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SEPTEMBER 1994

BYTE

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SEPTEMBER 1994 VOL.19, NO.9

News & Views

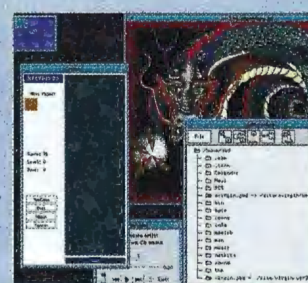
Cover Story

Features

Reviews

PAGE 151

PAGE 161



PAGE 167

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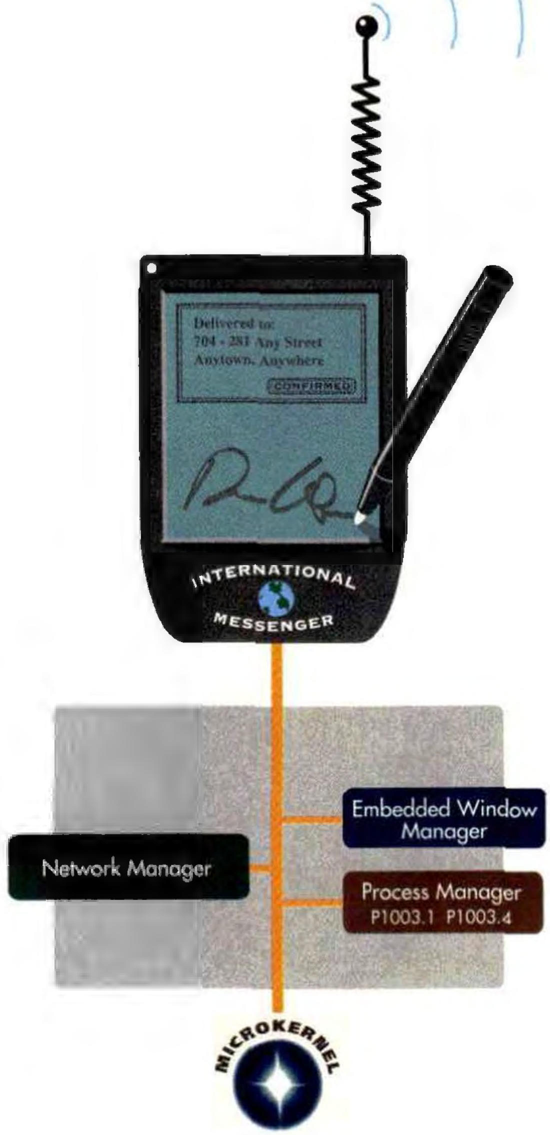

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Contents by Platform

This page presents the articles in this issue according to computing platform.

DOS/WINDOWS

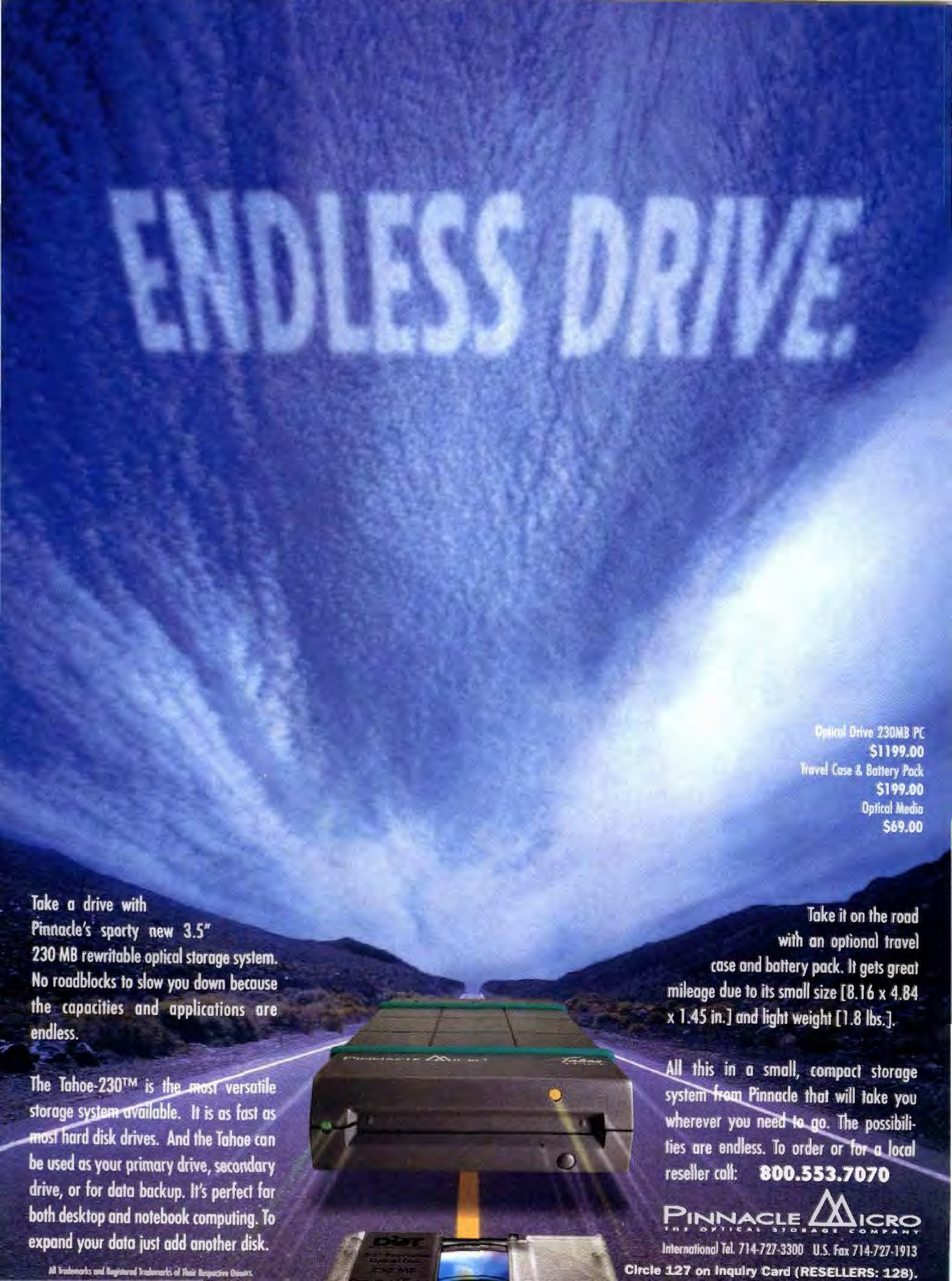
OS/2

MACINTOSH

UNIX

NETWORKS

Index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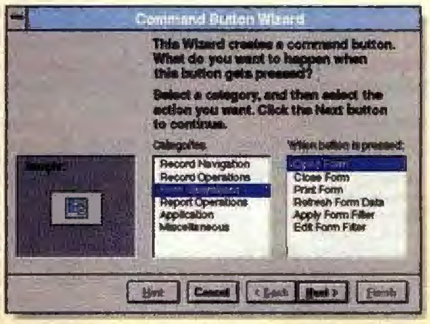

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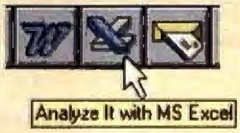

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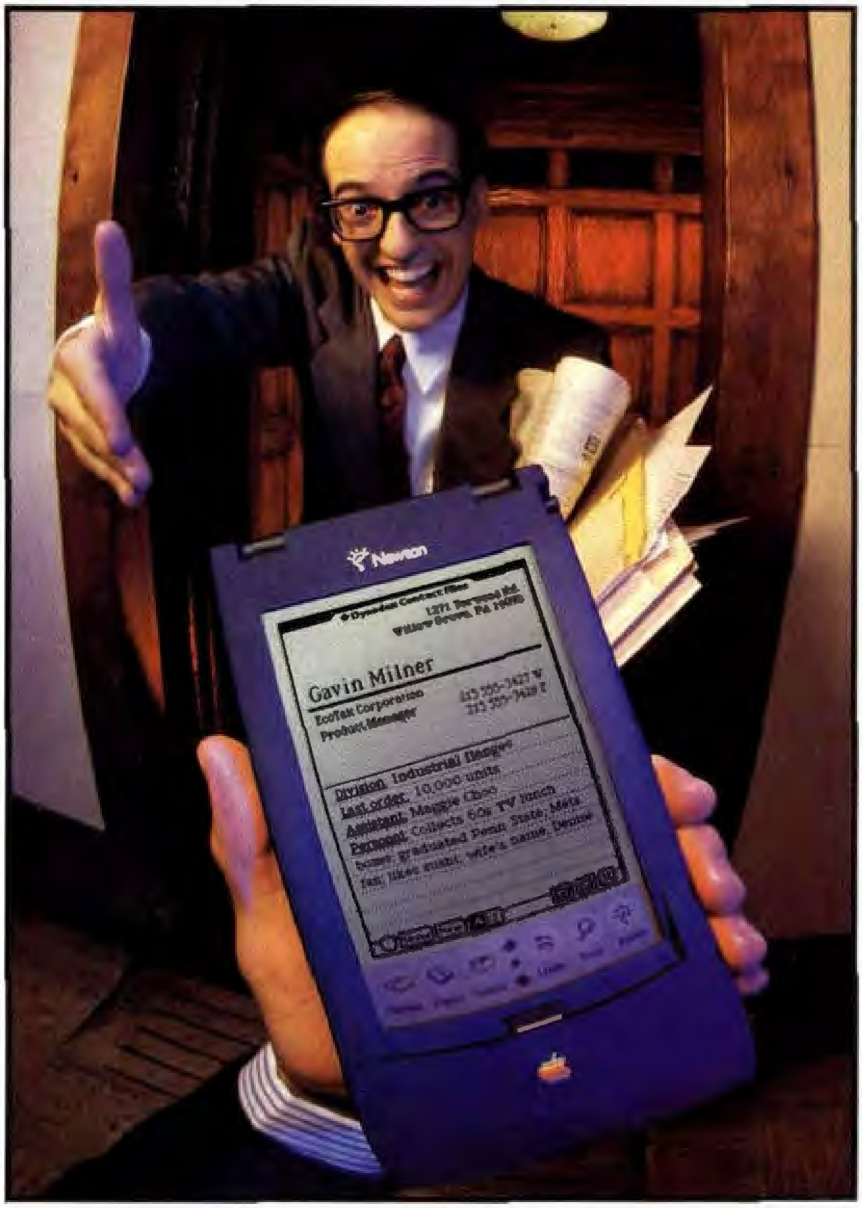

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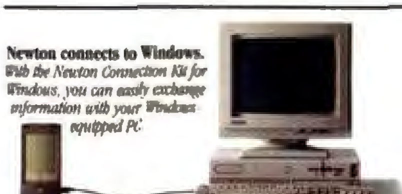
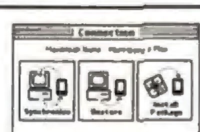
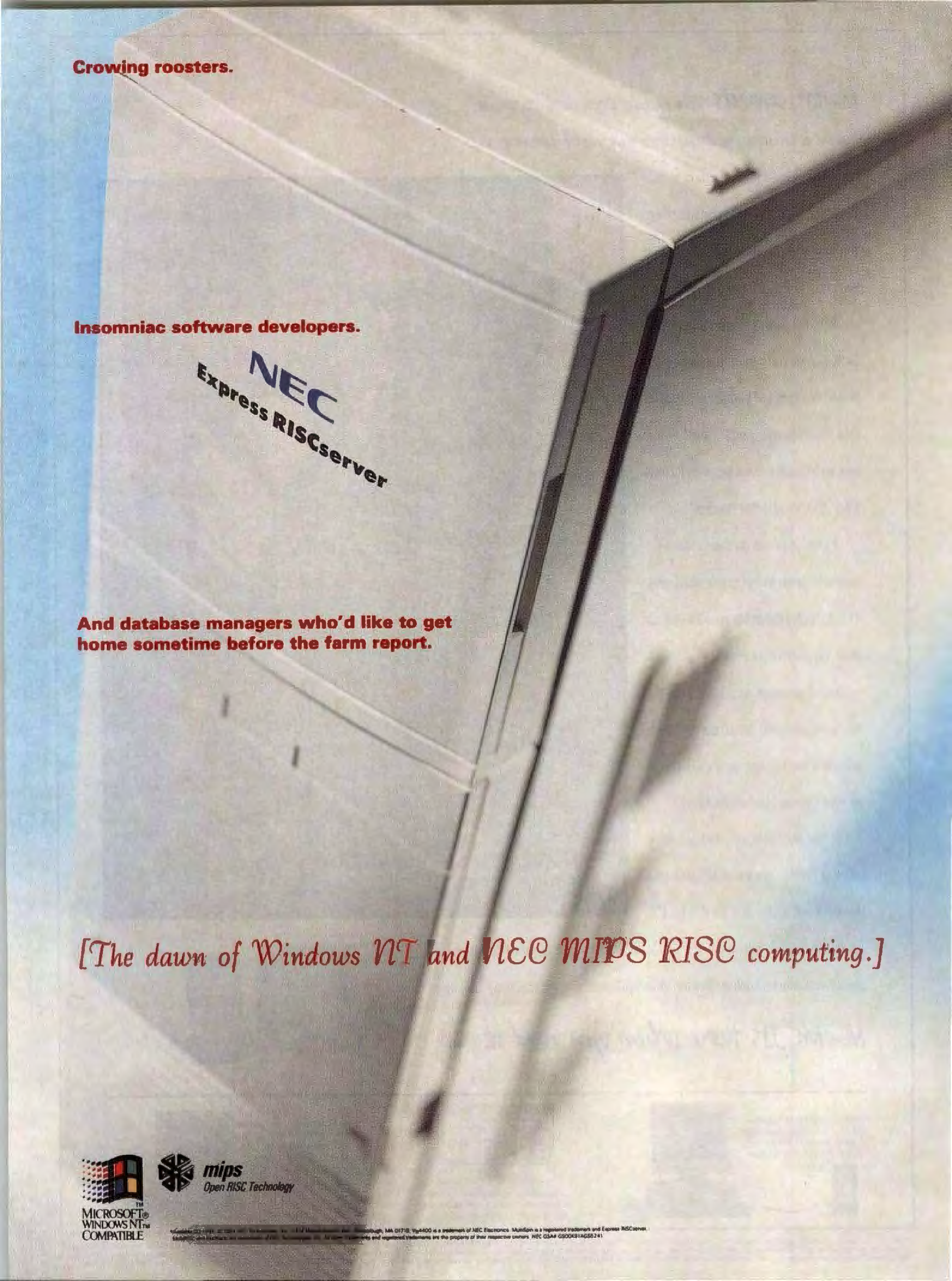


Newton connects to Windows.
With the Newton Connection Kit for Windows, you can easily exchange information with your Windows-equipped PC.



Downloading, updating and backing up information between your Newton and your computer is as easy as plugging in

Newton connects to Macintosh.
The Newton Connection Kit lets you work with your Macintosh via serial connection or your AppleTalk® network



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Plug and Play

An archaic PC architecture leaves us with the albatross of compatibility hanging from our necks

The most frequently heard phrase in the computer industry today, *plug and play*, is most often used to define what computers are not. That is a sad commentary on the state of computing, and the outlook is only a little brighter. While we all want a plug-and-play world, getting the PC platform there is not going to be a fast or easy process.

The reasons are many, and they are centered on a desire to maintain compatibility with hardware that was engineered in the early 1980s. Intel and Microsoft are leading a commendable effort to get the industry to adopt a set of standards rightly called Plug and Play. The problem, according to Tom R. Halfhill, a BYTE senior news editor and author of our cover story, is that moving to Plug and Play "won't be painless, won't come cheap, and will likely take years."

It's a move in the right direction, and there isn't anything particularly wrong with the Plug and Play standard—it's probably the best it can be, given the archaic PC architecture it must support. The problem is that if the transition will take years, perhaps moving to another platform altogether might make more sense.

Ah, but market demand is fickle, and as Halfhill points out, previous attempts to move to a plug-and-play kind of world with Micro Channel architecture and EISA have, more or less, failed. It occurs to me that in this sea of change, we're all aboard a boat going nowhere, and we have the albatross of compatibility hanging from our necks.

It is no longer clear to me why we must be so intent on clinging to an ideal notion of compatibility with a PC architecture that was introduced over 10 years ago. What happened to the revolution? Instead of forging ahead, we've become content with what we once saw as the fallacy of mainframes: the failure to embrace change.

Once, legacy systems referred to the mainframes and minicomputers in the data-processing center. Today, though, the real legacy systems are the PCs on our desks running DOS and Windows—including those 66-MHz 486s and Pentiums you just bought. In the end, those systems are still defined as fast, albeit very fast, IBM PC clones.

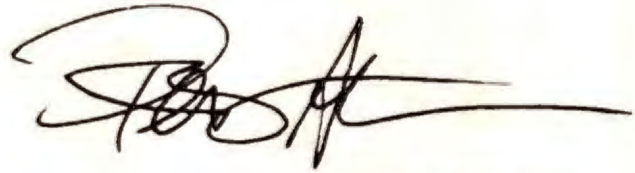
Working with PC clones in 1994 is like steering a 12-meter yacht to the moon—sure it's a fast, complicated boat, but it doesn't do well out of the water. With PC clones, you are still stuck with 640-KB limits, patchwork IRQ (interrupt request) and port management, device-driver hell, and error messages that no user should ever have to experience. Why do we tolerate this misery?

Many reasonable people will argue that software distribution in an enterprise would be impossible without adherence to so-called PC compatibility. Nonsense! Software distribution across networked computers is, for all practical purposes, already impossible. Ask people in large organizations, and they'll tell you war stories of trying to upgrade software across their networks. Even when everyone on a network uses the same brand and model computer and the same operating system, the configuration files, device drivers, additional memory and hardware devices, and even the lowly AUTOEXEC.BAT files can differ wildly. Where's the compatibility in that?

To Intel's and Microsoft's credit, the Plug and Play standard is at least a realistic approach to a market enthralled by the IBM PC standard. The problem is that, at best, it will take years for Plug and Play to significantly change our world for the better. By that time, the IBM PC standard will be even more outdated.

It seems to me that there is a vacuum where a computer industry vision ought to be. It's high time to cut loose this albatross of compatibility and sail ahead. Computer companies say rhetorically they're giving customers what they want. I say, give us what we need, platforms that break with the past. We need systems that don't make us wait for graphics, systems fast enough to deal with the complex issue of real human interfaces, and systems that plug and play into where we're going, not where we've been. ■

I would like to welcome the newest member to the BYTE family, BYTE Middle East, an Arabic-language edition that will be distributed throughout the Middle East and Arabic-speaking North Africa.



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Comparison Facts

End-user Features	Paradox 5.0	Access 2.0
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Integrated graphics	✓	
Built-in workgroup and mail capabilities	✓	
Quick Filter without Query Process	✓	
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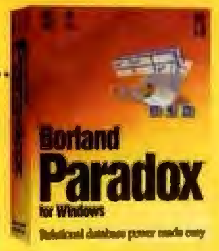

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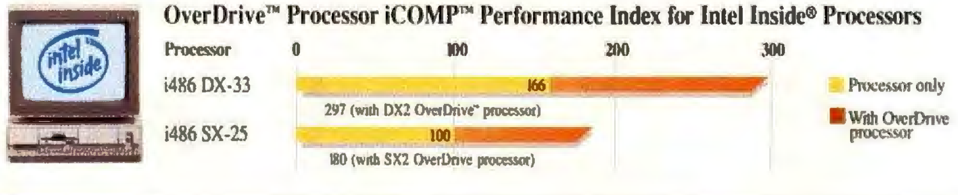

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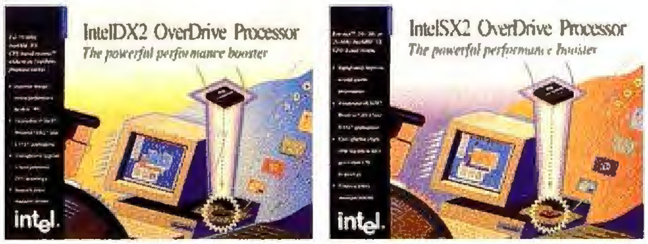

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Global Opportunities

I spent the first three months of 1994 developing software in Russia. Everything I saw confirms Edward Yourdon's view in "Developing Software Overseas" (June). The Russian programmers on our team were among the brightest I've ever met. They showed a hunger for American technology that neither the American and British team members had ever seen before. Today, few Russian firms can afford to purchase new technologies. Even if they could, they would wait months to legally bring equipment into the country or else depend on "friends." Building ground-breaking systems in developing nations expands our markets—the pie is getting bigger, and American firms can enjoy a sizable slice by actively promoting its growth.

Steven Glickstein
New York, NY

What's in a Number?

L. Chris Miller's article "Transborder Tips and Traps" (June) is interesting but inaccurate when referring to U.K. practice. She claims a billion refers to "1 followed by 12 zeros." The statement, "Therefore a BBC announcer says 'one-thousand-million dollars' where an American would say 'one billion dollars,'" is untrue. We have followed American practice for at least 20 years. Today's *London Times* talks of a U.K. public sector borrowing 4 billion pounds, without needing to explain that this means 4,000,000,000. She also said, "Apple's Trashcan icon, for example, looked like a postal box to British Macintosh users." I know, however, that although I find the word *Trashcan* jarring, the icon looks like a slightly old-fashioned dustbin of the sort inhabited by Top Cat.

Graham Asher
London, U.K.

We called the British Consulate in Boston, Massachusetts, to ask for the official value for one billion in the U.K. Representatives there responded that Miller is correct: Officially, in the U.K., one billion is a million million, whereas in the U.S., one billion equals a thousand million. Unofficially, practice does vary.—Eds.

No Favoritism Here

Your article "Accelerating Engineering Design" (July), which discussed a Formtek implementation at Lockheed, left out the salient point that Formtek is a wholly-owned subsidiary of Lockheed. The article is misleading in that it never mentions that Lockheed, in effect, awarded the contract to an in-house vendor.

David Hurwitz
San Jose, CA

You are correct when you state that Formtek is a wholly-owned subsidiary of Lockheed. My research confirmed the special relationship between the two companies but revealed that procedures for such internal procurements are more stringent than for arms-length transactions. But given that the effect of the Formtek-Lockheed relationship was to complicate—rather than simplify—the contract award to Formtek, in hindsight, I agree. This relationship should have been made clear.—S. Wallace

Not Socialist, Just Equitable

Andy Reinhardt's July Commentary is an example of socialist dogma, which has no place in a world that is abandoning those unproductive concepts. The federal government is capable of massive projects, but it is incapable of setting technical specifications (e.g., it has only recently acknowledged TCP/IP—instead of OSI [Open Systems Interconnection]—as an approved networking protocol for federal projects).

Resources on the Internet should be accessible, not free. Reinhardt fears that the cost of accessing the data highway may be "prohibitive for some" and that you and I should bear this burden. He also states that using the data highway may become an "essential aspect of citizenship" and thus must be made available to everyone, regardless of their means. He offers no solution but speculation and conjecture. I, for one, am tired of those who would reallocate my resources without first specifying with particularity any benefits.

Eric Seggebruch
Ho-Ho-Kus, NJ

My take on the government's involvement in the information superhighway is that it should follow the model of the interstate highway system. The government built the roads, and anybody with a truck, car, or motorcycle can use 'em. Free. When you stop off at the diner, you pay for the meal.

Terry Friedrichsen
Tucson, AZ

Reinhardt's call for "social control" of electronic communications would be nothing more than amusing drivel, if not for the fact that there are people in positions of power who would love to implement such a program. Reinhardt declares that "by granting such a huge opportunity for power and profits to the private sector, we have a right as a society to demand, in return, conformance..." But "the private sector" simply means individuals. And "we" do not exist "as a society"; we exist only as individuals. In Reinhardt's statist utopia, those who have the means to access the Internet will be forced to subsidize those who don't. Why is anyone entitled to a modem at my expense? Because unproductive people have a "right as a society to demand" it of me? Such a demand has all the legitimacy of a mugger's "right" to my money.

Gary McGath
Hooksett, NH

I reject the notion that my Commentary was "socialist dogma" or called for a "statist utopia." To the contrary, while I would prefer a data highway along the lines of what Friedrichsen proposes, I recognize the implausibility of a public resource in this era and support instead a private model. That we should aim for inexpensive basic service is by no means a radical notion: Cross-subsidies have been a fundamental tenet of telecommunications law since the 1930s.

I didn't propose free modems, just as today we don't have free phones or phone service. And I never proposed that the government regulate the content of data-highway traffic. Rather, I asked that the government not abandon its historic responsibility to ensure equity and

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freedom of expression, as it does now for the phone and cable systems. The data highway could turn out to be an open resource that enhances the democratic process or a closed oligopoly that exploits consumers and codifies majority values at the expense of minority ideas and people. I'm hoping for the former. —A. Reinhardt

Forecasting: Criticizing the Criticism

I was delighted that you included SmartForecasts in your review "Forecasting the Future" (June). However, in saying the program "lacks a convenient way of holding out data to verify forecasting accuracy," it's clear Stewart missed the concept of sliding simulation, the process we use to measure forecasting accuracy. Maybe our problem here is that this calculation is automatic; the user doesn't have to ask for it. He also said our Eyeball program "does not document the manual changes made in the forecast graph." However, we do document both on the graph and in the forecast data table that the changes resulted in a "manual" forecast.

Charles Smart
President, Smart Software, Inc.
Belmont, MA

Jerry Quenches Windows Envy

For the last few months, BYTE has taken a much more technical turn that I greatly appreciate. The Core Technologies section is particularly good. I am also pleasantly surprised by your June issue. Jerry Pournelle's column abounds with IRQ (interrupt request) problems, addresses that should be DEFF and not DC00, mixed up DMA channels, incompatible clones, and buggy software. Each month, just reading Jerry's masterful solutions to all this mess is enough to quench any Windows envy I could have. And people think Unix is difficult? Come on! X-Windows is *simple* compared to Microsoft Windows!

Frederic Mora
Montpellier, France

Popular, but Unacceptable

It's been some time since the Comdex Show in Atlanta, and now it's time to say something. The whole week was great, except for one thing that cast a grim and sleazy shadow on the show: porn CD-ROMs. I have no problem with personal freedom and liberty and the right to watch most anything a person wants, but do we really need this shoved in our faces at Comdex? Not only is cutting-edge consumer technology being used as a slime scoop, but the aisles are getting clogged with fish-eyed guys who want a long look.

Brent Carter
Jamestown, NC

The Interface Group announced on June 9th that it is excluding the display of all nudity and sexually explicit material from its trade shows. Quoting its press release, "such material has clearly caused offense and is therefore not in the best interests of the shows."—Eds.

Licensing Encryption

I appreciated Russell Kay's article "Distributed and Secure" (June). But I disagree that Philip Zimmermann's PGP (Pretty Good Privacy) encryption software is illegal because it uses the RSA algorithm without a license. Not all unlicensed use of patented software necessarily violates a patent holder's rights, which is what I assume Kay meant by the term *illegal*. Also, ViaCrypt sells a commercial use version that is—and always has been—licensed. The noncommercial version (2.6) is now available on an MIT server and is licensed. What's important is that licenses are available for commercial and noncommercial versions of the standard-setting PGP.

Curtis E. A. Karnow
San Francisco, CA

At the time I wrote the article, PGP 2.6 had not yet been announced. I was aware of the ViaCrypt product (I mentioned in the article that one of the people I quoted had bought and was using ViaCrypt), but I had no specific information about its operation and did not realize it was an "authorized" (I almost said "legal" but that's another issue, as you correctly point out) version of PGP. What I did know was that I had read a number of statements attributed to RSA president Jim Bidzos to the effect that PGP was totally unauthorized and there was no licensed version. I'm pleased to hear the licensing issues have since been resolved and an RSA-sanctioned noncommercial PGP is available for general use.—R. Kay

Fixes

In "Observing the Conventions" (June, page 96), the U.K. convention for dates should have been in the day/month/year format, not month/day/year.

In our review of Hewlett-Packard's new workstation, the pricing (July, pages 161 and 162) for the HP 9000 Series 700 Model 712/60 workstation, as tested, with 64 MB of RAM, a 20-inch monitor, and a 260-MB hard drive, should have read $12,250.

Due to a copyediting error, in "A Taligent Update" (July, page 183), IBM's OS/2 Presentation Manager was incorrectly attributed to Microsoft.

