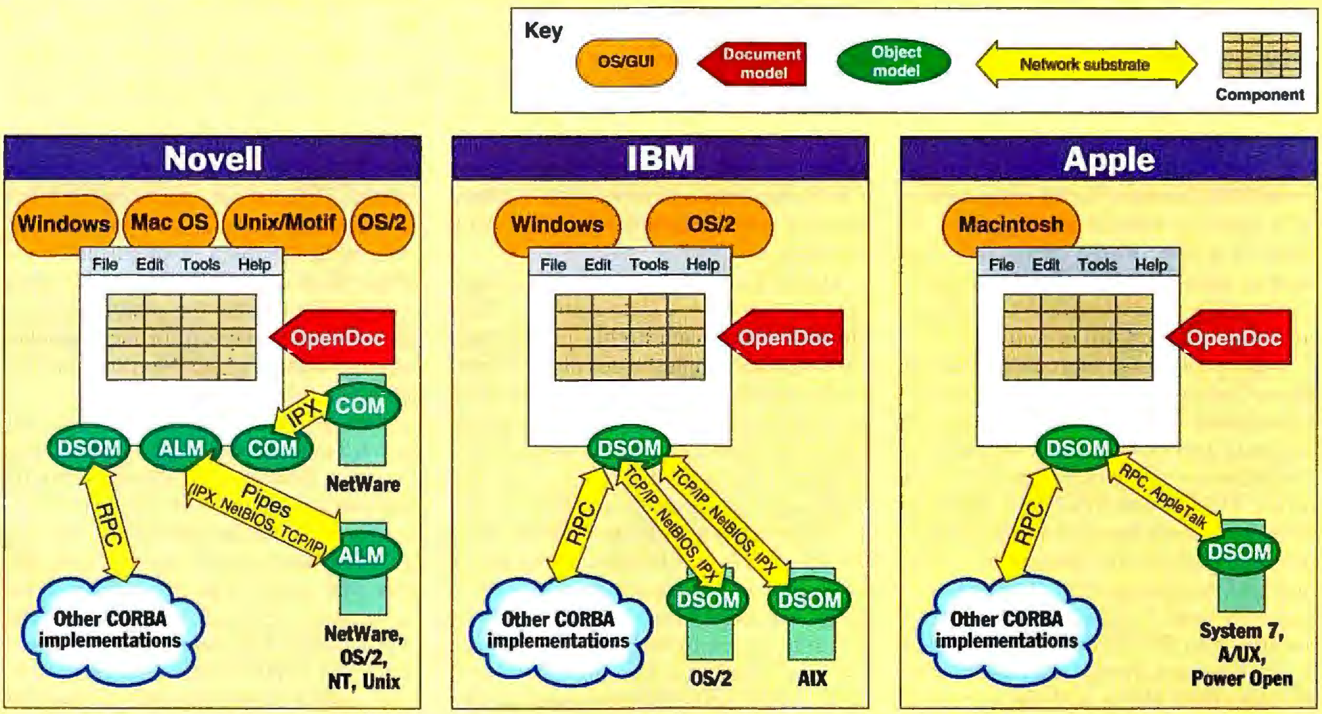
It's very likely that OCXes will also appear on the Macintosh, as a by-product of work that Microsoft is doing to support its own Mac applications. Versions of Visual C++ 2.0 that are hosted on Windows NT—but target 680x0- and PowerPC-based Macs—are in the pipeline. These tool sets support an MFC layer that rests on a Win32 layer that in turn talks to the native Mac Toolbox. FoxPro 2.5 for the Mac, which is built with an internal version of this technology, validates what Microsoft has long claimed: that the Windows API has the ability to serve as a cross-platform API capable of expressing the core of substantial commercial applications.

If Visual C++ 2.0, MFC 3.0, and OLE 2.0 all materialize on the Mac as planned, there's every reason to expect that OCXes will become portable, at least across those operating systems that matter to Microsoft—the Windows variants and System 7. Prospects for OS/2 and Unix, where Microsoft has no commercial interest, are rather dim, as members of the OpenDoc consortium like to point out.

VBXes talk to hosts by firing events. To implement OCXes in a similar way, the run-time DLL will add new interfaces to OLE 2.0 to implement an event mechanism. It will also supply common dialog boxes for property editing; stock properties, events, and methods; and mechanisms for self-registration, persistence, and licensing. From the developer's perspective, an OLE control will be just one more target the tool set can crank out, not noticeably different from a DLL or an EXE.

The transition from VBX to OCX is not hard at all, VBX vendors say, in part because Microsoft provides a jump-start tool that can look at the properties and events supported by a VBX and generate the skeleton of a compatible OCX. "It's a fairly mechanical port," says Joe Modica, vice president for R&D at Sheridan Software Systems (Melville, NY), "although if your VBX was written in C, you may want to think about converting to C++."

Dorai Swamy, executive vice president of Coromandel (Forest Hills, NY), also reports that the VBX-to-OCX transition is a no-brainer and that OCX performance seems fairly snappy. Especially interesting to him, in view of Coromandel's growing consultancy business, is the tool support for building OCX hosts. Just as controls are specialized OLE in-process servers, hosts are specialized OLE containers—thanks, again, to new MFC abstractions. The next version of Visual Basic will be one such host, but the idea is that any application should, with minimal effort, be able to host OLE controls. "We're defining frameworks for specific



Novell's AppWare strategy encompasses Windows-, Mac-, and Motif OpenDoc–based components. ALMs running on multiple operating systems will communicate across multiple network substrates. Novell is also considering DSOM and COM support.

IBM will support visual and interactive Windows- and Presentation Manager–based components using OpenDoc. The real payoff, though, will come from DSOM's ability to integrate these components into large-scale distributed systems.

For Apple, OpenDoc represents a way for the Macintosh to duplicate—and, it is hoped, improve upon—the kinds of document- and component-based applications that have flowered on Windows, thanks to OLE.

industries, such as retail and finance," Swamy says, "and the ability to plug OLE controls into our own applications will be very important to us."

Doesn't all this dependence on MFC and OLE extensions tie developers to the Microsoft tool set? In principle, no. "Everything works in terms of OLE 2.0," says Eric Lang, Microsoft program manager for OLE custom controls, "so anyone who understands those interfaces can reproduce what we've done." In practice, however, that will be very difficult.

In principle, OLE controls, unlike VBXes, can be extended—not by inheritance, which COM doesn't support, but by aggregation of interface pointers. In practice, that, too, will be difficult. Most developers say that, until Microsoft evolves tools that simplify the mechanics of aggregation, they aren't willing to wrestle with it. Note, however, that the audience for whom OCXes are intended won't necessarily find multiple inheritance any more congenial than inheritance. The VBX model succeeded precisely because it hid this level of complexity from corporate developers.

"The power of NextStep is that I always use the same messaging model, I always build objects and systems the same way, and I never have to shift paradigms."

Alex Cone, president, Objective Technologies

Alternative Approaches

Years ago, Visual Basic's spiritual ancestor, HyperCard, popularized the visual-prototyping, script-oriented programming style that now fuels the success of Visual Basic. It also defined a component standard of sorts—the XCMD/XFCN mechanism that's used to surface C or Pascal modules as HyperCard primitives.

Why, given these ingredients, did the HyperCard component industry stagnate? It happened in part because the Mac OS has lacked an effective way to load general-purpose extensions dynamically. As a result, XCMDs and XFCNs are awkward constructs, limited in their access to memory, global data, and toolbox calls. The new DLL technology in the PowerPC version of System 7 will solve that problem, according to BYTE's Macintosh expert Tom Thompson. At this late date, however, Macintosh DLLs will mean more to the emerging OpenDoc standard than the aging XCMD standard.

More recently, Parts from Digitalk (Santa Ana, CA) has stirred up many of the same ingredients—visual programming, scripting, and components—to create an attractive Smalltalk-based development kit for Windows, NT, and OS/2. Like Prograph CPX from Prograph International (Halifax, Nova Scotia, Canada) and Novell's Visual AppBuilder, Parts pushes visual programming to the limit. In these systems you program, at the highest level, by creating diagrams. You drag icons representing components, functions, and syntactic constructs onto the surface of a form and connect them with links. To encapsulate a complex part of a diagram—thereby creating a component—you draw a boundary that hides what's inside, exposing a few inputs and outputs.

In Digitalk's system, the simplest parts to create are those that encapsulate code expressed entirely in the diagrammatic language. More advanced parts wrap objects written in the system's native language, Smalltalk, or wrap DLLs that employ C, COBOL, CICS, SQL, or other languages. "Many of the most critical components come from technology specialists who cannot necessarily write VBXes in C," notes Mike Arrigo, vice president of marketing for Digitalk. Fortune 1000 companies with hundreds of millions of dollars invested in legacy systems can benefit enormously from the ability to componentize those systems so that, for example, a host-based CICS transaction becomes just another part that can be assembled using the Parts workbench.

Darrell Deming, manager of brokerage systems for USAA (San Antonio, TX), finds this approach highly productive. "We've built a sophisticated discount brokerage application, with a client/server connect, and we've stayed true to the paradigm of Parts as an object assembler," he says. What hasn't yet evolved is any significant exchange of components between the brokerage group and other units within USAA. It's feasible, using DLLs as the medium of exchange, but so far it hasn't happened. "Component distribution has to be driven by business needs," says Deming, "and because our specialized parts aren't useful to other groups, we're not being driven to distribute them."

While Parts today is a proprietary component model, Digitalk plans to support OCX controls and has already demonstrated that Parts can work with DSOM, the exchange standard that underlies OpenDoc. Another proprietary component model that's portable across Windows, NT, the Mac, Unix, and OS/2 is available today from XVT Software (Boulder, CO). XVT's thin, operating-system-neutral GUI layer is the linchpin of one of the premier cross-platform development toolkits.

Last year, XVT Software extended the kit with XVT-PowerObjects, which are modeled on VBXes but are portable across all XVT-supported platforms. The first set of components included toolbars, toggle buttons, status windows, and table and spreadsheet widgets. XVT Software, its partners, and its customers are busily extending the PowerObjects catalog. Because the company has always preferred to use native services where available, it's eyeing the emerging component-exchange standards with great interest.

Despite the incessant "Windows everywhere" mantra, Roger Oberg, XVT Software's marketing vice president, reports no slackening of Mac sales, and particularly strong demand on the Motif side. "If Microsoft's portable object technology doesn't address Motif," he says, "then it won't meet the XVT need." OpenDoc's multivendor heritage and CORBA-compliant DSOM foundation appeal to the company, however.

Rediscovering NextStep

One of the great strengths of the VBX approach is that it boils down a lot of traditional programming tasks to simple design-time editing. NextStep's Interface Builder was doing that—and in a more sophisticated way—long before VBXes ever existed. Objects that appear on the Interface Builder palette are true first-class citizens in the NextStep environment. Next's ObjectWare catalog lists dozens of these components—some for general-purpose use, others specialized for the financial-services realm, where NextStep has established a strong beachhead.

Next developers say that it's straightforward to palettize an object for use with Interface Builder. The job does require that you extend the system's generic inspector to create the specialized one used to display and edit the object's state, but even that task will be streamlined in the forthcoming version 3.3 of NextStep. The ability to drag links between the outputs of one object and the inputs of another comes essentially for free. Clearly, components arise more naturally from the normal NextStep development process than VBXes do from routine Windows development.

Moreover, says Dirk Fromhein, president of Watershed Technologies (Marl-

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Line-Interactive	YES	NO	YES
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Test Button	YES	YES	NO
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borough, MA), objects that use the NXConnection class get networking for free. That means that Watershed's GraphRight, a charting component, is able to serve both local and remote clients. "The NXConnection object traverses the whole netinfo domain automatically," says Fromhein, "so the client literally does not know whether the service is being provided locally or remotely."

Despite NextStep's undisputed virtues and its much-heralded port to Intel hardware, it continues to struggle for mind and market share. It's too early to know whether SunSoft's licensing of Next's application framework and tool set will turn the tide, but the once-unthinkable alliance between former rivals is a resounding affirmation of the value of Next's technology. "I used to have trouble getting IS people on Wall Street or in health care to consider a Next-based solution," says Objective Technologies' Cone, "but now the Sun deal has validated the whole concept."

SunSoft has intentions of grafting the NextStep (or rather, the *OpenStep*) application framework and tools onto its own

Object Wars

C++ created a peculiar sort of doublethink in the software industry. The object-oriented features of C++ presumably explain why it is slowly but surely eclipsing C. Yet it clearly has not delivered on one of the major promises of OOP (object-oriented programming): software reuse.

In terms of packaging and distributing binary modules, C++ arguably represents a huge step backward. Statically linked C libraries have always been an effective way to exchange reusable code. Dynamically linked C libraries worked even better. Freed from the burden of static linking, DLL-based operating systems such as Windows and OS/2 became collections of field-upgradable parts.

When C++ class libraries change, however, their clients typically have to recompile to accommodate them. Tom Pennello, vice president of MetaWare (Santa Cruz, CA), says that operating-system developers working in C++ are hard-pressed to explain to their managers why they can't release object-oriented libraries. The reaction, Pennello says, is invariably something like, "What do you mean? We've been doing this for years with procedure libraries!"

There is also the vexing problem of link compatibility across compilers. "This is where the type safety of C++ comes back to bite you," says Tom Keffer, president of Rogue Wave Software (Corvallis, OR), a leading vendor of C++ class libraries.

Although we reflexively equate OOP with reuse, Jim Bonine, former vice president of engineering and now a consultant to StepStone (Sandy Hook, CT), says that C++ was never even meant to solve the problem of large-scale component exchange. "When we pressed Bjarne on that point," says Bonine, recalling a 1987 debate between AT&T's Bjarne Stroustrup (inventor of C++) and StepStone's Brad Cox (inventor of Objective-C), "he admitted that the appropriate scope for reuse of C++ modules was probably [at] the project or department level."

StepStone's Objective-C was one response to this problem; IBM's SOM (System Object Model) is another. Each of these technologies employs a run-time engine to enable objects to bind dynamically while preserving the flow of inheritance across object boundaries. "With SOM, you can add virtual functions, or even refactor the class hierarchy," says MetaWare's Pennello.

The DirectToSOM feature Pennello is adding to MetaWare's High C/C++ parallels the compiler's internal object model with IBM's SOM, solving the problems of component exchange and link compatibility. The benefits of this tactic, Pennello says, more than repay its cost in performance. When IBM's C++ compiler adds the same feature, says Cliff Reeves, IBM's director of object-technology products, "you'll see the first [direct] binary exchanges between different C++ compilers."

StepStone's Bonine thinks that SOM makes sense for harnessing components written in multiple languages, but he questions the notion of retrofitting C++ in this way. "It's unclear how much more baggage C++ can take," he says. Mike Potel, vice president for technology development at Taligent (Cupertino, CA), says the DirectToSOM compiler won't initially handle the full complexity of C++. Taligent has built extensions to its C++ compilers to get the dynamic binding capability that is needed for its forthcoming object-oriented operating system.

Not surprisingly, the harshest criticisms of IBM's SOM and DSOM (Distributed System Object Model) come from the Microsoft camp. "We take seriously the idea that interfaces are signatures, separate from implementations," says Microsoft's Mark Ryland. "None of the CORBA [Common Object Request Broker Architecture] schemes, including SOM, face up to what it really means to have millions of binary objects out there."

SOM will break, he says, in cases where vendors supply competing implementations of the same interface—implementations that are at first equivalent but diverge over time. Microsoft's COM (Common Object Model), he argues, avoids such problems by spawning interfaces: A single object can simultaneously express multiple versions and varying sets of capabilities.

CILabs' (Component Integration Laboratories) executive manager Jed Harris responds heatedly. "It's a broken example," he says. "The two implementations would no longer be valid subtypes, and that's just a bug that you can detect mechanically." Neither SOM nor CORBA requires a singly rooted inheritance tree, he adds. Clients can use mixed-in multiple inheritance to select from a smorgasbord of components.

While that's possible with SOM, says Mark Bramhall, DEC's technical director for distributed computing services, it's less efficient than with COM. (DEC has licensed COM so that its own component toolkit, ObjectBroker, will be able to act as a gateway between OLE and the CORBA technologies.) "In the distributed case, with DSOM, thousands of remote objects means thousands of proxies," he says. "With COM, on the other hand, you can quantize these into a smaller set of interfaces so that things scale nonlinearly. You can get away with just tens or hundreds of proxies and avoid exploding the type environment."

Although the debate rages on, with no end in sight, there is a subtext of tacit consensus: Components are crucial; C++ alone can't deliver them; and new mechanisms need to evolve. The ferment is a sign of healthy growth.

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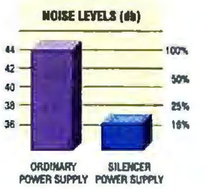

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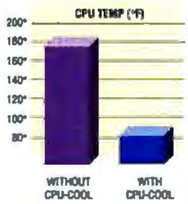

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CORBA-compliant distributed-object-plumbing layer, DOE. SunSoft's Probst likens this to IBM's plan to layer the Taligent application framework on top of the CORBA-compliant DSOM. A wrapper of CORBA IDL (Interface Definition Language) around Next components, says Probst, will enable them to plug into the same sockets that accept C++, Smalltalk, or Ada components.

Won't that destroy the seamlessness of pure Objective-C development that Next programmers so highly prize? Not necessarily. It's true that Objective-C objects can't converse intimately with foreign objects. But a library that internally exploits all the power of Objective-C can export multiple interfaces and so appear, to clients, as a collection of independent components.

The OpenDoc Alternative

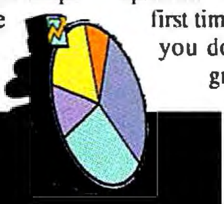
OpenDoc is the cross-platform compound-document standard that will be licensed by CILabs (Component Integration Laboratories), with the backing of Apple, IBM, Novell, WordPerfect, and others. OpenDoc's charter, like that of OLE 2.0, goes beyond compound documents; it defines a full-blown component architecture (see "A Close-Up of OpenDoc," March BYTE). OpenDoc parts, like OCXes and OLE servers, can load dynamically, embed themselves in containers, and respond to commands issued from a variety of languages.

Four foundation technologies underly OpenDoc—a compound-document framework for OLE-like embeddings, a compound file format (Apple's Bento), a language-neutral automation architecture (modeled on Apple Events), and a language-neutral run-time mechanism for dynamic object linking and binary component exchange (IBM's DSOM). (See "IBM's Assault on Distributed Objects," November 1993 BYTE.)

CILabs will license the source code for all four technologies to interested parties. "There aren't any secrets," says David Austin, Apple's manager of OpenDoc development. The first developer's releases of OpenDoc for at least three platforms should start appearing around the time you read this, from Apple (for the Mac), WordPerfect (Windows), and IBM (OS/2).

CILabs claims that OpenDoc will have a number of advantages over OLE. In the realm of compound documents, these include support for nonrectangular content and multiple active objects. "OpenDoc's screen-brokering technology is much better than OLE's," says Doug Donzelli, vice president for AppWare foundation technology in Novell's AppWare Systems Group. "ClarisWorks, which internally uses a highly sophisticated component integration scheme, was one of the benchmarks for the OpenDoc designers; you could not build ClarisWorks with OLE 2."

As a general component model, OpenDoc's strengths flow from its scripting technology and DSOM. To support scripting, OpenDoc will support the registration of standard protocols, or *event suites*, for major classes of applications. The event "advance to next word," for example, will mean the same thing in any word processing application. OpenDoc proponents argue that this discipline, like the Apple Events model, ensures at least some level of script reusability across applications and components, whereas OLE's approach guarantees none.



"If Microsoft continues to ignore the non-PC Motif platforms, then OpenDoc will have the edge."

Kimbo Mundy, Interleaf's chief architect

Microsoft's response? "We wanted to standardize on suites of OLE automation verbs," says Mark Ryland, senior program manager on the Cairo project, "but the major independent software vendors couldn't come to a consensus. Do you leave the cursor at the beginning of the next word? The end? What about punctuation? We would have had to mandate these things like Apple does, and we chose not to."

IBM's DSOM, say the CILabs backers, will endow all OpenDoc platforms with a network-capable, language-neutral mechanism for packaging and distributing components. The CORBA-compliant interface-definition language used to describe their interfaces means that users of components can extend them—without access to source code—using multiple inheritance. Microsoft disputes these claims, and the COM-versus-DSOM debate has lately turned into a pitched battle (see the text box "Object Wars" and "Extensible Software Systems" on page 57). Microsoft's Ryland argues that COM's aggregation, unlike DSOM's inheritance, cleanly separates interfaces from implementations.

A related argument is that while inheritance is useful—perhaps even essential as a private discipline for builders of components—it's inappropriate as a public discipline for users of components. OpenDoc proponents vehemently disagree. "Obviously, a well-encapsulated object has value," says Cliff Reeves, IBM's director of object-technology products. "But at what point does it stop being something for which inheritance is useful?"

Jed Harris, executive manager of CILabs, argues that Microsoft's approach forces the programmer to predetermine the boundary between a component and its environment. But that boundary can't be known in advance; it must be discovered during iterative, exploratory development. "You can never get it right the first time," says Harris, "and that's why you don't want two different programming models."

The uses of OpenDoc are as varied as the companies backing it. Apple, focused on the desktop, needs to enable the Mac to duplicate—and hopefully improve upon—the kinds of document- and component-based applications that have flowered on Windows, thanks to OLE. IBM, focused on the enterprise, wants to build complex, heterogeneous, distributed systems using standard interchangeable parts. WordPerfect sees OpenDoc as a platform-neutral way to decompose a monolithic application into pieces that can be specialized for particular markets and to enable that application to accept pluggable third-party extensions.

So far, developers have mixed reactions to OpenDoc. "I'm focusing on OLE 2," says Ray Côté, president of Appropriate Solutions (Antrim, NH). "It's the holy grail of reusable code, and it will be mature on the Mac and Windows by the time OpenDoc arrives." Interleaf's (Waltham, MA) chief architect Kimbo Mundy says, "If OpenDoc does a few more things than OLE 2, then, frankly, I don't care; I just want one interface that will keep me competitive on multiple platforms." But Mundy cautions that "if Microsoft continues to ignore the non-PC Motif platforms, then OpenDoc will have the edge."

Acceptance of OpenDoc will certainly depend, in part, on how effectively it can interoperate with OLE. Can two such complex standards really play together? "After months of analysis, we're convinced it will work," says Novell's Donzelli. "Otherwise we wouldn't have backed OpenDoc."

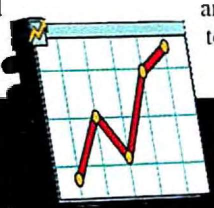
Novell's AppWare Bus

Another toolkit for the construction of portable components, due out by the time you read this, is Novell's AppWare. Version 1.0 will include about 70 bundled components, or ALMs (AppWare loadable modules), and will support development of ALMs—for Windows and the Macintosh—in C and BASIC.

Novell's AppWare Systems Group will

unite technology from two acquisitions, Serius and Software Transformation. Serius provided the pictorial programming environment, which is now called Visual AppBuilder, and the AppWare Bus, which defines how ALMs plug into and communicate with hosts. Software Transformation supplied cross-platform foundation classes that will make existing Windows and Mac components more robust, and it will also extend AppWare's reach to OS/2 and Unix platforms.

Central to the AppWare foundation is the notion of scalable families of components. AppWare's text widget, for example, comes in several API-compatible versions, ranging from a lightweight multiline edit control to a near-full-function word processor. This foundation won't be part of the initial AppWare products; Novell plans a developer's release of foundation-based versions of the AppWare Bus and Visual App Builder by the end of 1994, with final versions due in 1995.



"How will component vendors compete when a few hundred dollars buys you a whole application—or even a suite—that's also an integrated development environment with most of the objects you want and very few missing pieces?"

Jeffrey Tarter, publisher of Softletter

Concurrently, Borland is working to graft its OWL (Object Windows Library) framework onto the AppWare foundation, transforming OWL into a cross-platform API and making ALMs an easy target for Borland C++ developers. Eventually, claims Novell's Donzelli, "you'll be able to write an OLE part or an OpenDoc part or an ALM from a single source. In fact, OWL programmers are doing this today, although they don't realize it."

While Visual AppBuilder's pictorial approach to programming will likely receive the lion's share of attention at first, Novell says the product's main purpose is to expose the AppWare Bus and jump-start the ALM binary standard. "We're giving away the bus—the tool interface, the runtime event engine, the messaging system," says Joe Firmage, vice president for AppWare Bus technology in Novell's AppWare Systems Group. Early adopters include Gupta, which has announced that a future version of its SQLWindows will be able to accept plug-in ALMs.

Why might developers prefer AppWare over OLE or OpenDoc? These technologies are tuned for the desktop—for visual, interactive tasks, Firmage argues—whereas AppWare's inherently asynchronous approach favors distributed, communications-intensive applications. But version 1.0 does not let you distribute an application based on ALM components. The next version, due around September, will provide two mechanisms—PeerLogic's Pipes, and one of the CORBA-compliant technologies, possibly DSOM.

Specialized Applications

Mainstream applications can profit from component technology, notes Mark Ericson, object architect for WordPerfect (Provo, UT), who thinks that internal use of OpenDoc parts will enable his company's word processor to handle new kinds of content and thus appeal to specialty markets. "WordPerfect has a general equation editor," he says, "but scientists or engineers may require specialized equation editors."

In an era of shrinking margins, the ability to create and manage premium products could become critical to vendors of what has truly become commodity software. The same OpenDoc technology used internally to specialize WordPerfect for particular markets, Ericson adds, will give WordPerfect users access to third-party components. That means the company won't have to invent, maintain, and evangelize a proprietary extension mechanism.

But Microsoft desktop marketing product manager Mike Risse doesn't yet see a need to differentiate Excel by varying its core components. "We give you the object set and the tools to customize Excel for a medical office or an electrical-engineering firm," he says. The next version will be even more customizable, he adds, because you'll be able to export user-written Visual Basic for Applications functions to OLE automation controllers.

However, in Microsoft's development labs, experiments are validating an OLE building-block approach to applications. "We've been playing with a word processor built out of components," says OLE architect Tony Williams, "and it's blindingly fast." What's more, the user interface of Cairo, the Windows NT successor due in 1995, is literally a collection of user-customizable OLE components.

Applications vs. Components

Today's applications not only are in competition with the new pluggable components but also are growing increasingly component-like themselves. That's especially true on the Macintosh, where Apple Events are now widely exploited.

Symantec C++, for example, is actually a collection of independent components that talk to each other by means of Apple Events. When the debugger needs to evaluate an expression, it pipes it to the compiler. As a result, the debugger is able to handle very complex expressions, and it automatically benefits from compiler upgrades. Now that the Think Class Library encapsulates the Apple Events APIs, it's easier than ever before for users of Symantec C++ to achieve the same effect in their own applications.

Excel 5.0, Windows' bellwether application, exposes dozens of objects—and hundreds of methods and properties—to programs written in its own internal scripting language or in Visual Basic 3.0. This OLE automation capability, coupled with Excel's OLE embeddability, lets Visual Basic programmers use the application as though it were a high-powered custom control for charting or data analysis.

The increasing programmability of mainstream applications raises some interesting questions. "How will component vendors compete," asks Jeffrey Tarter, publisher of *Softletter* (Watertown, MA), "when a few hundred dollars buys you a whole application—or even a suite—that's also an integrated development environment with most of the objects you want and very few missing pieces?"

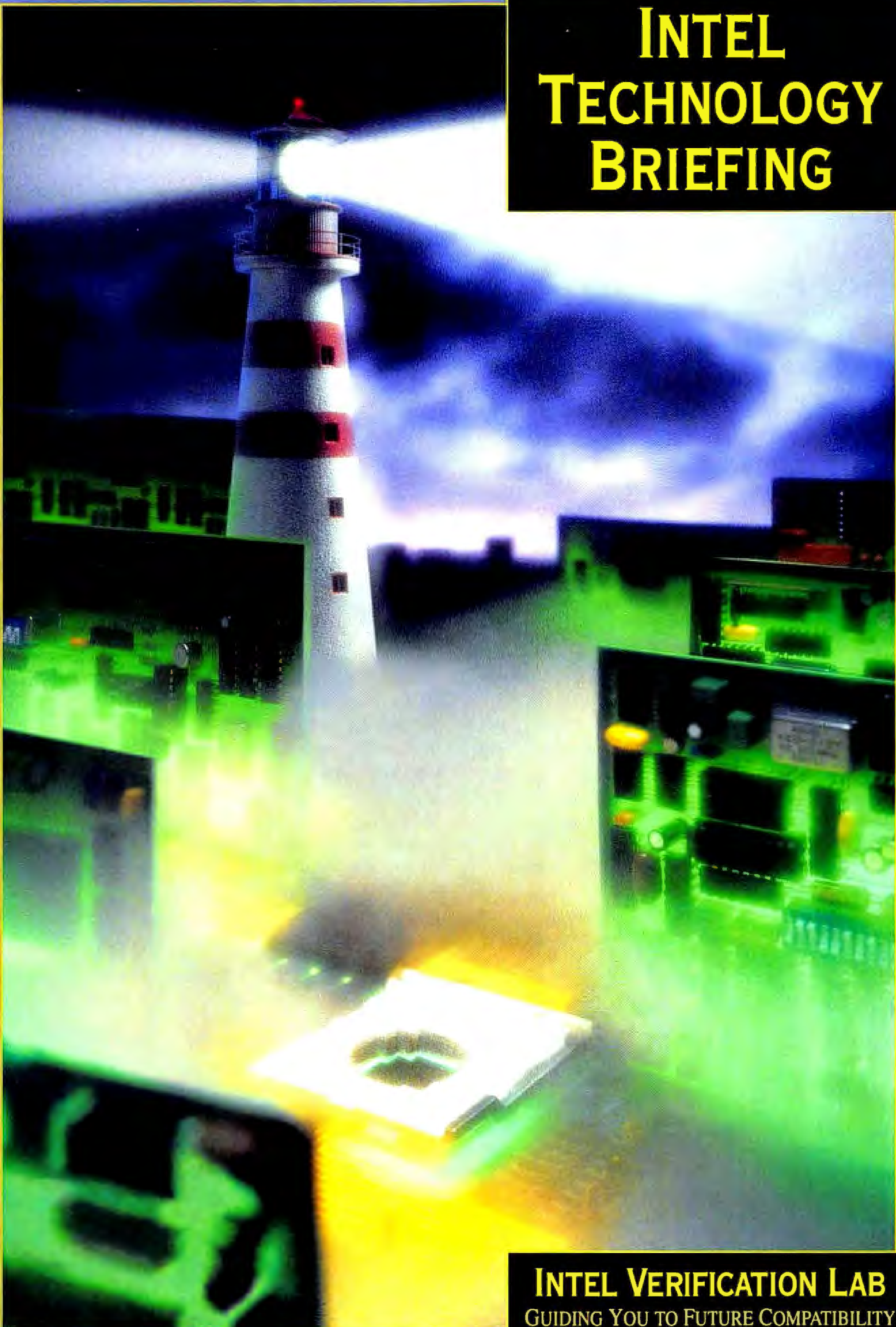
Peter Mullen, development manager for Shapeware (Seattle, WA), shares that concern. Shapeware's Visio, an intelligent business graphics application, was one of the first implementers of OLE automation. Visio Express, the first pure OLE 2.0 server, exists only to embed the graphics within OLE 2.0 containers.

Will Shapeware also cast its technology in the OCX mold? Mullen's not sure. "Resellers love Express because it's a secondary sell along with an application like Word," he says. "But where's the mass market for an OCX?"

While the VBX example proves that component vendors can find comfortable niches, these questions are extremely pertinent. Nearly everyone agrees that the issues of cost, distribution, and support will have to be worked out before a software-components market can really thrive. The technical foundations are being laid, but the business model is still up in the air. ■

Jon Udell is a BYTE senior technical editor at large. You can reach him on the Internet or BIX at judell@bix.com.

INTEL TECHNOLOGY BRIEFING



INTEL VERIFICATION LAB

GUIDING YOU TO FUTURE COMPATIBILITY

SHEDDING LIGHT ON UPGRADABLE INTEL PROCESSOR TECHNOLOGY.

One of the biggest benefits of Intel's microprocessor technology is its upgradability with Intel OverDrive™ processors. To help ensure today's systems are compatible with Pentium™ OverDrive processors, we've created the Intel Verification Lab. This Technology Briefing will explain the purpose and process of Intel Verification.

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Currently available for many Intel486™ systems, OverDrive processors are a family of CPU upgrades which significantly accelerate your software to give your system a mid-life performance boost.

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As the first step in building machines upgradable to Pentium OverDrive processors, Intel provides PC manufacturers (OEMs) with detailed design specifications for future OverDrive processors. Then, as an additional help, we provide a way for OEMs to supplement their own comprehensive system testing. That's where the Intel Verification Lab comes in.

THE IVL SOLUTION.

The Intel Verification Lab (IVL) is a multimillion dollar facility which tests new Intel486 and Pentium processor-based PC designs to help OEMs better meet Intel's criteria for upgradability and compatibility with Pentium OverDrive processors.

IVL conducts a battery of tests, applying Intel's extensive knowledge and experience in processor design and software compatibility. For example, in functional testing we uncover BIOS problems, such as BIOS timing loops, or incorrect microprocessor identification, which could lead to compatibility problems when a faster processor is installed.

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IN ORDER TO BE VERIFIED, DESIGNS MUST HAVE A ZIF (ZERO INSERTION FORCE) SOCKET, WHICH SIMPLIFIES THE UPGRADE PROCEDURE.

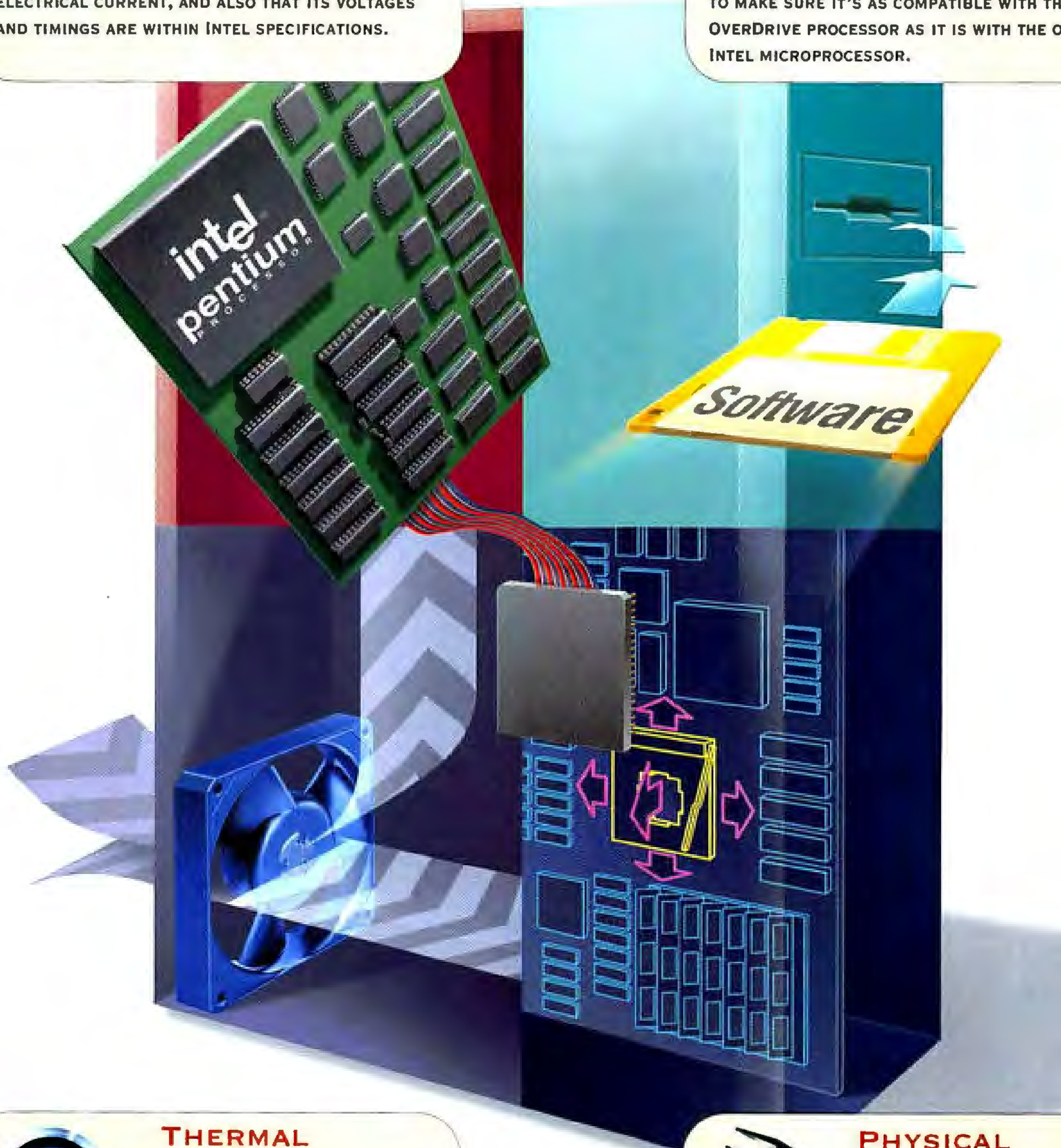
INTEL VERIFICATION LAB

Electrical

IVL testing looks at the electrical parameters of each system to make sure the OverDrive™ processor socket draws the proper amount of electrical current, and also that its voltages and timings are within Intel specifications.

Functional

Using the Pentium™ OverDrive processor emulator, the system design is tested with all major operating systems and popular software applications to make sure it's as compatible with the new OverDrive processor as it is with the original Intel microprocessor.



Thermal

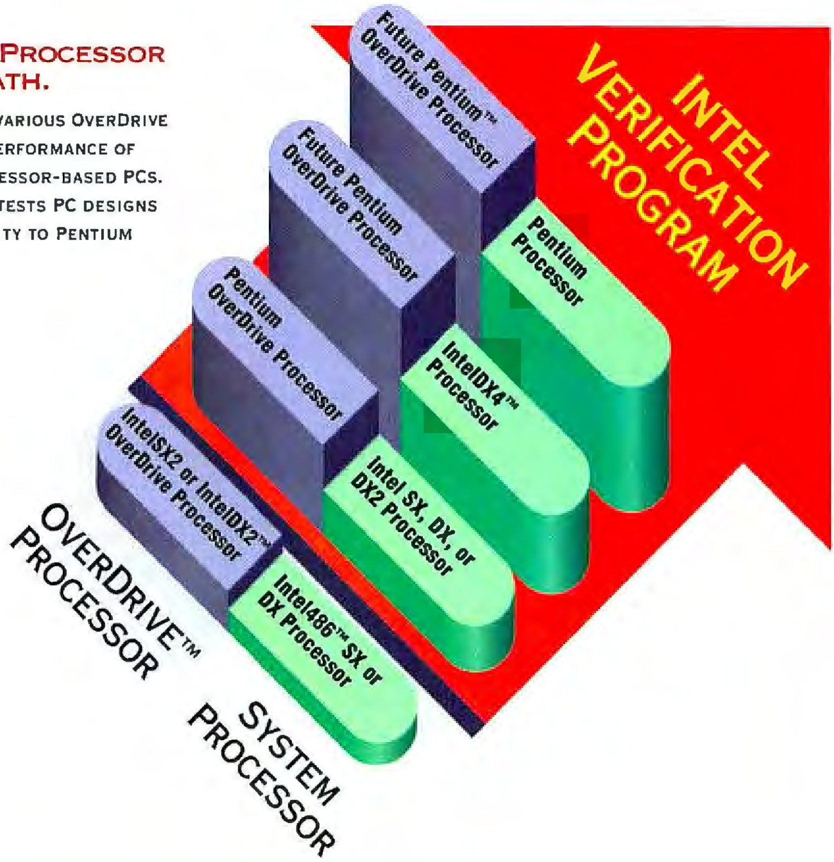
The thermal test measures the heat dissipation of the system design to ensure that it can properly maintain the Pentium OverDrive processor within specified temperature parameters.

Physical

This test measures the physical dimensions surrounding the Pentium OverDrive processor ZIF socket to make sure the socket is accessible to the user, and that the Pentium OverDrive processor can be easily installed.

The OverDrive™ Processor Upgradability Path.

Intel continues to develop various OverDrive processors to boost the performance of Intel486 and Pentium processor-based PCs. The Intel Verification Lab tests PC designs to help ensure upgradability to Pentium OverDrive processors.



Future OverDrive™ Processors.

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Looking Ahead.

In the future, you'll even be able to increase the performance of already-powerful Pentium processor-based PCs. In fact, there are currently many systems designed to take advantage of Pentium OverDrive processors.

And Intel's commitment to upgradability doesn't end there. Even more powerful new versions of OverDrive processors are already on the drawing board. And as new Intel microprocessors are introduced, you can be sure new generations of Intel OverDrive processors will soon follow.

For more information and a complete list of systems that have been **Intel Verified:** for the Pentium™ OverDrive™ processor, call 1-800-955-5599* and ask for literature pack #118.† Or dial Intel's FaxBack** at 1-800-525-3019 and ask for documents #3035 through 3039.

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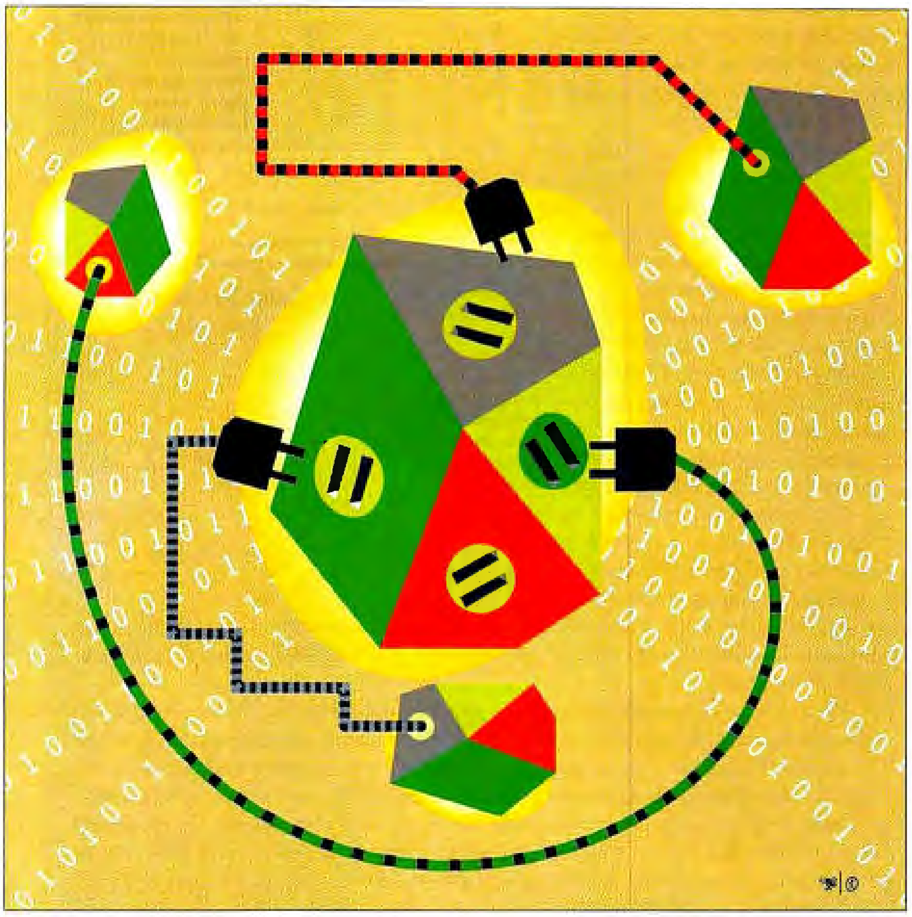
Extensible Software Systems



JOHN HERSEY © 1994

DICK POUNTAIN AND CLEMENS SZYPERSKI

You know you've accomplished the software engineer's nirvana—fully extensible software—when you can add new functionality to a system by interchangeably mixing and matching code modules at run time, without having to recompile anything.

For example, if you can add one spelling-checker module to your system that immediately becomes usable from any application, then you no longer have to worry about multiple dictionaries and interfaces and can work more efficiently. Such extensible systems hold the promise of increased economy and reliability. But what's the reality?

For the last decade, operating systems and applications have grown in an ad hoc fashion—in the way you might add outbuildings to a farmhouse. A new generation of microkernel-based operating systems promises to replace this haphazard, unreliable growth with a new kind of controlled extensibility.

Making software fully extensible means you can mix and match code modules at run time, without recompilation

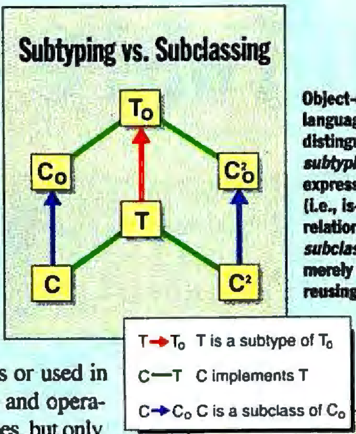
Extensibility: What Is It?

In one sense, all application programs are extensions of the operating system, because they add new functionality without forcing you to recompile the operating system. For example, MS-DOS can open and close text files, but it doesn't know how to edit them; for that, you must run an application (i.e., load an extension) such as EDLIN or WordPerfect. Many large applications—such as AutoCAD and Lotus 1-2-3—are extensible, letting you load extra modules that add new functions. Unfortunately, this is a limited and proprietary extensibility; you can't add AutoCAD tools to Lotus 1-2-3 or vice versa.

You can also extend MS-DOS with modules that any application can use. For example, loading a new driver via CONFIG.SYS at boot time might extend the system to support a CD-ROM drive. You can add TSR programs at run time that alter the way DOS manages memory.

You can even add what amounts to a whole new operating system—Windows 3.1. This is a stronger kind of extensibility, though still limited. It certainly won't guarantee reliability, as anyone who has wrestled with TSR conflicts can testify. These problems persist because the extension interfaces have been hacked out and modified by generations of third-party programmers, often using undocumented features. More important, this is one-way extensibility: Newly added code can use old code (e.g., DOS function calls), but old code cannot generally call new code, except for a few well-defined cases such as printer drivers. Sharing code modules also implies that once a module (e.g., the text-editing engine) is debugged and stable, it will be reliable throughout the system. At present, every new application introduces its own text-editing code and its own new bugs. But software doesn't need to be this way. DLLs, as used in Windows, suggest another approach for extensible systems, which could consist of a tiny fixed

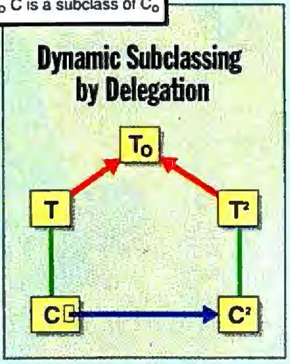
SUBTYPING OR SUBCLASSING?



Object-oriented languages ought to distinguish between *subtyping*, which expresses conformance (i.e., is-a-kind-of) relations, and *subclassing*, which merely means reusing code.

Inheritance and polymorphism are important concepts in OOP (object-oriented programming), but more subtle distinctions are usually not explained. One fundamental issue is the distinction between types and classes, something not reflected in current commercial OOPSes (object-oriented programming systems).

Type distinguishes kinds of objects; its purpose is to control what values can be assigned to variables or used in operations. Polymorphic variables and operations can accept objects of many types, but only if these conform to the declared base type. This means they must be subtypes (i.e., specialized kinds) of the base type. Expressed in a programming language, an object's type is its externally visible interface, represented by the names and formal parameters of its methods.



Delegation can avoid the formation of such wrong subtype relations—you can subclass another class (i.e., use its code) without at the same time creating a subtype-basetype relationship.

Class concerns how a type works (i.e., the code that implements those methods and thus defines the behavior of objects of the type). A class that reuses some code from a previously defined class is called a *subclass* and is said to inherit from its base class, or *superclass*. This subclass relation only involves sharing code and does not imply that the corresponding type is a subtype of the other.

Most OOP languages don't distinguish subtyping from subclassing, though it would often be desirable for a type to inherit code without having to create a subtype of the base type. If class and type are identical, you must use forwarding to simulate inheritance or introduce wrong subtype relations (as most OOPSes do, including Smalltalk).

As an example, in the original Smalltalk Collection class library, a set is implemented as a subclass of a bag, conveniently inheriting most of its code since their implementations are similar. Mathematically speaking, a set is not just a kind of a bag, since they behave differently under the multiple update operation. But a typed language like C++ will lead you into making a set a subtype of a bag, and hence to the common design error where a function that expects a bag may be called with a set, and will fail. Static type-checking cannot catch this kind of error if wrong subtype relations exist.

Why do current OOPSes allow wrong subtypes? Because a compiler can't check the behavioral (as opposed to syntactic) conformance of a subtype. It would have to check the mathematical definitions of sets and bags against the implementations. Unfortunately, such checks are equivalent to Turing's Halting Problem: undecidable in principle.

Another fundamental difference between OOP and traditional programming is the complexity introduced by recursion. Whenever a method invokes another method on the special "self" object, the code that is actually executed may be located in a subclass that overrode the original method. In other words, recursion can cause a subtle interaction of a class with its subclasses and superclasses.

Like Ethos, Microsoft's Component Object Model separates extensions from a base class's implicit recursion pattern. The only way to pass control from a class to its base class is by forwarding through an instance variable containing an object of the base class. For the base object to call the caller back, a callback object must be explicitly passed.

A more powerful scheme than forwarding is *delegation*, where the callback object is the caller itself and gets passed with every invocation of the base object. Delegation has the same expressive power as inheritance, so either can simulate the other. Forwarding can simulate delegation only in a cumbersome way by adding an extra callback parameter to each and every method. See the text box "Inheritance or Delegation."

microkernel augmented by DLLs. To get there from here, though, you need new programming tools to help enforce the required discipline.

Objects, Classes, and Extensibility

Extensibility is one of many benefits that OOPSes (object-oriented programming systems) promise to deliver through encapsulation, polymorphism, and late binding.

An encapsulated object behaves like a black box whose internal state can be changed only via a well-defined interface. Changing the internal implementations (i.e., methods) of such objects should not break any application programs that use them, if the interfaces remain unchanged.

A polymorphic operation can be applied to different types and classes of objects. With late binding, you don't need to know which kind of object until run time. Combining polymorphism with late binding (called virtual methods) allows you to write code that will work properly for types and classes that do not yet exist. This is essential for truly extensible systems, which are by definition never finished. Other programmers must be able to extend your work in ways you cannot anticipate. Late binding is what enables old code to call new code. *Inheritance* is the ability to derive child objects that inherit (i.e., reuse) the interface code of their parents.

The Real World Intrudes

In the real world, extensibility is more elusive than this story would suggest. A fully extensible system should be able to add and remove compiled code modules without forcing the recompilation of any modules already present (e.g., adding the new spelling checker must not force you to upgrade to a new version of your word processor). This presupposes that the OOPS supports separately compilable modules, but some object-oriented languages (e.g., Smalltalk) do not. In fact, an extensible OOPS needs to support a separate compilation unit whose granularity is typically larger than a single class, because some program constructs (e.g., cyclically dependent type definitions) cannot normally be compiled across module boundaries, and some definitions use auxiliary constructs that should not be visible outside the module.

Current object-oriented languages vary enormously in their attitude to *type-safety*, which is the detection of the illegal use of operations (see the text box "Subtyping or Subclassing?"). Smalltalk has no concept of type, so any operation can be applied to any object and only run-time checks can determine if a particular method call

will succeed. Object Pascal and Oberon use strong typing, so the legality of many operations can be checked at compile time. C++ falls in between—most operations are type-safe, but unchecked type-casts perform the important type-narrowing operation (i.e., going from a general type to a more specific subtype).

Needless to say, you must be able to compile new modules for an extensible system without needing the source for all the old code, and compiling a new module must not affect the correctness of older code, as can happen with some type-checking systems based on global program analysis.

SOM, COM, and Fragile Base Classes

It's highly desirable to be able to extend a system using a variety of compilers and languages, but we're not there yet. You can't use Microsoft C++ to extend Borland class libraries or inherit from Microsoft C++ libraries into Turbo Pascal. We need a vendor-independent object

Inheritance or Delegation?

To illustrate the difference between inheritance and delegation, consider the following code, which implements a rather poorly designed class called `printer` that supports the printing of documents:

```
Printer = POINTER TO PrinterDesc;
PrinterDesc =
RECORD
  pageno: INTEGER;     (* variable is private *)
  PROCEDURE (p: Printer) PageNo(): INTEGER;
  PROCEDURE (p: Printer) SetupNextPage
    (VAR endOfDoc: BOOLEAN);
  PROCEDURE (p: Printer) PrintPage;
  PROCEDURE (p: Printer) PrintDoc;
END;
```

(The language used here is Oberon-2, whose syntax bears a family resemblance to Object Pascal. The parameter `(p: Printer)` in front of each method name specifies the static type to which the methods are bound and is called the *receiver*; methods are invoked on an object of this [or a conformant] type as, for example, `P.PageNo`.)

`PrintDoc` prints an entire document by alternating calls to `SetupNextPage` with calls to `PrintPage` until the former returns with `endOfDoc` true. `PageNo` returns the page number of the page currently printed. `PrintDoc` also contains a lot of nasty code to locate, open, and close printer drivers, which cannot sensibly be reimplemented and must be reused.

The first implementation of `Printer` increments the page number before calling `PrintPage` and after calling `SetupNextPage`; however, the documentation says nothing about this order of execution. Later on, the implementation is changed to increment the page number before calling `SetupNextPage`. This does not violate any previously documented rules. But it may well break extensions that have been written in the meantime.

For example, a subclass `IndexPrinter` inherits from `Printer` and extends `SetupNextPage` to add marked words to an index; it takes `PageNo()+1` as the current page position, which worked fine with the original `Printer`. With the new implementation, the results are all off by one. Here, you have a fragile base class intertwined with its subclasses in such intricate ways that changing it becomes virtually impossible.

Now if you prohibit inheritance and extend `Printer` using only forwarding as follows:

```
IndexPrinter = POINTER TO
RECORD (PrinterDesc)    (* A type extension *)
  base: Printer; (* Pointer to the base class *)
  PROCEDURE (p: Printer) PrintDoc;
END;
```

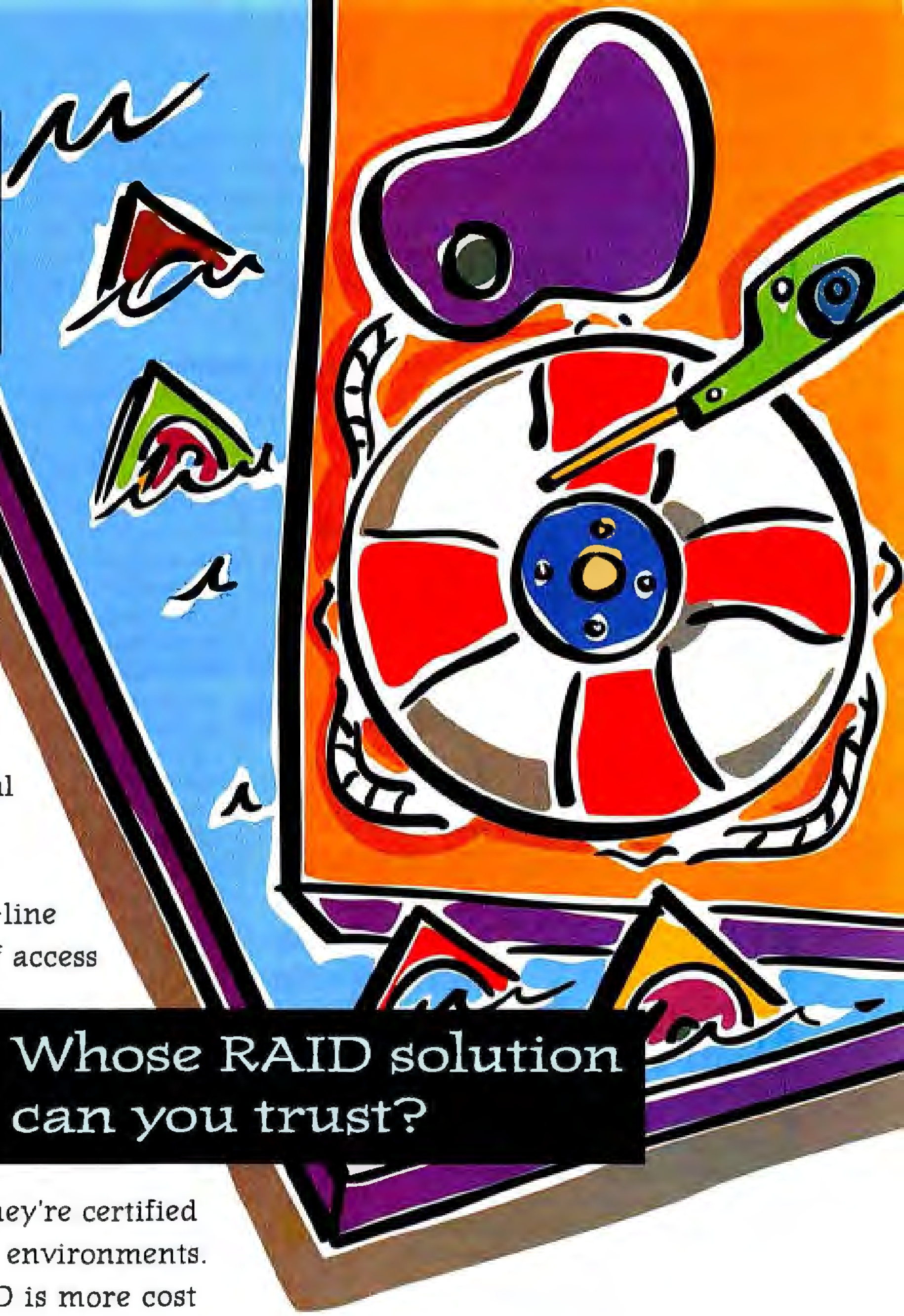
As it stands, this version of `IndexPrinter` can't do the job, because without inheritance or late binding, it can only call the original `PrintDocument` method and can't regain control after `Printer` calls `SetupNextPage` to add its own actions. Forcing the system to rely on pure forwarding reveals the design weakness in `Printer` the first time you try to extend it. However, by using explicit callback parameters, the `Printer` interface can be changed to make `IndexPrinter` work:

```
PrinterDesc =
RECORD
  ...
  PROCEDURE (p: Printer) PrintDoc (q: Printer);
END;
```

This last implementation of `PrintDocument` calls the methods of its callback parameter q instead of `self` to perform its job using callback "hooks":

```
PROCEDURE (p: Printer) PrintDoc (q: Printer);
BEGIN
  ... (* nasty driver code *)
  IF q = NIL THEN      (* no delegator *)
    ... (* as original version *) ...
  ELSE  (* pass control back to delegator *)
    WHILE ~endDoc DO
      q.SetupNextPage(endDoc);
      q.PrintPage
    END
  END;
  ... (* more nasty driver code *)
END PrintDocument;
```

The result of this interaction enables q to delegate `PrintDoc` to p, which in turn returns `self` invocations to q, thus achieving the effect of late binding (i.e., old code calling new). Now `IndexPrinter` must keep track of page numbers itself, relying on its own implementation instead of that in `Printer`. Making the callback explicit reduces the likelihood of a fragile base class.



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model to define a standard binary format for passing messages and parameters between objects.

Predictably, there are two rival models: Microsoft's COM (Component Object Model), which underlies OLE 2.0, and IBM's SOM (System Object Model), which was originally introduced to support OS/2 2.0's Workplace Shell but also forms the basis of OpenDoc, a new compound document model that IBM, Apple, Sun, and others support.

The two models are significantly different. SOM is language-independent and supports full inheritance, while COM is intimately tied to C++ and supports only forwarding, a weakened form of inheritance that Microsoft calls *aggregation*. The only way to reuse code from a parent class is by explicitly putting a pointer to an object of that class into a private data member of the child; this object then acts as a proxy for its parent class and forwards all relevant messages to it (see the text box "Subtyping or Subclassing?").

Microsoft says it pulled back from full inheritance to avoid the "fragile base-class problem" (see "Objects on the March," January BYTE). This problem arises when adding new variables or methods to a base class forces all its derived classes to be recompiled or modified. Here, even though the class's interface was unchanged, hidden semantic dependencies had violated the black-box walls that encapsulation was supposed to provide. Changing the self-recursion pattern of the base class (i.e., the way that its own methods call one another) often causes these dependencies (see the text box "Inheritance or Delegation?").

In essence, Microsoft says that full inheritance offers programmers too much freedom, which they will inevitably abuse by designing unsafe extensions and thus hinder easy upgrading of the product. However unpopular this argument, it contains a kernel of truth that OOP supporters must face: Module interfaces for truly extensible systems need stricter controls than current OOPSes provide.

Aggregation is one solution, disabling full-code inheritance and providing only the weaker alternative of forwarding to a base class. Unfortunately, this gives up much of the extensibility OOP was supposed to deliver. Other design techniques can restrict the potential for inheritance mischief while retaining its expressive power. One of the authors (Szyperski) has researched such techniques, which he calls EOO (extensible object orientation) at ETH (Eidgenössische Technische Hochschule) in Zurich. EOO amounts to object-orientation plus separate compilation plus type-safety.

Overriding Concerns

In OOPSes that employ inheritance, derived types inherit all the procedures or methods of their parent type but can override them and define new implementations. This powerful feature allows you to replace or modify inherited behaviors, but you must follow strict rules to avoid the fragile base-class problem.

To be safe, the overriding procedure must be both syntactically and semantically compatible with the original procedure. A language can express syntactic conformance by using a strong typing scheme that the compiler can check. Semantic compatibility is difficult to check, and no existing programming language has a mechanism for specifying behavioral conformance. Nevertheless, certain design principles can help.

> **Using derived types, you can replace or modify parent-class behavior, but you must follow strict rules.**

In general, it is only safe to extend procedures whose complete behavior is known. Using a "super" call to the parent procedure within the extended procedure can't guarantee safety; the parent may have had side effects or hidden behaviors that, when changed at a later date, caused the extended code to break. When replacing, rather than extending, the default behavior of a base procedure, the only safe course is to replace it totally, without making a super call. You must define completely the behavior of such base procedures, with no hidden actions, and you must export everything needed for the implementation so that reimplementers can use it.

Since an empty procedure does nothing, it can always be overridden safely. An empty procedure meant only to appear in an object's interface is called an *abstract procedure*; a type that provides at least one abstract procedure is often called an *abstract class*. You may not create instances of such types—they are just interfaces whose code must be implemented within some extension type. To avoid the fragile base-class problem, you only export and extend abstract classes, keeping the nonabstract classes that extend and implement them hidden within modules.

If you don't export the extended type, how can you create and use objects of that type? By exporting along with each abstract type a corresponding directory object (accessed via a global variable) that contains methods to create and manipulate new objects of the extended type. For example, a file directory object might contain methods to create new files and to look up existing files by name. Directory objects can be replaced at run time, allowing you to add and integrate extended services and thus support complete extensibility.

Future Directions for Safe Extensibility

These design principles emerged from research at ETH on an experimental extensible operating system called Ethos, implemented in Oberon-2, a strongly typed, modular OOP language that offers late binding and code inheritance but does not differentiate between subtyping and subclassing (see "Oberon: A Glimpse at the Future," May 1993 BYTE). Ethos demonstrated that strong typing and strong modularity are powerful means for achieving full extensibility. Ethos has led to Oberon/F, a commercial application framework for standard GUIs (e.g., Macintosh, Windows, and Motif) from Oberon Microsystems' (Solothurnerstrasse 45, CH-4053, Basel, Switzerland). Oberon/F extensions are platform-independent, provide native look and feel, and are document-centered rather than application-centered.

Restricting the use of inheritance proved to be the key to system manageability and extensibility in Ethos, allowing easy addition of extensions that are themselves extensible. But relying purely on forwarding to extend existing objects often proved too weak for adequate code reuse. Inheritance was no longer an option because the use of directory objects meant that the base objects were not visible at compile time. In such cases, delegation proved to be a highly effective substitute for inheritance, but since Oberon can only simulate delegation, it was too cumbersome to use everywhere.

It may be desirable to build support for delegation into the programming language, just as current OOP languages support inheritance. No current OOP language supports both delegation and inheritance, and whether such support can be implemented in a type-safe and efficient way remains a topic for further research. ■

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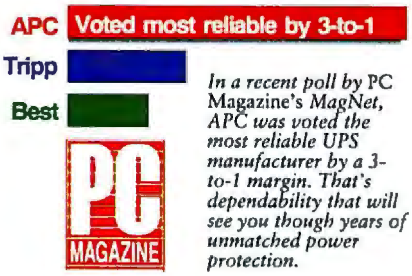

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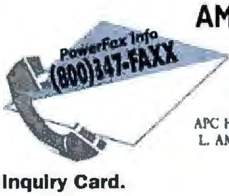

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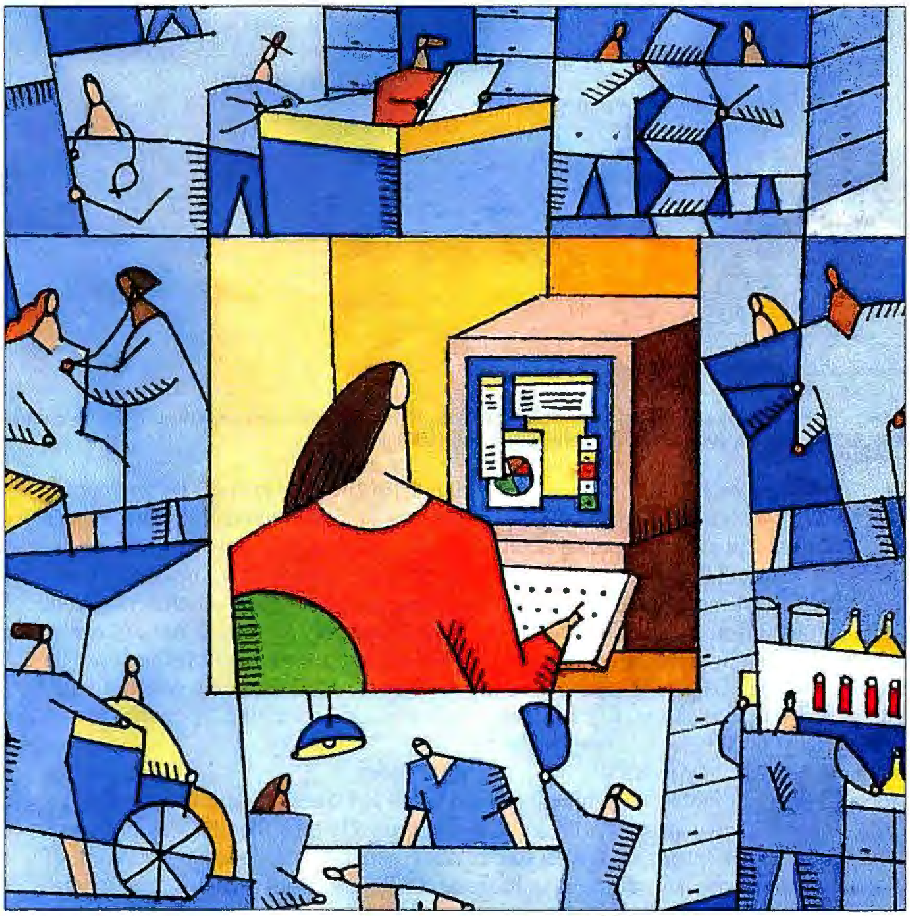

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SCOTT WALLACE

Medicine, like many scientific activities, cannot be practiced effectively without accurate and timely information: information about patients and their problems, appropriate care-giving procedures and their benefits and limitations, the medical and institutional resources available to support care providers and their patients, and the cost and result of care. Today, the vast bulk of this information can be found not on-line but in hard copy of one form or another: paper-based patient records derived from provider-patient encounters; film-based x-rays and scans from diagnostic procedures; strip charts and other output from laboratory and patient-monitoring equipment; and voice recordings of clinicians' notes. All are critical components of what, in the aggregate, is called the patient record.

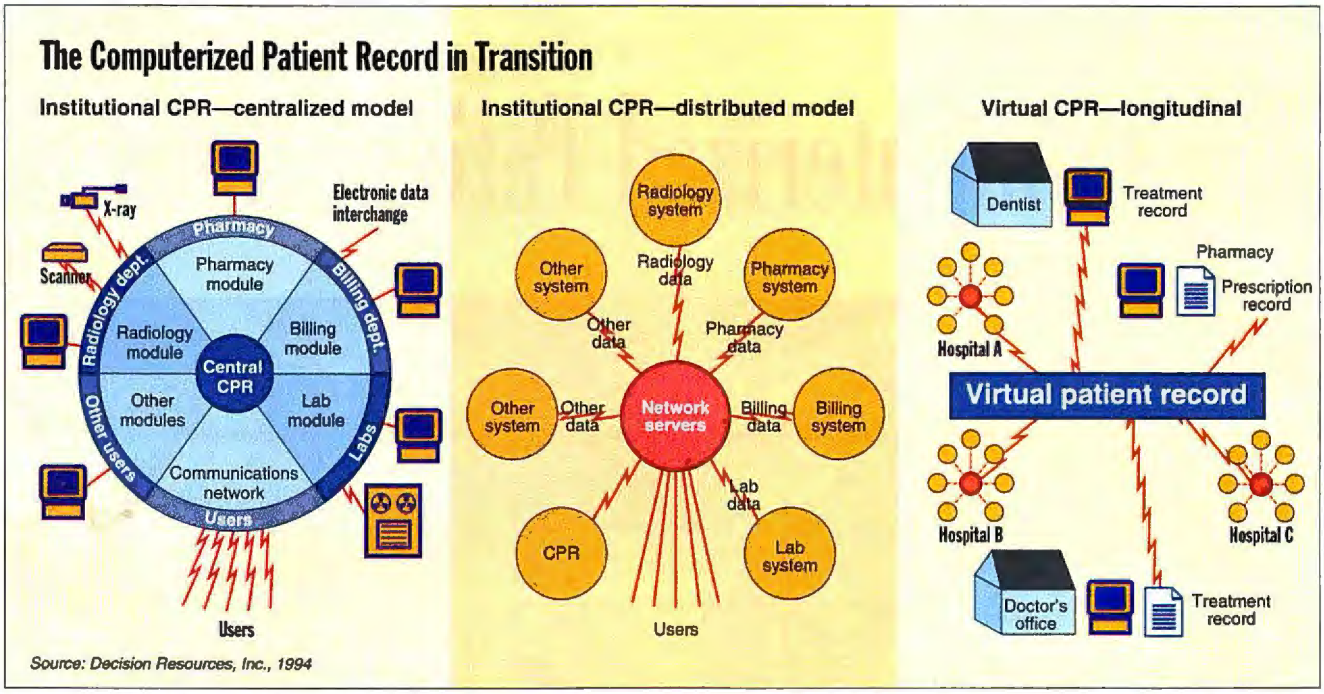
For many years, the medical community and its IT (information technology) suppliers have sought to improve, refine, and extend the support that computer-based systems offer in the delivery and administration of health care. Understandably enough, patient data has been a prominent focus in this effort. More recently, the health industry has been joined by regulatory and market interests eager to understand and contain the costs of health-care delivery. According to a Decision Resources report, 25 cents of every hospital dollar spent in 1990 paid administrative costs (many of which are associated with the management of patient information). Computerizing the patient record seems an excellent way to reduce administrative costs and deliver better health care.

Huge benefits in the quality of health care along with financial savings center on a broadly accessible computerized patient record

Focus on the Data

In 1991, after serious and comprehensive study of prospective health-care-delivery improvements, the Institute of Medicine issued a report called *The Computer-Based Patient Record: An Essential Technology for Health Care*. The report, which focused on the computerization and communication of patient and provider information, identified five objectives for the CPR (computerized patient record) of the future. The CPR must 1) support patient care and improve quality of care; 2) enhance productivity of health-care professionals and reduce administrative costs of health-care delivery and financing; 3) support clinical and health services research; 4) accommodate future developments in health-care technology, policy, management, and finance; and 5) ensure patient data confidentiality at all times. Neither paper-based records nor contemporary computer-based records can effectively support all these objectives today.

The Institute of Medicine report also noted that the future CPR



Decentralization of health-care delivery—combined with the movement from mainframes and minicomputers to client/server architectures—is driving the transition of the CPR from a centralized through a distributed to a virtual longitudinal model.

must be "far more flexible, allowing its users to design and utilize reporting formats tailored to their own special needs and to organize and display data in various ways. The patient-record system of the future must provide other capabilities as well, including links to administrative, bibliographic, clinical knowledge, and research databases. To meet the needs of clinicians, CPR systems must be linked to decision-support systems; they must also support video or picture graphics and must provide electronic-mail capability within and between provider settings." Given that telecommunications and computing infrastructures at health-care institutions typically lag five years behind mainstream business users of IT, the report poses quite an aggressive challenge.

Although the scope of the technical and operational tasks associated with realizing this vision of the CPR are monumental, so are the incentives. New purchasing patterns conjoined with institutional efforts to contain costs are "flattening" the health-care industry—creating new alliances of purchasers as well as of providers who supplement and compete with traditional hospital services. This has created an unprecedented need to share clinical and patient encounter information. At the same time, patients are becoming more mobile, routinely receiving treatment—and incurring billings—at many institutions even within a single episode. As a result, the need for accurate, accessible, timely, secure sharing of information has reached critical mass. And demand to apply the appropriate information and communications resources to the problem will only increase as IT-savvy stakeholders (e.g., insurance companies and Fortune 100 employers paying health-care bills for thousands of workers) exercise more prominent influence. The result is the need for a new system for delivering and accounting for health care.

CPR Today

The CPR systems found in hospitals today typically treat the hospital as the primary, and often sole, provider and venue of care delivery. Until recently, this orientation was appropriate and relatively effective. With the decentralization of health-care delivery and the consequent rise in specialty services and organizational alliances, this centralized model for patient information management is becoming less appropriate. Further, within individual institutions, patient record information is becoming decentralized, driven largely by an industrywide transition from centralized minicomputer and mainframe systems toward distributed, client/server systems (see the figure "The Computerized Patient Record in Transition"). Health-care providers, patients, and payers are restructuring their relationships, and the CPR is changing as well. It is being transformed from a centralized model through a distributed model to a longitudinal model.

In May 1992, the General Assembly of the state of Vermont created a Health Care Authority charged with developing plans to support universal access to health care for residents. In support of that goal, a non-profit corporation called the Vermont Health Care Information Consortium, or VHIC, was formed. Its mission is to plan and develop a modern, regional, integrated health-care information system. Bruce Post, president of VHIC, oversees research and policy development activities. Post has been working with all stakeholders—vendors, providers, payee organizations, and consumers—to develop definitions of functionality for the system and to identify interface standards and telecommunications policies that support the individual needs of institutions and the needs of the population at large. He sees collaboration as critical to the success of regional, community-based health information systems. "Health-care institutions can no longer operate as Towers of Babel. While there may be different languages and needs, we have to build a system with effective communications and information sharing. This means some kind of integrated database and communications system," says Post.

Post is not alone in his interest in developing regional health information networks. Last December, the C. Everett Koop Institute at Dartmouth sponsored a conference for health-care professionals, policymakers, and technologists to discuss the ways and means of developing an integrated health-care information network to serve the populations of Maine, New Hampshire, and Vermont. "We all know that the information highways of the future

are blocked by obstacles. We need to identify those obstacles and come up with plans to remove them," said former Surgeon General Koop at the conference. "How do we communicate now? What is our vision for communications in the future? What do we want to communicate? To whom should it be communicated?" These questions must be addressed before robust and effective networks can be implemented (see the figure "CPR: Many Users, Many Uses"). While the answers will differ from community to community and institution to institution, a set of common architectural and solution elements are emerging.

CPR at the Brigham

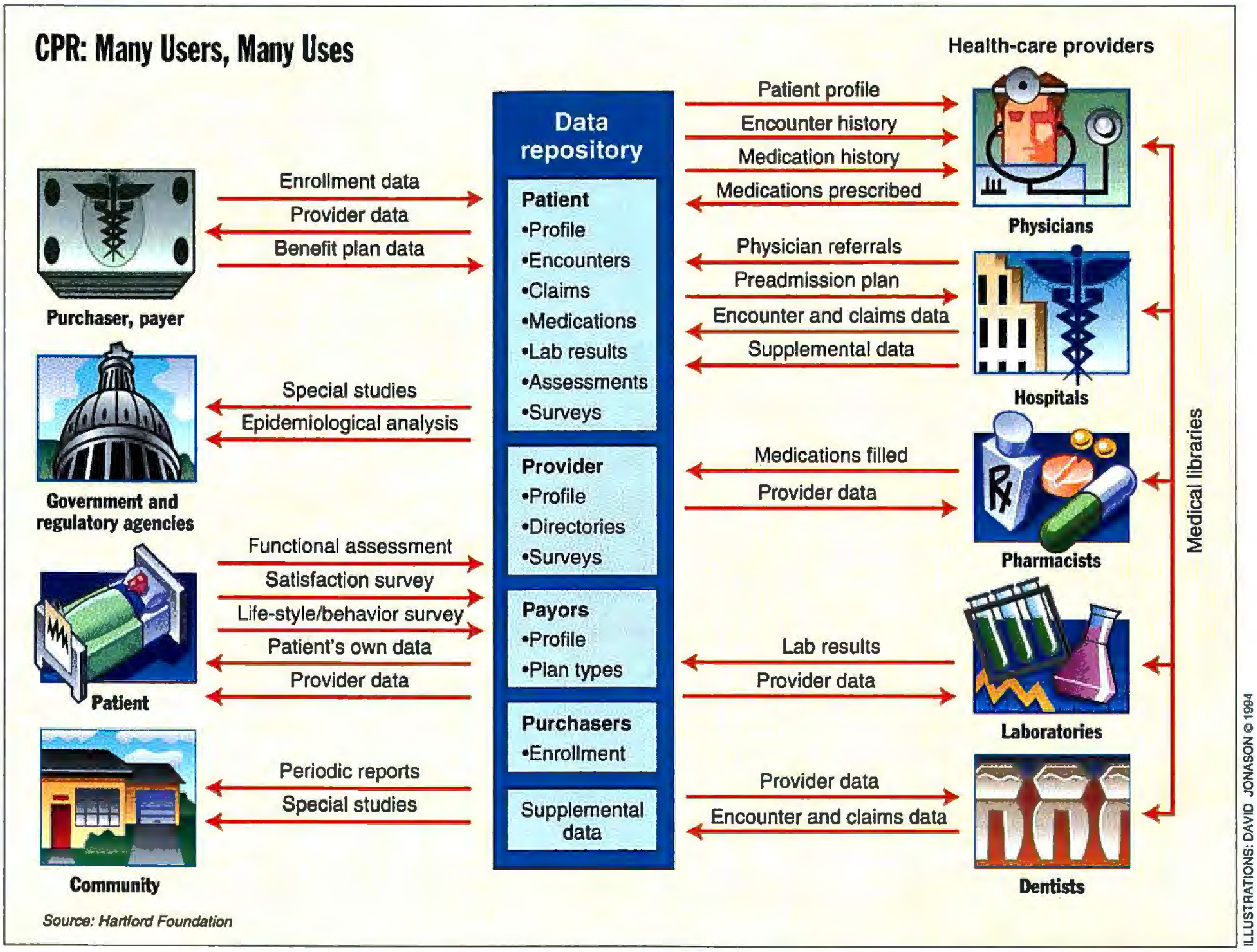
Today, one would be hard-pressed to find an institution with a more viable information architecture—or one that supports its care providers with more comprehensive or broadly accessible on-line patient data—than Brigham and Women's Hospital in Boston, Massachusetts. The Brigham is a teaching arm of Harvard Medical School and, like most hospitals, has a heavy legacy of centralized, minicomputer-based support systems. Unlike most institutions, the Brigham has successfully migrated to a LAN-based, distributed, client/server, desktop environment at the same time as dramatically increasing the availability of on-line patient information and the number of supporting applications.

At the hospital's main campus, over 3300 Intel clients and 120 servers are connected via 70 4-Mb Novell NetWare 3.0 token rings and two 16-Mb backbones (see the figure "Brigham and Women's Hospital Information Systems Infrastructure"). This infrastructure supports more than 65 applications software systems, such as Pathology Laboratories, Patient Accounting, Results Retrieval, and Physician Order Entry. Applications are written in resource-conserving MUMPS (Massachusetts General Hospital Utility Multi-Programming System), a client/server applications development and run-time environment. (MUMPS was originally developed in the late 1960s and early 1970s for minicomputer systems at Massachusetts General Hospital, and it still has a strong presence in health care as well as engineering and scientific markets.)

In part, because of the sophistication and effectiveness of its systems and, in part, because it provides health-care services to clinics remote from the main campus, the Brigham has a jump on most institutions trying to develop the next-generation CPRs required to support a distributed health-care-delivery system. Support for decentralized access is a key feature of the CPR.

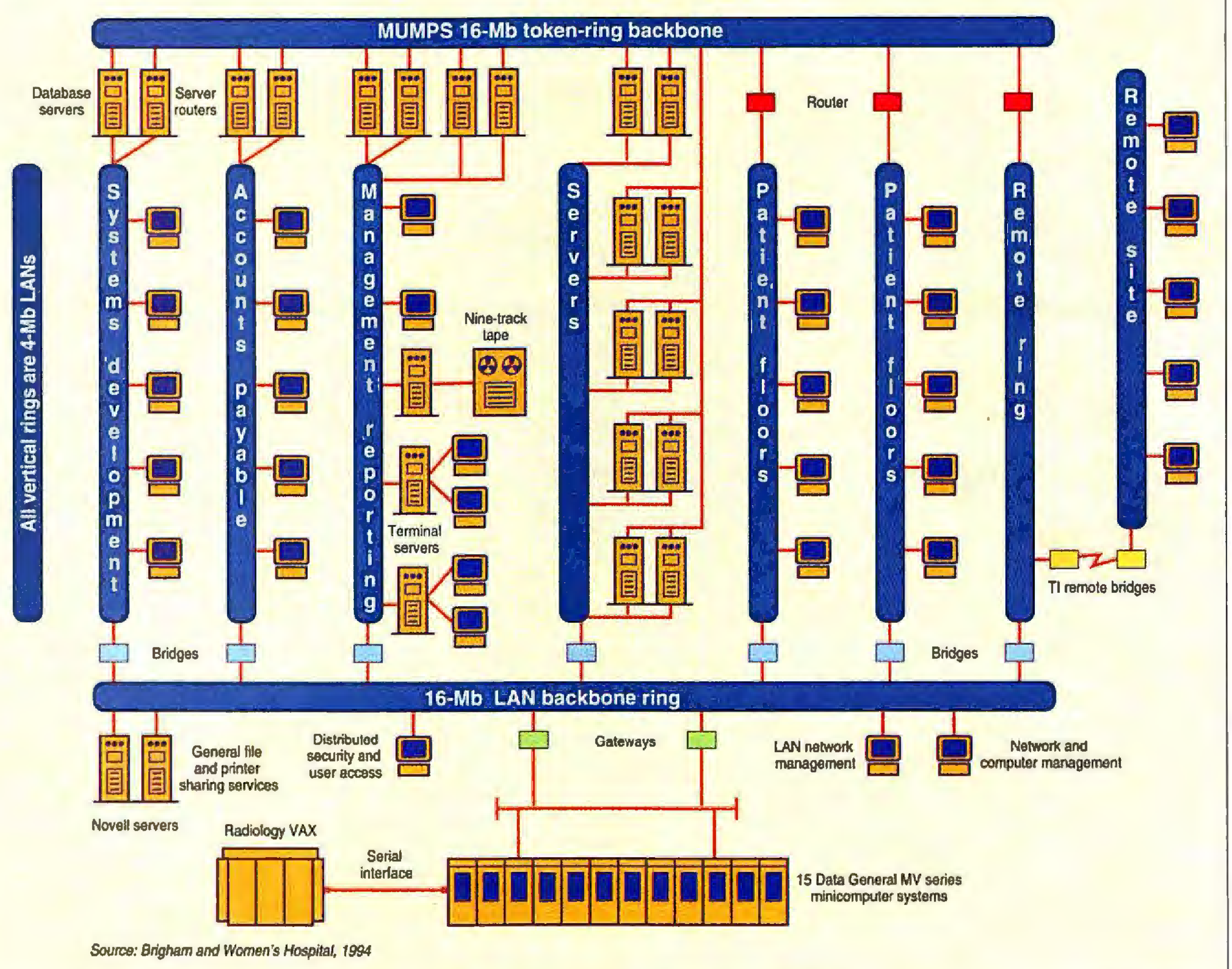
John Glaser, vice president of information systems, says there are three basic purposes of the CPR. "[The CPR] makes data available, so that no matter where or when the data was produced, you can get at it. It helps streamline the processes that surround the provision of care. And it makes ordering care more efficient. For example, [the CPR] allows us to put logic on top of the content to guide the care-giving process."

continued



The CPR must accommodate a wide variety of users and uses. These uses as well as the types of data of the CPR will change over time to accommodate evolving operational requirements and computing and communications platforms.

Brigham and Women's Hospital Information Systems Infrastructure



This large, urban teaching hospital is today transitioning from a legacy of minicomputers to a modern client/server architecture. The result: an institution uniquely prepared to support the modern CPR.

An example of guiding the care-giving process can be found in the hospital's fledgling expert systems that support care givers' planning and ordering processes through protocol-based analytics. Perhaps a CPR contains recent lab data on a patient's potassium levels and a care giver enters an order for a drug that has contraindications in patients with high potassium levels. If the potassium level was high, the system would alert the clinician to the contraindication and ask for confirmation of the order. If the level was normal, the order would be processed without query. Messages presented at the time of entry can also be delivered by E-mail or over the hospital's paging system. This degree of support is not a fundamental part of the CPR, but the CPR is a fundamental prerequisite to systems like this that rely on patient data to improve treatment planning, patient outcome, and quality of care.

CPR Data

For the most part, data in the CPR today at the Brigham is entered through a keyboard, although some diagnostic and laboratory devices output data via interfaces directly to workstations for ultimate inclusion in the patient record. This machine-to-machine interface is considered a tactic critical to reducing CPR misinformation, the vast bulk of which is induced by human error. Such linkages are not yet effectively standardized and thus require significant development effort to establish.

The radiology department at the Brigham uses these interfaces and offers a good example of how departmental data is generated, stored, and then accessed enterprise-wide. The primary computer for radiological support services is a DEC VAX, but hundreds of PCs and Unix workstations provide client, server, and computational support. Links to the hospital information system transfer not only patient scheduling and billing data but, through a new system emerging from development, image data from CAT and MRI (Magnetic Resonance Imaging) scans, as well as nuclear-medicine imagery.

A typical CAT scan results in 60 images, each 512 by 512 pixels requiring 2 bytes of storage—that's 32 MB of data per exam. In the course of treatment, a patient will often have more than one scan. The result is a hospitalwide accumulation of about 3 GB of image data per day.

Typically, these images are reviewed by primary-care physicians planning treatment

on Sun Microsystems' workstations with 19-inch 1280- by 1024-pixel displays. A doctor specifies the patient images desired, and in about 5 to 20 seconds, depending on the workstation and the network load, images appear on the screen. Initially, an overview showing thumbnail images of all 60 frames is displayed. The clinician would reference the radiologist's on-line audio or text interpretation and select individual frames for viewing in full resolution. "It takes about a second to get a half-a-megabyte frame transmitted over the network to the workstation," says Ethan Fenner, director of Radiology Information Systems. "The frame is 12 bits deep and must be reprocessed for an 8-bit-display buffer; that happens in about a second and a half."

Right now, Fenner and his colleagues have 10 GB of storage with Sun workstations acting as servers. This supports about three days of images. While the system has been well received by clinicians, storage limitations must be overcome, and broader access to the radiological databases must be established. "We have passed the feasibility test, and we're trying now to pass the test of scale," Fenner notes. Plans call for an increase in storage capacity to 30 or 60 GB (supporting one to two months of patient image data) and an increase in the number of supporting workstations from three in the radiology department to 10 or 15 stations distributed throughout the hospital.

Remote access to the images, scheduled for more full-scale implementation in the future, has been tested in limited fashion. The Brigham is part of the LMAnet (Longwood Medical Association network), a fiber-optic link connecting many health-care institutions in the Boston area, including the radiation therapy planning lab at the Dana Farber Cancer Institute. Clinicians can solicit images over the LMAnet from the Brigham to be used for local analysis and radiation treatment planning. While this use has proved the technologies, broader use requires more development. "These planners are basically physicists and are very competent Unix users," says Fenner. "They've been able to tap into the existing database and file system without a lot of application development. It will be difficult for us to support these kinds of applications outside the institution, and we need to develop some in-house operations experience before we open the floodgates to outside users."

CPR Challenges

Broad, distributed, timely access to patient information is an absolute element

of the CPR, and the practices and systems required to support it must be mastered. "At a minimum, you have to make sure that an authorized user at a workstation anywhere on the health-care network has the ability to get into any clinical database on the network," says Glaser. "So, if your doctor's office has a Mac sitting there but I've got applications written in Windows at the Brigham, what are we going to do? That's got to be resolved."

Other major issues requiring resolution include establishing and evolving networks to interconnect institutions, and buying and managing the storage systems required to keep thousands of patients' clinical information on-line for tens of years. Once these technical and operational issues are resolved, lesser challenges remain. "To effectively track a patient over the course of multiple visits, there must be 'glue data' that allows me to link Mrs. Smith's visit to the Brigham with Mrs. Smith's visit to Mass. General two months or two years later," Glaser says. "This means I need a common identifier, common definitions of diagnoses, and definitions of medicine—there's probably a dozen different types of data standards needed. And then the standards must be enforced."

There will be no dearth of interested parties ready, able and anxious to contribute to the standards development and deployment process. Professional health-care organizations (e.g., the American Medical Association, the American Hospital Association, the College of Healthcare Information Management Executives, and the Healthcare Information Management Systems Society), data exchange standards bodies (e.g., the IEEE, the ISO, the Health Industry Standards Coordinating Council, and the American College of Radiology and National Electrical Manufacturers Association), state and federal agencies (e.g., the Health Care Financing Administration, the Center for Disease Control, the National Institutes of Health, the FDA, the DoD, and the Veterans Administration), and other interested parties (e.g., CPR system vendors, communications suppliers, consumer advocates, and special-interest groups such as large-scale employers and insurers) are already involved. Balancing these interests, although essential, will be difficult.

Trouble Ahead?

As if the procedural and technical challenges weren't enough, finally, there are the legal obligations—and liabilities—associated with the distributed CPR. Care giving has become distributed more quickly than the information that supports that care, which creates a catch-22 of sorts. Hospitals, HMOs (Health Maintenance Organizations), and other providers are responsible not only for the quality of their services, which in today's evolving market implies responsibility for supporting broad and timely access to patient data by co-providers, but for the confidentiality of that information. Yet the infrastructure required to support secure storage, distribution, and management of that information simply doesn't exist. "I think we're heading for a train wreck," observes Glaser. "The technology and the transformation of the delivery system are moving faster than the legal apparatus is moving."

Clearly, patients want clinicians to have all the information necessary to provide quality care. And clinicians want to have on hand all the information needed to make informed decisions about their patients. Resolving security and confidentiality issues to the satisfaction of all parties—and there are quite a few of them—is a necessary and critical step in widespread CPR deployment.

CPR as a Universal Model

Developing a robust, effective CPR is a challenging task. However, clinicians, patients, technologists, and other stakeholders can clearly see the needs and the benefits of a viable CPR. It is of note that better-quality, lower-cost, more-available health care may not, in the long run, be the most important benefit the CPR provides.

If health-care institutions succeed in supporting broadly accessible, near-real-time, secure collection and use of data—data that is distributed throughout geographical regions on diverse hardware and software platforms—and are able to offer authorized users access and services contoured to their specific needs, then a model for the distributed use of information appropriate to any industry and to nearly any application will have been developed. The incentives and the technology are here today. With all businesses—not just the health-care industry—standing to benefit, the prognosis for the CPR is guardedly hopeful. ■

ACKNOWLEDGMENT

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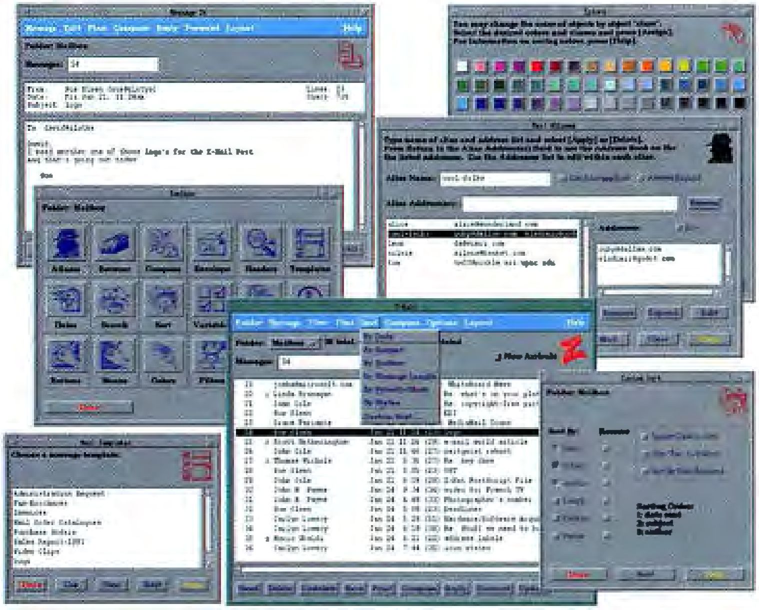
Scott Wallace is a BYTE technical editor. He can be reached on the Internet or BIX at swallace@bix.com.



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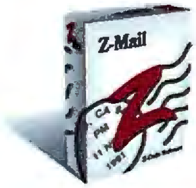

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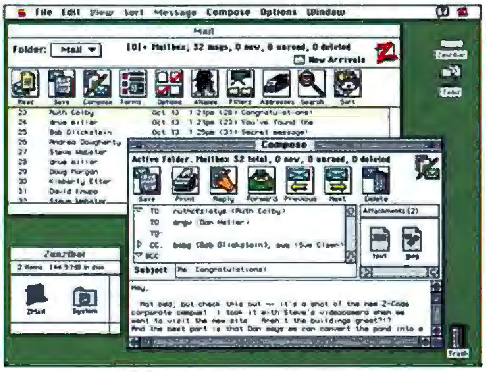

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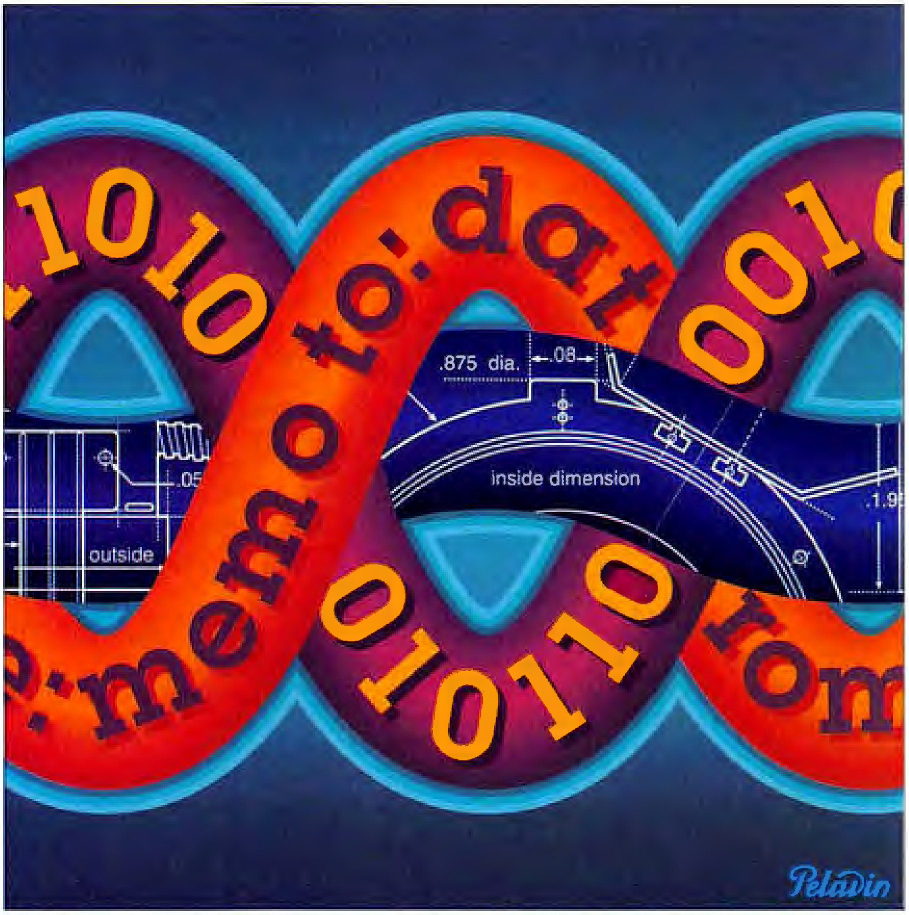
Desktop Data Conferencing



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ANDREW W. DAVIS

A revolution is quietly changing the desktop computing landscape. The resolution of DSP (digital signal processor) standards and the development of programming interfaces promise to dramatically change the nature of the PC peripheral board business. In a short time, companies marketing dedicated modem, sound, codec, and similar add-in cards will replace those dedicated cards with single-card multifunction products. What is making this feasible are new (RAM-based) DSP chips and the multitasking software that enables a single board to take on multiple personalities: You simply download the appropriate algorithms for communications, speech processing, sound editing, or even image/video decompression (see the text box "The High Cost of Videoconferencing?").

While business users have been slow to embrace desktop multimedia, this new breed of mixed-media modems is appealing because it holds the potential to save time and money as it changes for the better the way many of us do our work. The mixed-media modem can bring real-time, remote, interactive sharing of data to the desktop in a low-cost, easy-to-use platform that takes advantage not only of universal POTS (plain old telephone system) lines but of newer LAN and WAN (wide-area network) connectivity as well.

Companies are embracing mixed-media audiographics, or *data conferencing*, as an enabling technology for a variety of next-generation applications. These include lower-cost, higher-performance customer technical-support centers, remote presentations and sales calls, distance learning, telecommuting, and a variety of other remote collaboration applications. Whether the business driver is a need to reduce office space, to comply with the Americans with Disabilities Act, to meet local air pollution/traffic-control regulations, to enhance the effectiveness of remote collaboration, or to improve employee quality of life with work-at-home programs, desktop data conferencing is an increasingly viable option. Indeed, data conferencing might be the first "killer" commercial multimedia application.

Data conferencing might be the first "killer" multimedia application

Teleconferencing

Early teleconferencing products were essentially sophisticated telephones that provided a convenient way for one group of people in a room to converse with another group at the other end of the phone line. The current generation of these products relies on DSP technology to provide high-fidelity audio by balancing multiple microphones and providing signal processing that effectively eliminates room echoes and line delays.

Videoconferencing—which adds video of the meeting rooms to the transmission—allows distant colleagues to meet without the expense, waste, and inconvenience of traveling. Because videoconferencing requires significant investments in equipment and often entails the use of dedicated facilities with special communications lines, its applicability and appeal have been limited.

continued

The High Cost of Videoconferencing

Rising transportation costs and the time-wasteful aspects of travel have focused corporate attention on expensive broadcast-quality videoconferencing systems. But video on the desktop remains a problem. Although many solutions are available, the combination of desktop video and telephony is sure to disappoint—unless users are willing to make hardware investments that represent an order-of-magnitude increase over traditional desktop peripherals. Serious videoconferencing requires dedicated compression components and general-purpose DSP (digital signal processors) to handle the audio and modem algorithms.

Multimedia authoring systems that compress and decompress 24-bit-color, full-screen video at 30 frames per second require relatively wide, within-platform data transfer channels and are not adaptable to telecommunications applications. Teleconferencing systems must squeeze information into low-bandwidth POTS (plain old telephone system) lines. The bit stream weighs in at 18 Kbps even when images are small 160- by 120-pixel snapshots with 8-bit color (typically talking head shots), JPEG-compressed at a 35-to-1 ratio, and updated only four times per second (thus losing lip sync). Sun Microsystems published results stating that researchers "found no evidence that groups are more effective or efficient at solving problems or making decisions when they are connected through a video and audio link than when they use only an audio link."

Hence, in a desktop environment with an analog phone line, users will give up 90 percent of their communications bandwidth to information that adds, perhaps, 5 percent to the value of the communication. Most PC-based desktop videoconferencing vendors offer solutions that require costly, dedicated, high-bandwidth lines. This limits these products' market appeal.

Video has its strength in group-to-group conferencing, where dedicated systems are used. It may offer advantages in long (more than 60 minutes) person-to-person conferencing, since video provides more of the feel of a face-to-face meeting. But for individual business communications, data conferencing is probably the best solution. Bandwidth utilization is more sensible; the information is more useful, and systems without video cost 50 percent to 90 percent less than those with video. Most important, data-conferencing solutions provide high-productivity communications on POTS lines.

The present market attention on PC-based video for multimedia recording, playback, and desktop videoconferencing is misleading. The Apple Quadra 840AV and recent Windows-based machines announced by Acer America and NCR (now AT&T Global Information Solutions/NCR) lend insight into why. Customers generally applaud the Macintosh's sound capabilities but often describe the video as small, grainy, and too slow. Apple, in fact, has focused attention on the machines' new GeoPort telecommunications architecture, a software-based fax/voice/modem running on the motherboard's DSP3210 coprocessor.

Acer and NCR also recognize the limitations of video. They introduced computers with separate dedicated DSP subsystems for videoconferencing functions (which are based on AT&T's AVP 4000 chip set) and general-purpose DSPs for sound, audio, and telecommunications. The Acer motherboard includes two DSP3207s to support the bandwidth required for sound encoding and decoding, sampled synthesis, and echo cancellation, as well as modem, fax, voice coding, and telephone functions. AT&T's VCOS operating system supports multiple DSPs via a utility that balances compute tasks and I/O lines across DSP resources. The NCR architecture is similar, except that the general-purpose DSP for audio/modem and the dedicated ICs for video compression/decompression are on separate add-in boards, not the motherboard.

The Acer and NCR configurations are reflective not only of the compute horsepower needed for videoconferencing on the desktop but of the bandwidth requirements as well—both require ISDN connections. The question that begs an answer is, Why not just use data conferencing—videoconferencing without the video?

VIDEO BANDWIDTH REQUIREMENTS

Image resolution, pixel depth, compression, and the number of frames transmitted per second all affect bandwidth requirements.

HORIZONTAL RESOLUTION (PIXELS)	VERTICAL RESOLUTION (PIXELS)	PIXEL DEPTH	FRAMES PER SECOND	COMPRESSION RATIO	COMPRESSION METHOD	RESOLUTION BANDWIDTH (KBPS)	RATIO TO V.32BIS (19.2 KBPS)
640	480	24	30	1	None	221,184	11,520.00
640	480	8	30	1	None	73,728	3840.00
320	240	8	10	1	None	6144	320.00
320	240	8	10	16	JPEG	384	20.00
320	240	8	24	120	Indeo	123	6.40
160	120	8	5	10	JPEG	77	4.00
352	288	8	2	30	JPEG	54	2.80
352	288	8	10	200	MPEG	41	2.10
320	240	8	10	200	MPEG	31	1.60
120	100	8	2	10	JPEG	19	1.00
160	120	8	4	35	JPEG	18	0.90
352	288	8	2	120	Indeo	14	0.70

TELECONFERENCING OPTIONS

Users can match features to operational requirements and communications links.

	STANDARD PHONE/FAX	AUDIO CONFERENCING	AUDIOGRAPHICS	DEDICATED VIDEO-CONFERENCING	DOCUMENT CONFERENCING	PC DATA CONFERENCING	PC VIDEO-CONFERENCING
Voice	Yes	Yes	No	Yes	No	Yes	Yes
Fax/modem	Yes/no	No/no	No/no	No/no	Yes/yes	Yes/yes	Yes/yes
Whiteboard/file sharing	No/no	No/no	Yes/no	Yes/no	Yes/some	Yes/some	Yes/some
Video	No	No	No	Yes	Still image	Still image	Still image
PC/stand-alone	Stand-alone	Stand-alone	Stand-alone	Stand-alone	PC	PC	PC
Suitable for POTS	Yes	Yes	Yes	No	Yes	Yes	No
Conference focus	Two-way	Group-to-group	Group-to-group	Group-to-group	Individuals	Individuals	Individuals

While traditional videoconferencing systems enable groups to see and hear each other, these systems are not optimized to share on-line information such as spreadsheets, word processing documents, presentation files, databases, scanned or acquired images, and so on. Unfortunately, much of today's business information is on-line—generated and stored on PCs and other desktop workstations. Recognizing this disconnection, several vendors of dedicated videoconferencing equipment are incorporating the data elements into their desktop systems, even though most of these systems today suffer from video compression bottlenecks and requirements for relatively expensive, high-speed communications interfaces (see the text box "DSPs and the PC Mainstream"). While these limitations rule out truly interactive, broadcast-quality desktop videoconferencing on PCs using low-cost multimedia peripherals, what's practical today are data conferencing, collaborative computing, and individual-to-individual communications over a standard phone line (see the table "Teleconferencing Options").

Document Conferencing

Document conferencing is a new variant of screen sharing (previously called *remote log-in*). Instead of having full control of a local system, a remote user shares one or more designated windows with a local user. Most document-conferencing solutions use a whiteboard model. After establishing a desktop-to-desktop connection, the session presents a whiteboard window that both participants view and manipulate.

The whiteboard software includes a complement of drawing, painting, and annotation tools for brainstorming and sketching, enabling you to emulate the interactive discussions that often take place in real meeting rooms. Bit maps of the whiteboard are JPEG-compressed prior to being sent over the wire, and you can save snapshots of the whiteboard for future reference. However, if you want to make existing information from a spreadsheet or other file available, you must "cut" from the application and "paste" the bit map onto the common whiteboard. The whiteboard data is static—changes made in the collaborative window do not affect and are not affected by the "real" data.

A variation on this theme involves pasting objects—rather than bit maps—onto the whiteboard. Using Windows' OLE features, an OLE-compliant application such as a spreadsheet can provide server services to the collaborative program acting as a client. Embedded objects can be edited in the server application, and the editing changes are reflected in the client (whiteboard) application, after an Update command has been executed.

The next step up in document-conferencing capabilities is interactive file or application sharing. Here, you select a window or file that a remote partner can access, and then both of you can review and modify the document through the shared session. The main advantage is that you can directly modify source data, not an intermediate bit map. Most of the vendors marketing whiteboard products intend to add file sharing to their offerings.

Various technical approaches can be used to enable application sharing. One approach captures the Windows GDI (Graphical Device Interface) screen drawing commands and sends these commands over the phone line to the receiving system, where they are executed in parallel. Sending drawing commands and not bit-mapped images makes efficient use of the communications bandwidth while granting the remote and local users access to the same screen.

With document conferencing, you can send text, images, graphics, spreadsheets, and drawings over standard telephone lines using common modems, but voice is not part of the transaction. Because the data is digital, document conferencing readily lends itself to any computer-compatible communications channel, including LANs and WANs. Many of the document-conferencing solutions available today for POTS and LANs require the use of a separate phone line for simultaneous voice and data conferencing. This obviously doesn't work if access is limited to a single phone line or if you are working from a laptop on the road.

Data Conferencing

Data conferencing adds a key element to the document-conferencing equation: simultaneous voice and data transmission on the same communications line. Data-conferencing solutions digitize voice and treat it as one more element in the data stream. Many data-conferencing products were developed and marketed as subsets of desktop-based videoconferencing solutions.

While the host PC can readily handle document conferencing, voice coding for real-time interactive communications over a phone line requires the greater processing power DSPs provide. Fortunately, the new breed of mixed-media modems can accommodate voice coding as one more element in the data management library, although performance may be affected.

Voice is typically digitized at a 12-bit resolution (72-decibel dynamic range) at 8000 samples per second; this is sufficient to handle the approximately 3500-Hz bandwidth of most human speech. A simple "companding" system encodes each speech sample into an 8-bit value, producing a 64-Kbps data stream that exceeds the bandwidth of most modems and phone lines. This results in the need for speech compression, and numerous algorithms have been developed, reflecting a wide range of performance, voice quality, and cost trade-offs. For data-conferencing applications, the goal is to code an analog speech signal into compressed digital format, transmit the data, and then decode to an analog waveform in real time. For personal conferencing using POTS, transmission bandwidth is the primary obstacle.

Two types of voice coding technology exist today. The first type is waveform coders, which deal with signals on a sample-

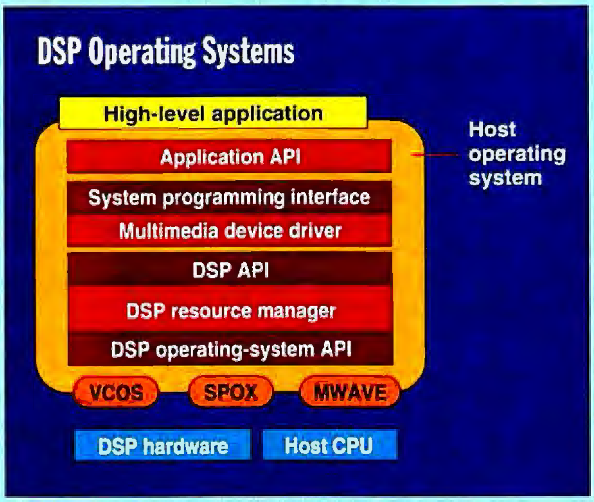
DSPs and the PC Mainstream

DSPs (digital signal processors) are not new, even to desktop computers. If you use a traditional modem or sound board, then you are likely using dedicated DSPs. What is new, however, is the availability of low-cost, high-performance, multipurpose DSPs capable of running several different tasks concurrently. General-purpose DSPs with sophisticated operating systems, algorithm libraries, and friendly programming interfaces are poised to enter the desktop mainstream.

There are several reasons for this. First, DSP vendors are working with PC and workstation developers to provide tight integration with host environments. Products encompass not only the DSP ICs but also sophisticated, preemptive multitasking DSP operating systems, clean interfaces to the host hardware and software, and multimedia libraries addressing a wide range of needs. One example is AT&T's VCOS operating system, which has an architecture based on a DSP kernel, an applications server running on the host, and separate APIs for both. IBM's MWAVE structure is similar (see the figure "DSP Operating Systems").

Standards are a second reason to pay attention to DSPs on the desktop. DSPs have had limited applicability because, until now, DSP architectures were proprietary. This meant that developers had to write high-level applications for each specific DSP hardware implementation. Now, under the auspices of the IMA (Interactive Multimedia Association) Digital Signal Processing Technical Working Group, a set of Windows-based standards is evolving—standards that promise to make it feasible for software vendors to develop applications that are independent of the underlying DSP hardware. A standardized API is the beginning of a new era of multimedia capabilities for Windows. At the center of the evolving standards architecture is the DSP resource manager, which connects any compliant DSP hardware/software engine to standard multimedia device drivers used by high-level applications.

Finally, DSPs are entering mainstream computing because the price/performance of general-purpose DSPs has reached the point where multifunction single-board peripherals cost less than the collection of individual fax, modem, sound, MIDI, or CD-ROM boards they replace. The appeal of a single multimedia peripheral, sharing the cost of hardware across multiple applications, is so strong that a number of vendors (e.g., Apple, NCR, and Acer America) have designed the DSP right into the motherboard. This approach makes the motherboard more expensive, but it lowers the overall system cost—and it also reduces demand on limited-chassis I/O connect space. Expect more vendors—and the market in general—to move in this direction.



With new DSP operating systems, software development efforts can be effectively applied to multiple DSP platforms.

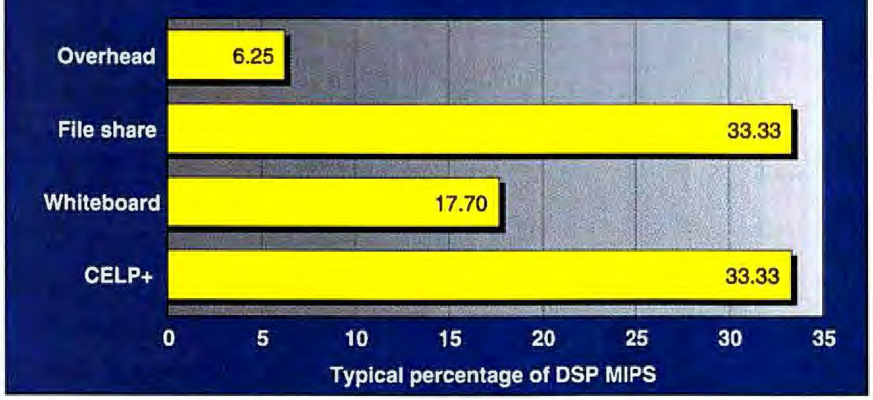
by-sample basis, using only the output signal in the coding process. Waveform coders such as ADPCM (adaptive differential pulse code modulation) make no assumption about the source of the input signal. Computationally simple ADPCM techniques produce bit streams with unacceptable voice quality at data rates below 24 Kbps and with unintelligible speech at rates below 16 Kbps, making them unsuitable for widespread POTS-based telecommunications. Source or parametric coders (or *vocoders*) encode speech signals in terms of parameters that drive a speech production model based on human vocal tract shape and excitation levels. Vocoders are computationally demanding but can operate at much lower bit rates than waveform coders (see the table "Telecommunications and Speech Coders"). Some speech-coding algorithms combine various techniques.

The most common vocoder technology in use today is CELP, or code excited linear prediction, which uses "codebooks" to quantize the input signal. Basic sounds are stored in the codebook and are then modified in amplitude and pitch to reproduce—in a fashion consistent with human vocal-cord anatomy and function—the input voice. The transmitter decomposes sounds into their codebook values and sends pointers plus modifying parameters to enable the receiver to reconstruct the source voice.

The CELP algorithm provides excellent speech quality and is well suited for teleconferencing, although some listeners complain that the resulting voices sound somewhat artificial. CELP is compute-intensive, however, straining even DSP resources. On a 16.7-MIPS DSP, 4800-bps CELP compression can consume approximately 90 percent of the DSP processing resources. Variations on CELP take advantage of higher output bit streams (less compression) or enhanced codebook search algorithms to reduce the computational load. One recent modification is CELP+, developed by Bell Labs and used in AT&T's PC-based TeleMedia conferencing system. CELP+ produces high voice quality at 6400-bps bit streams and consumes fewer DSP MIPS than earlier CELP approaches. The CELP+ algorithm and the V.32terbo modem algorithm can execute on a single DSP3210-based communications subsystem. Coded speech data is multiplexed with other digital data within the overall transmission envelope provided by the modem (19.2 Kbps), resulting in a POTS-compatible, desktop audiographics engine.

continued

DSP Resource Allocation



Typical demands on modem bandwidth during audiographics teleconferencing sessions. A combination of high-speed modem services and speech compression can consume nearly all of a typical DSP's resources (16.7 MIPS).

Performance Considerations

Data conferencing applications can place strenuous demands on desktop computers. Analysis of the MIPS requirements for different DSP tasks shows that the combination of high-speed modem services and concurrent speech compression consumes nearly all of today's mixed-media modem DSP (16.7-MIPS) resources (see the figure "DSP Resource Allocation"). Attempting such a task without a DSP, even on the new Pentium and PowerPC processors, won't provide satisfactory performance.

Once the connection is made, all data must fit into the performance envelope of the modem; this is where modem speed really counts. V.32 is the practical bottom end for data conferencing, and the new V.34 modems with 28,800-bps capabilities promise to make personal teleconferencing even easier and more interactive. Depending on the compression algorithm executed and the throughput of the modem, voice will consume 30 percent to 60 percent of the modem bandwidth.

Data-conferencing applications present multidimensional challenges to hardware and software designers. Design trade-offs involve compression factor, speech quality, computational complexity, and line delay. Compression algorithms are bounded on the high end by available MIPS and on the low end by the output bit stream, which must not exceed transmission-line bandwidth. More sophisticated modem algorithms like V.34 consume more MIPS but support more bandwidth, which, in turn, accommodates less compressed, more realistic speech.

VoiceSpan and VoiceView

An alternative technique to incorporating voice in PC-based personal conferencing is now available through VoiceSpan technology from the AT&T Bell Laboratories group. VoiceSpan increases the capacity of existing phone lines by splitting a single line into three virtual channels: one for voice or low-quality audio, one for data, and a third virtual channel for control information. With VoiceSpan, users can talk over the phone while simultaneously sending data, faxes, still images, or data from file-sharing applications.

Unlike other products, VoiceSpan is not based on speech coding or analog signal compression. In fact, voice is not converted to bits-per-second data. Rather, VoiceSpan channel coding is based on an extension to the digital data techniques employed in full-duplex, equalized, echo-canceled modems that provide simultaneous communication of both digital and analog information. A DSP digitizes and maps the analog voice signal into a combined analog-and-data signal suitable for communication through a POTS line over modems using QAM (quadrature amplitude modulation) techniques.

VoiceSpan also defines methods for automatically or manually originating and answering calls, as well as for interoperating with standard phones, faxes, and modems. The first product to embed VoiceSpan technology is the Paradyne DataPort 2001 modem. The 2001 provides 14.4-Kbps transmission when acting as a standard modem, or 4800 bps for data while simultaneously transmitting voice. AT&T Paradyne bundles the product with FarSite whiteboard software from DataBeam, and the technology has been licensed by various companies in the phone, games, computer, fax, and copier businesses.

Early this year, Radish Communications Systems announced a voice-modem technology, called VoiceView, that enables the integration of voice, data, and fax over a POTS line within a single phone call. The mixed-media communications are not simultaneous, however; you switch between them sequentially.

TELECOMMUNICATIONS AND SPEECH CODERS

ALGORITHM	BIT STREAM (KBPS)	DSP REQUIREMENTS (MIPS)
Parametric coders		
LPC10 (FS1015)	2.4	9 to 11
CELP (FS1016)	4.8, 7.2	15
CELP+	6.4, 6.8	5.8 to 6.3 (AT&T)
VCELP (cellular phones)	7.95	15 to 19
LMCELP (low-memory CELP)	4.8, 7.4	13 to 15
LDCELP (low-delay CELP)	8	19.6
G.728	12.8, 14.4, 16	16.5
TrueSpeech	6.8, 7.2, 8, 11	7 (DSP group)
Waveform coders		
G.726	16, 24, 32, 40	5 to 8
G.722	48, 56, 64	9 to 10.2
G.711	48, 56, 64	0.6
Modems		
V.22bis	2.4	~5
V.32bis	14.4	9.6 to 9.9 (AT&T)
V.32terbo	19.2	10
CCITT G3 fax	9.6	9.3

Data courtesy of DSP Software Engineering, Inc. (Bedford, MA)

Future

For professionals working on PCs and workstations who need to collaborate with others at different locations, the new DSP-based multimedia peripherals could become an important computing companion. Combining collaborative data sharing with simultaneous voice and operating over standard phone lines, data-conferencing solutions will let globally dispersed users with phone access work as if they were in their offices and at their desks. ■

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Wide-area wired communications and network-access services are rapidly being augmented by more flexible wireless solutions

DAVID A. HARVEY AND RICHARD SANTALESA

The year 1921 marks the first recorded use of mobile wireless in the form of two-way radio communications by the Detroit Police Department. A quarter of a century later, in 1946, the first mobile telephone rang through the air. Until recently, however, ubiquitous wireless connectivity seemed as fanciful as the communicators used on *Star Trek*. Not any more.

Today, wide-area wireless communications span the radio spectrum from the low kilohertz bands to the ultrahigh microwave frequencies (see the figure "Frequencies for Wireless Data Communications"). Even Orbit, a proposed telecommunications device from Bell Northern, is supposed to affix (in the best Captain Picard style) to your clothing. The wired ties that bind you to your wide-area communications, data transmission, and network-access services are rapidly being augmented by more flexible wireless solutions.

Catch the Wave

Since our last look at wireless mobile communications (February 1993 BYTE), the wireless market has evolved dramatically. CDPD (cellular digital packet data), which rides atop the existing analog cellular infrastructure to provide a digital data capability, has moved from the drawing board into the market with the backing of industry big guns such as AT&T, Bell Atlantic Mobile Systems, Nynex, GTE Mobilnet, PacTel, Southwestern Bell, McCaw Cellular, and Sprint. In response, RAM Mobile Data (Woodbridge, NJ), a data-packet-radio joint venture of BellSouth Mobile Systems and RAM Broadcasting, announced in early March flat monthly rates of $25 for up to 100 KB of messaging, $75 for up to 400 KB with additional messaging at 20 cents per KB—approximately 10 cents per packet—and $135 for unlimited messaging. The effects of such competition will be to bring wireless more quickly within the reach of more users.

In addition to wireless service providers, a slew of value-added companies are riding the wireless wave to double-digit growth. RadioMail, which provides links between user-wired E-mail services and the Ardis or RAM Mobile Data networks, and Wireless Telecom, a wireless hardware and gateway distributor, have experienced rapid expansion. In fact, RadioMail announcements of additional services and alliances are almost a weekly phenomena; its latest announcement introduced a wireless fax service complete with customized cover sheets at 99 cents per domestic page.

Further fueling the wireless marketplace is an increasingly broad range of wireless-enabled hardware and software products. On the hardware side, Dell Computer's new line of Latitude notebooks ship with a comprehensive communications package called CommWorks from Traveling Software, as well as a free subscription to RadioMail. Also, IBM's recent ThinkPads offer wireless connectivity, and AST's newly released PalmPad lists similar capabilities as an option.

On the software side, nearly every major LAN E-mail package and numerous stand-alone communications packages have added or are scrambling to add wireless support. Lotus cc:Mail, Microsoft Mail, WordPerfect Office, Da Vinci eMail, CE Software's QuickMail, and Connect Software's E-Mail Connection 2.0 all work with wireless services. E-mail is quickly moving beyond the LAN.

At the Speed of Light

Wireless technology breaks down into one-way and two-way communications. One-way communications, best typified by paging services, allows broadcasts of information to single or multiple receivers. Perfect for dispatching messages, news updates, pricing information, and routing assignments, one-way communication is a cost-effective method for delivering information to those who are able to easily respond through terrestrial means. For example, a number of financial institutions are using EMBARC's (Boynton, FL) one-way messaging service to post up-to-the-minute mortgage rates to all their branches and field-loan officers. The most interesting developments in one-way messaging come from products like Motorola's NewsStream PCMCIA cards coupled with providers like EMBARC to deliver information from various news services anytime, anyplace.

While one-way broadcasts play an important role—their lower price and one-to-many broadcast abilities make them extremely useful for information delivery—two-way communications will shape your untethered working future by allowing connection to LANs, wireless pay phones, real-time conferencing, and more. The three most important two-way technologies are analog cellular, RF packet radio, and CDPD.

Signals and Packets

One of the simplest forms of wireless communication is analog cellular. Designed originally for voice communications, analog cellular operates much like a land-line-based telephone—indeed a cellular call travels for most of its distance via land lines. Transmitting data over analog cellular requires a modem that links to your cellular service or phone.

Cellular gets its name from the hexagonal cells (which are roughly 8 miles in diameter but smaller in densely populated areas with heavy traffic) served by a single base station (i.e., a setup common to most wireless services). Moving between cells requires that your signal be handed off between adjacent cells. This is no problem for voice signals filled with gaps and pauses; however, add in data, and without special protocols or equipment, every handoff is a potential fouled transmission. Indeed, the problems with data transmission over analog cellular are manifold and are so inherently related to the nature of analog that in the long run, packet-based communications will be the way to go.

Packet-based communications represents the next step up the ladder of complexity. The basis for services such as RAM Mobile Data and Ardis and for technologies such as CDPD, packet-based communications is far better suited for

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Frequencies for Wireless Data Communications

Cellular	Private land mobile	Narrowband PCS	Industrial	Common carrier paging	Point-to-multipoint Point-to-point	PCS	Industrial
824–849 MHz 869–894 MHz	896–901 MHz 930–931 MHz Includes RF packet radio services such as RAM Mobile Data	901–902 MHz 930–931 MHz	902–928 MHz Unlicensed commercial use such as cordless phones and LANs	931–932 MHz Includes national paging services such as SkyTel	932–935 MHz 941–944 MHz	1850–1970 MHz 2130–2150 MHz 2180–2200 MHz	2400–2483.5 MHz Unlicensed commercial use such as LANs

The FCC has divided the available spectrum to support a variety of radio-based services. It is responsible for defining the limits of each class of service.

data transmission than analog. Even voice is moving to packets. In the future, voice cellular will take the packet route using CDMA (code division multiple access) and TDMA (time division multiple access). Both of these technologies increase the cellular capacity: TDMA by a factor of three and CDMA by 10 times over existing analog cellular systems. In part, this increase is due to their packet nature.

The advantages that packet transmission has over conventional circuit switching include the following:

- Robustness: Carrier loss between packets is typically not a problem.
- Security: Encryption on small packets is easily handled.
- Per-packet billing: Short messages, which encompass the majority of E-mail traffic, can be sent inexpensively, charging only for transmission air time.

The logic behind packet use is irrefutable. Radio is synonymous with interference, drop-outs, and static. This, in turn, dictates that wireless data transmission (where every bit counts) include robust error correction, either via cellular protocols—such as Microcom's MNP10, AT&T Paradyne's ETC (enhanced throughput cellular), and USRobotics' HST Cellular—or through the actual transmission mechanism (i.e., CDPD's TCP/IP or the Mobitex packet-based transmission architecture that RAM Mobile Data uses).

Analog radio transmission, particularly voice transmissions, maintain one advantage over pure digital wireless. Analog radios degrade more gracefully than digital radios as determined by a concept known as fade margins. *Fade margin* refers to the tolerated level of signal decay before communications cease. With digital, the distance between a completely valid signal and one that's totally useless is small and abrupt.

Using RF Packet Radio

Unlike analog cellular, packet communications is not connection-oriented; with RAM Mobile Data, for example, your radio modem is connected as long as it's turned on.

The message path from RAM Mobile Data to CompuServe is typical of packet wireless operation. Once powered on, the wireless modem identifies itself to the local base station, each of which provides up to 16 separate radio channels. If you need additional capacity, more than one base station can serve service areas known as MSAs (Metropolitan Statistical Areas). According to RAM Mobile Data, each channel can handle between 1500 and 5000 packets per hour.

To communicate, existing RAM Mobile Data–compatible modems, such as the Mobidem (Ericcson GE Mobile Communications), broadcast at 896 to 902 MHz and receive at 935 to 941 MHz. The modem establishes a link with your computer, and as the message text arrives from your system, the modem breaks it into packets with a maximum size of 512 bytes. Each packet is preceded by a header that can be up to 33 bytes long. The header contains a 3-byte sender code, a 3-byte addressee code, a 1-byte flag, a 1-byte packet-type marker, a 22-byte space for other addressees, and finally, a 3-byte network time stamp.

To ensure against multipath interference, the modem applies a Gaussian Minimum Shift Keying, or GMSK, modulation to the signal. In addition, it levels 16-bit CCITT standard CRC (cyclic redundancy check) error detection and correction on top of the Hamming error-correction coding applied to each byte. Before transmission, the modem interleaves the data blocks. According to RAM Mobile Data, the interleaving means that a fade-induced error burst of 20-bit duration results in no more than 20 correctable single-bit errors in the 20 Hamming-encoded data words; therefore, no retransmission is required.

As it assembles the packet, the modem checks signal strength, verifies the connection to the base station, and transmits at 8 Kbps. At the base station, the received packet is verified, and a receipt verification is transmitted back to the Mobidem. From the base station, the header information is analyzed, and the data is relayed to a local switch—usually over a wired network or system. From there, it passes to a long-distance carrier switch that confers with a national control center. Here, RadioMail's system tallies billing charges and routes the complete final message through its Internet gateway to CompuServe's Internet gateway for delivery. At present, RAM Mobile Data transmissions are limited to text-only messages delivered by means of the RAM Mobile Data–compatible modems and services.

CDPD Hops

Compared to the packet-radio networks, the nascent implementations of CDPD are more flexible, allowing a CDPD-compliant modem to serve both packet-based data and analog voice communications. CDPD is a clever hybrid of packet-based transmission and channel hopping that takes advantage of the natural pauses within voice transmissions. Like the RAM Mobile Data and Ardis schemata, CDPD breaks data into packets. (It uses GMSK modulation and Reed-Solomon forward error-correction code.) Also, as with packet networks, CDPD sends data on one set of frequencies and receives it on another. What differs is that CDPD was designed to work on top of the same bandwidth as

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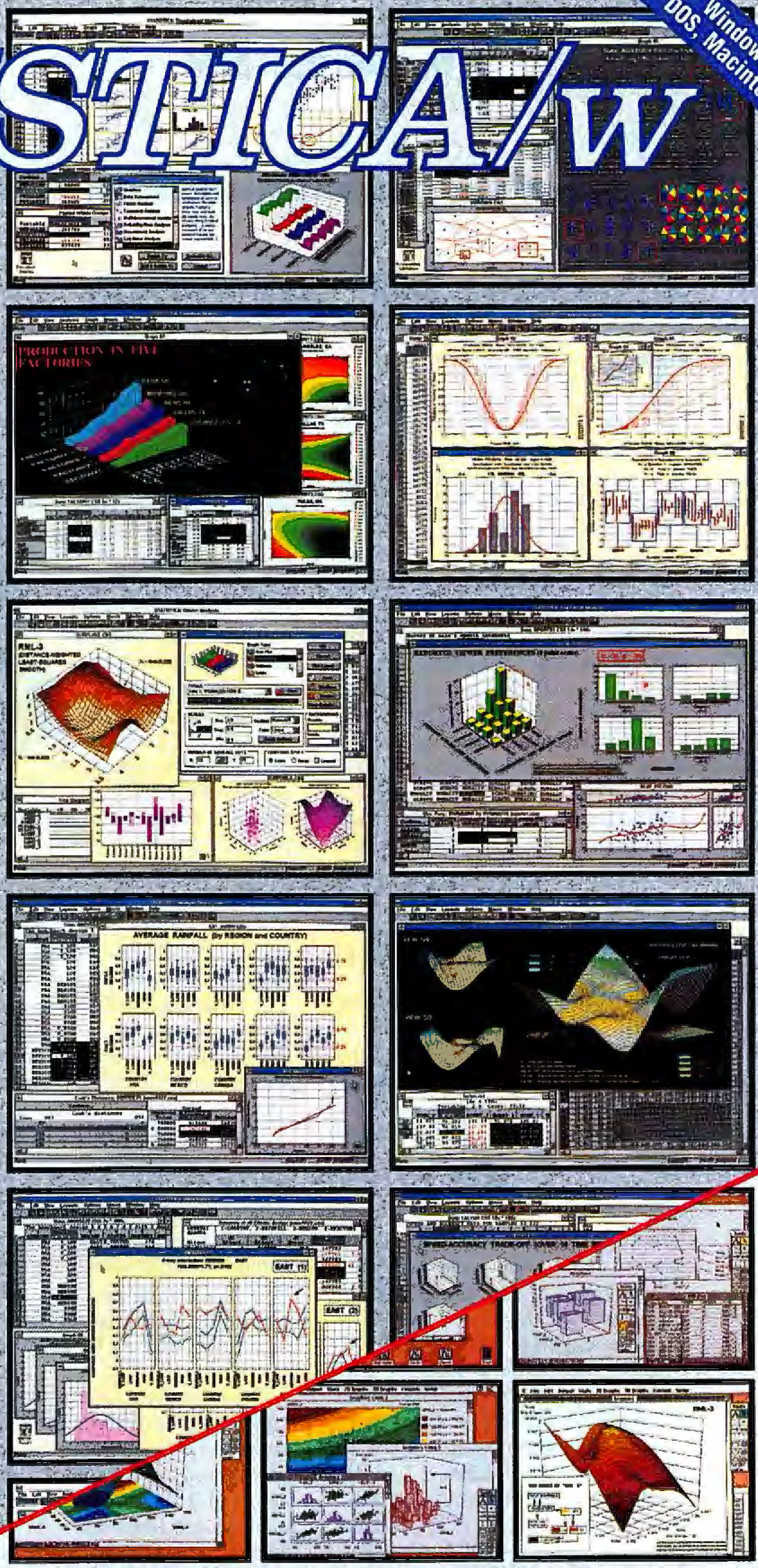

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analog voice transmissions. This feat of packetized contortion is achieved by CDPD's channel-hopping protocol.

A CDPD device works by "listening" for the idle time within voice calls. When the device detects a sufficient idle interval, it sends a packet using the full 30-kHz bandwidth of the channel. If the channel is full, a CDPD device "hops" to another channel and repeats the listening/sending/hopping cycle. Corporate connectivity is greatly facilitated through CDPD's built-in support of TCP/IP, allowing interconnection of LANs, WANs, the Internet, and other information services.

CDPD-compliant devices, just beginning to roll off the assembly lines, allow users access to both traditional voice cellular, as well as packet-switched CDPD transmission. This is a needed step, especially for personal communication devices that need to incorporate existing wireless phones to make a move toward ubiquity.

The only problem with CDPD is that it has limited coverage. At the time of this writing, all that exists are test networks in Las Vegas and California. Although promised for early 1994, current estimates see most providers (including McCaw, GTE, and Bell Atlantic) rolling back start-up dates to the second or third quarter of this year.

Packets to PDAs

An added boost to wireless transmission is the newly formed wireless modem standards committee of the Portable Computer and Communications Association. By the end of the year, it will approve a standard interface for wireless modems based on the same Hayes AT modem command set that wired modems currently use. This will greatly ease the problems of software developers and make it easy to interoperate wired and wireless modems.

The interface standard will merge nicely with the current move away from 1-pound wireless modems, exemplified by the Ericcson GE Mobidem and Motorola's InfoTac, to newer PCMCIA form-factor wireless modems. Today, the range of wireless PCMCIA devices available is restricted to paging cards and two-way wireless LAN cards. You can buy a Hewlett-Packard 100LX with a Mobidem wireless modem, but imagine how much more attractive the bundle would be if the modem were a low-power PCMCIA card.

The introduction of wide-area wireless

PCSes Are Coming

Today, a new form of wireless service is generating a lot of excitement. While CDPD (cellular digital packet data), packet radio, and eventually digital cellular will play the dominant roles in long-distance wireless communications, a new set of services called PCS (personal communication services) could change the face of short-distance wireless.

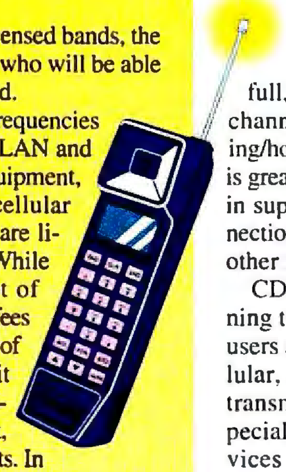
PCS denotes a group of wireless services ranging from pay phones to sophisticated PCNs (personal communication networks). PCS is not intended as a replacement for existing fixed-wire or cellular-based systems: rather, it will coexist by providing localized services such as inter-office and campus-wide voice, fax, and data. For the most part, PCS will be facilitated by PCNs operated by licensed providers, but some bandwidth will be reserved for unlicensed usage such as ad hoc LANs.

PCS is designed for localized implementations: The cells are smaller than conventional cellular, and the transmitters are less powerful. The advantage PCS brings to the airwaves over existing packet- and cellular-based systems is wider bandwidth.

Making Room

Regardless of the type of the transmission and service—whether cellular, microwave, AM, FM, HAM, or shortwave—all wireless technologies use wavelengths of different frequencies that occupy the electromagnetic spectrum. Most radio bands for digital information exchange (including voice) lie between cellular's 800 to 900 MHz and the unlicensed 2.4-GHz bandwidth slated for wireless LANs. Above that, you will find products such as Motorola's 18-GHz Altair Plus II LAN.

In the U.S., frequency allocation and licensing is the province of the FCC. In the case of unlicensed frequencies, the FCC simply allocates the band and sets the guidelines for proper usage. With licensed bands, the FCC actually decides who will be able to transmit in the band.



While unlicensed frequencies are used for wireless LAN and cordless telephone equipment, the frequencies for cellular and RF packet radio are licensed by the FCC. While this adds to the cost of wireless via licensing fees and limits the number of users and providers, it defuses a potential radio babel of rampant, uncontrolled broadcasts. In the cellular bandwidths, for example, the FCC allows one land-line-based provider and one alternative provider per metropolitan area.

The FCC has allocated 160 MHz of bandwidth for PCS, 40 MHz is allocated for unlicensed users, and 120 MHz for licensed providers between 1.85 GHz and 2.2 GHz. The FCC auction of the commercial bandwidths of the spectrum is slated for this month, with announcements of projected PCS services likely by this summer.

One of the hurdles that PCS faces is that there are already occupants within its licensed bandwidth. FCC rules require that PCS licensees pay for the relocation of current tenants. This is certain to add to the time it will take PCS to come of age. Thus, the winners in the looming auction of PCS frequencies may not be home free once the auction is over.

Once frequencies are cleared and established, the methods through which voice and data are transmitted and received need to be determined and standardized. Except in rare cases, these methods are frequency-independent; what governs their use is the type of information being transmitted, the range of the transmission, the sensitivity of the transmission to error, and of course, the broad morass of politics and industry infighting. In other words, don't look for PCS anytime soon.

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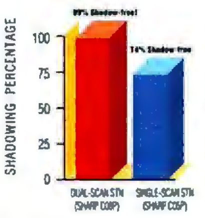

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Unlike earlier assays in PDAs, the Motorola Envoy is built from the ground up to support ubiquitous wireless connectivity.

PCMCIA devices will drive the young PDA market. Anywhere, anytime communications is the ultimate killer application for PDAs, a lesson that many companies have taken to heart seeing the disappointing sales of the Apple Newton. One of those paying attention has been Motorola, which introduced its Envoy communicator in March. Built around General Magic's Magic Cap operating system and Telescript communications language, the $1500, 1.6-pound Envoy boasts a wide range of software and hardware telecommunications capabilities, both wireless and wired. It includes subscriptions to America Online, AT&T PersonaLink, and RadioMail. With Telescript support in AT&T's PersonaLink, you can use the Envoy to send intelligent agents to other users or service providers (see "Agents Away" on page 113).

Of main interest to wireless communications is the Envoy's integrated 4800-bps MDC wireless packet modem that taps into the Ardis network. Combined with a range of applications powered by a 32-bit processor, the Envoy is an advanced look at what the wireless future storming its way into the business world holds. Motorola plans to introduce additional wireless PDAs using Newton Intelligence and Microsoft's WinPad operating systems, both of which it licensed.

While Apple's Newton MessagePad and Sharp's Expert Pad lack built-in two-way wireless ability, third parties are stepping in to fill the gap. ETE offers the ETE Communicator for Sharp's Expert Pad. Pricing starts at $500 for a version sporting a cellular phone with a wired 14.4-Kbps data/fax modem. An optional wireless modem ties the Expert Pad into the RAM Mobile Data network.