In the News & Views article "Kurzweil Brings Voice Dictation to Windows" (August), the telephone number for Kurzweil Applied Intelligence (Waltham, MA) is incorrect. The correct number is (800) 380-1234. ■

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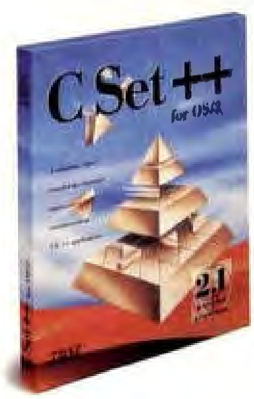

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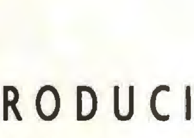

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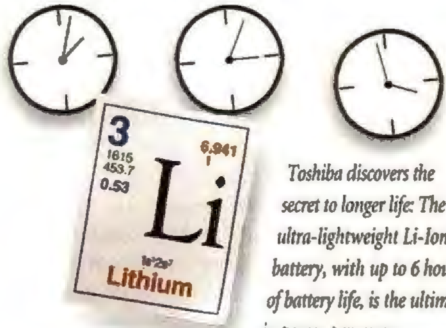

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News & Views

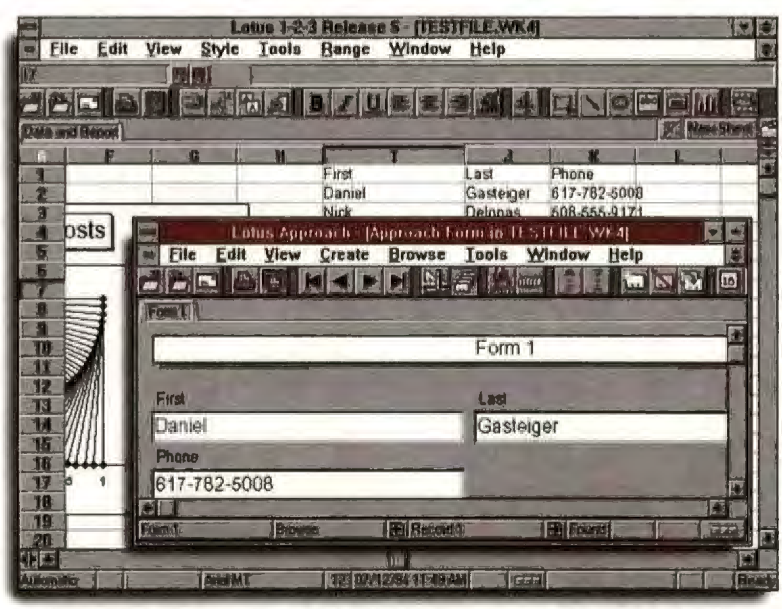
WINDOWS APPLICATIONS SUITES

Into the Enterprise

New software releases by Lotus and announcements by Microsoft and WordPerfect reflect the different strengths and directions of each company

DANIEL GASTEIGER AND RICK DOBSON

Recalculation speed, macro-language enhancements, and ease of use will always be important considerations when evaluating spreadsheets as stand-alone applications. However, Lotus 1-2-3, Microsoft Excel, and Quattro Pro (which was recently acquired by WordPerfect) are increasingly being sold in software suites and must be judged by how well they work with their brethren word processing, database, presentation, and network applications.



Lotus 1-2-3's reliance on Approach for added database management functionality is both a blessing and a curse. If you don't have SmartSuite or at least Approach, then you can't effortlessly generate fill-in-the-blanks data-entry forms, like the one shown here, on top of the worksheet that contains its associated database.

A case in point is the new 1-2-3 release 5 for Windows, which Lotus expects to release by the end of August. As a stand-alone spreadsheet, the new 1-2-3 feels more like a release 4.5. But as part of the new Lotus SmartSuite 3.0 for Windows, which is slated to ship by the end of September, the release 5 designation will seem valid to people who want more database management power and integration with Lotus Notes. Four applications in the new SmartSuite—1-2-3, Approach 3.0, Ami Pro 3.1, and Freelance Graphics 2.1—have been upgraded to take advantage of Notes/FX 1.1 (the FX stands for Field Exchange). This technology lets users share information from their Lotus desktop applications throughout an enterprise via Notes.

Recent developments at Microsoft and WordPerfect emphasize the importance of group collaboration in the office-suite category. By the time you read this, Microsoft should have released updates of Word, Excel, and PowerPoint for Windows that provide Notes/FX support. The company also says its office applications will support the Microsoft Exchange Server software for information sharing and electronic messaging. Microsoft Exchange Server, which is expected to ship in 1995, will provide an integrated messaging, scheduling, and management infrastructure for applications, company officials say.

New features planned for WordPerfect's new PerfectOffice 3.0 suite for Windows, which is slated to ship this fall, reflect the company's recent merger with Novell. Features made possible by the suite's integration with network and workgroup services will include the ability to install and update software across a network; client software for integrating with Symmetry, WordPerfect's E-mail, calendaring, and scheduling program; and support for workgroup publishing via the inclusion of WordPerfect Envoy.

When Lotus releases SmartSuite 3.0 for Windows, the package will not have a cross-application scripting language comparable to that of the Applications Edition of Microsoft's Visual Basic. But the new suite offers much stronger ties to Notes. Lotus 1-2-3 release 5 offers three levels of Notes interaction: Notes/FX; the NS4 file type; and a Notes ODBC (Open Database Connectivity) driver.

Through Notes/FX, 1-2-3 users can exchange application- and user-defined data to automate front-office processes and collaborate on forecasting and budgeting. *Application-defined data* refers to information about

Integration Strategies: Lotus vs. Microsoft vs. WordPerfect

SmartSuite:	Shares data and functions such as mailing-label generation and dynamic cross-tabs between desktop applications.
Office:	Shares data between desktop applications.
PerfectOffice:	Will share data between desktop applications.
SmartSuite:	Has ODBC and Notes/FX links to Notes, in addition to custom links from 1-2-3 and Approach.
Office:	Has ODBC connectivity to Notes in Excel and Access; will have Notes/FX connectivity to Notes in maintenance releases of Excel, Word, and PowerPoint.
PerfectOffice:	Will have ODBC links to Notes in Quattro Pro, Paradox, and WordPerfect.
SmartSuite:	A common macro programming language and a full-fledged implementation of the OLE 2.0 standard are due in 1995.
Office:	Has common programming languages for building custom integrated applications with OLE automation.
PerfectOffice:	A new PerfectScript allows cross-application programming and macro recording.
SmartSuite:	Has common SmartIcons, menus, and dialog boxes across 1-2-3, Ami Pro, and Freelance.
Office:	Has common icons, menus, tools, and dialog boxes across desktop applications.
PerfectOffice:	Has common icons, menus, and dialog boxes across desktop applications.

a file such as its author, size, creation date, revision information, and number of worksheets. A new Doc Info dialog box lists most application-defined fields, and information you store via the Doc Info command becomes available to users with whom you store worksheets via Notes.

User-defined fields in 1-2-3 refer to worksheet cells. When you embed a release 5 spreadsheet in a Notes document, you can specify those cells whose contents are to become available to Notes as fields. Changes made in a spreadsheet can affect the associated Notes database, and vice versa. Approach 3.0 can also publish database fields and application-defined data to Notes databases.

The NS4 file type enables multiple users to display and modify range values of a spreadsheet without overwriting each other's work. People can work on a file, store it locally, and, through Notes' replication facility, update and merge information in a central Notes database. NS4 files also support Notes' security, so administrators can manage the way that NS4 files are merged into Notes.

The third way to integrate 1-2-3 (as well as Approach) with Notes is through the ODBC driver for Notes SQL, which lets you work directly with Notes data on your desktop.

Interacting with Notes is only part of the new 1-2-3's interoperability story. Lotus 1-2-3 uses OLE to borrow capabilities in Approach. A new Tools Database Form command lets you create custom forms to input, edit, and search for data in 1-2-3 databases. An Assistant guides you through the form's creation. Other Assistants help you build database reports using Approach and access Approach's mailing-label facility.

For stand-alone users of 1-2-3, the most dramatic addition to release 5 is Lotus Maps, which lets you associate maps with your geographic data. A much-improved Print Preview mode lets you view more than one page at a time.

When choosing your office suite, your best choice will depend on your commitment to key applications. Organizations with a heavy emphasis on Notes will find the special hooks in 1-2-3 and Approach strong incentives to choose Lotus SmartSuite. Those with a commitment to Visual Basic will appreciate the power and ease with which they can cobble together applications in the current Microsoft Office suite using Visual Basic for Applications and OLE automation. The jury is still out on PerfectOffice, but with WordPerfect's acquisition of the Quattro Pro spreadsheet and 1 million licenses of Borland's Paradox database for Windows, the company has served notice that it has no intentions of being just an also-ran in this product category.

LASER PRINTERS

Color Laser Moves Toward Mainstream

Color laser printers for under $5000 may sound like science fiction, but the reality may be appearing in offices soon. Last year, QMS's ColorScript Laser 1000 shattered the previous $30,000 price barrier with its $12,499 price tag. Office personnel who once thought color was only for print shops could now produce color-enhanced documents and transparencies in-house. Now other companies are following QMS's aggressive pricing.

Grady Yarbrough, senior product manager at QMS, sees the beginning of a broader market for color laser printers, where customers will want to replace older laser printers. Eventually, Yarbrough foresees, color lasers will dominate the color market due to their high quality, ability to print on any paper, and lower cost than dye-sublimation printers. But he also thinks many customers are waiting for the price to drop below $5000.

George Mulhern, marketing manager of HP's Advanced LaserJet Operations, says "the HP Color LaserJet Printer with 300 dpi will list for under $7500 and have consumable prices at about the same rate as [those for] the HP ColorJet 1200C." HP says it will announce a target release date for the Color LaserJet in mid-September. The company says the printer will target everyday business printing.

Xerox's product manager for Workgroup Color Printing, David Kwiatkouski, sees two markets for his company's $8495 4900 color laser printer. The first is "offices that already use color but want to switch from minutes-per-page [i.e., dye sublimation] to pages-per-minute technology." The second is companies that want to bring all their color work in-house.

Greg Porell, director of Color Imaging Products and Service for market-analysis company BIS (Norwell, MA), is not as optimistic as the color printer companies. "Users want color but aren't really willing to pay much for it. Inexpensive, color-jet printers are very popular," he says.

Porell says that, for the short term, color laser printers will remain a small market, primarily for short-run color illustrations and spot color. Farther down the road, Porell believes that breaking the $5000 color laser printer price point is important but that "speed, not price, will open up the broader market for color laser printers."

—Steven J. Vaughan-Nichols

Color Laser vs. Color Ink-Jet

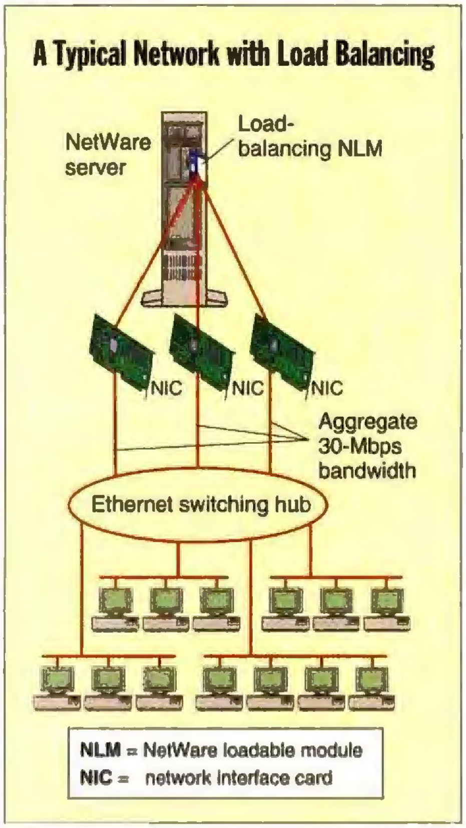
	Color Laser	Color Ink-Jet
Initial cost	$7500+	$500+
Consumables cost	>$150	>$130
Pages per minute	2	1
Resolution (dpi)	300-600	300-720
Production quality	High	Medium

Today, color ink-jets clearly are best for occasional color users, but serious color users will find that color laser printers work better. In the future, as prices drop, lasers will broaden their appeal. "Production quality" refers to the printer's ability to produce multiple excellent-quality copies. "Consumables cost" refers to cost per 1000 copies, 5 percent of which are color.

News & Views

NETWORKS

Load Balancing's Inexpensive Performance Boost



Load-balancing software running on a server balances traffic to and from numerous Ethernet LAN clients, while an Ethernet switching hub is used to direct traffic between the server and the appropriate LAN segment.

As client/server computing becomes more common, network servers need to handle an ever-increasing number of I/O requests from client PCs. As networks grow, the bottleneck that limits network performance is most often associated with passing data between the server and the network over an Ethernet connection.

Network administrators trying to minimize this bottleneck have had several solutions to choose from. One is to upgrade the client and server machines to higher-speed networks, such as FDDI (Fiber Distributed Data Interface) or 100-Mbps Ethernet. Another option is to move the servers to high-speed networks and connect them to LAN segments with either routers or Ethernet-switching hubs. A third option, called *load balancing*, offers a cost-effective way of handling the traffic that passes between a server and the rest of the network.

As the term implies, load balancing "balances" the traffic between a server and a network over multiple network adapter cards. Load balancing requires a bridge or Ethernet switch between the server and the clients (see the figure at left) and software running on the server.

For servers running NetWare, load-balancing software comes in the form of an NLM (NetWare loadable module), such as Balance.NLM from Network Specialists (Lyndhurst, NJ) or Switch.NLM from Kalpana (Sunnyvale, CA). As adapter cards are added to the server, the throughput increases proportionally. A typical load-balancing solution can increase the aggregate bandwidth between the server and clients from 10 Mbps to 20 or 30 Mbps via the addition of one or two Ethernet adapter cards in the server.

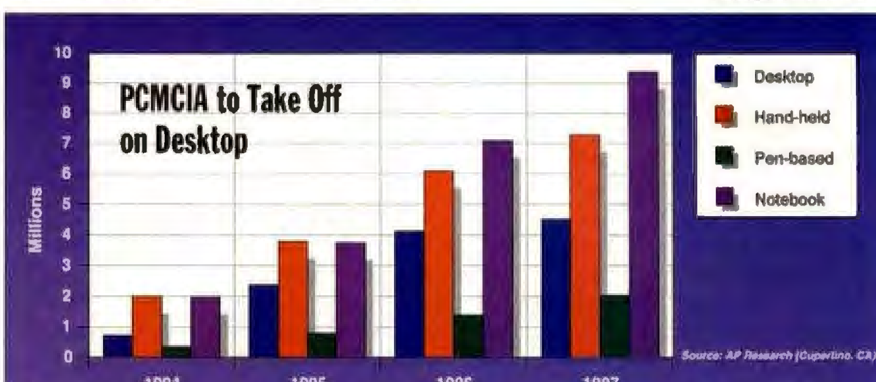
In addition to adding bandwidth, load balancing provides a level of fault tolerance. If one of the network adapter cards or network cables fails, traffic between the server and the network is simply passed to the other connections. That's in sharp contrast to the total disruption of traffic flow that takes place when a single high-speed connection linking a server to a network fails.

When does the performance enhancement from load balancing save money compared to moving to higher-speed LAN technologies such as FDDI and fast Ethernet? Surprisingly, the answer is simple if the server uses an Intel 486-class CPU. A 486-class server running a mix of common word processing, database, and file transfer operations in NetWare can deliver only about 20 Mbps, according to the results of an Infonetics Research (San Jose, CA) server-bandwidth congestion test that compared Ethernet switching/load balancing, fast Ethernet, and FDDI.

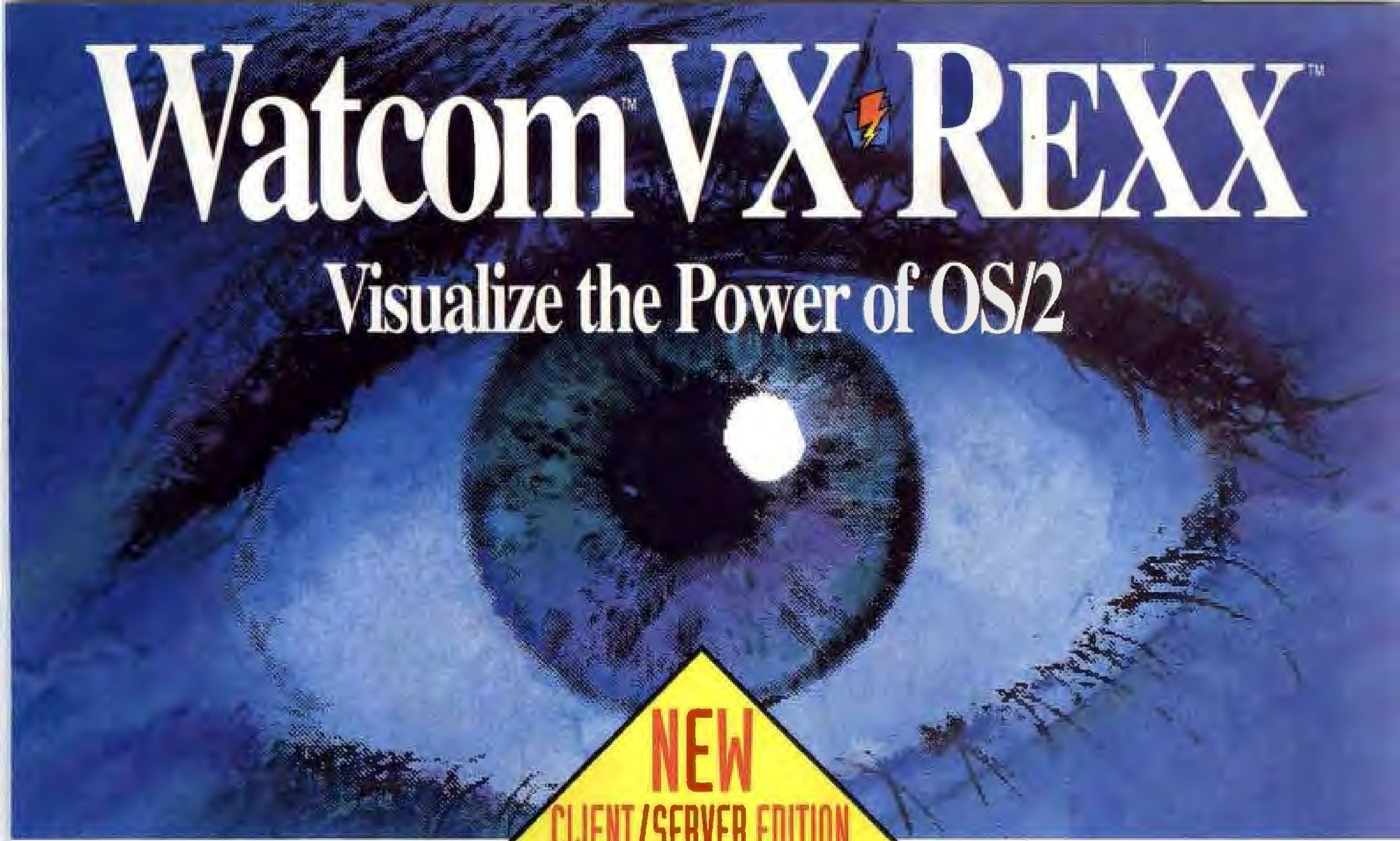
For the most common NetWare environments with 486 servers, that means load balancing with Ethernet switching is a practical, cost-effective choice, according to Michael Howard, president of Infonetics. The Infonetics study also determined that when a network server is upgraded to a Pentium-class CPU or better, then the processor is no longer the limiting factor. Howard says that for more powerful servers (i.e., Pentium or better) running a mixture of client/server applications, an upgrade to 100-Mbps technology will likely be needed.

Such sentiment is echoed by switching-hub vendors, who will most likely play a role in all three scenarios. "In the short term, multiple [network interface cards] are the best solution today, because [this approach] lets you use inexpensive 10Base-T Ethernet cards and gives you a degree of fault tolerance," says Jim Goede, product marketing manager at Lannet (Irvine, CA). "Down the road, you will see people moving to 100Base-T or FDDI to connect servers to the network."

—Salvatore Salamone



Although PCMCIA slots are not prevalent on desktop PCs now, many PC vendors and analysts expect them to become much more common on the desktop for a variety of reasons: easy exchange of I/O cards and data among portable and desktop PCs; PCMCIA's small form factor, which makes for smaller-footprint desktop PCs; lower power consumption; and easier swapping of peripherals. "PCMCIA is also happening on the desktop because people want to be able to use the cards that they bought for their notebook," says Jack Peterson, director of marketing at SCM Microsystems (Los Gatos, CA, (408) 395-9292), a company that plans on announcing products later this year that combine traditional I/O devices with PCMCIA. Martin Shan, product manager for DEC's PC MTE family of desktops that feature an optional PCMCIA slot, notes that PCMCIA peripherals are currently more expensive than their ISA counterparts but says those prices are already dropping.



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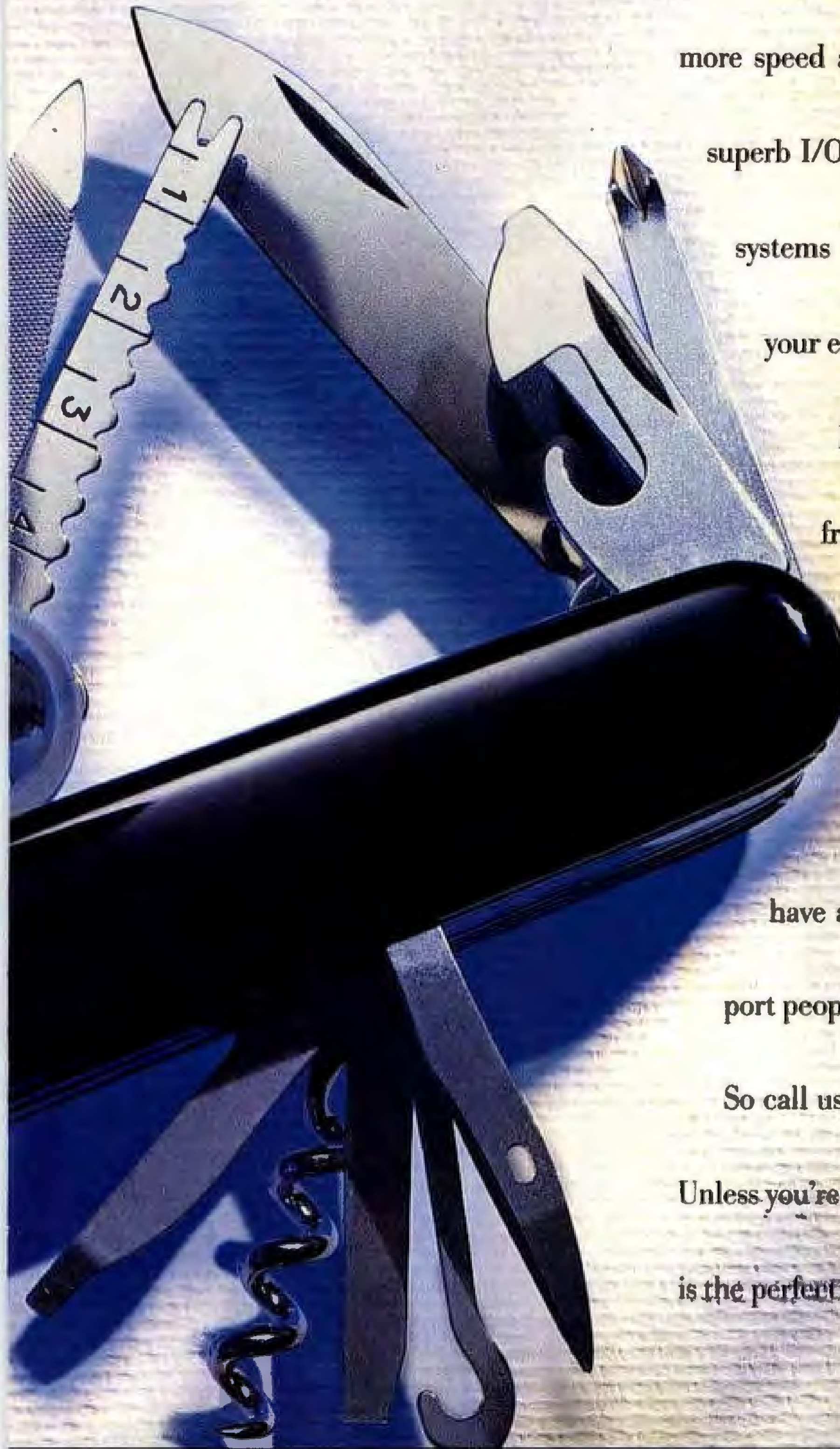

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WINDOWS AND MAC IMAGE EDITING

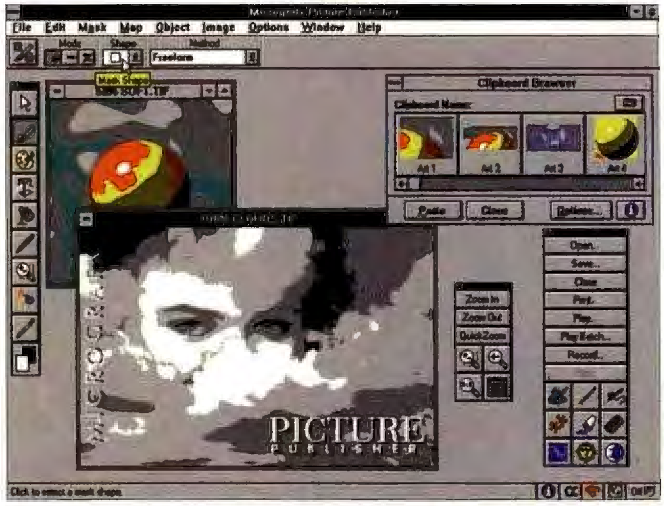
Photoshop and Picture Publisher Get a Face-Lift

The top vendors of image-processing software are unleashing new versions of high-end programs that have plenty of power to alter images. Adobe plans to release new versions of Photoshop for Windows, NT, the Mac, and the Power Mac by the end of September; Micrografx planned to release a new version of its Picture Publisher image-editing program for Windows 3.1 and Windows NT this summer.

Adobe's ((415) 961-4400) Photoshop 3.0 ($895) maintains its extensive set of editing and retouching tools but adds mightily to its performance and productivity. The most significant update is support for multiple layers. With this feature, you can now edit an element of an image on separate layers, a process akin to the manual design method of working on individual sheets of acetate. The result is faster and easier editing: You can experiment with ideas, color changes, and techniques on discrete layers and see the results without affecting the original image. When all the image elements are arranged to your satisfaction, you can "flatten" the image when saving the data into a file so that the layer information is discarded.

Another welcome new feature is enhanced color correction, which includes the ability to selectively adjust ink amounts on individual color channels (or color plates), a new CMYK quick preview, and the ability to interactively saturate or desaturate colors with a new Sponge tool. Adobe has improved upon Photoshop 3.0's tweaks by adding customizable floating palettes, a new preview feature for filters, and a Commands palette for assigning one-button access to often-used commands or for creating custom palettes for different editing tasks.

Photoshop also has another feature that's sure to please its fans: It is significantly faster than the current version, both on the Power Mac and under Windows.



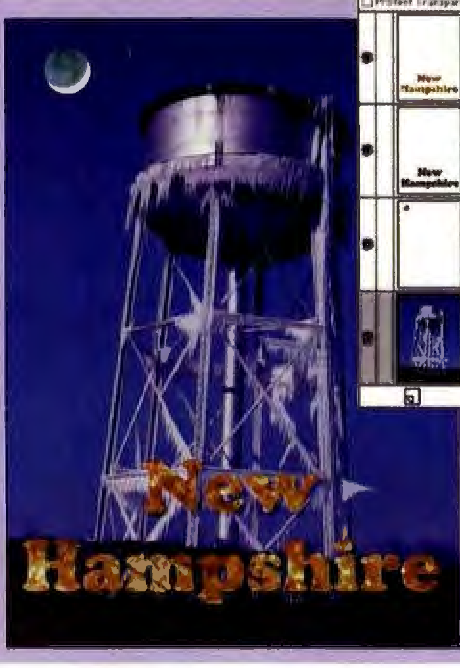
The new version of Picture Publisher's Clip Art Manager lets you drag and drop a clip-art image directly into another image.

The new Windows version supports multithreading under Windows NT, allowing it to support dual-processor PCs. On the Mac platform, the program is available in a completely native PowerPC version; Power Mac users will see an overall performance boost over Photoshop 2.5.1, which was written in 680x0 processor code but used a plug-in module written in code for the PowerPC that offered performance enhancements for certain operations.

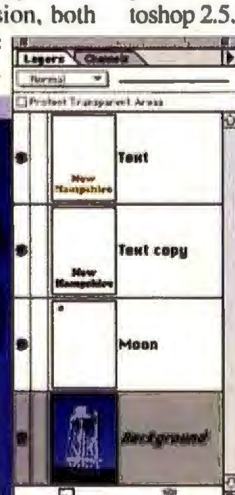
If you want a powerful image-editing program but also want to spend a bit less money, consider Micrografx's ((214) 234-1769) forthcoming Picture Publisher 5.0 ($595). (The status of Aldus's PhotoStyler program for Windows [see "PhotoStyler Fights Back," February BYTE] is unclear now that Aldus and Adobe have announced plans to merge.) Picture Publisher 4.0 already had layers available, but the new release adds several ease-of-use and productivity enhancements, including customizable toolboxes and workspaces, new monitor and printer-calibration tools, and extensive use of Chicago-style tabbed dialog boxes.

To save time and system resources, Picture Publisher allows you to work on images in low resolution and then automatically apply the edits to the high-resolution version of the image. And for those who can't make up their minds, the program has an Infinite Undo feature that saves your command list and allows you to undo all or selected commands.