Even though the wireless world still has much work ahead of it in laying the final touches on a nationwide infrastructure that reaches even rural areas, the moving curves of falling prices, increased wireless competition, new pocket-size devices, and the competitive business advantage that wireless brings points to one conclusion: The end of the decade will mark a communications landscape where wireless is mainstream. ■

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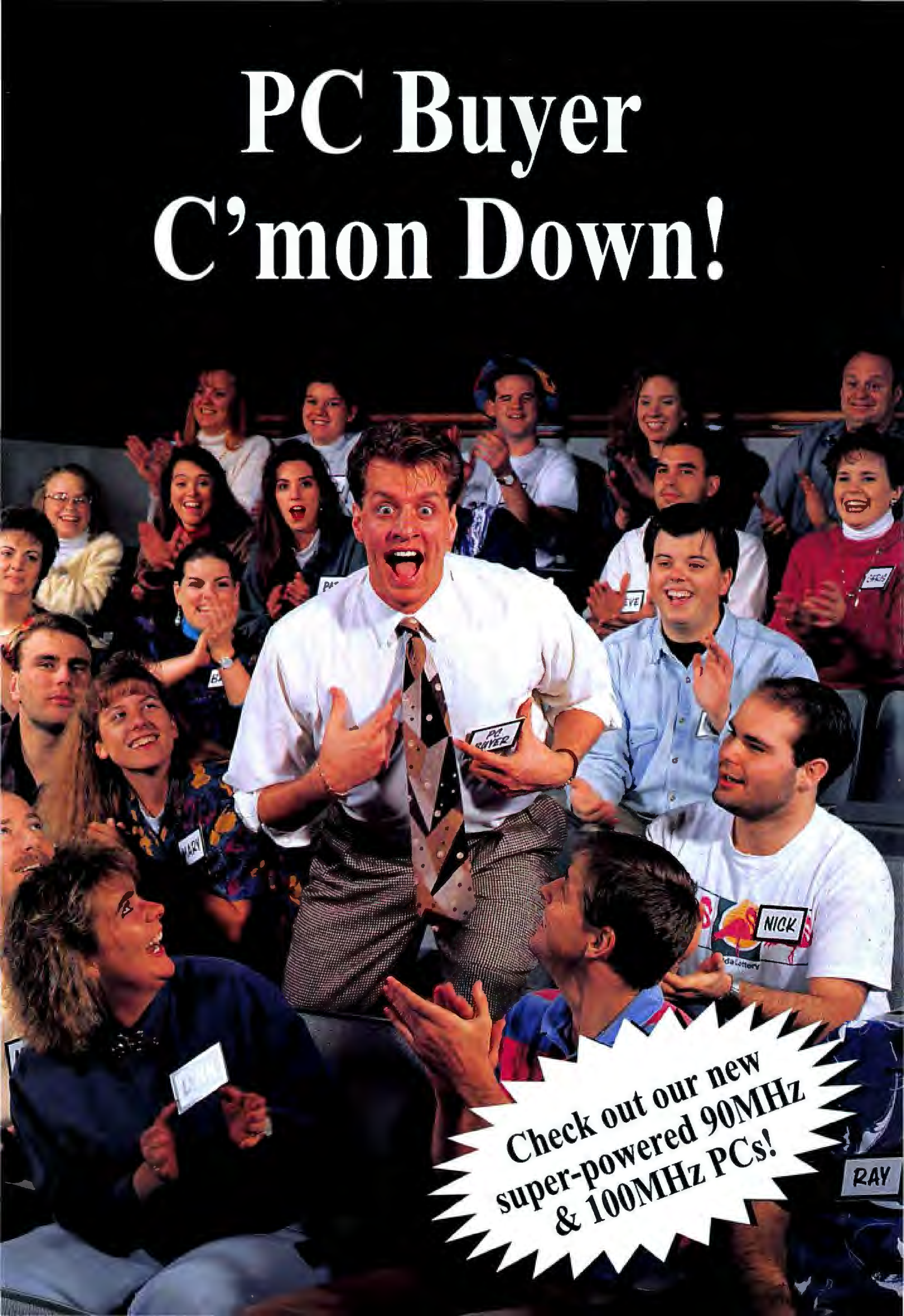

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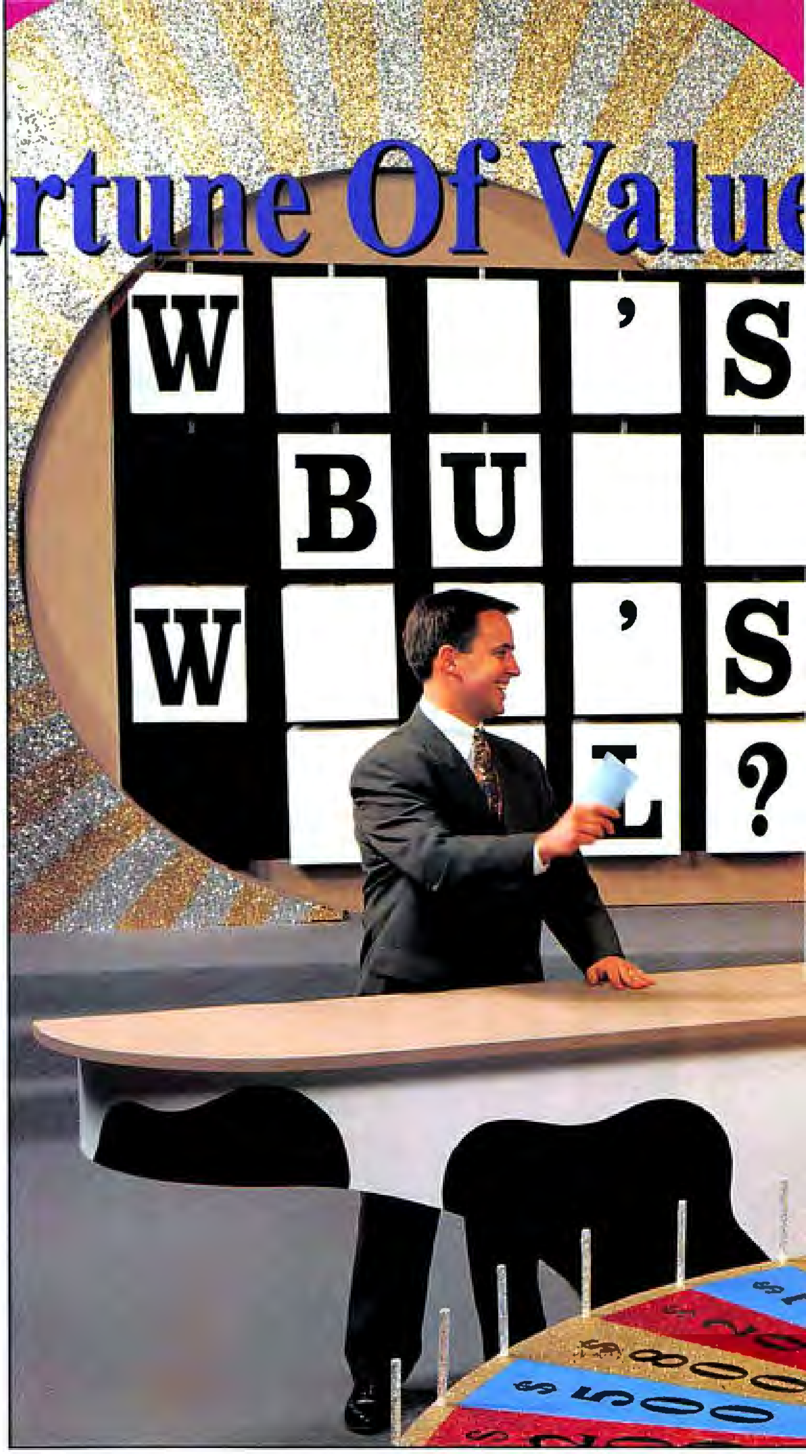

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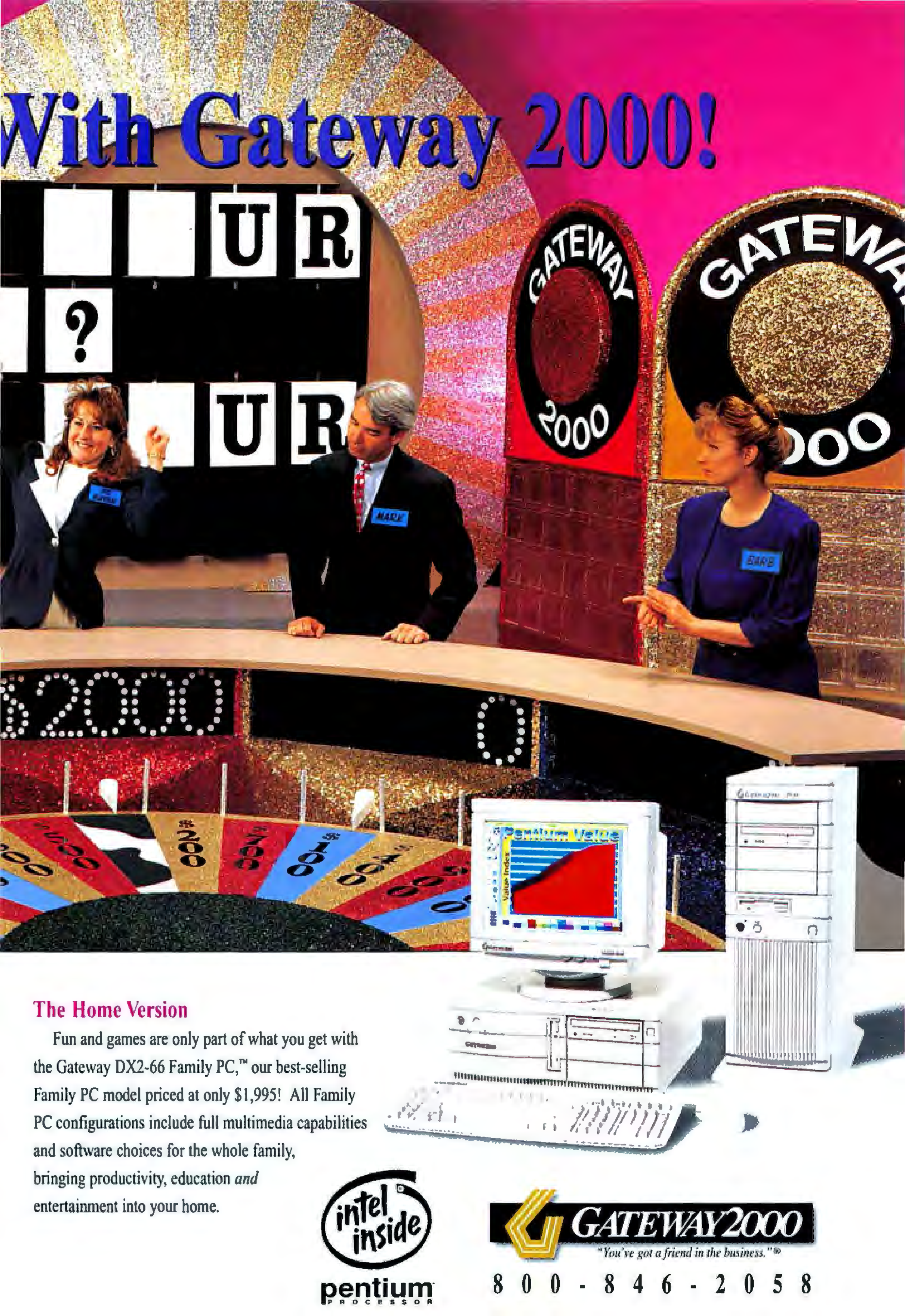
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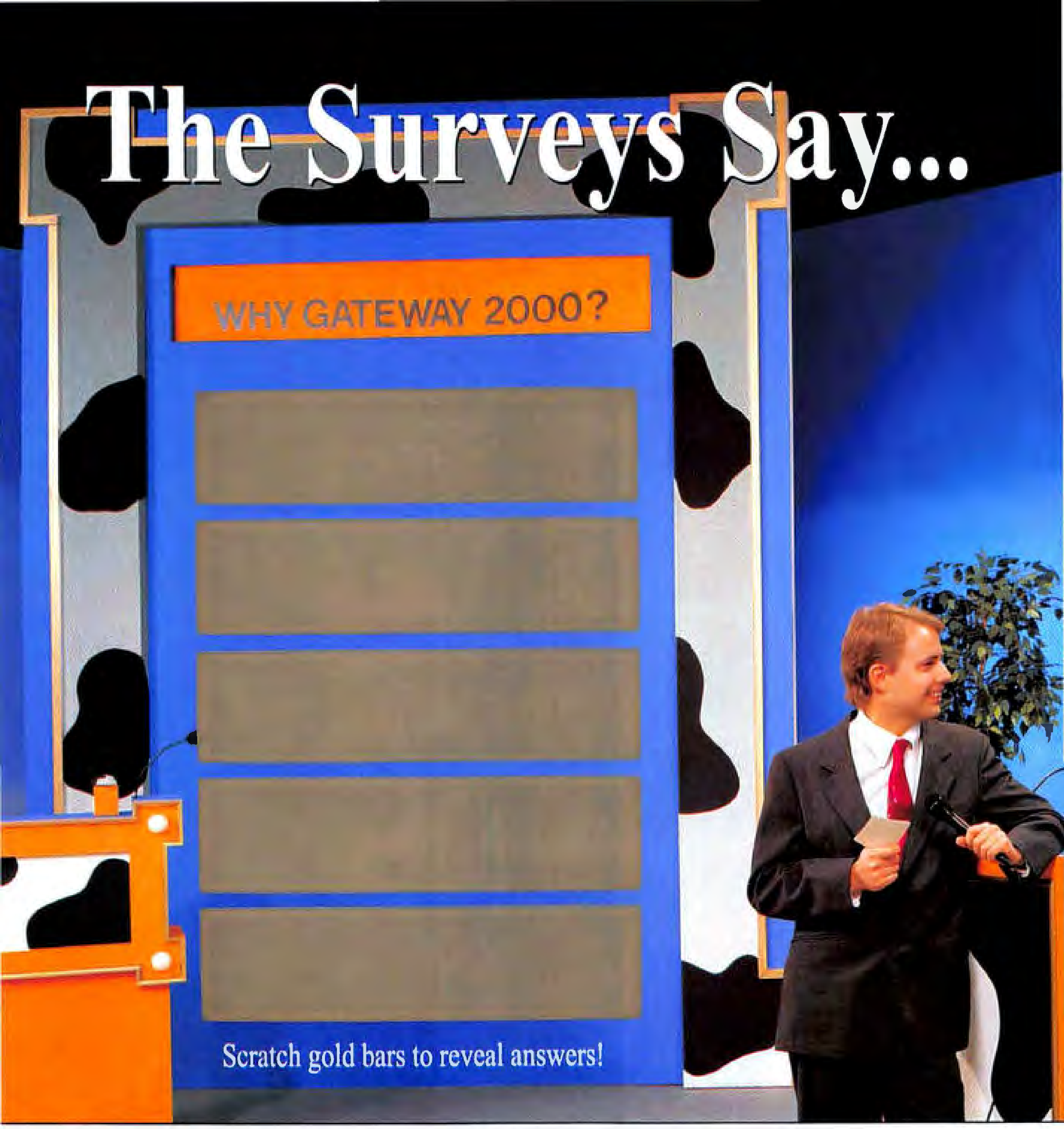

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PC World's 1993 World Class Awards found readers honoring Jateway 2000 with top honors in five categories including Best Service and Support (for the second year in a row!) and Best Mail Order Company. Thank you, *PC World* readers!

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Universal Wireless LANs

A new IEEE standard promises to bring interoperability to the wireless LAN marketplace

CEES LINKS, WIM DIEPSTRATEN, AND VIC HAYES

RAPHAEL LOPEZ © 1994

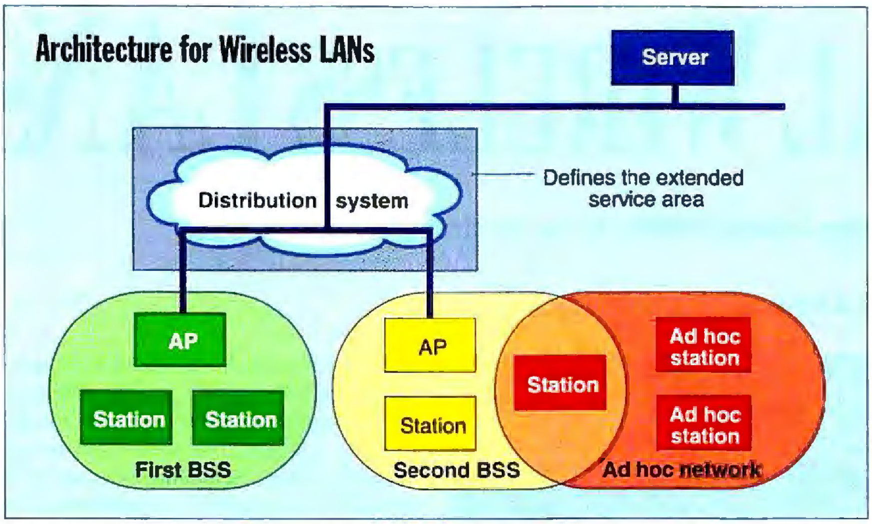
The wireless LAN marketplace is heating up. By giving you the ability to roam throughout a coverage area while remaining connected to your LAN-based services, wireless technology is a natural fit for today's horizontal corporations and mobile workforce. But as the market is flooded by interested parties—hardware manufacturers, system integrators, and computer manufacturers—the need grows for interoperability between competing products.

The worldwide authority on standardization in wireless LANs is the Wireless Local-Area Networks Standards Working Group, IEEE Project 802.11. Since 1990, the Project 802.11 committee has worked to establish a universal standard for the wireless marketplace. Recently, the committee selected the DFWMAC (distributed foundation wireless media access control) protocol proposal from AT&T Global Information Solutions/NCR Microelectronic Products Division's Wireless Communications and Networking Division, Symbol Technologies, and Xircom as the foundation for the development of a wireless LAN standard. Widespread adoption of the technology embodied in DFWMAC will ensure a vital and interoperable wireless LAN marketplace.

Requirements and Architecture

The initial task of the Project 802.11 committee was to analyze the applications and environments in which wireless networks are used. As early as March 1992, the committee formally established the functional requirements for a wireless LAN protocol.

The Project 802.11 committee established the minimum functional bandwidth at 1 Mbps. This was deemed necessary for common operations such as file transfer, program loading, transaction processing, multimedia, and manufacturing process control. For applications such as digital voice and process control, which require transmission of real-time data, the committee decided to require support for time-



In this example, two BSSes are interconnected by a single distribution system that also provides a gateway to off-site networks. The ad hoc network coexists with the infrastructure network and interoperates with it.

bounded services, which limit the packet delay variance. It also identified the need for reliable operation in a wide range of environments, including financial, retail, office, school, and industrial settings. In addition, it was decided that mobile computing should at least support pedestrian speeds of several miles per hour, with a vehicular-speed option for industrial users.

To address these requirements, the Project 802.11 committee formulated a basic architecture for wireless LAN systems. Generally speaking, wireless networks break into two types. The first type is infrastructure-based networks that let you roam through a building (e.g., a store, a hospital, or a manufacturing floor) while maintaining a connection with the organization's computer resources. Usually, wired networks form the foundation for wireless-network infrastructures. The second type is an ad hoc network that any number of users can set up instantly, as might be desired when meeting in a conference room, for example. The 802.11 architecture allows for overlap by using the same basic access protocol for both ad hoc and infrastructure-based networks. The basic architecture lets multiple networks share the same medium, using the same channel, thus ensuring a high degree of efficiency in frequency usage.

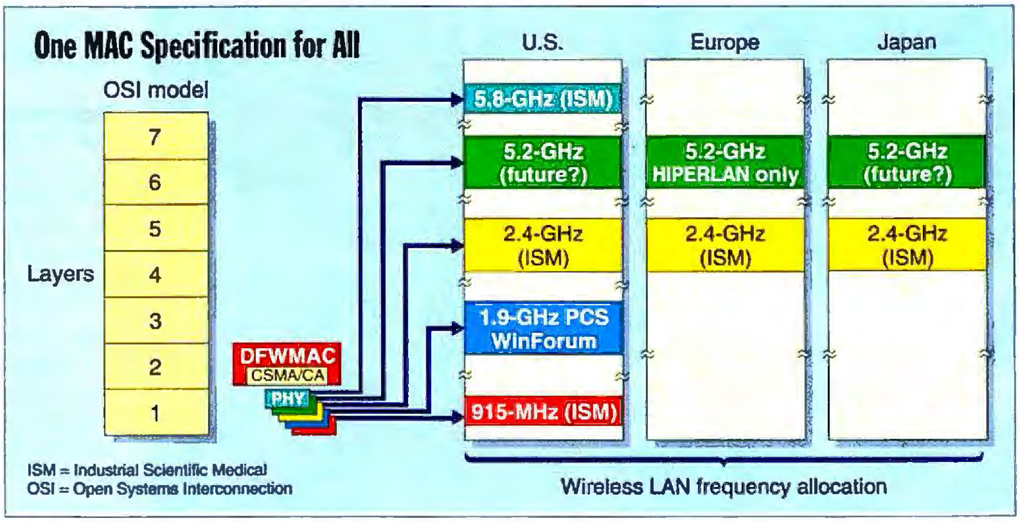
The Project 802.11 committee also defined the different components of a wireless LAN. A single cell within an infrastructure-based network is called a Basic Service Area, or BSA. The size of any cell is dependent on the environment and the power of the wireless transceivers. Any single BSA can contain a number of discrete groups of wireless stations. Multiple BSAs can cover larger areas, interconnected by APs (Access Points) and a distribution system (which is usually wired). Such interconnected BSAs form an ESA (Extended Service Area). The group of stations that are associated to the same AP is called the Basic Service Set, or BSS. The set of stations within multiple BSSes that are connected via a distribution system forms an ESS (Extended Service Set). The figure "Architecture for Wireless LANs" illustrates the basic architecture of wireless LANs.

The Reference Model

The Project 802.11 committee uses a reference model that divides protocols for wireless communications into two main groups. The first group of protocols is a common MAC (media access control) specification for all wireless networks. A single, medium-independent MAC protocol provides a unified network interface between different wireless and wired networks.

The second group of protocols are the PHY (physical) specifications for medium-dependent protocols. In wireless communications, the medium is defined by signal characteristics in a particular bandwidth of frequencies. There are different PHY specifications for each frequency bandwidth supported in Project 802.11. For example, there are different PHY specifications for the 915-MHz bandwidth, the 2.4- and 5.2-GHz bandwidths, the infrared bandwidth, and so on. The figure "One MAC for All" shows PHY layers supported by the IEEE Project 802.11 proposal.

Defining the reference model resulted in a list of criteria that any MAC proposal had to address, with support for multiple PHY specifications being one of the most important. Because NCR, Symbol Technologies, and Xircom individually use different PHY layers, support for multiple PHY technologies was built into the DFWMAC protocol proposal. Other proposals on the table were more focused toward a specific PHY layer. Other important criteria that must be met include



Wireless networks use many different unlicensed frequencies, including regions in the infrared, 915-MHz, and 2.4-GHz bandwidths. The DFWMAC layer supports underlying PHY layers in multiple-frequency bandwidths in multiple regions of the world.

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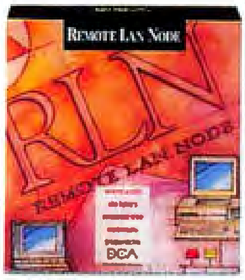

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THE EVOLUTION OF A STANDARD

DFWMAC (distributed foundation wireless media access control) has an involved parentage that demonstrates the standards-definition process in the 1990s. AT&T Global Information Solutions/NCR Microelectronic Products Division's Wireless Communications and Networking Division entered the wireless market in 1990, specializing in direct-sequence spread-spectrum technology. NCR became a market leader and in 1992, was joined by Symbol Technologies (San Jose, CA) in proposing a wireless LAN standard. The NCR/Symbol integration began due to customer demand to both companies for interoperability of their products.

The NCR/Symbol proposal was not alone, however. In the past three and a half years, the Wireless Local-Area Networks Standards Working Group, IEEE Project 802.11 has received over 11 proposals for a MAC (media access control) specification from various market players. These proposals have fallen into two main groups: distributed-access protocols, which, like Ethernet, distribute the decision to transmit over all the nodes using a carrier-sense mechanism, and centralized-access protocols, which involve single-node transmission regulated by a centralized decision maker. IBM submitted one example of a centralized protocol in July 1991.

Work began on the original NCR/Symbol proposal—called WMAC (wireless media access control)—in November 1992. WMAC used a distributed-access protocol as a foundation for more advanced functionality. This functionality included power management, synchronization, and optional support for time-bounded services. In March 1993, Xircom proposed the WHAT (wireless hybrid asynchronous time-bounded) MAC protocol. Xircom's WHAT protocol also used a distributed-access protocol, supporting hidden nodes as well as time-bounded services.

In May 1993, several companies proposed rival MAC specifications. While NCR and Symbol introduced the WMAC protocol, Spectrix offered the CODIAC (centralized or distributed integrated access control) MAC protocol; shortly thereafter, National Semiconductor (Sunnyvale, CA) proposed merging IBM's and Xircom's proposals into a hybrid protocol.

In September 1993, the Project 802.11 committee selected five of the original 11 proposals for further consideration with a goal of selecting a final protocol at the November meeting. The five selected proposals included two distributed-access protocols (the WMAC protocol from NCR/Symbol and the WHAT protocol from Xircom), two centralized access protocols (the IBM protocol and the CODIAC protocol from Spectrix), and one hybrid protocol (the WHO protocol from National Semiconductor). At that time, the CODIAC and WHO protocol proposals incorporated a secondary mode that mimicked aspects of the WHAT protocol at certain times.

Also, at the September 1993 meeting, NCR, Symbol, and Xircom decided to integrate their proposals, resulting in the enhanced WMAC protocol called DFWMAC (Distributed Foundation WMAC) that was introduced in the November meeting. The resulting DFWMAC protocol contained 95 percent of the functionality of the WMAC protocol, adding improvements in the areas of optional hidden-node protection from the WHAT protocol and PHY (physical) independence and synchronization support for extemporaneous ad hoc networks. Thus, the DFWMAC protocol ultimately has become an improvement over the individual protocols, and its popularity has been strengthened by the number of companies involved.

At the November 1993 meeting, the 802.11 committee reviewed the above proposals. At that time, National Semiconductor's WHO proposal was voted down, and it decided to support the DFWMAC protocol proposal. A voting procedure was held, and the required 75 percent majority then selected DFWMAC as the 802.11 foundation protocol for the MAC specification.

Global Considerations

To achieve worldwide standardization, the 802.11 committee is coordinating its efforts with other standards organizations where appropriate. These include the T1P1 group in the T1 Accredited Standards Committee and the TR32/TR45 groups in the Telecommunications Industry Association. T1P1 aims to provide public telephone, ISDN, and cellular telephone interoperability. The TR32/TR45 groups are primarily interested in digital-voice communications on cordless and mobile telephones.

The 802.11 committee is also well connected with the ETSI (European Telecommunications Standards Group). The ETSI-RES 2 committee defines standards for land mobile systems operating in the 2.4-GHz bandwidth. The ETSI-RES 10 committee is drafting a standard for a HIPERLAN (high-performance LAN), that will provide 10- to 20-Mbps bandwidths in the 5.2-GHz bandwidth.

AMD, DEC, International Computers, National Semiconductor, NEC, Norand, Telxon, and Toshiba have already put their voices behind DFWMAC, and more companies are joining the motion. Together with efforts to broaden the geographical reach of the standard, these endorsements will go a long way to ensure that any wireless LAN equipment you purchase will be interoperable.

power management and time-bounded services.

Access Control

The lowest protocol level in DFWMAC is the DCF (Distributed Coordination Function), which supports asynchronous communication between multiple stations. DCF supplies the basic medium access that allows for automatic medium sharing between similar and dissimilar systems. Contention between multiple stations wishing to access the same medium is resolved through a mechanism called CSMA/CA (carrier-sense multiple access/collision avoidance) with acknowledgment.

The CSMA function in DFWMAC is similar to the one Ethernet uses. The carrier-sense mechanism determines whether the signal energy in a particular frequency bandwidth is above a certain threshold. If the signal strength is below the threshold, that frequency bandwidth is available for wireless data communications, and the transmitter sends a parcel of data called a *frame*. If the signal strength is above the threshold, the medium is considered busy.

continued

When the carrier-sense mechanism determines that such multiple accesses to the medium are occurring (i.e., that the medium is busy), the transmitter waits for a short while before trying to retransmit. This waiting period is called *backoff*. To reduce the probability of access collisions and provide fair access to the medium by all stations, the time gap between stations accessing the medium is varied by backoff periods of random lengths.

DFWMAC's CSMA/CA and Ethernet's CSMA/CD (carrier-sense multiple access/collision detection) use a carrier-sense mechanism to determine whether other transmitters are using the medium. In both cases, if the transmitter senses the medium is free, then the transmission of the frame starts immediately. However, if the transmitter senses the medium is busy, CSMA/CD and CSMA/CA use slightly different methods to resolve the contention.

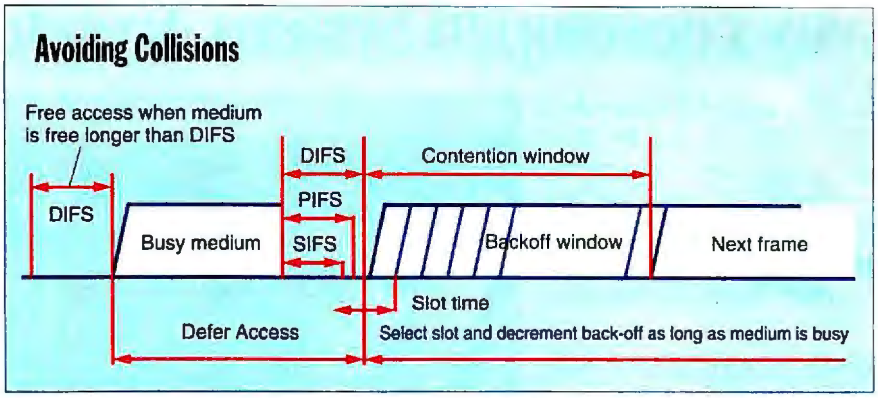
In Ethernet, when the transmitter detects a busy medium, it defers access until the end of the current frame plus an IFS (interframe space), or silence period. It then transmits its frame. If more than one station is deferring simultaneously, they will possibly start transmitting at the same time, causing a collision. Note that the probability of a collision occurring is highest when the medium becomes free. Collision frequency also depends on the total network load.

In Ethernet, the CD (collision detection) function detects this collision: All colliding transmitters sense collisions and generate a random backoff delay. After the delay, the transmitters reexamine the medium again to see if it has become free. By contrast, in wireless networks, the CD function is not viable. This is because the dynamic range of the signals on the medium used by multiple networks or stations is very large. As a result, no CD techniques can be used to resolve access contention. As collisions cannot be detected, the likelihood of transmission failures increases; therefore, lost frames in a wireless CSMA-only implementation become more likely.

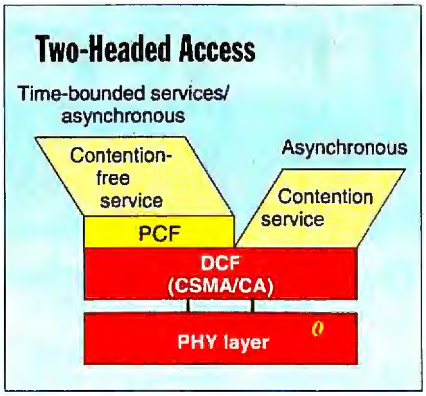
To keep collisions from destroying data, DFWMAC uses a CA mechanism. Backing off and waiting until the medium is free is not sufficient to provide reliable communications, so the CA (collision detection) mechanism adds a MAC-level acknowledgment to ensure the integrity of individual packets.

The acknowledgment protocol allows for data recovery at a low level, which is essential in a wireless environment to resolve reliability problems arising from access collisions and interference. To allow detection of a lost frame due to interference or collisions, the destination station (or stations) returns an acknowledgment immediately following a successfully received frame. When the acknowledgment fails to return, a MAC transmitter can recover from this error by retransmitting the frame after a random retransmission backoff.

DFWMAC defines an efficient backoff algorithm that is stable at high loads. The algorithm uses exponential backoff for retransmissions. To support coexisting asynchronous and time-bounded services, the algorithm also supports different priority levels that different IFS delays control. The figure "Avoiding Collisions" shows the basic access mechanism. The key procedure is that a station that wants access to



To resolve contention among users for the wireless data channel, DFWMAC uses CSMA/CA. When the medium is busy, access is deferred. Multiple access attempted during a busy period will defer until the end of that period, after which a random backoff resolves the contention. The scheme reduces collisions where they are most likely to occur.



The DFWMAC offers time-bounded services through the PCF access method. This can coexist with the standard DCF access method because it uses DCF with priority.

the medium needs to sense the medium first to ensure that a minimum IFS has been assigned.

The protocol defines three backoff priorities. The exact backoff period varies randomly. The priorities are as follows:

- SIFS (short IFS). This, the shortest IFS, is used for all immediate response actions. These actions include acknowledgment frames, RTS (request-to-send) frames followed by CTS (clear-to-send) frames, and any contention-free response frame sent during time-bounded services.
- PIFS (point coordination function IFS). A mid-length IFS, this is used for station polling for time-bounded services.
- DIFS (distributed coordination function IFS). The longest IFS, this is used as a minimum delay for asynchronous frames in the contention period.

In general, using a DCF-based CSMA/CA access technique extended with a MAC-level acknowledgment protocol ensures the reliability of transmitted wireless frames and the efficient recovery of transmission failures at the MAC layer itself.

Power Management

The mobile nodes used for wireless transmission are usually small, hand-held, battery-operated devices. Power conservation management functions in DFWMAC allow efficient battery operation while maintaining connectivity and network throughput.

Current wireless-network protocols assume that nodes are always ready to receive frames from the network. With power management, station receivers can be turned off most of the time, saving battery power without affecting functionality. The DFWMAC includes a protocol that lets you switch mobile computers from full-power (running) mode to low-power or sleep mode, where special mechanisms ensure delivery of all wireless data communications. The power conservation provisions are provided in both infrastructure and ad hoc modes. With these mechanisms, battery life in infrequently used scanners or palmtop devices can last for months.

Time-Bounded Services

In DFWMAC, time-bounded services are available via an optional PCF (Point Coordination Function). The PCF runs on top of the basic-access protocol to ensure coexistence of both time-bounded and non-time sensitive applications (see the figure "Two-Headed Access").

The PCF uses a superframe concept to ensure contention-free service. Within a given superframe period, the PCF is active in the contention-free period, while the DCF is active in the contention period.

continued

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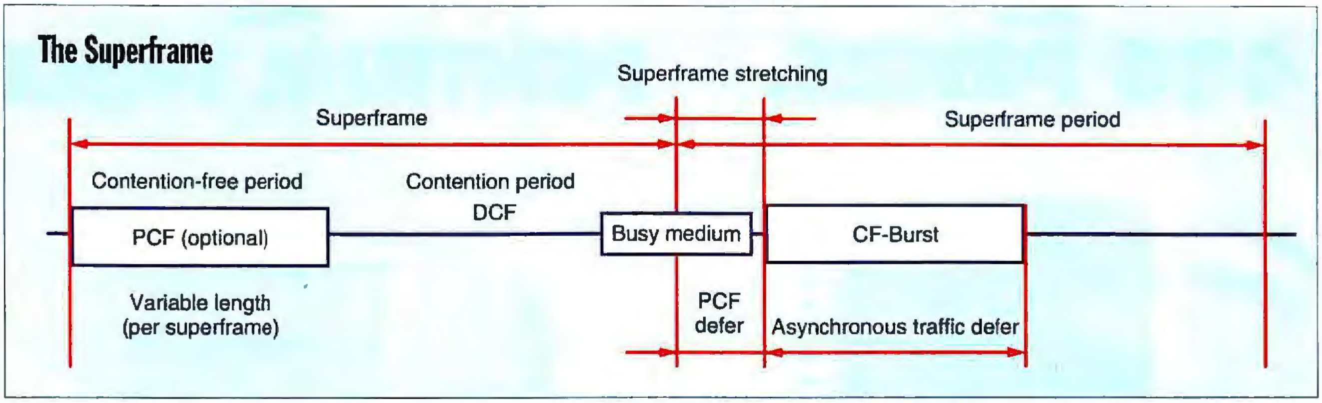

When mixing PCF and DCF access, the DFWMAC uses a superframe to ensure that every frame has both a contention-free period for time-bounded applications and a period where normal, contentious asynchronous transfers can occur.

The contention-free period can be variable in length on a per-superframe basis without incurring any additional overhead (see the figure "The Superframe").

At the beginning of the superframe, if the transmitter senses that the medium is free, the PCF gains control over the medium. If the transmitter senses that the medium is busy, then the PCF defers until the end of the frame; but when the transmitter gains control over the medium, the data channel is available for the PCF period. In the DCF, a frame can still start near the end of the DCF period. This causes stretching of the superframe, which, in turn, causes the contention-free period to start at variable intervals.

Asynchronous data traffic using DCF automatically defers until after the contention-free period. This is because the PCF uses the PCF priority level of the CSMA/CA access protocol, which causes a burst of traffic with interframe gaps that are smaller than the minimum DIFS period that the CSMA/CA needs. As DCF is the basic access scheme for both asynchronous and time-bounded services, with DCF running under PCF for time-bounded services, both asynchronous and time-bounded traffic defer to each other when appropriate.

Finalizing the Standard

Ultimately, the DFWMAC protocol proposes to solve the wireless standard debate by providing a complete wireless LAN system that would accommodate both the ad hoc wireless LAN environment and an infrastructure wireless LAN. By accommodating both environments with the same access protocol, DFWMAC bridges the gap in protocol interoperability. The breakthrough Project 802.11 MAC protocol vote, in particular, will bring computing and data communications solutions together to provide people access to information and to each other—anytime, anywhere. ■

Cees Links is director of product management for AT&T Global Information Solutions/NCR Microelectronic Products Division's Wireless Communications and Networking Division (Utrecht, The Netherlands). Wim Diepstraten is one of the authors of the DFWMAC protocol proposal and represents NCR in the IEEE Project 802.11 and ETSI-RES 10 standard committees. Vic Hayes is principal specialist for standards, and he chairs the IEEE Project 802.11 committee. All work for AT&T/NCR. You can contact them on the Internet or BIX at editors@bix.com.

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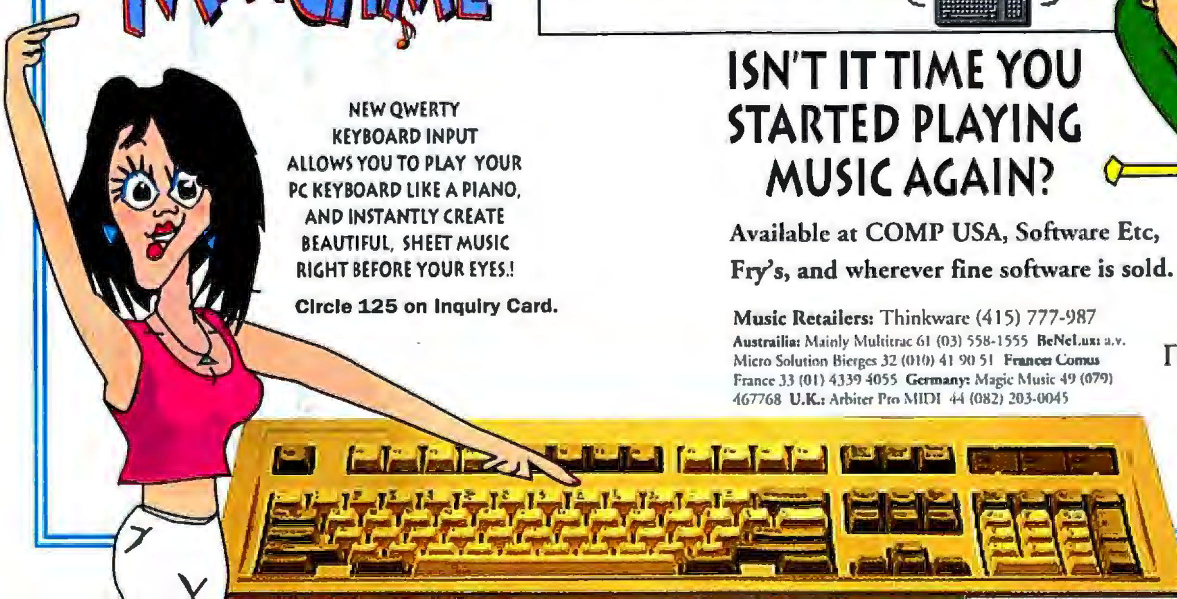

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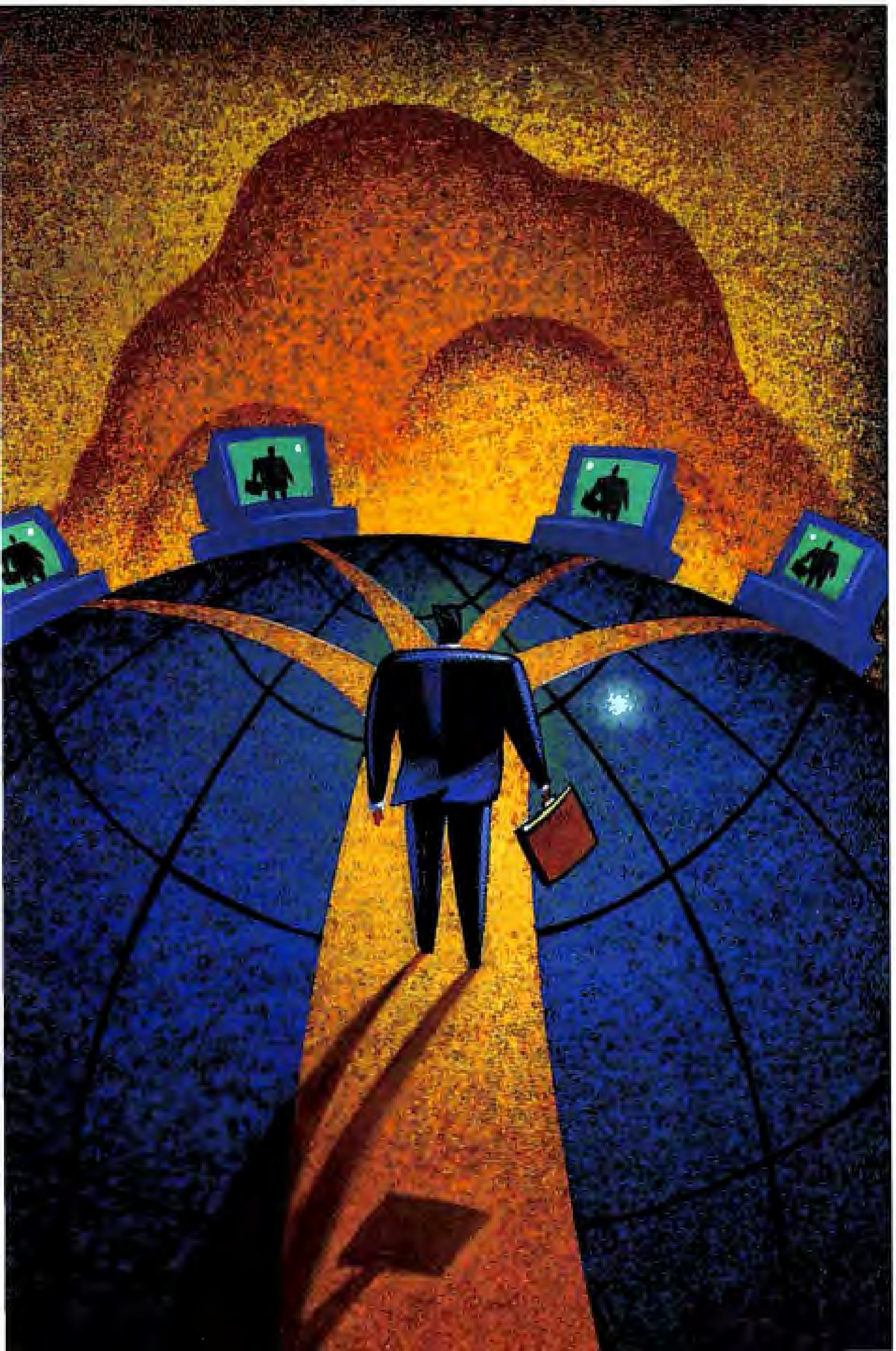
AGENTS AWAY

Telescript is a sophisticated communications language that is the centerpiece of a new style of information network—the electronic marketplace

PETER WAYNER



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One of the promises of PDAs (personal digital assistants) is portable, seamless, interactive access to information. The biggest challenge to realizing this goal is not the wireless communications hardware but rather the polyglot of protocols used in data communications. Getting different computers and networks to work together is analogous to building the Tower of Babel. And adding ease of use and transparency just multiplies the difficulties. From a communications point of view, Microsoft CEO Bill Gates's "information at your fingertips" seems far away indeed.

General Magic (Mountain View, CA) thinks it has a solution to the communications problem. Called Telescript, it is an interpreted language that works independently of any and all protocols and transports. It aspires to be the centerpiece of the global information network.

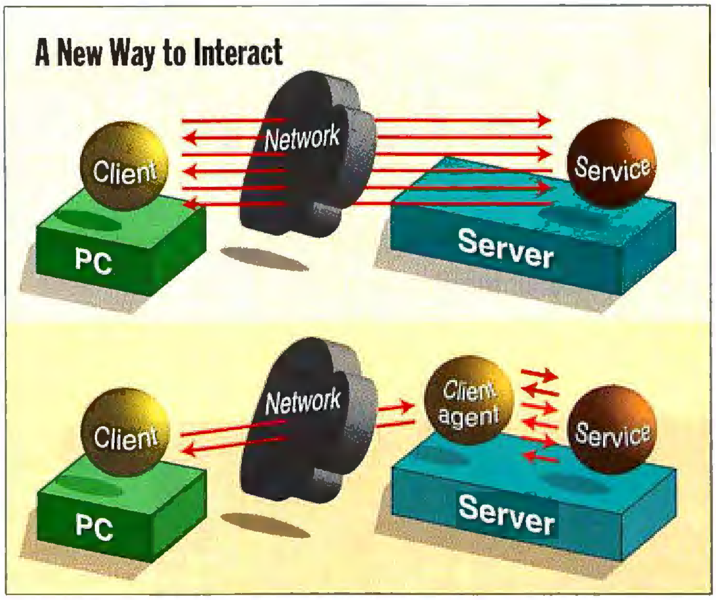
New World View

A common communications language is especially important in wireless communications. PDAs and their ilk are meant to be more than simply smart pieces of paper; they're supposed to be gateways to the world, letting you send and receive mail, make appointments, access data repositories, book a flight, and perform a host of other moderately intelligent tasks to make your life easier.

In General Magic's view, Telescript is necessary to a global interactive network, because the greatest limitation to interactivity is the time its takes for messages to travel across the network during a communications session. Each character travels in a small packet across the network to a computer that will often respond with another character or a small burst of information. Answering n questions would take $2n$ times the network travel time.

General Magic wants to do away with

all this communications chatter. Telescript lets you bundle your messages, requests, and preferences into an intelligent program that travels to a distant computer, gets answers to all your queries, and then returns with the answers. This results in just two trips across the network—a big saving in time, bandwidth, and money.



Telescript bundles functionality into an agent that is sent across the network. Intermediate requests and answers don't need to travel over the network.

The Telescript Difference

Built-in intelligence about how to interact with other systems is the major difference between Telescript and all the other software communications systems. As a language, Telescript is just as computationally powerful as C or BASIC. In contrast, most networking protocols like Novell's IPX or the Internet's IP merely pass packets of data between computers. The software running on the machines must know what to do with the bits when they arrive. A Telescript-ready machine will be able to understand any arbitrary Telescript program that arrives over the network.

You use this built-in intelligence to create messages that aren't just requests—they're smart programs that can make decisions based on your preferences. General Magic likes to refer to the packets of Telescript code as Telescript agents, which, you'll admit, sounds a lot cooler than Telescript programs.

Of course, a Telescript agent is nothing without a network filled with computers running Telescript interpreters. AT&T Easy-Link division (Parsippany, NJ) plans to be the first to offer such a network. It has teamed up with wireless-network providers such as Ardis (Schaumberg, IL), SkyTel (Washington, DC), and RAM Mobile Data (Woodbridge, NJ) to provide a Telescript-aware seamless domain of wired and wireless communication. Called AT&T Personal Link, the network is scheduled to go on-line this summer.

Beyond AT&T Personal Link, General Magic has ambitious plans to push Telescript as a standard for any type of network interaction. The company recently announced that Nippon Telephone and Telegraph (Tokyo, Japan), the world's largest telecommunications company, has taken an equity position in General Magic, although NTT has not announced any plans to field a Telescript network. Eventually, General Magic hopes to see Telescript adopted for everything from personal E-mail to enterprise computing.

What's in a Name

The idea of using a full-fledged language to transfer data is not new. Telescript's namesake, the PostScript language from Adobe Systems (Mountain View, CA), revolutionized printing by using programs to control the layout of text and graphics on a page. This approach is much more flexible and efficient than sending simple bit maps to the printer in terms of both size and speed. Most important, PostScript is machine-independent; the same program will run on printers of different capabilities, letting you render your page at the best available resolution and ensuring that the page you see on your 600-dot-per-inch laser printer will match the one created on a commercial quality printer.

Telescript promises to bring the same interoperability to the networked world. Like PostScript, it is an interpreted language. You won't have to worry about binary-level incompatibilities when your Macintosh-produced Telescript agent finds itself running on a DEC VAX cluster.

In addition to Telescript, General Magic is offering Magic Cap, a nice user interface cum general utility package for PDAs. Magic Cap includes many features for making phone numbers, calendar information, addresses, and the like easily accessible. When Magic Cap wants to communicate with the world, it spits out Telescript agents. Telescript does not require Magic Cap, however. Any operating system can host Telescript, and General Magic is trying to get the language adopted as a de facto standard for agent-based interaction over commercial data networks.

How It Works

Telescript comes in two flavors, high Telescript and low Telescript, although the analogy to spoken languages that this nomenclature implies is a bit misleading. High Telescript is a modern, high-level object-oriented language that General Magic says bears a striking resemblance to Smalltalk and Modula-3. The semantics are said to be clean and simple. I can't comment on these claims, however, because General Magic declined to provide code samples—perhaps to avoid giving clone makers a head start. But General Magic plans to release complete descriptions of the language at a Telescript developer's conference this September.

Telescript is similar to an object-oriented version of Lisp; the code is dynamically bound at run time, and the Telescript engine handles garbage collection and memory management. The dynamic binding is necessary because Telescript code needs to interface with routines on both the local and remote systems. Having the interpreter handle garbage collection and memory management is essential to plugging security gaps. If an agent were able to access memory directly, it could then change or damage host systems.

When generated, high Telescript is sent to the locally residing Telescript engine, which consists of a converter and the Telescript interpreter. The converter translates high Telescript into the low variety.

Low Telescript is a simple stack-based language similar to Forth and PostScript that runs on the Telescript interpreter. General Magic designed high Telescript to be easy for programmers to use. Low Telescript's design makes tasks easy for the computer. Its simplicity keeps the size of the interpreter down, minimizes the memory usage of agents, and also makes the interpreter easy to port from one platform

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to another. Low Telescript interpreters are much easier to create because they need only run code that a computer generates. Thus, the interpreter does not have to worry much about semantic errors. Also, the stack-based nature of low Telescript is harder for humans to read but much easier for computers to parse. A system on a network that provides services need implement only low Telescript, while the client machines need the more complicated high Telescript capability.

Just as you can use PostScript without ever seeing PostScript code, you will rarely, if ever, see either of the Telescript languages. The applications developer will create skeletal agents in high Telescript and add an interface to collect the parameters for the agent. This interface can be written in any language.

Going Places

When the Telescript engine finishes converting a new agent into low Telescript and commences execution, most agents will promptly ask to go somewhere on the network. The key command, called Go, initiates the move. When an agent executes this command, the local Telescript engine bundles up the agent, finds its destination, and sends it on its way.

The Telescript engine saves an agent by bundling up the agent's low-Telescript code, the program counter, the stack, and any of the memory-based objects that the agent owns. These states are captured into one big file and then sent over whatever network transports are appropriate.

An agent can specify a destination—a place, in Telescript-ese—in one of four ways. The first two—providing a name or an address—are similar. Both the name and address are 16-byte Telescript-generated entities that are unique to a particular place. The name consists of the authority and identity of the place, while the address consists of the authority and location of the place. This scheme provides flexibility as the nature of the network changes with the introduction of new services and new offerings. Of course, an agent has to first acquire the name or address of a destination before it can use them. Some names and addresses will be included with agents that service providers supply; others will be learned by agents themselves as they cruise the network.

The third way an agent can specify a destination is to ask to be sent to a machine offering a particular class of service. The Telescript engine would find the closest or least expensive service offering a particular class of information and then ship the agent off to it. One common service will be a directory that matches real-world names, addresses, and phone numbers with Telescript addresses.

The fourth method used to designate a destination is called "the way." In this method, the interpreter not only details the address of the destination but also specifies how to get to the address. For example, it might specify that the address can be reached through only the public telephone network and will provide the appropriate telephone number. This final method marries the destination with a specific means of communication.

Telescript includes another version of the Go command called Send. This instruction lets an agent create subagents and send them every which way in search of parts of the final answer. In this case, the entire agent does not move to a new location—it simply spawns versions of itself.

Security Matters

Running Telescript on an interpreter may be slower than using object code, but it is important for many reasons such as machine independence and ease of porting. Another reason to use an interpreter is that it bolsters security.

The Telescript interpreter, for example, can check the identity of each computer sending a request and then allow access to preauthorized users only. When running an agent, the interpreter can limit the amount of CPU time that a particular agent consumes by counting the number of Teleclicks it uses. Intrusive or nosy Telescript agents can also be stopped because the Telescript interpreter can limit the access to files. These features are a necessary precaution if your computer is going to participate in a worldwide network filled with good and evil people, agents, and programs.

The biggest danger of any networkwide system that allows intelligent agents is that some of the agents will deliberately or accidentally run amuck. Agents have much in common with viruses: Both are little programs that get to seize control of a foreign machine. The only real difference between viruses and Telescript agents is that Telescript agents have invitations and can execute on a system only after presenting the correct credentials.

Invitations are an important distinction. The local Telescript engine decides how visiting agents can use local features, memory, and services. Computer viruses find it easy to survive in the personal computer world because all the software is compiled. The virus can insert its string of instructions into another string, and the CPU will not notice because it executes its compiled code without question. Being interpreted, Telescript acts as an intermediate layer that examines and executes each instruction. It can stop a visiting agent that tries to insert instructions into a place where they don't belong. In fact, a visiting agent cannot read from and write to memory or the file system directly. It can only create objects and access their contents. The interpreter intercepts calls to objects that don't exist or don't belong to the visiting agent.

These measures are important security features that will stop most problems. The only danger is that there will be some hole in the Telescript engine that mistakenly allows an agent to access memory directly. The famous Internet virus from 1987 exploited a programming error in the "finger demon" software. This simple software protocol acts as a directory service for the Internet by offering a standard format by which each machine takes a name and checks to see if that person has an account. In theory, this shouldn't be dangerous because the local machine is only answering simple questions; it isn't executing programs or giving the outside user

A Vocabulary for Telescript

Agent—a program you create and send across a network. An agent carries out your transactions on a Telescript-aware network.

Place—a logical location on a Telescript network that corresponds to a Telescript engine. Your communicator is a place and so is an electronic shopping center or a directory of services. Places can be nested.

Travel—the movement of agents from your place to other places. Travel is enabled by the Telescript Go instruction, which indicates that the next instruction should be executed at the agent's destination.

Meeting—describes the interaction of two agents carrying out a transaction in the same place.

Connection—interaction between two agents in two different places. Telescript supports connections, but it is designed with meetings in mind.

Portal—a place where an agent can access systems and services that are not part of the Telescript network.

Speaking the Same Language

Telescript lets you create agents that can represent your needs and preferences to other agents on the network. For example, to make a plane reservation, you cast the request as a Telescript agent and send it off to a booking service on the network. The Telescript engine at this service would execute your agent, find the least expensive flight for the date you want, and choose the best seat available, knowing that you prefer mid-plane window seats or rear aisle seats.

To perform such a feat, your agent has to know more than just how to find the booking service and how to transmit your preferences. It must be able to cast your requests into a form that is understandable to the service agent.

Telescript is a general-purpose language; it provides a framework for agent interaction, but it doesn't have built-in knowledge of airline reservations, medical databases, electronic shopping, and other services. These services each require a specialized vocabulary extension analogous to an API. At first, service providers will need to supply client agents that have the required vocabulary built-in. But the eventual goal is to develop a standard interface so that agents from a service provider can visit your system, make you aware of a new service and its options, and even deposit an appropriate client agent in your toolbox. Such "traveling salesperson" agents are a few years off but will greatly enhance the electronic marketplace that General Magic wants to create.

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access to more information other than the name of the person. The security hole was that some versions of the software did not check the length of the name. The Internet virus stuck itself onto the end of the name and then let the finger program write the name and the attached virus onto the program stack. When the finger program stopped and erased the name, the virus was still left in memory. General Magic stresses that it is examining all its code to protect itself against these types of attacks.

Cash Cache

The second, and perhaps most important security feature, is a network version of money called Teleclicks. Local engines will use Teleclicks to regulate the consumption of resources such as computation time, memory, or communication bandwidth. When an agent hitches a ride to another machine or executes some local command, it spends some of its allotment of Teleclicks. The amount it spends depends on the local cost of services.

For most purposes, Teleclicks limit the action of an agent. When you create an agent, you give it a certain amount of Teleclicks to do its job. This prevents it from spending too much time or resources in its search for a solution. A limitation is important because in many cases, you will end up paying in one way or another for the resources that your Telescript agent uses. If you sent off a request to a big text database asking for information with a certain keyword, you'll probably be charged based on the CPU time that your agent consumes. Teleclicks can prevent unwelcome surprises on your credit-card bill.

The host Telescript engine can also limit the amount of Teleclicks that a visiting agent consumes. This is important because a host can't really know what a visiting agent is doing, even as the agent is caught in an infinite loop. Teleclicks provide the means for the host machine to stop memory or CPU hogs.

Who Are You?

Telescript also includes a third aspect of security: namely, identity. Each Telescript agent comes sealed with a cryptographically secure signature constructed by taking a secure checksum of the data and then signing this with an RSA Data Securities (Redwood City, CA) private key. The Telescript host can use this signature to verify that the packet of instructions and objects arrived securely from its owner.

The signature is also important for billing purposes. Networks offering Telescript services will need a secure way to ensure that the agent is operating for someone who will pay the bills. General Magic considered the more robust cryptographically secure digital cash systems, but it has put off decisions on these ideas.

In addition to identity services, Telescript uses software from RSA to do public- and private-key encryption based on certificate-guaranteed software. In many cases, the actual contents of any communication can be encrypted using a cipher like RSA's RC-4. At this time, the current version of Telescript will include encryption routines that are weak enough to pass through the State Department's division regulating export of military technology. The software, however, can be easily modified to use more sophisticated encryption algorithms, if necessary.

Telescript in the Real World

When it comes on-line, AT&T Personal Link will define the limits of the Telescript-aware world. Services from AT&T and others will populate this world. For example, AT&T has already signed up Mead Data Central (Dayton, OH), the giant owner of database services Lexis and Nexus, and News Electronic Data (Clinton, NJ), which is part of Rupert Murdoch's publishing empire. More radical offerings will come from companies such as eShop (San Mateo, CA) that plan to offer personalized stores, malls, and other shopping experiences. The real promise of Telescript won't be realized, however, until many more network providers make their systems Telescript-aware.

Until then, connectivity among the Telescript network and other networks will come via portals. An agent that needs to communicate with a machine on a non-Telescript network lodges its request at the appropriate portal, which establishes a traditional connection and performs a traditional transaction. The portal then passes the results of the transaction to the agent.

Despite the initial limitations of Telescript's reach, the technology is an important step forward. It allows you to perform complex network operations easily and it provides a glimpse of what future network-based computing might be like. One thing's for sure, no one else in network communications has come forward with a vision as broad as that defined by Telescript. ■

Peter Wayner is a BYTE consulting editor based in Baltimore, Maryland. He can be reached on the Internet at pcw@access.digex.com or on BIX as "pwayner."

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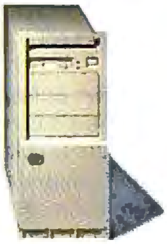

- **CPU:** 486DX/33MHz** or i486DX2/66MHz processor
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E-Mail from Afar

Lotus cc:Mail and Microsoft Mail provide the necessary tools if you need to communicate with offices in far-flung locations

HOWARD EGLOWSTEIN AND BEN SMITH

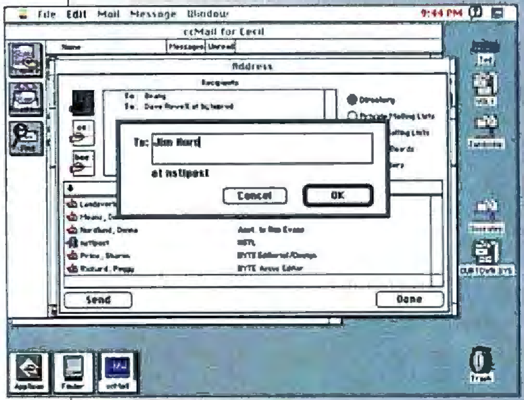
Businesses all over the globe are looking to E-mail as a way of communicating with remote offices. It's usually a lot less expensive than installing WAN (wide-area network) services, and E-mail permits people to take their work with them when they travel. In this review, we focus on two packages that command the lion's share of the E-mail market: Lotus's cc:Mail and Microsoft Mail.

Both packages are all-encompassing LAN-based E-mail systems that can run on just about any computing platform and can effectively tie large organizations together. Both support clients running DOS, Windows, the Mac, and OS/2; cc:Mail adds Solaris. As options, both packages provide remote client software and gateways to other major mail systems.

The two packages use a shared file access model, where a series of applications use a shared file area on a server to manage, transfer, and exchange E-mail. Administration software allows a network administrator to add users, mailing lists, and BBSes and perform other management tasks, such as directory synchronization.

We've looked at earlier versions of these E-mail giants before (see "Mixed Messaging," March 1993 BYTE), but much has changed since then (and is still changing). Of the two companies, Lotus has made more changes; it has revised its Windows client interface, for example, and added remote client software for Windows. (Since our review, Lotus has also added support for NetWare MHS and more flexible directory synchronization.) Microsoft has added MAPI support and X.25 and AT&T EasyLink gateways, along with more minor changes.

Both cc:Mail and Microsoft Mail still have good user interfaces, but when it comes to ease of setup and administration, cc:Mail comes out ahead. However, the fact that Microsoft Mail hasn't changed as much as cc:Mail may have an explanation: Microsoft is working on a totally new E-mail system with capabilities similar to those of Lotus Notes. The new mail server, EMS, will run on Windows NT.



The Mac version of cc:Mail has large, clearly marked icons for the selection of major mail functions. The global name directory is annotated with colorful icons that tell you at a glance whether the recipient is local to your post office or at a remote post office. Selecting a post office as the recipient is a handy way to send mail to someone who may not be in your directory.

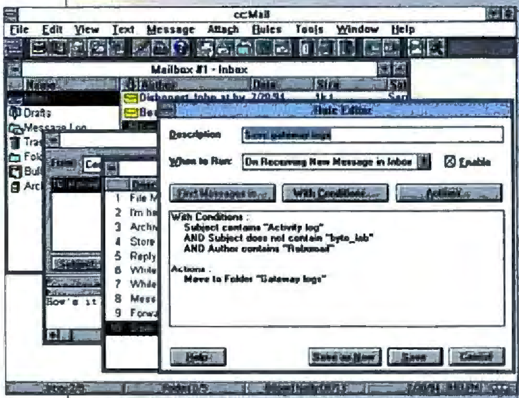
Lotus cc:Mail

Lotus's cc:Mail is easy for the administrator to configure, easy for users to handle without elaborate instruction, and reliable. Its faults are few. It suffers from a lack of consistency between platforms, which can complicate training. From a management perspective, it also lacks tracking ability, so you can't determine the status of a particular message.

A cc:Mail implementation uses one or more central post offices. In E-mail-speak, a *post office* is a place to collect messages and maintain a database of users. A post office can be physically a dedicated machine or a shared file area on a network. Local cc:Mail users run the cc:Mail client software on a DOS, Windows, or OS/2 system, a Macintosh, or a Sun workstation running Solaris.

The user interfaces on the client packages look and feel like other applications you might be familiar with. The DOS client software uses character-based menus, while the other versions use pull-down menus in the style of their respective environments. The Windows interface, for instance, uses drag-and-drop functions to do things such as adding recipients to a mail header.

To establish a cc:Mail post office, you need a LAN with enough shared file space for your user database and messages, and dedicated DOS or OS/2 machines for any gateways you want to install. Once the post office is established, the mail administrator runs a Mac- or DOS-based utility to add users and additional post offices to the system directory.



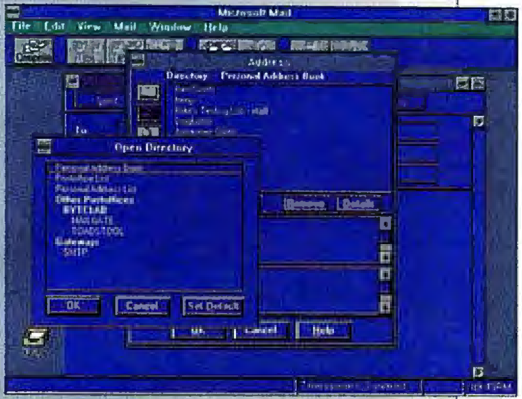
The Windows version of cc:Mail adds a spiffy new rules function that processes mail messages for you automatically. This example shows a rule that, when receiving a new mail message, looks to see if it comes from a user named "Robomail" with a subject of "Activity log." When it finds a new message, it automatically moves it to a storage folder.

Have My Gateway Call Yours

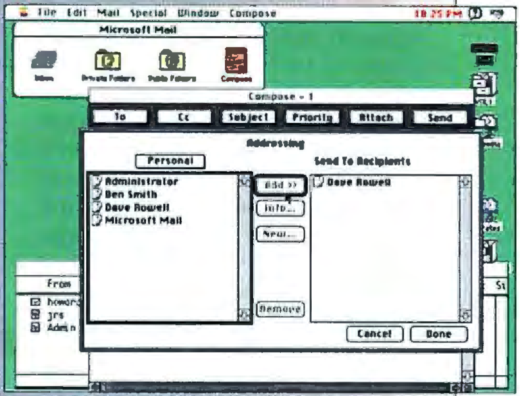
A key part of a cc:Mail setup is its collection of optional *gateways*, software that you run on dedicated PCs to connect your cc:Mail system to other mail systems. The most common gateway in a typical cc:Mail configuration runs a copy of Router 4.0 ($1295) under DOS. It serves to connect two cc:Mail post offices by a phone link or a LAN connection.

Lotus also offers gateways for many common mail systems. The SMTP Unix mail gateway ($349) uses a LAN's TCP/IP connection to a mail-equipped Unix system to transfer mail between your cc:Mail users and any standard Unix mail system. Other gateways include a UUCP Unix mail gateway ($495), an MCI Mail gateway ($1295), and a fax gateway ($1995) for converting ASCII mail messages to outgoing faxes.

Lotus's Router doesn't need big hardware, and it's easy to configure. To run the standard Router program, you need a DOS workstation (an old 286 or 386 will do nicely) with a network connection to



Microsoft Mail draws heavily on the Windows interface for most of its look and feel, making it easy for Windows users to learn. When you compose a new message, you can select the recipients from a full post-office list or from one of several alternative lists.



Unlike the Windows version, Microsoft Mail's Macintosh client software has a Spartan, monochrome look about it. While it does the same things as the Windows package, the Mac package lacks features that Mac users typically expect, such as drag-and-drop icons.

the post office it's going to serve, and a modem and phone line if you expect to share mail with cc:Remote users or other Router-equipped post offices. When several post offices coexist on one physical LAN, Router doesn't require a modem to transfer messages from one post office to another.

To try out Lotus's latest version of Router (4.0), we created a new post office on BYTE's editorial LAN, on a different file server than the one we use for everyday E-mail. Then we put a 33-MHz 486 PC with an AT&T DataPort 2001 14.4-Kbps voice/data modem on the network to serve as the gateway running Router. Novell NetWare allowed our 486 to access the two different post offices as different drives.

In the post-office database, a remote post-office entry can be one of three types of addresses: the phone number of a machine running Router for that post office, the name of another valid post office that has the target post office in its directory, or the drive and path through a network connection of the other post office. We successfully used the test post office to exchange mail with our production department's E-mail system with all three methods.

When a cc:Mail router is not connecting two post offices on the same LAN, it's calling another router to transfer mail or waiting for another router or a remote user to dial in. Once two post offices connect, they identify each other by post-office name and password; they then transfer their mail through an error-correcting protocol. Incoming mail for a local post-office user is posted directly into the mail database, and mail that needs to be forwarded to another post office is queued for the router to resend.

Unfortunately, Router can handle only one phone line. If you want multiple phone lines servicing your mail system, you'll need several machines, each running a copy of Router, or you can install a multiport serial board in an OS/2 machine and run cc:Mail Multisession Router 1.0 ($3495) with up to eight modems.

A router or multisession gateway connection accesses the mail database through a LAN connection. Besides the mail access, the gateway also needs a *call list* that defines each of the events that you want the gateway to handle. For instance, you might set up your gateway to automatically scan the database every 5 minutes and dial out to your California office if there's any urgent mail waiting to go out. (Mail can be of low, normal, or urgent priority.) You might choose to have normal-priority mail go out in batches a few times a day and have low-priority mail wait to go out until 11:30 p.m., when the rates are lower.

Mail administrators will appreciate that Router can keep a log of everything it does. However, the logs are in a nonreadable format. To decipher them, you need the help of a third-party or custom software package. The logs are useful for debugging a finicky modem connection and also serve as a form of mail tracking. Lotus cc:Mail has no mail-transaction tracking of its own—once you send a message, there's no way to tell if it's on its way.

Mail sent through Router will, at the very least, have the post-office transfer noted by date, author, and subject. BYTE's production mail system uses these logs for a robot mailer that summarizes the previous day's activity and sends the summary to an administrative mailing list each morning. Lotus plans to add tracking capability later this year, but in the meantime, the logs work well enough for interoffice mail.

From the Road

For the most part, the software for accessing a cc:Mail post office from a portable computer is nearly identical to the desktop version for any particular platform. The only real difference between the remote and LAN-based client software is that the remote software must establish a modem connection to a post-office gateway before exchanging mail. Remote packages cost $295 per client.

The Mac remote-access software uses the same clean front end as its desktop cousin (shown in the screen at left). The icons are large and clearly labeled; the clean screen design and simple operation make it a breeze to run from the small 640- by 480-pixel screen of a portable Mac. The latest versions of both the stationary and mobile software also support Apple Events for automating your mail sessions through AppleScript.

For folks who insist on the smallest possible E-mail system, Hewlett-Packard continues to bundle a reduced version of cc:Mail Mobile into the HP 100LX palmtop computer (see the text box "E-Mail in Your Pocket" on page 124).

The biggest change in cc:Mail's mobile lineup is the new cc:Mail Mobile for Windows software. Except for its added dialing directory and modem support, it's the spitting image of the desktop version 2.01 Windows client. In addition to pull-down menus, you get a large number of icons that you can build into any number of tool palettes. Drag-and-drop operation is the norm for most functions; to add a name to an address field, you simply select the name from the directory and drag it to the address field.

While the rich functionality of the Windows remote version is handy to have, the software is also difficult to use without a mouse. When you're already juggling a briefcase, your carry-on bag, and a computer while you're traveling, you may not want to pack a clip-on trackball as well.

Windows Rules

The shining feature in the Windows software (both remote and desktop versions) is its support for *rules*. They let you predefine certain events that cc:Mail automatically watches for. When you go on vacation, for example, you can have your desktop system check the subject heading of your incoming mail. If it's a system log that doesn't require your attention until you return, you can set up a rule to move that type of message into a folder.

Using rules both in and out of the office can greatly cut down on connect time, and it makes using the mail system much more efficient. We're looking forward to seeing rule support incorporated into the other clients as well.

Microsoft Mail

Microsoft Mail has different faces, depending on whether you're a user or an administrator. Users get an easy-to-use interface that is consistent with that of other Microsoft Office products on the same platform. Administrators, however, see something less attractive behind the scenes—an inconsistent, hard-to-use set of utilities for setup and management.

You can tell a good user interface by two things: the ease with which a new user learns it and the facilities that it offers for efficient long-term heavy use. Microsoft Mail does well in both of these categories. As proof, look at the user's guide—the core section is only 12 pages long. You simply don't need a manual.

Also, because there are several ways of accomplishing the same task with Microsoft Mail, you can use the product in a manner that reflects your personal style of working. Even the character-based MS-DOS interface is easy to navigate around in, but, as with any other DOS interface, you have to learn a few not-so-obvious keystrokes to move in and out of different modes—between text-entry mode and command mode, for instance.

Microsoft Mail provides a convenient set of options for every user. You can use system-defined address directories and personal address books, to which you add addresses either from system directories or on the fly. For DOS, the structure of the message folders and address books follows the same model as the DOS file system; for the Windows interface, it follows the same model as the File Manager.

The optional remote user interfaces, which let you connect to your E-mail system via modem rather than from directly on the network, are nearly identical to the on-line interfaces. The workstation and remote versions of Microsoft Mail allow you to create and view messages off-line while you're disconnected from the mail server, a feature that allows user productivity even while the network or server is not working. Lotus cc:Mail remote packages provide a similar capability.

The only real difficulty with the Microsoft Mail user interfaces is the differences among the DOS, Mac, and Windows interfaces; they are completely different, both visually and in their command organization. If it takes training for a user to learn the DOS interface, it will require retraining for that person to learn the Windows-based interface.

Installing Microsoft Mail

Microsoft Mail requires either a Microsoft LAN Manager–compatible network or a Novell NetWare network, a minimum of 4.5 MB of disk space on the server, plus an additional 6 MB for the DOS and Windows client programs. A DOS-based client workstation only needs to be a PC with 512 KB of free RAM, but a Windows

A Comparison of Key Features

Lotus cc:Mail	Microsoft Mail 3.2
+ Easy-to-learn client user interface	+ Easy-to-learn client user interface
− Lack of interface consistency between client platforms	− Lack of interface and feature consistency between client platforms
+ Easy setup and administration	− Inconsistent administrative tools; disorganized documentation
− No message tracking	+ Message tracking

E-Mail in Your Pocket

HOWARD EGLOWSTEIN

In its 100LX palmtop PC, Hewlett-Packard has managed to stuff a 7.91-MHz 8086-compatible processor, a full-function keyboard, 2 MB of memory, and a PCMCIA 2.0 slot into a package that easily slips into your jacket pocket. More important, HP includes a special version of cc:Mail Mobile in ROM, along with a half dozen or so other software packages. I recently took the tiny 100LX along with me on a trip that took me through several thousand miles and several airports.

The HP cc:Mail package shares some similarities with Lotus's cc:Mail DOS Remote client software. The interface is character-based and uses pull-down menus accessed through the 100LX's Menu key. Function keys across the bottom of the screen offer you relevant choices, depending on what you're working on. As you move from screen to screen, the function-key labels constantly update to suggest your next action.

Squeezing a full mail package into a 100LX requires some compromises. When you enter a name into the directory of any other cc:Mail client, for example, you store the post-office name and address first; then you use that post office to address other names. On the 100LX, you have to enter the post office as part of every name. It seems like a small thing, but when you're standing by an airport pay phone juggling luggage, it seems especially annoying.

HP doesn't sell a PCMCIA modem for the 100LX, but you can use a third-party modem card, or you can connect a pocket modem to the 100LX's serial port. A PCMCIA modem is much more convenient, but they suck the very life out of your batteries. Depending on the model you use, a PCMCIA modem can reduce the HP's normal 60-plus hours of operation to less than 15. It's best to save the PCMCIA slot for a storage card.

The rest of the software is quite handy, too. I would have liked the 100LX a lot better if it had security features to protect sensitive information. My electronic address book holds backup credit-card information and sensitive phone numbers. If I were planning to replace this gadget with an HP 100LX, I'd want some way of keeping prying eyes from reading it.

While I am not ready to replace my Toshiba T4600C (which weighs 12 pounds with batteries and case) with the svelte HP 100LX, I found that the HP unit makes a perfectly usable second machine. The next time I have to write a review while I'm on the road, I could happily leave the Toshiba at home and rely on just the 100LX. I'll end up fixing a lot of typographical errors that I wouldn't have made with a larger machine's bigger keyboard and more capable software, but that's the price you pay for progress.

"FirstClass Goes Beyond The Capabilities Of Most Mail Systems." BYTE Magazine, 09/93

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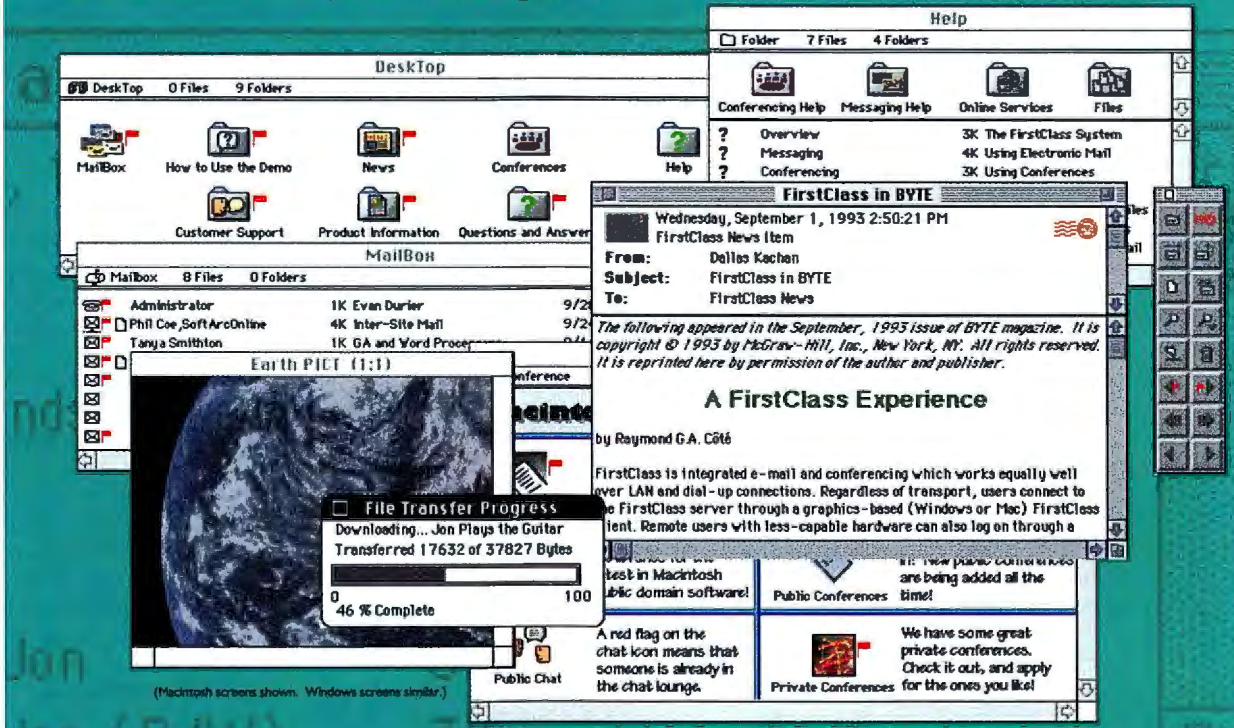

(Macintosh screens shown. Windows screens similar.)

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client should be at least a 386-based workstation with 4 MB of RAM (although it will run—more slowly—on a 286 with less memory). An OS/2 Presentation Manager client should have 8 MB, although, again, it will also work on less memory.

Without training, you may find the first Post Office (the E-mail server database) installation difficult. The documentation doesn't clearly define what model of E-mail server the system uses, nor does it distinguish between a file server and an E-mail server, referring to both as just "server." The model that Microsoft Mail uses is that of a shared file system sitting on a network server, by default mapped to drive M for all the PC clients. Each client user runs an interface that allows him or her to read and compose messages that are retrieved from and sent to the server either directly over the network or, in the case of a remote client, through a DOS-based MTA (Message Transfer Agent) that runs on a separate PC connected to the network.

The planning guides and installation instructions never explain a procedure as they lead you through it, so you never know if you're on the correct path until the module you've installed either works or fails. Even worse, every module and option has its own installation method; there is no standard overall installation interface, an attribute of almost all PC software today. Once installed, nearly every administrative module has its own interface as well. Some are command-line, some are character-based windows, and some are even Microsoft Windows–based.

Most pieces of a Microsoft Mail system require an INI file, whether or not they're Windows applications. Unfortunately, nearly every INI file has to be either created or edited by hand and placed in an appropriate directory path. The administration manual is full of examples, but it's not always specific about where these files need to reside. On the positive side, once

Can PC E-Mail Be the Wrong Choice?

BEN SMITH

For so many of us, most of our communications are necessarily beyond the boundaries of our own organization. We demand that our phone, fax, and mail systems have the ability to connect to the outside world. The same applies to E-mail.

Even though both Lotus cc:Mail and Microsoft Mail have gateways to other systems—to the Internet- and X.400-based E-mail worlds in particular—these connections come only with extra effort and optional licenses. Compared to the E-mail capabilities of most Unix systems, they're kludges at best.

PC-based E-mail systems require separate PCs to run the gateways, as well as extra installation and management for each E-mail post office. They also obfuscate on-the-fly Internet addressing with address directories. In short, they complicate life for the user and the mail administrator.

If your organization needs to communicate via E-mail with the rest of the world, it's possible to have very good PC LAN access to the Internet E-mail backbone without building a PC LAN E-mail system. The major TCP/IP providers for PCs—for example, FTP Software (North Andover, MA) and Spry (Seattle, WA)—provide DOS- or Microsoft Windows–based user interfaces to Internet E-mail. With some user agents, such as Portable Mail for Windows from Qualix Group (San Mateo, CA), you can work with messages while you're off-line.

The Internet E-mail server is typically a Unix computer, which can be either local or remote. E-mail is a standard part of Unix systems: You don't need to license separate software to have E-mail available on them. Networking also comes with Unix systems. Unix E-mail is the global de facto standard, despite its limitations on delivering nontext messages and attachments. But even these limitations can be avoided by the adoption of MIME (Multipurpose Internet Mail Extensions) and new MIME-intelligent user interfaces such as Z-Mail from Code Software (Novato, CA).

But open E-mail systems aren't always what is needed, and PC LAN–based E-mail works well for small- to medium-size organizations that want to improve their internal communications without changing the way they communicate with the outside world. Packages such as cc:Mail and Microsoft Mail are strong on security. A closed world not only protects inside communications from intrusions from the outside but also protects against vital information leaking out. Some very large installations have successfully based themselves on PC LAN E-mail, in spite of the complications of upscaling.

On the other hand, there are some real advantages to starting with a system designed from the ground up for a large organization's specific needs, systems where the E-mail server is built on a fault-tolerant database system that could serve any other corporate DBMS need. Because a PC LAN–based E-mail system requires that the database run a PC network server, the server is capable of handling only transaction loads that are appropriate for a PC. You don't want more than a few hundred E-mail accounts on a single server.

If you have 10,000 E-mail users, you need 50 to 100 E-mail servers. That means 50 to 100 mail directories must be synchronized. Directory synchronization is a problem that grows geometrically with the number of directories; in other words, synchronization of 50 to 100 directories is a very large problem. One alternative is a single server/directory with PC clients—for example, the products from Fischer International Systems (Naples, FL).

How does the Internet solve the directory-synchronization problem when it has literally millions of E-mail hosts? Actually, it doesn't solve the problem at all; it avoids it. It has no E-mail directory. You don't use Internet mail to find people; you use it only to communicate with people you've already found by some other means: meeting people and exchanging business cards, browsing through Usenet news messages for subjects and authors that interest you, and any of the other ways that people have been meeting each other over the last thousand years of commerce.

you have worked this out for yourself, Microsoft Mail is fairly consistent.

Once things are set up, you have a considerable amount of control over how directory synchronization takes place. When you have remote post offices, the data communications gateway can double as the connection between post offices. The remote post offices use the same message format as users do for keeping their user directories synchronized. There must be one directory server to and from which the other post offices (i.e., the requestors) pass and receive their changes, but you control when the updates occur, which users and groups get updated, and the address types to be updated other than Microsoft Mail directories (e.g., SMTP and X.400).

The server utilities include a program for building a text file to use for importing NetWare users' accounts into Microsoft Mail. Unfortunately, Microsoft still hasn't extended the character set for this directory to include all the characters supported by NetWare's name bindery. You must edit entries containing characters such as the underscore, a common character in both NetWare and Unix account naming.

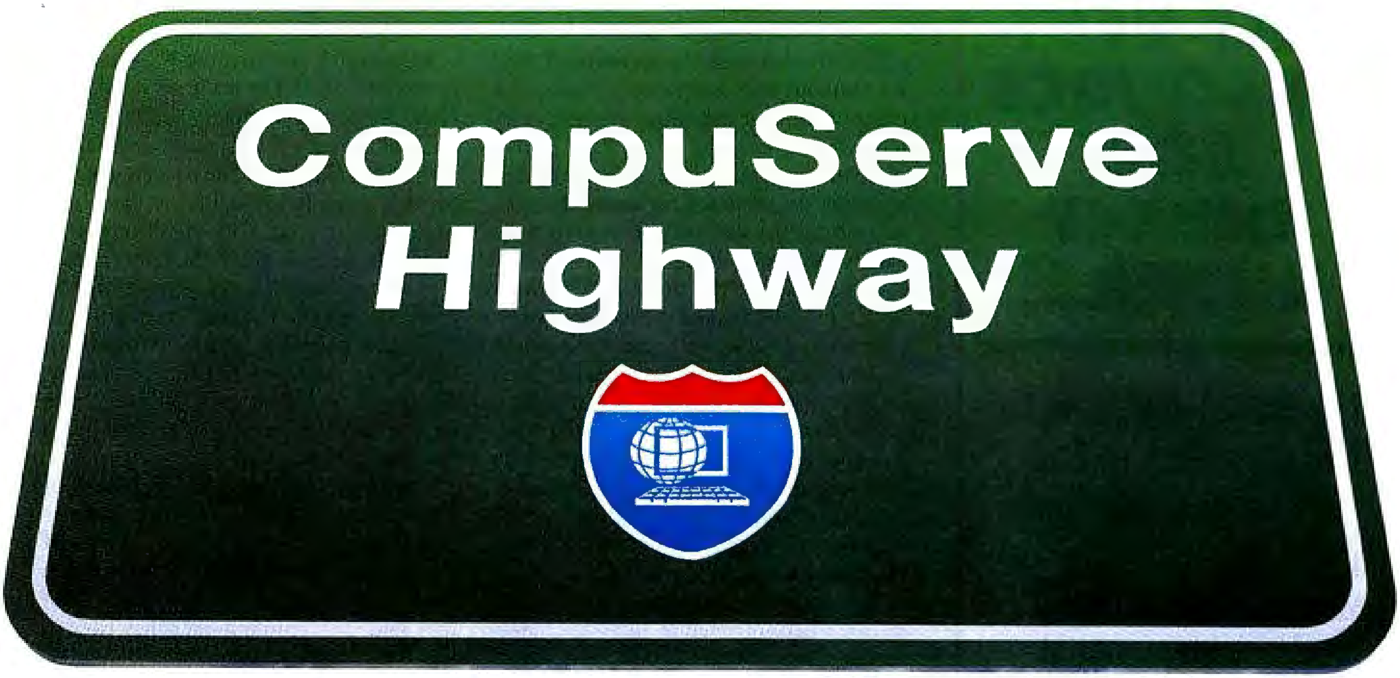
There is also a name-extraction utility for LAN Manager. But even though LAN Manager is a Microsoft product, Microsoft Mail account naming is more restricted than it is in LAN Manager. The name-importing function is slow; it takes almost a second to process each name on a 33-MHz 486 server with the administration application running on a 50-MHz 486 machine.

A very positive element for Microsoft Mail is its transaction logging. You can follow just about any kind of activity using these tools. Lotus provides transaction logs only with its Router software, but it doesn't give you any way of reading them.

Branching Out

For going beyond the LAN, there is a host of optional gateways and enhancers for Microsoft Mail, including those that support Fax ($1995), MCI Mail ($995), IBM Profs ($14,995), X.400 ($4495), and NetWare's MHS ($995). We evaluated the TCP/IP SMTP gateway ($4995), a feature that we believe should be built into all professional E-mail systems today. The most difficult part of this installation was adding a second network-protocol stack on the gateway machine.

Because of the load on the database and server, a reasonable maximum number of users for a PC-based E-mail system such as Microsoft Mail is about 300. Large installations require more than one E-mail post


CompuServe
Highway

office. Even though the second and third installations are easier, they introduce the complication of installing the necessary gateway for keeping the system E-mail directories synchronized. Microsoft Mail includes the modules for doing this, but its model scales well only up to a few thousand total E-mail users.

The problem is that this is a PC network with a PC DBMS, and the database operations must occur on a client PC across the network; the result is too small a server and too slow a database. Any organization with more than 300 users will probably want to develop its own E-mail directory scheme. Fortunately, Microsoft Mail can import and export directories, as well as interface to other programs, through DLLs and the MAPI protocol.

In other words, you can extend and automate Microsoft Mail by running external applications written in both C and Visual Basic. Despite Microsoft Mail's shortcomings as far as administration is concerned, the extensibility of the product is the one feature that makes it stand out in large and sophisticated installations.

An organization we talked to that has a very large Microsoft Mail installation indicated that the fact that it had standardized on a single mail system was far more important than the fact that it had to build its own directory service and write its own installation and administration manuals. Having one well-designed, consistent interface to E-mail is more important to this organization than the difficulties of adjusting a PC-scale product to a widely dispersed network of 20,000 users.

Easier Access

Lotus and Microsoft may own the bulk of the LAN-based E-mail market, but there are other contenders you may want to look into. Many run on top of MHS, a transport layer from Novell that uses a standardized shared file space on a server. An MHS mail package uses this transport layer to provide its communication services. In theory, this means any MHS package should work seamlessly with any other; many users find this to be true in practice.

Lotus is constantly tuning and enhancing cc:Mail. The latest new tool is the cc:Mail Mobile client for Windows. It's a tremendous tool for remote offices, although it might be a bit cumbersome to handle on your portable computer due to its heavy reliance on a pointing device. While the Mac mobile client also requires a mouse, it manages to accomplish its task with simpler motions.

Microsoft's totally new NT-based E-mail engine should be ready now, although client software is currently available only for Windows for Workgroups (and will be included in Chicago). The new engine will provide group functionality similar to that of Lotus Notes, and, with MAPI support, it should be just as open as Microsoft Mail. If it also includes access to the global E-mail community without optional packages, customization, and modification, it will be an attractive package. For now, Microsoft Mail is a good choice if you need a closed E-mail system with just a few post offices.

For LANs with around 300 users or fewer, a PC-based E-mail system such as cc:Mail or Microsoft Mail makes a lot of sense. Beyond that, finding names in the directory becomes a chore for users. With that said, we find both packages easy to use for clients (which should be one of your strongest considerations) and roughly comparable otherwise. The pros and cons cancel each other out. Either package provides you with the necessary administration tools as well as the means to connect with the outside world. ■

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About the Products

cc:Mail

DOS (version 4.0)	$295*
Windows (version 2.01), Mac (version 2.0), OS/2 (version 1.0)	$495*
Unix (version 1.0)	$895*
10-user upgrade	$345
25-user upgrade	$845
100-user upgrade	$3295

*Per post office.

Lotus Development Corp.
800 El Camino Real West
Mountain View, CA 94040
(800) 448-2500
(415) 961-8800
fax: (415) 961-0215
Circle 1340 on Inquiry Card.

Microsoft Mail for PC Networks 3.2

10 users	$695
20-user upgrade	$1349
100-user upgrade	$5500

Microsoft Corp.
1 Microsoft Way
Redmond, WA 98052
(800) 426-9400
(206) 882-8080
fax: (206) 936-7329
Circle 1341 on Inquiry Card.

Without Peer

Zenith Data Systems' $999 file server dramatically lowers the entry point for peer-to-peer networking

BARRY NANCE

The 8- by 11- by 12-inch Z-Stor Personal Server provides dedicated file and printer sharing for peer-to-peer Ethernet LANs. The optional internal CD-ROM adds $499 to the $999 base-unit price of the Model 400. Hooking to coaxial cable requires an optional FriendlyNet connector (inset).

Peer-to-peer LANs are an inexpensive networking option for workgroups and small businesses. But peer-to-peer design has drawbacks. Complex setup can be one, because there are so many possible arrangements for sharing resources compared to a similar-size client/server LAN. Depending on how many workstations double as servers, assigning drive mappings between machines can actually be harder with a peer-to-peer LAN.

More important, having a PC act as both workstation and server increases the risk of data loss. In a DOS or Windows environment, an application bug can lock up a shared server. At best, such a crash will cost you the time it takes to reestablish your connection to the shared hard drive. At worst, you may lose the file you were saving to the shared disk.

You can buy a separate PC to act as a dedicated server, but then you're getting away from a low-cost solution. You'll also find that people tend to ignore the "hands off" signs you attach to the server and use it to run applications anyway.

Collaborating with Novell, Zenith Data Systems has brought out a solution for these and other peer-to-peer LAN pitfalls: the Z-Stor Personal Server. It's a small, inexpensive PC with most of the functions you'd want in a small workgroup server, few of the functions you'd need to run applications on the server, and a $999 price that fits into a peer-to-peer budget. The Z-Stor also offers quick, simple setup, almost installing itself. You simply connect it to an Ethernet LAN and power it on to provide shared file and print services.

Defining "Personal"

In naming the Z-Stor a "personal server," ZDS has defined a new product category, one that also blurs the distinction between peer-to-peer and client/server LANs. This product is unusual in other ways, too. It's a small (8- by 11- by 12-inch) box that comes preloaded with Novell's Personal NetWare operating system. It provides built-in Ethernet, SCSI, and PCMCIA connections, but it doesn't provide keyboard or monitor connectors and it lacks expansion slots. It sets up in minutes and automatically reconfigures when you add the expansion options ZDS provides.

The Z-Stor comes with Cyrix's Cx486SLC CPU, running at 25 MHz, and 2 MB of RAM. The $999 Model 400 has a 210-MB IDE hard drive, while the $1599 Model 1000 runs a larger (540-MB) IDE drive. The server uses the on-the-fly file compression facility of Novell DOS 7 to give you about 400 MB of storage on the standard 210-MB IDE disk and around 1 GB on the Model 1000's 540-MB disk.

ZDS doesn't provide a keyboard or a monitor with the Z-Stor—or even connectors to attach them. You configure the unit remotely from a workstation using a utility preloaded on the server. Omitting the keyboard and monitor reduces the Z-Stor's price, discourages people from running applications at the server, and reduces the server's user interface to just the on/off switch. But the Z-Stor is only a partial solution in this regard, because you can still run character-based DOS applications on the server through remote control.

Connectivity and Storage

While you can't hook a keyboard and monitor to the Z-Stor, you can connect to, control, and share its resources through Ethernet or Token Ring or by modem. You also get an SNMP agent that you can optionally load at each PC running Personal NetWare. The Z-Stor doesn't have a serial port or an expansion slot. You can connect a modem through its PCMCIA 2.0 Type II slot, and a shared printer or a notebook PC to its 25-pin parallel port.

The on-board NE2000 Ethernet adapter in the Z-Stor provides an RJ-45 port for connecting to a 10Base-T Ethernet LAN, and a FriendlyNet port for connecting to thin or thick Ethernet. ZDS will sell you an optional Asante adapter ($69 for thicknet, $89 for thinnet) if your LAN doesn't use 10Base-T unshielded twisted pair.

The optional Token Ring PCMCIA card ($579) auto-senses your LAN's ring speed. (The card attempts to join the LAN first at 4 Mbps, then at 16 Mbps.) Installing the Token Ring adapter automatically disables the built-in Ethernet. ZDS also offers an optional 14.4-Kbps PCMCIA modem for $299. Because the Z-Stor has just one PCMCIA slot, you cannot simultaneously use Token Ring and connect to the server through the PC-card modem.

In addition to the internal 3½-inch IDE drive bay, two half-height 5¼-inch storage bays open to the rear of the Z-Stor. The server accepts up to two SCSI devices through its built-in SCSI-2 connector. SCSI hard drive options comprise a 500-MB drive for $999 and a 1-GB unit for $1599, letting you add up to 2 GB of additional storage space (and perhaps double that with Novell DOS 7 file compression).

A Toshiba CD-ROM drive ($499) is another SCSI option, and you can also purchase a floppy drive (3½- or 5¼-inch, or both); the Z-Stor comes with none. For backup, ZDS offers a $449 250-MB minicartridge quarter-inch tape drive or a $1599 1-GB DAT (digital audiotape) drive. The Z-Stor complies with EPA Energy Star guidelines and consumes only about 30 W of power while running. *continued*

Loaded and Ready

The Z-Stor comes with Novell DOS 7 and Novell Personal NetWare loaded on its hard drive, along with installation and remote maintenance utilities. DOS 7 is a new version of Novell's competitor to IBM PC-DOS and Microsoft MS-DOS. Novell DOS 7 offers features similar to those of PC-DOS and MS-DOS, including built-in file compression, but Novell's DOS also offers multitasking and comes with Personal NetWare. Novell's latest peer-to-peer NOS (network operating system) enables you to access NetWare file servers and also lets your PC play the role of file server to other workstations on the LAN. If you use just the Z-Stor as your file server, you have a LAN environment similar to but slightly slower than that provided by the server-based NetWare 3.x or 4.x.

With the Z-Stor you get one copy of Novell Personal NetWare to install on a workstation; for more workstations, you'll need to buy additional copies. The Z-Stor comes configured for a maximum of 25 workstations, but a workgroup size of two to 10 people is a more realistic load.

The Personal Server Extended Services utility gives you remote control of the server from a workstation. Through its menus you can install the server, run DOS commands, view or change the server's status and configuration information, and reboot the server from a workstation.

To discourage using the server to run applications, the remote-control function won't run graphical software (e.g., Windows), nor can you use your mouse through the remote-control link. Only text-mode, command-line software will run. You can connect to and administer the Z-Stor remotely via the optional PCMCIA modem as well as through a LAN connection.

The Extended Services software runs in text mode or under Windows. You run the Extended Services installation after connecting to the Z-Stor. The server-status menu option displays the amount of RAM, server disk space (free/total), number of reboots, hours in operation, and whether to run CHKDSK.

The server configuration option lets you see and modify the server's workgroup name, language, Ethernet frame type, and Token Ring speed. The server's built-in router function lets you access other servers when you connect to the server through a modem. If you opt for a tape backup unit in your Z-Stor, you can use the tape-drive menu option to back up your server. ZDS preinstalls modified Connor tape-backup software in the server.

You can't change the Z-Stor's AUTOEXEC.BAT or CONFIG.SYS files, nor directly modify the server's NET.CFG file. These prohibitions keep you from inadvertently reducing the server to a nonbooting, expensive paperweight. The Z-Stor uses preloaded NE2000.CFG, TOKEN.CFG, MODEM.CFG, IPXROUTE.CFG, and OTHER.CFG files to dynamically build the NET.CFG file at boot time. If you edit these files, the Z-Stor software checks your changes before applying them to the NET.CFG file.

To run a particular program at boot time, you create a PROFILE.BAT file the same way you'd create an AUTOEXEC.BAT file on a regular PC. Unfortunately, the Z-Stor does not remember the time of day across a power-off reboot; you must use the NET NTIME command each time you boot to synchronize the server's date and time with that of your workstation.

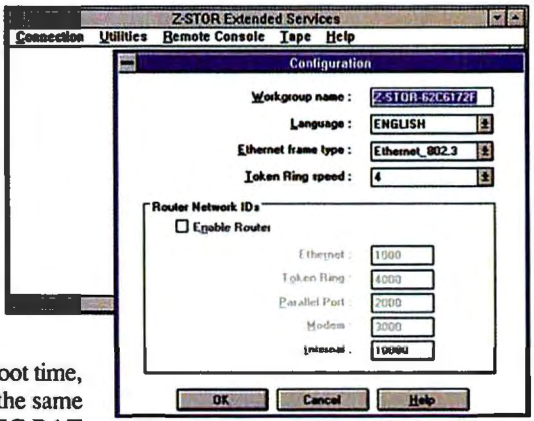
One of the software modules (codeveloped with Novell) running on the server is a network watchdog program that can determine if the network has failed. If the watchdog program senses a problem, it shuts down the server, reboots, and attempts to reestablish previous connections.

ZDS offers a special PCMCIA card ($149) to easily reinitialize the Z-Stor if the server's hard drive fails. To recover from a crash, you insert the PCMCIA card and power on the server. No CNE (certified NetWare engineer) need be present.

Up and Running

After only a few minutes out of the box, the Z-Stor was up and running as a file and print server. The floppy disk–based installation of Personal NetWare on a workstation actually took longer than putting the file server on the LAN. Total set-up time was less than 8 minutes.

I tested the Z-Stor on a 10Base-2 (thinnet) Ethernet LAN with several other PCs. One was a 25-MHz Compudyne 486 machine running Windows for Workgroups that I set up to be a Personal NetWare workstation. The Personal NetWare installation process transformed Windows for Workgroups to work cooperatively on the new LAN. A NetWare 3.11 server on the Ethernet segment allowed me to evaluate how the Z-Stor would work on an existing NetWare LAN.



With the Personal Server Extended Services utility you can remotely view the status and configuration of the Z-Stor Personal Server from a workstation.

And a LaserJet printer, which I attached to the Z-Stor's parallel port, became a shared resource for hard-copy output.

From the Compudyne system, Personal NetWare let me access the Z-Stor as easily as the NetWare 3.11 file server. Copying files between the servers and running applications, with a stopwatch to time the operations, told me the Z-Stor wasn't quite as fast as NetWare 3.11 running on an equivalent 25-MHz 486 machine. However, a typical workgroup of 2 to 10 workstations should be able to use it without significant performance penalties.

The Personal Server Extended Services utilities work well, but you probably will rarely need to use them; the Z-Stor Personal Server doesn't need a lot of babysitting. Except for making tape backups of your files at the server, there's simply no need to run any software on the server other than the NOS itself. Small, utilitarian, and easy to set up, the inexpensive Z-Stor is just right for peer-to-peer LAN workgroups that need to share files and a printer but want the reliability that a server-based LAN offers. ■

About the Product

Z-Stor Personal Server
Model 400 (210-MB hard drive).......$999
Model 1000 (540-MB hard drive)...$1599
Tested configuration (Model 400 with CD-ROM drive and FriendlyNet thinnet adapter) $1587

Zenith Data Systems
2150 East Lake Cook Rd.
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(708) 808-5000
fax: (800) 472-7211
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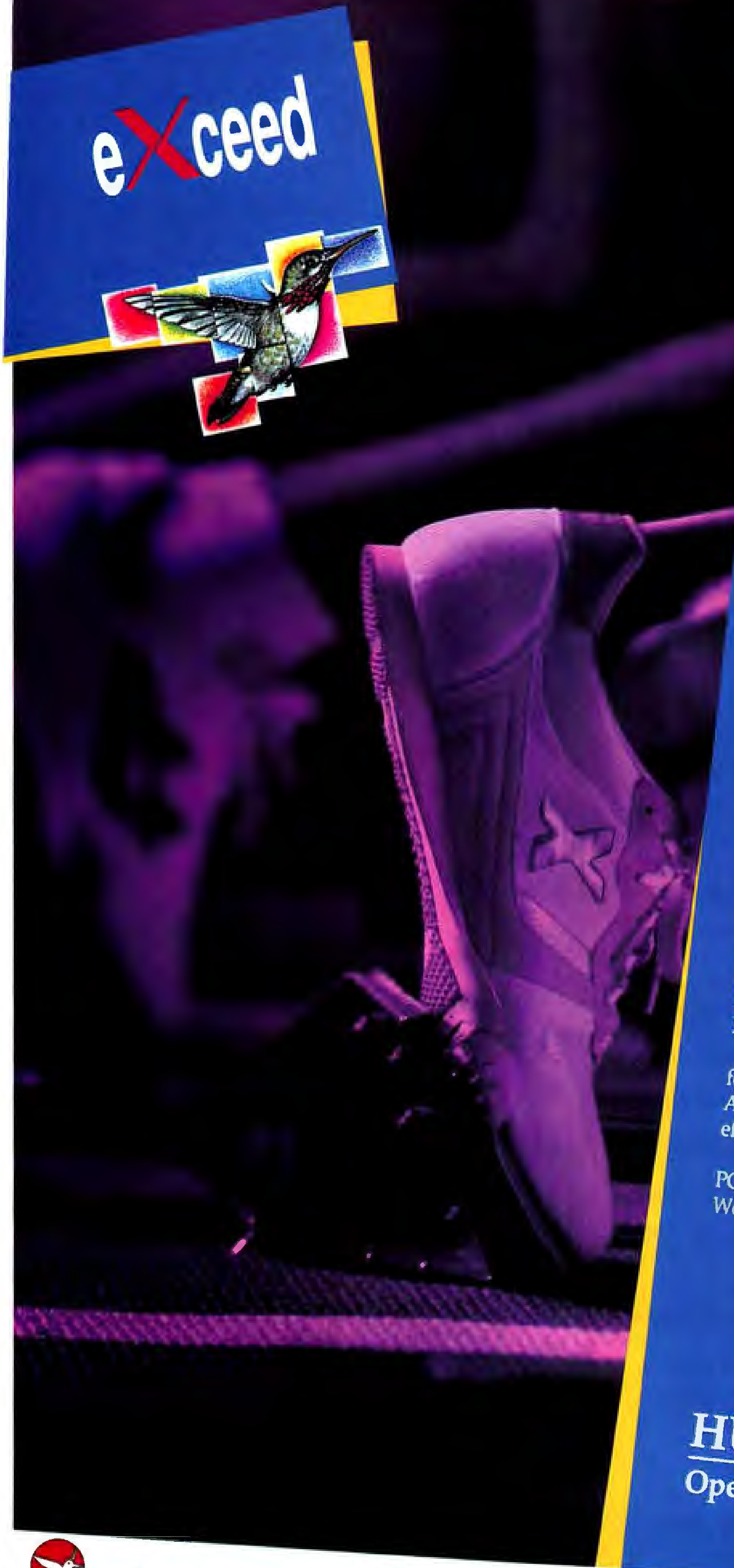

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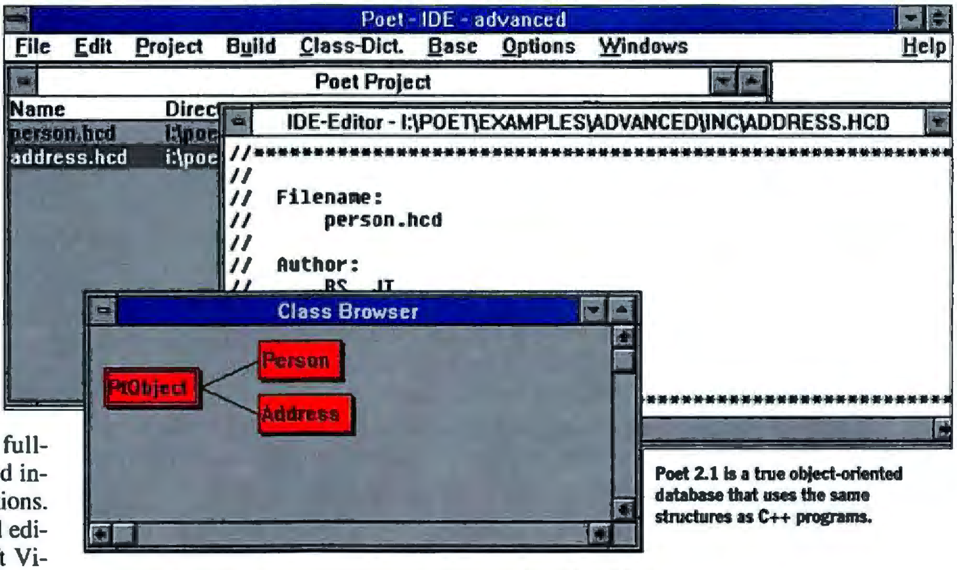
Poet in Motion

Poet 2.1 combines an object-oriented model with the best features of a multiuser database

RICK GREHAN



Poet 2.1 is a true object-oriented database that uses the same structures as C++ programs.

With everything in the programming world turning, it seems, into an object of one sort or another, it's inevitable that the trend of OOP (object-oriented programming) should spill into the database world. You would hope, of course, that such spillage would occur with a little thought behind it, not just as a consequence of technological inertia. Poet 2.1 puts the object-oriented model to good use and includes all the accoutrements you'll find in a full-blown multiuser database: compound indexes, locks, even multilevel transactions.

I explored the single-user personal edition for Windows 3.1 and Microsoft Visual C++. Versions are available for other compilers and platforms, including NT, OS/2, Mac System 7, NextStep, and several Unix variants. A professional edition (multiuser) is available on most of these platforms.

Beyond Relational Data

As justification for the move to ODBMSes (object-oriented database management systems), proponents claim that certain problems crop up when trying to manipulate a relational DBMS from within a C++ or Pascal program. In particular, there has appeared the notion of *impedance mismatching*, a term borrowed from the electronics world. Working with a relational database from within a language such as C++ forces your data to undergo a structural transformation when it passes from your application to the database or vice versa.

For example, suppose you have a database consisting of an EMPLOYEE table and a DEPARTMENT table. In your program, you might be tempted to lay out structures that will hold rows fetched from each table:

```
struct employee {
  char name[20];
  date birthdate;
  struct dept* department;
};
```

```
struct dept {
  char name[10];
  struct employee* depthead;
};
```

This scheme could produce a number of problems. First, the C++ structures represent the connections between employees and departments using pointers, while the database system (if it is relational) will handle these connections via foreign keys, which will likely be stored as strings.

Next, the `employee` structure includes a member of type `date`, which could be a class for which you've built methods that allow your program to easily perform sorting or comparison operations on calendar dates. If the internal storage format of a date as handled by the database is different, you'll have to build conversion functions to move data from one format to the other.

Poet seeks to alleviate these problems by creating a DML (database management language) within the structure of the C++ class syntax. At the heart of this idea is the notion of *persistent* objects: objects that have the look and feel of instantiations of C++ classes but can be placed in permanent storage in a database.

Poet manages the storage and retrieval of contained or referenced objects invisibly. When you load an object from the database, all referenced objects are also loaded, with pointers properly "wired."

The Front End

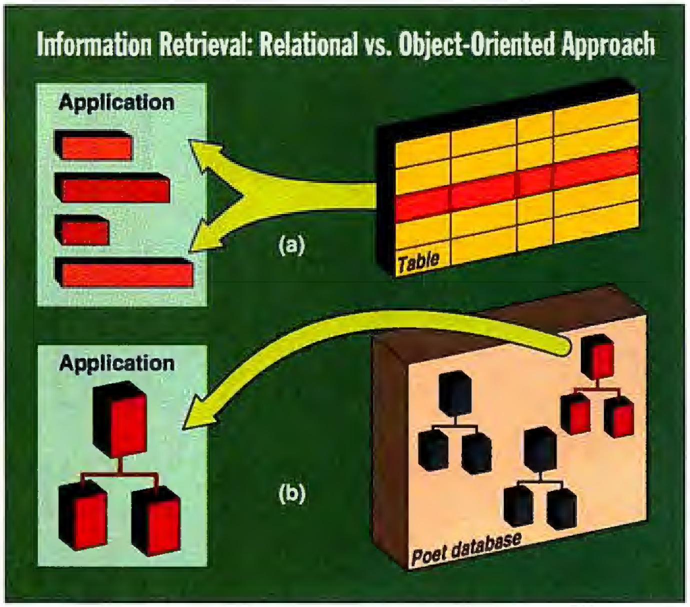
From the programmer's point of view, working with Poet is a matter of dealing with the preprocessor, PTXX. Actually more than just a preprocessor, PTXX takes a special header file (identified by a .hcd extension) into which you have placed the definitions of the classes whose objects will reside in your database and, from that file, generates all the C++ source needed to manipulate those objects.

Suppose you're working for an organization that has need of a client database and you decide to use Poet for the task. Since this is, after all, OOP, I'll assume that you've defined a class called Client that will hold each client's data. I'll also assume that you're a Poet pro: You've built your application's source code, you've fed everything to PTXX, and you're ready to include what PTXX has given you into your C++ program and hand it all to the compiler. What, precisely, has PTXX given you?

First, it has made a container class called ClientAllSet, a potentially humongous set whose elements are of class Client. Member functions allow you to traverse the set in various ways, retrieve elements from it, store new elements into it, delete elements, and so on. ClientAllSet is attached to the database of persistent objects out on disk. (This process of attaching a class to a database amounts to issuing a call to

"connect" the ClientAllSet class to a named database. From that point on, Poet handles the traffic flow of objects between disk and memory automatically.)

Second, PTXX defines a query class called ClientQuery. The member functions of ClientQuery allow you to specify a query's parameters. These specifications get assembled into an object of class ClientQuery, which you then pass to the `Query` member function of ClientAllSet.



Retrieving information from a typical relational database (a) usually means pulling a row from a table structure, disassembling the fields, and translating them into variables your program can use. Poet (b) lets you pull objects from the database and place them directly into C++ class structures—all pointers and references intact.

Finally, PTXX defines another container class, ClientSet. The behavior of ClientSet is much like that of ClientAllSet; its function is to hold an arbitrary number of objects of class Client, and you usually use ClientSet objects as a repository for query results. It is, however, not persistent.

All these classes are placed in .hxx and .cxx files, which you tie into your program via `include` statements. Simplest among the database manipulation methods are `Put()` and `Get()`, which, respectively, store objects into and retrieve objects from the database. Simple as they seem, however, things can get complex. An object of one class may contain as a member an object of another class. So an operation that appears to fetch a single object may actually fetch a nested Russian doll of objects containing objects. Furthermore, objects of class A may contain a pointer to an object of class B; fetching a classmember of A would require fetching the proper classmember B and resolving A's pointer to B. Poet handles it all, loading referenced objects and resolving pointers. Poet even allows you to control how much gets loaded.

For example, in the preceding case, you might want a fetch operation to retrieve *only* object A—leaving the pointer to B dangling—and retrieve object B only when you specifically issue a call to do so. Poet allows this via the `ondemand` keyword: The system will not retrieve an object of type `ondemand` unless it is explicitly told to.

Queries and Sorting

Querying is handled by the query class that Poet automatically builds for every persistent object class. Poet fills query classes with methods corresponding to each member of its parent class. If you define

```
persistent class Client {
  short clientid;
  char name[30];
};
```

Poet builds the following query class (I've left out some of the details of the member functions for clarity's sake):

```
class ClientsQuery: public PtQuery
{
public:
  Setclientid(...);
  Setname(...);
};
```

You can see that each member of Client has caused Poet to generate corresponding `Setxxx` functions. To locate the client whose ID is 47, the query would look like this:

```
ClientAllSet *call =
     new ClientAllSet(objbase);
ClientSet *result=new ClientSet;
ClientQuery clquery;

clquery.Setclientid(47,PtEQ);
call->Query(&clquery,result);
```

Reviews Poet in Motion

The `Setclientid()` member function of `clquery` lets you specify the parameters of the query. You then pass a pointer to this query object to the `Query` member function of `call`, which performs the query and places the results in `result`, a container class that can hold an arbitrary number of Client objects. Once the query has completed, you can use member functions defined for objects of class ClientSet to "browse" the query's results.

Finally, Poet also builds query class member functions that allow you to sort the query results. So, if you've built a query that locates all client IDs greater than 100 and you want to sort by name, you simply issue `call.SortByName(PtASCENDING)` before building the query. The items will be loaded into the result set in ascending order by client name.

Indexes

Indexes can significantly speed the querying and sorting process. If you create a class to which you wish to attach an index, you must build one or more class members of type `useindex`. The name of that member will appear elsewhere, in an `indexdef` definition. An `indexdef` looks like a typical C++-derived class definition, but it contains no methods—only data members. This is best illustrated by the following code:

```
persistent class Client {
  short clientid;
  char name[30];
  Address address;
  Phone phonenum;
  useindex IdIndex;
  useindex NameIndex;
  ...
};

indexdef IdIndex: ClubMember {
  clientid;
};

indexdef NameIndex: ClubMember {
  name[[20]];
  clientid;
};
```

Objects of class Client have two indexes associated: `IdIndex` and `NameIndex`. The first has only one component, `clientid` (in this example, a unique ID number assigned to each client). The second is a compound index, consisting of `name` and `clientid`. Notice the double brackets in the `name` member of `NameIndex`. This tells Poet to use only the first 20 characters of the name field in constructing the index. Poet is intelligent enough to use indexes whenever such use would speed a query. For example, Poet would use `IdIndex` for handling a query along the lines of "Which client's ID number is 400?"

Transactions

All Poet operations include some form of transactioning. Whenever you store an object, you may also be storing all other objects referenced by that object. (I say *may* because how much is actually stored can be controlled by the *depth mode* parameter in the store operation. This depth indicator has four settings, ranging from "store only the object itself" to "store the object and all objects it references.") When you issue a store operation that triggers placing multiple objects into the database, Poet stores either everything or—if any part of the operation fails—nothing.

If you're particularly antsy about the safety of your data, Poet does provide an optional two-phase commit. In this case, Poet builds a forward recovery file—a file that contains the write operations Poet *intends* to perform on the database—before making any updates. Even if the system crashes, Poet can use the forward recovery file to rebuild the database. Of course, enabling the two-phase commit option means that database I/O runs more slowly, since it requires twice the usual write operations.

The transactions I've described are system-level transactions. Poet also supports user-level transactions, which are handled using the time-honored begin/commit bracketing structures. Specifically, once you've connected to a database, you can issue a `BeginTransaction()` method call, carry on database operations, and conclude with a `CommitTransaction()` call. All operations between the two calls are posted to the database only when `CommitTransaction()` executes. If something goes awry during the transaction, you can issue an `AbortTransaction()` call and the database will be left in its original state.

Locks

Where transactions provide one form of concurrency mechanism, locks provide another. It's important to note that some locking goes on "under the sheets" when you enable transactions. Specifically, if you store or delete an object from within a transaction, Poet automatically places a transaction lock on that object to ensure that no other processes will mess with the object until the transaction is safely committed.

continued

Poet in Motion

In the case of explicit locks, Poet provides seven lock types, ranging from no locking to exclusive locking. In between, locks are classified based on what your process intends to do, along with what your process wants to prevent other processes from doing. For example, the `PtLK_READvWRITE` lock level indicates that your process will be reading the locked object so no other processes should try to write (or delete) it.

Since Poet is an object-oriented system, the question arises of how much in the database is being locked. Poet has four lock depths, from flat (which locks only the object being locked) to deep (which locks the object and all its referenced objects).

Events

Suppose you've initiated a query on a database that's likely to take a long time. It would be nice if you could keep the user apprised of the progress of the query and allow her to cancel the query if she decides it's taking too long.

Associated with each Poet database is an exception manager, and within the exception manager are methods that let you install callback functions for progress monitoring (a callback function being a routine in your application that Poet calls). You can build callback functions that are triggered at the beginning, during, and at the conclusion of a database operation. If you really want a spyglass into your database, every persistent class that is built by Poet inherits member functions `Watch()` and `Notify()`, which your program can use to track what operations other processes may be performing on an object. The `Watch()` member function accepts a *watch specification* as its argument; if the conditions of the watch specification are satisfied, the object's `Notify()` function is called. Again, some code will clarify this:

```
persistent class Client {
  short clientid;
  char name[30];
public:
  Client(short clientid,
      char* cname);
  Client();
  virtual int Notify(PtOnDemand
      *Object, PtOnDemand *Root,
      PtWatchMode Action);
};
...
Client MyClient(44,"Bob");
PtWatchSpec WatchDel
      (PtWATCH_DELETE,PtDEEP);

MyClient.Watch(&WatchDel);
...
```

In this example, I've defined the persistent class Client and overridden its virtual `Notify()` member function. Later in this hypothetical application, I've created a new Client object, "Bob," to which is attached a watch specification. The parameters of the specification tell Poet that I want my `Notify()` routine called whenever someone tries to delete "Bob."

You can create more than one watch specification for a given object. Poet allows you to set watches for store, update, lock, and unlock operations. Furthermore, you can set the depth of the watch, in fashion and function similar to setting the depth of a lock operation, which I described earlier.

About the Product

Poet Personal Edition for Windows 2.1
(as tested) $499
Requires Windows 3.1, 4 MB of RAM, and 5 MB of free disk space; versions available for Microsoft Visual C++, Borland C++, and Symantec C++. Other platforms supported.

Poet Professional Edition SDK
(multiuser), compatible with Windows for Workgroups and Microsoft Visual C++ $1995
Other platforms are supported; contact Poet Software for prices.

Poet Software Corp.
4633 Old Ironsides Dr., Suite 110
Santa Clara, CA 95054
(800) 950-8845
(408) 970-4640
fax: (408) 970-4630
Circle 1078 on Inquiry Card.

Coda

Hard-core, meat-eating C++ programmers faced with their next database project would do well to examine the possibilities offered by Poet, since it allows them to use the structures they'll be coding into their programs as the same structures that will feed the database. If you couple Poet with a good class library that allows the rapid construction of GUI objects (e.g., Microsoft Foundation Classes), you've got a platform that approaches—and in terms of flexibility, probably exceeds—many of the self-proclaimed fourth-generation GUI/database applications generators that are on the market today. ■

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Desktop Dictation

The IBM Personal Dictation System delivers a voice-controlled computer interface and sophisticated speech-to-text software—on a 486-based PC

STANFORD DIEHL

The IBM Personal Dictation System, or IPDS, brings computer-based dictation services to a mainstream corporate audience. The system combines a voice-controlled application interface with a sophisticated dictation system. Less than two years ago, this type of system required the horsepower of an RS/6000, but the system I evaluated ran on a 486-based OS/2 desktop. IBM is currently working on a Windows version.

The Technology of Speech

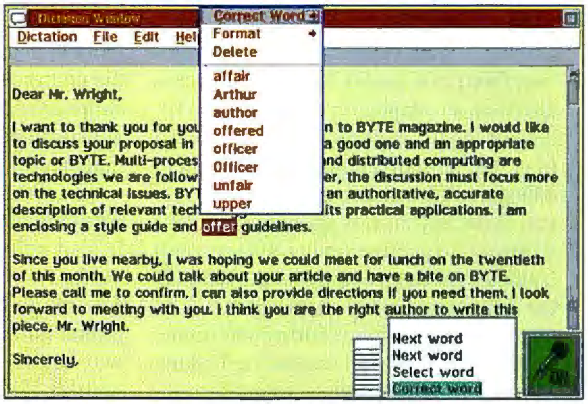
The IPDS requires a single adapter, along with OS/2 2.1 software. The adapter provides audio input and output and also includes a DSP (digital signal processor) that handles the computationally intensive dictation algorithms. The system must be able to immediately access the acoustic models of up to 32,000 words as well as the parameters stored for the speaker's voice.

Naturally, this requires some memory. IBM recommends 16 MB of RAM—8 MB for IPDS, the rest for OS/2. IPDS occupies 32 MB of hard disk space and consumes an additional, recoverable, 30 MB during training. After training, 2 MB or less should hold your voice parameters, but optional dictionaries add 10 to 15 MB each to the hard disk requirements. During a dictation session, the system stores data for the correction phase, including audio data (for playback) and possible alternative words. So you'll need lots of space during a dictation session—over half a megabyte per minute of speech. At the end of a session, those resources are recovered.

Discrete-speech systems support large vocabularies. IBM's dictation system ships with a 20,000-word office correspondence dictionary. Optional specialized dictionaries range from 16,000 to 30,000 words; you can add 2000 words to each dictionary. You must pause discretely between each word you speak, and you have to train the system to understand your voice. Combining a command interface with dictation technology enables you to create and save documents in a completely "hands-free" environment: You can dictate *and* enter system commands with your voice.

Basic Training

To train the system, you must recite, one sentence at a time, a script that appears on your screen. My training session took well over an hour. The process can get a bit tedious, but you can pause the session at any time and resume training later. Once you have completed the training session, the system requires another 2 hours to process the data.



The IPDS includes voice control of the OS/2 desktop and a sophisticated dictation application. When you correct a word, the system offers a list of possible alternatives. Note the button for turning the microphone on and off and the history of voice commands.

The system builds an icon for you on the desktop. Double-click on it, and the system loads the IPDS. Clicking on the microphone button at the bottom right corner of the screen turns the microphone on and off. Say "dictation window," and the dictation application starts up. You are presented with a window that looks much like a blank word processing document. Say "start dictation," and the system will begin translating your speech into text. Once I got the hang of speaking with a pause between words, I dictated fairly quickly, up to 70 words per minute.

I dictated a number of different types of documents into the system: press releases, magazine articles, excerpts from popular novels, technical manuals, office memos, business letters, and even some poetry. In each case, the system improved as I read additional documents into it. The adaptive language model does its job well. It entered new words into the dictionary so that the system understood words I commonly use, including special formatting (e.g., capitalizing all the letters in BYTE). But it also updated data on my word-usage patterns; in effect, it learned the frame of reference for a particular set of documents. For instance, the more that I read press releases into the system, the better it got at translating press releases.

I found that the system works much better for documents (e.g., legal papers and technical manuals) that abide by a consistent language structure; with such documents, the system can better predict what words will be used. It is much less accurate on more free-form prose, such as a novel, but in general, the system is very accurate—considerably better than other computer-based dictation systems I've used.

Hands-Free, Eyes-Free

When you first start using the system, you have to correct quite a few words. Luckily, you can complete a dictation session without watching the screen to check for any errors that are being made. This makes the system "eyes-free" as well as "hands-free." When you go back to correct the mistakes, you select the offending word, and the system plays back your pronunciation of the word. So even if the system really mangles the translation, you can always go back and hear what you said. The system also lists possible alternatives for an incorrect word. Often, the correct word is on this list, and you simply select it (see the screen). If the word is not on the list, you type it in. New words are added to the dictionary in this way.

Over a few weeks, not only did the system adapt to me, but I adapted to the system. I spoke more rapidly and rarely ran words together. I also learned how to correct words quickly. I transferred documents to a word processor and completed any final edits there. Voice macros were simple to create and extremely convenient. For instance, I could say "open letter," and the system would print my name and address, the current date, and a general

Learning to Listen

To translate speech into text, the IBM Personal Dictation System, or IPDS, employs four distinct but interwoven procedures. The first one is *acoustic processing*, which extracts usable information from raw audio data. The process also uses an adaptation mechanism to filter out steady-state background audio (e.g., the hum of a computer fan) and to adjust to different microphones. The system collects your raw speech and breaks it down into centisecond (1/100-second) frames. Spectrum analysis determines the distinct frequency characteristics (i.e., feature vectors) of the centisecond frame.

A statistical model, called the Hidden Markov Model, predicts which feature vectors are likely to represent a subphonetic sound (such as the *t* sound). These subphonemes are called *labels*. So, for example, the Hidden Markov Model for a *t* sound will most likely predict *t*-type labels. The system knows what sounds you are making during training because you are following a known script. It learns how you make a *t* sound, how you make an *a* sound, how you make an *a* sound when it follows a *t*, and so on.

The next step, *acoustic matching*, compares the extracted labels to the acoustic models in the dictionary. Every word in the dictionary is broken down into these subphonetic labels, so the labels generated through acoustic processing can be matched to the dictionary entries.

The system does not decide on the best word based on acoustic matching alone. It also employs an *adaptive language model* to enhance recognition accuracy. The language model is based on unigrams (single words), bigrams (sets of two words), and trigrams (sets of three words). The model maintains data on word usage and knows the probability that any single word or set of words will be used.

For instance, there is a relatively high probability that the word *the* will be spoken, and a lower probability that the word *creed* will be spoken. The system then looks at a pair of words and determines the probability that a particular pair of words will appear together. Next, it considers a set of three words and checks its probability data again. The system constantly refines its recognition of a particular word by looking ahead and back. As you dictate, you can watch the system dynamically alter its word guesses as the frame of reference around that word expands.

The last step of the process, the *hypothesis search*, combines the results of both the acoustic matching and the language model to determine the most probable word string.

In addition to adding new words to the dictionary as you specify them, the system updates the probability models to reflect your unique word-usage patterns. This adaptive process allows the system to become more accurate as you use it. It also explains why the system works better with documents that share consistent terminology and phraseology: It can better predict what words you are likely to say if you follow consistent patterns of word usage.

---

salutation. You can generate often-used phrases or paragraphs by simply saying a single word. The system can be frustrating at first, but it gets more accurate and much easier to work with as you go along.

The IPDS should appeal to markets where voice recognition has traditionally done well. The ideal environment for the IPDS is a "hands-free/eyes-free" one, such as a hospital where a nurse could enter patient data while taking a blood sample. The alternative is a manual procedure (e.g., a pen and clipboard) that requires the use of your hands. Legal applications are also well suited for IPDS. IBM sells supplemental dictionaries for journalism ($499), emergency medical ($499), and radiology ($599) applications, and more are in the works. IBM is also porting RS/6000 European language versions to the PC.

Breaking Tradition

Beyond the traditional markets, IBM is targeting IPDS for general business correspondence. During my evaluation, I found that most of my correspondence shares consistent terminology and phraseology. The system became quite accurate at creating memos and business letters.

However, the corporate environment is not as amenable to speech recognition as traditional voice applications are. The range of documents is more diverse, and the physical environment might be unsuitable. Although the training process accounts for steady background noise, the system will still pick up any loud stray noises. In a shared-office or cubicled arrangement, you give up confidentiality when reciting your documents, and your coworkers might grow weary of listening to your dictation sessions.

If you are accustomed to regular typing, you will generate correspondence more quickly from your keyboard. If you currently use a stenographer, you must consider the tradeoffs. The IPDS involves more work (i.e., training the system and correcting mistakes), but it costs much less than a stenographer, is always available when you need it, and requires no health insurance. If you don't type well or don't feel comfortable working with a computer, the IPDS system should appeal to you. It's easy to use and employs the most natural interface of all: Just talk to it.

Voice recognition is becoming viable. IBM is on the right track, and the future looks exciting. The company showed me a prototype system running on a ThinkPad with a PCMCIA adapter, promising that speech recognition for mobile applications will be available soon. And IBM believes that the PowerPC processor has the horsepower required to support the IPDS without the need of additional DSP hardware. A PowerPC-based personal digital assistant may then adopt a voice-activated interface. Voice-controlled computers are no longer relegated to the realm of science fiction or even to specialized niche markets; viable speech recognition has arrived on the desktop. ■

About the Product

IBM Personal Dictation System
Software and microphone headset....$499
Micro Channel adapter....................$579
ISA adapter....................................$499

IBM Corp.
Speech Recognition Support Center
Mail Stop 2236, Route 100
Somers, NY 10589
(914) 766-9251
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Stanford Diehl is director of the BYTE Lab. You can reach him on the Internet or BIX at sdiehl@bix.com.

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Printer at Work

Microsoft At Work makes Lexmark's WinWriter 600 a capable personal laser printer. It's not a good choice for most networks, however.

ED PERRATORE

Microsoft outlined its broad At Work strategy for integrating office equipment and PCs in June 1993, specifying five types of hardware as potential At Work devices: fax machines, photocopiers, telephones, printers, and, incongruously, hand-held PDAs (personal digital assistants). Microsoft's At Work partners previewed some pieces of the technology during the official At Work debut to show its potential. Ricoh, for example, demonstrated a prototype of its networkable IFS66 fax machine (which is due this quarter). The fax capability in Microsoft Windows for Workgroups 3.11 also adds to the At Work picture.

The first available At Work device from a company other than Microsoft, however, is Lexmark's WinWriter 600. The $1399 WinWriter provides a nearly complete model of what At Work can do for printers. In doing so, it demonstrates both goals of Microsoft's At Work strategy. The first goal is to make complex, feature-laden office equipment and PC peripherals more useful through a common GUI (not necessarily Windows) that guides you through setup and operation. The second At Work objective is to integrate office peripherals and PCs as much as possible. This happens through communications capabilities and document-rendering standards that move digital data from point to point in the most useful form permitted by a particular communications channel.

Hooked to a network, an At Work office copier could, for example, serve to scan documents into digital form and send them via E-mail around the LAN. Likewise, a networked At Work fax machine, with a touchscreen LCD to display the At Work GUI, could give you the same control features that fax software now provides for PC-based fax boards, such as off-hours fax mailing and routing to mailboxes.

It's a grand plan, and one that's still evolving, with implications yet to be realized. Microsoft's total At Work strategy, however, will succeed only if it receives support from other companies in the hardware, software, and telecommunications industries and if customers are willing to pay for the added functions. My experience while testing the WinWriter 600 indicated that at least some parts of the At Work technology will survive, whether the total Microsoft initiative catches on or not.

Lexmark's $1399 10-ppm WinWriter laser printer has a minimalist front panel. It relies on Microsoft At Work Printing Software as an interface for configuration and feedback.

A Familiar Story

Microsoft's At Work Printing Software gives the WinWriter two advantages: unusual ease of use and RISC-like performance that belies its fairly slow (and inexpensive) CISC processor. The former advantage comes from the At Work user interface, and the latter from having the host PC preprocess the print image. Using a slow processor also helps to keep the printer's price down.

This printing approach should sound familiar. Microsoft's Windows Printing System provides the same benefits for Hewlett-Packard's LaserJet II and III printers. Indeed, the At Work software is a scalable update of this older cartridge-based system, which has become an official At Work product by default.

The WinWriter 600, which has the same laser engine as Lexmark's 4029 printers, provides high-quality output and a rated printing speed of 8 pages per minute with 600-dot-per-inch resolution, and 10 ppm when printing 300-dpi output. The WinWriter 600 also has IEEE 1284–compatible bidirectional communication, allowing the printer to provide detailed feedback to the host computer—a key requirement for At Work printing.

Lexmark was able to meet its under-$1400 price point by focusing on Windows. It didn't build in support for HPGL (Hewlett-Packard Graphics Language) or the ability to take a PostScript printing option. If you're printing from DOS, you do get PCL 4 (Printer Control Language) emulation, six printer-resident bit-mapped PCL fonts, and a printer-control utility. But from DOS you miss out on the At Work software's performance advantages and the pleasurable user interface.

For paper handling in the WinWriter 600, you get a 200-sheet input tray that, to the possible dismay of some users, outputs (collated if you want) to only a 100-sheet upper tray. A snap-on front tray can accept 20 sheets of face-up heavy- and sensitive-stock output, fed through a rear removable manual-input tray. Options include a $349 500-sheet feeder that goes underneath the printer ($359 for legal size), and $229 100-sheet auxiliary and $349 75-envelope feeders that go in the same rear position as the manual-input tray.

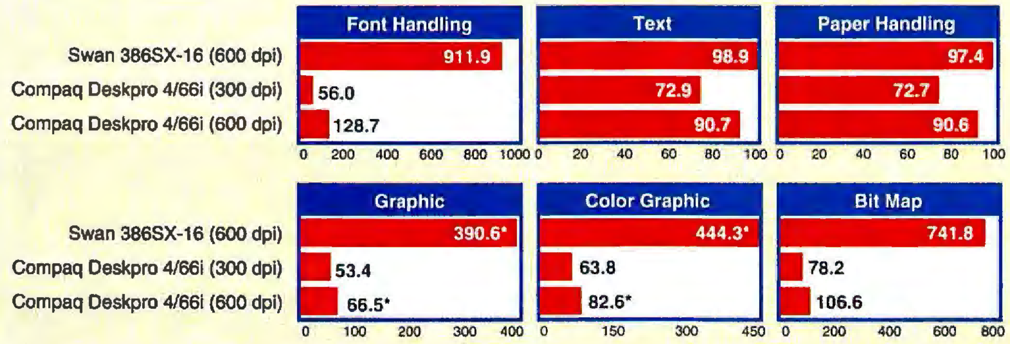
The WinWriter comes with a 4000-page toner cartridge. Replacements cost $199 for a 7000-page cartridge and $259 for a 9500-page cartridge, all based on 5 percent toner coverage.

Finer Feedback

The WinWriter's At Work Printing Software takes up a whopping 6 MB of hard disk storage. However, it provides performance benefits and an exceptionally well-designed setup and feedback interface. You also get the 44 TrueType fonts of the Microsoft Font Pack. The At Work software turns the WinWriter into a very smart printer, one that can converse with your PC about print-job status and any problems requiring attention.

During the approximately 10-minute installation process, the software looks for your printer (it must be on-line) and determines the resources of both PC and printer. Changes in setup are a snap, thanks to several graphical panels in the setup

WinWriter 600 Printing Performance



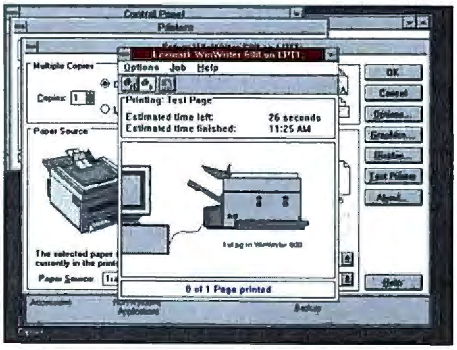
* Microsoft At Work printed the document at 300 dpi after issuing a warning and recommending a RAM upgrade.

The Lexmark WinWriter 600 had 2 MB of memory; the Compaq Deskpro 4/66i had an Intel 66-MHz 486DX2 CPU, 8 MB of RAM, and a 240-MB hard disk; the Swan 386SX-16 had a 16-MHz Intel 386SX CPU, 4 MB of RAM, and a 50-MB hard disk.

Due to preprocessing by Microsoft's At Work Printing Software, the processing abilities of the host PC have a big performance effect. All results are from using NSTL's printer-performance tests. All times are in seconds.

dialog box that replace the usual (often unintuitive) click-on options. The panels range from graphical representations of portrait versus landscape to a dot-pattern diagram that changes when you adjust brightness or contrast levels.

When you print a document, a pop-up window gives you an accurate estimation



The WinWriter 600's Microsoft At Work user interface, which runs on the host PC, provides detailed feedback during the printer process (shown here) and if any problems pop up.

of the time required until the last page drops into the printer's output bin. A status bar at the bottom of the window tells you how many pages of the total have been printed thus far, and a masculine voice from your PC's speaker announces such things as "printing completed." I personally tired of the voice and disabled it.

The animated window also provides valuable feedback on printing problems. Its flair for diagnostics isn't flawless, but messages such as "toner low," "check cover/cartridge," "clear paper jam" (I had no jams in nearly 4000 pages), and "paper out" take plenty of the guesswork out of your printing.

Unfortunately, bidirectional communications doesn't work across a network. However, Microsoft intends to issue an upgrade to the software (no date has been specified yet) that will handle this shortcoming. This piece of software will take care of the added communications hop between the client PC and the PC that's hosting the printer. No hardware changes are required.

The WinWriter has a minimalist front panel. Two buttons give you cancel, form-feed, and pause/resume functions; four LEDs indicate ready, printing in progress, paper status, and service needed. The rest is handled nicely through the At Work software, as described above.

At Work Printing

Unlike previous Windows printers, the WinWriter isn't dumb. It has a relatively inexpensive 16.7-MHz Motorola 68000 CPU, and it comes standard with 2 MB of RAM. The Motorola chip isn't fast by current printer standards, but it's good enough to handle the built-in PCL 4 for DOS applications and to team up with the CPU in your PC.

The At Work software is quite sophisticated in getting maximum speed from the printer while involving the host CPU as little as possible. It uses a process that Microsoft calls *load balancing* to distribute the workload so that the printer processor does as much of the work as possible. Taking the processor and memory configuration of both printer and host PC into account, the At Work software divides each page of a document's Windows metafile representation into bands, analyzes each band for the complexity of its printed objects, and then allocates CPU horsepower and RAM as needed. Typically, At Work assigns the printer processor as much work as it can handle in real time, but on occasion the software will assign it and the host PC the preprocessing of difficult bands before starting up the laser engine.

The At Work Printing Software requires a minimum Windows configuration of a 386SX processor and 4 MB of RAM. The faster the host CPU and the greater the available memory, the faster the WinWriter 600 prints, to the limit of the 8- or 10-ppm print-engine speed.

Another benefit of the At Work software is that every page always prints. Lexmark guarantees that if your PC meets the minimum configuration, a standard 2-MB WinWriter will always give you output, though perhaps not at 600 dpi. On some tests I ran, for example, the At Work software dropped resolution from 600 dpi to 300 dpi with a displayed warning indicating which pages required this action. If you need detailed bit maps at 600 dpi, get the $279 upgrade to 6 MB.

Performance Tests

To test the WinWriter 600, I ran the same NSTL benchmarks used for this month's Lab Report (see "Head to Head: 71 Printers" on page 164). To show the effect of the host PC configuration, I tested the printer attached to two different machines, a Swan 386SX-16 with 4 MB of RAM and a Compaq Deskpro 4/66i with 8 MB of RAM. Except for the text and paper-handling tests, where laser-engine speed was the determining factor, printing with the 66-MHz Compaq was five to seven times faster than with the 386SX-powered Swan (see the figure "WinWriter 600 Printing Performance").

About the Product

WinWriter 600 ....$1399
Lexmark International, Inc.
740 New Circle Rd. NW
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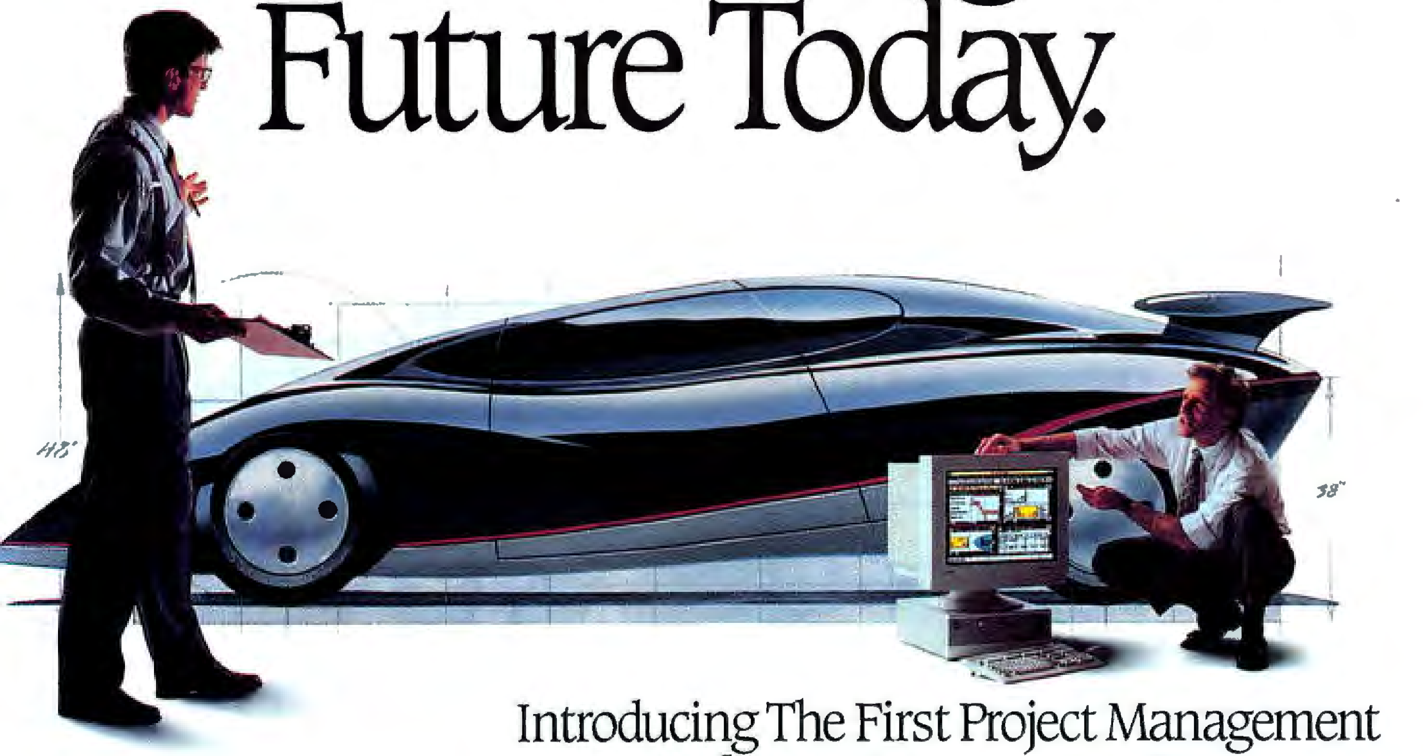

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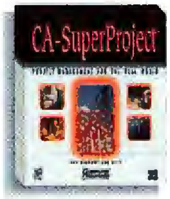

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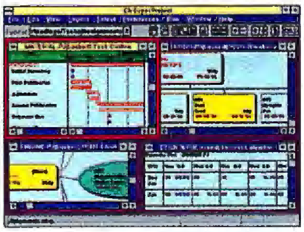

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Circle 76 on Inquiry Card.