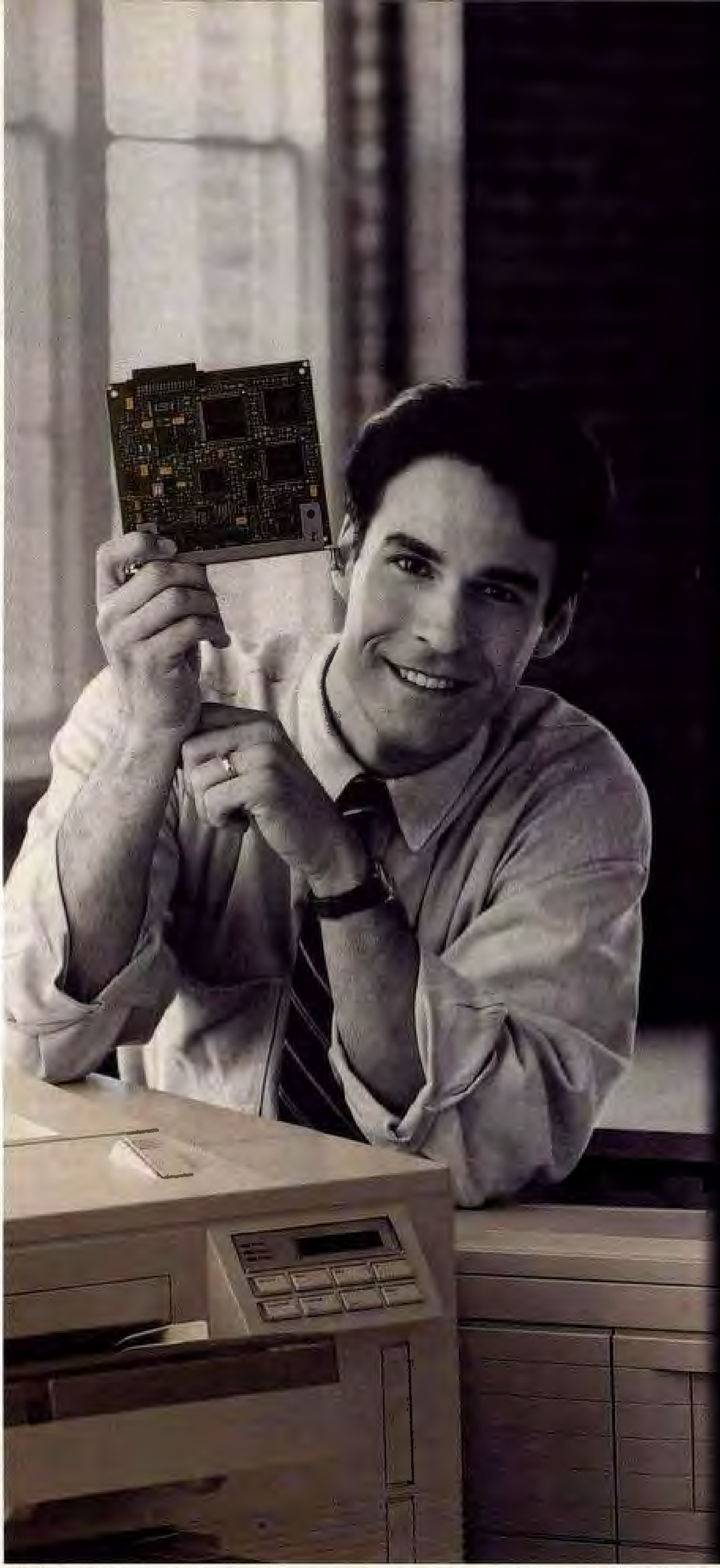
If you are budget-conscious and only want to do occasional editing, you can choose from several less-expensive tools in Windows, including Leadview 3.0 for Windows (Lead Technologies, (704) 549-5532), PhotoFinish 3.0 (Softkey International, (617) 494-1200), and PhotoPaint (Corel, (613) 728-8200). —Jon Pepper



BYTE technical editor Tom Thompson made heavy use of Photoshop 3.0's new layering capability in creating this image. The scanned image of the water tower was assigned as the image's background layer. Next, a scanned image of the moon was opened. The moon was isolated from the rest of the scan (using the Marquee tool configured to make a circular selection) and dropped into a second layer, which was named "Moon." Text was added to a third layer, which was duplicated to make the drop-shadow text. The drop-shadow-text layer was edited with a blur filter and then applied as an overlay characteristic to the background image. A scanned image of autumn leaves was copied into the topmost layer, and the text layer's characteristics were modified to protect transparent areas.



A prominent new feature in Photoshop is a palette that lets you manage the various layers in an image you're creating.



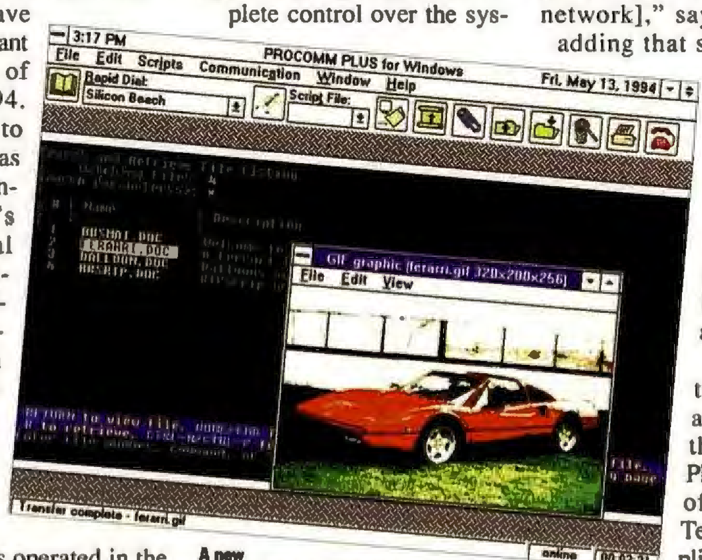
COMMUNICATIONS

Businesses Turn to BBSes

A new Wildcat BBS Suite from Mustang Software (Bakersfield, CA, (805) 873-2500) offers many new features designed to appeal to both the business and entertainment fields. A new programming language called wcCode lets the BBS operator customize the BBS to provide unique menu choices and place any feature or wcCode application on any Wildcat menu.

The concept of the information highway has captured the imaginations of computer users and editors alike. But in the midst of all the headlines, one alternative that business and government agencies are increasingly using to share information has existed since the early days of personal computing: the electronic BBS.

Says Scott Brinker, president of Galacticomm (Fort Lauderdale, FL, (305) 583-5990), which produces The Major BBS, "We have seen a significant ramping up of sales in 1994. People used to see the BBS as a hobbyist venture. Now it's seen as a real tool for business." *Boardwatch* magazine, which covers the BBS market, estimates that at the end of 1993, approximately 60,000 BBSes operated in the U.S.—roughly twice as many as there were 18 months earlier. Today's BBSes offer multitasking (allowing multiple users to perform activities such as E-mail, file transfers, and electronic chatting), customizable GUIs, security, and gateways to the Internet, E-mail, and other networks.



A new add-on option for The Major BBS called Search and Retrieve 3.0 lets users search several megabytes of preindexed text files, using up to eight keywords. It also adds the ability to preview graphics on-line before downloading the file.

In the world of business communications, BBSes sit between internal LANs running Lotus Notes or Microsoft Mail and external on-line services, such as CompuServe and BIX. BBSes provide a relatively inexpensive way—both in terms of cost and training—for employees to communicate with outside customers and with each other.

In the business environment, BBSes are most popular for external communications, such as customer support, and for providing a central information system for field offices. In contrast to a product like Notes, which requires a user to have client software to access a Notes database, anyone who has a terminal program can dial into most BBSes. In addition, many BBSes offer the advantage that the operator has complete control over the system, from the user interface to the levels of security.

Citibank uses The Major BBS to connect its audit-division offices all over the world. "We used to send audit reports on diskettes by overnight express," says Gene Friedman, the firm's manager of data communications. "It was expensive and unreliable." Today, the offices send reports by modem directly to the central BBS at Citibank headquarters in New York. The BBS is connected to the office LAN, so internal users also have the ability to post files and messages.

Friedman estimates that the company spent under $15,000 (about $5000 for the PC, $1000 for modems, $6000 for an X.25 line lease, and $2000 for software) to hook up 30 offices around the world. "There really was no alternative other than some kind of WAN [wide-area network]," says Friedman, adding that since he's set the system up—which took about a week—maintenance has been minimal; most of it, such as deleting old files, is automatic.

Another interesting BBS application is that of Wieck Photo Databases of Carrollton, Texas, which supplies photographs and graphics to the media. Using the Mac-based TeleFinder BBS from Spider Island Software (Irvine, CA, (714) 669-9260), Wieck offers a central repository in which news services and major newspapers, such as the *Washington Post* and the *New York Times*, post their photos, which can then be downloaded via JPEG data compression by other newspapers and publications. Travis Hughes, a partner in the business, says newspapers and public-relations firms use his company's service to retrieve photographs to use with articles and trade brochures.

Some BBS systems are designed to run on LANs and modem connections alike. One such system is the Mac-based FirstClass from SoftArc ((905) 415-7000) of Markham, Ontario, Canada (see "A FirstClass Experience," September 1993 BYTE). This system uses a client/server model and supports multiple network protocols. The client software, which is installed on Macs or Windows-based PCs calling into the system, is distributed free of charge, while the server software is priced according to the number of users. SoftArc also offers a command-line client interface that allows connections for any computer that can emulate a VT100 terminal.

SoftArc's vice president of corporate affairs, Scott Welch, says that a "Big 6" accounting firm is now using FirstClass to maintain an "intellectual capital" repository, available to all the firm's offices around the country. If one office generates a report on the textile industry, for example, it's posted on the FirstClass BBS so that other offices can access it.

BBSes are relatively easy to set up and maintain and are priced in the $200-to-$1000 range, depending on the configuration and number of users. The bottom line is that if you want full control over your company's internal and external communications, a BBS is worth considering.

—Nicholas Baran

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CD-ROM COMPRESSION

Two Ways to Cram More Data on a CD-ROM

For a lot of commercial and corporate CD-ROM software developers, 660 MB just isn't enough. Once a rarity, multidisc packages are now becoming more common. Because each additional CD-ROM disc increases production and packaging costs, developers are seeking ways to get more data on a disc.

Until now, lossless compression utilities have not been available for CD-ROM drives because of incompatibilities between DOS and CD-ROM file systems. Two companies aim to change that. CD-ROM USA (Golden, CO, (303) 526-7600) has created a driver for Stac Electronics' Stacker that allows it to compress files written to the CD-ROM file format. EWB and Associates (Carlsbad, CA, (619) 930-0440) has announced a package comprising a number of compression schemes that are optimized for CD-ROM. Both companies claim to minimally double the amount of data that can be recorded on a disc.

CD-ROM USA's CRI-X2 Driver, which is available now, fools PCs into writing to the ISO-9660 file format that is standard for most CD-ROMs. The computer thinks that it is writing to a standard DOS FAT (file allocation table), but in reality it's writing to an image of the DOS FAT that the CRI-X2 Driver creates in virtual memory. The driver then encapsulates all the compressed files into one large file on the disc. To the computer, it looks like one large ISO 9660 file. The CRI-X2 Driver, however, sees all the files as compressed DOS FAT files.

CapaCD, EWB's compression utility, takes a similar approach in that it encapsulates the compressed files into one large file. But the program sees the data in the file in either ISO 9660 or Apple HFS format. The advantage to this approach, according to EWB, is that it avoids the limitations of the DOS file system, including its 2-GB maximum volume size.

EWB says its own "distributed indexing" scheme, where each compressed file carries its own indexing data, offers another advantage: It provides faster file access. The CRI-X2 Driver places all the indexing data in one header for the entire compressed volume. EWB says that the CapaCD utility will be available sometime during the third quarter.

While CD-ROM USA uses the popular Stac compression engine, EWB has gone with its own engine, which is called Multipress. Actually, it is several engines; each, the company claims, is optimized for a particular data type, such as text, image, or audio.

EWB president Ed Brakus sees the choice between the two engines as a technology issue. "Stac will need to develop an entirely new compression technology to catch up," he says. CD-ROM USA is banking on Stacker's proven track record and the close ties between Stac Electronics and Microsoft (Stac and Microsoft announced in June a cross-license agreement to end their disk-compression patent dispute).

In reality, there is likely room for both engines. Some companies need as much compression as they can get. Others will sacrifice the smallest possible file size for a familiar and trusted compression method.

—Michael Nadeau

CODE TALK

RICK GREHAN

Seer-Sem Offers Realistic Forecasting for Programmers

One of the MIS world's many holy grails is a forecasting methodology that can be accurately applied to software projects: a software swami, if you will, to whom you could hand a project specification and who would hand back an accurate prediction of how much time or lines of code a given project would require.

That's the basic idea behind Seer-Sem from Galorath Associates (Los Angeles, CA, (310) 670-3404). A simplified description of Seer-Sem might be that it is a software engineering tool that leads you through a well-structured hierarchy of fill-in-the blank fields. When this process is complete, Seer-Sem generates a variety of reports and charts that tell you what resources your company will have to devote to the project.

Seer-Sem is extremely flexible. For example, the package is quite content to work with incomplete information, thanks to "knowledge bases" that are provided with the package. When you begin describing your project, you tell Seer-Sem what type of application your organization will be building—for example, a CAD package or a database package—and Seer-Sem will draw from its knowledge base of such applications to fill in the missing information. Of course, the more you tell Seer-Sem about your application, the more you override those defaults, and the more accurate Seer-Sem becomes.

As you use Seer-Sem, its knowledge bases learn more about your programmers, engineers, and organization, and its predictions become fine-tuned. Galorath updates the program's knowledge bases about once a year.

To test the package, I fed it information from a database-engine project I worked on some time ago, the fruits of which (to be honest) never saw the light of day. Seer-Sem allows three levels of hierarchy in the software's model: CSCI (computer software configuration item, which is topmost in the hierarchy), CSC (computer software component, the middle level), and CSU (computer software unit, the bottom level).

The manual doesn't press a rigorous definition of what should be at each level, so I considered CSCIs to represent individual programs, CSCs to represent major functions, and CSUs to represent individual routines (i.e., the actual code). This is probably a good approach, as I was able to quickly factor my application into its components.

For example, to enter information about a CSC, Seer-Sem's outline-structured questionnaire required that I provide the following: an estimate of new lines of code and an estimate of pre-existing code. The pre-existing code category was further divided into subcategories, such as whether the code was designed for reuse and what percentage of the code would have to be redeveloped and retested. I could also select the development language, such as assembly, C, C++, Ada, or SQL. The pick list is quite extensive. All this data influences the program's predictions.

I suspect that Seer-Sem's greatest benefit is largely hidden. As you fill in the blanks, you are forced to dig up information about the project that cannot help but lead you to a greater understanding of it. The journey becomes its own reward.

And my test project? Seer-Sem told me that I was looking at a two-year job. No wonder I never finished it.

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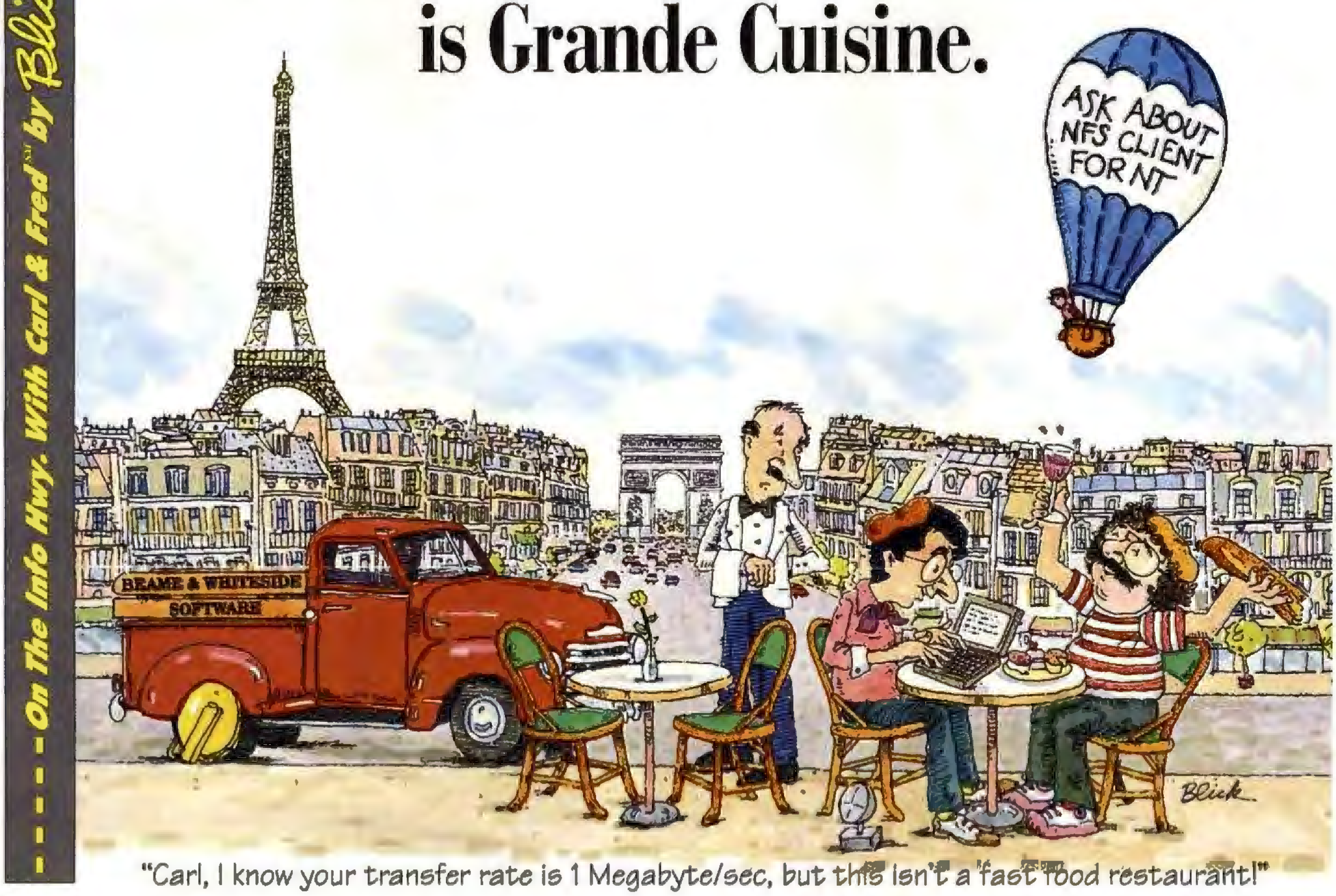

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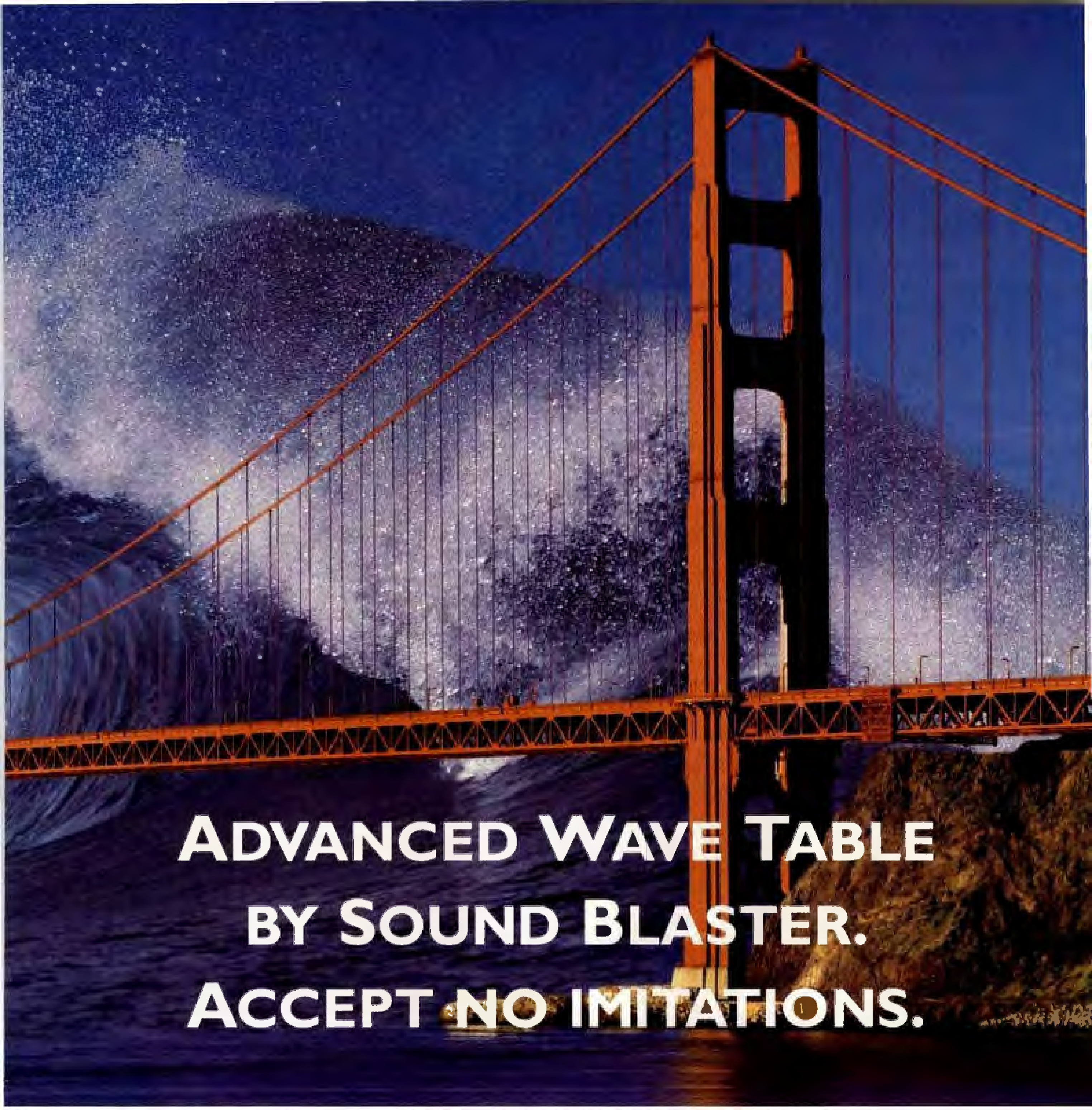

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News & Views

PROCESSOR TRENDS

Getting CISC into RISC

The RISC-versus-CISC debate is taking some interesting turns that could have a profound effect on the future of the personal computer industry. For the past few years, conventional wisdom has stated that, all things being equal, RISC performs better.

What's muddying the waters is software. For better or for worse, as Andy Keane, manager of product marketing at Mips Technologies, puts it, the 80x86 architecture "owns the binary." The one bright spot in the RISC firmament—Apple's success with its Power Macs—is because of Apple's powerful influence in the Mac software universe.

The challenge facing RISC vendors is to support enough of the 80x86 software base so that switching to RISC becomes a tolerable alternative to continuing to invest in 80x86 machines. The prevalent approach today is to offer some sort of software emulation that allows users to continue to use their DOS/Windows software on RISC hardware. But software emulation, for the most part, is too slow, while the installed base of RISC PCs is too small to tempt most software makers into converting their 80x86 software into native RISC code.

A more patient approach is to wait for the binary to come to you. Mips and DEC are banking on Windows NT to provide a ready source of applications that can be easily ported to RISC. The fact that an application written to the Windows NT Win32 API can be compiled relatively painlessly to 80x86, Mips, Alpha, and (soon) PowerPC platforms encourages the likes of Mips, DEC, and Motorola to stay the course while NT increases its market share. Their RISC PC strategies are predicated on the belief that the migration of the Windows 3.1 installed base to the far-more-capable NT platform is inevitable.

Chicago (aka Windows 4.0) applications written to the Win32 API should increase the number of programs that can take advantage of most of the features of an NT platform. But Chicago's popularity may discourage faster migration to NT, especially given that NT currently requires about three times as much RAM as today's 4-MB PCs. Neither Mips nor DEC sees a major impact for NT in the general desktop market before 1996.

Two years is a long time, and a number of companies are working hard to get more of that 80x86 binary today. Prominent among these is IBM, which is now working to perfect its PowerPC 615 chip. Like software emulators, the 615 will let you run 80x86 code on a RISC platform—in this case, a native PowerPC machine. The difference is that the 615 provides a hardware-emulation capability that is significantly faster at executing 80x86 binaries than software-based emulation. How much faster is unknown, and it depends greatly on how IBM approaches hardware emulation.

Approaches to hardware emulation include providing an assist to a software-based emulator, putting a separate 80x86 processor on the same die as a RISC processor, and creating a hybrid execution pipeline that can handle RISC and CISC instructions. The first solution is the least costly, but it provides the smallest 80x86 performance gain. The second solution provides the best 80x86 performance gain, but it yields very big—and therefore very expensive—chips. The third solution, according to sources, is the one IBM has settled on for the 615.

The 615 has two modes of operation. In one, it acts like a normal PowerPC chip. When the operating system tweaks a specialized mode bit, however, the 615 decodes 80x86 instructions into microcode that is then sent to the execution pipelines. In 80x86 mode, the 615 also tracks things like 80x86 condition codes. Switching between modes is much like a standard context switch.

As for performance, one estimate puts the 615's 80x86 capabilities on a par with those of a 100-MHz Pentium, although there is too little information available to judge this estimate's validity. Also unknown are the physical characteristics of the chip. These questions will remain unanswered until IBM begins sampling the chip—probably in the first half of 1995. Given that schedule, don't expect to see 615-based systems until late 1995 at the earliest. **—Bob Ryan**

IMS Takes On 80x86 Emulation

International Meta Systems (Torrance, CA) is looking to make a big splash in the RISC-versus-CISC wars. This spring, IMS filed a patent application for technology that enables a RISC processor to emulate other instruction sets, such as 80x86 and 680x0. According to company President George Smith, the IMS technology is applicable to just about any RISC processor. In the case of 80x86 emulation, it provides a modified decoder to handle 80x86 instructions, a means to track 80x86 condition codes, special hardware to handle 80x86 addressing and execution modes, and a way to emulate the machine state—particularly the register set—of an 80x86 processor.

IMS has developed a processor—the IMS 3250—that uses a RISC pipeline to emulate both a 486 and a 68040, and it claims that just about any RISC processor can provide CISC emulation with little additional circuitry. According to Smith, IMS has discussed its technology with more than one RISC processor maker, although at press time no company had committed to the technology. If the IMS technology plays out, it could provide a significant bridge between the CISC and RISC worlds. **—B.R.**

Whatever Happened to...?

Apple's Mac Quadra 610 DOS-compatible system
(see "Apple Provides PC on a Mac," January BYTE)

Apple no longer makes the system but might offer a similar but improved product for Power Macs. Eric Wee, a spokesman for Apple, says the original DOS compatibility card for the Quadra 610 was produced in limited quantities because Apple couldn't predict what the consumer demand would be for the first systems.

However, Apple recently demonstrated a Power Mac 6100 running a prototype DOS compatibility card that had a DX2/50 processor and could play SoundBlaster files. Dave Daetz, product-line manager for cross-platform products at Apple, says that if Apple were to release a DOS compatibility card for Power Macs, it would likely offer improved networking over the original card. Apple wouldn't comment on whether it will bring a DOS-compatible Power Mac to market, but Apple's past technology demonstrations have typically evolved into products.

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News & Views

PORTABLE COMPUTERS

Bigger and Better

Call it a reverse trend. For years, major PC manufacturers seemed bent on producing the smallest and lightest "full-featured" machines possible. The subnotebook category of portables that emerged, which typically comprises systems that weigh between 1.9 and 4.6 pounds and are about 8.75 inches wide, attracted the kind of excitement usually associated with a flashy new sports car.

But now reality is setting in: *Small* too often translated into products that were too flimsy or underpowered for all but the most minimal work. Subnotebooks often had compromises in screen size, number of PCMCIA slots, and storage capacity.

Expect to see a new round of subnotebooks introduced this summer and fall that are more similar to their slightly larger brethren (e.g., with larger screens, more power, and even somewhat larger size) or repositioned in the market as portable communications devices instead of as full-fledged desktop replacements.

A prime example of the first trend is the NEC Versa S series, which NEC is touting as a reduced-weight notebook rather than a subnotebook. The machine, which ranges in weight from 4.2 to 5 pounds depending on the choice of display (monochrome or TFT [thin-film transistor] color), is just about the standard notebook size: 10.8 inches wide and 8.3 inches deep. NEC includes a larger display (9.5 inches), more power (up to a 50-MHz 486DX2), and more disk space (up to 260 MB). Toshiba's new Portege T3600CT subnotebook offers similar improvements over the current T3400CT model.

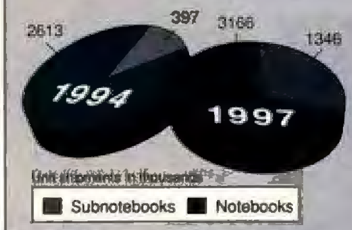
AST is also upgrading its new Ascentia 500S subnotebook, with a keyboard that's 95 percent the size of the Ascentia notebook's keyboard. The Ascentia 500S is a system that will be positioned as a "mobile companion" for on-the-go professionals who need to communicate. It will be available only with a passive-matrix display, partly because communications doesn't generally require active-matrix screens.

Zenith Data Systems is trying to cover both ends of the spectrum with a new color version of its Z-Lite subnotebook. The company has added larger hard drives (up to 340 MB), a standard 7.8-inch passive-matrix color LCD, and a 33-MHz Cyrix 486DLC processor. Zenith is complementing the tiny 4.3-pound machine with the Z-Star EX, which sports a faster processor (a 50-MHz 486DX2 from Cyrix), a larger keyboard, and many options in a traditional notebook-size package ranging in weight from 5.2 to 5.7 pounds.

Epson has discontinued its line of subnotebooks. Instead, the company is making its ActionNote notebook line lighter—but not smaller—to minimize compromises. A new line of ActionNote computers will have a 66-MHz Cyrix 486DX2 3-V processor and weigh about 4.9 pounds. Part of the weight savings was achieved through putting a 14.4-Kbps data/fax modem on-board and including just one PCMCIA Type II slot instead of two.

And Gateway 2000, which helped pioneer the subnotebook market with its tiny HandBook line, has dropped prices on current models in anticipation of adding faster processors, and possibly color, in the same form factor. But Gateway is now marketing the HandBooks as super-portable communications tools. It appears that vendors are realizing that less is indeed less, after all. **—Jon Pepper**

Subnotebooks: A Controversial But Growing Market



Source: International Data Corp. (Framingham, MA)

Although subnotebooks will probably represent only 13 percent of the total 1994 notebook/subnotebook sales in the U.S., IDC sees growth in the area, thanks in part to a further drop in prices of PCMCIA options, such as fax/data modems; growth in usage of E-mail; and increasing availability of color models.

WINDOWS PRINTERS

Inexpensive, Fast, and Slow to Acceptance

Whether they're based on Microsoft's At Work or Destiny Technology's (Santa Clara, CA) WinStyler printing architecture, Windows printers can deliver high-quality output, fast printing, and, through bidirectional feedback, instantaneous, user-friendly information regarding a print job's status.