Lexmark suggests that if you regularly print complex bit maps, you should upgrade your printer from the standard 2 MB to 4 or even 6 MB. (The maximum is 8 MB, for which you must discard the standard 2 MB and install two 4-MB SIMMs.) The whole rendered page must fit in the printer's RAM to print as intended.

Lexmark claims that the WinWriter 600 should print faster than HP's LaserJet 4, despite the WinWriter's slower processor. Comparing my WinWriter test results with the Compaq Deskpro 4/66i to results from NSTL's testing of the LaserJet 4, I can't verify Lexmark's claim. The NSTL results came from testing with a slightly faster Compaq Deskpro 4/66m (also with 8 MB of RAM), and the tested LaserJet 4 had 4 MB of memory. Still, I can say that the results for both printers are in the same ballpark, although HP has just released a faster version of the LaserJet 4.

Weighing In

Your first consideration of the WinWriter 600 must take Windows into account. The printer's most important features, including performance, depend on the Windows-based At Work Printing Software. Performance also depends on the host system.

The At Work user interface is an important feature, but you must determine if the challenges you now face in printing from Windows applications necessitate a printer that says and shows so much. HP's LaserJet 4L and 4P printers provide similar, though less complete, feedback.

As useful as printing feedback would be on a network, the WinWriter 600 is not a network printer. The status feedback does not yet go any farther than the PC that the printer is attached to.

The WinWriter's lack of PostScript support will be a greater shortcoming for many networks, especially where people use high-end graphics applications or systems other than Windows-using PCs. The WinWriter supports PCL 4, but without the benefit of host processing.

If you don't need a network printer, but you do need fast graphics speed in a Windows environment, you will have much to like in the WinWriter 600: quality output with a helping hand and reasonable graphics speed, plus guaranteed compatibility with Chicago, Windows for Workgroups, and, eventually, Windows NT clients. ■

Ed Perratore is a BYTE news editor based in New York. You can contact him on the Internet or BIX at eperratore@bix.com or on MCI Mail as "eperratore/byte."

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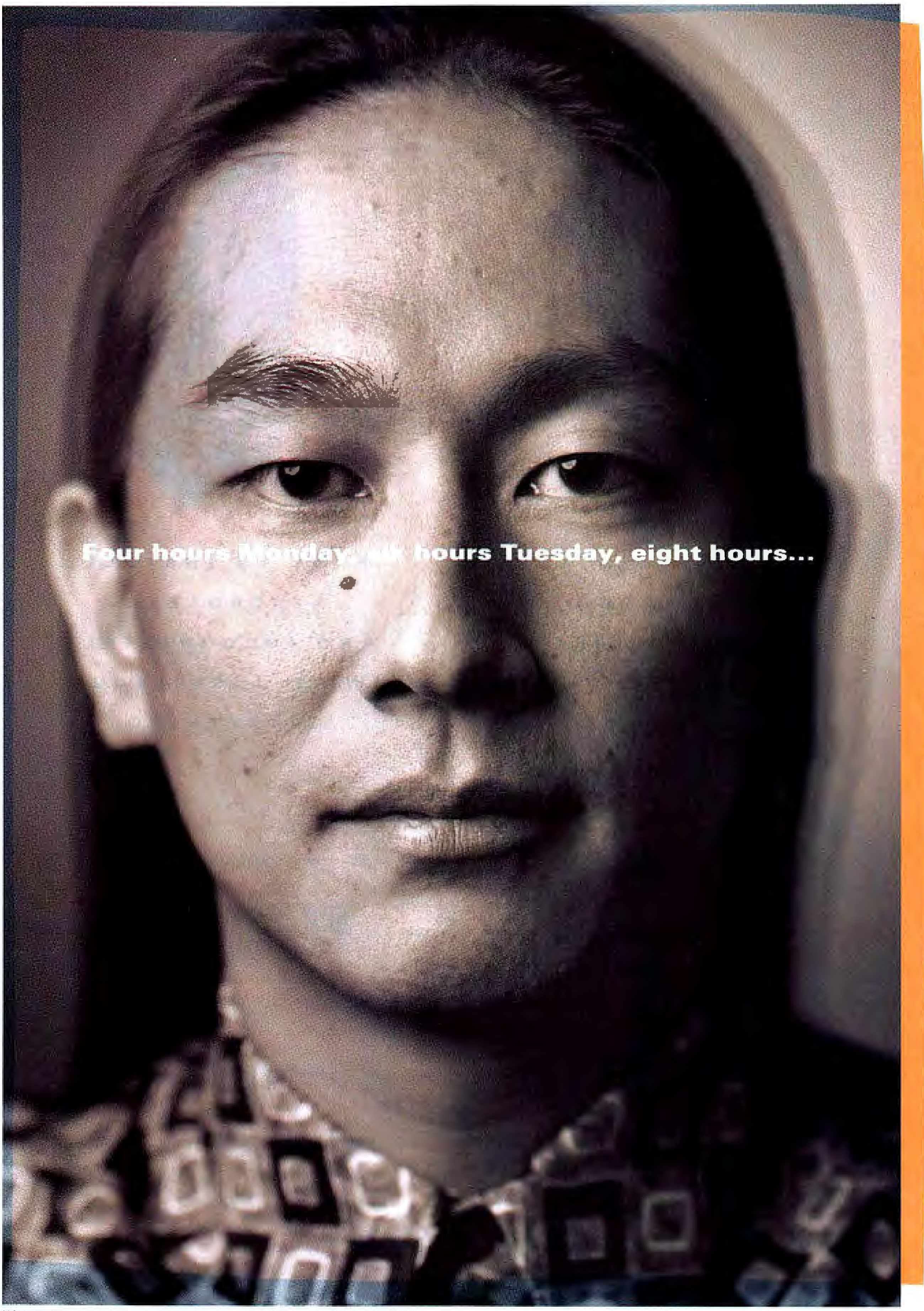
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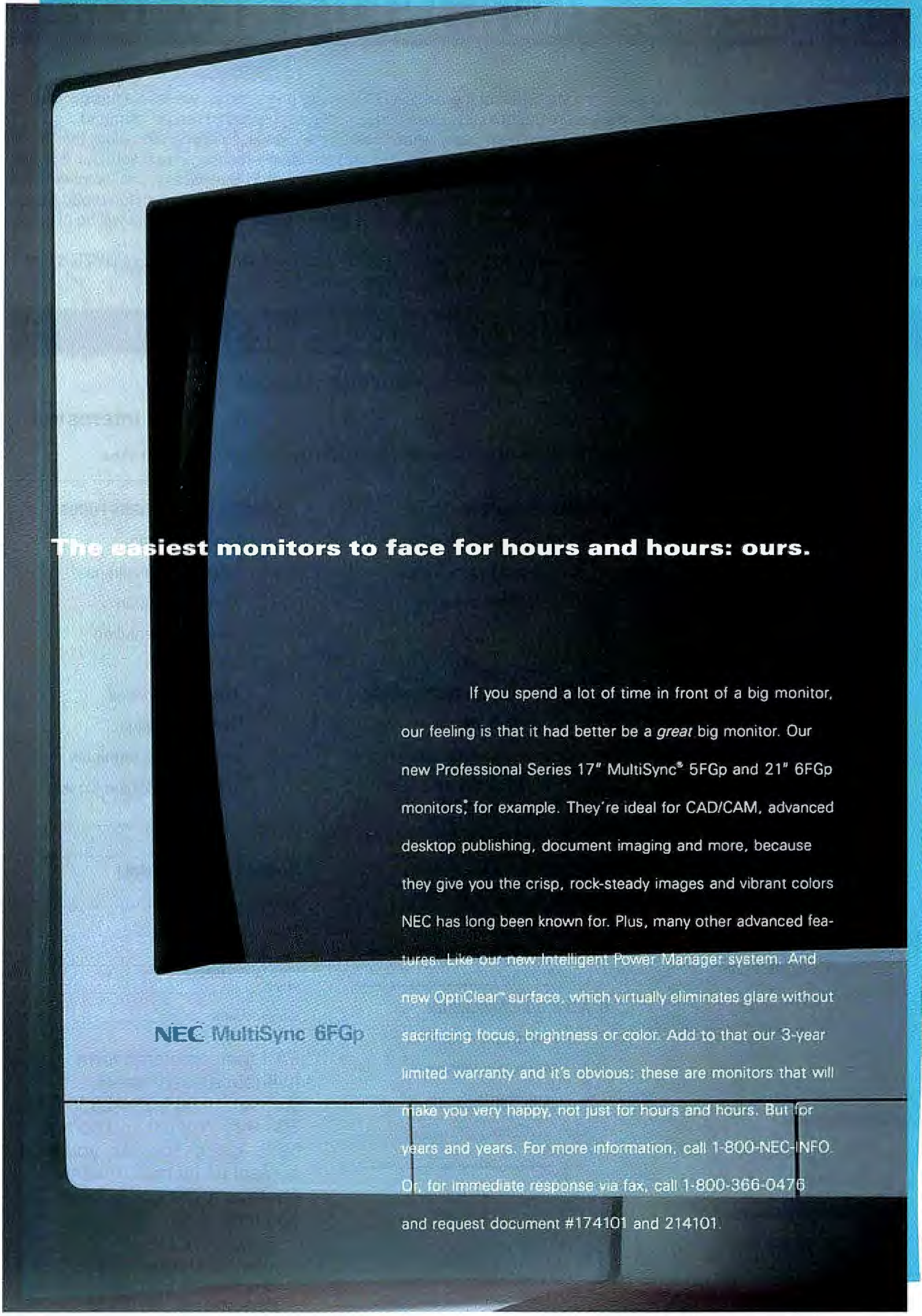

*17" and 21" CRTs yield 15.6" and 19.8" viewable screen areas

Circle 115 on Inquiry Card.

NEC

URGENT—YOUR INPUT NEEDED

Dear Reader—

One of BYTE's important sections is our unique "State of the Art" (SOTA), where every month we take a narrow slice of computer technology and examine it in the kind of depth that you, as a technically sophisticated reader, demand.

We plan our SOTA coverage based on what we hear from users, what's new on the market, emerging technology that BYTE editors hear about in our ongoing discussions with vendors, and last—but far from least—feedback from you, our readers.

With this issue, we're trying to get that all-important reader input well before the fact. Specifically, the October 1994 SOTA will deal with some aspect of the general topic of Data Acquisition in Business. This is clearly much too broad a subject to cover comprehensively; therefore, we want to identify the appropriate slice or slices of this topic that will be of greatest interest and most use to you, our readers.

Therefore, please take a minute to fill out this form and fax it back to us. Your cooperation will help make BYTE a better magazine and will allow us to focus on those areas that you're most interested in. Thanks.

DATA ACQUISITION IN BUSINESS

For each question, please rate your interest in these topics using the following scale:

Not at all interested 1 2 3 4 5 Very interested

If there is an important answer that we haven't offered you, please write that in on one of the provided lines.

---

1. DATA INPUT TECHNOLOGIES

- ☐ A/D conversion
- ☐ bar coding
- ☐ brainwaves
- ☐ handwriting recognition
- ☐ handprinting recognition
- ☐ mark-sense
- ☐ OCR
- ☐ other optical scanning
- ☐ touchscreen
- ☐ video
- ☐ voice recognition
- ☐ ____________________
- ☐ ____________________

2. DATA VALIDATION

- ☐ boundary controls
- ☐ algorithms
- ☐ AI and expert-system checks
- ☐ ____________________
- ☐ ____________________

3. ERROR HANDLING

- ☐ automated systems
- ☐ graphics-based systems
- ☐ exception queues
- ☐ AI-based systems
- ☐ ____________________
- ☐ ____________________

4. PROCESS CONTROL

- ☐ feedback loop design
- ☐ sensor technologies
- ☐ real-time systems
- ☐ ____________________
- ☐ ____________________

5. ELECTRONIC DATA INTERCHANGE

- ☐ interface design
- ☐ integrity verification
- ☐ origination verification/ nonrepudiation
- ☐ authorizations, signatures, sign-offs
- ☐ forms technology
- ☐ standards
- ☐ ____________________
- ☐ ____________________

6. A/D & D/A CONVERSION

- ☐ hardware or software
- ☐ sampling techniques
- ☐ standards
- ☐ ____________________
- ☐ ____________________

7. SPECIFIC APPLICATIONS FOCUS

- ☐ manufacturing
- ☐ telecommunications
- ☐ survey research
- ☐ lab/instrumentation
- ☐ medical
- ☐ financial services
- ☐ service tracking
- ☐ point-of-sale terminals
- ☐ public information kiosks
- ☐ ____________________
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BYTE SOTA Poll
c/o Market Research Dept.
One Phoenix Mill Lane
Peterborough, NH 03458

Big-Screen Stars

Nanao's and Nokia's best monitors set a new benchmark for 21-inch CRTs—flicker-free at 1600 by 1200 pixels

STEVE APIKI

Nanao's FlexScan F780iW (left) and Nokia's Multigraph 445X define the leading edge in monitor technology, with 1600- by 1200-pixel resolution at an 80-Hz refresh rate. The FlexScan sacrifices low-end graphics support for excellent performance at high resolution, while the Multigraph 445X relies on digital fine-tuning to enhance display quality. Both monitors provide a wide variety of configuration options—the FlexScan through the front panel, and the Multigraph through a configuration menu.

For the manufacturers of the next generation of high-resolution displays, high-quality 1600- by 1200-pixel resolution on a 21-inch screen presents formidable technical challenges. The Nanao FlexScan F780iW ($3999) and the Nokia Multigraph 445X ($3225) are the first mainstream PC and Macintosh monitors capable of flicker-free 80-Hz refresh at 1600 by 1200 pixels. But while both are excellent displays, they arrive at the next high-resolution frontier by two very different paths, and not without trade-offs.

The technical challenge in building a high-quality, high-resolution display is simply one of numbers. Displaying 1600- by 1200-pixel resolution on a 21-inch screen requires a dot pitch of 0.26 mm or finer, but putting more phosphor dots on a big screen increases the chance of manufacturing defects. The combination of large tube and small spot size also calls for more precise electronics because the alignment of the scanning electron beams is more critical.

Because so much of a large screen image falls in your flicker-sensitive peripheral vision, the electronics in a 21-inch monitor are further pushed by the need for a high vertical refresh rate. A 76-Hz refresh rate is flicker-free for many people, but 80 Hz is better. Displaying 1600 pixels by 1200 pixels by 80 screens per second requires a very large bandwidth. (In fact, very few graphics cards can drive these monitors at the 200-MHz bandwidth required for this screen mode.)

To meet these demands, Nanao has chosen a traditional approach that provides uncompromised image quality at high resolution but limits the FlexScan's capabilities on the low end. Nokia's design is more radical, relying on digital tuning of display parameters to overcome display defects and provide more flexible configuration. I worked with both of these high-end monitors and ran them through quantitative tests in the BYTE Lab to measure performance. By both quantitative and qualitative measures, the FlexScan is the better monitor, despite Nokia's more revolutionary architecture.

Nanao FlexScan F780iW

As the new top of the FlexScan line, the F780iW has a great pedigree. Like the other models in that very successful line of monitors, Nanao's latest FlexScan is well designed and delivers outstanding display performance: sharp, bright, uniform, and flicker-free at 1600- by 1200-pixel resolution.

The cost of great high-resolution performance, unfortunately, is lack of support for standard VGA modes. This is the F780iW's weak spot. Monitors can perform optimally over only a limited range of frequencies, even within their specified bandwidth. Rather than sacrifice optimal performance at high resolution, Nanao decided to shift the horizontal frequency range upward, putting the lowest supported horizontal scan frequency at 45 kHz—above the standard VGA scan rate of 31.5 kHz. That means that the F780iW is unable to support the boot video mode of most PCs, so it's relegated to use as a second monitor.

Nanao's fix is to offer the FlexScan bundled with a modified 4-MB Matrox MGA Ultima Plus graphics board ($4999 for monitor and board). The MGA Ultima's built-in VGA can drive the F780iW at boot-up; equally important, the modified MGA Ultima includes a 200-MHz color DAC (D/A converter) chip and is set to support refresh rates of up to 76 Hz at 1600 by 1200 pixels.

For almost any application except CAD, a second monitor for booting is an unreasonable requirement. I ran the FlexScan with an MGA Ultima, so using it as a primary monitor for Windows applications was practical, and the board and monitor combination worked fine.

Once past the boot, the FlexScan's display was great. Running AutoCAD, the monitor's ability to run the visible image to the edge of the display bezel without black borders (a capability that Nokia's monitor shares) was wonderful. It put AutoCAD's top and right menu borders square up against the edge of the screen.

Windows is often a stringent test of monitor capability, as the large, bright display background easily shows any nonuniform brightness characteristics. The FlexScan showed a bright Windows display with high contrast, although there was

Comparing screens between the FlexScan F780iW (left) and the Multigraph 445X shows that both displays provide clean, sharp lines and good convergence. However, despite tuning monitor parameters for this shot, the FlexScan provided somewhat better contrast and less luminance variation over the white areas.

a small, slightly pink diagonal region. When it was running in one area of the BYTE Lab, near a large linear power supply, the FlexScan also showed some flicker interference that did not affect the Multigraph. As an FCC Class A device, the FlexScan may also generate more EMI/RFI in addition to being more sensitive to interference.

The FlexScan's display was sharp at all corners. Nanao uses two optimizations, Dynamic Focus and Dynamic Beam Spot Control, which help to improve sharpness away from the center of the screen. These technologies compensate for changes in focal length across a scan and keep the electron-beam spot circular on all areas of the tube.

Nokia Multigraph 445X

Nokia's Multigraph tackles the image-consistency problem from a new angle. Instead of having a single set of analog beam adjustments that optimize display quality at the center of the screen, the Multigraph provides digital control over 16 adjustment points, which cover the center, the corners, and selected points in between. This is new technology—as of this writing, only Nokia offers a monitor with this capability. Philips, which has announced a similar system, was not able to deliver a production unit in time for this review.

Parameter adjustments are made on the fly, but the targets for each adjustment point are preset, since there is no feedback mechanism to enable the monitor to measure its own performance. The targets, stored in EEPROM, are set at the factory to compensate for individual variances in each tube and to provide a uniform image. A service technician can also readjust a monitor if it changes over time.

Despite these compensations, the Multigraph simply did not perform as well as the FlexScan. In fact, Nokia's own ratings for misconvergence (0.3 mm at center) and luminance uniformity over the screen (70 percent) are only average among 21-inch monitors.

The Multigraph is also unusual for the level of control the user has over monitor parameters. In addition to the image size, location, and trapezoid and pincushion settings typically found on high-end monitors, you can also set convergence, color temperature, white uniformity, and other parameters through a menu that pops up on-screen when you hit a button on the front panel.

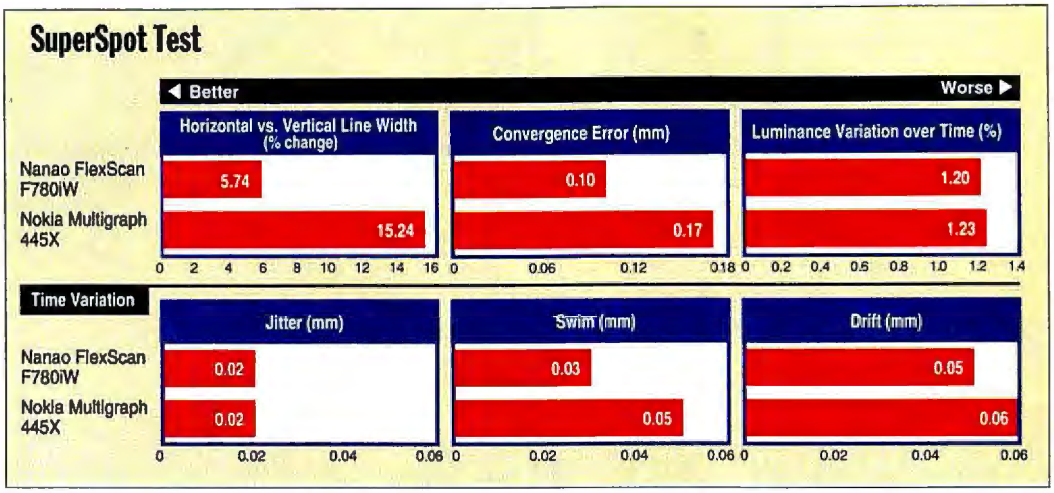
The on-screen menu has a few glitches. It sometimes has trouble displaying when you switch the frequency of the main display, and although it's designed to appear when the monitor loses sync, it sometimes continues to flicker on and off well after sync is lost. However, compared to the FlexScan with its limited palette of front-panel adjustments, the Multigraph is considerably easier to tweak to your liking.

Although Nokia's monitor held a rock-steady 1600- by 1200-pixel image at 80 Hz, the display had some minor problems. Despite making numerous adjustments to contrast, brightness, and focus, I was not able to get quite as clear or bright a display on the Multigraph as I could get on the FlexScan. Convergence also remained

MONITOR CAPABILITIES COMPARED

Top-of-the-line monitors use the best consumer technology to present accurate, clear images on large screens and at high resolution. Among the optimizations both share are 200-MHz bandwidth, antireflection screen panels, a full-screen viewing range, Invar shadow masks, and phosphors with a wide chromaticity range.

	NANAO FLEXSCAN F780IW	NOKIA MULTIGRAPH 445X
Size (in.)	21	21
Dot pitch (mm)	0.26	0.25
Maximum resolution (pixels)	1600 × 1200	1600 × 1200
Refresh rate at highest resolution (Hz)	80	80
Horizontal scanning frequency (kHz)	45–100	30–102
Vertical scanning frequency (Hz)	55–120	50–120
Visible screen area (mm)	403 × 298	400 × 300
Video bandwidth (MHz)	200	200
Screen treatment	Conductive antireflection panel	Conductive antireflection panel
Controls		
Control type	Front panel	On-screen menu
Presets (factory/user)	9/19	14/14
Shadow mask type	Invar	Invar
Phosphor type	Medium-short	Medium-short
Power consumption (W)		
Active	160	160
Standby	16	15
Power-down	11.2	8
Regulatory approvals		
Emissions	MPR-II, TCO 92	MPR-II, TCO 92
Flicker	ISO 9241-3	ISO 9241-3
EMI/RFI	FCC Class A	FCC Class B
Dimensions (H × W × D; in.)	19.1 × 19.7 × 21.1	20.4 × 20.2 × 19.7
Weight (lb.)	83	71
Warranty	3 years	3 years



BYTE's display-quality measurements show a slight but consistent advantage for Nanao's FlexScan over Nokia's Multigraph 445X. Note that all measurements were made at 1024- by 768-pixel resolution at 60 Hz, so these tests do not fully stress either monitor. The top-left graph shows the difference in size between horizontal and vertical lines, a measure of the sharpness of the electron beam. The top-center graph shows convergence error at the center of the screen; both monitors have excellent convergence (BYTE tuned the Multigraph for best convergence). The remaining graphs chart image variations over time, which reflects the steadiness of the display. Although the FlexScan performs somewhat better than the Multigraph, both of these monitors show almost negligible luminance and position variation.

noticeably off at the sides of the display, again despite adjusting it through the menu. Finally, running Windows with a bright white background showed a large yellowish area just off the center of the screen, as well as a few smaller spots in other areas.

The Best Parts

These are high-end monitors by any measure, including price: The FlexScan sells for $3999, and the Multigraph for $3225. At these stellar levels, you expect a top-quality monitor, so both Nanao and Nokia have included high-end design elements beyond those directly related to bandwidth and image uniformity.

Both monitors have a conductive anti-reflection panel that provides the best antiglare/antireflection performance available on PC displays. Unlike a diffusion coating, which diffuses reflected light, the antireflection panel absorbs most incident light without diffusing transmitted light from the image. Both the FlexScan and the Multigraph had very low reflections and were easy to use even in an office lit by fluorescent tubes.

Besides cutting reflections, the anti-reflection panel includes a conductive element that cuts static buildup and electromagnetic radiation through the screen. This second characteristic gives both CRTs low-enough emissions to conform to Sweden's TCO standard, which is more rigorous than MPR-II.

Behind the glass, both the FlexScan and the Multigraph use Invar shadow masks (which are less sensitive to thermal changes) and medium-short-persistence phosphors (which have a wide chromaticity range). These elements are common in most high-end CRTs.

These two monitors also include roughly comparable power conservation features for reduced power consumption in standby modes. The FlexScan supports the VESA DPMS (Display Power Management Signaling) specification, while the Multigraph complies with the Swedish NuTek standard. However, both of the monitors implement their power-down features in such a way that they will work even if you don't have a "green" PC or workstation; all they require is a blank screen saver.

Spot Comparisons

Besides the qualitative comparisons gleaned from Windows and AutoCAD, I made quantitative measurements of display quality using a Microvision SuperSpot monitor-test unit (see the figure "SuperSpot Test"). The SuperSpot measures line size and a host of other parameters for each screen using an optical sensor and computer-controlled display patterns. I made these measurements at 1024- by 768-pixel resolution with a 60-Hz refresh rate, so keep in mind that these tests don't push the monitors to their limits.

I evaluated the FlexScan F780iW with the special Matrox Ultima card Nanao recommends; Nokia supplied an Infotronic IGP64 PCI1600 card with the Multigraph 445X. Both cards use the 200-MHz color DAC necessary to drive 1600- by 1200-pixel resolution at an 80-Hz refresh rate, although the Matrox card goes to only 76 Hz at that resolution. Both monitors work with either card.

Many of the SuperSpot's test results, including those for line width, were very close for these two monitors, so only the few results that show differentiation are graphed in the figure. The FlexScan was uniformly better for the following tests: difference between horizontal and vertical line sizes, convergence, and time variations for luminance and beam position. But for each of these tests, the results for both the Multigraph and the FlexScan are very good relative to results for lower-resolution devices.

Taking both the SuperSpot measurements and the qualitative results into consideration, the Nanao FlexScan F780iW is the clear winner. While neither monitor is inexpensive, the FlexScan costs over $750 more than the Multigraph 445X. But in the display-sensitive CAD and imaging arenas where these monitors will first make their mark, the price difference will not be much of an issue. ■

About the Products

Nanao FlexScan F780iW..............$3999
Bundled with Matrox MGA Ultima Plus 200-MHz controller..................$4999
Nanao USA Corp.
23535 Telo Ave.
Torrance, CA 90505
(800) 800-5202
(310) 325-5202
fax: (310) 530-1679
Circle 1075 on Inquiry Card.

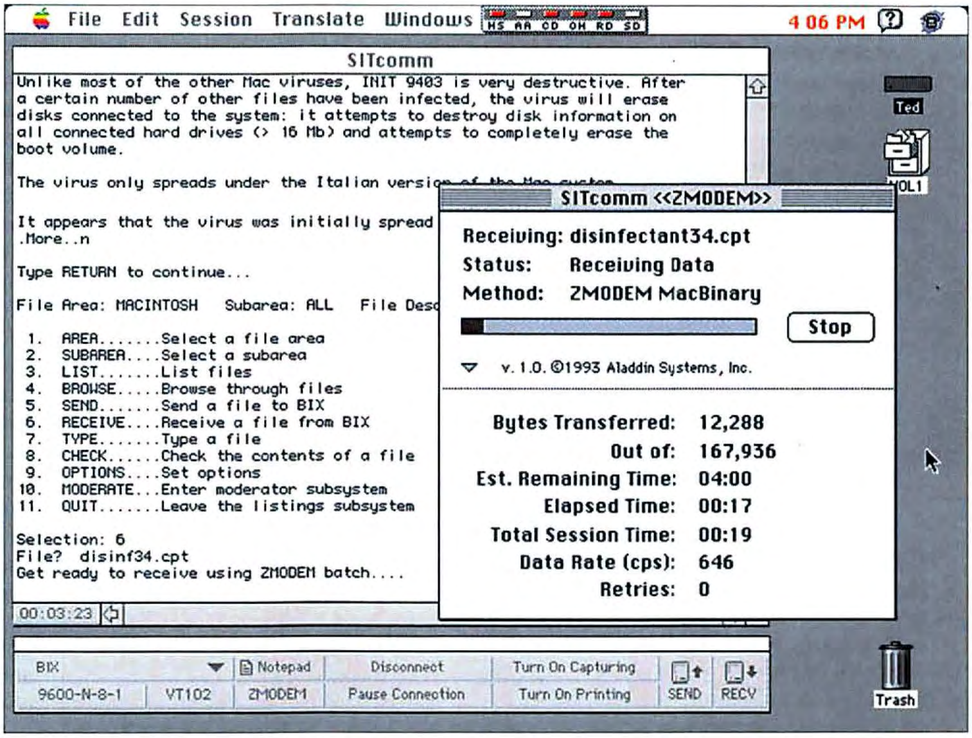
Nokia Multigraph 445X.................$3225
Nokia Display Products, Inc.
3000 Bridgeway Blvd.
Sausalito, CA 94965
(800) 296-6542
(415) 331-0322
fax: (415) 331-0424
Circle 1076 on Inquiry Card.

Steve Apiki is a BYTE contributing editor and former director of the BYTE Lab. He is senior developer at Appropriate Solutions, Inc., a consulting firm based in Peterborough, New Hampshire. You can reach him on the Internet or BIX at apiki@bix.com.

SITcomm Is Serious

Advanced features make this $120 terminal emulator for the Macintosh a standout

TOM THOMPSON



A floating toolbar below SITcomm's terminal window displays current line speed, terminal emulation, and protocol settings on buttons. You can press these buttons to configure the settings.

Aladdin Systems is well known for its Mac utility programs. This visibility comes from the quality of its products—and the offbeat names some of these programs sport. For example, its file compression and archiver utility goes by the frank title of StuffIt Deluxe. Now Aladdin has a terminal-emulator program called SITcomm.

At first you may wonder whether to take SITcomm seriously—not because of the pun, but because the telecommunications market is a mature one with fierce competition and little room for newcomers. What can Yet Another Terminal Program offer?

Surprisingly, SITcomm offers a lot of features, several of which make it stand out in the crowd. These include one-button log-on sequences for popular on-line services such as CompuServe and GEnie, automatic decompression of incoming archive files, and, most important, full-blown Apple Event support. This last capability lets you record and edit on-line sessions to create automated scripts—to log on and download your mail, for example. Finally, at $120, the price is right.

Good Things Come

With all these bells and whistles, you'd expect SITcomm to be massive, but the complete package fits on two 800-KB floppy disks and takes up just 2.5 MB of disk space after installation. The SITcomm application itself weighs in at 343 KB and requires only 600 KB of memory.

A custom Installer application (built by another Aladdin utility, InstallerMaker) lets you pick the desired configuration. After installation, you get the SITcomm application, an Address Book file that stores frequently called services and settings, two terminal fonts, plug-in tool files that implement various connections and transfer protocols, and sample scripts in both the AppleScript and UserLand Frontier languages.

Aladdin achieved its economy of size by using Apple's Communications Toolbox, an API that supplies basic networking and communications services. Using the API to handle the details of modem connections and terminal emulation, Aladdin's software engineers only had to write the application-specific code. Because the Communications Toolbox is part of System 7, SITcomm requires this version of the Mac OS to run.

The Communications Toolbox's modular design allows great flexibility in how a program establishes a communications session. Its API provides a hardware-independent interface, while separate plug-in modules called *Tools* handle such hardware- or implementation-specific details as the serial connection, modem type, terminal emulated, and file transfer protocols. There is, for example, a Serial Tool for establishing direct serial connections.

An Apple Modem Tool lets you choose the serial port, the modem type (which configures the modem command set), and the baud rate as well as stop bit, parity, and other hardware-specific settings. A VT102 Tool and a TTY Tool handle terminal emulation. Aladdin supplies Tools to manage XMODEM, YMODEM, ZMODEM, and Kermit file transfer protocols. As the company introduces new Tools with new capabilities, you just add the files to the Extensions folder.

Serious Features

SITcomm provides a sparse but informative display (see the screen above). A floating Toolbar below the terminal window sums up the current line speed, terminal emulation, and protocol settings, displaying them on buttons; you can click on the buttons to change the settings. Other Toolbar buttons activate functions such as storing text selected in the terminal window to a notepad file, capturing the terminal's I/O stream to a file, or routing it to a printer.

SITcomm uses an Address Book file that lets you organize on-line contacts by name. With each name you can store a phone number, baud rate, file transfer protocol, and terminal emulation to use. The program maintains a separate notepad for each Address Book name. When you select

Sample AppleScript to Log On to BIX

```
tell application "SITcomm"
  activate (* Launch SITcomm and make it the foreground app *)
  Load Address "BIX" (* Load the speed and transfer protocol settings for BIX *)
  Connect
  Wait For Text "bix\"): " (* Look for the TYMNet prompt *)
  (* Tell it we want BIX *)
  Send Text "bix
"
  Wait For Text "Name? " (* Log-on name and password prompts *)
  Send Text "scriptsavant
"
  Wait For Text "sword: "
  Send Text "notapassword
"
  set banner to 1 (* Prime escape flag to loop at the beginning *)
  repeat while (banner = 1)
    (Wait For Text {":", "more..."} timeout 6) (* Look for these 2 strings *)
    copy result to messResult (* Save returned string in variable *)
    if messResult = "more..." then (* We're caught in system banner *)
      Send Text "
"
      (* Fire off returns to push through the banner text *)
    else if messResult = ":" then (* Found regular prompt, escape loop *)
      set banner to 0
    end if
  end repeat
  (* Go to the mail service *)
  Send Text "mail
"
  (Wait For Text "No unread inbasket messages." timeout 6) (* Save response *)
  copy result to messResult
  if messResult = "No unread inbasket messages." then (* No mail, quit service *)
    Send Text "q
"
  else
    (* File and download mail here *)
  end if

  Wait For Text ":" timeout 6 (* We're done, sign off *)
  Send Text "bye
"
end tell
```

a name from the pop-up menu in the Toolbar, SITcomm configures each Tool setting and dials the number.

The program contains automated sequences for several popular on-line services, including CompuServe, Dow Jones, MCI Mail, EasyLink, and GEnie. There are also canned sequences for connecting to several types of BBSes (i.e., FirstClass, TBBS, and TeleFinder), a medley of Unix systems, and even a VAX. You configure them via the Address Book item in the Session menu. A session is then only a pop-up menu away in the Toolbar.

If your service isn't on SITcomm's list, there's no easy way to create an automatic sequence entry. The best solution is to use the manual log-on setting and create an AppleScript that drives SITcomm through the service's log-on sequence. However, you need the developer version of AppleScript or UserLand Frontier to gain access to a script editor.

Because SITcomm fully supports Apple Events, the script editor can capture the stream of high-level event traffic into an editable script file. You can then edit this script and save it as an executable file.

When you launch the resulting application, it issues a sequence of Apple Events that steers SITcomm through the log-on process for your service. This capability is one of the greatest features of the Mac OS, and SITcomm excels at it.

Lacking Examples

Having said how wonderfully SITcomm handles high-level events, I must also report that the manual is woefully short on information on how to use them. To be fair, the manual provides an appendix detailing the events SITcomm understands, including descriptions of any required arguments and returned results. But it's served up as reference material only; there are no useful examples.

As a result, it took me hours of experimenting and intense study of the AppleScript manual to figure out how to write a script that could retrieve any new E-mail or messages if they are present and then disconnect. I've provided the resulting AppleScript (see the listing).

About the Product

SITcomm 1.0 .... $120
Aladdin Systems
165 Westridge Dr.
Watsonville, CA 95076
(408) 761-6200
fax: (408) 761-6206
Circle 1079 on Inquiry Card.

SITcomm's support of high-level events, its most significant feature, gives it the potential to act as a communications engine in a variety of component-based applications, or in environments such as OpenDoc. But it won't be of much use if these features aren't documented better.

Putting On the Squeeze

Because Aladdin makes StuffIt Deluxe, one of the Mac standards for file compression and archiving, the company incorporated this technology into SITcomm in a way that makes file transfers painless. Once you've received several files and want to leave SITcomm, it automatically decompresses any StuffIt Deluxe, Compact Pro, AppleLink package, or encoded BinHex files before it quits.

For downloading file archives with oddball formats, SITcomm comes with an army of format translator modules that you can pick and use from its Translate menu. Just a few of the translators are PC .ZIP and .ARC, and Unix tar, compress, and uuencode. If you send files, SITcomm can automatically compress them before transmitting them. This eliminates one more annoying intermediate step in the process of moving data over the phone wires.

I tested SITcomm on a Quadra 840AV, a Quadra 800, a PowerBook 170, and a PowerBook Duo 270c. Sending and receiving files using the various Aladdin transfer protocol Tools went without a hitch, and it was nice to have immediate access to decompressed files once I exited SITcomm. Setting up an Address Book entry for my GEnie account took only a minute or two, and SITcomm nailed the connection perfectly the first time.

SITcomm is a latecomer to the communications scene, but its unique features give it a hefty advantage over the competition. Its small footprint makes it essential for the PowerBook-toting crowd, and its transparent compression and decompression of files eliminates one more nuisance when dealing with matters in Cyberspace. With better documentation, its high-level event capabilities can make it a communications component for custom in-house solutions. Check it out. ■

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HEAD TO HEAD:

The newest laser, ink-jet, dot-matrix, and color printers vie for top honors in our applications-based rankings

SCOTT HIGGS AND CHANDRIKA MYSORE

The printer market continues to be one of the most competitive segments of the computer industry, thanks to an almost constant supply of new models and falling prices. This Lab Report, our third on printers in the last year, tracks these changes with evaluations of 71 laser, ink-jet, dot-matrix, and color printers. Thirty-eight of those printers weren't available when we compiled our last printer Lab Report (see "176 Printers Face Off," November 1993 BYTE). Among the new models is Apple's LaserWriter Select 360, a 10-page-per-minute laser printer with exceptional print quality. Also new are lasers from Alps and Genicom, built around a 10-ppm, 600-dpi engine from Brother that's teamed with a 20-MHz Motorola 68030 processor. These are among the fastest midrange lasers we tested: Genicom's Model 7610 won our General Business rankings, while the Alps LSX 1000 and Brother's HL-10h (a similar configuration that was ranked in November's report) placed as close runners-up in that category.

New designs and lower costs account for different winners in some categories. For example, Canon's recently introduced BJC-600 now ranks as the ink-jet printer with the best print quality, supplanting the Epson Stylus 800, November's winner. But some past winners still reign: Hewlett-Packard's LaserJet 4 Si remains the top printer for workgroups (as in all three printer reports), and the Compaq PageMarq 20 still leads for CAD and DTP (for an update on Compaq's plans to support this printer, see "As We Went to Press..." on page 166).

Compared to the printers we tested in our last report, prices have fallen in each segment of the market. The average cost has dropped from $1000 to $700 for PCL-only lasers rated at 4 ppm. Ink-jet prices overall now average about 10 percent lower than for comparable models in the November report.

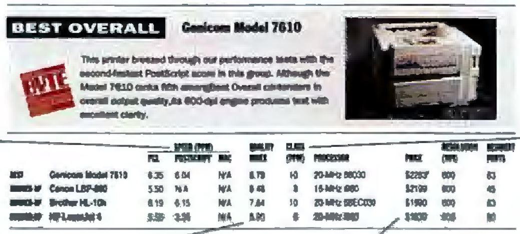
In all, we tested 31 general-business printers (10 ppm or less), eight workgroup lasers (12 ppm or faster, with Ethernet support), and six CAD and desktop publishing lasers (able to handle 11- by 17-inch paper). We also ranked eight draft-quality printers (ink-jets under $1000) and 11 general-purpose color printers (ink-jet, thermal-wax-transfer, and dye-sublimation printers costing no more than $5000). Finally, we evaluated 10 large-format dot-matrix printers designed for high-volume print jobs.

How to use this guide

We used our standard suite of PC- and Macintosh-based printer tests to choose printers with the best speed and output quality for six key business applications.

We summarize test details about the winners and important runners-up in each of the categories, using charts like the one shown here.

Combined engine and processor speed when running our test files, measured in ppm. Higher numbers indicate faster performance.



Vendor's rating for engine or print-head speed; does not include printer processing time.

A composite rating for text and graphics output quality; based on a 10-point scale, with higher numbers indicating better print quality.

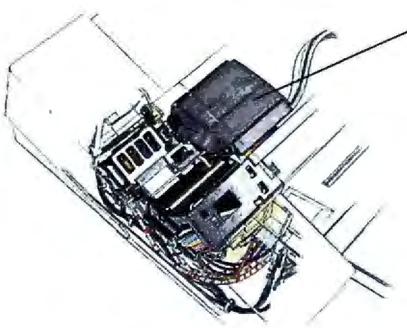
Retail price; may include optional memory to conform to our testing specifications (see "How We Tested").

PHOTOGRAPHY: STEVE BELKOWITZ © 1994

71 PRINTERS

What to Look For in a Printer

Color Ink-Jet



PRINT HEAD
For affordable color printing and output that's appropriate for business reports, ink-jets perform well. Choose thermal-transfer printers for higher-quality color with intense colors and subtle dithering.

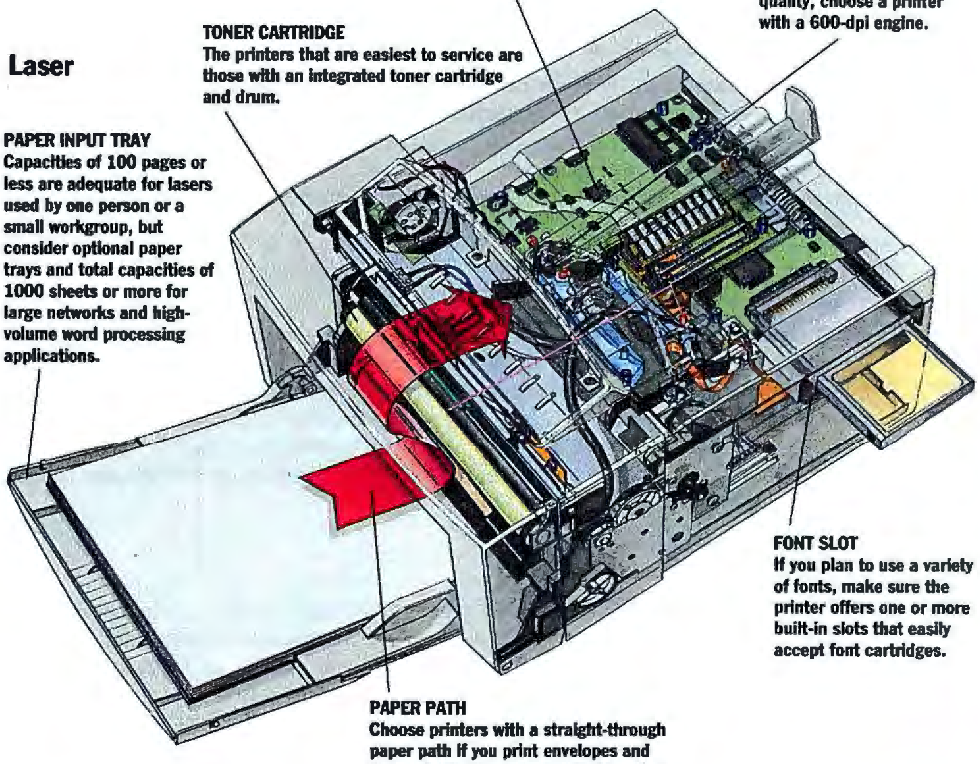
PROCESSOR
Select lasers with a fast RISC processor (the most common we saw were from Intel, AMD, or Weitek). Fast processing is essential for printing graphics and PostScript.

ENGINE
Low-cost lasers typically rely on 300-dpi engines rated at from 4–6 ppm. Output quality from these engines is acceptable for business correspondence, especially if you primarily print text and little graphics. For better quality, choose a printer with a 600-dpi engine.

Laser

TONER CARTRIDGE
The printers that are easiest to service are those with an integrated toner cartridge and drum.

PAPER INPUT TRAY
Capacities of 100 pages or less are adequate for lasers used by one person or a small workgroup, but consider optional paper trays and total capacities of 1000 sheets or more for large networks and high-volume word processing applications.



FONT SLOT
If you plan to use a variety of fonts, make sure the printer offers one or more built-in slots that easily accept font cartridges.

PAPER PATH
Choose printers with a straight-through paper path if you print envelopes and heavy stock. The curved path (depicted here) is typical for standard size and weight paper.

MAY 1994 BYTE BEST PRINTERS

BEST

General Business
Genicom Model 7610
This 10-ppm laser printer offers a 600-dpi engine and a 20-MHz 68030 processor to produce clear text at speeds that lead or compete closely with every other midrange laser printer. **PAGE 166**

Workgroups
Hewlett-Packard LaserJet 4 Si
This 17-ppm printer continues its year-long reign as the best-performing laser for networks. At $3749, it's also one of the least expensive in this group. **PAGE 169**

CAD and DTP
Compaq PageMarq 20
Although Compaq is withdrawing from the printer market, it will continue to sell this 20-ppm laser for the immediate future. There's still no laser better for fast speed and support for 11- by 17-inch paper. **PAGE 171**

Color
General Parametrics Spectra Star GT
In addition to speed, this thermal-wax-transfer printer offers excellent color quality and smooth paper handling. It has parallel, serial, and LocalTalk ports. **PAGE 173**

Draft Quality
Canon BJ-200e
This ink-jet delivers clean output at speeds comparable to a 4-ppm laser's for half the cost. Its on-line documentation is a plus. **PAGE 175**

Listings and Forms
Texas Instruments Omni 800 Model 8930
For high-volume printing of multipart forms and continuous-feed stock, no other printer matches the Omni's output quality. It ranks second for this category in our high-quality-mode performance tests. **PAGE 177**

THE BEST PRINTERS FOR

GENERAL BUSINESS

Whether you print reports, memos, spreadsheets, graphics, or simple desktop-published documents, high-quality laser output is the standard for business. The good news is that 300-dpi quality no longer commands a premium price; if you mainly print only text, we found four 4- to 6-ppm lasers (see Low Cost chart on page 167) with good speed and output for less than $1000. One of them, NEC's host-based Silentwriter Superscript 610, retails for only $600 (it lacks memory and relies on the host computer for this resource).

If your print jobs often combine text and graphics, 600-dpi printers offer sharper images for prices that run about $500 to $1000 more than the lowest-cost 300-dpi lasers. Today, 600-dpi output is more than ever the standard for laser printers: All but four of the 14 lasers we ranked for General Business support this resolution. In addition to sharper output, these midrange models offer faster speed, with print engines rated at 6 to 10 ppm (see Best Overall chart on page 167).

Only three of the printers that we ranked for General Business in the November report appear in our rankings this month: HP's LaserJet 4, NEC's Silentwriter Superscript 610, and Texas Instruments' MicroLaser Pro 600 PS23. Price cuts for these models currently average over 15 percent. You can take home today's winners for Macintosh and High Quality for 18 percent less than the comparable models in November's report cost.

Several printers that did not win one of the General Business categories outright deserve attention as runners-up, and one of these may be the best printer for you, depending on your needs. For example, Canon's new LBP-860, the first runner-up for Best Overall, is ideal if your work is graphics intensive. This printer tied with Apple's LaserWriter Select 360 for the second-highest quality score for lasers ranked here. Although the LBP-860 fell a few percentage

AS WE WENT TO PRESS...

Here are some updates on changes in important printers we evaluated:

Lexmark IBM LaserPrinter 4039 family

Both the 12R and the 16L will be replaced in the second quarter of this year with new models that offer bidirectional communications, among other features. The print engines and processors will remain the same, however, and Lexmark will sell an upgrade kit (at press time, $350 for either model) for existing 4039 printers. The upgrade consists of new software and a SIMM module that will allow the printers to send and receive status messages to and from a network administrator. The administrator could change default settings or make other adjustments to a printer from any connected computer. The communications protocol is based on one developed by the Network Printing Alliance. In addition, upgraded printers will have enhanced PCL 5 and PostScript Level 2 support. (See "Printer at Work" on page 149 for details on another new Lexmark laser printer that shipped too late to be included in this Lab Report.)

Compaq PageMarq 20

Compaq announced late last year that it will discontinue future development of the PageMarq printer family and won't compete in the printer market with new products. However, as we went to press, the company said it plans to support existing PageMarq printers for the next five years and will continue to manufacture units based on the existing design to meet demand. Compaq says inventories and future production will keep PageMarqs in the market into the second half of the year.

Canon LBP-860

A PostScript option, the first ever offered by Canon, is due to be available by the time you read this. According to Canon, the $495 upgrade will use a controller from Peerless Systems that requires only 2 MB of memory to produce PostScript Level 2 files that would need 6 MB of memory with standard controllers. (See the summary chart for General Business Best Overall category and the Roll Call for data about the PCL version of this new printer. Because the PostScript option wasn't yet shipping, we weren't able to test it or the memory claim for this Lab Report.)

DEC PrinterServer 17/600

DEC plans to be shipping its new network printer by the end of the first quarter (we received a preproduction version of the printer during our test cycle, but a production unit didn't arrive in time for inclusion in this report.) The 17-ppm, 600-dpi printer is designed for Ethernet environments and accepts Windows NT, NetWare, Unix, OS/2, and Macintosh print jobs simultaneously. The printer can also communicate print-job status and print-job problems to users on the network. At press time, the PrinterServer 17/600 was priced at $4695.

points behind the LaserWriter and Sharp's JX-9460PS for text quality, it beat all printers we tested (including the 1200-dpi models) in rendering fine lines. For detailed graphics and excellent bit-map rendering, the LBP-860 will serve admirably. However, during our test cycle, Canon was not yet shipping the optional PostScript upgrade (see "As We Went to Press..." on page 166).

The Brother HL-10h is the only printer that gave the top-rated Genicom serious competition in performance tests. This is not surprising, since both use the same engine and class of processor. On every PCL test, only a couple of seconds separate these printers. The sole exception to this rule is the bit-map test, which takes almost 50 percent longer with the HL-10h. Their positions are reversed in PostScript, again with matching speeds except on the bit-map test, where the Genicom takes 40 percent longer.

Members of HP's LaserJet 4 family appear as runners-up in each of the four General Business categories. The 4L is a runner-up for Low Cost, with 300-dpi resolution and the fastest PCL score for printers in that group. The 4M is a good choice for Macintosh, with text quality second only to that of the top-rated Apple LaserWriter Select 360. The LaserJet 4 ranks high in overall quality for the same reason: excellent clarity of text and better line rendering than all but the three top printers.

Note that the Sharp JX-9460PS was the lowest-cost PostScript printer ranked here, and its stunning 600-dpi output achieved the highest score in this group (the JX-9460PS's text sharpness rivaled that of some 1200-dpi printers). However, we penalized this printer because it couldn't print our bit-map test in 600-dpi resolution (the test printed with no problem at 300 dpi). We consulted Sharp, but we weren't able to solve the problem during our test cycle. Accordingly, the printer placed as a runner-up rather than the winner for High Quality.

BYTE BEST — GENERAL BUSINESS

For best combination of speed and quality...

BEST OVERALL — Genicom Model 7610

MAY 1994 BYTE BEST GENERAL BUSINESS PRINTER

This printer breezed through our performance tests with the second-fastest PostScript score in this group. Although the Model 7610 ranks fifth among Best Overall contenders in overall output quality, its 600-dpi engine produces text with excellent clarity.

		Speed (PPM) PCL	Speed (PPM) PostScript[1]	Speed (PPM) Mac	Quality Index	Class (PPM)	Processor	Price	Resolution (DPI)	Resident Fonts
BEST	Genicom Model 7610	6.35	6.04	N/A	8.79	10	20-MHz 68030	$2283[2]	600	83
RUNNER-UP	Canon LBP-860	5.50	N/A	N/A	9.48	8	16-MHz i960	$2199	600	45
RUNNER-UP	Brother HL-10h	6.19	6.15	N/A	7.84	10	20-MHz 68EC030	$1890	600	83
RUNNER-UP	HP LaserJet 4	5.56	3.38	N/A	8.90	8	20-MHz i960	$1839	600	80
RUNNER-UP	Sharp JX-9460PS	4.29	3.22	N/A	9.77	6	16-MHz AMD29005/14	$1428	600	62

Need good performance for under $1000?

LOW COST — Okidata OL 410e

Priced under $1000, this 4-ppm printer posted the highest quality score in this group. However, the trade-off is slow print speed. If you need PostScript for under $1000, choose the TI MicroWriter PS23.

		Speed (PPM) PCL	Speed (PPM) PostScript[1]	Speed (PPM) Mac	Quality Index	Class (PPM)	Processor	Price	Resolution (DPI)	Resident Fonts
BEST	Okidata OL 410e	2.59	N/A	N/A	8.76	4	—	$899	300	14
RUNNER-UP	TI MicroWriter PS23	3.17	1.20	1.82	8.46	5	—	$997	300	23
RUNNER-UP	HP LaserJet 4L	3.29	N/A	N/A	7.87	4	18.5-MHz i960	$849	300	80
RUNNER-UP	NEC Silentwriter Superscript 610	2.98	N/A	N/A	8.10	6	8-MHz NEC 87C51	$600	300	Host-based

For unmatched Mac speed...

MACINTOSH — Texas Instruments MicroLaser Pro 600 PS23

None of the General Business printers we tested came close to the MicroLaser in our Mac speed tests. In addition to fast speed in our text tests, the MicroLaser Pro renders fonts 15 percent faster than its closest competitor, the HP LaserJet 4ML.

		Speed (PPM) PCL	Speed (PPM) PostScript[1]	Speed (PPM) Mac	Quality Index	Class (PPM)	Processor	Price	Resolution (DPI)	Resident Fonts
BEST	TI MicroLaser Pro 600 PS23	3.15	2.44	4.26	8.43	8	20-MHz Platinum	$1599	600	31
RUNNER-UP	Apple LaserWriter Select 360	N/A	4.09	3.76	9.48	10	16-MHz AMD29200	$1599	600	64
RUNNER-UP	HP LaserJet 4M	5.56	3.38	3.98	8.90	8	20-MHz i960	$2479	600	80
RUNNER-UP	NEC Silentwriter 1097	5.14	3.73	3.97	7.97	10	20-MHz i960	$1400	600	57

When print quality matters

HIGH QUALITY — Apple LaserWriter Select 360

This new printer has a parallel port for PCs and generates exquisite output. Particularly good are its fine lines and bit-map graphics. Its text quality is the highest in this class.

		Speed (PPM) PCL	Speed (PPM) PostScript[1]	Speed (PPM) Mac	Quality Index	Class (PPM)	Processor	Price	Resolution (DPI)	Resident Fonts
BEST	Apple LaserWriter Select 360	N/A	4.09	3.76	9.48	10	16-MHz AMD29200	$1599	600	64
RUNNER-UP	Genicom Model 7610	6.35	6.04	N/A	8.79	10	20-MHz 68030	$2283[2]	600	83
RUNNER-UP	Sharp JX-9460PS	4.29	3.22	N/A	9.77	6	16-MHz AMD29005/14	$1428	600	62
RUNNER-UP	HP LaserJet 4	5.56	3.38	N/A	8.90	8	20-MHz i960	$1839	600	80
RUNNER-UP	Brother HL-10h	6.19	6.15	N/A	7.84	10	20-MHz 68EC030	$1890	600	83
RUNNER-UP	Alps LSX 1000	5.41	5.19	N/A	7.96	10	20-MHz 68EC030	$1599	600	83

[1] PC [2] Price includes 10 MB of memory. N/A = not applicable — = data not available at press time

How We Tested

On the PC, we ran tests at each printer's highest resolution and at the lowest resolution available in each category. Whenever possible, we also tested the printers on the Macintosh platform.

PERFORMANCE

Our nine speed tests measure each printer's ability to print documents with dense or sparse text, graphics, and fonts in a range of styles and sizes. The dense-text test requires printing a 2-KB file of ASCII text with little white space. Performance in this test correlates to raw speed, since there are no fonts or graphics for the printer to interpret. A second text document consists of ASCII text blocks broken up by areas of white space. Designed to simulate the printing of invoices and forms, this test is geared primarily to evaluating how fast dot-matrix printers can advance paper.

The graphics tests use bit-mapped images to simulate documents with custom fonts or screen shots. These tests help us determine how efficiently each printer communicates with a computer. One test component measures the printer's ability to draw complex lines and filled areas. A second test concentrates on producing curves and gray scales.

We use the font test to measure the speed of the printer's processor. The test requires printers to create serif and sans-serif fonts in regular and bold faces in 30 different point sizes.

We generated a performance index for each printer by combining individual test scores with weightings that emphasized the tests that were most significant for an application category. For example, the results of the graphics tests counted for more of a color printer's overall speed score than did the results of the paper-handling test.

PRINT QUALITY

This month we introduce the second version of our monochrome print-quality tests. As in past reports, these PostScript-based tests measure a printer's ability to reproduce a photographic image; print attractive, legible text in a wide range of sizes; and draw lines. For example, the line-squeeze test forces a printer to draw two lines successively closer together until the gap between them vanishes—indicating that the printer can no longer make the black-to-white-to-black transition. The monochrome suite also gauges more esoteric features, such as how accurately the printer positions paper and how well the printer displays reversed (i.e., white on black) text and graphics.


The evaluation team: Seated, from left: Chandrika Mysore, Scott Higgs; standing, from left: Alan Joch, Morgan Nec.

The color-quality tests, also written in PostScript, stress a color printer's ability to print a wide range of hues and to blend hues. Other parts of the test examine ink placement: the ability of the printer to accurately place lines without misregistration or smearing.

Although we wrote the monochrome and color tests in PostScript, we were able to test printers that don't support PostScript by using Freedom of Press, a PostScript interpreter from ColorAge that translates PostScript into low-level printer driver calls.

FEATURES AND EASE OF USE

For each printer, we evaluated how easy it was to set up and configure the machine, load paper, and replace consumables. For individual application categories, we used the presence or absence of important features to determine whether a printer was eligible. For example, the CAD and DTP category considered only laser printers that could accommodate 11- by 17-inch paper.

THE TEST CONFIGURATION

Our printer benchmarks are applications that run under Windows 3.1 or Apple's System 7. We disabled print servers, spoolers, and buffers during testing. We required workgroup lasers to have at least 8 MB of RAM and PostScript, if available. Other lasers had at least 4 MB of RAM and PostScript, if available.

We ran PC-based tests using Compaq Deskpro 66M (66-MHz) computers with 540-MB hard drives, 8 MB of RAM, and DOS 6.0 and Windows 3.1. For Macintosh testing, we used Quadra 640AV computers with System 7.1, 16 MB of RAM, and 400-MB hard drives.

Test data for this report cannot be directly compared to previous printer Lab Reports. In addition to running a new version of our quality tests, we upgraded our PC test-bed for this report (for previous reports, we used 33-MHz Compaq systems to run our tests).

This month's test sample focuses on printers for high-end business and professional applications. We selected only high-end dot-matrix printers; we think this is the most important niche for this technology. We tested all available new models of laser and ink-jet printers, but we didn't retest models that received low speed scores in previous reports.

Contributors

Scott Higgs, *Project Manager/NSTL, has tested hardware for NSTL for six years. He spent last year in Europe, where he helped establish a testing facility in France.*

Alan Joch, *Senior Editor/BYTE, coordinates the combined testing between the BYTE Lab and NSTL.*

Chandrika Mysore, *Printer Report Project Manager/NSTL, manages evaluations of printers, systems, and peripherals.*

Morgan Nec, *Consultant/NSTL, has tested printers and systems for NSTL since 1988.*

The Lab Report is an ongoing collaborative project between BYTE Magazine and National Software Testing Laboratories (NSTL). BYTE Magazine and NSTL are both operating units of McGraw-Hill, Inc. Contact the NSTL staff via the Internet at editors@nstl.com; at NSTL, Inc., Plymouth Corporate Center, Plymouth Meeting, PA 19462; or at (610) 941-9600. Contact BYTE on BIX via the Internet at ajoch@bix.com or at (603) 924-9281.

BYTE BEST

WORKGROUPS

We tested eight printers that led the laser field in print speed and high-quality output. To be ranked for this category, a laser printer had to be rated at 12 ppm or faster, and, as a minimum, it had to provide an Ethernet connector.

Three printers, the Compaq PageMarq 20, the Genicom Model 7170, and the HP LaserJet 4 Si, save Novell network users the cost of a dedicated PC print server. All three use coaxial Ethernet connections and their own software to act as print servers in themselves. The remaining printers that we looked at connected to a dedicated print server via an EtherTalk connection, which is the setup we used for testing.

These full-featured printers range in price from $1999 for Lexmark's IBM LaserPrinter 4039 12R to $9775 for the Genicom Model 7170. Apple's LaserWriter Pro 810 offered the highest resolution, at 800 by 800 dpi, but its quality score fell below that of the ranked printers.

The Genicom and HP products provide a base paper-tray capacity of 2000 sheets. Except for the two Lexmark printers we tested, all the printers offer at least three paper trays (the Lexmarks have two trays standard). Multiple paper trays are useful if you print on standard U.S. letter and legal sizes as well as European A4 paper. The Genicom was the most generous, with four trays.

The unranked 16-ppm Alps LSX 1600c laser printer (see the Roll Call on page 180) is a new product targeted for networks. It offers a maximum input-tray capacity of 750 sheets and 35 envelopes. However, it didn't support Ethernet, and its PostScript option wasn't available during our test cycle.

For speed and networking ease...

BEST OVERALL — Hewlett-Packard LaserJet 4 Si

This fast, high-quality printer continues to reign as the leading choice for workgroups. Although it's rated behind the Genicom 7170 for PCL speed, the LaserJet provides significantly better quality than all the other workgroup printers. It has 10 MB of base memory, 600- by 600-dpi resolution, 2000-sheet capacity (in three trays), and an Ethernet connection. And it's among the least expensive printers in this group.

		Speed (PPM) PCL	PostScript¹	Mac	Quality Index	Class (PPM)	Processor	Price	Resolution (DPI)	Maximum Input (Sheets)
BEST	HP LaserJet 4 Si	7.91	5.63	N/A	9.10	17	25-MHz i960CF	$3749	600 × 600	2000
RUNNER-UP	Genicom Model 7170	8.96	3.54	3.20	8.52	17	20-MHz 68030	$9775	300 × 300	2000
RUNNER-UP	Lexmark LaserPrinter 4039 12R	5.66	3.47	4.56	8.63	12	16-MHz AMD29000	$1999	600 × 600	700

When price matters...

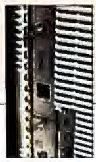
LOW COST — Lexmark IBM LaserPrinter 4039 12R

This is the only workgroup-class printer we tested that offers a significant price difference from the rest of the pack: At $1999, it costs nearly half as much as the HP LaserJet 4 Si (which doesn't support Macs). But the LaserPrinter 4039 12R's speed and quality scores are good enough to rank it third among workgroup printers, even with a 12-ppm engine.

		Speed (PPM) PCL	PostScript¹	Mac	Quality Index	Class (PPM)	Processor	Price	Resolution (DPI)	Maximum Input (Sheets)
BEST	Lexmark LaserPrinter 4039 12R	5.66	3.47	4.56	8.63	12	16-MHz AMD29000	$1999	600 x 600	700

Need top Mac speed?

MACINTOSH — Hewlett-Packard LaserJet 4 SiMX



In the MX configuration (which boosts the base price of the LaserJet 4 Si by $1750), this 17-ppm printer significantly outperforms all other workgroup printers in Mac speed and output quality. With both EtherTalk and AppleTalk connectors standard, this printer is easy to install on any Mac network.

		Speed (PPM) PCL	PostScript¹	Mac	Quality Index	Class (PPM)	Processor	Price	Resolution (DPI)	Maximum Input (Sheets)
BEST	HP LaserJet 4 SiMX	7.91	5.63	7.87	9.10	17	25-MHz i960CF	$5499	600 x 600	2000
RUNNER-UP	Compaq PageMarq 20	6.76	6.10	6.45	8.59	20	20-MHz AMD29000	$4636	400 x 800	1500
RUNNER-UP	Lexmark LaserPrinter 4039 16L	6.90	3.60	5.10	8.24	16	16-MHz AMD29000	$4137	600 x 600	1000
RUNNER-UP	Lexmark LaserPrinter 4039 12R	5.66	3.47	4.56	8.63	12	16-MHz AMD29000	$1999	600 x 600	700

Want the highest quality for networks?

HIGH QUALITY — Hewlett-Packard LaserJet 4 Si

This printer uses 600- by 600-dpi resolution to produce the best quality scores in this category. It did especially well in our line tests, scoring roughly 25 percent better than the other products. However, when reproducing photographic images, it lagged the Compaq PageMarq, the Dataproducts LZR 2080, and the two Lexmark IBM 4039 printers by about 10 percent.

		Speed (PPM) PCL	PostScript¹	Mac	Quality Index	Class (PPM)	Processor	Price	Resolution (DPI)	Maximum Input (Sheets)
BEST	HP LaserJet 4 Si	7.91	5.63	N/A	9.10	17	25-MHz i960CF	$3749	600 × 600	2000
RUNNER-UP	Compaq PageMarq 20	6.76	6.10	6.45	8.59	20	20-MHz AMD29000	$4636	400 × 800	1500
RUNNER-UP	Lexmark LaserPrinter 4039 12R	5.66	3.47	4.56	8.63	12	16-MHz AMD29000	$1999	600 × 600	700
RUNNER-UP	Genicom Model 7170	8.96	3.54	3.20	8.52	17	20-MHz 68030	$9775	300 × 300	2000
RUNNER-UP	Lexmark LaserPrinter 4039 16L	6.90	3.60	5.10	8.24	16	16-MHz AMD29000	$4137	600 × 600	1000

¹ PC N/A = not applicable

Circle 150 on Inquiry Card.

BYTE BEST

CAD AND DTP

While midrange lasers suffice for business memos, correspondence, and reports, desktop publishing and CAD applications require high-resolution lasers that can handle 11- by 17-inch paper. The printers we evaluated for this category represent the luxury models of their respective printer families. All come with at least 35 resident PostScript fonts and at least 4 MB of memory. The Compaq PageMarq 20 and the GCC SelectPress 600 cater to PC users with PCL 5 support. The Apple LaserWriter Pro 810 includes PCL 4 emulation. A built-in hard drive on the LaserMaster Unity 1200XL-O holds over 200 resident fonts.

In addition to printing in any style, these printers operate in any environment. In almost all cases, built-in ports or low-cost options include RS-232, parallel, LocalTalk, and Ethernet (the Dataproducts LZR 2080 and the Apple LaserWriter Pro 810 we tested lacked a parallel port). All except the Apple LaserWriter Pro 810 include auto-sensing to switch into an appropriate mode depending on the data received.

Performance and quality vary considerably, because the print engines in this category cover a wide range of resolutions. The GCC SelectPress 600, NewGen ImagerPlus 12, and LaserMaster Unity 1200XL-O are rated at 8 ppm, with resolutions of 600 dpi for the GCC SelectPress 600 and 1200 dpi for the others. The Apple LaserWriter Pro 810, Dataproducts LZR 2080, and Compaq PageMarq 20 are 20-ppm printers. The first two offer 800-dpi output; the last prints 400 by 800 dpi. Given these differences, it is no surprise to find that the Compaq PageMarq 20 ran performance tests 52 percent faster than the second-fastest, the GCC SelectPress 600.

Need fast speed for 11- by 17-inch paper?

BEST OVERALL Compaq PageMarq 20

MAY 1994 BYTE BEST CAD AND DTP PRINTER

The PageMarq ran almost twice as fast as any other printer in this category in our PostScript tests. Its output quality ranked third, however, hampered by a 400- by 800-dpi print engine in a class dominated by higher-resolution printers. Standard are PCL 5, PostScript, and HPGL. For excellent output quality for less cost but far slower speed, choose the 600- by 600-dpi GCC SelectPress 600.

		SPEED (PPM) PCL	POSTSCRIPT[1]	MAC	QUALITY INDEX	CLASS (PPM)	PROCESSOR	PRICE	RESOLUTION (DPI)	MAXIMUM MEMORY	RESIDENT FONTS
BEST	Compaq PageMarq 20	6.76	6.10	6.45	8.59	20	20-MHz AMD29000	$4636	400 × 800	20 MB	50
RUNNER-UP	GCC SelectPress 600	4.26	3.12	3.25	9.53	8	25-MHz AMD29030	$4499	600 × 600	16 MB	50
RUNNER-UP	LaserMaster Unity 1200XL-O	3.63	2.99	2.82	10.00	8	33-MHz Unity	$8995	1200 × 1200	48 MB	241

Is your budget limited to $5000?

LOW COST Compaq PageMarq 20

Only three printers in this category retail for less than $5000, and none comes close to matching the PageMarq's speed. The trade-off is lower resolution (see above).

		SPEED (PPM) PCL	POSTSCRIPT[1]	MAC	QUALITY INDEX	CLASS (PPM)	PROCESSOR	PRICE	RESOLUTION (DPI)	MAXIMUM MEMORY	RESIDENT FONTS
BEST	Compaq PageMarq 20	6.76	6.10	6.45	8.59	20	20-MHz AMD29000	$4636	400 × 800	20 MB	50
RUNNER-UP	GCC SelectPress 600	4.26	3.12	3.25	9.53	8	25-MHz AMD29030	$4499	600 × 600	16 MB	50
RUNNER-UP	Apple LaserWriter Pro 810	N/A	N/A	4.12	8.21	20	Weitek 8200	$4899	800 × 800	32 MB	0

For top Mac performance...

MACINTOSH Compaq PageMarq 20

The PageMarq's performance looks even more impressive in the Mac environment. It completed BYTE's tests 56 percent faster than the second-place (for speed) Apple LaserWriter Pro 810, and 125 percent faster than the 1200-dpi LaserMaster Unity 1200XL-O. If price and quality matter more to you than speed, both the Dataproducts LZR 2080 and the GCC SelectPress 600 are excellent candidates for Macintosh environments.

		SPEED (PPM) PCL	POSTSCRIPT[1]	MAC	QUALITY INDEX	CLASS (PPM)	PROCESSOR	PRICE	RESOLUTION (DPI)	MAXIMUM MEMORY	RESIDENT FONTS
BEST	Compaq PageMarq 20	6.76	6.10	6.45	8.59	20	20-MHz AMD29000	$4636	400 x 800	20 MB	50
RUNNER-UP	Dataproducts LZR 2080	N/A	N/A	3.85	8.69	20	7.25-MHz Weitek 8200	$5495	800 x 800	32 MB	35
RUNNER-UP	Apple LaserWriter Pro 810	N/A	N/A	4.12	8.21	20	Weitek 8200	$4899	800 x 800	32 MB	0
RUNNER-UP	GCC SelectPress 600	4.26	3.12	3.25	9.53	8	25-MHz AMD29030	$4499	600 x 600	16 MB	50
RUNNER-UP	LaserMaster Unity 1200XL-O	3.63	2.99	2.82	10.00	8	33-MHz Unity	$8995	1200 x 1200	48 MB	241

Do you require unexcelled quality?

HIGH QUALITY LaserMaster Unity 1200XL-O

The Unity 1200XL-O is designed to serve those who want camera-ready copy from their desktops. Speed is not its forte, but the quality of the output rewards your patience. With over 240 fonts preloaded on its internal hard drive, the Unity 1200XL-O delivers unrivaled capabilities for serious desktop publishing.

		SPEED (PPM) PCL	POSTSCRIPT[1]	MAC	QUALITY INDEX	CLASS (PPM)	PROCESSOR	PRICE	RESOLUTION (DPI)	MAXIMUM MEMORY	RESIDENT FONTS
BEST	LaserMaster Unity 1200XL-O	3.63	2.99	2.82	10.00	8	33-MHz Unity	$8995	1200 x 1200	48 MB	241
RUNNER-UP	Compaq PageMarq 20	6.76	6.10	6.45	8.59	20	20-MHz AMD29000	$4636	400 x 800	20 MB	50
RUNNER-UP	GCC SelectPress 600	4.26	3.12	3.25	9.53	8	25-MHz AMD29030	$4499	600 x 600	16 MB	50

[1] PC N/A = not applicable

COLOR

Color printouts enhance presentations and reports, and the general-purpose color printers we tested perform well when producing both monochrome text and color graphics. We limited our evaluations to printers priced under $5000, and, in general, the ink-jet, thermal-transfer, and dye-sublimation printers we received will not serve for specialized applications such as color proofing and photographic-quality output.

Ink-jets offer the most affordable color technology, with over half of our test models qualifying for the low-cost category (under $1300). What's more, some ink-jets, including the Canon BJC-600 and Lexmark IBM Color JetPrinter PS 4079, provide excellent dithering and shading that place their output quality among the leaders. In this regard, the Canon's $719 price tag is nothing short of remarkable. The Lexmark's ability to handle 11-by 17-inch paper is a unique advantage in this category. Still, ink-jet output, including that from these two printers, lacked the intensity of color that we saw from thermal-wax technology.

Among the thermal-wax printers, the DEC ColorWriter 1000 provides the top quality overall, with intense colors and subtle dithering. It consistently placed second, about 0.15 ppm behind the speed-leading General Parametrics Spectra Star GT.

The Fargo Primera uses thermal technology. For an extra $250, you can add a dye-sublimation cartridge, making it the only dye-sublimation printer under our $5000 price limit on color. But its speed was slow and its print quality only marginally better than the thermal version's.

KEY

★ Thermal ■ Ink-jet

Want the best color for general business?

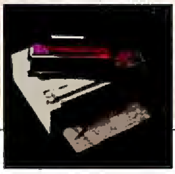
BEST OVERALL — **General Parametrics Spectra Star GT**

The Spectra Star was the only color printer to complete BYTE's PC benchmark mix faster than 1 ppm. To complement its good speed, the Spectra Star offers color quality second only to the DEC ColorWriter 1000's and has excellent paper handling that avoided jams during the intricate thermal-printing process. The printer comes with parallel, serial, and LocalTalk ports (with automatic switching) and PostScript Level II.

			SPEED (PPM) POSTSCRIPT[1] B&W	POSTSCRIPT[1] COLOR	MAC B&W	MAC COLOR	QUALITY INDEX	CLASS (PPM)	PRICE	RESOLUTION (DPI)	INTERNAL HARD DRIVE
BEST	General Parametrics Spectra Star GT	★	1.67	1.09	1.54	1.17	5.88	2	$4495	300 × 300	Yes
RUNNER-UP	DEC ColorWriter 1000	★	1.43	0.84	1.48	1.09	6.15	2	$3999	300 × 600	No
RUNNER-UP	Tektronix Phaser 200e	★	1.05	0.68	0.90	0.73	5.67	2	$4480	300 × 300	No
RUNNER-UP	HP DeskJet 1200 C/PS	■	1.69	0.35	1.59	0.66	4.96	7	$2749	600 × 300	No

Need economical color?

LOW COST — **Fargo Primera Color (Thermal)**



Among the printers available for under $1500, the Primera occupies a unique niche. With its ability to change modes from thermal to dye sublimation (with a $250 option), you can invest a bit more time and money to achieve even greater quality. However, our tests showed that the dye-sublimation mode took three times longer to print.

			SPEED (PPM) POSTSCRIPT[1] B&W	POSTSCRIPT[1] COLOR	MAC B&W	MAC COLOR	QUALITY INDEX	CLASS (PPM)	PRICE	RESOLUTION (DPI)	INTERNAL HARD DRIVE
BEST	Fargo Primera Color	★	N/A	N/A	0.87	0.38	4.55	0.5	$995	203 × 203	No
RUNNER-UP	Canon BJC-600	■	1.35[2]	0.14[2]	N/A	N/A	5.60	240 cps	$719	360 × 360	No
RUNNER-UP	HP DeskJet 560C	■	1.52[2]	0.27[2]	N/A	N/A	4.81	3	$719	600 × 300	No

Do you require Mac support?

MACINTOSH — **General Parametrics Spectra Star GT**

Performance differences are particularly marked on the Mac, with the three leaders running 34 to 60 percent faster than the runners-up. The Spectra Star's built-in LocalTalk port gives it an additional advantage over the runners-up in this category.

			SPEED (PPM) POSTSCRIPT[1] B&W	POSTSCRIPT[1] COLOR	MAC B&W	MAC COLOR	QUALITY INDEX	CLASS (PPM)	PRICE	RESOLUTION (DPI)	INTERNAL HARD DRIVE
BEST	General Parametrics Spectra Star GT	★	1.67	1.09	1.54	1.17	5.88	2	$4495	300 × 300	Yes
RUNNER-UP	DEC ColorWriter 1000	★	1.43	0.84	1.48	1.09	6.15	2	$3999	300 × 600	No
RUNNER-UP	Tektronix Phaser 200e	★	1.05	0.68	0.90	0.73	5.67	2	$4480	300 × 300	No

For top print quality...

HIGH QUALITY — **General Parametrics Spectra Star GT**

For ultimate quality, the DEC and Tektronix printers offer slightly better color transitions. We still favor the Spectra Star, however, because of its print quality and speed.

			SPEED (PPM) POSTSCRIPT[1] B&W	POSTSCRIPT[1] COLOR	MAC B&W	MAC COLOR	QUALITY INDEX	CLASS (PPM)	PRICE	RESOLUTION (DPI)	INTERNAL HARD DRIVE
BEST	General Parametrics Spectra Star GT	★	1.67	1.09	1.54	1.17	5.88	2	$4495	300 × 300	Yes
RUNNER-UP	DEC ColorWriter 1000	★	1.43	0.84	1.48	1.09	6.15	2	$3999	300 × 600	No
RUNNER-UP	HP DeskJet 1200 C/PS	■	1.69	0.35	1.59	0.66	4.96	1–2	$2749	600 × 300	No
RUNNER-UP	Tektronix Phaser 200e	★	1.05	0.68	0.90	0.73	5.67	2	$4480	300 × 300	No

[1] PC [2] Native mode, not PostScript N/A = not applicable

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Byte 5/94

DRAFT QUALITY

If your budget is limited and you print only a small number of pages a day, one of today's monochrome ink-jet printers can offer quality competitive with a laser's for half the price.

We tested eight monochrome ink-jets that sell for under $1000. The five that support both monochrome and color printing start at $719, while the monochrome-only models average under $400. (For rankings in this section, we considered only monochrome performance.)

The four ink-jets that we ranked Best Overall help the technology overcome its low-speed stereotype: Performance as a group approached the ppm rate of under-$1000 lasers. In addition, ink-jets can be more flexible than low-cost lasers; for example, the CalComp TechJet Personal can handle 11- by 17-inch paper.

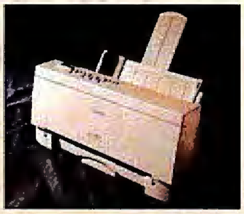
Another notable runner-up is the Texas Instruments MicroMarc, which doesn't win any categories outright but bundles fast speed and high quality in an affordable ($329) package. Its performance (third-fastest among all ink-jets in draft mode and second-fastest in high-quality mode) is even more remarkable given that this was the lowest-priced printer in the entire sample.

Macintosh support was lacking in the test sample of monochrome ink-jet printers we received. HP does sell a Macintosh version of the new DeskJet 520, called the DeskWriter 520. Like its PC cousin, the DeskWriter offers 600- by 300-dpi resolution and sells for $365. We did not receive a DeskWriter for testing.

The Brother HJ-400, with an 8-pin serial port, comes ready for easy connection to a Macintosh. However, it is the slowest printer in this category (40 percent slower than the BJ-200e).

Need the best in ink-jet economy and speed?

BEST OVERALL — Canon BJ-200e



MAY 1994 BYTE BEST DRAFT QUALITY PRINTER

The BJ-200e delivers clean, readable output at speeds comparable to those of a 4-ppm laser, for about half the cost. It easily outpaced the runners-up in draft-mode speed, and its high-quality-mode score also set the pace for this category. Its quality score lagged that of its big brother, the BJC-600.

		SPEED (PPM) PC	MAC	QUALITY INDEX	CLASS (PPM)	PRICE	RESOLUTION (DPI)	STANDARD MEMORY	WARRANTY (YEARS)	MAXIMUM INPUT (SHEETS)
BEST	Canon BJ-200e	2.81	N/A	5.98	4	$399	360 x 360	256 KB (host-based)	2	100
RUNNER-UP	CalComp TechJet Personal	2.41	N/A	6.20	3	$699	360 x 360	40 KB	1	100
RUNNER-UP	TI MicroMarc	2.16	N/A	5.61	4	$329	300 x 300	24 KB	1	100
RUNNER-UP	Canon BJC-600	1.76	N/A	7.04	240 cps	$719	360 x 360	60 KB	2	100

Is $500 your limit?

LOW COST — Canon BJ-200e

The BJ-200e outclasses the under-$500 competition with fast speed—almost 20 percent faster than its closest competitor, the TI MicroMarc. The BJ-200e also offers the best print quality in this price range.

		SPEED (PPM) PC	MAC	QUALITY INDEX	CLASS (PPM)	PRICE	RESOLUTION (DPI)	STANDARD MEMORY	WARRANTY (YEARS)	MAXIMUM INPUT (SHEETS)
BEST	Canon BJ-200e	2.81	N/A	5.98	4	$399	360 x 360	256 KB (host-based)	2	100
RUNNER-UP	TI MicroMarc	2.16	N/A	5.61	4	$329	300 x 300	24 KB	1	100
RUNNER-UP	Lexmark IBM ExecJet II 4076	2.03[1]	N/A	5.02	3	$349	600 x 300	21-KB buffer	2	150
RUNNER-UP	HP DeskJet 520	1.66	N/A	5.67	3	$365	600 x 300	—	3	100
RUNNER-UP	Citizen Projet II	1.91	N/A	5.09	3	$349	300 x 300	128 KB	2	70

Not for PCs only...

MACINTOSH — Brother HJ-400

This was the only monochrome ink-jet in our test sample to support the Mac. It gives Macintosh users output quality that ranks above average and acceptable print speed.

		SPEED (PPM) PC	MAC	QUALITY INDEX	CLASS (PPM)	PRICE	RESOLUTION (DPI)	STANDARD MEMORY	WARRANTY (YEARS)	MAXIMUM INPUT (SHEETS)
BEST	Brother HJ-400	1.18	1.08	5.91	2	$419	360 x 360	64 KB	2	100

Need high quality at a low price?

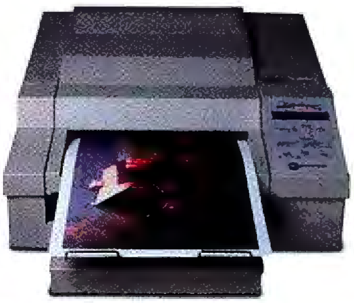
HIGH QUALITY — Canon BJC-600

The BJC-600 took almost twice as long to complete our printer tests as its sibling, but the BJC-600 compensates with top-notch output. Text was sharper and line rendering clearer than with any other printer in this class.

		SPEED (PPM) PC	MAC	QUALITY INDEX	CLASS (PPM)	PRICE	RESOLUTION (DPI)	STANDARD MEMORY	WARRANTY (YEARS)	MAXIMUM INPUT (SHEETS)
BEST	Canon BJC-600	1.76	N/A	7.04	240 cps	$719	360 x 360	60 KB	2	100
RUNNER-UP	CalComp TechJet Personal	2.41	N/A	6.20	3	$699	360 x 360	40 KB	1	100
RUNNER-UP	Canon BJ-200e	2.81	N/A	5.98	4	$399	360 x 360	256 KB (host-based)	2	100
RUNNER-UP	Brother HJ-400	1.18	1.08	5.91	2	$419	360 x 360	64 KB	2	100
RUNNER-UP	HP DeskJet 560C	1.55	N/A	5.87	3	$719	600 x 300	—	3	100
RUNNER-UP	HP DeskJet 520	1.66	N/A	5.67	3	$365	600 x 300	—	3	100
RUNNER-UP	TI MicroMarc	2.16	N/A	5.61	4	$329	300 x 300	24 KB	1	100

[1] Native mode, not PostScript N/A = not applicable — = data not available at press time

It's Time For A Reality Check In Desktop Color Proofing.



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LISTINGS AND FORMS

Dot-matrix technology continues to fill an important niche for those who need workhorse printers for multipart forms, large runs of labels, and oversize paper. We evaluated 10 high-end dot-matrix models (none supported the Mac) that serve these needs as no laser or ink-jet printer can. Several of these printers, all priced above $1000, run faster than typical low-end lasers. However, there are two trade-offs for this speed: noise and inferior print quality.

These printers emphasize raw output over fancy formatting. None offers PostScript, PCL, HPGL, or scalable fonts. All distinguish draft from letter-quality mode, at typical speed differentials of 500 percent. All offer at least two paper-feed paths to accommodate your preferred setup. For those who do not require presentation-quality output, the Advanced Matrix Technologies AMT Accel-535dsi, Brother M4309-A, Okidata Microline 395, and TI Omni 800 Model 8930 support color printing.

The Mannesmann Tally MT 360-2T provides the fastest available output and more font options (nine) than most of the other printers. The Dataproducts Dot Matrix 8524 scores just behind the TI Omni 800 Model 8930 in most categories, but it gave our testers trouble aligning margins.

Although the Advanced Matrix Technologies AMT TracJet III doesn't quite fit in this category, it deserves mention as the only laser printer tested that uses pin-feed instead of sheet-feed paper. Its quality is comparable to that of the best dot-matrix printers; however, it cannot handle wide paper or multipart forms. If you need good print quality on narrow-width, pin-feed paper, consider this unusual and (at $7995) expensive niche product.

Want the leader for multipart forms?

BEST OVERALL Texas Instruments Omni 800 Model 8930

MAY 1994 BYTE BEST LISTINGS AND FORMS PRINTER

For high-volume printing of multipart forms and continuous-feed stock, no other printer matches the output quality of the 18-pin Omni. In our high-quality-mode speed tests, this printer ranks second to the 24-pin Mannesmann Tally MT 360-2T, which places fourth among printers here for print quality. The Omni is also only one of two printers we ranked that offers as standard the ability to print bar codes. If print-head noise is a concern, however, note that the Omni's decibel rating is the highest of all the dot-matrix printers we ranked.

		SPEED (HIGH QUALITY)	QUALITY INDEX	CLASS (CPS)	PRICE	RESOLUTION (DPI)	STANDARD MEMORY	WARRANTY (YEARS)	RESIDENT FONTS	OPERATING NOISE (DB)	NUMBER OF PINS
BEST	TI Omni 800 Model 8930	2.96 ppm	4.42	600	$2545	216	32 KB	1	2	63	18
RUNNER-UP	Mannesmann Tally MT 360-2T	3.52 ppm	3.89	720	$2795	360	128 KB	1	9	55	24
RUNNER-UP	Dataproducts Dot Matrix 8524	2.70 ppm	4.14	780	$2395	360	60 KB	1	10	55	24
RUNNER-UP	Epson DFX-8000	2.03 ppm	3.72	1066	$3199	300	32 KB	1	3	55	9 (two rows)
RUNNER-UP	Brother M4309-A	2.24 ppm	4.11	800	$2195	216	96 KB	1	9	57	18
RUNNER-UP	Genicom Model 3840EP	2.16 ppm	3.56	600	$2922	400	64 KB	1	9	55	18

Want high quality for an economical price?

LOW COST Okidata Microline 395

The Microline 395 combines economy with highly readable output. It ranked second among all the dot-matrix printers we tested in overall quality and costs about $1000 less than the other quality leaders. Its speed is much slower than that of the Best Overall contenders, but the Microline easily outruns the only other Low Cost candidate. As a bonus, the standard-configuration Microline 395 can print bar codes (like the Omni; bar code printing is an option on the AMT Accel-535dsi).

		SPEED (HIGH QUALITY)	QUALITY INDEX	CLASS (CPS)	PRICE	RESOLUTION (DPI)	STANDARD MEMORY	WARRANTY (YEARS)	RESIDENT FONTS	OPERATING NOISE (DB)	NUMBER OF PINS
BEST	Okidata Microline 395	2.78 ppm	4.14	607	$1499	360	64 KB	1	12	58	24
RUNNER-UP	AMT Accel-294d	1.61 ppm	3.96	540	$1190	240	8 KB	1	4	55	9 (dual heads)

Want the speed leader?

HIGH SPEED Epson DFX-8000

This is the dot-matrix printer to choose if flat-out speed for large print runs is an overriding requirement for you. Although its quality is acceptable, this printer's forte is fast print-head and paper-handling performance, as evidenced by its draft-mode speed score of 4.77—6 percent faster than that of the nearest competitor, Genicom's Model 3840EP. The DFX-8000 comes standard with a Centronics port and offers RS-232 as an option. For only slightly slower performance with a price saving of about $300, consider the Genicom 3840EP.

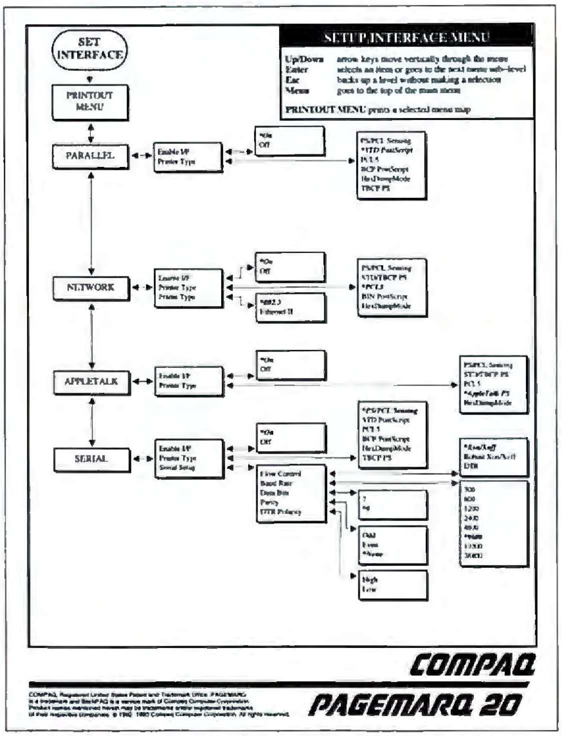
		SPEED (DRAFT QUALITY)	QUALITY INDEX	CLASS (CPS)	PRICE	RESOLUTION (DPI)	STANDARD MEMORY	WARRANTY (YEARS)	RESIDENT FONTS	OPERATING NOISE (DB)	NUMBER OF PINS
BEST	Epson DFX-8000	4.77 ppm	3.72	1066	$3199	300	32 KB	1	3	55	9 (two rows)
RUNNER-UP	Genicom Model 3840EP	4.47 ppm	3.56	600	$2922	400	64 KB	1	9	55	18
RUNNER-UP	Dataproducts Dot Matrix 8524	4.07 ppm	4.14	780	$2395	360	60 KB	1	10	55	24
RUNNER-UP	Mannesmann Tally MT 360-2T	4.02 ppm	3.89	720	$2795	360	128 KB	1	9	<55	24
RUNNER-UP	TI Omni 800 Model 8930	4.00 ppm	4.42	600	$2545	216	32 KB	1	2	63	18

HONORABLE MENTIONS

The reduction mode on Canon's BJ-200e is a unique feature that enables you to print wide documents such as spreadsheets on regular-size paper. It reduces the output file to two-thirds or one-half of its full size.

The Apple LaserWriter Select 360 and Apple LaserWriter Pro 810 offer **fax modules. This capability means the printers can act as stand-alone fax machines that receive faxes and deliver them as plain-paper documents.**

A "paper out" flag on the HP LaserJet 4MP tells you at a glance when the input tray is low on paper. The bright-orange flag, which is easily seen whether the printer is at your desk or connected remotely to a network, drops automatically. The printer need not be on for this feature to work.



Finding your way using the menu tree can be difficult unless you're using the TI MicroWriter PS23 or the Compaq PageMarq 20. Both have a complex control-panel menu system. However, each also lets you print out the entire system, which makes it easy to find the proper buttons and sequences to reconfigure the printers.

Dubious Achievements

The GCC SelectPress 600, LaserMaster Unity 1200XL-O, and NewGen ImagerPlus 12 all have a plastic security key for letter, legal, and larger-size paper. The corresponding keys must be installed in the paper tray for the paper to load properly. We found this an added nuisance when switching to different-size paper, and we worry that a misplaced key might be responsible for bringing your printing resource to a standstill.

SEE TO IT THAT THE PRINTER YOU CHOOSE TODAY IS THE PRINTER YOU'LL USE TOMORROW.

Insist upon a printer with genuine Adobe™ PostScript™ software inside. It's the industry standard and the only way to guarantee that your printer will work with virtually every software application and hardware environment, today and tomorrow. Adobe PostScript software sets the standard for new color and network printers. In fact, leading printer manufacturers offer over 300 Adobe PostScript printers. Adobe PostScript is your assurance of the highest-quality output—every time—whether you're printing from DOS, Windows™, OS/2®, Macintosh®, or UNIX®. So if you're anyone from a small business owner to a professional publisher, an Adobe PostScript printer is the best long term value for your company, today and tomorrow. For a free guide on how to choose a printer, call 1-800-833-6687, Dept E, Ext. 0106.

SET YOUR SIGHTS ON GENUINE ADOBE POSTSCRIPT DEVICES: BLACK-AND-WHITE, COLOR, NETWORK AND FAX PRINTERS.

IT'S NOT JUST PRINTING,
IT'S ADOBE POSTSCRIPT PRINTING.

Circle 63 on Inquiry Card.

ROLL CALL OF PRINTERS TESTED

	VENDOR	MODEL	PRICE (AS TESTED)	SPEED (PAGES PER MINUTE) HIGH-QUALITY	DRAFT	POSTSCRIPT	MAC	QUALITY INDEX	CLASS (SPEED)
DOT-MATRIX	Advanced Matrix Technology, Inc.	AMT Accel-535dsi	$2495	0.89	1.88	N/A	N/A	4.03	480 cps
	Advanced Matrix Technology, Inc.	AMT Accel-294d	$1190	0.82	1.61	N/A	N/A	3.96	540 cps
	Brother International Corp.	M4309-A	$2195	2.24	3.80	N/A	N/A	4.11	800 cps
	Dataproducts Corp.	Dot Matrix 8524	$2395	2.70	4.07	N/A	N/A	4.14	780 cps
	Epson America	DFX-8000	$3199	2.03	4.77	N/A	N/A	3.72	1066 cps
	Genicom Corp.	Model 3840EP	$2922	2.16	4.47	N/A	N/A	3.56	600 cps @ 12 cpi
	Mannesmann Tally Corp.	MT 360-2T	$2795	3.52	4.02	N/A	N/A	3.89	720 cps
	Okidata	Microline 395	$1499	1.81	2.78	N/A	N/A	4.14	607 cps @ 15 cpi
	Output Technology Corp.	Model 850XL	$2095	1.67	2.92	N/A	N/A	3.81	850 cps
	Texas Instruments	**Omni 800 Model 8930**	**$2545**	**2.96**	**4.00**	**N/A**	**N/A**	**4.42**	**600 cps**
INK-JET	Brother International Corp.	HJ-400	$419	1.12	1.18	N/A	1.08	5.91	110 cps
	CalComp	TechJet Personal	$699	2.22	2.41	N/A	N/A	6.20	248 cps
	Canon Computer Systems, Inc.	**BJ-200e**	**$399**	**2.43**	**2.81**	**N/A**	**N/A**	**5.98**	**248 cps**
	Citizen America Corp.	Projet II	$349	1.78	1.91	N/A	N/A	5.09	180 cps
	Epson America	Stylus 800	$399	1.97	1.96	N/A	N/A	4.28	150 cps
	Hewlett-Packard Co.	HP DeskJet 520	$365	1.55	1.66	N/A	N/A	5.67	240 cps
	Lexmark International, Inc.	IBM ExecJet II 4076	$349	2.03	N/A	N/A	N/A	5.02	300 cps
	Texas Instruments	MicroMarc	$329	2.23	2.16	N/A	N/A	5.61	300 cps
LASER	Advanced Matrix Technology, Inc.	AMT TracJet III	$7995	8.96	N/A	3.95	N/A	7.47	16 ppm
	Alps Electric	LSX 1000	$1599	5.41	N/A	5.19	N/A	7.96	10 ppm
	Alps Electric	LSX 1600e	$3295	4.82	N/A	N/A	N/A	8.33	16 ppm
	Apple Computer, Inc.	Personal LaserWriter 320	$959	N/A	N/A	N/A	2.26	8.24	N/A
	Apple Computer, Inc.	LaserWriter Select 360	$1599	N/A	N/A	4.09	3.76	9.48	10 ppm
	Apple Computer, Inc.	LaserWriter Pro 810	$4899	N/A	N/A	N/A	4.12	8.21	20 ppm
	Brother International Corp.	HL-10h	$1890	6.19	6.85	6.15	N/A	7.84	10 ppm
	Brother International Corp.	HL-6V	$1643	4.14	N/A	0.67	N/A	8.09	6 ppm
	Canon Computer Systems, Inc.	LBP-860	$2199	5.50	5.93	N/A	N/A	9.48	8 ppm
	Canon Computer Systems, Inc.	LBP-430	$799	2.58	N/A	N/A	N/A	8.30	4 ppm
	Compaq Computer Corp.	**PageMarq 20**	**$4636**	**6.76**	**N/A**	**8.1**	**6.45**	**8.59**	**20 ppm**
	Dataproducts Corp.	LZR 2080	$5495	N/A	N/A	N/A	3.85	8.69	20 ppm
	Epson America	ActionLaser 1500	$1028	4.54	N/A	N/A	N/A	7.83	6 ppm
	GCC Technologies	SelectPress 600	$4499	4.26	4.43	3.12	3.25	9.53	8 ppm
	Genicom Corp.	Model 7170	$9775	8.96	N/A	3.54	3.20	8.52	17 ppm
	Genicom Corp.	**Model 7610**	**$2283**	**6.35**	**6.93**	**6.04**	**N/A**	**8.79**	**10 ppm**
	Hewlett-Packard Co.	HP LaserJet 4MP	$1729	3.19	N/A	2.44	2.52	8.27	4 ppm
	Hewlett-Packard Co.	HP LaserJet 4P	$1229	3.19	N/A	N/A	N/A	8.27	4 ppm
	Hewlett-Packard Co.	HP LaserJet 4M	$2479	5.56	N/A	3.38	3.98	8.90	8 ppm
	Hewlett-Packard Co.	HP LaserJet 4	$1839	5.56	N/A	3.38	N/A	8.90	8 ppm
	Hewlett-Packard Co.	HP LaserJet 4 SiMX	$5499	7.91	9.91	5.63	7.87	9.10	17 ppm
	Hewlett-Packard Co.	**HP LaserJet 4 SI**	**$3749**	**7.91**	**9.91**	**5.63**	**N/A**	**9.10**	**17 ppm**
	Hewlett-Packard Co.	HP LaserJet 4ML	$1279	3.29	N/A	2.47	2.65	7.67	4 ppm
	Hewlett-Packard Co.	HP LaserJet 4L	$849	3.29	N/A	N/A	N/A	7.87	4 ppm
	Kyocera Electronics, Inc.	Ecosys FS-1500A	$3300	4.05	N/A	1.08	1.18	8.72	10 ppm
	Kyocera Electronics, Inc.	Ecosys FS-3500 A	$5380	6.63	N/A	5.57	8.05	8.66	18 ppm
	LaserMaster Corp.	Unity 1200XL-O	$8995	3.63	N/A	2.99	2.82	10.00	8 ppm
	Lexmark International, Inc.	IBM LaserPrinter 4039 12R	$1999	5.66	8.52	3.47	4.56	8.63	12 ppm
	Lexmark International, Inc.	IBM LaserPrinter 4039 16L	$4137	6.90	7.37	3.60	5.10	8.24	16 ppm
	Lexmark International, Inc.	IBM 4037 5E	$1078	3.22	N/A	N/A	N/A	8.71	5 ppm
	NEC Technologies, Inc.	Silentwriter Model 1097	$1400	5.14	N/A	3.73	3.97	7.97	10 ppm
	NEC Technologies, Inc.	Silentwriter Superscript 610	$600	2.98	N/A	N/A	N/A	8.10	6 ppm
	NEC Technologies, Inc.	Silentwriter Model 640	$800	N/A	N/A	N/A	2.04	7.75	6 ppm
	NewGen Systems Corp.	ImagerPlus 12	$8193	3.34	N/A	2.54	2.06	8.13	8 ppm
	Okidata	OL 410e	$899	2.59	3.38	N/A	N/A	8.76	4 ppm
	Okidata	OL 850	$1999	4.24	N/A	1.31	2.36	8.66	8 ppm
	Panasonic Communications	KXP 4440	$1549	4.38	N/A	N/A	N/A	6.97	10 ppm
	Panasonic Communications	SideWriter KX-P4400	$1048	2.77	N/A	N/A	N/A	8.50	4 ppm
	Sharp Electronics Corp.	JX-9460PS	$1428	4.29	N/A	3.22'	N/A	9.77	6 ppm
	Texas Instruments	MicroLaser Pro 600 PS23	$1599	3.15	3.27	2.44	4.26	8.43	8 ppm
	Texas Instruments	MicroWriter PS23	$997	3.17	N/A	1.20	1.82	8.46	5 ppm
	Xerox Corp.	Xerox 4011 Desktop	$1599	4.21	N/A	1.43	N/A	7.80	8 ppm

	VENDOR	MODEL	TECHNOLOGY	PRICE (AS TESTED)	B&W SPEED (PPM) PC	MAC	COLOR SPEED (PPM) HIGH-QUALITY	DRAFT	POSTSCRIPT
COLOR	Canon Computer Systems, Inc.	BJC-600	■	$719	1.35	N/A	0.14	0.33	N/A
	Dataproducts Corp.	Jolt PSe	■	$4995	1.09	1.15	N/A	N/A	0.31
	Digital Equipment Corp.	DEC ColorWriter 1000	★	$3999	1.61	1.48	0.94	N/A	0.84
	Fargo Electronics, Inc.	Primera Color	★	$995	1.28	0.87	0.32	N/A	N/A
	Fargo Electronics, Inc.	Primera Dyesub Color	◆	$1245	0.18	0.15	0.10	N/A	N/A
	General Parametrics Corp.	**Spectra Star GT**	**★**	**$4495**	**1.67**	**1.54**	**N/A**	**N/A**	**1.09**
	Hewlett-Packard Co.	HP DeskJet 560C	■	$719	1.52	N/A	0.27	0.30	N/A
	Hewlett-Packard Co.	HP DeskJet 1200 C/PS	■	$2749	2.96	1.59	0.49	0.89	0.35
	Lexmark International, Inc.	IBM Color JetPrinter PS 4079	■	$3199	1.11	0.79	N/A	N/A	0.37
	Star Micronics America	SJ-144	★	$599	1.24	N/A	0.31	N/A	N/A
	Tektronix, Inc.	Phaser 200e	★	$4480	1.05	0.90	N/A	N/A	0.68

= BYTE Best N/A = not applicable — = Data not available at press time ■ = Ink-jet ★ = Thermal ◆ = Dye-sublimation

FEATURES CONTINUE ON NEXT PAGE

RESOLUTION (DPI)	EMULATIONS: AUTO-SENSING	HP DESKJET 500/500C/550C	POSTSCRIPT	TRUE IMAGE	PCL 5	PCL 4	HPGL	EPSON LQ/FX	IBM PROPRINTER	IBM GRAPHICS	DIABLO 630
480	No	No	No	No	No	No	Optional	Yes	Yes	No	Yes
240	No	No	No	No	No	No	No	Yes	No	No	No
216	No	No	No	No	No	No	No	Yes	Yes	No	No
360	No	No	No	No	No	No	No	Yes	Yes	No	No
300	No	No	No	No	No	No	No	Yes	Yes	Yes	No
400	No	No	No	No	No	No	No	Yes	Yes	Yes	No
360	No	No	No	No	No	No	No	Yes	Yes	No	No
360	No	No	No	No	No	No	No	No	No	No	No
216	No	No	No	No	No	No	No	Yes	Yes	No	No
216	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes
360	Yes	No	No	No	No	No	No	Yes		Yes	No
360	No	No	Level I	No	No	No	Yes	Yes	Yes	No	No
360	No	No	No	No	No	No	No	Yes	Yes	No	No
300	No	Yes	No	No	No	No	No	No	No	No	No
360	No	No	No	No	No	No	No	Yes	No	No	No
600	No	Yes	No	No	No	No	No	No	Yes	No	No
600	No	Yes	No	No	No	No	No	No	Yes	Yes	No
300	No	Yes	No	No	No	No	No	No	No	No	No
300	Yes	No	Level II optional	No	Yes	Yes	Yes	No	No	No	No
600	Yes	No	Level I	No	Yes	No	Yes	Yes	Yes	Yes	Yes
300	Yes	No	Level II	No	Yes	No	Yes	No	No	No	No
300	No	No	Level II	No	No	No	No	No	No	No	No
600	Yes	No	Level II	No	Yes	No	No	No	No	No	No
800	No	No	Level II	No	No	Yes	No	No	No	No	No
600	Yes	No	Level I	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
300	Yes	No	Level I or II optional	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
600	Yes	No	Level II	No	Yes	No	No	No	No	No	No
300	No	No	No	No	Yes	Yes	Yes	No	No	No	No
400	Yes	No	Level I or II	Yes	Yes	Yes	Yes	No	No	No	No
800	Yes	No	Level II	No	No	Yes	No	No	No	No	No
300	Yes	No	Level I or II optional	No	Yes	Yes	Optional	Yes	No	No	No
600	Yes	No	Level I or II	No	Yes	Yes	Yes	No	No	No	No
300	No	No	Level I optional	No	Yes	Yes	Yes	No	Yes	No	No
600	Yes	No	Level I	No	Yes	Yes	Yes	Yes	Yes	No	Yes
600	Yes	No	Level II	No	Enhanced	No	Yes	No	No	No	No
600	Yes	No	Level II	No	Enhanced	No	Yes	No	No	No	No
600	Yes	No	Level II	No	Yes	Yes	Yes	Optional	Optional	No	No
600	Yes	No	Level II	No	Yes	Yes	Yes	Optional	Optional	No	No
600	Yes	No	Level II	No	Yes	Yes	Yes	Optional	Optional	No	No
600	Yes	No	Level II	No	Yes	Yes	Yes	Optional	Optional	No	No
300	Yes	No	Level II	No	Enhanced	No	Yes	No	No	No	No
300	Yes	No	No	No	Enhanced	No	Yes	No	No	No	No
300	No	No	Level I optional	No	Yes	No	Yes	Yes	Yes	No	Yes
300	No	No	Level I optional	No	Yes	No	Yes	Yes	Yes	No	Yes
1200	Yes	No	Level I	Yes	No	Yes	No	No	No	No	No
600	Yes	No	Level I	No	Yes	Yes	Yes	No	Yes	Yes	No
600	Yes	No	Level I	No	Yes	Yes	Yes	No	Yes	Yes	No
300	Yes	No	No	No	No	Yes	No	No	Yes	Yes	No
600	Yes	No	Level II	No	Yes	Yes	Yes	No	No	No	No
300	No	No	Level I optional	No	No	Yes	No	No	No	No	No
300	No	No	Level II	No	No	No	No	No	No	No	No
1200	Yes	No	Level I	Yes	Optional	Yes	Yes	No	No	No	No
300	No	No	No	No	Yes	No	Yes	No	No	No	No
300	No	No	Level I	No	No	Yes	No	No	No	No	No
300	No	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes
300	No	No	Level II optional	No	No	Yes	No	No	No	No	No
600	Yes	No	Level I	No	Yes	No	No	Yes	Yes	Yes	No
600	Yes	No	Level II	No	Yes	No	Yes	No	No	No	No
300	Yes	Yes	Level I	No	No	Yes	No	Optional	Optional	No	Yes
300	No	No	Level I optional	No	Yes	No	Yes	Yes	Yes	No	Yes

MAC	QUALITY INDEX	CLASS (SPEED)	RESOLUTION (DPI)	EMULATIONS: AUTO-SENSING	PCL 5C	HP DESKJET 500/500C/550C	POSTSCRIPT	PCL 5	PCL 4	HPGL	EPSON LQ/FX	IBM PROPRINTER	IBM GRAPHICS
N/A	7.04	240 cps	360	No	No	No	No	No	No	No	Yes	Yes	Yes
0.52	5.22	2 ppm	300	No	No	No	Level II	No	No	No	No	No	No
1.09	6.15	2 ppm	300	Yes	No	No	Level II	Yes	No	Yes	No	No	No
0.38	4.55	1/2 ppm	203	No	No	No	No	No	No	No	No	No	No
0.11	5.70	1/5 ppm	203	No	No	No	No	No	No	No	No	No	No
1.17	5.88	2 ppm	300	No	No	No	Levels I, II	No	No	Yes	No	No	No
N/A	5.87	3 ppm	600	No	No	Yes	Level II optional	No	No	No	No	Yes	No
0.66	4.96	7 ppm	600	Yes	Yes	No	Levels I, II	Yes	Yes	Yes	No	No	No
0.49	5.23	3 ppm	360	Yes	No	No	Level I	No	No	Yes	No	No	No
N/A	5.28[2]	459 cps	360	Yes	No	No	No	No	No	No	Yes	Yes	No
0.73	5.67	2 ppm	300	No	No	No	Level II	No	No	Yes	No	No	No

[1] The Sharp JX-9460PS could not complete our bit-map test in PostScript in 600 dpi.

[2] The Star SJ-144 printed banding in all the graphics and quality outputs.

ROLL CALL OF PRINTERS TESTED

	VENDOR	MODEL	MEMORY (AS TESTED)	MAXIMUM MEMORY	CONSUMABLES RATING	CONSUMABLES COST	FCC RATING	PRINT ENGINE VENDOR
DOT-MATRIX	Advanced Matrix Technology, Inc.	AMT Accel-535dsi	32 KB	480 KB	—	$13.33	B	Advanced Matrix
	Advanced Matrix Technology, Inc.	AMT Accel-294d	8 KB	512 KB	—	$11.03	B	Advanced Matrix
	Brother International Corp.	M4309-A	96 KB	96 KB	900 pages	$34.90	B	Brother
	Dataproducts Corp.	Dot Matrix 8524	60 KB	60 KB	—	$45	B	N/A
	Epson America	DFX-8000	3 KB	32 KB	15 million characters	$33	B	Epson
	Genicom Corp.	Model 3840EP	64 KB	64 KB	15 million characters	$31.70	B	N/A
	Mannesmann Tally Corp.	MT 360-2T	128 KB	128 KB	15 million characters	$27.95	B	Mannesmann Tally
	Okidata	Microline 395	64 KB	64 KB	5 million characters	$29.95	B	Okidata
	Output Technology Corp.	Model 850XL	2 MB	2 MB	76 million characters	$21.38	B	N/A
	Texas Instruments	**Omni 800 Model 8930**	**32 KB**	**32 KB**	**15,000 characters**	**$20**	**A**	**Texas Instruments**
INK-JET	Brother International Corp.	HJ-400	64 KB	64 KB	900 pages	$26 mono	B	N/A
	CalComp	TechJet Personal	40 KB	40 KB	450 pages	$25 mono	B	Canon
	Canon Computer Systems, Inc.	**BJ-200e**	**256 KB**	**Host-based**	**450 pages**	**25**	**B**	**Canon**
	Citizen America Corp.	Projet II	128 KB	384 KB	300 pages	$8.00	B	N/A
	Epson America	Stylus 800	32 KB	32 KB	200 pages	$19.99	B	N/A
	Hewlett-Packard Co.	HP DeskJet 520	—	—	1000 pages	$31.95	B	Hewlett-Packard
	Lexmark International, Inc.	IBM ExecJet II 4076	21 KB	1 MB (for fonts)	1000 pages	$31.95	B	Lexmark
	Texas Instruments	MicroMarc	24 KB	24 KB	1400 pages	$32	B	N/A
LASER	Advanced Matrix Technology, Inc.	AMT TracJet III	4 MB	9 MB	8000 pages	$120	B	Pentax Technologies
	Alps Electric	LSX 1000	4 MB	34 MB	—	$99	A	Brother
	Alps Electric	LSX 1600e	4 MB	34 MB	—	$168	A	Matsushita
	Apple Computer, Inc.	Personal LaserWriter 320	4 MB	8 MB	3000 pages	$79	B	True Laser
	Apple Computer, Inc.	LaserWriter Select 360	4 MB	16 MB	4000 pages	$99	B	Fuji/Xerox
	Apple Computer, Inc.	LaserWriter Pro 810	8 MB	32 MB	11,000 pages	$279	A	Fuji/Xerox
	Brother International Corp.	HL-10h	4 MB	34 MB	4000 pages	$130	B	Brother
	Brother International Corp.	HL-6V	3 MB	5 MB	3500 pages	$114	B	Brother
	Canon Computer Systems, Inc.	LBP-860	6 MB	32 MB	6000 pages	$150	A	Canon
	Canon Computer Systems, Inc.	LBP-430	5 MB	5 MB	3000 pages	$85	B	Canon
	Compaq Computer Corp.	**PageMarq 20**	**12 MB**	**20 MB**	**14,000 pages**	**$259**	**A**	**Fuji/Xerox**
	Dataproducts Corp.	LZR 2080	8 MB	32 MB	11,000 pages	$309	A	—
	Epson America	ActionLaser 1500	3 MB	5 MB	6000 pages	$159	B	Minolta
	GCC Technologies	SelectPress 600	8 MB	16 MB	—	—	B	Toshiba
	Genicom Corp.	Model 7170	9 MB	9 MB	13,000 pages	$269	B	Toshiba
	Genicom Corp.	**Model 7610**	**10 MB**	**34 MB**	**4000 pages**	**$125**	**B**	**Brother**
	Hewlett-Packard Co.	HP LaserJet 4MP	6 MB	22 MB	3000 pages	$89	B	Canon
	Hewlett-Packard Co.	HP LaserJet 4P	6 MB	22 MB	3000 pages	$89	B	Canon
	Hewlett-Packard Co.	HP LaserJet 4M	6 MB	22 MB	6000 pages	$155	B	Canon
	Hewlett-Packard Co.	HP LaserJet 4	6 MB	22 MB	6000 pages	$155	B	Canon
	Hewlett-Packard Co.	HP LaserJet 4 SiMX	10 MB	26 MB	8000 pages	$169	A, B	Canon
	Hewlett-Packard Co.	**HP LaserJet 4 Si**	**10 MB**	**26 MB**	**8000 pages**	**$169**	**A, B**	**Canon**
	Hewlett-Packard Co.	HP LaserJet 4ML	4 MB	4 MB	3000 pages	$89	B	Canon
	Hewlett-Packard Co.	HP LaserJet 4L	4 MB	4 MB	3000 pages	$89	B	Canon
	Kyocera Electronics, Inc.	Ecosys FS-1500A	4 MB	5 MB	7000 pages	$49	B	Kyocera
	Kyocera Electronics, Inc.	Ecosys FS-3500 A	10 MB	18 MB	7000 pages	$49	B	Kyocera
	LaserMaster Corp.	Unity 1200XL-O	32 MB	48 MB	5000 pages	$59	A	Toshiba
	Lexmark International, Inc.	IBM LaserPrinter 4039 12R	4 MB	16 MB	7000 pages	$199	B	Lexmark
	Lexmark International, Inc.	IBM LaserPrinter 4039 16L	8 MB	16 MB	12,800 pages	$269	B	Lexmark
	Lexmark International, Inc.	IBM 4037 5E	4.5 MB	4.5 MB	3500 pages	$114	B	Lexmark
	NEC Technologies, Inc.	Silentwriter Model 1097	7 MB	9 MB	8000 pages	$200	B	Minolta
	NEC Technologies, Inc.	Silentwriter Superscript 610	Host-based	Host-based	4000 pages	$115	B	NEC
	NEC Technologies, Inc.	Silentwriter Model 640	3 MB	3 MB	4000 pages	$115	B	NEC
	NewGen Systems Corp.	ImagerPlus 12	40 MB	96 MB	5000 pages	$49	A	Toshiba
	Okidata	OL 410e	4 MB	5 MB	2000 pages	$29	B	Okidata
	Okidata	OL 850	2 MB	4 MB	2500 pages	$33	B	Okidata
	Panasonic Communications	KXP 4440	4 MB	5 MB	5000 pages	$54	B	Panasonic
	Panasonic Communications	SideWriter KX-P4400	4 MB	5 MB	1600 pages	$14.95	B	Panasonic
	Sharp Electronics Corp.	JX-9460PS	4 MB	9 MB	15,000 pages	$210	B	Sharp
	Texas Instruments	MicroLaser Pro 600 PS23	6 MB	22 MB	15,000 pages	$199	B	Sharp
	Texas Instruments	MicroWriter PS23	4 MB	4 MB	2500 pages	$48	B	Samsung
	Xerox Corp.	Xerox 4011 Desktop	3 MB	5 MB	1500 pages	$32	B	Tokyo Electric

	VENDOR	MODEL	MEMORY (AS TESTED)	MEMORY MAXIMUM	CONSUMABLES COST	FCC RATING	PRINT ENGINE VENDOR	CONTROLLER
COLOR	Canon Computer Systems, Inc.	BJC-600	Host-based	60 KB	$7.50	A	Canon	16-MHz Toshiba
	Dataproducts Corp.	Jolt PSe	6 MB	10 MB	$179.95 Color pack	B	Dataproducts	24-MHz Weitek 8220
	Digital Equipment Corp.	DEC ColorWriter 1000	8 MB	8 MB	$125	B	Tektronix	16-MHz AMD29000
	Fargo Electronics, Inc.	Primera Color	32 KB	32 KB	$45	B	Fargo	—
	Fargo Electronics, Inc.	Primera Dyesub Color	32 KB	32 KB	—	B	Fargo	—
	General Parametrics Corp.	**Spectra Star GT**	**6 MB**	**32 MB**	**$342 (3 colors)**	**A**	**Sharp**	**33-MHz i960ca RISC**
	Hewlett-Packard Co.	HP DeskJet 560C	—	—	$34.95	B	Hewlett-Packard	—
	Hewlett-Packard Co.	HP DeskJet 1200 C/PS	4 MB	26 MB	$34.95 (1 color)	B	Hewlett-Packard	—
	Lexmark International, Inc.	IBM Color JetPrinter PS 4079	4 MB	16 MB	$34.95	B	Canon	16.7-MHz AMD29200
	Star Micronics America	SJ-144	176 KB	176 KB	$7.50	B	Star	—
	Tektronix, Inc.	Phaser 200e	6 MB	8 MB	—	—	Sharp	16-MHz RISC AMD29000

= BYTE Best   N/A = not applicable   — = Data not available at press time

FEATURES CONTINUE ON NEXT PAGE

CONTROLLER	AUTO-SWITCHING	CENTRONICS	RS-232	RS-422A	LOCAL-TALK	ETHERNET	TOKEN RING	SCSI	OTHER	FONTS STANDARD	FONT SLOTS
	INTERFACES										
AMT Accel-535dsi	No	Yes	Yes	Yes	No	No	No	No	Twinax, coaxial	4	2
AMT Accel-294d	No	Yes	Yes	Yes	No	No	No	No	Twinax, coaxial	4	0
—	No	Yes	Yes	No	No	No	No	No	None	9	0
—	No	Yes	Yes	Optional	No	No	No	No	None	10	0
—	No	Yes	Optional	No	No	No	No	No	None	3	0
—	No	Yes	Yes	Optional	No	Optional	No	No	10Base-T, TCP/IP	9	1
MT 360	Yes	Yes	Yes	No	No	No	No	No	Twinax, coaxial	9	0
—	No	Yes	Yes	No	No	No	No	No	None	12	0
—	No	Yes	Yes	No	No	No	No	No	None	—	—
—	No	Yes	Yes	No	No	No	No	No	None	2	0
N/A	Yes	Yes	Yes	Yes	No	No	No	No	None	0	0
N/A	No	Yes	No	No	No	No	No	No	None	7	0
N/A	No	Yes	No	No	No	No	No	No	None	20	—
N/A	No	Yes	No	No	No	Yes	No	No	None	9	0
N/A	No	Yes	No	No	No	No	No	No	None	11	0
N/A	—	Yes	No	Yes	Yes	No	No	No	None	55	2
10-MHz 68000	No	Yes	Optional	Optional	No	Optional	Optional	No	None	14	0
N/A	No	Yes	No	No	No	No	No	No	None	3	—
6-MHz i960 & i961	Yes	Yes	Yes	Optional	No	Optional	Optional	No	Twinax, coaxial	7	2
20-MHz MC68EC030	Yes	Yes	Yes	No	No	No	No	No	None	83	1
16-MHz AMD29200	Yes	Yes	Yes	Yes	No	No	No	No	None	27	2
AMD29205	—	No	No	No	Yes	No	No	No	None	35	0
16-MHz AMD29200	Yes	Yes	Yes	No	Yes	No	No	No	None	64	0
Weitek 8200	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	None	0	0
68EC030	Yes	Yes	Yes	No	Yes	Yes	Yes	No	None	83	1
16-MHz 68000	Yes	Yes	Yes	No	No	No	No	No	HP Bitronics	50	1
16-MHz i960	Yes	Yes	No	No	Optional	No	No	No	PCMCIA	45	1 PCMCIA
—	No	Yes	No	No	No	No	No	No	None	15	0
20-MHz AMD29000	Yes	Yes	Yes	No	No	No	No	No	EtherTalk, TCP/IP	50	Unlimited
7.25-MHz Weitek 8200	Yes	No	Yes	No	Yes	Yes	No	Yes	None	35	0
16.67-MHz 68000	Yes	Yes	Yes	Optional	Optional	No	No	No	Twinax, coaxial (optional)	0	1
25-MHz AMD29030	Yes	Yes	Yes	Yes	Yes	Yes	No	No	TCP/IP	50	0
—	Yes	Yes	Yes	Yes	Optional	Optional	Optional	N/A	TCP/IP	0	2
20-MHz 68030	Yes	Yes	Yes	Yes	Optional	Optional	Optional	Optional	M10 interface	83	2
20-MHz i960KA	Yes	Yes	No	No	Yes	Optional	Optional	No	Jet Direct HP Bitronics parallel	80	0
20-MHz i960KA	Yes	Yes	No	No	No	Optional	Optional	No	Jet Direct HP Bitronics parallel	80	0
20-MHz i960	Yes	Yes	Yes	Yes	Yes	Optional	Optional	No	None	80	1
20-MHz i960	Yes	Yes	Yes	Yes	No	Optional	Optional	No	None	80	1
25-MHz i960CF	Yes	Yes	No	No	Yes	Yes	Optional	No	None	81	2
25-MHz i960CF	Yes	Yes	No	No	No	Yes	Optional	No	None	81	2
18.5-MHz i960KA	Yes	Yes	No	No	Yes	Optional	Optional	No	None	80	0
18.5-MHz i960KA	Yes	Yes	No	No	No	Optional	Optional	No	None	80	0
16-MHz MC68000	Yes	Yes	Yes	No	Optional	Optional	Optional	No	None	92	2 PCMCIA
16-MHz AMD29000	Yes	Yes	Yes	No	Optional	Optional	Optional	No	None	146	2 PCMCIA
33-MHz Unity	Yes	Yes	Yes	No	Yes	Yes	No	Yes	None	241	0
16-MHz AMD29200	Yes	Yes	Yes	No	Optional	Optional	Optional	No	None	14	1
16-MHz AMD29000	Yes	Yes	Yes	No	Optional	Optional	Optional	No	None	0	1
10-MHz 68000	No	Yes	Optional	Optional	No	No	No	No	None	0	0
20-MHz i960	Yes	Yes	Yes	Yes	Yes	Optional	Optional	Yes	Optional	57	0
8-MHz SuperScript 87C51	No	Yes	No	No	No	No	No	No	None	Host-based	0
NEC custom ASIC	No	No	No	No	Yes	No	No	No	None	17	0
25-MHz XL-8220	Yes	Yes	Yes	Yes	Yes	Optional	No	Yes	None	35	—
—	Yes	Yes	Yes	No	No	No	No	No	None	14 bar code	1
—	No	Yes	Yes	No	No	No	No	No	AppleTalk	26	1
16-MHz i960SA	Yes	Yes	Yes	No	No	No	No	No	None	36	1
15-MHz NS32CG16	No	Yes	Optional	No	No	No	No	No	—	28	0
16-MHz AMD29005/14	Yes	Yes	Optional	No	Optional	No	No	No	None	62	1
20-MHz Platinum	Yes	Yes	Optional	Optional	Yes	Optional	No	Optional	High-speed parallel	31	—
—	No	Yes	Optional	Optional	Yes	Optional	Optional	No	None	23	0
16-MHz 68302	No	Yes	Optional	No	No	No	No	No	None	15	2

AUTO SWITCHING	CENTRONICS	RS-232	RS-422A	LOCALTALK	ETHERNET	TOKEN RING	SCSI	OTHER	FONTS STANDARD	FONT SLOTS
INTERFACES										
No	Yes	No	No	No	No	No	No	None	8	0
No	Yes	Yes	No	Yes	Optional	No	No	AppleTalk	39	0
Yes	Yes	No	No	No	Optional	No	No	AppleTalk	12	0
No	Yes	No	No	No	No	No	No	Serial to Mac	1	—
No	Yes	No	No	No	No	No	No	Serial to Mac	1	—
Yes	Yes	Yes	No	Yes	No	No	No	None	52	2
N/A	Yes	No	No	No	No	No	No	None	6 (DOS), 14 (TrueType), 35 (Mac)	2
Yes	Yes	No	No	Yes	Optional	Optional	No	Ethernet/10Base-T and BNC	45	1
Yes	Yes	Yes	No	Yes	Optional	Optional	No	None	35	0
No	Yes	No	No	No	No	No	No	None	8	0
Yes	Yes	No	No	Yes	No	No	No	None	17	0

ROLL CALL OF PRINTERS TESTED

	VENDOR	MODEL	PAPER SIZES: LETTER	LEGAL	A4	11" × 17"	ENVELOPE	TOLL-FREE PHONE	PHONE	INQUIRY NUMBER
DOT-MATRIX	Advanced Matrix Technology, Inc.	AMT Accel-535dsi	Yes	Yes	Yes	Yes	Yes	(800) 992-2264	(805) 388-5799	1105
	Advanced Matrix Technology, Inc.	AMT Accel-294d	Yes	Yes	Yes	Yes	Yes	(800) 992-2264	(805) 388-5799	1106
	Brother International Corp.	M4309-A	Yes	Yes	Yes	No	No	(800) 276-7746	(714) 859-9700	1107
	Dataproducts Corp.	Dot Matrix 8524	Yes	Yes	Yes	Yes	Yes	(800) 283-1932	(818) 887-8000	1108
	Epson America	DFX-8000	Yes	Yes	—	—	No	(800) 922-8911	(310) 782-0770	1109
	Genicom Corp.	Model 3840EP	Yes	Yes	Yes	Yes	Yes	(800) 443-6426	(703) 949-1708	1110
	Mannesmann Tally Corp.	MT 360-2T	Yes	Yes	Yes	No	Yes	(800) 458-4701	(206) 251-5593	1111
	Okidata	Microline 395	Yes	Yes	—	—	No	(800) 654-3282	(609) 235-2600	1112
	Output Technology Corp.	Model 850XL	Yes	Yes	Yes	Yes	No	None	(509) 536-0468	1113
	Texas Instruments	Omni 800 Model 8930	Yes	Yes	Yes	Yes	Yes	(800) 848-3927	(817) 774-6001	1114
INK-JET	Brother International Corp.	HJ-400	Yes	Yes	Yes	No	Yes	(800) 276-7746	(714) 859-9700	1115
	CalComp	TechJet Personal	Yes	Yes	Yes	Yes	Yes	(800) 932-1212	(714) 821-2000	1116
	Canon Computer Systems, Inc.	BJ-200e	Yes	Yes	Yes	No	Yes	(800) 423-2366	(714) 438-3000	1117
	Citizen America Corp.	Projet II	Yes	Yes	Yes	No	Yes	None	(310) 453-0614	1118
	Epson America	Stylus 800	Yes	Yes	No	No	Yes	(800) 922-8911	(310) 782-0770	1119
	Hewlett-Packard Co.	HP DeskJet 520	Yes	Yes	Yes	No	Yes	(800) 752-0900	(208) 323-2551	1120
	Lexmark International, Inc.	IBM ExecJet II 4076	Yes	Yes	Yes	No	Yes	(800) 358-2380	(606) 232-2000	1121
	Texas Instruments	MicroMarc	Yes	Yes	Yes	No	Yes	(800) 848-3927	(817) 774-6724	1122
LASER	Advanced Matrix Technology, Inc.	AMT TracJet III	Yes	Yes	Yes	No	Yes	(800) 992-2264	(805) 388-5799	1123
	Alps Electric	LSX 1000	Yes	Yes	Yes	No	Yes	(800) 825-2577	(408) 432-6000	1124
	Alps Electric	LSX 1600e	Yes	Yes	Yes	No	Yes	(800) 825-2577	(408) 432-6000	1125
	Apple Computer, Inc.	Personal LaserWriter 320	Yes	Yes	Yes	No	Yes	(800) 767-2775	(408) 996-1010	1126
	Apple Computer, Inc.	LaserWriter Select 360	Yes	Yes	Yes	No	Yes	(800) 767-2775	(408) 996-1010	1127
	Apple Computer, Inc.	LaserWriter Pro 810	Yes	Yes	Yes	Yes	Yes	(800) 767-2775	(408) 996-1010	1128
	Brother International Corp.	HL-10h	Yes	Yes	Yes	No	Yes	(800) 276-7746	(714) 859-9700	1129
	Brother International Corp.	HL-6V	Yes	Yes	Yes	No	Yes	(800) 276-7746	(714) 859-9700	1130
	Canon Computer Systems, Inc.	LBP-860	Yes	Optional	Optional	No	Optional	(800) 423-2366	(714) 438-3000	1346
	Canon Computer Systems, Inc.	LBP-430	Yes	Yes	Yes	No	Yes	(800) 423-2366	(714) 438-3000	1347
	Compaq Computer Corp.	PageMarq 20	Yes	Optional	Yes	Optional	No	(800) 345-1518	(713) 378-8820	1348
	Dataproducts Corp.	LZR 2080	Yes	Yes	Yes	Yes	Yes	(800) 283-1932	(818) 887-8000	1349
	Epson America	ActionLaser 1500	Yes	Yes	Yes	No	Yes	(800) 922-8911	(310) 782-0770	1350
	GCC Technologies	SelectPress 600	Yes	Yes	Yes	Yes	Yes	(800) 422-7777	(617) 276-8620	1351
	Genicom Corp.	Model 7170	Yes	Yes	Yes	No	Yes	(800) 443-6426	(703) 949-1708	1352
	Genicom Corp.	Model 7610	Yes	Yes	Yes	No	Yes	(800) 443-6426	(703) 949-1708	1353
	Hewlett-Packard Co.	HP LaserJet 4MP	Yes	Yes	Yes	No	Yes	(800) 752-0900	(208) 323-2551	1354
	Hewlett-Packard Co.	HP LaserJet 4P	Yes	Yes	Yes	No	Yes	(800) 752-0900	(208) 323-2551	1355
	Hewlett-Packard Co.	HP LaserJet 4M	Yes	Yes	Yes	No	Yes	(800) 752-0900	(208) 323-2551	1356
	Hewlett-Packard Co.	HP LaserJet 4	Yes	Yes	Yes	No	Yes	(800) 752-0900	(208) 323-2551	1357
	Hewlett-Packard Co.	HP LaserJet 4 SiMX	Yes	Optional	Optional	No	Optional	(800) 752-0900	(208) 323-2551	1358
	Hewlett-Packard Co.	HP LaserJet 4 Si	Yes	Optional	Optional	No	Optional	(800) 752-0900	(208) 323-2551	1359
	Hewlett-Packard Co.	HP LaserJet 4ML	Yes	Yes	Yes	No	Yes	(800) 752-0900	(208) 323-2551	1360
	Hewlett-Packard Co.	HP LaserJet 4L	Yes	Yes	Yes	No	Yes	(800) 752-0900	(208) 323-2551	1361
	Kyocera Electronics, Inc.	Ecosys FS-1500A	Yes	Yes	Yes	No	Yes	(800) 367-7437	(510) 748-6680	1362
	Kyocera Electronics, Inc.	Ecosys FS-3500 A	Yes	Yes	Yes	No	Yes	(800) 367-7437	(510) 748-6680	1363
	LaserMaster Corp.	Unity 1200XL-O	Yes	Yes	Yes	Yes	Yes	None	(612) 944-9331	1364
	Lexmark International, Inc.	IBM LaserPrinter 4039 12R	Yes	Yes	Yes	No	Optional	None	(606) 232-3000	1365
	Lexmark International, Inc.	IBM LaserPrinter 4039 16L	Yes	Yes	Yes	No	Yes	None	(606) 232-3000	1366
	Lexmark International, Inc.	IBM 4037 5E	Yes	Optional	Yes	No	Yes	None	(606) 232-3000	1367
	NEC Technologies, Inc.	Silentwriter Model 1097	Yes	Optional	Yes	No	Yes	(800) 388-8888	(508) 264-8000	1368
	NEC Technologies, Inc.	Silentwriter Superscript 610	Yes	Yes	Yes	No	Yes	(800) 388-8888	(508) 264-8000	1369
	NEC Technologies, Inc.	Silentwriter Model 640	Yes	Yes	Yes	No	Yes	(800) 388-8888	(508) 264-8000	1370
	NewGen Systems Corp.	ImagerPlus 12	Yes	Yes	Yes	Yes	Yes	(800) 888-1689	(714) 436-5150	1371
	Okidata	OL 410e	Optional	Optional	No	No	Yes	(800) 654-3282	(609) 235-2600	1372
	Okidata	OL 850	Yes	Yes	Yes	No	Yes	(800) 654-3282	(609) 235-2600	1373
	Panasonic Communications	KXP 4440	Yes	Yes	Yes	No	Yes	(800) 222-0584	(201) 863-7845	1374
	Panasonic Communications	SideWriter KX-P4400	Yes	Yes	Yes	No	No	(800) 222-0584	(201) 863-7845	1375
	Sharp Electronics Corp.	JX-9460PS	Yes	Optional	No	No	Optional	(800) 732-8221	(201) 529-8200	1376
	Texas Instruments	MicroLaser Pro 600 PS23	Yes	Optional	Optional	No	Optional	(800) 848-3927	(817) 774-6001	1377
	Texas Instruments	MicroWriter PS23	Yes	Yes	Yes	No	Yes	(800) 848-3927	(817) 774-6001	1378
	Xerox Corp.	Xerox 4011 Desktop	Yes	Yes	Yes	No	Yes	(800) 821-2797	(310) 333-2192	1379
COLOR	Canon Computer Systems, Inc.	BJC-600	Yes	Yes	Yes	No	Yes	(800) 423-2366	(714) 438-3000	1380
	Dataproducts Corp.	Jolt PSe	Yes	Yes	Yes	No	Yes	(800) 283-1932	(818) 887-8000	1381
	Digital Equipment Corp.	DEC ColorWriter 1000	Yes	No	Yes	No	No	(800) 777-4343	(508) 493-5111	1382
	Fargo Electronics, Inc.	Primera Color	Yes	Yes	Yes	—	—	(800) 327-4622	(612) 941-9470	1383
	Fargo Electronics, Inc.	Primera Dyesub Color	Yes	Yes	Yes	—	—	(800) 327-4622	(612) 941-9470	1384
	General Parametrics Corp.	Spectra Star GT	Yes	No	Yes	No	No	None	(510) 524-1060	1385
	Hewlett-Packard Co.	HP DeskJet 560C	Yes	Yes	No	Yes	Yes	(800) 752-0900	(208) 323-2551	1386
	Hewlett-Packard Co.	HP DeskJet 1200 C/PS	Yes	Yes	No	Yes	Yes	(800) 752-0900	(208) 323-2551	1387
	Lexmark International, Inc.	IBM Color JetPrinter PS 4079	Yes	Yes	Yes	Yes	Yes	None	(606) 232-3000	1388
	Star Micronics America	SJ-144	Yes	Yes	No	Yes	Yes	(800) 447-4700	(908) 572-3300	1389
	Tektronix, Inc.	Phaser 200e	Yes	No	No	No	No	(800) 835-6100	(503) 682-7377	1390

= BYTE Best — = Data not available at press time

The Panose Typeface-Matching System

A system for matching static or distortable fonts

SCOTT BOGGAN AND MICHAEL DE LAURENTIS

As the popularity of the dozen or so inexpensive font libraries on the market attests, computer users cannot resist fonts. Perhaps because fonts deliver on the promise of personalizing the PC, documents are dressed in everything from Aachen to Zapf Dingbats.

This creative freedom comes at a price, however, as fonts present a significant barrier to document portability. When documents containing fonts are exchanged between platforms and among networked workgroup users, problems inevitably occur. For example, a proposal formatted in Century Old Style that's sent to a Windows system that doesn't have Century Old Style installed will likely be displayed and printed on the Windows system in Times New Roman, destroying the document's line endings and page breaks in the process. Or a PC document containing CG Omega might be sent to a Macintosh counterpart that doesn't recognize that the font is identical to Optima and instead displays the document in Courier.

The Panose typeface-matching system from ElseWare (Seattle, WA) attempts to solve these font problems. Panose has been adopted by a variety of software and hardware vendors, including Aldus, Go Corp., Hewlett-Packard, Lotus, Microsoft, and No Hands Software. Many type vendors, including Agfa, Bitstream, and Microsoft, have also licensed Panose for use in their retail font products. By objectively classifying fonts according to their visual characteristics, the Panose system selects and replaces fonts in documents on a variety of platforms, including Windows, Macintosh, DOS, Unix, and PenPoint systems.

The Trouble with Fonts

Font-portability problems are not surprising, given the widespread popularity of font libraries from many vendors. Since font packages provide users with lots of fonts at a cost of just pennies each, most users have one or two of these packages installed on their system.

The font vendors themselves are partially to blame for the font-portability problem. Over the past 20 years, many font vendors have licensed or recut the popular type designs, marketing the fonts under new names. Name variations between vendors are the most common. Linotype-Hell owns a typeface that it calls Optima; Agfa calls its version of the same design CG Omega. Interplatform font-name variations are also common, even within a single vendor's product line. Adobe uses the name GoudyOldStyle for one of its fonts on the Macintosh but calls its PC version Goudy Old Style (with spaces). Such confusing name variations alone are enough to throw a monkey wrench into the process of sharing documents.

The growing popularity of workgroup products such as Lotus Notes and Microsoft Windows for Workgroups aggravates font-portability problems by increasing the likelihood of shared documents between computers. Portable computing also adds to the document shuffle between computers with different font configurations. Since fonts don't travel with documents, formatting is lost unless all computers that call up a document have the fonts requested by it.

JAMES YANG © 1994

Current Approaches to Font Substitution

Windows and the Macintosh address the font-substitution problem in very different ways, as do different applications vendors. Even without knowing it, most Windows users have experienced the Windows solution to missing fonts: When you open a document containing a missing font, the Windows font mapper finds a substitute and supplies it to the application. Since the Windows font mapper provides no notification of this process, it's often difficult to tell when a font is missing. Furthermore, there is no easy way to customize Windows font replacements, since Microsoft chose not to provide an interface to Windows font mapping.

How does the Windows font mapper work? The Windows core mapper uses weighted penalties to identify the closest font replacement and then provides the application with the font having the smallest penalty. The mapper assigns large penalties to font attributes such as character set, output precision, variable or fixed pitch, face name, family type, and height. Although these attributes preserve the overall feeling of the font, they ignore such critical visual characteristics as serif style, weight, proportion, and contrast. In addition, the Windows mapper doesn't handle font-name variations very well. In practice, Windows usually replaces missing fonts with either Arial or Times New Roman.

The Mac OS takes a different approach: If the requested font is not available, it notifies the user and displays the missing font in Courier. Although it effectively highlights the problem, this approach forces the user to either install the missing font or reformat the document.

Windows 3.1 provides vendors of applications and fonts with a solution to font portability: font embedding. Embedding lets you include TrueType fonts in a document file. There are two types of font embedding: read-only and read-write. Read-only fonts allow a recipient of a shared document to use the embedded font for viewing and printing only; when the document is closed, the fonts are deleted. Read-write embeddable fonts are permanently installed on the system, allowing the user full access to the font for editing, viewing, and printing documents.

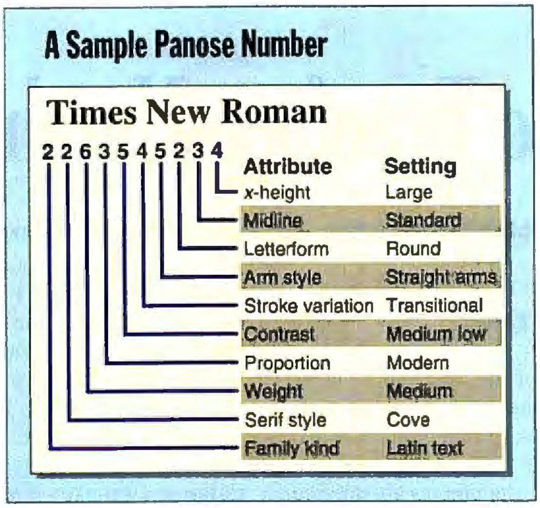
However, font embedding is not a practical solution to the font problem. Few applications vendors support it, and the idea has been coolly received by font vendors, most of whom limit their support to read-only access. Most important, embedding fonts increases document file sizes according to the size of the font files. For instance, because TrueType fonts range from 35 KB to 70 KB, embedding four fonts in a document increases its size by approximately 200 KB.