Also, because they use a desktop PC's CPU and RAM to off-load tasks such as rasterization, which previously required a powerful RISC processor and memory in a traditional printer, Windows printers are inexpensive. For example, Destiny predicts laser printers based on its 1200-dpi WinStyler solution will ship in the second half of this year in the $750 price range.

Even so, market analysts and managers at leading printer vendors see slow market acceptance of this printer category. One of the problems with Windows printers has been incomplete networking. Printers based on the WinStyler technology can currently communicate only with the desktop PC to which they are connected. Current At Work–based printers, such as the LexMark WinWriter 600, are networkable, but only the PC that is directly connected to the printer gains the benefit of bidirectional feedback through the graphical At Work interface.

Destiny planned to improve WinStyler's networking capabilities by shipping to vendors in August a solution that delivers bidirectional feedback to users on NetWare and Windows for Workgroups networks; printers based on this new technology should start appearing in the first half of 1995. And Microsoft says it will add bidirectional communications over networks in a future release of its At Work software.

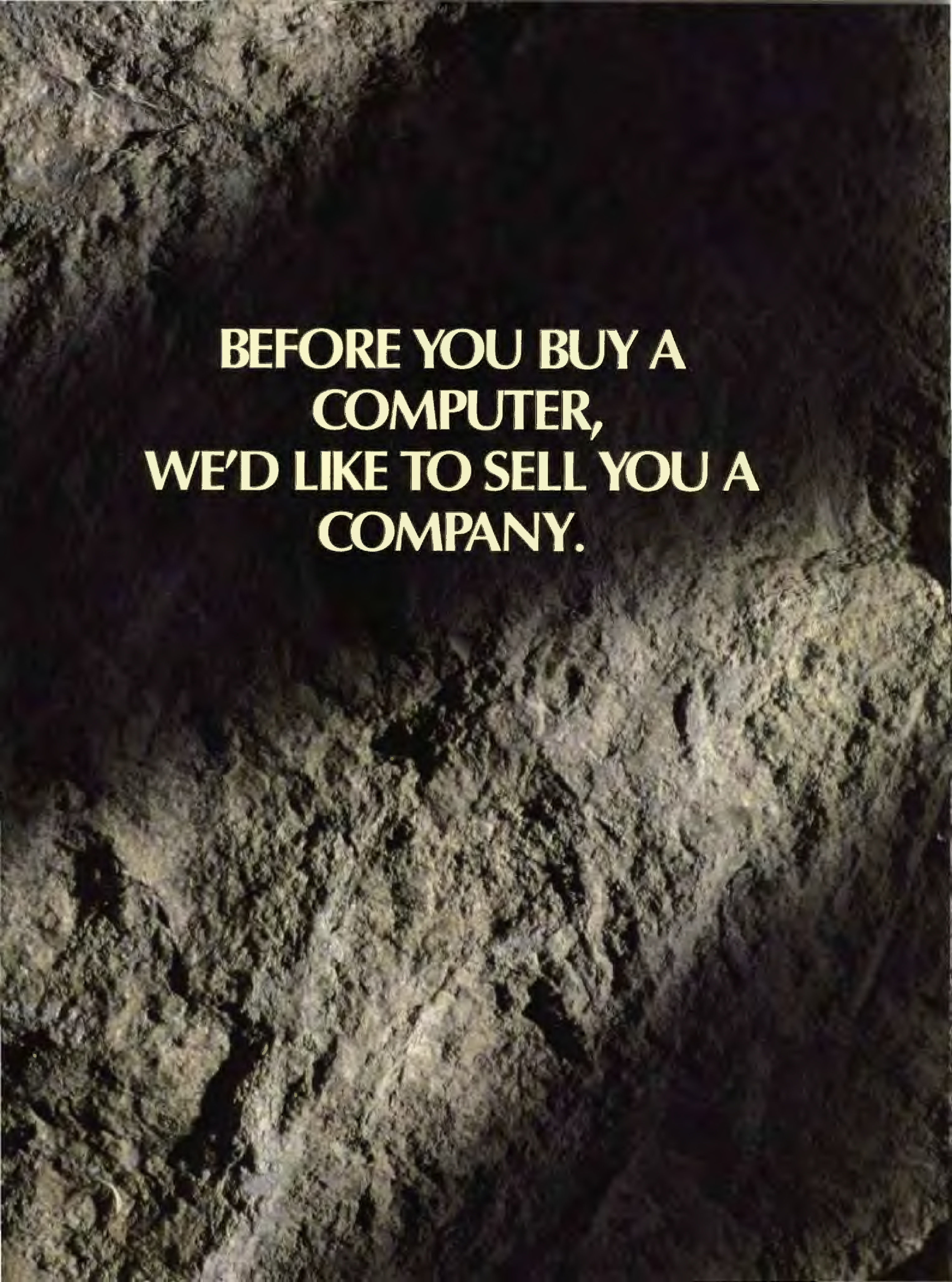
Another problem with Windows printers is their incomplete DOS support. For example, printers based on the current WinStyler technology require you to print from MS-DOS applications inside Windows, but not all applications can print this way.

Analysts at BIS Strategic Decisions (Norwell, MA) believe that as more users buy new Windows PCs, Windows printing will eventually take off as a product category: Until then, the engineers and marketers in Santa Clara and Redmond will be busily working on new versions of their solutions and educating the market.

—Dave Andrews

Pros
- Fast printing, thanks to a high-speed parallel interface
- Inexpensive
- Bidirectional feedback

Cons
- Networking is currently incomplete
- Trade-offs with printing inside DOS applications
- Benefits are hard to communicate to end users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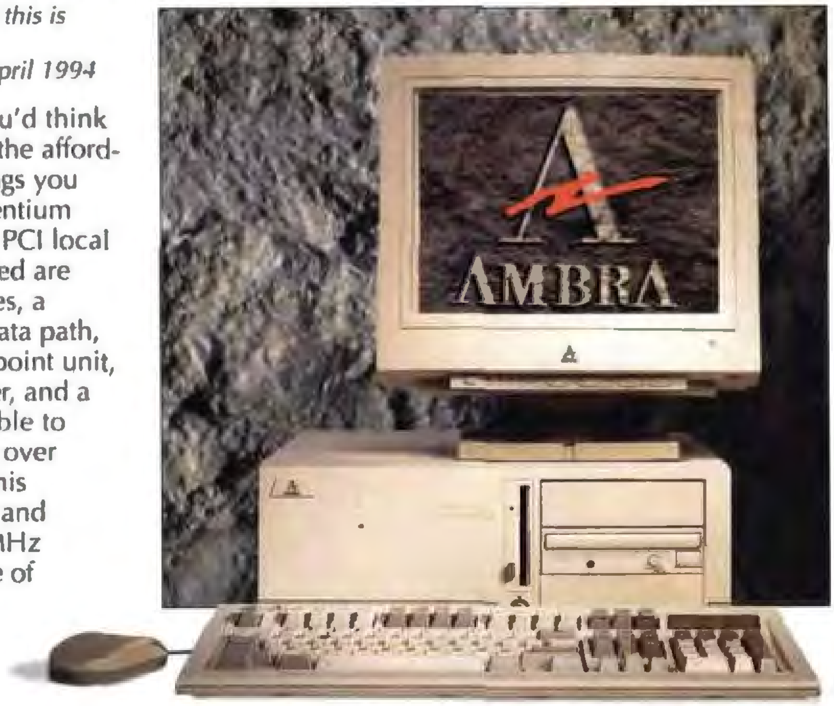

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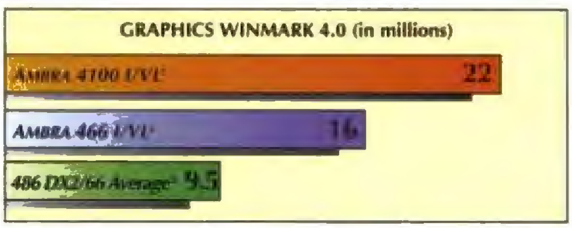

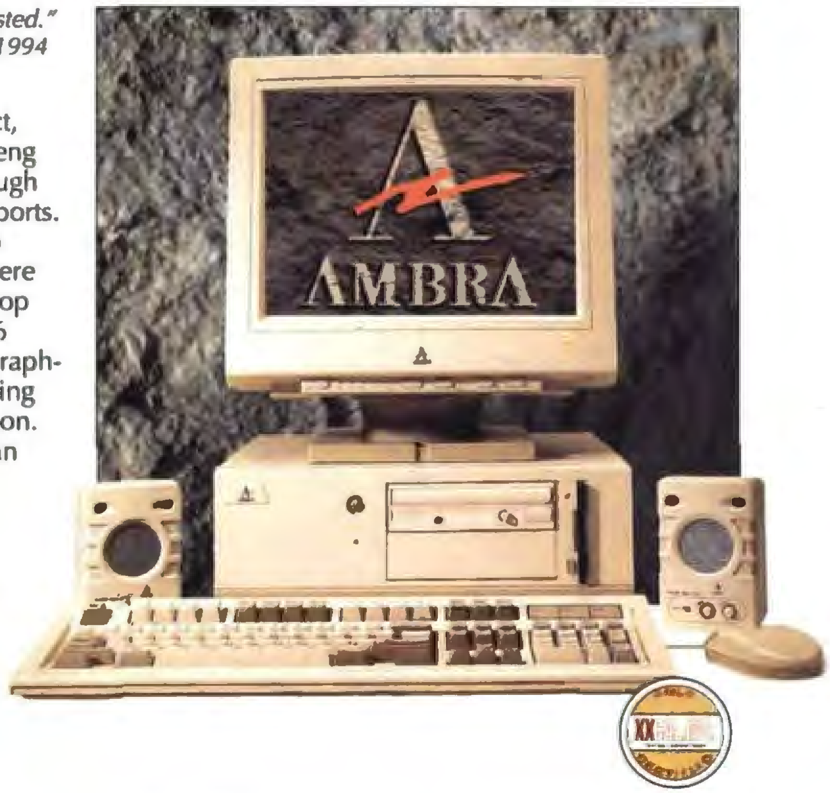

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N75D-340 PC World, August 1994 issue

The AMBRA N75D-340, InfoWorld, May 23 1994

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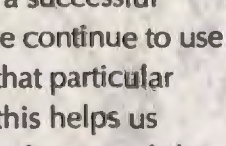

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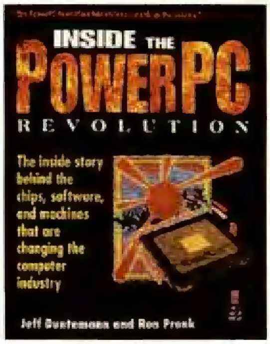


PowerPC: Cultural and Technological Perspective

JON UDELL

The PowerPC family of processors has rocketed to prominence atop two powerful boosters. One is technological. These speedy processors exemplify practical RISC design. The other is cultural. The PowerPC has become a lightning rod for those weary of Intel and Microsoft's near-monopolistic control of desktop computing. Like the revolution it chronicles, *Inside the PowerPC Revolution* mixes technology and rebellion.

On the technological front, there's plenty of engaging and informative discussion of RISC versus CISC, pipelining, branch prediction, multiple execution units, primary and secondary cache architectures, chip fabrication, and how these subjects relate to the PowerPC 601 and 603. (There's some coverage of the 604, which was announced as the book went to press.) All this will be useful to readers looking for a clear, accessible primer on RISC.

The authors point out, for example, that there's nothing minimalistic about RISC. The PowerPC, as is typical of the RISC genre, has plenty of instructions, some rather complex. There's nothing "reduced" about RISC. The PowerPC merely exemplifies what the authors call "microprocessor new art"—abundant registers, simplified addressing, fixed-length instructions, specialized execution units, and pipelining. A solid analysis of Intel's Pentium shows why it's vulnerable, not only to RISC competitors like the PowerPC, but also to alternative 80x86 offerings like Cyrix's M1.

On the cultural front, things sometimes get heavy-handed. Take the inexplicable claim that the 80x86 instruction set is "unfriendly to object-oriented operating systems." Say what? The IBM/Apple/Motorola alliance has a lot going for it, but to anoint microkernel-based PowerPC systems that IBM and Apple have yet to deliver as the ideal platforms for object computing is just plain weird.

A fascinating survey of IBM's previous RISC efforts—the early 801 project, the ill-fated RT, and the RS/6000—reveals lessons learned along the way and puts the PowerPC in a historical context. But the authors don't place the PowerPC in a modern context. There's no discussion of Mips, Alpha, SPARC, PA, or other RISC alternatives.

On Apple's side of the PowerPC coin, that's probably OK. After all, Power Macs did vault Apple, almost overnight, to the top of the heap of RISC-system vendors. The authors tell this incredible Cinderella story with relish, describing Apple's new machines in detail and not flinching from revealing the software compromises that got the product to market so quickly.

On the flip side of the coin, though, there's an awful lot of hand waving in support of IBM. With no corroborating evidence, the authors all but proclaim victory for PReP (PowerPC Reference Platform) systems running IBM's still-embryonic Workplace operating system and human-centered user interface, while deriding "Bill Gates' Windows NT drivel." This unnecessary antagonism detracts from an excellent discussion of the operating-system options for PowerPC systems and the strategies those operating systems will use to emulate legacy Mac and Windows software. On balance, though, you'll learn a lot about the history, politics, technologies, and commercial prospects of PowerPC-based systems, and about RISC in general. ■

INSIDE THE POWERPC REVOLUTION

Jeff Duntemann and Ron Pronk
Coriolis Group
ISBN 1-883577-04-7

$24.95

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

THAT PERFECT MATCH

BARRON'S PROFILES OF AMERICAN COLLEGES, 19th ed. **Laser Resources, Inc., 20620 South Leapwood, Suite F, Carson, CA 90746, (310) 324-4444, $49.95**

LOVEJOY'S COLLEGE COUNSELOR **InterMedia Interactive Software, Inc., 3624 Market St., Suite 302, Philadelphia, PA 19104, (215) 387-0448, professional version, $199; student version, $59**

You quickly learn that there are an awful lot of schools out there when you start to search for that "perfect match" for your child. Two hefty resource tomes, *Barron's Profiles of American Colleges* and *Lovejoy's College Counselor*, have been transported, with varying degrees of success, to CD-ROM.

Of the two, Lovejoy's is by far the easiest to use because of its slicker user interface. Above and beyond the standard facts about median SAT scores and degree offerings, Lovejoy's includes campus photos and, in some cases, short but mostly inane talking-head videos. (Lovejoy's professional version includes additional information on two-year schools—community, vocational, technical, trade, and business—and lets a high school guidance counselor store up to 1000 student profiles.)

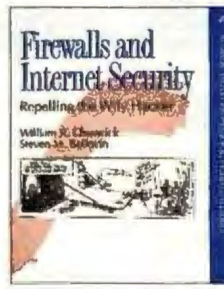
The Lovejoy's disc lets you search for schools in numerous ways: alphabetically, geographically, by admission competitiveness, by cost, by areas of study, and even by sports (228 colleges and universities across the U.S. offer lacrosse, a fact of utmost importance to my college-bound eldest son).

However, both CD-ROMs only scratch the surface in providing helpful information in what most students and parents would agree is a difficult, frustrating, subjective, and emotional process. They would be greatly improved by opinionated material from sources such as *U.S. News & World Report*'s annual college guide. I'd like to quickly search for those colleges that experts believe give the best value for the dollar, have the best dorm food, have the lowest reported incidence of rape or alcohol abuse, or have the lowest rates of locking students out of popular courses. Both publishers say they are updating their CD-ROMs by the end of the year.

—Rich Friedman

SECURING YOUR INTERNET CONNECTION

FIREWALLS AND INTERNET SECURITY: REPELLING THE WILY HACKER by William R. Cheswick and Steven M. Bellovin Addison-Wesley Professional Computing Series, ISBN 0-201-63357-4, $26.95



Forget *The Silence of the Lambs*. This is the book that will keep system administrators sleepless and shivering. While it wasn't intended as a compendium of computer-user horror stories, once you finish it, you will never look at the `sendmail` program in quite the same way again.

This is an encyclopedia of computer cracking via a network. It is neither exhaustive nor sufficiently detailed to be of much use to the would-be digital criminals of the world (who, as the authors point out, have better sources of information), but it is invaluable to those who want to foil them. Ostensibly, the audience is system administrators for Unix sites connected to the Internet. The focus is on Unix, as the mother tongue of the Internet, and the authors assume a fair level of Unix literacy. However, much of what they have to say applies to any network, and much more is applicable to NetWare, DOS, and Windows.

The basis of a safe connection, according to the authors, is a *firewall*, a computer system that sits between the Internet and your LAN, acting as an active gateway to keep the bad guys away from your goodies. However, bringing in your network connections through a separate system and calling it a firewall isn't enough. Creating a true firewall means limiting what that system will pass along to other systems, what an outsider can do with it, and how to ensure that you can keep track of who is trying to do what. Sometimes creating a firewall means creating a fool's paradise, where the crackers can bask in the delusion they have penetrated the system as they are being hunted down.

Chapter 10, "An Evening with Berferd," includes a detailed account of a persistent attempt to crack the AT&T Internet gateway that the authors are responsible for. It shows how a determined attack proceeded and was defeated. The account is also a wry comment on the nature of modern Internet culture and computer criminals. The crackers were a group of Dutch teenagers who were beyond legal reach, because cracking was not then a crime in the Netherlands. When the law failed, someone from AT&T called the mother of one of the ring members. The cracking attempts dropped off sharply

A useful appendix provides sources of information on building firewalls, network management and monitoring tools, auditing software, and cryptographic software. A 20-page bibliography and a checklist of security holes round out the book.

The book deals with serious business, but through it all, the authors maintain a sense of humor, sprinkling the text with quotes from Juvenal to Tolkien to E. E. "Doc" Smith. ■

—Rick Cook

Rick Cook writes about computers but occasionally turns his hand to science fiction. You can contact him on BIX as "rcook."

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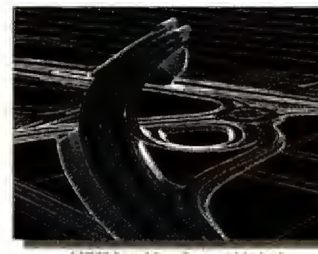
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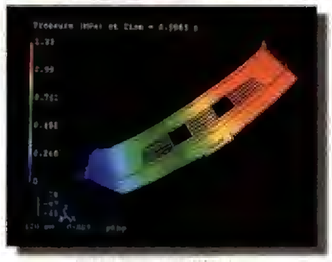
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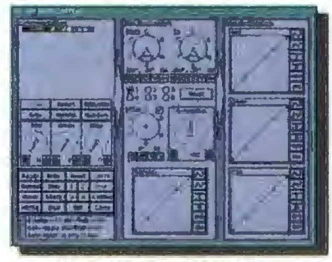
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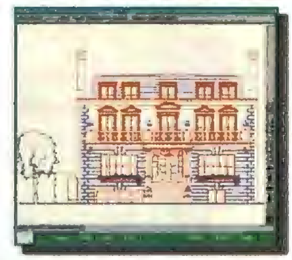
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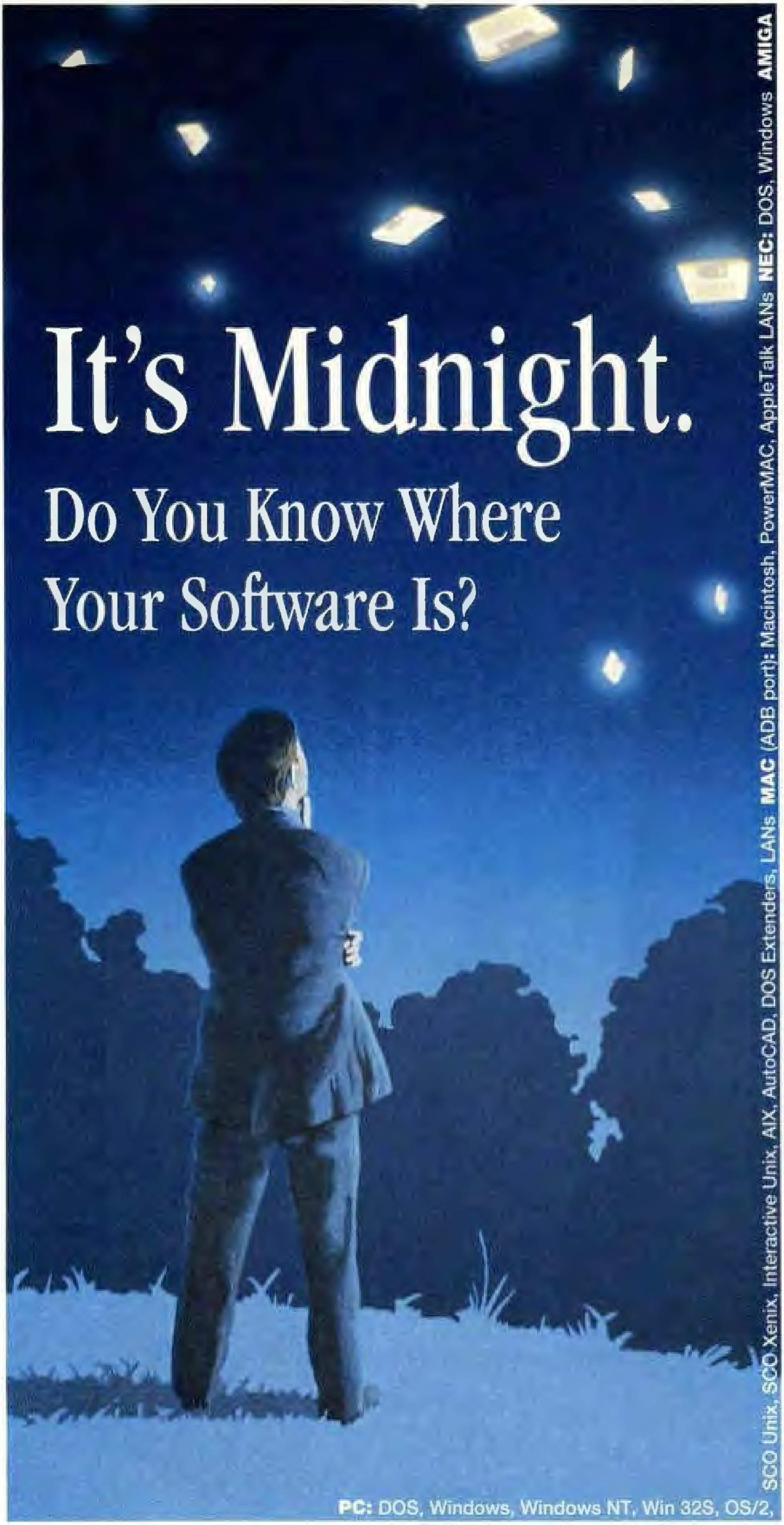

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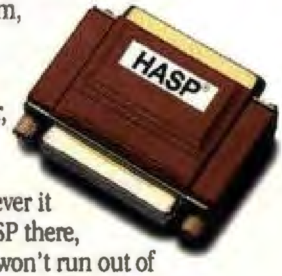

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The Last Bastion

ROY WIEMANN © 1994

DICK POUNTAIN

The new Mips R8000 chip set signals a number of trends in processors. First and foremost, it shows the determination of Silicon Graphics, which acquired Mips in 1992, to take a piece of the supercomputer market. Conventional wisdom has thus far held that microprocessors can't cut it in supercomputing, despite what they've done for mainframes and minicomputers.

The launch of the R8000—currently in limited production—is also further confirmation that the RISC processor market has matured to a point where products need to be differentiated. Applying every trick in the design textbook and announcing the world's fastest CPU is no longer enough; now you need to answer the question "Fastest at what?" and then demonstrate the proper design trade-offs to make your answer credible.

Mips's answer is that the R8000 is fastest for technical and scientific computing tasks involving huge data sets and lots of floating-point math. The R8000's design emphasizes an external cache of up to 16 MB in size and with gigabyte-per-second bandwidth, so it's not intimidated by applications that won't fit into on-chip cache. Combined with a loosely coupled superscalar floating-point processor, this cache enables the R8000 to claim a peak performance of 310 SPECfp92 and 108 SPECint92 (faster than IBM's Power2 on floating-point operations), or 300 MFLOPS, which is equivalent to the performance of the Cray Y-MP.

The Mips R8000 takes microprocessors where they have never been before: Into the realm of supercomputing

The cost of this performance is a four-chip set with over 1000 pins, high power consumption, and a high price, so you definitely won't want to use it in a PDA (personal digital assistant). But because the R8000 is binary-compatible with existing Mips chips, you can run a network of Silicon Graphics workstations driven by less expensive R4400s, all accessing an R8000-based departmental compute server. Mips is not alone in moving to this high-end/low-end strategy; the PowerPC group (with the yet-to-appear 620 at the high end) and Hewlett-Packard (with the PA-RISC 7200) are blazing similar trails.

The Silicon

The R8000 chip contains the integer-register file and multiple execution units, primary caches, and the branch-prediction unit, while its sister FPU—the R8010—contains the floating-point registers and two full floating-point execution units. Both chips are fabricated in a 0.5-micron CMOS process operating at 3.3 V and are designed to run at 75 MHz in the first generation. The R8000 and R8010 are large chips (17.3 mm by 17.2 mm each), although between them they contain only 3.4 million transistors, which is fewer than the PowerPC 604 crams onto a single, much smaller die. Both chips are packaged as 595-pin PGAs (pin-grid arrays).

continued

To build an R8000 system, you also need a pair of custom dual-ported RAM chips, which act as tag RAM for the external cache; this external cache must be built from SSRAM (synchronous static RAM) chips, which are more expensive than ordinary SRAMs. The SSRAMs and the huge die will probably make the R8000 the most expensive microprocessor chip set ever built, but the supercomputer market is not known for bargain pricing.

Mips Goes Superscalar

The R8000 is a 64-bit superscalar processor that issues up to four instructions per cycle. This is a departure for Mips, which was previously the champion of superpipelining (i.e., deep pipelines and fast clocks) as an alternative to multiple-instruction issue. However, Mips's designers realized that their floating-point performance goals could be met only by a vector processor or by going superscalar, and they preferred the latter as a more general-purpose solution.

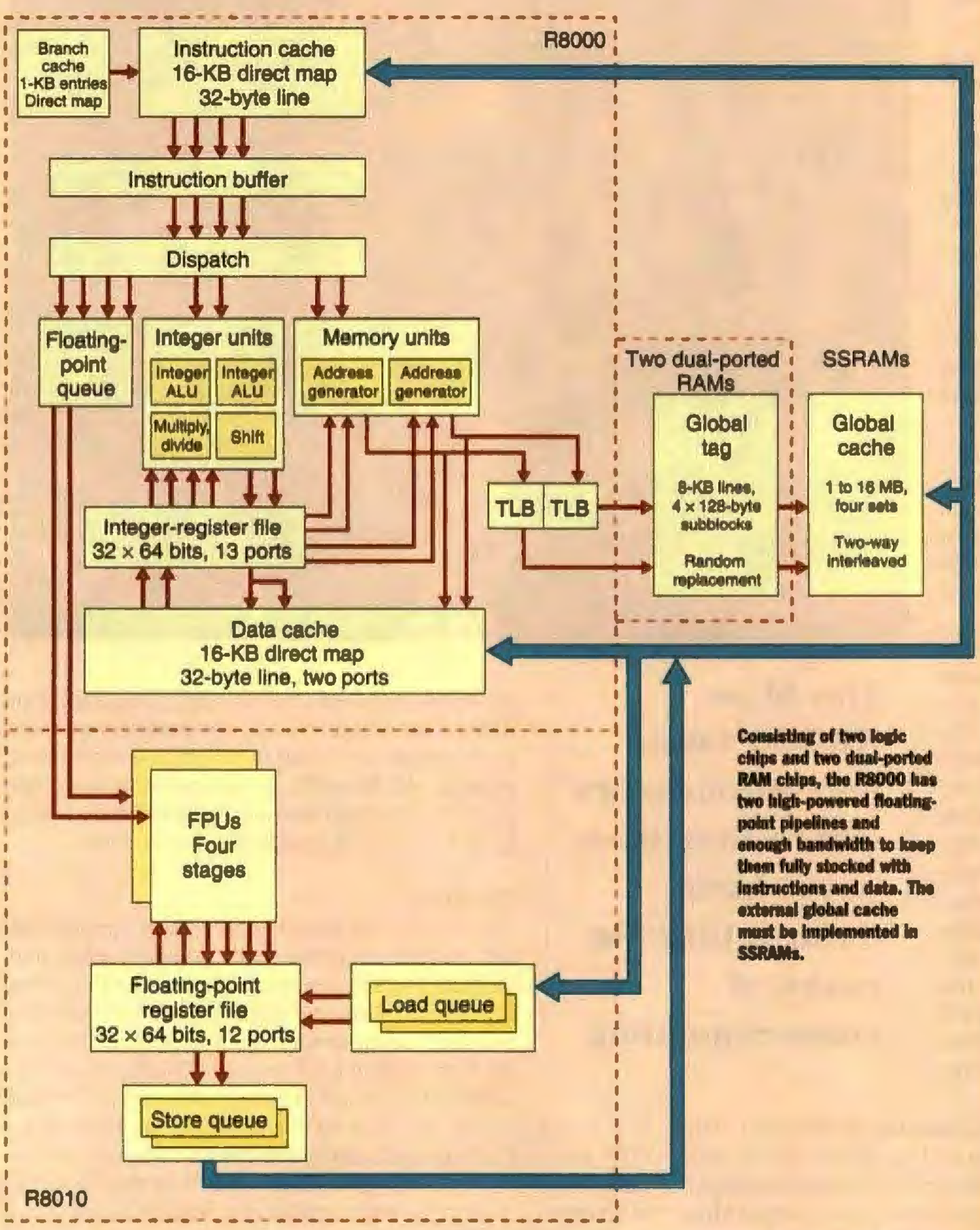
The R8000 integer unit contains four integer-execution units (see the figure "R8000 Microarchitecture"). Three of these units—two ALUs and a shifter—operate in one cycle; the fourth, a multiply/divide unit, is not pipelined and takes four to six cycles for a multiply and 21 to 73 cycles for a divide. There are four parallel pipelines within the R8000, each five stages deep (i.e., fetch, decode, address generate, execute, and write back). Two pipelines feed the integer ALUs, and two are for loads/stores, allowing ALU operations to occur in parallel with data-cache accesses. Of the four instructions that the R8000 can dispatch each cycle, two are integer or load/store operations, and two are floating-point operations.