Panose Font Mapping

In an effort to resolve font problems in portable-document software, the Panose font mapper uses techniques that differ from those of font embedding. The key to the Panose font classification and matching system is the Panose typeface classification number, a 10-byte description of a font's visual characteristics.

There are two other components to the Panose system: classification procedures and the Panose mapper. The classification procedures are used to assign a Panose number to a font. The Panose mapper accepts the number of each missing font, compares it against the fonts on the system, and then selects the closest match. The mapper also provides an interface for the user to adjust the mapper tolerances and override the replacements it provides.

The Panose number is an array of 10 digits. The first digit identifies the font family and determines the meaning of the remaining nine digits. The standard fonts used for European languages belong to the Latin Text and Display family, and the remaining nine digits describe serif style, weight, proportion, contrast, stroke variation, arm style, letterform, midline, and x-height. Script fonts belong to the Latin Script family, and the remaining nine digits describe tool kind, weight, monospace, aspect ratio, contrast, topology, form, finials, and x-ascent (see the figure "A Sample Panose Number").



The Panose typeface classification number is a 10-digit description of a font's critical visual characteristics.

Since each digit in the Panose number is an integer, it expresses a few discrete values. Therefore, a font's weight (which can range from light to extra black) is measured and categorized in one of 11 buckets. Similarly, serif style is placed in one of 14 buckets according to its shape. This approach keeps Panose numbers very compact while providing enough information to find the closest match to a given font.

Panose classification procedures are the rules and equations used for determining a 10-digit Panose classification number. Font classification begins by printing selected characters from a font and measuring various attributes. For example, the widest and narrowest stems on the uppercase *O* are measured, and the ratio between the two is used to determine the value of the contrast digit. There are a total of 65 Panose measurements, but through a process of elimination most fonts can be accurately classified in five steps (for sans serif) or nine steps (for serif), depending on shape complexity.

Once a font has been classified, the Panose classification number is registered and stored in a database that is distributed with the Panose mapper. Panose numbers are also embedded in documents created by applications that are Panose-aware. When documents are shared between Panose-aware applications, those applications reference the Panose database before referencing the Panose numbers that are already embedded in the documents.

The Panose Mapper

When a document is brought into a Panose-aware application, the application or operating system requests a font name from the MAI (Mapper Application Interface), which in turn queries the Core Mapper Services. The core mapper returns a Panose number to the MAI, which consults the Panose exceptions database for a custom mapping. If there is no exception in the database, the mapper displays a Results dialog box that tells the user what was found and allows the option to override the mapping. Finally, the mapper supplies the replacement font to the application or operating system (see the figure "The Panose Architecture" on page 190).

The Panose mapper software determines the closest possible font match on any given system by comparing the Panose numbers of the requested and available fonts. The individual Panose digits are compared, weighted by their typographic importance (e.g., weight carries more importance than contrast), and summed to provide a numerical visual distance.

The components of the Panose mapper include the Core Mapper Services and the MAI. The Panose mapper also includes a database of registered Panose numbers for most common font

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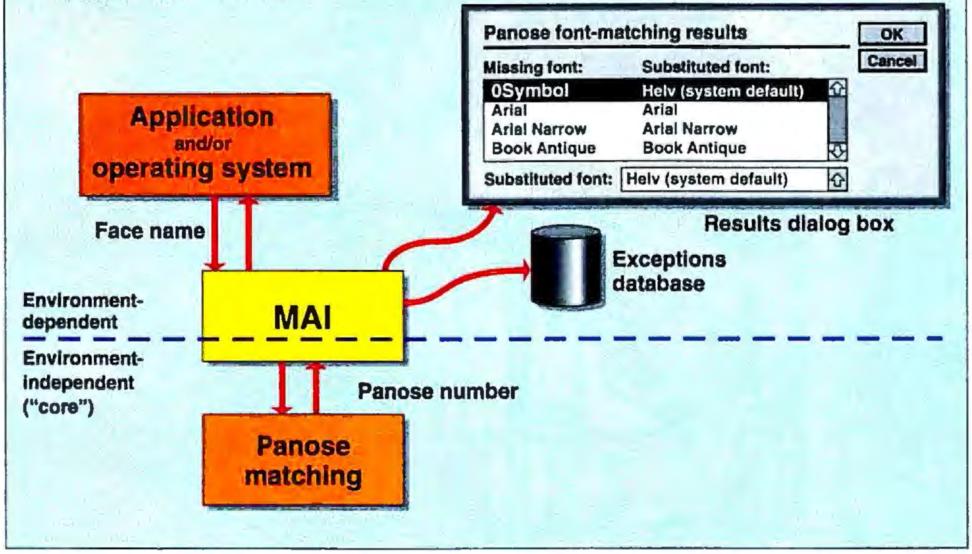
The Panose Architecture



A depiction of the Panose mapper's execution flow when a font is requested by an application and/or the operating system. A font is requested when a document is brought into a Panose-aware application.

The MAI provides additional services for Windows and Macintosh applications developers. The MAI includes sample dialog boxes for both platforms, database services for retrieving Panose numbers, and an API that's designed for simple integration of Panose mapping into the application's existing font-selection mechanism.

The mapper algorithm starts with two lists: fonts requested by a document, and fonts available on the system. The mapper considers each font in the requested list independently and looks for the best choice among the available fonts. The result is a one-to-many mapping from the required list to the available list.

The mapper first checks the available fonts; if no matches are found, it looks at the exceptions list. Finally, it compares the required font against the entire list of available fonts and maps to the first font returned. If the mapper can't find a match within the specified tolerance, it returns the default font.

The MAI also looks at other factors when matching fonts. These include the following:

• *Substitution tolerance* sets Panose mapping tolerance, which determines when the mapper gives up and substitutes the system default.
• The *Alternate Spellings* feature enables the user to modify the spelling list that comes with the MAI. This list captures cross-platform naming variations, such as Avant Garde (Macintosh) and AvantGarde (Windows).
• The *Matching Exceptions* feature lets the user customize the behavior of the mapper. Exceptions are typically used to break ties between two otherwise identical matches. For example, Times on the Macintosh would typically map to Times New Roman in Windows, but an equally valid match may be Dutch Roman (a Bitstream font). Exceptions can also be used to create special mappings should the user want to do so.

names. This allows accurate replacements should a document provide only the missing font's name or request a font without an embedded Panose number.

The Core Mapper Services represent the basic Panose services for selecting the closest visual match or enumerating fonts by visual distance from a target font. The mapper looks at several factors when mapping fonts. These include the following:

• The *match value* is the number returned by the font mapper to assess the visual similarity of two fonts. It is obtained by comparing each of the digits of the Panose number, multiplying each comparison by a weight, and adding them together. A small match value indicates a good match.
• The *threshold* is a number that indicates the highest acceptable match value. This is used as an optimization by the font mapper to abort the match process once it has determined that the match value will be beyond the threshold. If no fonts can be found with a match that's less than the threshold, the default font is used. The threshold can be relaxed so that the mapper computes the match value regardless of its size.
• *Penalty tables* contain the numbers that evaluate the closeness of two Panose digits. The tables can be thought of as 2-D arrays where the value from one digit indexes the row and the value from the other digit indexes the column. In reality, the mapper stores the tables in a compact form since, depending on the digit, there may be a great deal of repetition or a clear pattern in the penalty values. Each digit in a Panose number has one penalty table.
• *Mapper weights* are numbers that control the impact each penalty table value has on the match value. There is one weight for each digit. After the mapper computes the penalty value, it multiplies the result by the weight. All the weighted penalties are added together to yield the match value.
• *Cross-class mapping* makes it possible to use a Panose number from one classification system to select a font in a different classification. The current mapper supports cross-class mapping for Latin text to kanji text and vice versa.

The Panose number database contains over 2500 name-to-Panose number records for common TrueType, Type 1, Unix, and printer fonts. The database is included with the rest of the Panose mapper components and is redistributed to the end user. All the Panose mapper components contribute very little overhead to a Windows system, consuming only 238 KB of file space.

Overcoming the Limitations

Panose 1.0's bucketizing scheme keeps Panose numbers compact while providing enough information to find the closest match to a given font, but it does have some limitations. For instance, since the font mapper uses lookup tables to calculate the differences between two fonts, classifying a new family (e.g., kanji) under Panose 1.0 requires an updated table for all existing systems. In addition, a large number of font attributes don't fit neatly into buckets, especially with distortable font technologies such as

Panose Space Properties

1. **Each digit represents an axis; thus, Panose space can have up to *m* dimensions, where *m* is the maximum number of Panose digits.**
2. **A single static font is represented as a point in Panose space.**
3. **A distortable font is represented as a higher-order object, such as a line, polygon, or cube.**
4. **The distance between two fonts in Panose space measures the visual similarity between the fonts: The shorter the distance, the greater the similarity.**
5. **Panose space is extensible. In the rare circumstance that a font is created that does not exist in Panose space, new digits are used to account for it, thus widening the scope of Panose space to include the font.**

Apple's TrueType GX and Adobe Multiple Masters. Distortable type allows the user to modify a font's attributes (e.g., weight or width) to generate thousands of variations from a single master outline.

The revised Panose system, Panose 2.0, expands the 10 digits used in Panose 1.0 to define 36 font traits in 100 bytes of data. In addition, the classification scheme is more quantitative. For example, Panose 1.0 uses a single value for serif style; Panose 2.0 has individual measurements for serif width, height, tip size, tip roundness, angle, balance, foot pitch, and more.

Panose 2.0 numbers have an arithmetic relationship and can be viewed as axes of a coordinate system. In Panose 2.0 terminology, each Panose 2.0 digit is represented by an axis in Panose space. The value of a single Panose digit is represented by a point along the axis. The Panose match value is simply a weighted distance between two points (here, *weighted* means each axis can be scaled to place greater emphasis on the distance for that digit). In simple terms, the Panose match value (or *visual distance*) can be expressed using the standard Cartesian distance formula.

Given the Panose-space base properties, any font can be defined in terms of Panose space. This provides a comprehensive system for describing and comparing fonts. In the figure "A 2-D Panose 2.0 Space," the font that is closest to font A is font G, a single-axis distortable font (increasing the axis value for the font increases its contrast and weight). To find the closest match for a particular distortable font, Panose first locates the normal through the distortable font (line G in the figure) that passes through the requested font (point A in the figure). The distance along that normal is the match value between the two fonts. In addition, that point on the distortable font represents the instance of the font that you want to match.

A Panose 2.0 number contains sufficient information for converting from Panose space to the distortable font's space. Thus, once it finds the point nearest to the requested font, Panose can derive the appropriate settings for the distortable font technology to construct the font.

This highlights a fundamental difference between Panose 1.0 and 2.0. Panose 1.0 digits describe a font, but the logic for assessing the visual distance between two fonts resides in the mapping software. Panose 2.0 digits represent a font's position in a Panose space where, by definition, the distance between two fonts is their visual distance. Thus, the logic for assessing visual distance actually happens when the font is classified (i.e., when its position in Panose space is determined).

This means the Panose 2.0 mapping algorithm is very simple: Each digit is stored with an ID number, or *tagged digit*. The mapper lines up digits with the same ID value and executes the distance algorithm. This allows for a small, fast, scalable algorithm that never needs to be modified.

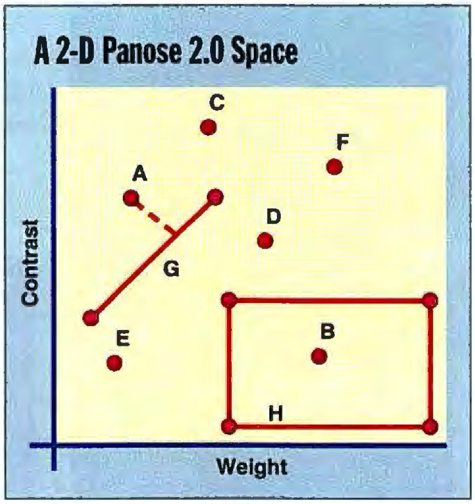
The Next Step

Since Panose can provide so much detail about a font, the next logical step is to use Panose numbers to synthesize fonts. ElseWare's Infinifont system, an extension of the Panose system, can do just that. For distortable font technologies such as TrueType GX and Multiple Masters, Panose can create many fonts from one master font. As with Panose 2.0, each of these master fonts can be represented by a shape (e.g., a line, square, or cube) in Panose 2.0 space.

Using the 36 Panose 2.0 digits, Infinifont can synthesize a font that captures the basic serif shape, stem shape, weight, contrast, and width. This provides enough data for Infinifont to recreate the approximate shape of the font, but the font would be somewhat homogenized and would lack the subtle intricacies that distinguish the best type designs.

To capture these intricacies, the Infinifont system accepts input from detail strings, which provide additional data for adjusting specific aspects of a font design. Infinifont supports global detail strings that adjust the characteristic of a font (e.g., the thickness of all uppercase diagonal stems) and local detail strings that adjust the individual aspects of a particular character (e.g., the distance by which a lowercase *j* extends below the baseline).

The small size of these descriptor files makes Infinifont very efficient. Because most TrueType fonts consume 30 to 70 KB of disk space, a library of 150 fonts could easily consume 7.5 MB; Infinifont can store the same library in roughly 500 KB. This makes Infinifont attractive for such system components as printers, personal digital assistants, operating systems, and software applications. ■



A 2-D Panose 2.0 space containing distortable fonts. Known Panose-classified fonts are represented as a single point in Panose 2.0 space (e.g., points A–F). Distortable fonts can be represented by a shape such as a line or a square (e.g., line G and square H).

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The Icon Programming Language

A new way to deal with strings and structures

RALPH E. GRISWOLD

Icon is a very high-level, general-purpose programming language with a strong emphasis on processing strings of characters and complicated structures. It was developed at the University of Arizona under the support of the National Science Foundation as a byproduct of research on high-level facilities for nonnumeric computation.

That description is accurate, but it doesn't really tell you what the language is like or why so many programmers love it. I'll explain these things and give some examples that convey the nature of the language.

An important issue in designing Icon was making programming easy, quick, and, we hoped, fun. The success of this design philosophy is illustrated by the fact that Icon programs are typically one-tenth to one-third the size of equivalent C programs and can be written correspondingly faster.

Programming tasks that require extensive manipulations of strings and structures are surprisingly common. Compilers, word processors, and databases are examples. Icon has been used for many things, including text formatting, natural-language processing, program generation, rapid prototyping, and AI. Because it's easy to program in Icon, programmers often use it for one-shot, throwaway applications. But this language is also popular for the most complex applications, including those of a speculative nature, where quick results and ease of modification are vital.

Icon started on Unix but is now available for many platforms, ranging from PCs to mainframes: the Amiga, the Atari ST, the Macintosh, MS-DOS, MVS, OS/2, many Unix systems, VAX, and VM/CMS. Implementations for Win32 and Windows NT are in progress. All implementations, including the source code, are in the public domain.

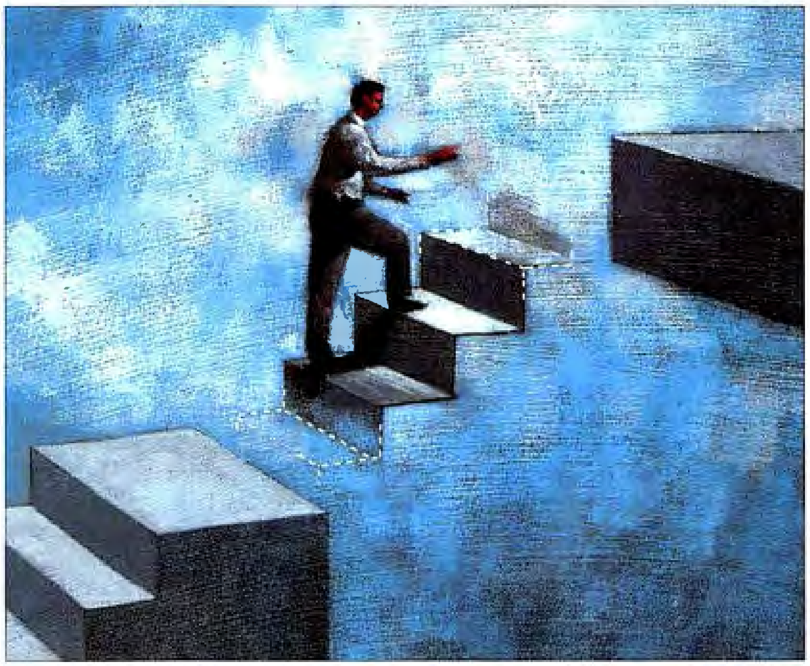
Major Features

Icon has many types of data to support a wide range of computational tasks. Integers, real (i.e., floating-point) numbers, and strings are familiar. In Icon, structures such as lists and tables with associative lookup are also data types. More on this later.

To make programming easier, Icon does not have type declarations. Type declarations make it easier to implement a language, but they often require tedious, verbose, and error-prone coding.

Although Icon lacks type declarations, it is a strongly typed language. During program execution, it checks types when necessary to ensure that they are correct. It also converts types automatically when necessary; for example, it converts numbers to strings for writing without any explicit action in the program. Similarly, in operations that expect a number, a string that looks like a number is automatically converted to a number. In other words, the implementation handles many matters that you have to explicitly program in most programming languages.

Like other powerful programming languages that date back to Lisp, Icon manages storage automatically. It creates objects as needed during program execution. Space



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for them is provided automatically, and unused space is garbage-collected when necessary. There also is no limit on the size of objects other than the amount of available memory. Some kinds of objects even grow and shrink automatically.

With an emphasis on processing strings and structures, you'd expect Icon to have a large repertoire of operations for dealing with such data. It does, but more important, it provides new ways of thinking about strings and structures that make programming easy and natural. For example, strings in Icon are true first-class values, not

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arrays of characters. A string-scanning facility supports sophisticated pattern matching without tedious bookkeeping. At the heart of Icon is goal-directed evaluation, which automatically searches among alternative results.

On the face of it, an Icon program looks a lot like a C or Pascal program. A program consists of a collection of procedures, and each procedure contains expressions that perform computations. Syntax clearly isn't everything, and as you get into programming in Icon, you'll see how its powerful semantics and automatic handling of details stand behind a familiar appearance.

> **Control structures use the success or failure of a computation initiated by an Icon expression instead of the somewhat formal notions of true and false. This idea alone makes Icon programs shorter and easier to write than those in most programming languages.**

It's time for a few simple examples. Here's about as simple a program as you'll find—a main procedure that writes out a greeting:

```
procedure main()
  write("Hello world")
end
```

Now suppose you have a file that contains a lot of numbers, one per line, and you want to know their sum:

```
procedure main()
  count := 0
  while count +:= read()
  write(count)
end
```

Each number that is read increments the count. Note that Icon automatically converts the values read from strings to numbers for addition, and it automatically converts the final number to a string for writing. The loop terminates when there is no more data to read. No test for an end-of-file is needed—`read()` simply fails at the end of data.

Expression Evaluation

Much lies behind expression evaluation. In the real world, we constantly try to do things that may or may not be possible, and sometimes our attempts fail. That's fundamental to expression evaluation in Icon. If a computation cannot be performed (which is different from an erroneous computation), the expression fails. Control structures use the success or failure of a computation initiated by an Icon expression instead of the somewhat formal notions of true and false. This idea alone makes Icon programs shorter and easier to write than those in most programming languages.

In the real world, there are often many ways of doing things—alternative courses of action. For example, you may have a choice of doors by which to leave a large store. The same situation occurs in many programming tasks. Suppose, for example, that you want to locate equal signs in a line of a program. There may be many equal signs. You may or may not want to know where the first one is. You may want to know where all of them are. In most programming languages, you have to pick your way through the line, keeping track of where you are, doing index arithmetic, and so forth.

In Icon, the computation is handled differently. A computation that has many alternatives *generates* those alternatives as needed. For example, `upto(s1, s2)` generates all the locations, from left to right, at which characters of `s1` occur in `s2`. If you only ask for one, you get the first, as in

```
first := upto("=", line)
```

which produces the location of the first equal sign in the line. If there is no equal sign, `upto()` fails, and no assignment is made. It's a good idea to check for this. If you want all locations, there is a control structure to do that:

```
every write(upto("=", line))
```

writes all the locations.

Sometimes a successful computation depends on a combination of things. For example, to find out if an equal sign occurs in a line at a location greater than 10, all that's needed is

```
if upto("=", line) > 10 then write("yes")
else write("no")
```

Here, the comparison operation keeps asking for locations until one is greater than 10. If there is one, `yes` is written. If there isn't, `no` is written.

The idea of generators opens up all kinds of possibilities. One useful generator is `i to j`, which generates the integers from `i` to `j` in sequence. With this, Icon doesn't need a `for` control structure. For example,

```
every step := 1 to 10 do
  p(step)
```

calls `p(1)`, `p(2)`,...`p(10)`. This can also be done more compactly with just

```
every p(1 to 10)
```

Alternation, denoted by a vertical bar, generates its arguments. For example, in

```
upto("=", line1 | line2)
```

the second argument of `upto()` is a generator, so the locations of equal signs first in `line1` and then in `line2` are generated. You can even write your own generators using procedures, so the possibilities are endless.

String Scanning

I'll shift gears now and look at string analysis. Scanning is based on the idea of a subject string that is the focus of the analysis. A cursor keeps track of the location of interest in the subject.

String scanning has the form `s ? expr`, where `s` is the subject of scanning and `expr` performs the scanning. The cursor starts at the beginning of the subject and can be moved by `move(i)`, which advances it `i` characters, and `tab(i)`, which sets it to the `i`th character. These functions fail and don't move the cursor if it is outside the range of the subject. As an example,

```
text ? while write(move(1))
```

continued

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writes the characters of `text`, one per line.

Much of the power of string scanning comes from using analysis functions like `upto()` to provide the argument to `tab()` and to move the cursor accordingly. Suppose, for example, that you are interested in the op codes that are used in an assembly language program. I'll assume a syntax in which op codes follow the first blank field of a line and are themselves followed by a blank field before their operands. Op codes can be found as follows:

```
ws := " \t"
line ? {
  tab(upto(ws))
  tab(many(ws))
  opcode := tab(upto(ws))
}
```

The string `ws` defines *white space*—blanks or tabs. Several expressions are needed for scanning, so they are enclosed in braces. The first expression locates the beginning of the first blank field. (In string scanning, analysis functions are applied to the subject and need no second argument.) The second expression skips over this field, using `many()`, which produces the location at the end of a sequence of characters. The op code is whatever follows until the next white-space character.

In practice, a little bit more is needed to skip comment lines, handle op codes without operands, and perhaps check for correct syntax. I've omitted these niceties here to avoid complicating the example, but you'll find them in the listing "Tabulating Op Codes."

You can use the scanning expression above in a number of ways, which suggests that you should encapsulate the code in a procedure:

```
procedure opcode(line)
  ws := " \t"
  line ? {
    tab(upto(ws))
    tab(many(ws))
    return tab(upto(ws))
    }
end
```

The argument is a line of code, and the value returned is the op code. For example, you could use this procedure to write out all the op codes:

```
while line := read() do
  write(opcode(line))
```

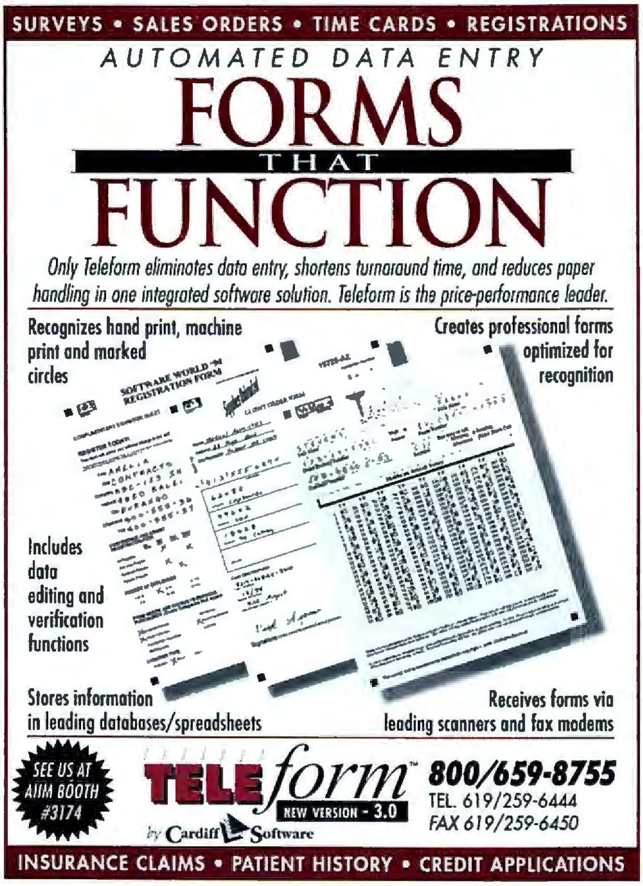
This is just one example of the endless possibilities of string scanning.

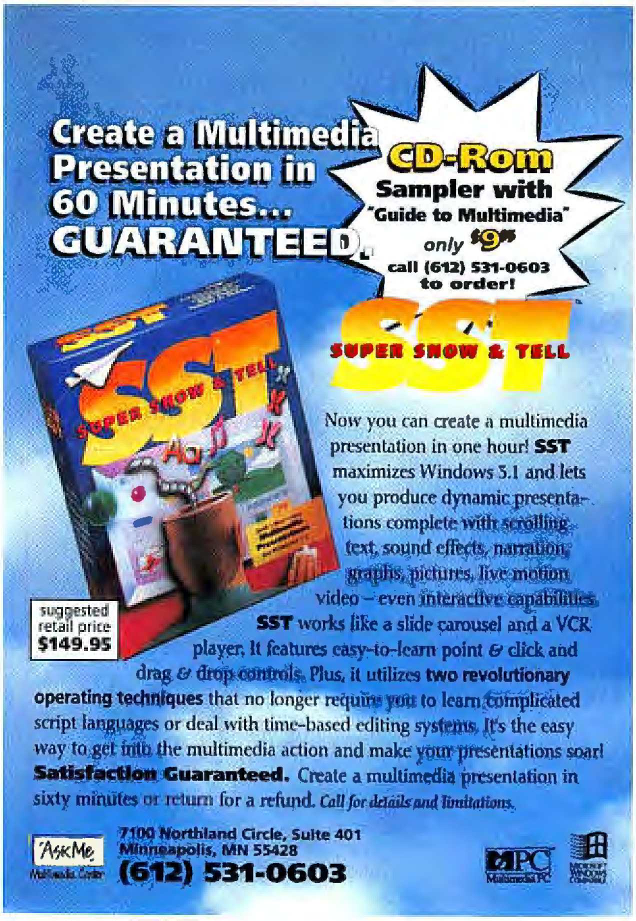
Structures

Except for the simplest file analysis and generation, string-processing tasks require structures to organize the data—lists of strings, symbol tables, and so on. Icon provides four kinds of built-in structures: records, lists, sets, and tables.

Records are similar to those in other programming languages, and I won't bother to describe them here. Lists in Icon can be used in two ways: as one-dimensional arrays subscripted by position, and as stacks and queues in which elements are added and removed at the ends.

continued





Hands On Some Assembly Required

Sets are collections of distinct values. You can add and remove members to and from sets and compute the union, intersection, and differences of sets.

Tables provide associative lookup; they are like lists, but they can be subscripted with any kind of value, not just integers. Table subscripts are called *keys*, and each key has a value associated with it. If a table is subscripted with a key that is not already in the table, a new table entry is added.

Structures themselves are data values. You can assign them to variables, pass them as arguments to procedures, and so on. All structures in Icon can be heterogeneous; that is, they can contain values of any type, and the same structure can contain values of different types. For example, a list can contain integers, strings, and even lists.

I'll continue with the example of extracting op codes from an assembly language file to illustrate how you can use some of Icon's structures. Writing out all the op codes as illustrated above might be useful in some situations, but it's usually more helpful to accumulate all the op codes and process them in some way. A list of op codes is a good place to start. It can be constructed as follows:

```
oplist := list(0)
while line := read() do
  put(oplist, opcode(line))
```

The first line assigns an empty list—a list with no elements—to `oplist`. In the loop, instead of writing out the op codes produced by `opcode()`, you can append them to `oplist` using one of Icon's functions that treat a list as a queue. The final result is a list of all op codes in order of appearance. Note that it is not necessary to know in advance how many op codes there are: Lists grow in size automatically, and there's no limit to their size except the amount of available memory.

You could use the list of op codes in many ways. To get a listing of the op codes, you could index through the list, writing each element:

```
every i := 1 to *oplist do
  write(oplist[i])
```

The expression `*oplist` gives the number of elements in the list.

There's a better way to do this. The expression `!X` generates all the elements of the structure `X`. For lists, it generates them from beginning to end. To write all the elements of `oplist`, all you need is the following:

```
every write(!oplist)
```

Suppose, now, that you want to know which op codes are used in the program. The complete list almost certainly contains duplicates—probably many. Finding the distinct op codes is a job for a computer, not a person.

Icon's sets make this easy. By definition, a value can be a member of a set only once. A simple change to the code above is all that's needed for writing the distinct op codes:

```
opset := set()
while line := read() do
  insert(opset, opcode(line))
every write(!opset)
```

continued

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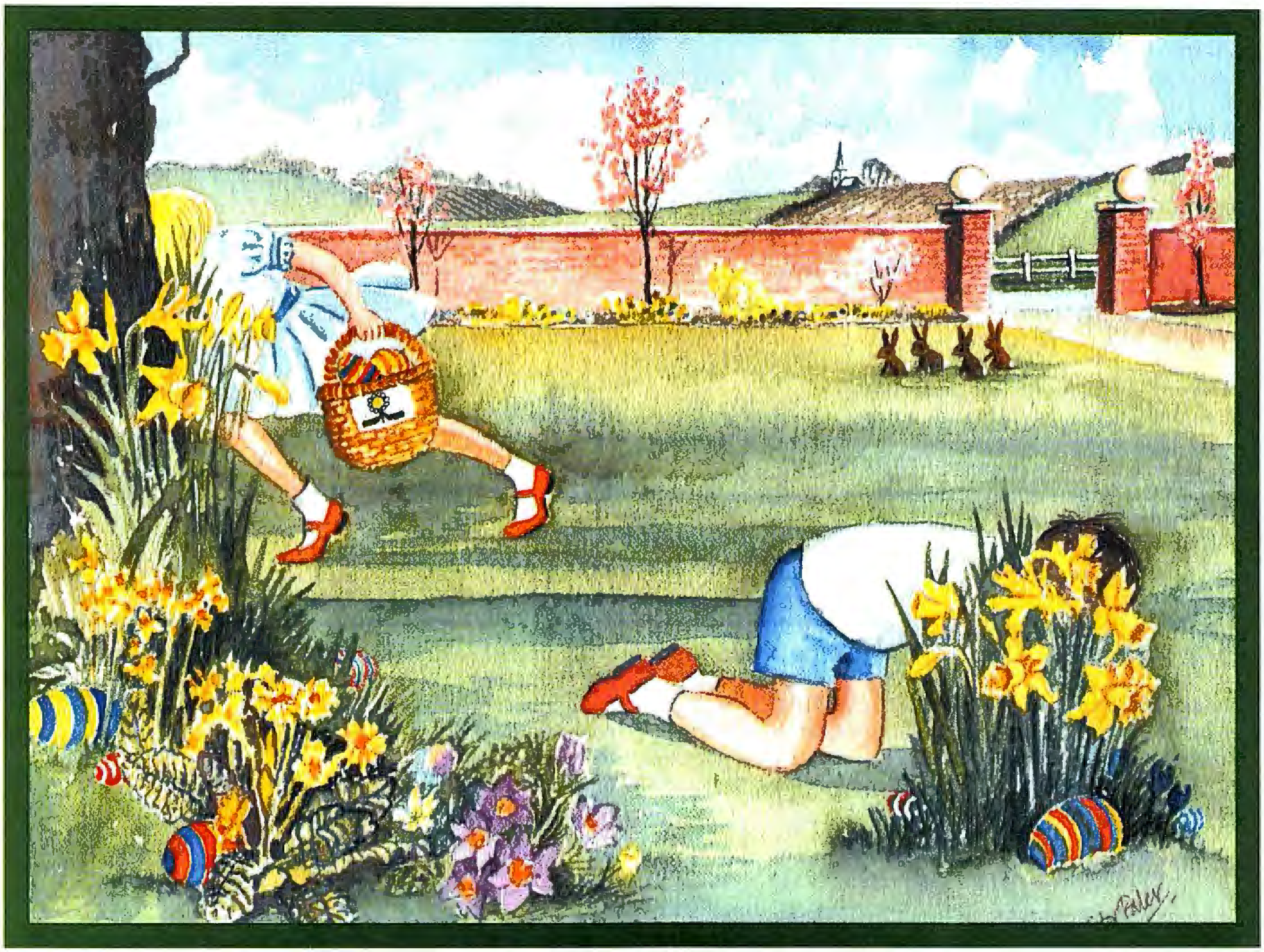

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Circle 199 on Inquiry Card.

The function `set()` creates an empty set. Insertion automatically checks for values already in the set and doesn't add them—something you'd have to program in most languages. Incidentally, Icon does this efficiently with dynamic hashing—not something you'd be likely to implement yourself.

Another thing needed to make the code really useful is *sorting*. All you need is an additional function in the last line:

```
every write(!sort(opset))
```

Having gotten this far, you can do one more thing that might be useful in the analysis of op-code usage: Count the number of occurrences of each one. Here is where Icon's table data type comes in:

```
optab := table(0)
while line := read() do
  optab[opcode(line)] +:= 1
oplist := sort(optab, 3)
while write(get(oplist), " : ", get(oplist))
```

The first line assigns an empty table to `optab`. The `0` is not the size of the table, but rather the initial value used for all entries in it.

Each value that `opcode()` produces is used as a key to subscript the table. For example, if `opcode()` returns `"mov"`, the subscripting expression is equivalent to

```
optab["mov"] +:= 1
```

which increments the entry for `"mov"` by 1. The first time `optab` is subscripted with this key, a new entry is created with an initial value of 0, increasing the table size. This new value is then incremented to 1.

The expression `sort(optab, 3)` sorts the table, producing a list in which there are two elements for each table entry: one for the key, and another for the value associated with the key. The value `3` sorts the table according to the key so that the op codes are in alphabetical order. The last line writes out the keys and their associated values with a separating colon. The function `get()` removes the first (i.e., left-most) element of the list—first a key and then its associated value. Note that `write()` has three arguments, which are written in order on a line.

Tabulating Op Codes

```
procedure main()
  # Table for the opcodes
  optab := table(0)
  # Process the input, counting the opcodes
  while line := read() do
    optab[opcode(line)] +:= 1
  oplist := sort(optab, 3)

  # Write out the results in columns
  write("Opcode tabulation:")
  write()
  while write(left(get(oplist), 6), right(get(oplist), 6))
end

procedure opcode(line)
  ws := " \t"                       # White-space characters
# Analyze the line
  line ? {
    if any(";") then fail           # Skip comment lines
    if tab(upto(ws)) &              # Find blank field
      tab(many(ws)) &               # Skip blank field
      code := tab(upto(ws) | 0)     # To blank or end of line
    then return code
    else fail
    }
end
```

Program Output

```
Opcode tabulation:

call      2
cmp       1
db        1
dd        3
dw        8
jnz       1
les       3
mov      22
pop       1
push      6
ret       2
xor       3
```

A complete program to tabulate op codes is shown in the listing "Tabulating Op Codes." In addition to the improvements on string scanning mentioned earlier, the output is formatted in columns, as shown in the sample output.

Other Features

Icon has a large repertoire of functions. It's not just a language for processing strings and structures. You can do numerical computation if you want. It also has a number of sophisticated features, including an expression-level coroutine facility, that I don't have room to describe here.

Recently, contributors at the University of Arizona have added high-level facilities for graphics and window operations to Icon; these facilities are comparable in power to Icon's repertoire for processing strings and structures. But that's a whole other story. ■

Editor's note: *The source code for OPCODES is available electronically.* *See page 5 for details.*

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What's Available and Where

There is both an interpreter and an optimizing compiler for Icon. The interpreter gets into execution quickly and is best for program development. Interpreted code runs fast enough for most applications. A 32-bit C compiler can be used for applications where you need the fastest possible execution time. There is also a large library of programs and procedures that is an excellent resource for persons new to Icon as well as for experienced Icon programmers.

The main documentation for Icon is *The Icon Programming Language* (Griswold and Griswold, Prentice-Hall, 1990, ISBN 0-13-447889-4). There is also a book on the implementation: *The Implementation of the Icon Programming Language* (Griswold and Griswold, Princeton University Press, 1986, ISBN 0-691-08431-9). Technical reports provide supplementary documentation. A free newsletter about Icon is published three times a year and is available from the Icon project.

Implementations, the program library, and supplementary documentation are available by anonymous FTP to cs.arizona.edu; cd /icon and get READ.ME for navigation instructions.

The Internet newsgroup comp.lang.icon provides a forum for discussion about Icon. BIX also has a conference on Icon, named Icon. It contains the current version of the most popular PC implementations of Icon and provides gateways to comp.lang.icon and the Arizona FTP site.

To subscribe to the newsletter, order books, get program material on magnetic media, or just find out more about Icon, contact

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IPX and NetBIOS for OS/2

Programming IPX and NetBIOS is easier than you think

BARRY NANCE

If your organization is like the one I work in, in the past two years you've grown to have a mixture of DOS, DOS-and-Windows, and OS/2 machines in your office. Your file servers probably run Novell NetWare, IBM OS/2 LAN Server, or a combination of the two. I've found that writing software for such an organization can be interesting, to say the least.

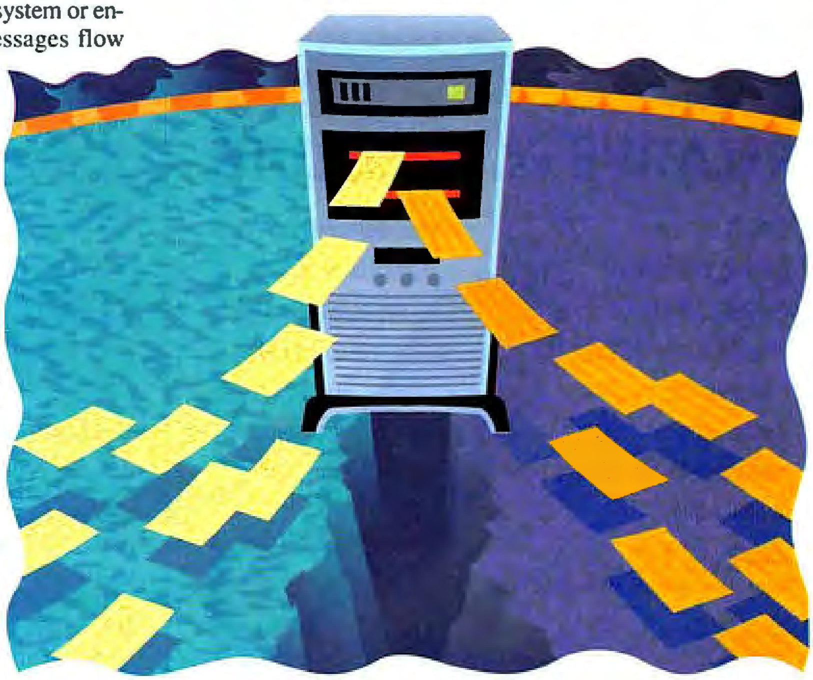
When my team recently developed a SQL Server–based application that everyone on the LAN could access, I wrote the over-the-wire message-passing software for each of the three platforms. I also wrote the code that, through SQL Server's 16-bit programming interface, delivered SQL statements to the database manager and sent responses back to each workstation.

In a heterogeneous LAN environment, message packets don't carry an identifier of the operating system or environment running on each computer. Messages flow through the wire from PC to PC (most often from workstation to file server and back—the vast majority of LAN messages are file-server packets), and it's up to the sender and receiver to agree on the content and purpose of each message.

If you transmit a message packet from a computer that uses the EBCDIC character set, an ASCII-based receiver will have to translate the textual portions of the message from EBCDIC to ASCII. For nontext (i.e., binary) data fields, some computers store low-order bytes first, and some computers store high-order bytes first.

However, between computers that use the same character set and store binary data in the same format (e.g., DOS, DOS-and-Windows, and OS/2 on an Intel CPU), you can send and receive message packets without worrying about the operating systems the sender and receiver are using. The programming interface is the only difference from platform to platform. In a DOS environment, you invoke Interrupt 5Ch to access NetBIOS or Interrupt 7Ah to access IPX.

From within an OS/2 program, you call functions in a DLL, which comes with the requester (i.e., LAN Server or NetWare) that allows the workstation to access the file server. The NetBIOS function you'll use most often is `NetBiosSubmit()`. One of the data items in the NCB (Network Control Block) indicates which operation that NCB should perform. While NetBIOS uses NCBs, IPX uses ECBs (Event Control Blocks). NCBs and ECBs are data structures containing information about the message packet that you want to send (or that you expect to receive), including the address and length of the message buffer. IPX has separate functions for different operations: `OpenSocket()`, `CloseSocket()`, `IpxReceive()`, and `IpxSend()`.



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Requests and Responses

For the new application my team created, SQL Server runs on an OS/2 2.1 PC. Workstations might run OS/2, DOS, or Windows. The workstation software, written by the other team members, calls a low-level client module when the application needs to access the database. The client module transmits the request over the wire to the database-server PC.

At the database server, several operations take place. A computer program receives the request, delivers the SQL to SQL Server, binds the result to a data item in the program, and transmits the data item in a message packet back to the client workstation. The program in the database server, running concurrently alongside and interfacing with SQL Server, launches a different thread to handle each request.

As is true for most—if not all—relational DBMSes, SQL Server includes multiplatform *enablers* that the team could have used to make the workstation-to-server communications link. The SQL Server enabler is a DOS TSR program, called DBNMPIPE, which implements named pipes over NetBIOS. The enabler does essentially what my program modules do—redirect SQL statements across the LAN.

But the team wanted snappier performance than the enabler, based on named pipes, would provide. The team wanted the client software to take as little memory on DOS machines as possible. And the team wanted an over-the-wire delivery system for SQL statements that would work equally well through either NetBIOS or IPX.

Talking with NetBIOS and IPX

This last criterion became important when a second group of people, on a separate LAN, wanted to use the application. While the first group used NetBIOS to access LAN Server file servers, the second group used IPX to access NetWare servers. The second group also strongly resisted adding Novell's NetBIOS emulator on top of the IPX protocol stack they already had in place.

Replacing the NetBIOS calls with IPX calls was almost a one-for-one process. The changes to the low-level code were simple. The programming techniques for NetBIOS datagrams and IPX datagrams are similar, making it easy to send and receive over-the-wire messages in OS/2 programs using either protocol.

With the NetBIOS interface, the sender and receiver add their respective names to the NetBIOS name table using the NB_ADD_NAME_WAIT command. The name you arbitrarily choose to give each workstation can have a length of up to 15 printable characters. NetBIOS returns a name number to each participant in the NetBIOS dialogue.

The name number is a reference point for both sides as the receiver issues NB_RECEIVE_DATAGRAM_WAIT commands and the sender issues NB_SEND_DATAGRAM_WAIT commands. Both sides can send and receive messages; you decide how the dialogue between the participants flows. At the end of the dialogue, both sides delete their names from the NetBIOS name table.

The IPX programming interface parallels that of NetBIOS for sending and receiving datagrams. Both sides open a socket at the beginning of the conversation between the workstations. At the end, both sides close their respective sockets. Through an open socket, one side or the other can send or receive message packets with their respective program statements.

Message Passing

The IBM and Novell technical references provide more detail on the NetBIOS and IPX programming interfaces. That detail, however, is easy to understand if you have a basic understanding of the functions you use to send and receive message packets. One of the few difficulties you might run into involves pointers (i.e., addresses) that you pass to the NetBIOS and IPX DLLs. NETBIOS.OS2 and IPXCALLS.DLL are 16-bit DLLs that expect 16-bit pointers. The following prototype shows one way to tell the IBM C/C++ tools compiler to emit the proper 16-bit code for the `NetBiosSubmit()` function:

```
extern unsigned short NetBiosSubmit(short, short,
void *);
#pragma linkage (NetBiosSubmit, far16 pascal)
```

To take advantage of the parallelism between NetBIOS and IPX datagrams, I built two DLLs. I used the same name (NBIPX.DLL) for each DLL file and the same function names within each DLL

(`OpenLAN()`, `CloseLAN()`, `SendMsg()`, and `ReceiveMsg()`). In one DLL, I coded to the NetBIOS interface. In the other one, I coded to the IPX interface.

The main program insulated itself from NetBIOS and IPX by invoking the functions in the NBIPX DLL. This meant that, on a given LAN, I didn't have to distribute a different executable file for NetBIOS and IPX. I could simply install either the NetBIOS or IPX version of NBIPX, depending on which protocol that particular LAN uses. The main program is the same for both protocols. For my specific application, I achieved the same level of generality that named pipes would have offered, without sacrificing the performance and memory usage that several layers of Novell or IBM system software would have cost me.

Hidden Awareness

I managed to hide the differences between the NetBIOS and IPX APIs from my program, but I had to be constantly aware of the limitations that using datagrams imposes. The transport protocol does not guarantee the delivery of datagrams (datagrams are *connectionless*), which meant that each message packet had to contain a sequence number. The receiver verifies each packet to ensure that no packets in a logical group of packets are dropped.

I also designed the dialogue to allow the client workstation to expect an acknowledgment for each work request packet sent to the database server. The workstation reissues a request if it doesn't get a response within a short time. I used staggered retry intervals of ½ second, 1 second, 5 seconds, and 20 seconds.

Finally, I designed the format of each packet to not exceed the size limitation of datagrams. NetBIOS datagrams can be up to 512 bytes, while IPX packets can be up to 546 bytes. Stepping up from datagrams to a connection-oriented protocol, unfortunately, wasn't a solution to the small-packet problem.

NetBIOS session services, which are connection-oriented and offer guaranteed delivery, can send and receive 64 KB at a time and aren't difficult to use. But Novell's session services, provided by the SPX protocol, can send and receive only 534 bytes at a time. (IPX and SPX can sometimes use larger packets, up to 4202 bytes, depending on the brand of network adapter and software driver in a PC. But Novell's software development kits for both DOS and OS/2 recommend sticking to the lower size limit.)

Nothing to Fear

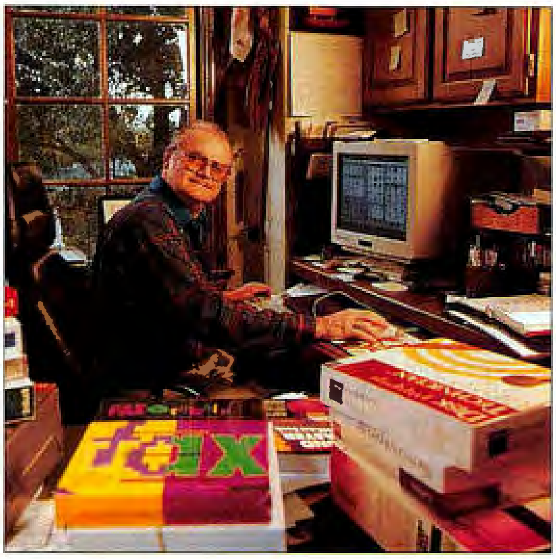
Using either NetBIOS or IPX in an OS/2 environment is easier than you might think. Both protocols are especially good at letting workstations send work requests to software running on unattended PCs on the LAN. Sharing files on a file server, through the file-redirection functions inherent in the network operating system, is sometimes the wrong way to design a LAN-aware application, particularly if the application uses the file server to store queues of work requests.

Named pipes are easy to use, of course, but the extra layers of system software may slow down your application. Going to the "bare metal" of NetBIOS or IPX will give you better performance and a new perspective on how LANs work. With a little extra effort, you can even insulate your program from the differences between NetBIOS and IPX. ■

Barry Nance, a BYTE contributing editor and a programmer for the past 20 years, is the author of Using OS/2 2.1 *(Que, 1993),* Introduction to Networking *(Que, 1992), and* Network Programming in C *(Que, 1990). He is the exchange editor for the IBM Exchange on BIX. He can be reached on the Internet or BIX at barryn@bix.com.*

JERRY POURNELLE

Crash, Bang—Quake



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Orchids and Onions issue forth despite an earthquake, operating-system wars, and a Flying Windows ordeal

I had been working late on part 2 of my User's Choice Awards and got to bed about 3:15 a.m. At 4:31 the earthquake hit Chaos Manor. We knew it was bad because it went on and on, and we could hear things crashing all over the house. Eventually it stopped, and we could escape from the bedroom by clambering over the bookcases that had torn loose and fallen.

We determined that no one in the house was injured, so I went upstairs to the office. When I got to the head of the stairs, I could go no farther. The Great Hall is 30 feet high, with built-in bookcases extending up 12 feet. Many of those had torn loose, and all of them had shed their books. Way over at the far side of the room, I could see that Percy, the IBM PS/2 Model 77, was running off the Best Patriot UPS (uninterruptible power supply), but there was no way I could get to it. I could see that both the Cheetah 486/25 and SuperCow, the Gateway 2000 486/66, had fallen over, or at least their monitors had.

I could also see that the tropical fish tank had fallen in shards, making a horrible "soup" of books, splinters, fallen plaster, hardware, software, disks, cables, unanswered mail, dead fish, and everything that had been on the ready-line tables. It was impossible to get to the other machines, although I was pretty sure they were still turned on because I could hear the Clary UPS screaming its "Power Is Off" warning. It would just have to wait until the morning.

Alex and I got out the tools and flashlights and did a quick inspection. Three feet of the back chimney had fallen into the pool—right through the pool cover. The front chimney had new cracks. Amazingly, all the brick facing was intact. We'll need some repairs, but the outside of Chaos Manor wasn't badly hurt.

Alex and I then went around the block checking on neighbors. Everyone was outside despite the cold. We noted things like down power lines, fallen transformers, and burst water mains, which we reported as soon as telephone service came back.

I don't suppose the Los Angeles Department of Water and Power collects these things, but I've got a big Chaos Manor Orchid for them. Within hours, they had patched all the water lines, got a new transformer up on the pole, and strapped the dead one so it was harmless; and well before dark, we had both power and water. Thanks, fellows.

Amazingly, we lost very little. The important computers all work. SuperCow's NEC MultiSync 4FG monitor fell onto a pile of wet books. Part of the built-in swivel base broke, so it now rests on a wok stove ring; otherwise, SuperCow was undamaged. Big Cheetah fell over still running, and the Nanao FlexScan T560i monitor fell on top of it. Neither one seems damaged. The cat ran away and was gone for three days, but she came back dirty and hungry and now angrily ignores the aftershocks. The dog stays close to humans and seems to know when new shakes are coming.

I brought in some help from the Los Angeles Science Fantasy Society to box everything, so that I could get into the office quickly and rebuild. My particular thanks go out to LASFS Vice President Bob Null and Librarian Leigh

Strother-Vien for their assistance.

Although there was a lot of destruction, nothing irreplaceable was ruined. A great deal of software was part of the soup and has gone away, as have a number of CD-ROM drives, boards, modems, some gadgets, and countless disks. A lot of books were ruined, but not one rare edition. The Falcon I was awarded by the U.S. Air Force Academy has been shattered, but I still have the base with the plaque. We did lose some Venetian glass, including a decanter of 70-year-old port, but the Apollo commemorative glasses Mrs. Heinlein gave me from Robert's collection were untouched.

Chaos Manor went from its usual mild but chronic chaos to an acute state, but we've pretty much returned to normal. The truly amazing part is that despite all the stuff that was destroyed, there's *still* more to write about than I'll ever get to.

IBM showed up a week later. Dave Whittle had made an appointment weeks before. He brought with him an IBM PS ValuePoint Pentium, alas incomplete; a full report on the machine another time. He also brought Charlie Brown, an OS/2 LAN Server 3.0 Advanced guru. They got here after the worst was cleaned up, but there was still plenty of damage control going on while they set up the system.

The first thing was to install network cards in both the Pentium (which we have named Ozzie) and Percy. I have always named my machines and some of you have laughed at me, but now the network software demands it. Anyway, we had an IBM Ethernet card for the Pentium; but, alas, there wasn't one for the Micro Channel PS/2. We called a number of electronics stores: no one stocked either IBM or 3Com Micro Channel Ethernet cards. We did find a Danpex EN/2, which is compatible with NE 2/T (Novell), so Alex went right out and bought that.

Unfortunately, while the card would work with NE 2/T, there is no OS/2 driver for it, as we found out after making a number of phone calls and BBS downloads. (The IBM OS/2 BBS at (919) 517-0001 is a great source of such information, and I should have consulted it before getting the board.) We returned the EN/2 and ordered a 3Com EtherLink III board. It works just fine, but we didn't have it while the IBM team was here.

Of course, our mission wasn't to demonstrate that two OS/2 machines can talk to each other, but to get an OS/2 machine networked with Windows for Workgroups systems. I'd intended to use an Intel EtherExpress card in the Pentium, because that's what I have in all my other machines, and under Windows, the EtherExpress card really is "plug and play"; but the IBM team wasn't sure there was an IBM-certified driver for that. I fear I was rather rudely sarcastic about that. Anyway, by sheer accident we did have an ISA-bus genuine IBM Ethernet card, and while getting that running under OS/2 wasn't *quite* as simple as installing an EtherExpress card in W4WG, it was easy enough. (As it happens, the EtherExpress card would have worked as well.)

Then the fun began. First, open up the OS/2 LAN Server network and look at what assets are available. Not many. That turns out to be my fault, sort of; that is, the name of my workgroup is JERRY ONE (note the space), and the name of my Cheetah 486/33 is BIG CHEETAH 486. The Cheetah 386 is, of course, CHEETAH 386, and the 486/25 is CHEETAH 486/25.

continued

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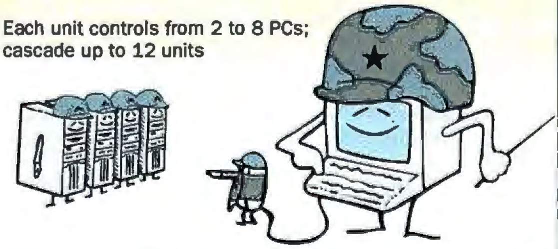

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Circle 81 on Inquiry Card (RESELLERS: 82).

Those are all legal names to W4WG, but not to OS/2 LAN Server.

Fortunately, there is a workaround: open an OS/2 window and issue commands. NET VIEW "\\BIG CHEETAH 486" (the quotation marks are part of the command) gets the name of all available assets on Big Cheetah, including the fact that the C drive there is named BIG C. Then: NET USE G: "\\BIG CHEETAH 486\BIG C" (once again, the quotation marks are part of the command) connects the OS/2 machine to the W4WG network, so that local G is the C drive on Big Cheetah.

IBM OS/2 LAN Server 3.0 Advanced has a GUI that works well with other OS/2 machines. It supports drag and drop, and all that sort of thing; but if you try to invoke it for W4WG connections, you get an error message. OS/2 systems work with 32-bit operations, and W4WG can't support those. [Editor's note: *Windows for Workgroups 3.11 does support 32-bit file access.*] You may now decide just whose fault that is: Microsoft, for not supporting full 32-bit network standards, or IBM, for not making provisions to dumb down its network requests so they'll work with W4WG.

Fortunately, Norton Commander, which is plenty good enough as a file manager, works just fine across the network. Launch Commander for DOS, log on to the foreign drive (G in this example), and Bob's your uncle. You can copy, delete, view, and edit files; cut and paste from Word for Windows documents; run programs; and so forth across the network just fine. Commander isn't quite drag and drop, but to me it's intuitive enough. It's quick, too.

Once you figure out how to set up the network connections from the command line, you can write a .CMD file (similar to a DOS batch file) that will do all that for you, on start-up if you like, and let Commander take care of the rest.

The next thing to try was printing. My Hewlett-Packard LaserJet III is physically connected to the Cheetah 486DX2/33. We had no trouble seeing the printer across the network, and not much more connecting the OS/2 machine to it; and when we sent a file across, the printer lit up. Alas, what came out was garbage. The IBM team spent a couple of hours trying to fix that, but they never did, and I have yet to print a file sent from an OS/2 machine to a W4WG machine.

It does work the other way; that is, once you get a W4WG machine to connect to an OS/2 machine that has a printer, you can print easily enough. I'll get to how in a moment. First, you need to connect your W4WG machine to the OS/2 LAN Server 3.0 Advanced network.

Go to the W4WG system, open File Manager, and click on the little share directories button to open a window called Connect Network Drive. When you do that, you will not see any OS/2 systems at all; but if you go to the area entitled PATH and type in \\PERCY (or whatever name you have given your OS/2 machine), the connection will be established and the networkable assets on the machine will appear. You can connect them to a physical-drive letter in the same point-and-click way you make any W4WG connection.

Unfortunately, you're still not done: while you have access to the OS/2 machine's drive, you can't see any files on it. This is because OS/2 LAN Server 3.0 Advanced has rather sophisticated security provisions, and they have to be turned off before an outsider can tamper with your files. You do that by going back to the OS/2 system, opening the Net Configuration icon, and making account GUEST an administrator account. Guest is the default

name for an outsider. Once that's done, you can access the OS/2 machine from W4WG.

Now you can connect the printer. Leave File Manager and go to W4WG's Print Manager. Do the PATH trick, and you'll see the OS/2 printer. Select it, leave Print Manager, and go to the Control Panel. Open the Printers icon there and assign your OS/2 printer; in my case, I called it LPT2. It's tedious but simple, and when you're done, you can print just fine.

OS/2 LAN Server 3.0 Advanced is considerably more complex than W4WG. In general, it's more powerful, but there are maddening anomalies. If you want your W4WG systems to see all the assets available on the OS/2 network, you have two choices: do as I described above, typing in the name of the OS/2 machine in the PATH area in the Connect Network Drive box; or, seeing that your workgroup name is the same as the name of the domain you have set up on the OS/2 LAN Server. Alas, OS/2 LAN Server requires that both machine and domain names be no more than eight letters and contain no spaces. W4WG workgroup names don't have that limit. The GUI part of OS/2 LAN Server isn't as consistent as W4WG's interface.

First conclusion: it works, provided that you have the right equipment. Remember, it *is* OS/2, meaning that while there's a lot of hardware it works with, there's a lot more it can't use: recall my first attempt to find an OS/2-compatible Ethernet board on short notice. OS/2 LAN Server 3.0 Advanced is harder to set up or reconfigure, but it has considerably more security and power than W4WG. In fact, it's a real network, comparable to NetWare in capabilities, reliability, and difficulty in using.

It's an expensive way to go if you're networking only a couple of machines, but the cost per workstation goes down dramatically as you add to the system. If you need to network OS/2, DOS, and W4WG workstations, it will do the job, and if you have many OS/2 systems to network, it's clearly a good choice.

Which brings us to the real question: should you change to OS/2? I have no final answer, but I do have guidelines. If you run mostly DOS programs, OS/2 remains a better DOS than DOS, and a lot better DOS than Windows. It's still not a better Windows than Windows, but if you have good enough hardware, that may not matter. We installed a SoundBlaster Pro 16 board in the Pentium and ran Wing Commander. Even with a lot of other stuff, including the network, running in the background, it ran absurdly (and unplayably) fast, faster than under DOS with a 486DX2/33.

Moreover, when we ran the Texas Instruments Windows benchmark utility Win Tachometer on the Pentium (which has the latest ATI Technologies Mach 32 video board with OS/2 drivers), it pegged the meter. That is, we could *see* that it was very fast, but Win Tachometer reported unrealistically low numbers—11.3 overall. My guess is that we should add 64 to that total.

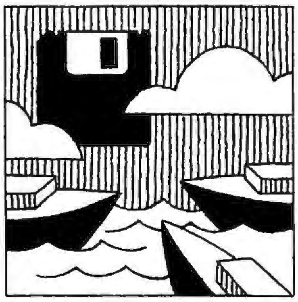
Incidentally, the reason Win Tachometer wouldn't run earlier (see my March column) is that the Win-OS/2 default for program installation is to have it run in a windowed session; you must go into the settings and tell it to run Win Tachometer in a full Win-OS/2 window or it will crash. Maybe that's not so incidental: if you hate having to learn little arcana like

that, you probably won't like OS/2. This is a system that gives you a great deal of control over things, but it demands that you learn how to use it properly—and comes with some singularly ill-chosen defaults.

If you do become an OS/2 enthusiast, be prepared to get on-line to BIX or GEnie and spend some time learning these tricks and more. The good news is that OS/2 users are like early computer enthusiasts (or BYTE readers, for that matter): proud of their system and willing to go out of their way to help newcomers.

And that, I guess, is the real bottom line. OS/2 will do all that DOS and Windows will do and more. Many DOS games won't run in Windows but give OS/2 no trouble at all. OS/2 networks extremely well to other OS/2 systems and acceptably well to W4WG. It's true 32-bit code, it truly does multitasking, it really knows objects and object linking in ways Microsoft doesn't seem to have learned, and as long as you're not experimenting to find the limits, it's solid as a rock. Technically, OS/2 is a winner, and it's sure to get better.

On the other hand, the user interface seems to have been an afterthought, and changes have to be cleared by a committee within the most hierarchical top-down company I know of. Moreover, its success depends on IBM learning how to do mass marketing. The OS/2 2.0 and 2.1 marketing strategy was definitely a step in the right direction. That strategy was designed by two very bright people, but both of them are gone: Lucy Baney is not with IBM at all, and John Patrick has been promoted out of OS/2.



Microsoft is a big company, but Bill Gates gives his managers a lot of authority. Big ships like IBM turn slowly; Microsoft is more like a fleet of medium-size ships—some elements turn quite quickly. Moreover, PC operating systems are Microsoft's heart of hearts, the flagship product of a company built on software sales; OS/2 must compete with many other products within IBM. Microsoft will always give DOS and its follow-ons high priority and a great deal of top management attention. OS/2's priority depends on how skillfully its product managers play corporate power games.

There's a lot at stake for developers, who have to decide where to allocate their resources. Do they go into Windows products, where the market is larger and likely to stay that way for a while, but where they may have to compete head-on with the Microsoft Applications Group; or into OS/2, which at the moment has a distinct technical edge and needs applications badly. I'm glad I don't have to make that choice.

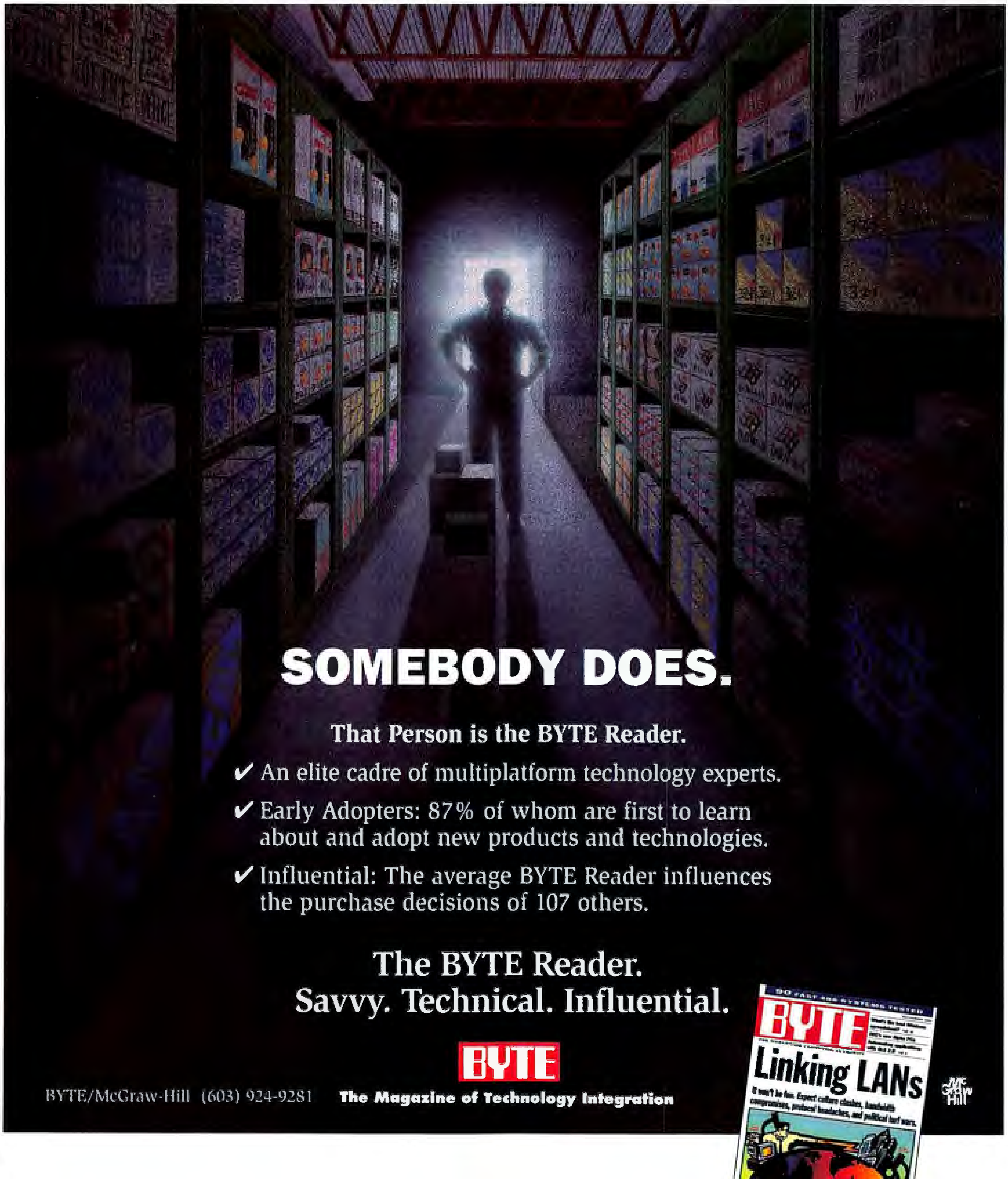
It's easier for users. OS/2, particularly OS/2 for Windows, is cheap enough that you can afford to try it. Many BYTE readers will love it; every time I get infuriated with OS/2, I find some new feature that I just love. It is powerful, and it really does multitasking.

On the other hand, you should prepare to be infuriated: while OS/2 is technically complete, the user interface has lots of "gotchas." The defaults seem to have been chosen at random by an unlucky gambler. If you've been in the PC world very long, you probably own hardware that OS/2 doesn't support.

continued

Next Year, Over 130 Million Software Packages Will Arrive in Corporations Worldwide.

SOMEBODY BETTER KNOW WHAT THEY'RE DOING.



Pournelle

Andy Seybold and other industry analysts have pronounced the operating-system wars over, with Microsoft the winner. I'm not so sure. I think IBM has a window of opportunity for about one year. It won't be easy to take advantage of it, because it's not clear that IBM's top management knows what they must do.

First, they must get OS/2 finished; they've pretty well done that. Technically, OS/2 2.1 is a superior product. Second, make it easy to go from Windows to OS/2. They took a big step in that direction with OS/2 for Windows, and if they'll get OS/2 LAN Server out at a low-enough street price, they'll have finished that job; OS/2 LAN Server is neat. Third, make the user interface more friendly. That's not hard.

Finally, they need some luck, because most people aren't going to change operating systems just for a lark. There has to be something you can do with OS/2 that you can't do with Windows. I'm not real sure what that will be, but as a guess it will involve multimedia. Whether it's written by IBM or a third party, they need that killer application, and they need it soon.

Me, I'll stay with OS/2 for a while; but I'm still writing this on Big Cheetah running DOS 5 and W4WG. I may change that. When I do, I'll let you know.

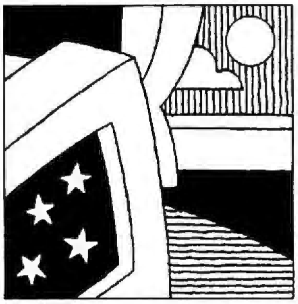
Two bug reports, both concerning W4WG. First, the problem with the Maximum Storage Duette optical drive was not W4WG, but the Maxsys SCSI driver. If you run the Duette with a Corel driver, the problem goes away. Moreover, I cured the problem we had with the Pioneer read/write optical drive by switching to version 3.11 on all W4WG machines.

Second, a rare but infuriating bug in both W4WG 3.1 and 3.11. How we found it is instructive.

The earthquake put me way behind on fiction, so I didn't cancel the afternoon writing session with Larry Niven when Whittle showed up by appointment in the morning to install OS/2 LAN Server. As it happens, the Cheetah 486DX2/25 that he usually works with was the most convenient machine for the IBM team to link up with for their network tests. That should have been no problem: but suddenly—and without explanation—Larry's machine popped up a blank-error dialog box and completely locked up. Fortunately, we had lost little text, but this was definitely not good. Moreover, it appeared that the only thing that had changed was that the IBM OS/2 LAN had logged on to that Cheetah.

I disconnected the Ethernet T connector. We worked until dinner with no problems. Everyone went home. I reconnected the

Ethernet and did some file transfers from that machine to the OS/2 network. Nothing happened. I left the machine with Norton Commander in the foreground and went to bed. The next morning everything was fine: Commander had brought up its "twinkling stars" screen saver. The system was operating perfectly.



Then I switched to Program Manager and left that on-screen while I did some more network tests. Within 5 minutes, the machine was locked up tight. This time, the dialog box wasn't *quite* blank: it said "Application Err." Nothing worked, and I had to do hardware reset to recover. Test again: log on to the machine from the OS/2 system, leave Program Manager up, wait. Crash in 2 minutes, dialog box totally blank, hardware reset. Do the same thing again, but disconnect the Ethernet T connector. Wait an hour. No crash. Connect the Ethernet. Crash in 5 minutes.

It has to be the OS/2 network, right? I called the IBM people. They reasonably asked, why didn't it crash any other machine? Clearly, this ancient Cheetah has a BIOS problem. "Let us send you a new motherboard. Install that, and I guarantee you won't have that problem."

So, what the heck, I did. Alex bought 16 MB of new memory chips. It took about 2 hours to change motherboards, and it really wasn't hard to do. The new board has VL-Bus slots, which the Cheetah doesn't have, and an updated AMI BIOS. When I got the board fastened down, I carefully removed the Intel OverDrive chip from the Cheetah and installed it on the new motherboard. Plug in the power lead. Turn it on. Everything works. Do some tests, and discover that this is about 10 percent *slower* than the Cheetah had been. Connect the Ethernet, log on to the system, wait—and it crashed within 5 minutes.