With this degree of parallel issue, Mips had to find a cure for the "load shadow" problem of earlier RISC pipeline designs: The cycle immediately following (and, hence, shadowing) a load instruction can't use the result of that load. As with branch-delay slots, the compiler tries to fill this dead slot with an independent instruction, but no compiler can be expected to find four such instructions.

Mips's solution was to place the ALU one stage later in the pipeline than usual (after address generation), which removes the load-to-ALU shadow but instead introduces an ALU shadow over the load addresses: Whenever a base address is calculated using an ALU operation, there is a one-cycle delay before the address can be used by a following load or store. Mips considers this a good trade-off for two reasons: because load-use dependencies occur far more often than compute-load dependencies and because extensions to the R8000 instruction set include a new register+register addressing mode for floating-point loads/stores that reduces the need to precalculate addresses.

The integer-unit pipelines incorporate several other tricks to increase internal parallelism. For historical reasons, the Mips instruction set requires all branches to be followed by a one-cycle delay slot. The R8000 has to retain these delay slots for backward compatibility, but it executes them in parallel with their branch instruction. The on-chip data cache is dual-ported to support two memory accesses per cycle, and it incorporates a bypass so that a store followed by a dependent load can still be issued in parallel. *continued*

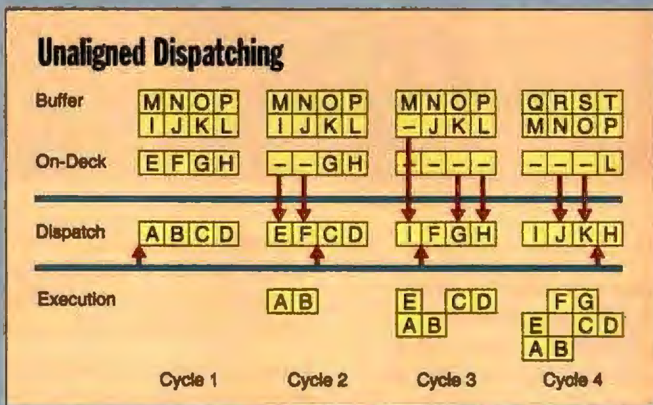
R8000 Microarchitecture



Consisting of two logic chips and two dual-ported RAM chips, the R8000 has two high-powered floating-point pipelines and enough bandwidth to keep them fully stocked with instructions and data. The external global cache must be implemented in SSRAMs.

Aligning Instructions for Multiple Dispatch

The R8000's instruction buffer is a FIFO (first-in/first-out) queue in which each entry is a quadword (i.e., 128 bits) containing four instructions read from the instruction cache. The last entry in this queue is made visible via a set of four 32-bit registers called the *on-deck registers*, which feed another set of four dispatch registers. The latter are equivalent to the instruction register of a conventional single-issue microprocessor and connect to the decode logic and the register file. The figure at right shows four cycles of the buffer operation with individual instructions represented by letters of the alphabet. The cycles are explained below.



Cycle 1: Instruction C depends on the result of A, so the dispatch logic decides that only instructions A and B can be issued in parallel (as D must not be issued out of order).

Cycle 2: A and B are dispatched for execution, E and F move from the on-deck registers to replace them, and the program counter points to C.

Cycle 3: C, D, and E are dispatched in parallel and are replaced by G and H (from the on-deck registers) and I, which bypasses the on-deck registers. The emptying of the on-deck registers triggers a buffer advance on the next cycle.

Cycle 4: The buffer advances one line and reads four more instructions from the cache. F and G are dispatched.

The overall effect of this mechanism is to provide a continuous stream of aligned instructions for execution. Meanwhile, the dispatch-decision logic has to manipulate only the four dispatch registers and is not burdened with the whole instruction-fetch pipeline.

The FPU

Floating-point instructions are executed in the R8010, so the R8000's dispatcher puts floating-point operations into a queue where they can wait, without holding up the integer pipelines, until the R8010 is ready for them. Floating-point operations can, therefore, execute out of order in relation to any following integer instructions, but the R8010 uses FIFO (first-in/first-out) queues at both input and output to ensure they execute in order among themselves. This decoupling of the FPU from the integer pipelines improves integer performance by hiding not only the delay of floating-point execution, but also the latency of the external cache pipeline, which is mostly used for floating-point data (more about this later).

The downside of this decoupling is that while integer exceptions remain precise, floating-point exceptions become imprecise, being reported as asynchronous interrupts some time after the causing event. You can confine the extent of this lag, at a price, by writing code that repeatedly reads the floating-point status register (which flushes all pending exceptions), or you can enter a precise-exception mode, in which the integer pipeline is stalled for the whole duration of a floating-point operation. This provides backward compatibility with earlier Mips CPUs, but at the cost of a large hit in integer performance.

The R8010 contains two identical floating-point data paths that are completely indistinguishable to software. These data paths can perform double-precision multiplies, adds, divides, square roots, and conversions, as well as a new, fused multiply-add (i.e., multiply A by B and then add C without intermediate rounding), which is especially useful in image processing and similar applications.

It's the execution of two such multiply-adds per cycle at 75 MHz that allows Mips to claim 300-MFLOPS peak performance. Floating-point compares and moves take one cycle; multiplies and multiply-adds take four cycles and are fully pipelined; long operations, such as divides and square roots, are not pipelined and can take up to 20 cycles. However, the data paths are fully independent, so while one unit is executing a long, nonpipelined operation, the other can still execute one pipelined operation per cycle.

Dispatch and Branch Prediction

A major design goal for the R8000 was to achieve superscalar instruction issue that's not critically sensitive to instruction alignment. Some superscalar RISC processors can issue instructions in parallel only if they're aligned on 64-bit or 128-bit boundaries; otherwise, the time taken to align the instructions would consume all the advantage gained. For example, the DEC Alpha can waste up to three cycles when branching to a nonaligned target.

So often in the RISC world it's up to the compiler (and, hence, the wretched compiler writer) to solve this problem by padding the instruction stream with NOPs to achieve the correct alignment. This reduces code density and can cause secondary performance losses by increasing the cache-miss rate. Mips solved this problem by implementing an instruction buffer that takes blocks of instructions from the cache aligned on 128-bit boundaries and issues up to four aligned instructions per cycle into the execution units. The text box "Aligning Instructions for Multiple Dispatch" explains how the instruction buffer does its job.

To dispatch four instructions per cycle, you have to fetch four instructions per cycle, and that makes the R8000 very vulnerable to breaks in the instruction stream caused by program branches. To reduce this impact, the R8000's designers implemented a dynamic branch-prediction scheme. The branch cache holds 1-KB entries, and, for the sake of speed and economy of silicon space, it's direct-mapped, allowing it to be physically laid out as just an appendage of the single-ported instruction-cache RAM. The branch cache employs a 1-bit prediction scheme, which has a rather low accuracy. However, its large size of one entry per line (i.e., per four instructions) in the instruction cache compensates for this by eliminating almost all conflicts.

continued

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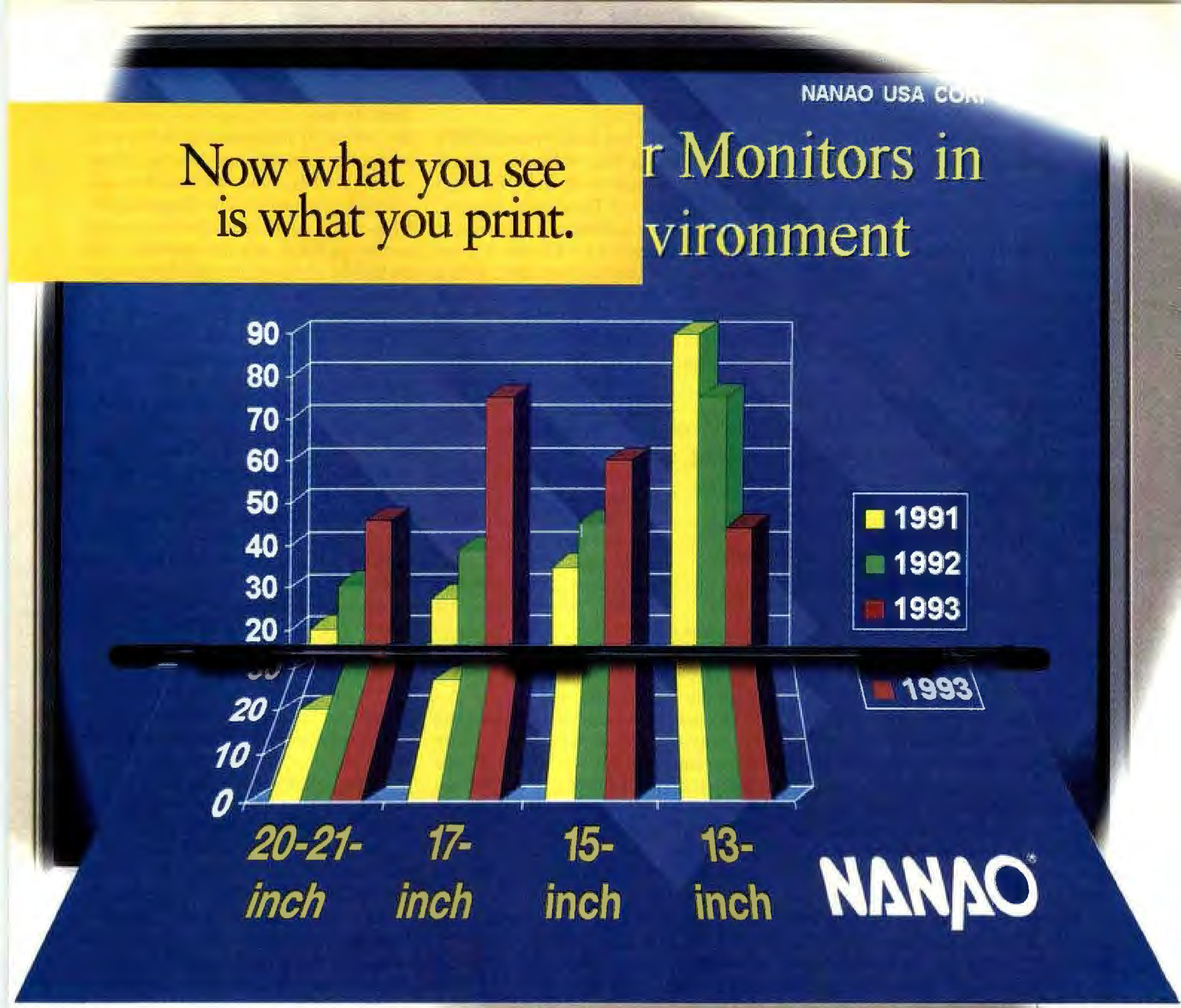

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The fetch stage of the integer pipeline accesses the branch and instruction caches in parallel, reading from the branch cache a single prediction bit (i.e., taken/not taken), the instruction-cache index of the branch target, and the alignments of both the last instruction in the source block and the branch target. These latter two quantities are used to mask off the unwanted instructions from the quadwords that contain the source and target. In the interest of space, only 10 bits of the instruction-cache index are stored in each branch-cache entry; the remaining high-order bits of the target address are recovered on the next cycle from the virtual instruction-cache tag. This scheme assumes that all predicted branch targets will hit in the instruction cache; consequently, this increases the penalty for instruction-cache misses.

Because each branch-prediction entry is shared among four instructions, the possibility of cache thrashing arises if two branch instructions occur in the same four-word block (no more than two could occur because of Mips's compulsory branch-delay slots). The answer to this problem is to design compilers that avoid creating such small basic blocks (i.e., branches so close together).

Another extension to the R8000 instruction set helps with this task; the new conditional move instructions can often implement IF...THEN...ELSE structures, using either a single branch or none. For example, the instruction

```
cmove %r1=%r2?%cc1
```

says, "move the contents of register r2 into r1, but only if condition code cc1 is set." Conditional instructions always execute, consuming one cycle even when the move doesn't happen, so they don't cause a discontinuity in the instruction stream.

Mips claims that, although this branch-prediction scheme is somewhat less efficient than multibit ones, it works uniformly with respect to the taken and fall-through cases and for jump-to-register instructions, so the same hardware can predict branches, jumps, and subroutine calls/returns. It turns out to be very effective for dynamic object-oriented programs that call many small procedures (i.e., methods) indirectly via pointers. The code generated by such programs is full of jump-to-register instructions with invariant targets, which get predicted very well.

The Cache Hierarchy

The biggest problem faced by the R8000's designers was getting sufficient memory bandwidth to keep such a fast floating-point processor fed. The answer, as usual, lay in the cache architecture. The integer R8000 has separate 16-KB on-chip instruction and data caches, both with a 32-byte line size filled from an external secondary cache (which Mips calls the *global cache*) in two 16-byte chunks. The instruction cache is direct-mapped and is both virtually addressed and tagged.

Mips needed to achieve a bandwidth of over 1 GBps from the global cache; this required some drastic steps.

Virtual tagging confers two advantages here. First, it dispenses with an instruction TLB (translation look-aside buffer) and the associated speed penalty for TLB misses. Also, it means that the instruction cache's contents need not always be a subset of the global cache, so the loading of huge floating-point data sets into the global cache doesn't have to displace still-useful instructions.

The data cache is direct-mapped and virtually addressed, but it's physically tagged and is used only for integer loads and stores. It's dual-ported to support two loads (or one load and one store) per cycle. Unlike the instruction cache, the data cache's contents are always a proper subset of the global cache, with coherency maintained by hardware. All floating-point loads and stores bypass the on-chip data cache and go directly to the off-chip global cache after they're translated to physical addresses in the TLB.

The global cache, which can be anywhere from 1 to 16 MB in size, directly feeds the R8010's FPU and acts as local memory in multiprocessor systems. To reduce thrashing problems (such as during repetitive matrix processing), the global cache is four-way set-associative, with a sector size configurable to between 32 and 128 bytes.

To meet its floating-point performance target, Mips needed to achieve a bandwidth of over 1 GBps from the global cache; this required some drastic steps. The first was to implement the cache in what was at design time (1990) an exotic new breed of memory, the SSRAM. These chips integrate input and output registers onto the chip, so access is internally pipelined into three cycles: address setup, RAM access, and data output.

The R8000 global cache is interleaved in two banks of 64-bit-wide SSRAM cycling at 10 to 12 nanoseconds, for a total bandwidth of 1.2 GBps. This, however, does not take into account set associativity, which, if implemented in the most straightforward way (i.e., reading all four sets in parallel), could quadruple the bandwidth requirement again. To avoid this, Mips designed a custom four-way-associative tag RAM, in which addresses must be looked up before the SSRAMs are accessed.

The end result is a five-stage pipeline between the R8000 and the global cache: cycle 1, address into tag RAM; cycle 2, tag lookup; cycle 3, signal cross from tag RAM chip to SSRAM chip; cycle 4, SSRAM access; and cycle 5, data out to the R8000 or R8010. The cost of a miss in the on-chip data cache is, therefore, seven cycles (five for the pipeline plus two loads to fill a line), while an instruction-cache miss costs 11 cycles, as it must also pass through the TLB and branch-prediction cache.

The main motivation for uncoupling the R8000 from its R8010 FPU was to hide this five-cycle external cache latency from integer code. In a tightly coupled design, each floating-point load could cast a 20-instruction shadow (5×4 instructions per cycle), whereas in the actual design it casts none.

One problem with interleaved caches is that two data references might attempt to access the same bank during the same cycle. Even the smartest compiler cannot always foresee such conflicts, which threaten to halve the available bandwidth by stalling one of the references. Mips provides special hardware—a one-entry queue coupled to a crossbar called the *address bellow*—that has the ability to delay one of each pair of cache references to improve the chances of the ideal odd-even, odd-even sequence.

For example, a pathological sequence such as odd-odd, even-even, odd-odd, even-even would normally stall on one reference of each pair and run at 50 percent efficiency, but the address bellow delays one reference (the one marked with an asterisk) to yield odd-stall, *odd-even, odd-even, odd-even, in which only a single cycle is lost. The address bellow can resolve only local conflicts, however, and it relies on the compiler to generate a sensible global mix of odd-even references.

Cache Coherence

The R8000 design uses a relatively simple scheme to maintain consistency between the on-chip contents and the global cache's contents. First, the on-chip integer-data cache was made write-through with respect to the global cache; there is enough write bandwidth for the global cache to

Feature

absorb write-through at full speed without buffering. This reduces the amount of chip logic and also simplifies multiprocessor support, since you can invalidate a data-cache line at any time with no pending write-backs to worry about.

Integer-cache write-throughs can potentially steal bandwidth that is needed for floating-point loads and stores, but Mips claims this is seldom a problem with real-world code. The global cache itself is write-back and uses a snooping protocol to support multiprocessor buses.

This split-level cache poses a special problem of consistency between integer and floating-point data. Suppose, for example, that location A is first written by an integer operation in both caches and then rewritten by a floating-point operation in the global cache only; a subsequent integer load would fetch stale data from the on-chip cache. Simply invalidating the on-chip cache line whenever a floating-point store occurs would provide a cure, but at the cost of causing severe cache thrashing during the processing of data structures that contain both floating-point and integer data within the same cache line. This is quite common, especially in graphics applications.

Instead, Mips employed an invalidation scheme whose granularity is finer than a whole cache line. Every 32-bit word in the on-chip integer-data cache has a valid bit attached. In a newly filled cache line, all these bits are set, but a floating-point store to the global cache causes the corresponding bits in the on-chip cache to be cleared. Integer stores of 32 or 64 bits set their corresponding valid bits, while integer stores of smaller size (e.g., bytes) and integer loads cause a cache miss if the appropriate bit is not set.

Like the Hewlett-Packard PA-RISC 7200 I wrote about last month (see "A Different Kind of RISC," August BYTE), the Mips R8000 design is evidence that RISC designers are looking beyond benchmark performance to the difficult real-world computing problems that are, at present, fodder for supercomputers. The R8000 looks like it's set to be the floating-point performance winner for a while, but it's hard for me to shake off the nagging feeling that the multichip implementation raises some of the very problems it solves and that in the future we will see the R8000 chip set shrunk down to a single die, just as the IBM RS/6000 shrank to become the PowerPC. ■

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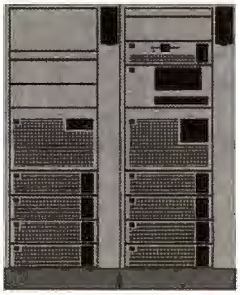

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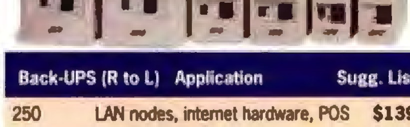

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Data over Cellular

JOHN BRYAN

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The cellular-phone network was built with voice communication in mind. Thus, the transmission glitches and pauses caused by handoffs are merely an annoyance, because the human brain is great at inferring what it doesn't actually hear.

The explosion in portable computing, however, has created an explosion of interest in wireless data communication—particularly in cellular data communication, because cellular is the most popular and accessible form of wireless communication now available. The problem is that the mere annoyances that plague voice transmission over cellular are anathema to data communication. Dropped or missing bits or bytes cause retries or, in the worst case, a lost connection.

Cellular transmission is a circuit-switched technology. In it, cellular transceivers switch between frequencies to avoid interference as new calls come on the air or simply to acquire a better signal-to-noise ratio on a transmission channel. Because the transmission is wireless, it is susceptible to all types of atmospheric conditions, emissions, and electronic interference. The act of switching itself also produces a momentary cessation of the transmission signal, which interrupts the data stream.

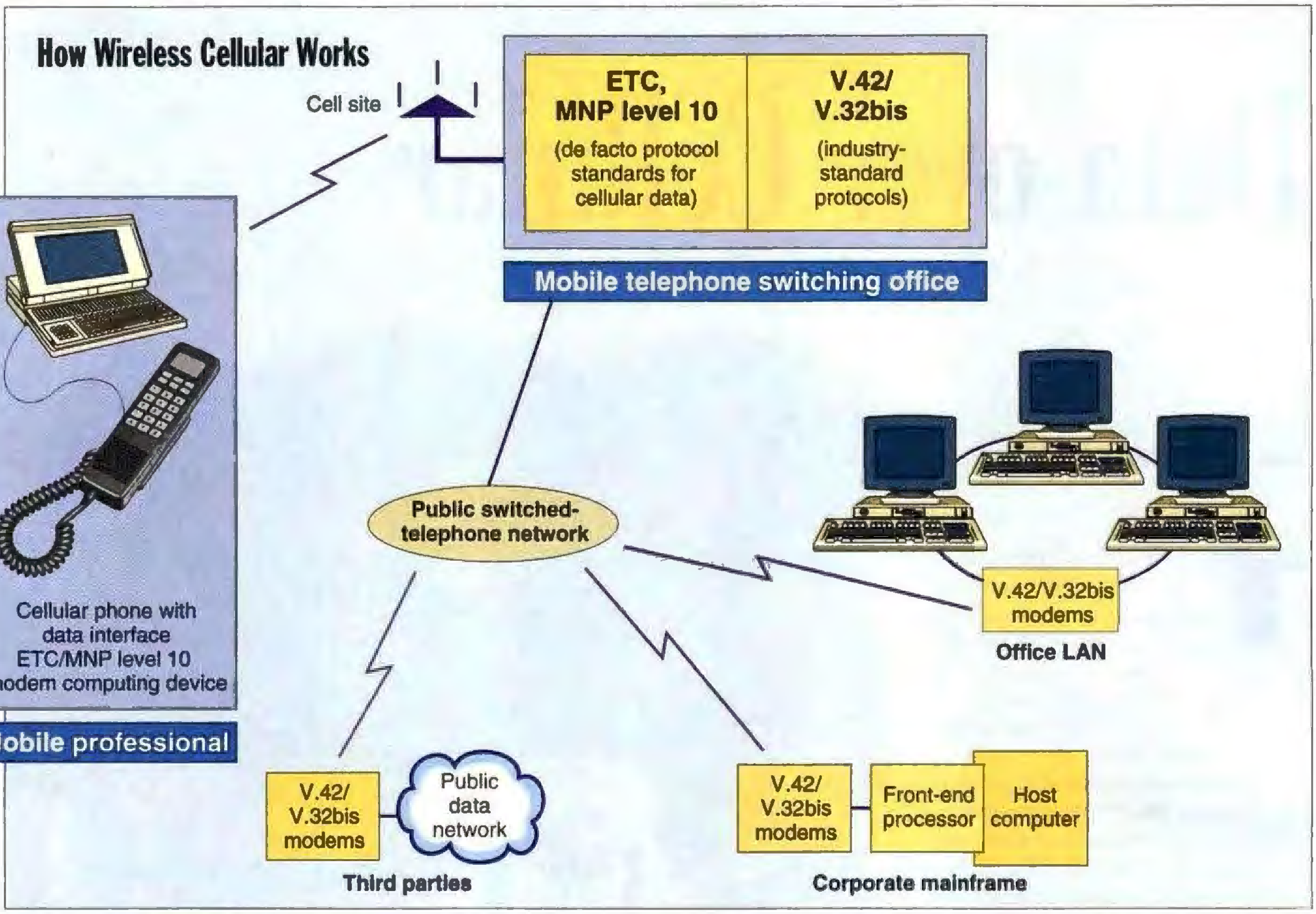
Last year, AT&T Paradyne (Largo, FL), a data and communications technology firm, introduced ETC (Enhanced Throughput Cellular) as a means of solving not only data-continuity problems, but speed, error-correction, reliability and call setup, and handshaking issues as well. Other protocols (e.g., MNP level 10 and V.42 error correction) deal with these issues, but none as comprehensively as ETC. With more than a dozen cellular providers supporting ETC, it is quickly becoming a checkoff item for cellular data communication.

Enhanced Throughput Cellular makes you forget that your data is riding on an analog connection

Modem Standards

Modem standards are numerous, and they come with confusing names and numbering schemes. The ITU-TSS, which recently replaced the CCITT, sets the V.xx standards. The ITU-TSS is located in France, so its designations, like those of the CCITT, are French. The "bis" designation, for example, means "second," as in the second iteration of a standard. Thus, V.22 is the original 1200-bps standard, while V.22bis is 2400 bps. V.32 covers 4800 and 9600 bps. V.32bis adds 7200 bps, 12 Kbps, 14.4 Kbps, and some fast rate-negotiation parameters to the speed switching. In particular, if either modem specifies a transmission speed, the connection must maintain that speed or disconnect.

V.42 is an error-correction protocol based on LAP-M (Link Access Procedure-Modem), which in turn is basically HDLC (high-level data-link control), the original bit-oriented synchronous link-layer protocol used in data connections. MNP level 10 is



For the greater part of its journey, a data packet sent by way of cellular uses the public switched-telephone network. The only components that require wireless capabilities are the mobile system and the cellular switching office, where the wireless-wired modem pairs reside.

another error-correction scheme. It's a de facto standard, widely used but not formalized by a committee.

Cellular communication is organized on OSI's seven-layer network model. ETC's big advantage over protocols like MNP level 10 and V.42 is that it operates on both layer 1 (i.e., the physical layer) and layer 2 (i.e., the link layer). The physical layer is largely concerned with how the data is modulated for transmission. Today's modems use simultaneous amplitude and FM. The link layer is where handshaking and error control are handled.

To realize all the benefits of ETC, a modem that supports both V.32bis and V.42 is required. V.32bis is used because it handles the handshake setup between modems, and it is easier and faster to take advantage of the handshake than to duplicate the effort. As the handshake takes place, the sending modem determines if ETC is supported by the modem on the receiving end. If it is supported by both modems, they work together to determine the highest data transfer rate the circuit is likely to support. Only after this has been established do you get a connect message.

V.42 is put to similar use. Standard implementations of it require the sending modem to repeat all frames transmitted after a flawed frame is received, regardless of whether subsequent frames are error-free. (This is also the case with MNP level 10.) On average, a modem will have received two additional frames by the time a retransmission request reaches the originating modem. Thus, all three frames would need to be retransmitted. However, ETC uses V.42's selective reject feature and requires the retransmission of only frames with errors.

ETC Enhancements

Besides working with existing protocols, ETC brings many improvements to the table. One of the primary benefits is Transmit-Level Control. A typical (i.e., non-ETC) modem's amplitude modulation may often exceed the cellular channel's transmission capabilities. This results in a condition called *clipping*, a harmonic distortion that damages the signal.

V.32bis-compliant cellular modems have a flat-frequency response, but the cellular network gives the frequencies from 600 to 3000 Hz, the ordinary vocal range, a 6-decibel boost. ETC deemphasizes the same bandwidth area by 6 dB, which results in more consistent data transmission. The theory and the effect are similar to the function of Dolby noise reduction in stereo tape recording and playback equipment.

ETC also monitors the cellular channel. *Auto-rating* is a technology that works in conjunction with the V.32bis standard to measure disruptive phenomena, like harmonic distortion, phase jitter, and signal-to-noise ratios. The measured figures are translated into a cumulative absolute number, which is compared to a table of acceptable levels for any given transmission speed.

While V.32bis supports speeds of 4800 bps to 14.4 Kbps, ETC will let the modem drop even lower, to the V.22 standard of 1200 bps. ETC skips the V.22bis 2400-bps standard, because a quirk in the modulation algorithm causes it to yield worse results than V.32bis at 4800 bps. Auto-rating is capable of adjusting the transmission speed, in certain cases, as often as every 5 seconds, although a more realistic number is about every 15 seconds. This reduces the risk of dropped calls while simultaneously taking advantage of the fastest possible transmission rates. The net

Feature

Modem Pools

One of the tangential benefits of ETC (Enhanced Throughput Cellular) design is that it works, albeit not at its best, when present in only one-half of a modem-to-modem connection. This is the theory behind a relatively new concept called modem pools. One of the reasons that so many cellular carriers are endorsing ETC is that it makes their services look that much better, but they're not stopping with appearance.

A modem pool is an array of modems, maintained by the cellular carrier, that provide error correction and signal-reliability enhancement without active participation or investment from the end user. The primary modem at the carrier accepts the mobile call and applies the appropriate error-correction technology (e.g., TX-Cell, MNP level 10, or ETC). The data is translated (if necessary) to a landline-based error-correction protocol (e.g., MNP level 2 or V.42) and is switched to a second modem back-to-back with the primary modem. The second modem switches the call to landlines and on to the call destination. The user sees only the results, which, with ETC, are good.

Primary Access (San Diego, CA) is the supplier of modem-pool hardware and software to the cellular industry. Primary's product is a single digital platform supporting many pairs of back-to-back modems. The modems themselves are DSP (digital signal processor) systems that are configurable via software. These platforms are interfaced on T1 lines that provide 24 channels and a cumulative bandwidth of 1.5 Mbps.

One of the carriers using this technology is NYNEX Mobile Communications (Orangeburg, NY). The company selected ETC because it delivers increased reliability for NYNEX services. It also increases the throughput of all data calls, resulting in increased customer satisfaction. Installing ETC in the network relieves corporate customers from the responsibility and cost of replacing or upgrading all their modems. Finally, it gives the end user point-to-multipoint benefits, rather than the point-to-point benefits that are derived from any protocol required on both ends of a connection.

Jim Ducay, director of wireless data services for NYNEX, believes that "Cellular can meet all of our customers' needs, both voice and data. One such need is wireless modem service, which we supply with ETC-protocol support in the network. The entire process is transparent to the customer, who only sees increased carrier reliability and throughput." While this system delivers benefits without customer investment, if the end user does have ETC installed on his or her end of the link, the benefits are greater.

Of the 15 cellular providers currently endorsing ETC, about half have implemented modem-pool technology in their systems. Most provide it as a value-added service to the customer at no cost. Some are even looking at the possibility of providing reduced-rate data-only services to their customer base.

effect of this protocol is the efficient use of air time, which is the expensive component of cellular communication.

ETC also breaks up data to be sent into smaller frames than most error-correcting protocols. ETC frames are 32 bytes in length, one-quarter the standard V.42 setting. (There is a modem command that enables the manual selection of smaller frame sizes, but who has ever used it?) Using smaller frames has two positive results in error correction. First, frames that the receiving modem determines need replacing are smaller and can be sent in less time than their larger predecessors. Second, a modem can send more frames before receiving an acknowledgment from the receiving device.

This is another timesaving device. The transmit/acknowledge cycle takes time to complete over the length of the cellular circuit, and while it is transpiring, no data can be transmitted. Even though 15 32-byte frames represent about half the data of seven 128-byte frames, the net result of a longer transmission window is more data sent.

Finally, ETC increases the number of retries a modem will make when attempting to send a frame with errors. Currently, standard modems will retry about eight times before breaking the connection. ETC makes 20 attempts, which results in a significant percentage in the percentage of maintained calls.

Deploying ETC

ETC will provide improvement when present in only a single modem in a connection, but it isn't as significant as when it's present in both. If ETC is present in both sending and receiving modems, test results have shown that its overall reliability is nearly 20 percent greater than when it is present at only one end of the connection. One factor to note here is that to provide any improvement, MNP level 10 is required on both ends of the connection, while ETC may be present at only one end. This is the theory behind cellular carrier's *modem pools* (see the text box "Modem Pools").

ETC provides improvement in transfer rates for all file sizes, but a real bonus of the protocol is that significantly larger files can be sent in under 1 minute. None of the other protocols now available can beat the 1-minute threshold, even for files as small as 4 KB, which means that the same call will cost twice as much without ETC. Obviously, as the file transfers get larger, the percentage of savings is not as dramatic. However, the average on-air time for the transfer of a 100-KB file is 3 minutes, 57 seconds, for an ETC-ETC connection.

Real-World ETC

ETC is available in AT&T products like KeepInTouch, which is a PCMCIA cellular modem card, and Dataport and Comsphere, which are desktop system cards. For pre-ETC customers of these products, the technology is downloadable at no charge to the end user. AT&T has licensed ETC, and several modem vendors have also done so. Among the hardware vendors are Compaq, Intel, and Xircom. The list of the service providers who support it reads like a who's who of cellular communication in the U.S., and several of the companies are involved in communications operations worldwide.

Intel's Cellular Faxmodem was the first ETC-compliant product available from a third-party vendor. The Cellular Faxmodem for PCMCIA, descriptively if unimaginatively named, was introduced in June. It

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is compatible with both wireless and wired communications and is capable of 14.4 Kbps, the fastest V.32bis speed. Besides supporting ETC, the Cellular Faxmodem supports MNP level 10, enabling error correction in communication with modems that also support MNP level 10 but do not comply with V.42.

The retail price for the Cellular Faxmodem is $349; an RJ-11 phone cable is a $99 option. The modem is compatible with AT&T's cellular phones and Nokia Consumer Electronics' Technophone. It is not, however, directly compatible with the line of cellular phones from Motorola Codex, the best-selling cellular products in the U.S. Some third-party vendors make products that let you attach an ETC-compliant modem to just about any type of phone, but a direct connection to a Motorola phone through its MC2 bus requires a Motorola modem or a KeepInTouch card.

The Motorola Difference

Motorola's products do not feature ETC. Instead, Motorola has developed its own proprietary protocol called ECC (Enhanced Control Cellular), which is designed to provide the same advantages as ETC. ECC works, like ETC, at both the physical and link layers of the cellular network model. Unfortunately, no further information on ECC was available at press time, including whether it is compatible with other standards, what its specific benefits are, and the availability of licenses from Motorola.

Xircom is an industry leader in the development of LAN and WAN (wide-area network) technology for the mobile market and a technological partner of Motorola. However, Xircom is going with ETC. Jim Soriano, senior engineering director at Xircom, says, "Our products feature a Motorola 68302 processor and plenty of RAM and are capable of supporting multiple simultaneous protocols; space and compute power are not a problem. Xircom simply feels that ETC is the best protocol for the type of marginal conditions that cellular sometimes delivers."

The LAN/WAN group at Xircom is devoted to providing remote connections to LANs and other types of networks. It developed and is marketing two ETC products, the CreditCard Ethernet + and the Pocket Ethernet +. As its name implies, the CreditCard Ethernet + is a PCMCIA product, while the Pocket Ethernet + plugs into a system's parallel port. Both are unique in that they provide an Ethernet interface and a V.32terbo-compatible modem. (Terbo is a word play on the V.32ter standard, which wasn't passed. V32terbo is capable of 19.2-Kbps modulation.)

Xircom chose ETC because AT&T is actively marketing and supporting the product; the secrets of MNP level 10 and ECC, on the other hand, remain veiled. Xircom has left its options open, though. If ECC becomes an important standard, you will be able to download the technology onto Xircom products. ETC will be available as a software upgrade in the fourth quarter at no charge for those who own the CreditCard Ethernet + and the Pocket Ethernet +.

The Cellular Future

The fact that cellular today is a virtual circuit-switched technology adds to the necessity of a product like ETC. Signals sent in an open-broadcast format will always be more susceptible to various types of interference than data carried over a wire.

ETC is just one way to safeguard the transmission of data over a cellular connection. Part of its popularity comes from the fact that ETC isn't required on both ends of a connection. You can buy an ETC modem and still benefit even if your cellular carrier doesn't use it on the other end of the connection. The same can't be said of ETC's biggest rival, CDPD (Cellular Digital Packet Data).

CDPD is a connectionless digital transmission technology that uses some of the unused bands in the cellular frequency spectrum to transmit digital information. Because it breaks information into packets, it can take advantage of standard digital compression and error-correcting techniques. It also doesn't need the long setup time an analog cellular connection does.

Many of the same companies that support ETC also support CDPD. These technologies are not mutually exclusive; one cellular base station can support them both. Because it is required by both parties in a transmission, CDPD technology will roll out far slower than will ETC. Both will undoubtedly exist side by side until after the turn of the century, when the analog cellular network makes the transformation to all-digital technology.

Because of its open-standards nature, and the backing of companies like AT&T, IBM, Intel, and others, ETC looks like a ready-made success. There is no question that it represents a significant boon to the many thousands of cellular users around the country, and that it makes cellular data communication a viable tool for the mobile business professional. ■

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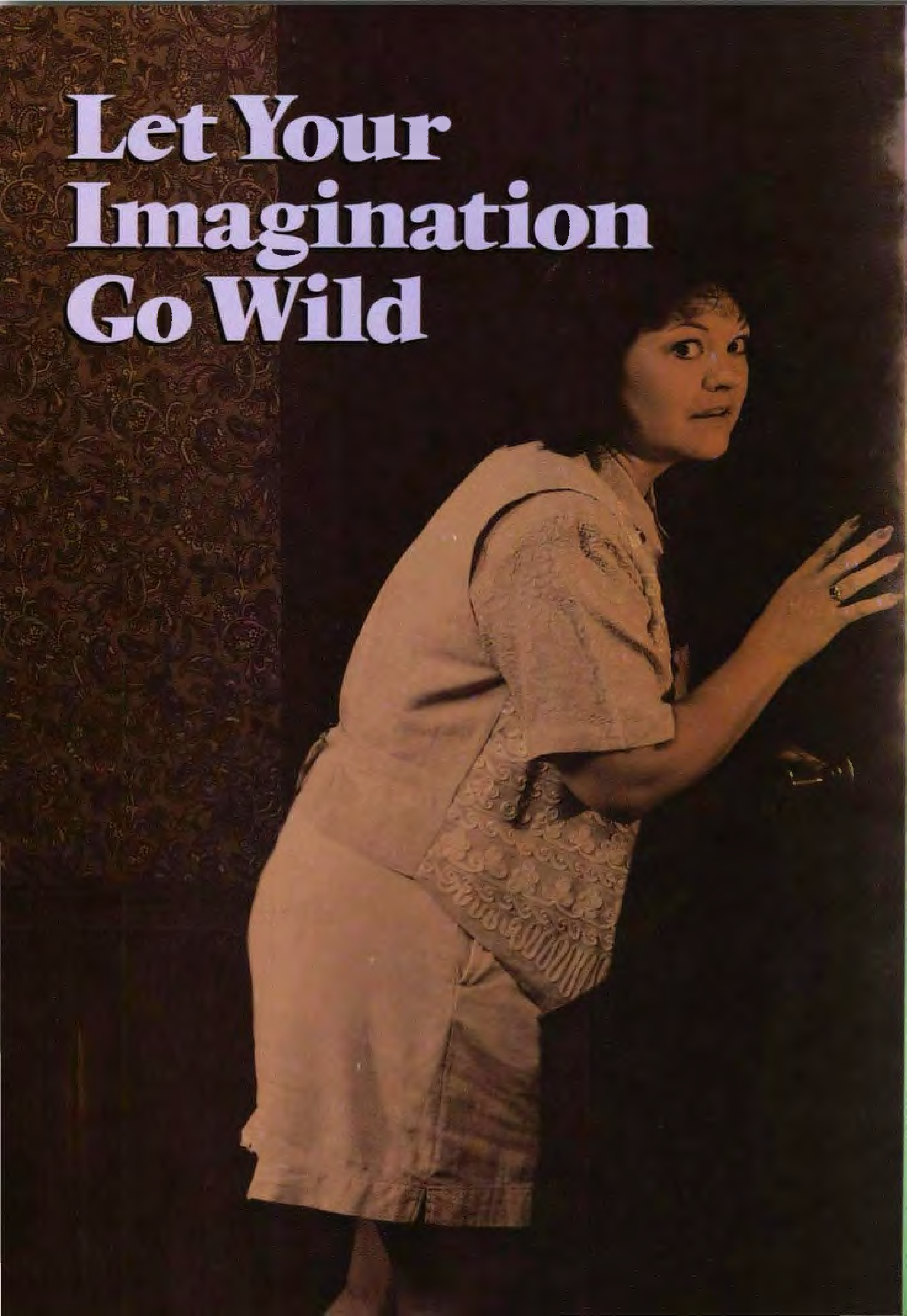


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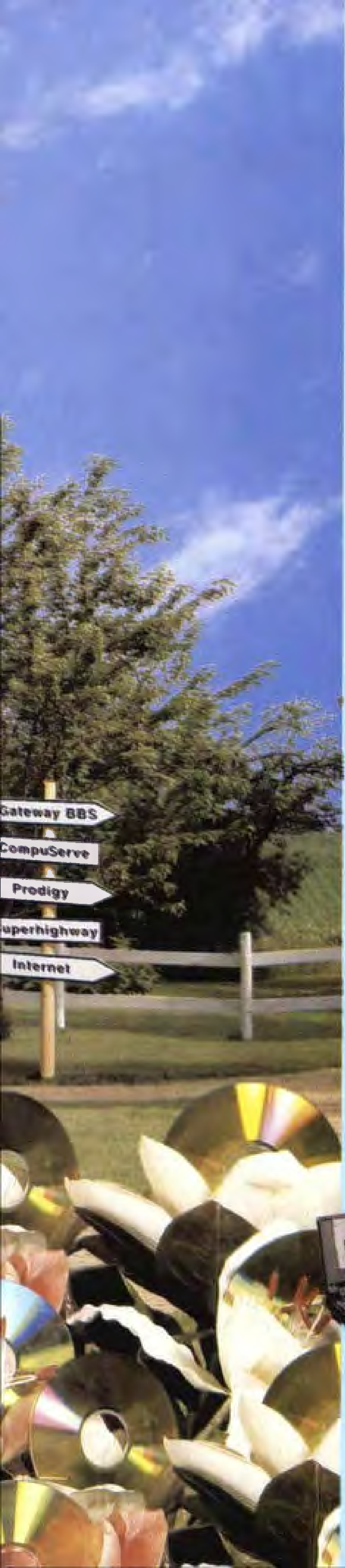

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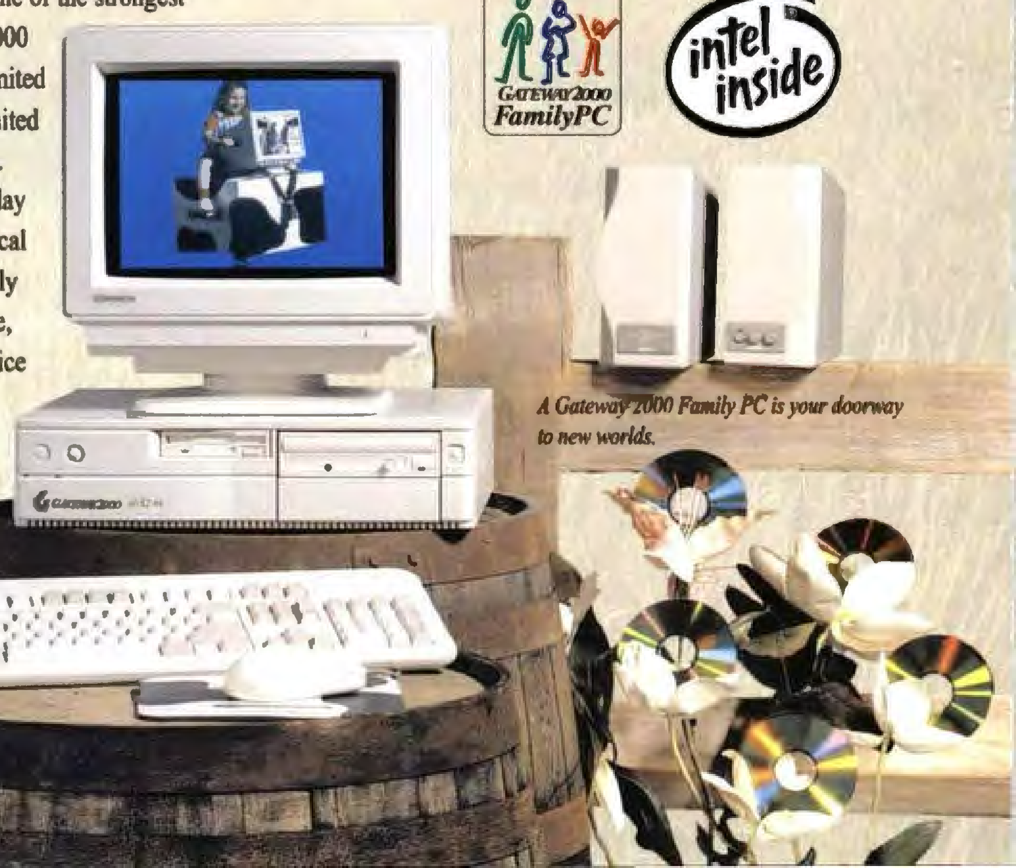

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- PCI Enhanced IDE Interface
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- Double-Speed CD-ROM
- 3.5" Diskette Drive
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Processors Proliferate

NIKOLAI PUNIN © 1994

RICK GREHAN

Good things in small packages are generating big product opportunities

While companies such as DEC, Intel, and Mips have been cranking up the megahertz on their latest 64-bit CPUs, wrapping spacious PCI-bus-based motherboards around them, and strapping on heat sinks the size of waffle irons, other companies, such as Microchip Technology, Motorola, and Zilog, have been happily slipping tiny microprocessors into the nooks and crannies of our lives.

Microprocessors have been used in automobiles for some time, and you've probably guessed that many of the talking and otherwise electrically animated toys that your children now lust after have some sort of microprocessor inside. Cordless and cellular communications equipment are also obvious homes for these chips, but maybe you haven't guessed that one of the biggest markets for microprocessors is the hand-held infrared controller: that thing you use to change channels with every night.

Welcome to the world of the IBP (itty-bitty processor), where bigger and faster take a back seat to—more accurately, barely cling to the rear bumper of—smaller and lower-power. While denizens of the PC motherboard are only now beginning to acclimate themselves to the reduced electronic blood pressure of 3-V power, some IBPs are already running at 2 V and less. While PC CPUs expand their data buses to 32, 64, and even 128 bits, IBPs echo—with some modification—the famous line from *The Treasure of the Sierra Madre*: to wit, "Data bus? We don't need no stinking data bus."

It's true. After all, these are microcontrollers. By definition, as many of their pins as possible are given over to I/O lines, since they are the means by which the CPU communicates with the outside world. All program memory and RAM data reside entirely on the CPU. There are no external data or address lines. These would require external RAM or ROM, plus traces to connect everything, all of which means more real estate, and that's a definite no-no in the land of the small.

An IBP, however, is a very special microcontroller—one that takes the *micro* in *microcontroller* seriously and one that fits entirely in a 20-pin, 18-pin, and sometimes even 16-pin DIP chip. The unbelievably small footprint of these processors makes them hard to take seriously. But don't be fooled. Inside are full-blown CPUs (albeit 8-bit ones) with accumulators, index registers, stacks, and well-rounded instruction sets. They are always adorned with parallel I/O ports; virtually all have one or more timers; many are available in versions with on-chip serial I/O; and some can be outfitted with specialized analog components.

Simply put, they provide electronic intelligence that can be targeted at specialized applications. A single IBP, for example, has the ability to do the job of a pile of discrete electronics. Then you can take that same IBP and reprogram it, and it can do the job

The Taming Power of the Small

I've seen other small microcontroller development systems besides the Basic Stamp from Parallax. Blue Earth Micro, for example, sells a device that connects to your PC's serial port and looks no bigger than an RS-232 gender-changer, yet it includes an 8051 with 32 KB of RAM and a BASIC interpreter on-board. But even these features can't compete with the elegant simplicity of the Basic Stamp (see the photo).

The Basic Stamp is a surprisingly small, yet surprisingly complete, PIC 16C56 development system. It consists of two—that's right, two—ICs, a 4-MHz resonator (i.e., an oscillator circuit), a voltage regulator, and a handful—not even a thimbleful, actually—of passive electronics. The whole thing can be powered by a 9-V transistor battery (you can see the battery clip in the photo).

A three-pin header connects the Basic Stamp to your PC's printer port via a cable supplied by Parallax. Parallax also supplies development software that allows you to program the Basic Stamp in a trimmed-down version of BASIC.

Measuring 1½ by 2½ inches, the Basic Stamp is not much bigger than a Matchbox car. When you consider that at least half of the board's surface area is prototyping area, the Basic Stamp becomes even more amazing.

The board's larger chip is the PIC 16C56 processor. Parallax has programmed it with a run-time kernel that executes the tokenized BASIC program that you create using the development software mentioned above. The code on the PIC 16C56 also contains all the routines necessary to download the program from your PC onto the board's other chip—a 256-byte serial EEPROM. Eight of the PIC processor's pins are available as I/O from a header strip that lies adjacent to the prototyping space.

The Basic Stamp's dialect of BASIC is limited but capable. Obviously, mathematical expressions are restricted to integers, and expression evaluation proceeds from left to right. Multiplication and division are a little strange in that there are separate operations for returning the high word and the low word of the result. Also, programs have access to only seven general-purpose variables.

Nevertheless, you can use LET statements, GOSUB...RETURN statements, IF...THEN statements, and FOR...NEXT statements. Furthermore, the language's designers have added numerous special functions that are useful for—or even critical to—embedded applications builders.

For example, the BUTTON function reads the state of a switch on an input pin, handles debouncing automatically, and lets you specify an auto-repeat delay and rate (if the button is held down). The PULSIN function reads the duration of a pulse on one of the PIC's I/O pins, accurate to 10 microseconds. The PWM function will output a pulse-width modulation on one of the processor's output pins. With the SERIN and SEROUT functions, you can specify pins as serial inputs and/or outputs and transmit or receive characters at speeds of up to 2400 bps.

By anyone's standards, the Basic Stamp is quite an accomplishment of both hardware and software engineering. Documentation from Parallax suggests that it's possible to get, on average, about 80 lines of BASIC on a Basic Stamp. And since your code is being programmed into an EEPROM each time you download it, it's quite reasonable for you to simply take your development system and attach it directly to whatever target it will be controlling.

Personally, I'd love to get a chance to look at the source to the code in the PIC 16C56. Parallax managed to cram all the run-time capabilities of the functions described earlier—the BASIC control statements; digital and analog I/O handling; serial ports; and even the code to communicate with the PC, download the tokenized program into the EEPROM, and execute the tokens—into 512 12-bit instructions. If I were to achieve a similar programming feat, I would die a happy man.

of a different pile of discrete electronics. Repeat that last sentence over and over to yourself, and you begin to appreciate the versatility of IBPs.

Similarities

Before delving into some individual examples of IBPs, we should first get our bearings. After all, most of us have been living in a larger world; we need to get accustomed to thinking small.

As I mentioned above, the distinguishing characteristic of an IBP is its tiny footprint. If you are at all versed in digital electronics, you know that typically a 20-pin DIP holds, for instance, a collection of eight tristate transceivers, not a whole processor. With an IBP, all the ROM and RAM the processor needs is on-chip. Since there are no external address or data lines to feed, more chip pins can be given over to I/O.

Timers are usually critical in embedded applications; they are used for tasks that can be as simple as making lights blink or as complex as generating accurate pulse trains. Every IBP that I have been able to find has on-chip timers, including a specialized version referred to as a *watchdog timer* (at least one processor's data book calls it the COP—computer operating properly—watchdog). Its raison d'être is keeping the processor from lapsing into a coma due to a program failure or a hardware glitch.

Once the processor is started and the watchdog is armed, the program *must* reset the timer within a certain time period; otherwise, the watchdog will reset the processor. Developers therefore build into their programs routines that reset the watchdog every so often. If a failure in program flow occurs, the reset routine won't execute, and the watchdog will resuscitate the processor upon time-out.

continued

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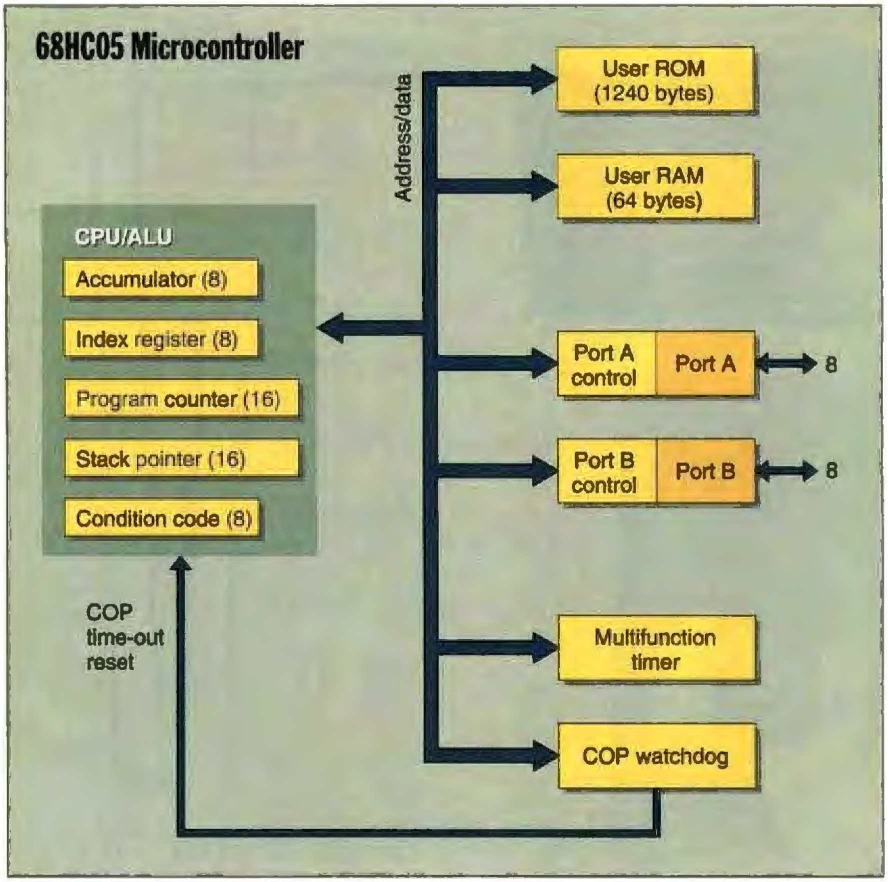

The core of the Motorola 68HC05 microcontroller. Note that the program counter is constrained to 11 bits and the stack pointer is constrained to work in the range of 00C0h to 00FFh. Also, four of the port A pins can be programmed to serve as external interrupt lines.

The Manufacturer's Perspective

While users and developers might view IBPs as atomic, indivisible units of computing, manufacturers see them as a collection of parts rather than as individual, discrete CPUs. I discussed this idea with Paul Grimme, Motorola's HC05 operations manager, and James Goodhart, Zilog's Z8 microcontroller channel manager. Both described remarkably similar approaches to product design. Specifically, manufacturers have, over time, built foundries of processor parts. At the heart of these foundries are processor cores to which manufacturers can attach varying amounts of ROM and RAM, as well as I/O ports, timers, and other peripheral components.

In essence, this is object orientation on a microelectronic scale. It's one area where product longevity does not lead to obsolescence; it leads to increased reliability. For example, the Z8 was available as long ago as 1979; to Zilog's Goodhart, that means not only have all the bugs been worked out of the silicon, but it's given Zilog plenty of time to build up a library of useful software algorithms. When a customer approaches Zilog with a new custom microcontroller specification, Zilog can dip into its hardware foundry and software library, quickly lash together the needed components, and, according to Goodhart, "turn a new design in six to nine months."

This is precisely what happened when a major TV OEM manufacturer recently knocked on Zilog's door. Zilog was able to quickly build a 2-V custom IC with a Z8 core and specialized timers. The result was the Z86L71, the heart of the TV OEM manufacturer's multibrand infrared remote.

Of course, other manufacturers of IBPs have similar stories. As I mentioned earlier, microchip IBPs are crawling throughout the automotive industry. And have you got a Logitech MouseMan cordless mouse next to your computer? If you had x-ray vision, you would see a 20-pin Motorola 68HCL05J1A inside.

Anatomy I: Motorola's HC05

Motorola's HC05 line has—like those of the other manufacturers in this article—a number of members, thanks to Motorola's voluminous component foundries. HC05 microcontrollers are all proud descendants of the venerable 6800, an 8-bit processor that found its home in such long-gone personal computers as Ohio Scientific's Challenger series and computers marketed by Southwest Technical Products.

Of course, as compared to its ancestor, the HC05 is both much expanded and much reduced. For example, if you examine the block diagram of the 68HC05J1A (a 20-pin member of the HC05 family) in the figure "68HC05 Microcontroller," you'll see that the chip has a single 8-bit accumulator and an 8-bit index register. The original 6800 had two 8-bit accumulators, referred to as the A and B accumulators. (Later members of the 6800 family—the 6801, for example—provided instructions that allowed programmers to manipulate the two accumulators as a single, 16-bit accumulator.) In addition, the 6800's index register was 16 bits wide, allowing indexed address operands to span that processor's full 64-KB address range.

It was perfectly reasonable for Motorola to choose a reduced register set for the HC05; that design translates directly to less chip real estate. Furthermore, a 16-bit index register wouldn't provide any advantage on a processor with only 64 bytes of user RAM. All I/O ports (which, by the way, the original 6800 did not possess as on-chip components) and user RAM lie within that processor's first 256 memory locations and are therefore directly addressable by the index register.

The HC05's instruction set also shows modifications to the original 6800 beyond those that you might expect as a result of the reduced memory space and register set. The HC05 repertoire includes bit-set and bit-clear instructions, as well as the bit-test-with-accumulator instruction that was present on the 6800. A rich set of bit-manipulation instructions is a bonus for efficient embedded systems, since the processor spends much of its time either reading from or writing to single I/O pins. Finally, the HC05 has an unsigned 8-bit by 8-bit multiply instruction (the 16-bit result is cut into two halves and placed in the accumulator and index register).

Motorola continues to carry the HC05 to lower and lower levels of power and size. In February, a collection of HC05 members were introduced that operated at 1.8 V. One, the 68HCL05K0, is an HC05 processor with 512 bytes of ROM and 32 bytes of RAM—all in a 16-pin package.

Anatomy II: The Zilog Z86xx Series

Members of Zilog's Z86xx family all have beating in their silicon substrates the heart of that company's workhorse microcontroller, the Z8. A block diagram of one representative, the Z86C04, is shown in the figure "Z86C04 Microcontroller."