This is getting annoying. What's different about this machine from other systems that are *not* being crashed by the OS/2 network? Well, surprise: it's running W4WG 3.1, not 3.11. OK, install version 3.11 from floppy disks. Test that. Crash again.

Time to apply logic. Had we ever had problems with this machine locking up? Well, yes, there had been a couple of times when the Berkeley screen saver would pop up and suddenly the machine would die. Not often; and I knew it wasn't really Berkeley's fault to begin with, because, for rather complicated reasons, I had an old version of the screen saver on the Cheetah 486DX2/25. And by coincidence, the night before the IBM troops came over, I turned off the Berkeley screen saver and turned on the Flying Windows screen saver that comes with Windows. It was still turned on.

But surely it couldn't be the Flying Windows screen saver? One way to find out. Disconnect the IBM machines from the network. Log on to the 486DX2/25 (no longer a Cheetah, but I don't have a new name for it) from another W4WG machine. Wait. Crash within 5 minutes. OK, go into the Control Panel, bring up desktop, and say NO SCREEN SAVER. Exit. Wait. No crash. Connect the IBM systems in. Still no crash. Turning off Flying Windows did the job.

Moreover, I then installed the newest version of Berkeley's Star Trek screen saver and left it on: still no crashes. But turning on Flying Windows will reliably and repeatedly bring the machine down if it's connected to the network and another machine is logged on to it. This seems to be specific to this machine, or at least this speed (486DX2/25). I have since got SuperCow up and running and connected to the network, and it's had Flying Windows going for two days while I've been moving files through the network. Incidentally, SuperCow has that Hercules Dynamite VL board, and those windows really *fly*.

I hate to give short shrift to User's Choice Award winners, but that's what I'm about to do. I generally like to write a short squib on why I've chosen some product for an award, but I haven't enough space.

Hard drive controller: An Orchid to Perceptive Solutions for their WinStore/6 IDE controller; drop one into an IDE-drive machine and see real performance improvement. But for solid trouble-free SCSI caching controllers, this year's User's Choice Award goes to Distributed Processing Technology's SmartCache III SCSI host adapters.

Word processor: This tends to be a matter of taste, because many of them are good enough. For example, WordPerfect 6.0 for Windows is now acceptably easy to learn and gets a Chaos Manor Orchid; but I have found Microsoft Word for Windows 6.0 to be outstanding. I particularly like its version controls, including document comparison and merging. It handles footnotes splendidly. The user interface has been improved, the help system is really neat, the hints and cue cards make it easy to learn features I never knew about, and so far I haven't found anything I really dislike. Hands down, this gets my User's Choice Award for Word Processor.

I talked about Quantum Leap 2.1 in the December 1993 column. It's an OS/2 business modeling and forecasting program that's so good you might change to OS/2 just to run it. It easily deserves a User's Choice Award.

Monitor: A User's Choice Award to Nanao. The FlexScan T560i monitor survived the earthquake: it fell face-down on the floor from a considerable height. Fortunately, some books had fallen first. Anyway, we set it back up and turned it on, and there was my bright, colorful, glare-free, rock-steady, eyesight-saving screen. I love this thing.

Micro 2000's Micro-Scope and Post-Probe are available separately and in a small kit (the Toolkit) containing diagnostic software and a diagnostic board. If your system fails to boot, this will tell you why, if anything will. If it boots but behaves oddly, this gives you a fighting chance of finding out if it's a hardware error. Software for low-level formats of IDE, SCSI, RLL, ESDI, and MFM drives. Memory tests. IRQ (interrupt request) tests. You name it, this tests it. If you maintain PCs, you'll love it. It gets a User's Choice Award.

A renewal of last year's User's Choice Award to BSE for their Flashdrives, which are pocket hard drives (see my March column). They really work.

The User's Choice Award for Windows Shareware of the Year: Plug-In for Program Manager (see my May 1993 column) does neat things for Windows, and does them unobtrusively. I've seen no problems with it in nearly a year of use.

When we decided to change motherboards on the Cheetah 486/25, we wanted to do a backup, preferably over the network using Palindrome's Network Archivist and Fast 2000 DAT (digital audiotape) drive. I didn't manage that because I didn't read the Network Archivist documents correctly. It turns out that it's absurdly simple and can be done from either Windows or DOS: the W4WG network works quite well from command-line DOS once the network is started. Network Archivist will act as if it wants a lot of information, but in fact all you enter is the drive letter. In my case, the C drive of the Cheetah 486/25 is X, so X is all I needed to tell Network Archivist. Then tell it to export the contents of that drive to tape and go to dinner.

Network Archivist gets a small pearl Onion for its documents, which have too few examples; but it also gets the User's Choice Award as backup and archive manager of the year. Despite rather cryptic documentation, Network Archivist has saved my bacon a dozen times in the last year, and I have yet to lose 1 byte of data it protects. It even protects against operator stupidity.

The biggest Orchid I can find for NASA's Dan Goldin, who came up with $990,000 for a last-minute save of the DC/X spaceship after ARPA refused to spend money already appropriated to keep her flying. NASA may be changing, moving back toward the gung ho, can-do outfit that flew the X-15 and led America to dominance in aerospace. I sure hope so.

continued

Product Information

A portable, battery-powered hard drive that's smaller than a cigar box, the **Flashdrive** (available in 80 to 520 MB from $499 to $1149; smaller sizes are also available) gets a renewal of last year's User's Choice Award. Contact **The BSE Co.**, 2114 North Fourth St., Flagstaff, AZ 86004, (602) 527-8843; fax (602) 527-1540. **Circle 1146 on Inquiry Card.**

A User's Choice Award for Monitors to Nanao's **FlexScan T560i** monitor ($1999), hands down. It's a bright, colorful, glare-free, rock-steady, eyesight-saving screen. I love this thing. Contact **Nanao USA Corp.**, 23535 Telo Ave., Torrance, CA 90505, (800) 800-5202 or (310) 325-5202; fax (310) 530-1679. **Circle 1147.**

Micro-Scope ($399) and **Post-Probe** ($299) can be bought separately or as the **Toolkit** ($698), containing diagnostic software and a diagnostic board. You name it, this tests it. If you maintain PCs, you'll love it. It gets a User's Choice Award. Contact **Micro 2000, Inc.**, 1100 East Broadway, Glendale, CA 91030, (800) 864-8008 or (818) 547-0125; fax (818) 547-0397. **Circle 1148.**

Microsoft Word for Windows 6.0 ($495) gets my User's Choice Award for Word Processor. The user interface has been improved, the help system is really neat, it has easy-to-learn features I never knew about, and so far I haven't found anything I dislike. Contact **Microsoft Corp.**, 1 Microsoft Way, Redmond, WA 98052, (800) 426-9400 or (206) 882-8080; fax (206) 883-8101. **Circle 1149.**

Network Archivist ($1695) gets the User's Choice Award as backup and archive manager of the year. It has saved my bacon a dozen times in the last year, and I have yet to lose 1 byte of data it protects. Contact **Palindrome**, 600 East Diehl Rd., Naperville, IL 60563, (708) 505-3300; fax (708) 505-7917. **Circle 1150.**

OS/2 LAN Server 3.0 Advanced ($1460) is a real network comparable to NetWare in capabilities, reliability, and difficulty in using. If you need to network OS/2, DOS, and W4WG workstations, it will do the job, and if you have many OS/2 systems to network, it's clearly a good choice. Contact **IBM Corp.**, 1 Old Orchard Dr., Armonk, NY 10504, (800) 342-6672 or (914) 765-1900; fax (313) 225-4020. **Circle 1151.**

A User's Choice Award for Windows Shareware of the Year to **Plug-In for Program Manager** ($20). It does neat things for Windows and does them unobtrusively. Contact **Plannet Crafters, Inc.**, 2580 Runic Way, Alpharetta, GA 30202, (800) 651-1000 or (404) 740-9821; fax (404) 740-1914. **Circle 1152.**

Quantum Leap 2.1 ($695, stand-alone; $995, client/server) combines a powerful math tool set, including simplex and reduced gradient solution algorithms, with an easy-to-use spreadsheet interface, what seems to be a fully relational database, and the capability to incorporate expert-system rules. There may be a more advanced business-modeling and problem-solving system available for mainframes, but I don't know of any for small computers. Contact **Quantum Development Corp.**, P.O. Box 970, Claymont, DE 19703, (302) 798-0899; fax (302) 798-6813. **Circle 1153.**

SmartCache III SCSI host adapters (from $285 to $595) are a family of solid, trouble-free SCSI caching hard drive controllers that receive this year's User's Choice Award for Controllers. Contact **Distributed Processing Technology**, 140 Cadence Dr., Maitland, FL 32751, (800) 322-4378 or (407) 830-5522; fax (407) 260-5366. **Circle 1154.**

An Orchid to Perceptive Solutions for their **WinStore/6** ($159) IDE controller; drop one into an IDE-drive machine and see real performance improvement. Contact **Perceptive Solutions, Inc.**, 2700 Flora St., Dallas, TX 75201, (800) 486-3278 or (214) 954-1774; fax (214) 953-1774 **Circle 1155.**

WordPerfect 6.0 for Windows ($495) is now acceptably easy to learn and gets a Chaos Manor Orchid. Contact **WordPerfect Corp.**, 1555 North Technology Way, Orem, UT 84057, (800) 824-3323 or (801) 225-5000; fax (801) 222-5077. **Circle 1156.**

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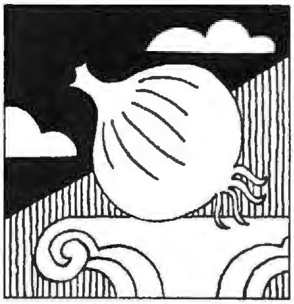
An enormous Chaos Manor Onion to the U.S. Patent and Trademark Office, which managed to award Dr. Roger Billings a patent for inventing distributed file systems in 1982. Specifically, he claims to have invented the notion of sharing data between computers using devices known as "dedicated servers" with software "pursuant to an access-control program."

I'm a firm believer in intellectual property, but how could he possibly have invented that? Distributed file systems have existed since the 1970s. I wrote about distributed computing, including networking, in some of my early columns. Billings' claim is analogous to my getting a patent on the letter *e*.

An even larger Onion to Bank of America for paying Billings $125,000 to drop his lawsuits so Bank of America can use its Ethernet systems in peace. I know that settling was cheaper than fighting, but Bank of America has done none of us any favors by feeding the energy monster. And the largest Onion I can find, with garlic clusters, to those who have "invested" in shares in Billings' lawsuit.



In any rational world this mess would be settled in weeks, but I have no doubt that it will wind its way through the courts for years, enriching lawyers and harassing business users of NetWare and I suppose IBM OS/2 LAN Server. No wonder this nation is in trouble.

On which score, the book of the month is Edward Luttwak's *Reclaiming the Endangered American Dream* (Simon & Schuster, 1993). In my judgment, Luttwak is better at diagnosing than prescribing, but this book deserves a careful reading by anyone who is concerned with just where this nation is going. Agree with him or not, he clearly gives you much to think about.

There are two computer books of the month. One is Bill Camarda's *Inside Word for Windows 6* (New Riders, 1993). Word 6 has many features, and they're all covered in this readable book. I keep it right near my desk. There's also Microsoft Professional Editions' *Word Developer's Kit* (Microsoft Press), which gives you the software and instructions for doing Word BASIC and customizing Word 6. Some tough slogging, but all the information is right in there.

We've been too busy to play games, so there's no game of the month. Meanwhile, although floods of soggy software went out when we cleaned up the horrible mess in the Great Hall, a steady stream of very neat stuff has come in. If anything will save us from Luttwak's fear that we're becoming a third-world country, it will be this industry. ■

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future. Jerry welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply. You can also contact him on the Internet or BIX at jerryp@bix.com.

What's New Hardware

FULL-FEATURED PORTABLE WORKSTATION

Preloaded with the Solaris 1 or 2 operating environment and version 2.0 of the Nomadic Computing Environment, Tadpole's Sparcbook 3 portable workstation has a removable 340- or 520-MB hard drive. The unit, which weighs 6½ pounds with battery pack, has PCMCIA slots for two Type I/II cards or one Type III card. Other features include an on-board Weitek P9000 graphics accelerator, a ThinkPad keyboard with an integrated Pointing Stick, a built-in data/fax modem, and SIMMs that you can upgrade from 16 MB to 64 MB. With the Sparcbook 3, you get your choice of an internal 12-V nickel-metal-hydride battery pack, an external 12-V nickel-cadmium pack, or both. Prices start at $10,950.

Contact: Tadpole Technology, Austin, TX, (800) 232-6656 or (512) 219-2200.

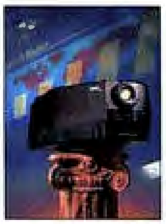
Circle 1271 on Inquiry Card.

LET A TROLL TOUCH YOUR POWERBOOK

Troll Touch PB touchscreen ($695) for the PowerBook 180c is made of clear, pressure-sensitive, resistive-coated layers of polyester that will not shatter or break when in transit. You activate the screen by touching it up to 60 times per second. Since the screen is resistive, it will not react to heat or humidity and will not drift out of calibration. Troll Technology (Valencia, CA) integrates the screen onto your PowerBook's LCD when you send the unit to the company.

Phone: (805) 295-0770.

Circle 1274 on Inquiry Card.



COMPUTER PROJECTIONS

A compact projection system that works with most PCs and Macs, the LitePro 540 ($7499) projects screen images measuring as large as 15 feet on the diagonal. The active-matrix LCD displays more than 1.4 million colors simultaneously from a palette of more than 16.7 million. From In Focus Systems (Tualatin, OR), the unit includes a hand-held remote device that you can configure with the commands you use most frequently.

Phone: (800) 294-6400 or (503) 692-4968.

Circle 1276 on Inquiry Card.

INTERNAL FAX MODEM

An internal fax modem that transfers data at 2400 bps and sends and receives faxes at 4800 bps and 9600 bps, respectively, the MX-2496B ($59) includes MNP 5 and V.42bis capabilities. From Calpak (Torrance, CA), the modem ships with software to send and receive faxes in the background, send faxes at night, print faxes on a laser printer, and prepare cover sheets. You can also create a personal phone and fax directory and automate your fax/phone answering and receiving capabilities, among other functions.

Phone: (310) 539-8366.

Circle 1275 on Inquiry Card.

SHARE A PRINTER

MosesSpool (two-node starter kit, $149) lets two PCs share a printer; you can upgrade to a LAN if you wish. From Moses Computers (Los Gatos, CA), the printer sharer connects directly to your PC's bus to transfer data at 2 Mbps. Its design eliminates jumper settings, specialized hubs, transmitters, and complex wiring.

Phone: (408) 358-1550.

Circle 1277 on Inquiry Card.

COLLECT SCIENTIFIC DATA ON YOUR MAC

The Serial Box Interface ($99) from Vernier Software (Portland, OR) connects to the modem port of your Mac. With your sensors and the company's Data Logger software (site license, $30), you can monitor elements such as temperature, pH, pressure, heart rate, light intensity, and voltage.

Phone: (503) 297-5317.

Circle 1279 on Inquiry Card.

A VIDEO CAMERA FOR THE MAC

A color video camera that works from the top of your monitor, the PC-7 Multimedia Video Camera ($349.95) has a resolution of 380 horizontal lines. It has automatic white balance and exposure functions, a low-light-sensitivity rating of 2 lux, and an f1.8, 4.44-mm medium-wide-angle lens. The outputs of the Advanced Microvideo (Austin, TX) camera are standard composite video and line-level audio. You can use the camera for desktop teleconferencing, video mail, and making QuickTime movies.

Phone: (512) 335-2200.

Circle 1280 on Inquiry Card.

FLEXIBLE DIGITAL VIDEO

The Targa 2000 (from $5995) lets you display a Video-in-a-Window image while outputting video in NTSC or PAL format. From Truevision (Indianapolis, IN), the Targa 2000 is based on the company's DVR architecture, which features a set of logical components that encode, decode, process, and store digital video. The digital video card supports displays of up to 1152-by 870-pixel resolution at 24 bits per pixel and lets you capture full-frame, full-motion images with CD-quality audio. You can also marquee a portion of the desktop or resize the entire desktop prior to recording the selected area on video.

Phone: (800) 344-8783 or (317) 841-0332.

Circle 1281 on Inquiry Card.

MAKE YOUR PC LOCALTALK-READY

The pocket-size PCTalk adapter ($199) from Apexx Technology (Boise, ID) snaps onto your PC's parallel port to provide a connection to LocalTalk. The adapter lets you connect any number of PCs to an AppleTalk network or connect your laptop to Macs, network printers, and other shared resources. The adapter supports Farallon Timbuktu for Windows (kit, $399) and PhoneNet PC software.

Phone: (800) 767-4858 or (208) 336-9400.

Circle 1278 on Inquiry Card.

TCP/IP TERMINAL SERVER

An eight- or 16-port terminal server that provides native serial access to a TCP/IP host regardless of where the users are on the network, the PortServer (from $1595) eases serial port configuration and management. The server lets you connect workgroups or clusters of as many as 16 asynchronous RS-232 serial I/O devices to any Ethernet network that's running the TCP/IP protocol. From DigiBoard (Eden Prairie, MN), the PortServer uses the company's Net C/X protocol software and includes 1 MB of RAM with a throughput rate of up to 38.4 Kbps. The PortServer's front-panel display enables system administrators to track network and asynchronous line activity and monitor the status of attached devices.

Phone: (612) 943-9020.

Circle 1286 on Inquiry Card.

A PRINTER FOR THE NETWORK

A 300-dpi color and monochrome printer, the Codonics (Middleburg Heights, OH) NP-1600 Photographic Network Printer ($9995) uses dye-sublimation technology with 16.7 million simultaneously printable colors to produce continuous-tone prints. Designed for use with any TCP/IP or EtherTalk network, the Codonics NP-1600 can print files from DOS, Unix, and DEC VMS systems and recognizes image file formats such as TIFF, GIF, PCX, PICT, and PostScript Level II. The printer's five output formats range from $8\frac{1}{2}$ by 11 inches to $9\frac{1}{2}$ by 12 inches, and it accepts paper and transparencies interchangeably.

Phone: (800) 444-1198 or (216) 243-1198.

Circle 1282 on Inquiry Card.

HUBS WITH SPLIT PERSONALITIES

Available in Ethernet, Token Ring, and terminal-server versions, each INXLink hub has its own internal management system. This lets you use a hub as an independent, standalone network for a workgroup of up to 24 Ethernet or 26 Token Ring users or stack the hubs to form larger networks. Each hub can be managed in-band from a Telnet client or an SNMP management station. For out-of-band management, you can attach any VT100 terminal or modem to the console port. Prices start at $2395.

Contact: Racal-Datacom, Boxborough, MA, (800) 722-2555 or (508) 263-9929.

Circle 1272 on Inquiry Card.

GRAPHICS VIA THE PCI BUS

Designed for the PCI bus, the GraphMax P12 (from $399) is based on IBM's XGA architecture. From VidTech Microsystems (Minneapolis, MN), the card features resolutions as high as 1600 by 1200 pixels with 16 colors and a noninterlaced refresh rate of 120 Hz. The 1 MB of VRAM on the card is upgradable to 2 MB.

Phone: (612) 780-8033.

Circle 1283 on Inquiry Card.

A NOTEBOOK DESIGNED FOR CAD

The top-of-the-line Tri-CAD DesignBook ($4595) provides 340 MB of hard disk storage and 12 MB of RAM (expandable to 20 MB). The 486DX2/66 CAD graphics system has a 10-inch TFT active-matrix VGA color display, a PCMCIA Type III slot, a built-in trackball, and a 200-pin docking port. The optional Docking Station ($475) includes two VESA slots, four 16-bit ISA slots, built-in speakers, and a SCSI controller. The system is from Tri-Star Computer (Chandler, AZ).

Phone: (800) 755-1000 or (602) 961-3401.

Circle 1284 on Inquiry Card.

HIGH-TECH TERMINAL

The QVT520 video display terminal ($359) from Qume (San Jose, CA) provides ANSI emulations such as DEC PCTerm, VT420, VT320, VT100, WY-85, WY-60 native mode, and a Unix Console mode. The 15-MHz terminal supports 10- by 16-character resolution, selectable full overscan, and the simultaneous display of 512 distinct characters per session. It has an 85-Hz noninterlaced refresh rate and 96 KB of high-speed static RAM. Capable of running dual terminal sessions from two host computers, the QVT520 can simultaneously display both sessions on a split screen.

Phone: (408) 473-1500.

Circle 1285 on Inquiry Card.

CD-ROM TOWER OFFERS FLEXIBILITY

Compatible with ISA, EISA, and Micro Channel systems, Online Computer Systems' (Germantown, MD) CD-ROM tower supports from four to seven double-speed SCSI-2 CD-ROM drives. Each drive supports 200-ms random-access speeds and sustained transfer rates of up to 330 KBps. In addition, each drive has a 256-KB buffer and fully integrated audio, is MPC-2 compliant, and supports multisession Kodak Photo CD. The CD-ROM tower (from $3875) can be used as a stand-alone system or with a network.

Phone: (800) 922-9204 or (301) 428-3700.

Circle 1288 on Inquiry Card.

STORAGE FOR THE MAC

A rewritable magneto-optical storage system for publishing, prepress, CAD/CAM, multimedia, and imaging applications, the Olympus 128MO Macintosh ($1195) has a continuous read-transfer rate of 768 KBps. From Olympus Image Systems (Irvine, CA), the system provides 120 MB of storage and has the ability to transfer synchronous and asynchronous files. It dynamically renders partitions when you drag a handle in the interface and electronically locks files for read-only security.

Phone: (800) 347-4027 or (714) 753-5935.

Circle 1287 on Inquiry Card.

What's New Hardware

POWER DOWN AND SAVE ENERGY

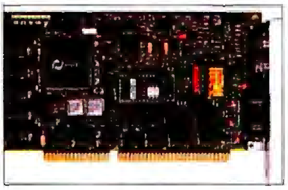
The 17-inch digitally controlled DX17F monitor ($849) from MAG InnoVision (Santa Ana, CA) can power down to 15 W in its standby and suspend modes and to 10 W in its off mode. The video signal circuits are VESA compatible and meet DPMS requirements. The monitor has a flat-square screen and a noninterlaced resolution of up to 1280 by 1024 pixels; refresh rates go up to 76 Hz at 1024- by 768-pixel resolution. The monitor has a dot pitch of 0.26 mm and a bandwidth of 100 MHz.
Phone: (800) 827-3998 or (714) 751-2008.
Circle 1289 on Inquiry Card.

WIRELESS COMMUNICATION BETWEEN BUILDINGS

The AirPort Wireless Interbuilding Systems use spread-spectrum radio technology to provide 16-Mbps wireless point-to-point and point-to-multipoint communications at distances of up to 1.8 miles. The systems combine a data throughput rate of 5.7 Mbps with full Ethernet compatibility and SNMP network management. Components include a wireless hub with an antenna, one or more wireless remote units, and an optional SeePort Network Management System. AirPort I provides line-of-sight connectivity between two or more buildings at distances as far as 1000 feet; AirPort II comes with an indoor antenna or an all-weather outdoor antenna for a range of 1.8 miles. AirPort I costs $12,450; prices for AirPort II start at $22,000.
Contact: Windata, Northborough, MA, (508) 393-3330.
Circle 1273 on Inquiry Card.

TELECOMMUNICATE IN WINDOWS ▼

A Windows-based telephone management system, Spectrum Envoy ($349) provides phone, data modem, fax, answering machine, voice-messaging, and PC audio functions in a single package that includes DSP hardware and Octus PTA software. From Spectrum Signal Processing (Burnaby, British Columbia, Canada), Envoy includes an Mwave discriminator that recognizes if an incoming call is a fax, modem, or voice call and handles each one appropriately. Other features include support for caller ID, speakerphones, and advanced on- and off-hook sensing.
Phone: (800) 667-0018 or (604) 421-5422.
Circle 1290 on Inquiry Card.



REMOTE POWER BY PHONE

Activated by a phone, the Mac Power On/Off + Aux ($199.95) remote power-control unit detects incoming phone calls and powers up a remote Mac, providing remote users access to a host Mac without keeping the host running when it's not needed. From Server Technology (Sunnyvale, CA), the unit operates in three modes. In the remote-power-switch mode, the host Mac powers on when a specific number of phone rings is detected; it automatically powers off when the call is disconnected. In the AUX-port mode, the unit permits the Mac's modem and answering machine or fax to share a single phone line. The reboot mode lets you phone the host Mac's modem to reboot a remote Mac workstation, gateway, or server that has locked up.
Phone: (800) 835-1515 or (408) 745-0300.
Circle 1294 on Inquiry Card.

DATA ACQUISITION AND CONTROL MODULE

A general-purpose measurement and control device, the Model 40 ($99) from Prairie Digital (Prairie du Sac, WI) features 28 programmable digital I/O lines and eight analog input channels. The serial-port unit, which can be connected to any RS-232 device, also has three stepper-motor-controller ports, four relative resistance channels, and a pulse-width-modulation output. The battery-operated Model 40 is easily connected to your laptop or palmtop.
Phone: (608) 643-8599.
Circle 1291 on Inquiry Card.

LET YOUR NOTEBOOK ANSWER THE PHONE

The Pocket FaxLink ($299) PCMCIA fax/modem card automatically answers incoming phone calls, records messages of up to several minutes in length, and prompts the caller to review, modify, or re-record the message. From Radio, Computer & Telephone (Minnetonka, MN), the 14.4-Kbps fax and data modem lets you scroll through a phone list, select the name you want, and then touch a button to prompt the system to automatically dial that person's number. You can save a recorded message to a file and download it to play it back.
Phone: (800) 543-0000 or (612) 542-1081.
Circle 1292 on Inquiry Card.

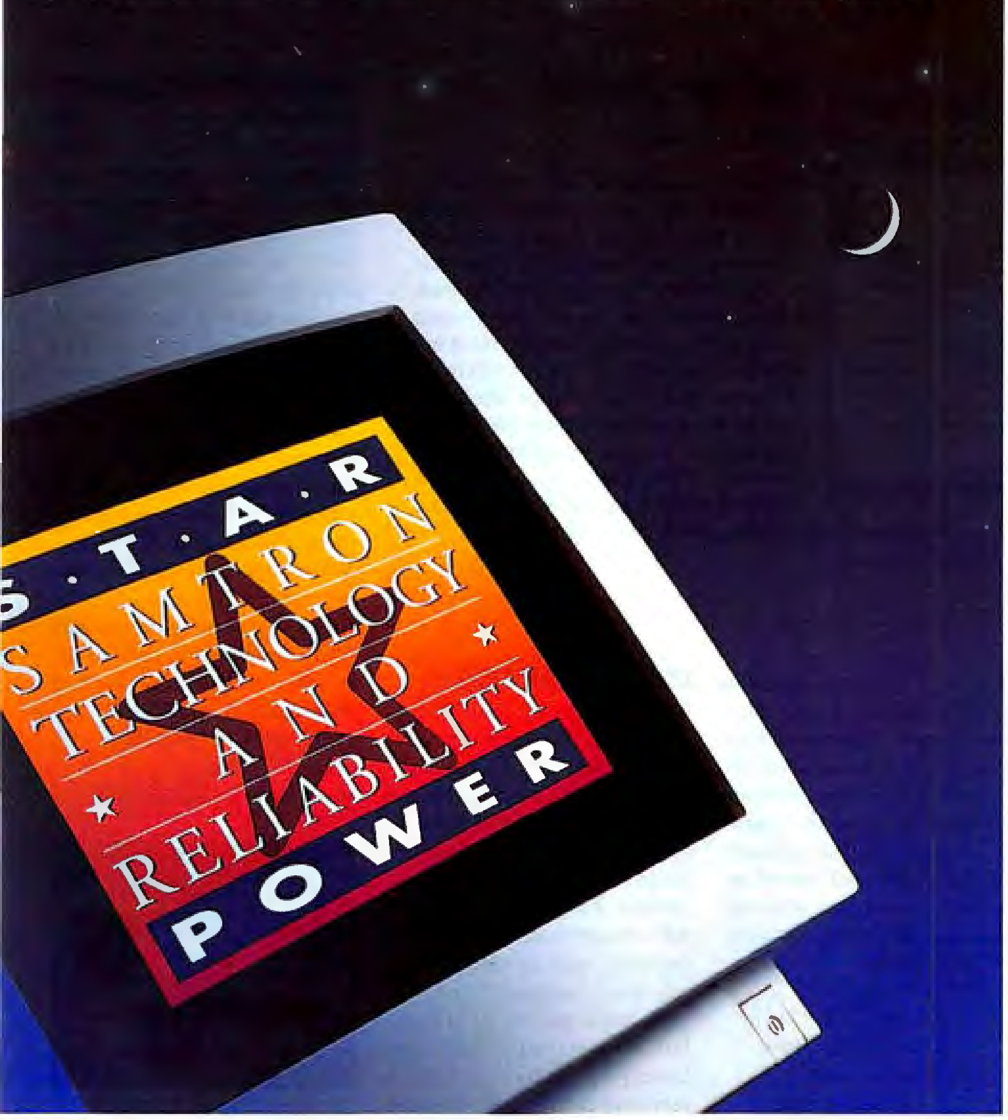
PROJECTION PANEL

The latest of In Focus Systems' (Tualatin, OR) PanelBook projection panels, the PanelBook 530 ($5299) can project more than 1.4 million colors simultaneously with a resolution of 640 by 480 pixels. Compatible with PCs and Macs, the unit has an 8½-inch-diagonal active-matrix LCD and fits into a briefcase. The panel has built-in, full-motion video support for NTSC and PAL/SECAM video signals. A hand-held remote control includes a customizable button for storing commands.
Phone: (800) 294-6400 or (503) 692-4968.
Circle 1293 on Inquiry Card.

MAKE THE CONNECTION WHILE TRAVELING

The Model 305 Konexx Modem Koupler ($299) has a built-in 2400-/9600-bps data/fax modem and connects to the serial port of your PC. Compatible with telephones the world over, including pay and cellular phones, the Model 305 is powered by a 9-V alkaline battery for 6 hours of transmission time. The unit is from Unlimited Systems (San Diego, CA).
Phone: (619) 622-1400.
Circle 1296 on Inquiry Card.

REACH FOR THE STARS



SC-726UXL
17" Flat Screen
1,280 x 1,024 (60Hz) High Resolution
Mac Compatible

SC-528UXL
15" Flat Screen
1,280 x 1,024 (60Hz) High Resolution

SC-428UXL
14" 1,024 x 768 (75Hz) High Resolution

For generations, we have looked to the stars as symbols of that which cannot be reached. To be considered a star, one must display rare talent and ability to rise above the masses. While the average person may never literally reach the stars, it is possible to put one to work for you. ★ Consider the Samtron StarPower™ line of high resolution monitors. Featuring digital controls, flicker-free screens to ease eye strain and non-interlaced displays for edge to edge viewing, the entire line complies with EPA Energy Star™ standards. ★ In addition, every Samtron monitor comes with an unparalleled three year parts and two year labor warranty, adding up to heavenly performance at down-to-earth prices.

★ Contact your local dealer about the StarPower line.

You won't even need a telescope to see them up close.

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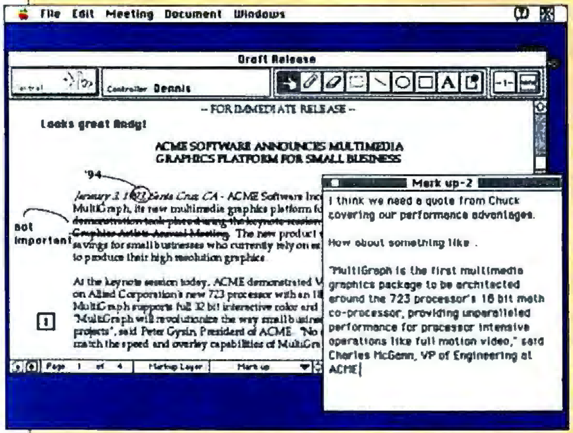
Distributors: Canada, Tel: (416) 858-3000
Mexico, Tel: 011-525-325-0993

Circle 143 on Inquiry Card.

What's New Software



Real-Time Document Conferencing

Platform-, application-, and network-independent, Face to Face lets two people use any combination of Macs and Windows-based computers to work together on a document while they discuss the work in progress over the phone. After viewing and annotating identical, synchronized images of the document, each participant can save, print, or forward an electronic copy of the finished product via E-mail. Face to Face lets you scroll through the document, letting you work on the entire document rather than just individual pages or sections. The software ($295 per copy) operates via modems, LANs, and ISDN networks.

Contact: Crosswise, Santa Cruz, CA, (408) 459-9060.

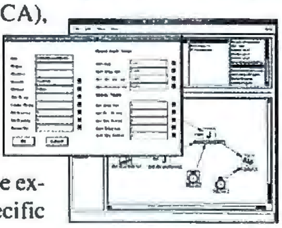
Circle 1298 on Inquiry Card.

Network Job Scheduler ▼

A distributed-network job-scheduling and workload management system, OnSchedule (server version starts at $2500) has the ability to automatically schedule, execute, and manage processes over a network of heterogeneous machines. From Paradigm Systems (Newark, CA), OnSchedule groups related jobs into cycles, which allows interrelated jobs to be executed in a specific sequence. The system's GUI identifies all components in the system, the flow of each cycle, and the relationships among all components. Users can customize their own event-driven scheduling. A Hot Back-Up option is available.

Phone: (510) 440-8551.

Circle 1302 on Inquiry Card.



Relational Database Management

A contact management program for the Mac, Full Contact ($169) uses RAM-based relational technology to keep track of contracts, activities, and dates. From Fit Software (Santa Clara, CA), the program's MultiLinking capability lets you link any item with any other item (or several other items) in your database without having to rekey information. Intelligent filters in the software let you define a specific search for information. The software can also export and import information to and from other applications or computers.

Phone: (800) 725-3734 or (408) 562-5990.

Circle 1303 on Inquiry Card.

Put Your RAM to the Test

RAMexam ($29.95), from Qualitas (Bethesda, MD), helps you avoid system crashes resulting from RAM failure. The software uses a consistent fault model that is based on a strategy of specific sequences of bit patterns designed to detect specific types of memory failures. The DOS-based utility installs automatically and includes six tests based on the most likely categories of memory failure. You can configure RAMexam to test system memory daily, weekly, monthly, or as frequently as you like.

Phone: (800) 733-1377 or (301) 907-6700.

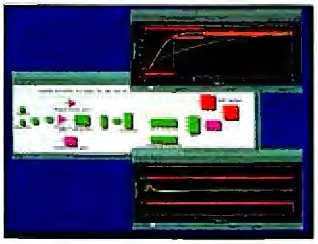
Circle 1304 on Inquiry Card.

Control-System Designer

The Nonlinear Control Design Toolbox (Windows version, $895) from The MathWorks (Natick, MA) works with the company's Matlab and Simulink software to help you design controllers directly in the nonlinear domain. Targeted for engineers who design controllers for industries such as automotive, aerospace, process control, and petrochemicals, the NCD Toolbox lets you use the GUI to interactively specify time-domain response constraints. You can conduct live optimizations, displaying responses as they evolve at each iteration to provide access to intermediate solutions. You can also seamlessly access Matlab, Simulink, and optimization routines to automatically tune controller parameters. The software is also available for the Mac and Unix.

Phone: (508) 653-1415.

Circle 1305 on Inquiry Card.



Build a Skyscraper for OS/2

From Binar Graphics (San Rafael, CA), SkyScraper—Desktop Manager for OS/2 ($99) provides a visual representation of OS/2's multitasking capabilities. Each video display represents a desk in a virtual office in which you can place as many desks as you wish. Each application or group of applications sits on its own desk and is represented by a button in the on-screen toolbar. You can open all your OS/2 applications to full-screen size on different desks and switch among them with the click of a button. You can also organize your desks into multiple offices on different floors. You configure the way SkyScraper looks by defining the number and arrangement of desks, offices, and floors.

Phone: (800) 228-0666 or (415) 491-1565.

Circle 1306 on Inquiry Card.

Presentation Software for Unix ▲

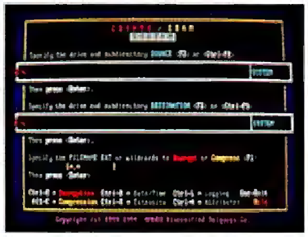
A native X Window System application, Ovation presentation graphics software ($795 per user) runs on X terminals, workstations, or PCs running X software on a network. From Visual Engineering (San Jose, CA), Ovation allows you to drag and drop graphics from other Unix applications. It provides hyperlinks to trigger Unix multimedia features; graphical on-line help; a graphical slide sorter; built-in outlining to help you quickly develop presentation text; drawing and charting tools; and support for speakers' notes and audience handouts.

Phone: (408) 452-0600.

Circle 1307 on Inquiry Card.

ENCRYPT AND COMPRESS DATA

Crypto/Cram, a data-encryption/data-compression system (from $30), lets you compress or encrypt multiple files by wild card with or without a specific file-attribute criterion. The compression engine is based on the public domain LZ77 sliding-window-compression algorithm to achieve, on average, a 2-to-1 compression ratio. From Radix2 Software Engineering (Libertyville, IL), the program includes Auto Path Walking, which allows you to quickly change directories; user-definable encryp-



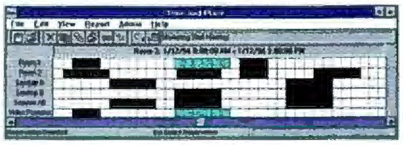
tion or compression activity log files; infinite cipher layering with intermixed access codes; alternate extension binding; and four utilities.

Phone: (800) 946-8086 or (708) 549-6733.

Circle 1308 on Inquiry Card.

FACILITY SCHEDULER ▼

A Windows-based program for scheduling facilities and their related support equipment, Time



and Place (from $89) enables you to see and manipulate all your room schedules at once so that you can schedule blocks of rooms and move events from one room to another. You can create, stretch, shrink, copy, and move events by dragging and dropping them on a grid, and you can enable five controls for any room. Controls for the relationships between reservations include linking one reservation to another. From Facility Innovations (Walnut, CA), the multiuser database application is network ready.

Phone: (818) 810-8031.

Circle 1311 on Inquiry Card.

MAC FILE MANAGEMENT

A file management application for the Mac, ProFiles ($129) from Dayna Communications (Salt Lake City, UT) lets you work in a window called the Filelist. Here you can create a customized list of files and folders on which you can synchronize folders and volumes, move and copy in the background, send an alias to a new destination, and compress or expand files. Find capabilities let you search by multiple criteria. The program is compatible with AppleShare, Personal File Sharing, NetWare, and Unix.

Phone: (801) 269-7394.

Circle 1309 on Inquiry Card.

CD-ROM NETWORK CACHING

Opti-Net Lite (CD-ROM server license, $179) adds data caching and data prefetching to shared CD-ROM drives installed in peer-to-peer network servers. According to Online Computer Systems (Germantown, MD), this boosts network performance and user productivity by providing up to 600 percent faster access to CD-ROM applications. You can store recently and frequently used applications and data in high-speed extended memory.

Phone: (301) 428-3700.

Circle 1310 on Inquiry Card.

SEE THE HANDWRITING ON YOUR PC

Rite-Expressions ($379) from Inforite (San Mateo, CA) lets you annotate and import handwritten information to off-the-shelf Windows and DOS programs using your MP100 Writing Pad. In Windows, the PC software works through the OLE 2.0 and DLL interfaces. You run your application, open a document file, and select from the Rite-Expressions toolbar to activate a function. The MP100's pressure-sensitive pad captures the writing, transmits it to the computer, and puts it into the open document as an overlay at the cursor.

Phone: (415) 571-8766.

Circle 1322 on Inquiry Card.

Software Update

Catalog On Disk for Windows 2.20, Curtis Software (Torrance, CA), improves speed, adds Format Viewer and the capability to copy complete product records to a buffer and paste them to create new records, modifies Product Line files, and adds enhanced on-screen ordering and importation as options. $1795.

Phone: (310) 320-2451.

Circle 1324 on Inquiry Card.

Pixar Typestry 2, Pixar (Richmond, CA), includes Adobe

Illustrator import, a particle system tool, new options for building objects, enhanced animation control, a Looks editor, new perforation control, editable bevels, new Environment Looks, and fog. $299.

Phone: (510) 236-4000.

Circle 1325 on Inquiry Card.

Tech Help 6.0, Flambeaux Software (Glendale, CA), has an enlarged hypertext database of BIOS and DOS functions, covers system-extension APIs, and uses the latest version of the Flambeaux Help Viewer. $99.95.

Phone: (800) 833-7355 or (818) 500-0044.

Circle 1326 on Inquiry Card.

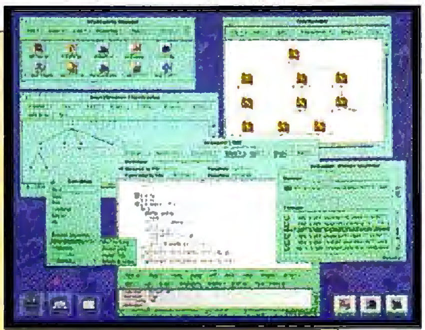
Automenu 5.0 Net, Magee Enterprises (Norcross, GA), updates its look with menus arranged in overlapping windows,

improves setup and maintenance, lets multiple MDFs (Menu Definition Files) reside on the same screen, adds a software-detection module, supports cutting and pasting of items between menu pages and MDFs, and provides hot-key access for any displayed menu item. $399.95 per server.

Phone: (800) 662-4330 or (404) 446-6611.

Circle 1337 on Inquiry Card.

A WORKSHOP FOR UNIX



SunPro WorkShop is an integrated product suite for C, C++, or FORTRAN Unix developers running the Solaris 2 operating environment for SPARC. The Sparcompiler C component aids in cross-language development and migration between C and other programming languages. The SparcWorks tool set includes integrated run-time error checking and Fix and Continue capabilities. The SparcWorks/TeamWare code management tools automate software-version control, release integration, release management, and project building. SparcWorks/Impact extends Sparcompiler FORTRAN to automatically parallelize FORTRAN applications to run on multiprocessors without any source code changes. SunPro WorkShop for C costs $2195; the version for C++ costs $2995; the FORTRAN version is $3195.

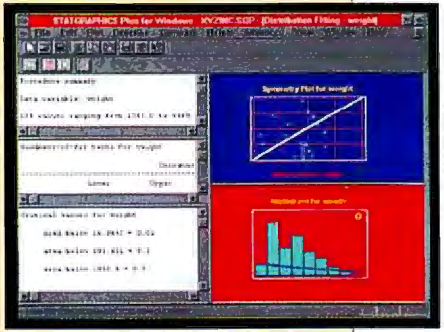
Contact: SunPro, a unit of Sun Microsystems, Mountain View, CA, (415) 960-1300.

Circle 1299 on Inquiry Card.

What's New Software

SOPHISTICATED STATISTICS IN WINDOWS

Built specifically for Windows, Statgraphics Plus for Windows emphasizes the exploration of data and interpretation of results in its interactive graphics. Available in every procedure, the graphics let you fully interrogate statistical data on-screen.



The software's StatFolio function lets you automatically save and reuse work without writing code or recording macros; when you run a StatFolio analysis on a new set of data, the graphics and tables are updated in real time on the screen. A DDE link lets you manage data in a spreadsheet without having to export it to Statgraphics Plus. You can dynamically link the data into the data editor and use it inside the program as if you had entered it directly into the system. All changes you make to the spreadsheet are automatically reflected in the updated statistical output and graphics. The base system includes simple and multiple regression; ANOVA; one-, two-, and multiple-variable analyses; and distribution fitting. The base system costs $649; each additional module is $399.

Contact: Manugistics, Rockville, MD, (301) 984-5000.

Circle 1300 on Inquiry Card.

CHARTING THROUGH WINDOWS

Charts Now ($99.95), a Windows-based graphics editor, lets you quickly create organizational charts, flowcharts, network and block diagrams, project schedules, and viewgraphs. From Foundation Microsystems (Mountain View, CA), the program includes drag-and-drop editing, intelligent wizards, and a zoom capability that provides chart-editing availability at all times. You can individually configure the chart symbols and use the unlimited note field for entering details about the item represented by a symbol.

Phone: (510) 814-1695.

Circle 1314 on Inquiry Card.

AUTOCAD FILE CONVERTER

An HPGL/2-to-AutoCAD file converter, HP2Design for Windows ($395) converts HPGL files to DXF, DXB, or binary DXF formats and works with AutoCAD releases 10, 11, and 12. From Tailor Made Software (Kent, WA), HP2Design has a Feature Recognition function that re-creates features such as arcs, circles, and ellipses, rather than transliterating HPGL line segments, for more compact converted files. The software also recognizes overlapping segments. A typical conversion rate on a 33-MHz 386 PC is less than 15 seconds, according to the company.

Phone: (206) 631-1513.

Circle 1312 on Inquiry Card.

SCREEN ILLUSIONS

Stereolusions ($49) from I/O Software (Cucamonga, CA) lets you turn your Windows- and Windows NT–compatible drawings and pictures into SIRDSes (Single Image Random Dot Stereograms). The SIRDSes consist of a picture containing a semi-random pattern of dots that forms a 3-D image when viewed at a certain angle on your computer screen.

Phone: (909) 483-5700.

Circle 1313 on Inquiry Card.

FONTS ON CD-ROM

The Bitstream 500 Font CD for Windows ($49.95) has more than 500 professional-quality typefaces in TrueType and PostScript Type 1 formats. From Bitstream (Cambridge, MA), the CD-ROM disc includes the Mini-MakeUp stand-alone Windows mini-application, which lets you stretch, bend, twist, color, shade, fill, and rotate text to create special effects. Mini-MakeUp can support OLE as well as standard Windows graphics file formats.

Phone: (617) 497-6222.

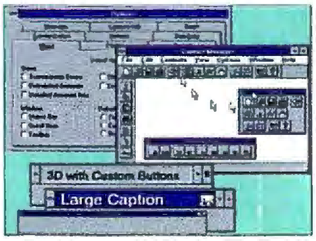
Circle 1315 on Inquiry Card.

DESIGN WITH THESE WIDGETS

A set of custom controls for Visual Basic, Designer Widgets ($129) lets you add graphical interface design elements to the applications you design. You use the Dockable Toolbar to create floating toolbars of buttons that the user can attach to the top, sides, or bottom of a Multiple Document Interface form. When the toolbars are not docked, the user can resize and reshape the palette. The Index Tabs control enables you to design efficient dialog boxes using the index tab metaphor to group collections of related options. With the FormFX control, you can customize the look of your forms by manipulating captions and borders. The Designer Widgets software is from Sheridan Software Systems (Melville, NY).

Phone: (516) 753-0985.

Circle 1316 on Inquiry Card.



Software Update

Energize 2.5, Lucid (Menlo Park, CA), supports automatic precompiled header files, reduces the size of files by 50 percent, uses automatic dependency analysis for make files, speeds up application development, incorporates compiler technology advancements, and supports the "long double" type for more precision in floating-point arithmetic. Single unit, $4250.

Phone: (415) 329-8400.

Circle 1328 on Inquiry Card.

ABC FlowCharter 3.0, Micrografx (Richardson, TX), features expanded shape palettes, an automatic alignment tool for graphics within flowcharts, improved quick-and-easy connection lines, OLE 2.0 implementation, and new keyboard shortcuts and hot keys. $495.

Phone: (214) 234-1769.

Circle 1329 on Inquiry Card.

CodeBase 5.1, Sequiter Software (Edmonton, Alberta, Canada), includes the CodeControls Windows interface designer and the CodeReporter developer's report writer. $495.

Phone: (403) 437-2410.

Circle 1330 on Inquiry Card.

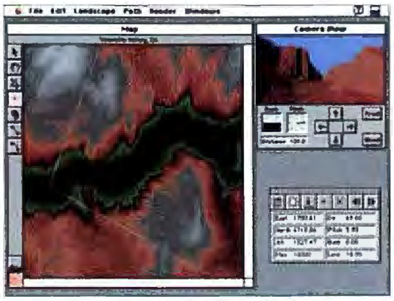
OS/N (Optical Storage for NetWare) 2.0, LaserData (Tyngsboro, MA), adds NLM optical drivers with multitasking and multithreaded capabilities, supports configurations that include a mix of 5¼- and 12-inch WORM and CD-ROM optical storage devices, provides direct connection of WORM optical drives and jukeboxes to NetWare servers, and provides server-based optical backup and automatic synchronization. From $4476.

Phone: (508) 649-4600.

Circle 1331 on Inquiry Card.

What's New Software

CREATE LANDSCAPES IN 3-D ►



A 3-D landscape-rendering software program for the Macintosh, Scenery Animator ($149) uses 3-D models from the U.S. Geological Survey to ensure accuracy when rendering pictures of scenes as diverse as national parks and a simulated lunar landscape. From Natural Graphics (Rocklin, CA), the software includes adjustable lighting, landscape color, clouds, trees, and snow level to use in creating pictures from any perspective or in drawing a flight path for animation. A built-in fractal landscape generator helps you create random landscapes.
Phone: (916) 624-1436.
Circle 1318 on Inquiry Card.

AUTOMATIC FILE INTEGRATION

Trans Plus for Windows ($225) from Intex Solutions (Needham, MA) converts most ASCII files into valid spreadsheet files and then automatically launches your spreadsheet program and opens the file in a ready-to-use format. The software, which eliminates the data-parsing procedure, supports standard ASCII text files and is compatible with most spreadsheet programs.
Phone: (617) 449-6222.
Circle 1319 on Inquiry Card.

FILE TRANSFER WITH OS/2

Net/WrkOS2 ($1495) allows you to transfer files bidirectionally and remotely execute programs across similar and dissimilar hardware platforms without doing any programming. From KnowledgeNet (Palatine, IL), Net/WrkOS2 provides seamless integration between individual PCs and LAN platforms running OS/2, as well as between OS/2 platforms and PCs or LANs running software such as Windows NT. The software uses a simple command language to operate across APPC/APPN networks and TCP/IP backbones. It supports Dynamic SQL and includes the Net/Wrk Scheduler and the API Tool Kit.
Phone: (800) 292-0127 or (708) 705-0400.
Circle 1317 on Inquiry Card.

WORK IN 3-D WINDOWS

Caligari trueSpace for Windows immerses you in a 3-D-perspective workspace where you can shape objects as if working in clay and interact with them in real time. You can make changes as you navigate around the space with a mouse and view 3-D objects from all angles by rotating, bending, twisting, molding, and manipulating them. You can create beveled metallic 3-D logos by selecting any TrueType font and typing in perspective space. The software's ray-tracing feature lets you create effects such as refractions and reflections, and you can combine textures with shadows and transparencies to add realism. You can drag objects around or use the spreadsheet-like visual time editor to create animations. You can then output the animations to videotape or save them in AVI/Video for Windows format. The program costs $795.

Contact: Caligari, Mountain View, CA, (415) 390-9600.
Circle 1301 on Inquiry Card.

SCANNING IN UNIX

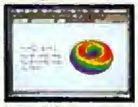
Unix software that can run on SunOS, Solaris, RS/6000, and DEC systems, Imager Desktop ($795) supports Hewlett-Packard ScanJet IIcx color flatbed scanners. From Advent Imaging (Princeton, NJ), the software lets you generate and save color images as monochrome, gray-scale, or 8- or 24-bit color at up to 1600 dpi. The program's preview mode lets you view the image before you scan it.
Phone: (609) 252-6933.
Circle 1320 on Inquiry Card.

DOS EXTENDER

A 386-based DOS extender, CauseWay for Assembly Language ($147) has an integrated linker with a morphing feature that allows it to read and use most linker scripts without modification. You can nest link-script files up to 10 levels deep. From Devore Software & Consulting (Naperville, IL), the software also includes a symbolic debugger for running programs under protected mode and a file compressor that allows you to compress DOS-extended applications by as much as 50 percent.
Phone: (708) 717-6369.
Circle 1321 on Inquiry Card.

Software Update

Mathcad 5.0, MathSoft (Cambridge, MA), offers usability enhancements; learning aids; and additional graphics, numeric functions, and DDE support. $99.95.



Phone: (617) 577-1017.
Circle 1332 on Inquiry Card.

CV Mate/Pro 6.0, Vermont Microsystems (Winooski, VT), boosts the graphics performance of Computervision's Personal Designer by as much as eight times and features productivity tools such as a Bird's-Eye View, Magnifying Glass, and Real-Time Anti-Aliasing. $295.
Phone: (802) 655-2860.
Circle 1333 on Inquiry Card.

HyperHelp 3.1, Bristol Technology (Ridgefield, CT), adds support for kanji, Frame 4.0, DEC's Alpha OSF/1 workstation, and Silicon Graphics' Indigo and Iris workstations. $5000.
Phone: (203) 438-6969.
Circle 1334 on Inquiry Card.

DP Umbrella 2.5, Vycor (College Park, MD), supports Microsoft Mail and cc:Mail, adds task dependencies associated with activities and work orders, provides equipment searches for equipment items on any number of fields, and adds a zoom feature in the Help Desk Monitor module as well as configuration options to set counters in activity, personnel, and component windows. $7995 for five simultaneous users.
Phone: (800) 888-9267 or (301) 220-4450.
Circle 1335 on Inquiry Card.

MacAnalyst 4.1, Excel Software (Marshalltown, IA), adds enhanced object-oriented design, code browsing, and reengineering capabilities. $995.
Phone: (515) 752-5359.
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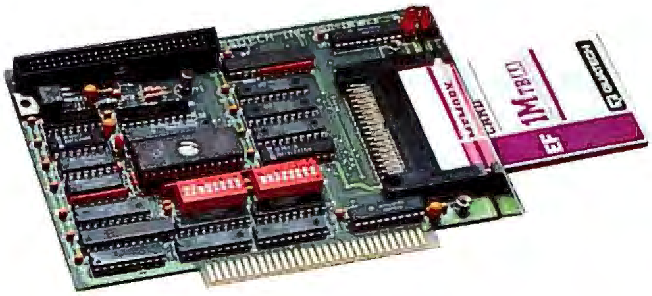

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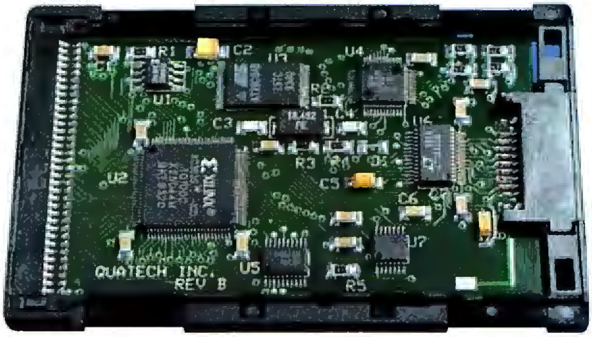

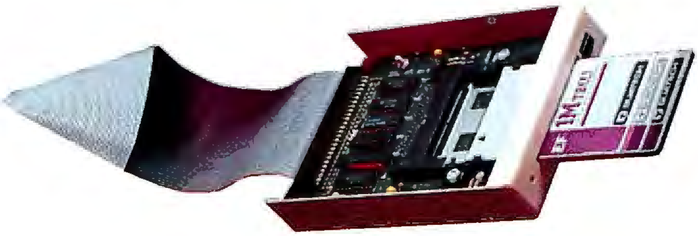

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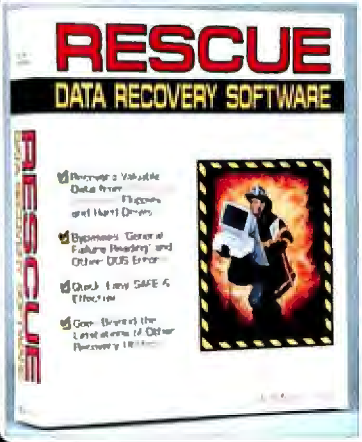

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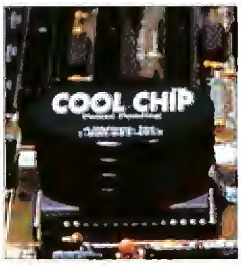

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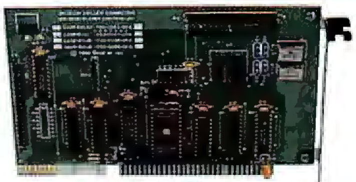

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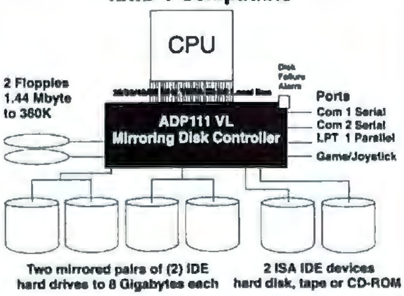

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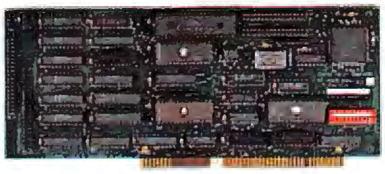

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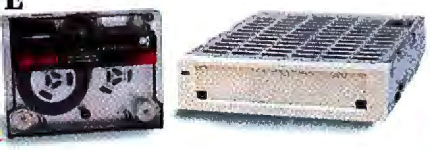

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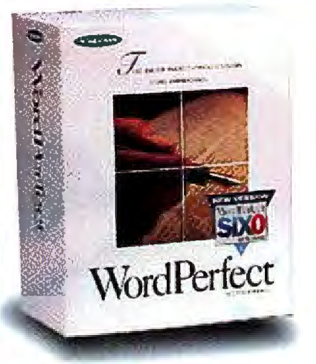

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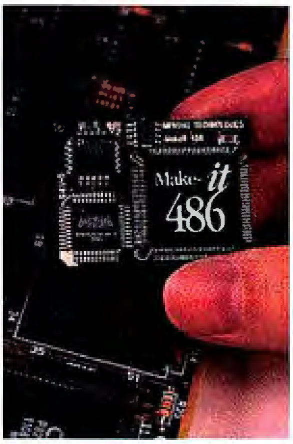

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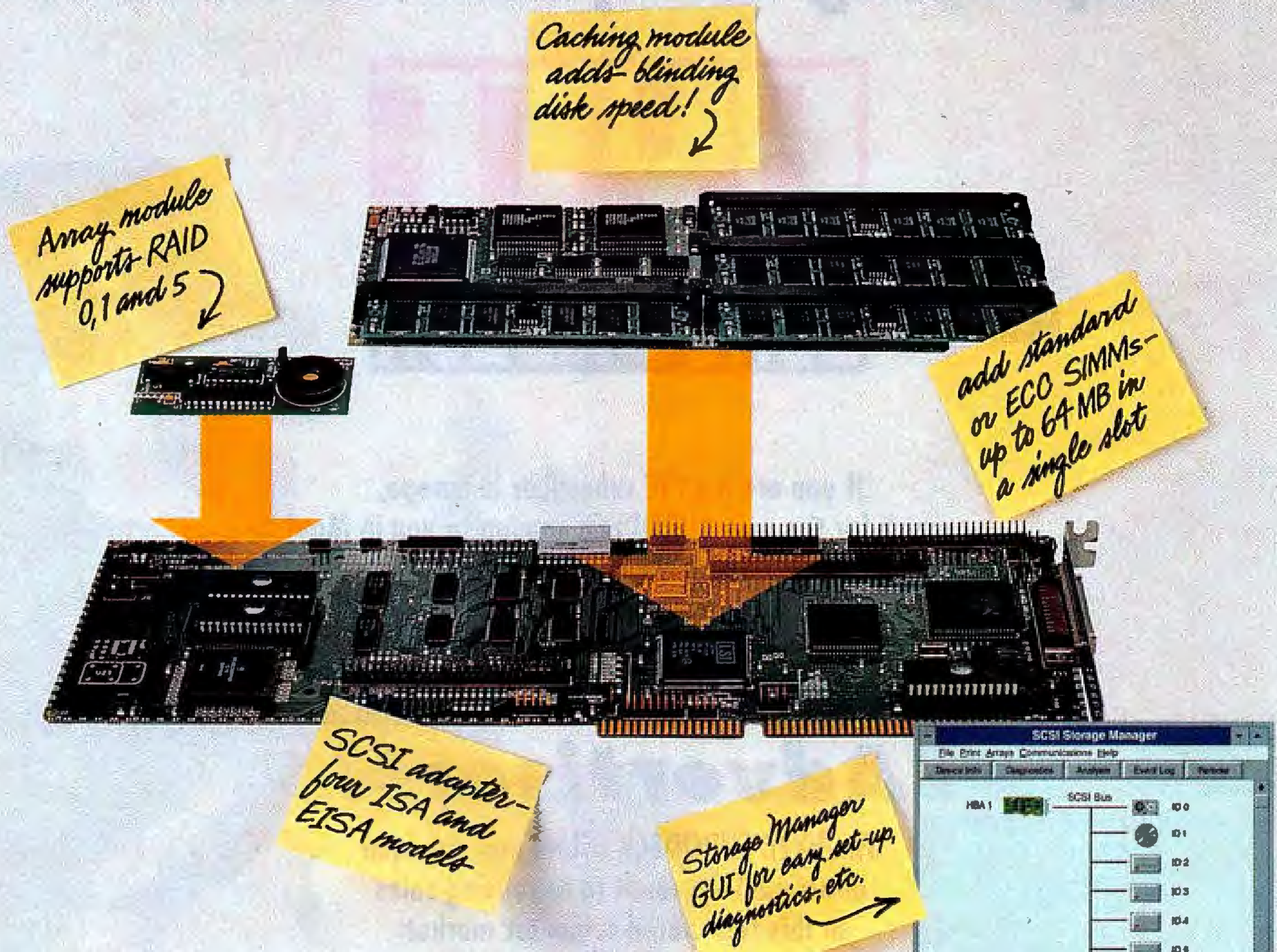

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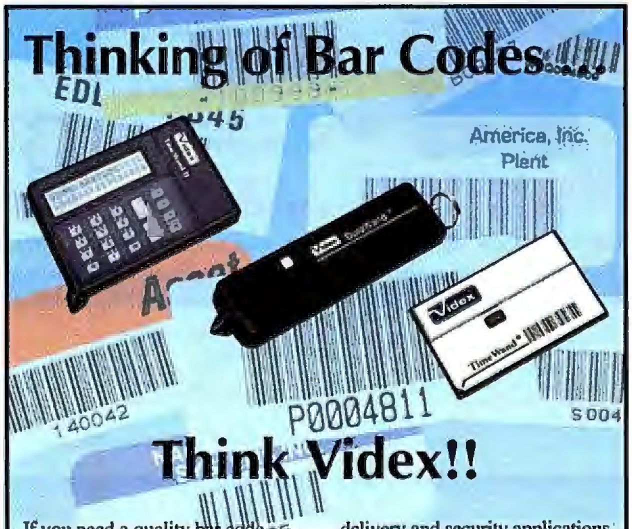

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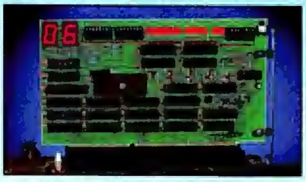

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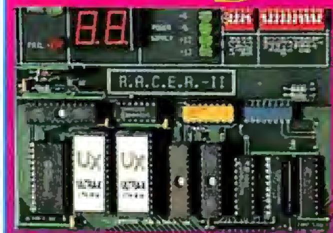
PC Diagnostics



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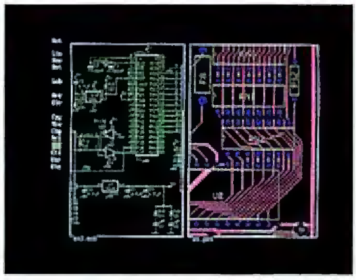

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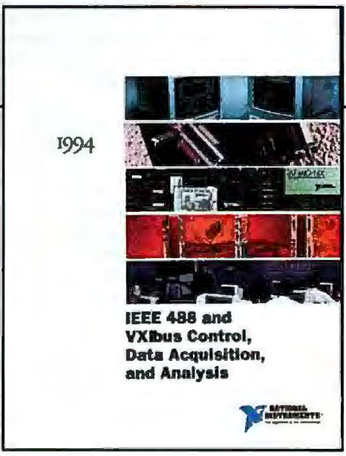

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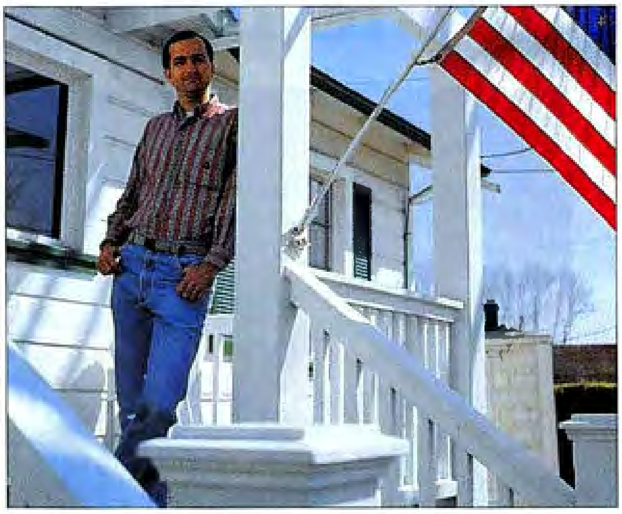
The Introversion of America

Virtual communities are no substitute for real communities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Walk through any residential neighborhood built in America over the last 75 years, and you'll notice a revealing architectural pattern: Houses erected before World War II almost invariably have large front porches, while houses that came later don't. Broad, full-frontage porches have given way to simple stoops or abbreviated entryways that are more decorative than functional.

The abrupt demise of the front porch isn't merely symbolic. It says a lot about how America has changed over the last 50 years and how new technology can significantly alter our communities and social relationships.

Consider how front porches once defined our interactions with family members and neighbors. As an external room attached to the face of the house, the porch represented an intersection between public and private life. Before air conditioning, porches were a shaded refuge on hot summer days. Before TV, they were gathering places for socializing and courting in the evenings. In urban neighborhoods, they were public parlors, inviting random encounters with passers-by. Porches were designed for a lifestyle that was fundamentally extroverted.

Over the years, that connection to the outside world has gradually been replaced with electronics that span great distances. First telephones, then radio, then TV, and now computers have changed the way we socialize, maintain relationships, and relate to our neighbors. Most recently, millions of people have started communicating with each other via computers and modems plugged into on-line networks—and soon, via the data superhighway.

The interactive networks make it possible to maintain far-flung *virtual communities* of like-minded people. In itself, this is nothing new. It's the next logical step in a long trend toward basing relationships on common interests instead of geographical proximity. In the old days, especially in rural communities, folks *had* to associate with their neighbors, because there wasn't much choice. Nowadays, modern transportation and communication free us to associate with those who share our views and interests, and that's good. But they also threaten to isolate us from our immediate communities, and that's bad.

Unlike some observers, I don't fear that the expanding bandwidth of communications will fracture us into virtual communities that are too narrowly focused. According to this argument, cable TV channels and on-line forums are growing so numerous and specialized that we won't be exposed to differing viewpoints. As viewership declines on broadcast TV networks, say the critics, we'll no longer share a common media culture. We'll lose our national identity and become so enmeshed in self-reinforcing feedback loops that we lose touch with reality.

I don't think that will happen. Sure, some people will maroon themselves on virtual info-islands, but they already do anyway. Most will be liberated by the interactivity and finely tuned narrowcasting of the new media. Whether passive lurker or aggressive flamer, you can't surf the networks for long without stumbling across a spirited debate about something that grabs your attention. Log on and see for yourself: Our virtual communities are lively places that roar with the noise of democracy.

Virtual communities are exciting and healthy, but they become a problem when they displace similar discourse in real communities. No matter how little you have in common with your next-door neighbors, you still have one thing in common: You are neighbors. If that relationship is abandoned, the real community begins to lose its cohesion, just as the virtual community unravels if everyone stops posting messages. It would be a serious mistake to sacrifice the old community for the new.

Turn off your computer, take a walk around your neighborhood, and observe how dwellings continue to evolve. Prison bars disguised as decorative grilles protect doors and windows from break-ins. Front porches have moved to the back of the house, where they're called *decks*, and become the centerpieces of backyards walled in by privacy fences. Or they're relocated within the house itself, where they're euphemistically called *family rooms* (e.g., TV rooms), thereby offering even more privacy—plus easy access to the remote, virtual neighborhoods.

At best, our real communities will become sterile and boring. At worst, they'll become hostile places where criminals fill the void of street life. Isolationism doesn't work any better locally than it does internationally, and the results can be equally self-destructive. ■

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

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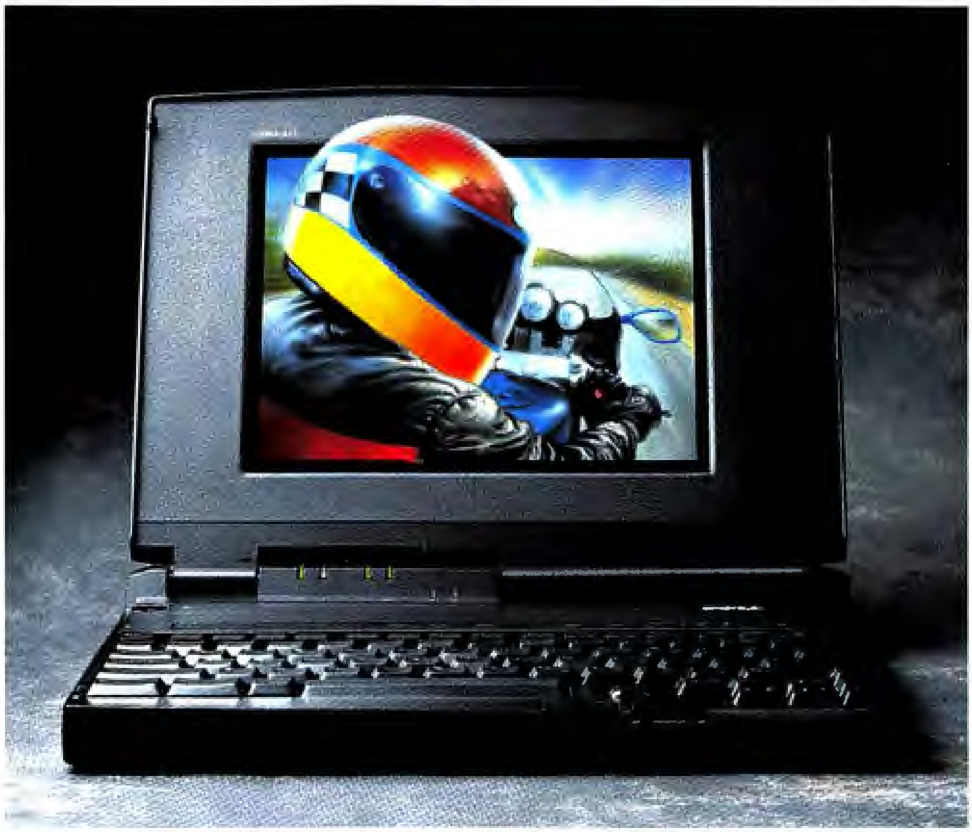

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