This particular version of the Z86xx is

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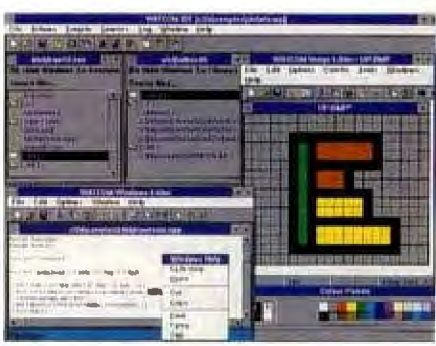

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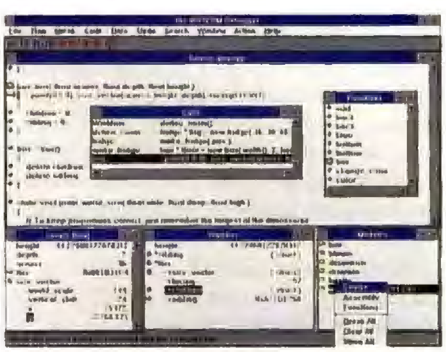

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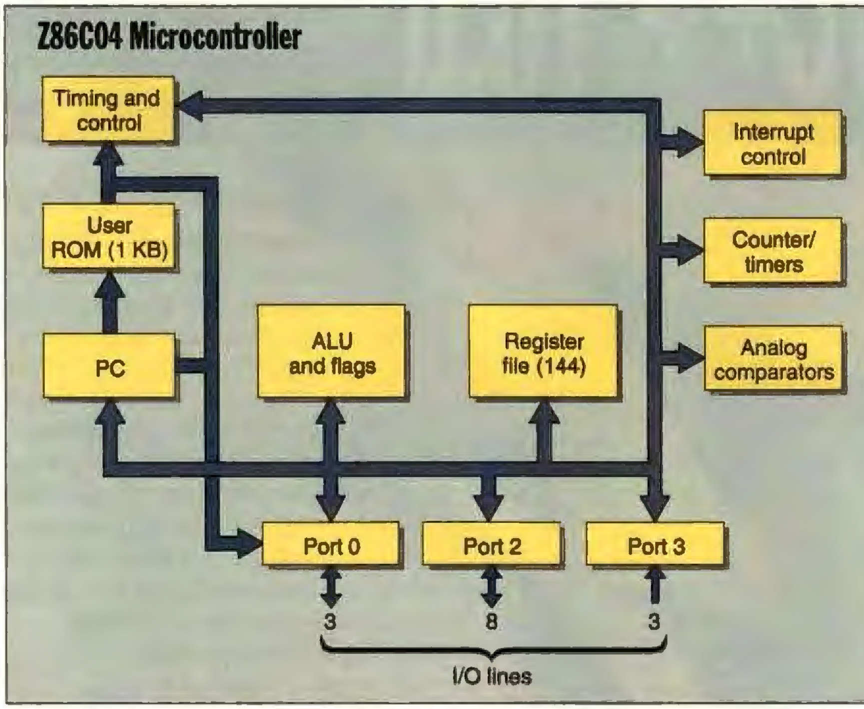

A diagram of the Z86C04, an 18-pin, low-end version of the Z8 family. Note that with 14 pins given over to I/O, only four pins remain for the power supply, ground, and oscillator. Although this part can operate at voltages as low as 3 V, its oscillator can run at up to 8 MHz.

available in an 18-pin package. Cousins to the Z86C04 can run at voltages as low as 2 V and at clock speeds as high as 20 MHz. (There are two branches to the Z86xx tree: the Z86Cxx branch, which can operate down to 3 V, and the Z86Lxx branch, which can operate at 2 V.) The highest clock speed of the low-cost Z86xx processors is 12 MHz.

The original Z8 was Zilog's first one-chip microcomputer. Interestingly, it uses a Harvard architecture (i.e., separate program and data memories), which might not mean much if you were to use the Z8 in its most minimal configuration: only on-board ROM and RAM active. However, the Z8 can also be configured so that some of the I/O pins are given over to address and data lines. In that case, you can attach 62 KB of external program memory and 62 KB of external data memory. (This is, of course, not the case with the Z86xx family, whose members are designed to be used only with on-chip data and program memory.)

With only 18 pins to the outside world, a Z86xx processor is basically a Z8 in its minimal configuration. The Harvard architecture might otherwise be an inconvenience, because an embedded application may need constant data from a table burned into ROM—which would be in the code space. Fortunately, the Z8 includes special instructions for reading from the code space into registers.

One powerful attribute that members of the Z86xx family inherit from the Z8 is that processor's unique register structure. Specifically, the internal RAM of the Z8 is *all* registers. There is no accumulator or index register (as with the 68HC05); every member of the internal register set (referred to as the register file in the figure) can be addressed with equal ease.

You'll notice that the figure indicates 144 members in the register file. Actually, only 124 of the registers are available for general-purpose use. The others are reserved for specific operations, such as I/O-port control, I/O-port data, timer control, the stack pointer, flags, and so forth.

Although the original Z8 had three on-chip I/O ports, and was thus more a microcontroller than a microcomputer, its instruction set looked more like one designed for a microcomputer. In particular, there were neither bit-manipulation nor branch-on-bit-condition instructions. Furthermore, none were added as the Z8 core was moved into the small form factor of the Z86xx processors (as Motorola had done when it moved the 68xx instruction set down into the HC05). Zilog acknowledges this deficiency in the processor but points out that the weakness is offset by the fact that, in the HC05, one has to move data into a register (the accumulator) to do any work, while on the Z8 the data is in a register to begin with.

Zilog has added peripheral components to the Z86xx that make it more attractive for use with embedded applications. There is, for instance, a watchdog timer on all Z86xx processors; some even have an on-chip serial interface. The figure "Z86C04 Microcontroller" shows an "analog comparators" block; there are two individual analog comparators on the Z86C04.

You can configure the processor so that I/O lines normally given over to one of the ports are devoted to the analog comparators. In such a case, the comparators can be used as building blocks for A/D or D/A converters. Zilog's Goodhart told me that, by using discrete components and clever software, one Z86xx customer built an A/D converter with 12-bit accuracy.

Anatomy III: Microchip's PIC 16C5x

The Microchip Technology PIC 16C5x series is a species of the larger Microchip PIC 16x genus; all share more or less the same core processor architectures. Any differences you find are in physical features, such as available I/O pins and specialized on-chip components (the 16C71, for example, has an on-chip A/D converter). A block diagram of the PIC 16C5x processor is shown in the figure "PIC 16C5x Microcontroller."

The PIC processors have features that make them technically more interesting than the Motorola and Zilog components. To start off, the HC05 and Z86xx processors are more or less variations on previous 8-bit-processor themes, while the PIC-series processor is actually—get this—a RISC processor. There are only 33 instructions in the PIC 16C5x processor's repertoire; compare this to the 117 instructions in Motorola's HC05 instruction set and the approximately 75 instructions in the Z8 instruction set.

Understand that this is a RISC processor only in the sense that it has a reduced instruction repertoire. RISC processors typically have large register sets, and operations proceed by fetching data into the registers, manipulating the data once it's there, and then returning the results back to memory. There are only 25 8-bit read/write memory locations on the PIC 16C5x processor, and they're all referred to as registers (as they are on the Z8). There is a W register, a kind of half-hearted accumulator that participates in most mathematical operations. If, therefore, this is considered a RISC chip because all operations occur in registers, remember that there's no other place where they can occur.

It's perfectly reasonable to be skeptical of the benefits of a reduced instruction set in such a small processor. In the larger world of 32- and 64-bit processors, the rule of thumb is that a RISC processor requires more machine-code instructions per

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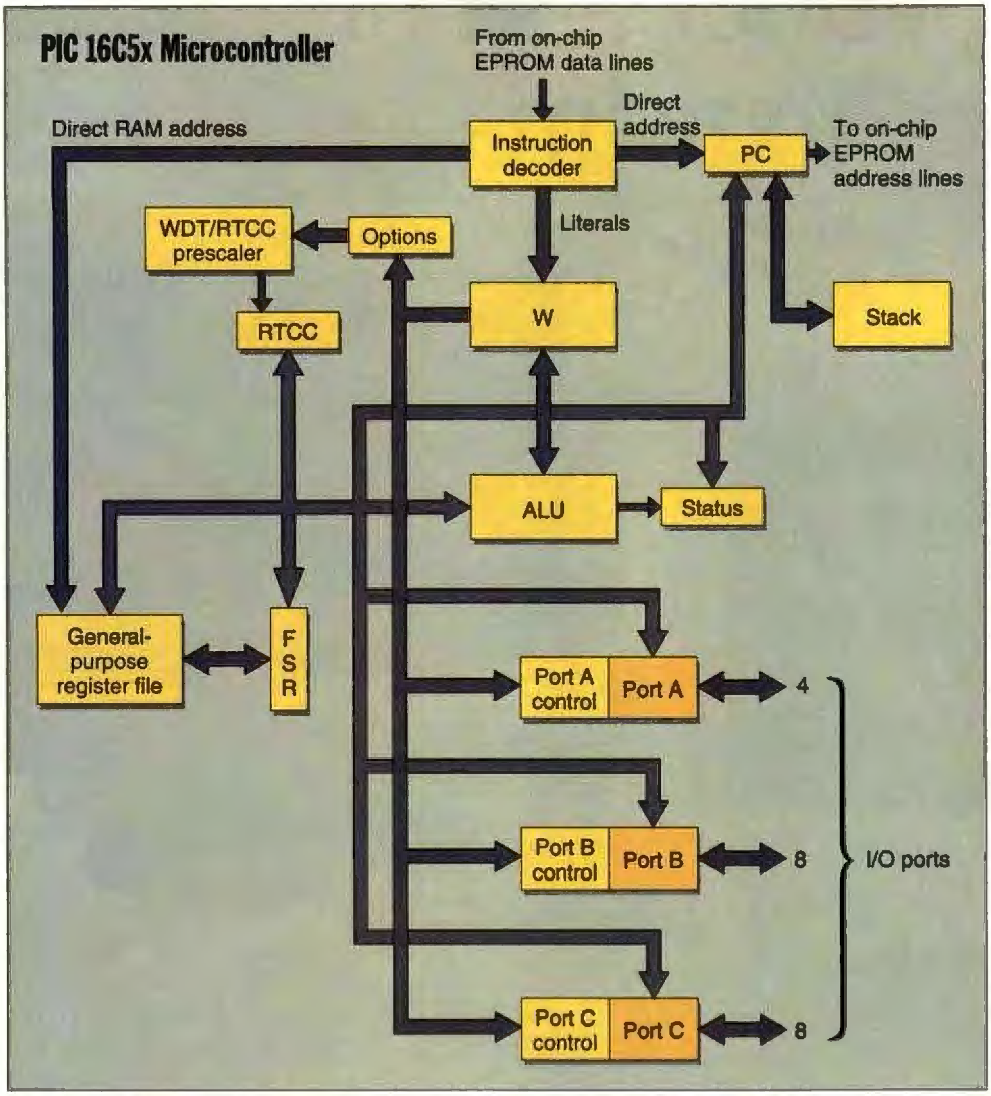

A block diagram of the PIC 16C5x series of microcontrollers. Note the on-chip stack RAM (which is two elements deep). The FSR (file-select register) can be used as a general-purpose register, as an indirect address register, or (on some PIC models) as a bank-select register. Also note that smaller PIC models do not have I/O port C; the associated registers are available as general-purpose registers.

high-level operation. This is not the case with the PIC 16C5x, however. The trick is that the instruction-bus width on the PIC 16C5x is 12 bits, and—if you consider that to be the processor's word size—all instructions are PIC-word-wide instructions. For example, the instruction to load an 8-bit literal into the W register encodes the operand in the upper 4 bits, and the literal value in the lower 8 bits. (Astute readers are now saying to themselves: "Fixed instruction length: another RISC attribute.")

This should be put into perspective, however. The PIC chips achieve the *reduced-instruction* part of the RISC acronym by eliminating instructions that many programmers may deem downright necessary. For instance, there are no comparison instructions, nor are there any conditional branch instructions. There is an unconditional GOTO instruction (implemented as an absolute, as opposed to a relative, branch), and conditional branching can be built into a PIC program by placing a GOTO immediately following one of the four instructions that include a "skip if condition" modifier. Such instructions will skip the next instruction if a particular condition is met.

Here's an example: The DECFSZ instruction tells the processor to decrement one of the registers and, if the result is zero, to skip the next instruction. You can see that, if the next instruction happened to be a GOTO, the effect would be a "decrement register and branch if not zero" instruction.

There are other remarkable traits lurking in the PIC processors. Their CPUs are actually pipelined, with overlapping fetch and execute cycles. All instructions, except GOTO, execute in a single machine cycle (GOTO takes two cycles). Some members of this processor family enjoy the full range of clock speeds, from 0 MHz all the way up to 20 MHz. All have a power-saving sleep mode.

Perhaps the best example to date of IBP innovation, however, is available thanks to the PIC 16C5x and some imaginative people at Parallax, who developed the Basic Stamp. This is a microcontroller development system that connects to your PC via a parallel port and requires only two ICs. (See the text box "The Taming Power of the Small" for details.)

Don't Look Now

In 1993, Motorola published the results of research concerning microcontroller applications. The research focused on home, office, and auto use and included projections to the year 2000. The big winner was the home. Motorola forecast that the typical home in the year 2000 will have over 200 microcontrollers embedded in appliances, telephones, VCRs, stereos, and so on.

Zilog's Goodhart probably wouldn't argue with his competitor's finding. "The largest consumer electronics usage right now is IR remotes," he says. Goodhart envisions the day when that handheld channel-changer in your living room grows in capabilities (but not in size) until it becomes the input device to all the computer and electronic gear in your home.

Like an incurable infection, the use of IBPs is spreading. While doing research for this article, I found it impossible to identify just one or two market forces driving IBP proliferation. The marketing currents that today push technological development come from all compass points: portable communications, intelligent PC peripherals, autos, consumer electronics, and even toys, for heaven's sake.

While some CPU builders sweat and strain on new designs for bigger caches, bigger data buses, and bigger address buses, it's refreshing to know that other designers are discovering wholly new products and markets for the incredible, shrinking IBP. ■

Rick Grehan is technical director of the BYTE Lab. He has a B.S. in physics and applied mathematics and an M.S. in mathematics/computer science. He can be reached on the Internet or BIX at rick_g@bix.com.

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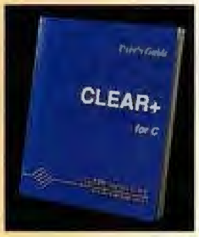

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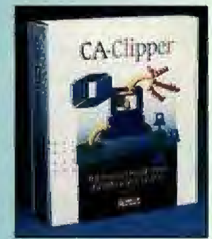

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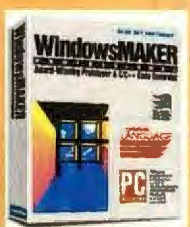

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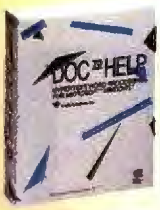

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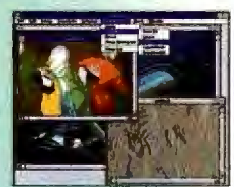

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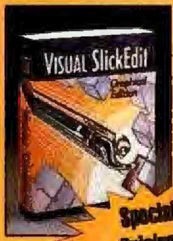

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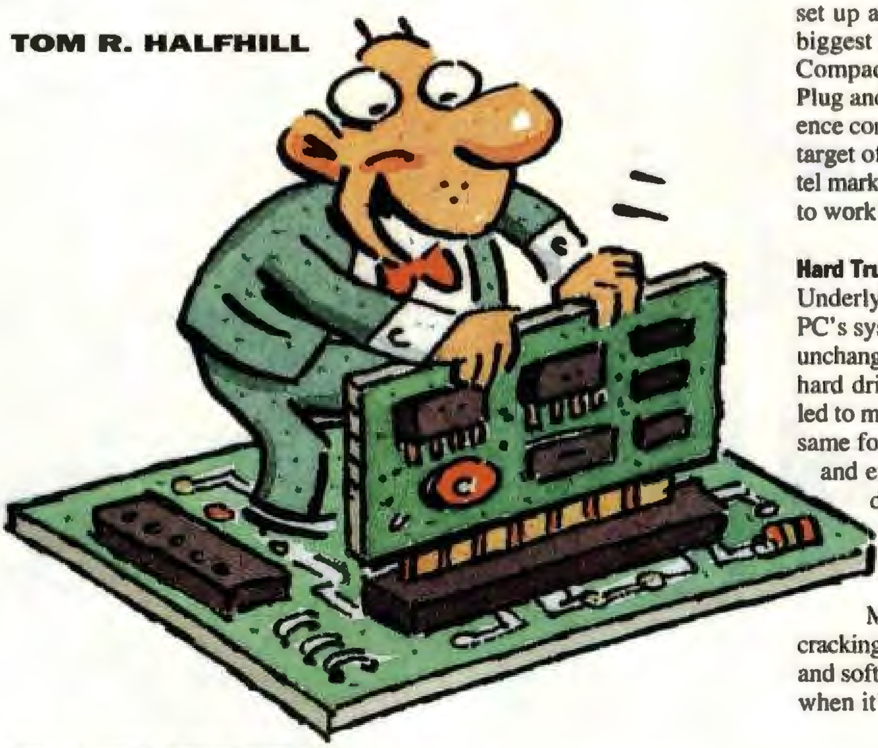
Cover Story

Transforming the PC: PLUG and

An industry-wide effort, Plug and Play will make PC compatibles easier to configure and maintain while reducing support costs for vendors and users. Although businesses and individuals both stand to gain substantial benefits, the transition to full adoption of Plug and Play won't be painless, won't come cheap, and will likely take years.

TOM R. HALFHILL



At first glance, Plug and Play looks like a collection of paradoxes. To achieve its ambitious goal of making PC compatibles easier to set up and use, it requires changes to the computer's BIOS, operating system, peripherals, device drivers, and applications software. Changes are made to nearly everything, in fact, but the core component that most needs changing: the decade-old PC system architecture with its obsolete ISA bus. And although Plug and Play does a remarkable job of making PCs friendlier while maintaining compatibility with existing hardware, it also requires that you eventually replace almost all that hardware.

Another paradox is the marketing challenge presented by Plug and Play. The handiest way to describe what it does—"Plug and Play makes your PC as easy to set up as a Mac"—isn't likely to be embraced by its biggest backers, which include Microsoft, Intel, and Compaq. And the users who most desperately need Plug and Play—first-time buyers who have no experience configuring PCs—probably won't be the primary target of Plug and Play advertising because, as one Intel marketing person explains, "Naive users expect PCs to work this way already."

Hard Truths

Underlying these paradoxes are some hard truths. The PC's system architecture *has* remained fundamentally unchanged for 10 years. Faster microprocessors, bigger hard drives, and more memory have unquestionably led to more powerful PCs, but underneath it all lies the same foundation that IBM defined for the PC in 1981 and extended for the AT in 1984. Without a single defining leader since IBM lost control over the architecture in the mid-1980s, the world's leading computer platform has been propelled forward by sheer market momentum.

Meanwhile, the foundation has been slowly cracking under the weight of more and heavier hardware and software. The 8-MHz ISA bus is now a bottleneck when it's mated with a 100-MHz Pentium processor.

PLAY

Expansion slots are crowded with devices that were rare or unheard of a decade ago: LAN cards, fax modems, CD-ROM interfaces, SCSI host adapters, stereo sound boards, and video digitizers. The 640 KB of RAM that once seemed luxurious is now choked with contentious device drivers and TSR programs. IRQs (interrupt requests), DMA channels, I/O memory ports, and other system resources are now fought over like the last pebbles of ore in a played-out gold mine.

The results are ominous. Users are frustrated with the complexities of IRQs, DIP switches, jumpers, and drivers. Technical-support costs for businesses and vendors are skyrocketing. Marketers worry that the supply of customers willing to tolerate this chaos will soon reach a saturation point. An "unacceptably high" return rate (reportedly in excess of 25 percent) for multimedia upgrade kits sold for PCs prompted CompUSA (Dallas, TX), a nationwide retailer, to offer free installation in PCs purchased from its stores. Microsoft says nearly half the calls to its Windows help lines are from users struggling to install or configure hardware and software. A 1993 study by the Gartner Group (Stamford, CT) estimated that the five-year cost to a business of owning a Windows-based PC was more than $37,000, largely due to system complexity.

Past attempts to renovate the PC architecture—such as Micro Channel architecture and EISA—or to establish alternatives like ACE (Advanced Computing Environment) have met with limited success or total failure. The most successful alternative is Apple's Mac, but its proprietary nature has discouraged widespread adoption.

Experience has shown that users want a gradual transition, not a clean break with the past, and no initiative will succeed without pervasive industry support. Plug and Play is a conscious effort to heed those lessons while driving the market forward.

In the short term, Plug and Play is an impressive patch on the creaking PC architecture. Although it doesn't add any system resources, it does codify the way existing resources are rationed. In the long term, Plug and Play is a ladder to a future architecture that by the end of the decade will recast the PC platform. The primary I/O bus will most likely be PCI (Peripheral Component Interconnect). Branching off will be a cascading series of secondary I/O buses (e.g., Enhanced IDE, PCMCIA, SCSI, Access.bus, P1394, and others). The hardware will be more tightly integrated with the system software, much as it is in today's Mac. For both the industry and users, the challenge is how to get there from here.

Step by Step

Plug and Play has three immediate goals. First, it will make PCs easier to set up and configure. Second, it will ease the task of installing new hardware and software. Third, it will endow PCs with entirely new features, such as the ability to change configurations on the fly and allow both the hardware and software to respond dynamically to configuration events. Examples include adding or removing a PCMCIA fax modem, attaching a mobile computer to a network, or hooking a notebook computer to a docking station.

It's important to distinguish between *Plug and Play* as an officially defined framework and *plug and play* as an increasingly popular buzzword. Many new devices, peripheral buses,

and platforms are described as "plug and play," and they may offer the advantages of easy setup, configuration, and expansion. But Plug and Play (usually abbreviated PnP) grew out of an ISA-specific standard first proposed by Microsoft and Intel at the Windows Hardware Engineering Conference in March 1993.

Over the following months, the two companies founded the Plug and Play Association, distributed preliminary specifications, and solicited input from vendors and users via the PlugPlay Forum on CompuServe. The association released the latest revision of the ISA specification in May. A revised PnP BIOS specification, authored by Phoenix Technologies, Compaq, and Intel, appeared at the same time. Meanwhile, a number of companies and industry groups have collaborated on PnP specifications for other buses, ports, and devices.

Full PnP compliance requires changes to four major elements of a PC system: the computer's ROM-based BIOS, the operating system, hardware devices, and applications software. When all those pieces are in place, PnP will bring automatic, software-driven configuration to almost every I/O bus and port on a PC, including ISA, EISA, PCI, VL-Bus, PCMCIA, SCSI, Micro Channel architecture, IDE, Access.bus, P1394, parallel ports, RS-232 serial ports, and SVGA monitors. PnP will also configure hard-wired motherboard devices in your system, such as the keyboard, mouse, joystick, and display controllers. No more jumpers, no more DIP switches, no more messing with configuration files such as AUTOEXEC.BAT, CONFIG.SYS, SYSTEM.INI, or WIN.INI.

At least, that's the plan. PnP is off to a good start and is slowly gathering strength throughout the industry, but some confusing gray areas in the specifications leave room for improvement. For example, some new PnP ISA cards actually add a jumper that users must change when installing the device in a non-PnP system. "These things will get refined as we go along, in a point-one release or whatever," says Carl Stork, Microsoft's director of Windows hardware programs. "The important thing is that we're doing the best we can at providing a solution that works now."

So nirvana isn't right around the corner, but the journey is under way. Most current users will spend years building toward full PnP capability. Most people will have to buy a new computer or motherboard just to upgrade the BIOS, because BIOS ROMs typically aren't upgradable.

To get full system software support for PnP, you'll need a PnP-integrated operating system like Chicago. Future versions of OS/2 and Windows NT will utilize PnP as well. Chicago is scheduled for release this year. IBM says a new version of OS/2 will fully support PnP in the first half of 1995. Another version of OS/2 that's due this fall (sometimes called Warp) will allow hot-plugging of PCMCIA cards but won't include other elements of PnP. NT won't fully integrate PnP until Cairo (scheduled for 1995), but it already includes some foundation features, such as a system configuration record and a browsing tool called the Registry Editor.

A stopgap solution is to retrofit MS-DOS and Windows 3.1, a task that Microsoft delegated to Intel. Intel's Plug and Play Kit for MS-DOS and Windows 3.1 is available to vendors, who will resell it to users with PnP systems and devices. The retrofit offers significant benefits, but it doesn't go as far as a fully integrated PnP operating system. For example, the only I/O buses it supports are ISA, PCI, and PCMCIA, and its ability to reconfigure on the fly is severely limited. As of now, there is no retrofit for OS/2 2.1 or other operating systems, although IBM's PC-DOS 6.3 already supports PCMCIA hot-plugging and will add hot-docking in early 1995.

All of today's hardware devices (including internal cards and external peripherals) will work in a PnP system, but because they are as susceptible as ever to configuration problems, you will eventually need to replace them if you want full PnP flexibility. Likewise, current applications software is compatible with PnP, but any applications that need to respond to configuration events (e.g., a communications program that knows when a fax modem has been added or removed) must be upgraded. The bottom line is that

Plug and Play with DMI

In some ways, Plug and Play overlaps another industry initiative that promises to make PCs easier to maintain: DMI (Desktop Management Interface). DMI is a new standard proposed by the Desktop Management Task Force (Hillsboro, OR), an industry group that counts DEC, Hewlett-Packard, IBM, Intel, Microsoft, Novell, SunConnect, and SynOptics among its charter members.

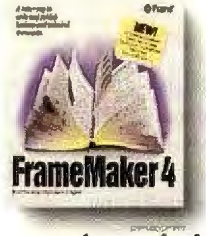
Finalized in April, DMI is a standard mechanism for managing PCs, servers, peripherals, and applications from the network level to the desktop. It should be particularly useful for network administrators who use desktop management tools to maintain and troubleshoot LANs. It supports existing standards like SNMP as well as PnP.

"DMI is a superset of PnP," says Shannon Gray-Voigt, who is the industry standards marketing manager for Intel and a member of the DMTF. "Both technologies have the same goal. PnP is really a step toward DMI."

DMI adds a layer of system software that provides configuration information and other services to higher-level applications. It stores the information on the computer's hard disk in a series of small files called MIF (Management Information Format) files. Ideally, every hardware and software component on the system would have its own MIF file describing various attributes of the component, including the system resources it needs. Diagnostic tools can query the MIF files to help users and administrators solve problems.

On a PnP system, the DMI layer can talk directly to the PnP Configuration Manager to retrieve information about the machine. This communication is vital, because a PnP system can reconfigure itself on the fly. A network management tool might get confused if a PC's network card swapped resources with another device and suddenly appeared to drop off the LAN.

The DMTF's goal is to put DMI services on all major operating systems, including MS-DOS, Windows 3.1, OS/2, Chicago, and NetWare. Apple is involved, too, so DMI could become a broad-based standard for managing heterogeneous networks.



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to derive maximum benefit from PnP, you'll eventually have to replace or upgrade almost everything you own.

Fortunately, PnP softens the transition by letting you mix and match virtually any combination of PnP and non-PnP components. The more parts of your system you upgrade, the more PnP functionality you'll get. How smoothly you'll weather the transition depends on how quickly PnP products come to market, how much you've got invested in current technology, and how soon you can afford to upgrade.

Time Slices

"PnP is more of a long-term solution than a short-term solution," says Carter J. Lusher, program director of personal computing at the Gartner Group. "We probably won't see widespread PnP products until early 1995. Most companies depreciate their machines on a three- or five-year cycle, so I don't expect to see them converting to PnP until late 1996 at the earliest."

Not surprisingly, Microsoft, Intel, and other PnP backers prefer a more optimistic view. "The release of Chicago will accelerate demand for PnP software and devices, especially on high-end systems," says Stork. The first systems with PnP-enabled BIOS ROMs began shipping a few months ago, and all the major BIOS vendors support PnP. Peripheral vendors seem to be moving a little more slowly, but the first PnP devices—including a SCSI host adapter from Future Domain (Irvine, CA)—actually appeared in 1993, based on the PnP SCSI specifications.

Even without all the pieces in place, there's enough to gain by incrementally adopting PnP that it should quickly become a checkoff item for future purchases. This is especially true for businesses, because configuration woes directly affect productivity and maintenance costs. The Gartner Group 's most recent estimates put the five-year cost of owning a Mac at about 10 percent less than a Windows PC. The difference is partly attributable to the Mac's plug-and-play capabilities, which date from the release of the Mac II in 1987.

Mac users, incidentally, tend to regard PnP as merely the latest effort in the industry's 10-year struggle to turn PCs into Macs. It seems to prove once again that everybody wants a computer that works like a Mac, but for various reasons, only about 12 percent of them want to buy that computer from Apple.

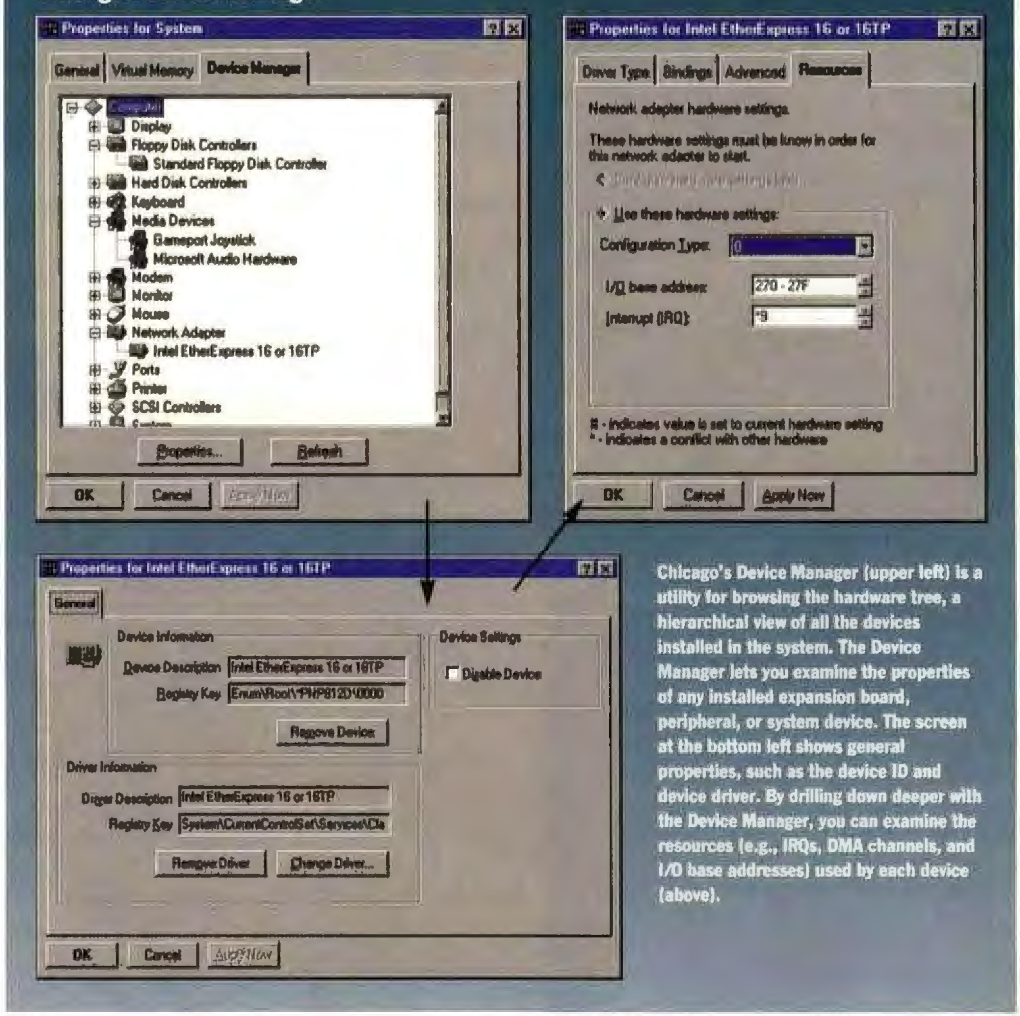
Actually, PnP can do some tricks that even today's Macs can't do, such as hot-docking. Nevertheless, there is no denying the Mac's lead in plug-and-play technology, made possible chiefly because Apple maintains rigid control over the Mac's system architecture and system software. That's the advantage of a proprietary platform. To change something, all Apple has to do is send an internal memo to a dozen product managers.

That's an oversimplification, of course. But change *is* much more difficult on the PC side, where hundreds of competing vendors must coordinate their actions. The power vacuum left behind by IBM has largely been filled by Microsoft (the leading system software vendor) and Intel (the leading chip vendor), with help from Compaq (a contender for the title of leading system vendor). Like Border collies working on a sheep ranch, these companies

Tips for Plug and Play

- **Be sure the next PC or motherboard you buy has a BIOS that supports Plug and Play. This may take some snooping, because PnP may not be widely advertised by all vendors.**
- **Look for a BIOS that's stored in flash ROM, not mask ROM. It will be easier to upgrade in the future.**
- **Upgrade to a fully integrated PnP operating system as soon as it's available. If your computer isn't fast enough or doesn't have enough memory, Intel's retrofit for MS-DOS and Windows 3.1 is a good interim solution.**
- **PnP cards and peripherals will be scarce for a while, but they're worth having if you can wait. Plan on gradually replacing your legacy cards.**
- **Watch for software vendors to announce upgrades to applications that can benefit by responding to dynamic run-time events.**
- **Don't buy a notebook docking station that doesn't support PnP.**

Chicago's Device Manager



Chicago's Device Manager (upper left) is a utility for browsing the hardware tree, a hierarchical view of all the devices installed in the system. The Device Manager lets you examine the properties of any installed expansion board, peripheral, or system device. The screen at the bottom left shows general properties, such as the device ID and device driver. By drilling down deeper with the Device Manager, you can examine the resources (e.g., IRQs, DMA channels, and I/O base addresses) used by each device (above).

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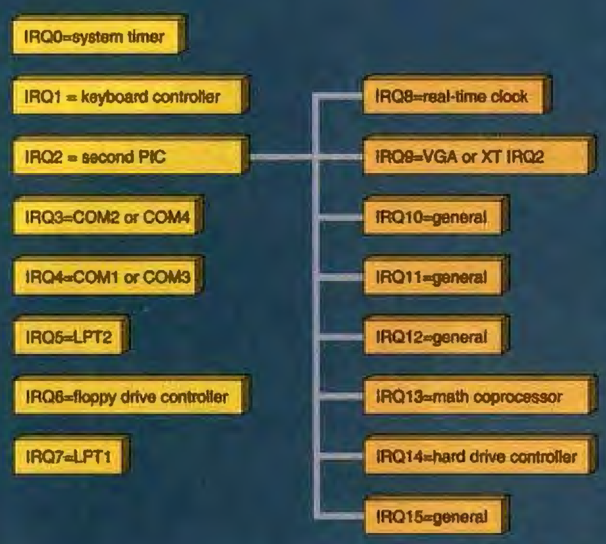
IRQ Assignments in PCs



Early PCs and XTs had only eight IRQ inputs, numbered 0–7. Starting with the IBM AT in 1984, IRQs 9–15 were added, and this arrangement is found in all PC compatibles today. Many IRQs are preassigned to various system devices and cannot be reassigned to add-on peripherals. To make matters worse, some devices insist on having high-priority IRQs. Note that lower-numbered IRQs get higher priority, except that IRQs 8–15 get higher priority than IRQs 3–7.

are running hard to get everyone else moving in the same direction at the same time.

Resource Bottleneck

Users who have trouble configuring their PCs typically run afoul of conflicts between devices contending for the same system resources. PnP doesn't solve the root problem by adding more resources, but it does try to resolve conflicts by assigning currently available resources in a more systematic manner.

The scarcest resources in a PC are IRQs, DMA channels, I/O memory ports, and conventional memory. For historical reasons that in some cases date back to the 1970s, even the latest Pentium PCs are limited to the same set of resources.

IRQs are crucial to the operation of I/O devices, allowing them to send hardware interrupts to the CPU. Without them, the CPU would have to continually poll I/O devices to check for activity. Thanks to IRQs, the device can sit idly on the I/O bus without consuming processing cycles and interrupt the CPU only when the I/O device needs processor time. In PCs, IRQs are mediated by PICs (programmable interrupt controllers) on the motherboard.

Early PCs and XTs had a single 8259A PIC chip that could handle eight IRQs, numbered IRQ0–IRQ7. It quickly became apparent that eight IRQs weren't enough, so IBM added a second PIC to the AT in 1984, creating an arrangement common to all PC compatibles to the present day. Unfortunately, this yields only 15, not 16, available IRQs, because the second PIC is a slave that bridges to IRQ2 of the master PIC. This prevents IRQ2 from being assigned to another device.

The slave PIC also upsets the priority assignments of IRQs. In PCs, lower-numbered IRQs are serviced before higher-numbered ones. However, because the IRQs on the slave PIC are cascaded onto IRQ2 of the master PIC, the slave inputs (i.e., IRQ8–IRQ15) inherit the priority of IRQ2, thus enjoying a higher priority than IRQ3–IRQ7 on the master PIC. Some I/O devices are especially picky and demand high-priority IRQs, so the numbering makes a difference. Adding more PICs at this point isn't feasible because it would disrupt the PC system architecture. (See "IRQ Assignments in PCs.")

If all this sounds complicated, it is. First-time PC users who don't know an IRQ from the IRS are often thrust into this quagmire as they struggle to install and configure their expansion boards. Some boards are software-configurable, meaning you can change their IRQ settings by running a setup program, but others require you to fiddle with DIP switches or jumpers.

IRQs are just the beginning. Some devices also want a DMA channel. DMA grants a device direct access to system memory without using the CPU as an intermediary. Although this boosts system

PnP and You

A device "installation wizard" in Chicago (top screen) guides you through the process of installing a new device and its associated software. When Chicago detects a new device in the system (either dynamically or after boot-up), it prompts you to install or select the required driver, if necessary (bottom screen).

throughput, because a typical PC has only seven DMA channels, it creates another source of conflict.

Next come the I/O ports. The rivalry over this system resource predates the 80x86 family itself. At least as far back as the 8080 chip—a 1974 predecessor to the 80x86 line—Intel CPUs have offered special instructions for communicating with I/O devices and have allowed those devices to be mapped into a block of address space that's separate from main memory.

This was a clever conservation measure in the days when a typical microcomputer had a few kilobytes of RAM. But today, when Pentium CPUs execute at speeds of 100 or more MIPS and computers have megabytes of RAM, the scheme leads to maddening constraints on the way I/O space is allocated.

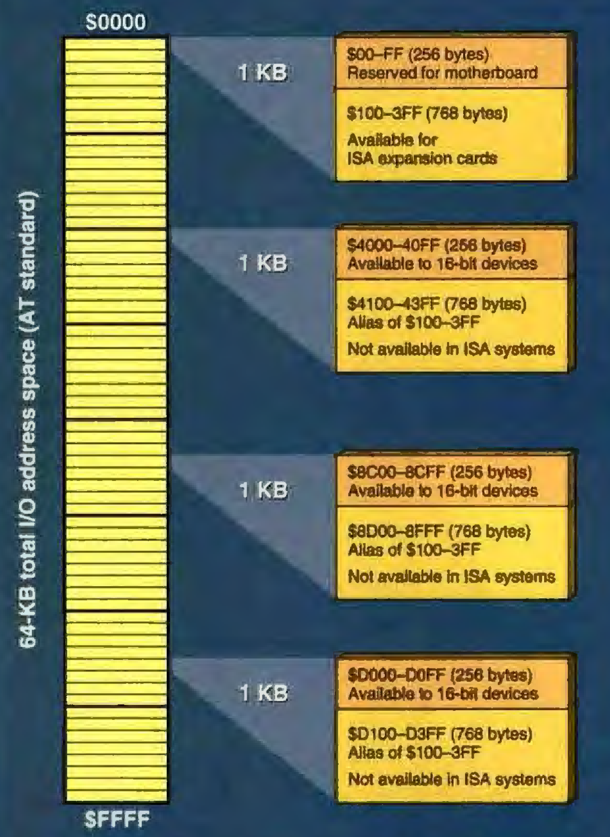
To communicate over the bus, each I/O device needs to reserve some address locations, known as I/O ports. (These ports are not to be confused with physical ports, such as parallel and serial connectors.) Because only 16 address lines are used to access I/O devices, the total address space available for those ports is 64 KB. The original 8-bit I/O bus in PCs and XTs made this even worse by decoding only 10 of the bits on those 16 lines, thus reducing the I/O address space to 1 KB. And the first 256 bytes of that 1 KB of address space are reserved for motherboard devices. Barring the use of a trick or two that let you gain a few extra noncontiguous bytes, all the I/O ports on the ISA expansion bus had to be mapped to the remaining 768 bytes.

In 1984, IBM's AT extended the architecture with a 16-bit I/O bus and allowed devices to decode all 16 address lines. Theoretically, this liberated the 63 KB of I/O address space ignored by the original architecture. Unfortunately, to maintain compatibility with older devices that don't recognize 16-bit addresses, most of that memory is off limits, and what's left is scattered around in 256-byte fragments. Even I/O buses that came later and were designed for 16-bit addressing from the start (e.g., EISA, VL-Bus, and PCI) must deal with these fragments to preserve backward compatibility with ISA cards. As a result, I/O devices in today's PCs continue to squabble over tiny crumbs of bytes, even in systems that have many megabytes of main memory. (See "I/O Addressing in PCs.")

You can map device drivers into main memory instead of I/O memory, but that causes headaches, too. Operating systems like DOS that run in 80x86 real mode are normally limited to 1 MB of addressable memory, and only 640 KB is so-called conventional memory. This space can become so overpopulated with drivers and TSRs that some applications hungry for conventional memory won't run at all, no matter how much RAM is free elsewhere in the system.

continued

I/O Addressing in PCs



Most PC compatibles made since 1984 (based on the IBM AT standard) can theoretically use 64 KB of address space for device I/O ports. However, only 768 bytes of that space is available to older devices that decode only 10 bits of the 16-bit address. To maintain compatibility, even today's 16-bit devices can use only 256 bytes out of each 1-KB memory block because of aliasing, which renders the other 768 bytes of each block unavailable.

What They're Saying About Plug and Play

"**PnP** will help us build our systems better, build them more quickly, and have more confidence that they'll work properly when delivered to the customer. Home users should be able to buy an accessory, take it home, install it themselves, and get it to work the first time. It will let them expand their systems without fear."—Mark Clauder, product manager for Compudyne products at CompUSA (Dallas, TX), which operates 78 superstores throughout the U.S.

"There's a crying need for PnP, no doubt about that. This is why the Macintosh is still popular, and why so many people who get their hands on a Mac never want to go back to a PC or Windows."—Carter J. Lusher, program director for personal computing, the Gartner Group (Stamford, CT).

"PnP will probably eliminate about 20 percent of our [technical-support] calls, but we still get about 60 percent of our calls from people who don't understand much about the software of networking. We spend lots of our time helping people configure their software, like Windows for Workgroups or LANtastic. It's not really our problem, but you can't tell people that or they get really upset."—Fred Thiel, vice president of marketing and sales, Alta Research (Deerfield Beach, FL), manufacturer of the first PnP-ready ISA network adapter.

"I certainly think a move away from the ISA bus would be a win, but our success is not gated by that."—Carl Stork, director of Windows hardware programs, Microsoft (Redmond, WA).

"We will have full support for PnP in OS/2 at about the same time Microsoft does [in Chicago]. And we have a 32-bit operating system that's stable and has been out there for several years."—Lois Dimpfel, director of the Boca Raton Programming Center, IBM Personal Software Products.

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Resource Rationing

PnP attempts to bring order out of this mess by apportioning system resources according to a complex but consistent set of rules. As is the case with welfare reform, PnP also promises to take care of the truly needy first.

In this case, the truly needy are so-called legacy devices—those that don't support PnP. Another paradox? Not really. Legacy devices often require users to select IRQs and DMA channels by changing DIP switches and jumpers. Once they're adjusted, those settings can't be changed without taking the computer apart and monkeying with controls that are smaller than your fingers. Too often, the result is what's referred to in the industry as a "negative user experience." So PnP gives legacy devices first dibs on system resources and tries to fit everything else in around them.

The degree to which resources are rationed greatly depends on which components in your system are PnP-aware. There are numerous combinations, and the most likely ones are summarized in the table on page 90. The prime components in this process are the BIOS and the operating system. (See "How Plug and Play Works.")

If the BIOS supports PnP, it tries to configure the system first. If it succeeds, you're home free. If the BIOS fails, it hands off to the operating system. If the operating system supports PnP, it finishes the job or tells you if a conflict can't be resolved with your current setup.

If the operating system doesn't support PnP, you must pick up where the BIOS left off. At the minimum, a PnP BIOS will auto-configure three devices at boot-up time: an input device (typically the keyboard controller), an output device (typically the video controller), and an initial program load device (typically the hard drive that holds the operating system). The PnP BIOS also configures motherboard devices (e.g., the PIC, the DMA controller, and the floppy drive controller) and maybe other devices as well. (See "Building a Better BIOS" on page 92.)

If your system has a legacy BIOS (no support for PnP), you can still gain by upgrading to a PnP operating system—either one that's fully integrated (e.g., Chicago) or the retrofit solution for MS-DOS and Windows 3.1. In either case, a new layer called Configuration Manager does its best to configure any PnP devices in the system and minimize the chances that you'll have to manually edit any configuration files, such as CONFIG.SYS or WIN.INI.

In going about its business, Configuration Manager calls upon new system software components known as *bus enumerators*, as well as the *resource arbitrator*. Bus enumerators are drivers that check each I/O bus to see what devices are installed and which resources they need. Each bus has its own enumerator, but PnP leverages existing mechanisms wherever possible. For example, the SCSI driver itself enumerates the SCSI bus. The information is reported back to Configuration Manager, which calls the resource arbitrator. The resource arbitrator employs sophisticated algorithms to balance the needs of all the devices, gradually building a hierarchical configuration table called the *hardware tree*.

If the resource arbitrator can't configure everything, the last resort is new utilities that help you identify and solve configuration conflicts. Intel's upgrade kit for MS-DOS and

How Plug and Play Works

Because legacy devices—those that are not PnP-aware—get the first crack at system resources, they reduce the options available to PnP devices. You get maximum flexibility by using only PnP devices.

Windows 3.1 includes a program called the ICU (ISA Configuration Utility). Some PnP BIOS vendors offer similar utilities, such as PnPView from SystemSoft (Natick, MA) and Phoenix System Essentials from Phoenix Technologies (Norwood, MA). Likewise, Chicago will have a built-in tool that's called Device Manager.

Although you still might have to take the computer apart and play with DIP switches on legacy devices, these utilities will offer some guidance by informing you how resources are allocated and which resources are available. That alone is a big improvement over the current method, which relies heavily on trial and error.

When the configuration process is complete, the information in the RAM-based

THE ROAD TO PLUG AND PLAY

	What You Get				
What You Have	**ASSISTED CONFIGURATION OF HARDWARE**	**AUTOMATIC CONFIGURATION OF HARDWARE**	**AUTOMATIC CONFIGURATION OF HARDWARE AND DRIVERS**	**DYNAMIC CONFIGURATION OF HARDWARE AND DRIVERS**	**DYNAMIC CONFIGURATION OF HARDWARE, DRIVERS, AND APPLICATIONS**
Non-PnP BIOS, non-PnP operating system, non-PnP devices, non-PnP applications	No	No	No	No	No
PnP BIOS, non-PnP operating system, non-PnP devices, non-PnP applications	No	Boot devices only*	No	No	No
Non-PnP BIOS, PnP or retrofitted operating system, non-PnP devices, non-PnP applications	Yes	No	No	No	No
PnP BIOS, PnP-retrofitted operating system, non-PnP devices, non-PnP applications	Yes	Boot devices only*	No	No	No
PnP BIOS, PnP-retrofitted operating system, some PnP devices, non-PnP applications	Yes	PnP devices only	No	No	No
Non-PnP BIOS, PnP or retrofitted operating system, some PnP devices, non-PnP applications	Yes	PnP nonboot devices only**	PnP nonboot devices only (with PnP operating system)	PCMCIA only (with PnP operating system)	No
PnP BIOS, PnP-retrofitted operating system, PnP devices, non-PnP applications	Yes	Yes**	No	No	No
PnP BIOS, PnP-retrofitted operating system, PnP devices, PnP applications	Yes	Yes**	No	No	No
PnP BIOS, PnP operating system, some PnP devices, non-PnP applications	Yes	PnP devices only	PnP devices only	PnP devices only	No
PnP BIOS, PnP operating system, PnP devices, non-PnP applications	Yes	Yes	Yes	Yes	No
PnP BIOS, PnP operating system, PnP devices, PnP applications	Yes	Yes	Yes	Yes	Yes

* System devices on motherboard that are PnP-aware.

** Retrofitted OS supports ISA, PCI, and PCMCIA devices only.

The left-hand column shows typical system configurations for users making the transition to Plug and Play.

"Assisted configuration of hardware": The user gets some help from a utility but still has to allocate system resources manually and reboot the computer.

"Automatic configuration of hardware": The system configures motherboard devices, expansion boards, and peripherals during boot-up without user intervention, unless there's an unresolvable conflict.

"Automatic configuration of hardware and drivers": Includes previous category, plus the capability of automatically loading and setting up device drivers without manually editing CONFIG.SYS.

"Dynamic configuration of hardware and drivers": Includes the previous category, plus the capability of on-the-fly reconfiguration without user intervention or rebooting.

"Dynamic configuration of hardware, drivers, and applications": Includes the previous category, plus the ability of application software to respond to dynamic events.

"PnP BIOS" = Plug and Play BIOS.

"PnP OS" = Operating system such as Chicago that feature full PnP integration.

"PnP-retrofitted OS" = Operating system with PnP extensions, such as MS- DOS and Windows 3.1 with Intel's Plug and Play Kit.

"PnP devices" = Expansion boards and peripherals that support PnP.

"PnP applications" = Application software that can respond to PnP events.

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hardware tree is stored in some type of nonvolatile memory. Some low-cost clones will cram an abbreviated bit-mapped table of the configuration data (maybe 64 or fewer bytes) into the system's extended CMOS. Other systems will build a more verbose registry (perhaps 2 to 4 KB) and store it on the hard disk or in the same flash ROM as the BIOS. The next time you boot up, the PnP BIOS or Configuration Manager can survey the computer's status and compare it with this registry to see if anything has changed since the last session. If there's no change, the system continues booting up normally. Otherwise, the configuration process begins anew.

Now it's apparent why you'll eventually want to replace your legacy devices. The more of these devices in your system, the less flexibility is enjoyed by the PnP BIOS and Configuration Manager. Because boot-up and legacy devices get the first crack at system resources, any devices that boot up later must make do with whatever resources are left over. And some devices are very particular about the resources they need.

Although the PnP configuration process is complicated, remember that almost everything happens in the background—especially in an up-to-date system with a PnP BIOS, a PnP operating system, and PnP devices. Ideally, the machine will boot up in a minute without any intervention on your part, even when you've altered the configuration. In a worst-case scenario, you may have a partial PnP system with several legacy devices whose conflicts cannot be resolved, forcing you to take manual action.

Upgrading to a full-fledged PnP system will reduce such headaches. Although Intel's upgrade kit for MS-DOS and Windows 3.1 is a good solution for the interim, it will never offer the same

Building a Better BIOS

Key to the success of Plug and Play is the BIOS (Basic Input/Output System), which is primarily responsible for booting up a PC compatible and handling low-level device I/O. Without the BIOS cornerstone, even a fully PnP-integrated operating system like Chicago cannot provide hassle-free system configuration.

The BIOS is a historical holdover from the days when hard drives weren't available for PCs and even floppy drives were optional. Some mechanism was needed to bootstrap the system before a higher-level operating system loaded, and the solution was to store some low-level code in ROM chips on the motherboard. By some accounts, Microsoft would like to see the BIOS vanish from the PC architecture altogether. (Programmers in Redmond have reportedly been spotted wearing T-shirts with the slogan "BIOS? We Don't Need No Stinkin' BIOS!") But short of redefining the PC platform, the BIOS will be around for a while longer.

To accelerate the rollout of PnP, Intel has been supplying a set of PnP extensions to BIOS vendors. This kit makes it easier to get a PnP-ready BIOS to market, while still leaving room for vendors to differentiate their products. As usual with a BIOS, however, you probably won't perceive much difference unless something goes horribly wrong.

In a PnP system, the BIOS is minimally responsible for booting up motherboard devices like the DMA controller and the PIC (programmable interrupt controller), as well as an input device (typically the keyboard controller), an output device (typically the video controller), and an initial program load device (typically the hard drive that stores the operating system, although some mobile computers might boot up the system software from ROM or a PCMCIA card).

Due to gray areas in the PnP specifications, what happens next isn't clearly defined. If the system has a PnP operating system as Chicago will, Microsoft would prefer to see the BIOS bow out at this point and let the operating system's more sophisticated arbitrators take over. But some BIOS vendors are going a little further, incorporating simpler routines that try to configure all other devices in the system. That's desirable for PCs without a PnP operating system. But if there is a PnP operating system, the BIOS might leave the machine only partially configured and limit the operating system's options for resolving the problem. Unfortunately, the current PnP specifications don't define a way for the BIOS to know if a PnP operating system is going to run.

"PnP is a really complex technology," explains Albert Saraie, senior marketing manager for advanced technology at Phoenix Technologies (Norwood, MA), the leading BIOS vendor. "If we try to solve every problem in the PC industry the first time around, we'll never get anything out the door."

Phoenix shipped its first PnP-ready BIOS early this year, and it's already appearing in new systems from NEC and Gateway 2000. Like most major BIOS vendors, Phoenix offers its PnP BIOS in a flash ROM, as well as a conventional mask ROM. Flash ROMs are rewritable, so if the BIOS ever needs upgrading, the system vendor can distribute a simple flash upgrade program on a floppy disk. The only way to upgrade a mask ROM is to swap chips.

Adding PnP to a BIOS isn't a trivial task. For the sake of economy, everything has to fit inside a single flash ROM with 1 Mb (128 KB) of memory. SystemSoft (Natick, MA) says its new PnP BIOS includes the regular system BIOS (about 64 KB), PCI (Peripheral Component Interconnect) extensions (10 to 12 KB), power management (2 to 10 KB), and PnP support (12 to 16 KB). Computers with an onboard VGA controller (mostly notebooks, but also some desktops) require an additional 32 to 40 KB of BIOS code. If there's any room left, BIOS vendors want to make it available as nonvolatile storage for PnP configuration information.

SystemSoft's solution is to compress the BIOS code to conserve space in the flash ROM and then decompress the code and copy it into shadow RAM during boot-up. Other BIOS vendors also take this approach. SystemSoft began shipping its PnP BIOS in February, and the first systems should be available now.

Retrofitting Windows 3.0

Intel's Plug and Play Kit retrofits MS-DOS and Windows 3.1 with Configuration Manager and utilities that provide some PnP functionality—although not as much PnP integration as found in Chicago. The ICU, much like Chicago's Device Manager, lets you browse through the devices installed in your system (first screen). When you install a new device, the ICU provides a database of known devices and the resources they require. The database isn't exhaustive, but Intel is working with vendors to compile information on most products currently available (second screen). If the Configuration Manager can't automatically configure a device that's not listed in the ICU's database, you can allocate resources manually (third screen). Advanced users can solve conflicts by using the ICU to examine the resources allocated to every device in the system and then reassign certain resources, if necessary (fourth screen).

PnP functionality as a fully integrated BIOS and operating system. A true PnP system offers PnP support for every I/O bus and port, with provisions for easily incorporating new buses in the future.

Change on the Fly

Dynamic configuration is perhaps the most exciting benefit of full PnP integration. Until recently, this wasn't a factor, because few I/O buses allowed hot-plugging. But newer buses like PCMCIA and P1394 actually encourage you to add or remove devices while the computer is running. To cope with this, the operating system must juggle system resources and device drivers without unduly pestering you. Moreover, the operating system should be able to pass messages about dynamic events to applications, which in turn should be capable of responding appropriately.

Retrofitted system software just isn't that versatile. It doesn't pass messages about dynamic events, and it lacks the dexterity to juggle device drivers in memory. Chicago, on the other hand, will broadcast messages of dynamic events to all running applications, and it can also load and unload drivers as their associated devices come and go, thus maintaining only the minimum working set of drivers in RAM. Without resorting to tricky hacks, MS-DOS (and, by extension, Windows 3.1) must load its drivers during boot-up to avoid conflicts later on. In fact, as anyone who has wrestled with a CONFIG.SYS file knows, DOS can be very stubborn about the order in which device drivers load.

Flexible System

The ability of a PnP system to morph itself in response to a wide range of dynamic events is in tune with today's increasingly flexible work force. Outbound salespeople and telecommuters who visit an office once a week could dock their notebooks or plug into a network without a second thought. A worker with a PDA (personal digital assistant) could stroll into a room and instantly print a document via an infrared link to a PnP-aware desktop system. Users could share a single fax modem or LAN adapter between their notebook and desktop merely by swapping a PCMCIA card back and forth.

Indeed, PnP and hot-pluggable I/O buses are considered key technologies in the never-ending quest to turn PCs into consumer appliances. "Our culture is such that we're always warned against opening the back of any electronic appliance, including our $300 TV and VCR," says Timothy Saponas, Intel's manager for desktop ease of use. "If people aren't comfortable opening their $300 TV to change parts, are they going to be comfortable opening their $2000 computer? I think not."

PnP is a significant step forward for PCs. Painless configuration when installing new hardware and software is long overdue and really does little more than drag PCs, kicking and screaming, into the 1980s. But the ability to dynamically reconfigure a system to keep pace with active users—although still in its infancy—hints at what lies ahead in the late 1990s and beyond. ■

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

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	hrs:mins
Compaq Contura 4/25c (SL/25) passive	4:32
IBM ThinkPad 755Cs (DX4/75) TFT	5:00
Toshiba T4800ct (DX4/75) TFT	5:30
IBM ThinkPad 500 (486/slc) mono	6:30
IBM ThinkPad 350C (SL/25) passive	8:50
Previous record for 486 mono	12:07
NEW RECORDS:	
Dell Latitude, 2 batteries DX2/50 STN	12:15
Dell Latitude XP DX4/100 TFT	14:48
Dell Latitude XP DX2/50 STN	17:05

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*‡So you've come down here to find out about this Steeplechase thing. Well, it's not a horse race but a thorough test of battery life. The Steeplechase test includes mechanical typing, pausing, task switching and printing in MS Windows v3.1, MS Word for Windows v6.0 and MS Excel v5.0. All numbers represent an average of at least two trials with power management function enabled. Test simulates executive usage, i.e. carrying notebook between meetings and intermittent use. Competitors' times are published in Portable Computing Magazine. For a complete copy of the VeriTest results, call our TechFax℠ line at 800-950-1329. †This 3-year limited warranty consists of Dell's standard return-to-factory warranty during the first year, plus 1-year of next-business-day on-site service provided by BancTec Service Corp. during the first year, plus a 2-year parts only contract for years 2 & 3. *Latitude XP is powered by one Lithium Ion battery. Latitude is powered by a NiMH battery, with the option of replacing the floppy drive with a second NiMH battery, which will increase the weight of the Latitude by 0.5 lbs. *Prices valid in the U.S. only. Some products and promotions may not be available outside the U.S. Prices subject to change without notice. °Business leasing arranged by Leasing Group, Inc. Intel and the Intel Inside logo are registered trademarks and DX4, DX2 and SX are trademarks of Intel Corp. Dell disclaims proprietary interest in the marks and names of others.*

CONNECTING NETWORKS

When you want to link one network with others, you're going to need some heavy-duty connectivity. ATM, digital switching, and ISDN are among the candidates you should consider.

Two topics dominate the networking arena today—ATM (Asynchronous Transfer Mode) and switching. You could argue, of course, that because ATM is a switching technology, it is subsumed under the general switching umbrella. Practically speaking, however, ATM is such a powerhouse that it deserves a category unto itself.

ATM is nothing more than a compromise designed to handle two conflicting types of applications and data. The first is regular old data communications—you know, the type of communications traffic generated when you hitch together geographically separate LANs. Such traffic is characterized by its bursty nature and consequent varying bandwidth requirements. Experience has shown that such traffic is best handled by shoveling the data into packets of varying—and normally large—sizes and transporting them via some sort of switching matrix.

The second type of traffic ATM must contend with is the high-volume data required for multimedia applications such as voice and videoconferencing. This traffic has traditionally been handled by dedicated connections: You dial a phone number and someone answers, establishing a connection. Connections are much more predictable in their bandwidth requirements than are packetized data communications, and they also include a real-time character that is normally absent from data communications. Simply put, if you can't move that video data fast enough to reconstruct a sustainable signal on the receiving end, you're hosed. Dedicated circuits are the best way to handle such real-time data, but they are expensive to operate.

Enter ATM. As with traditional data communications, it is packet-based, allowing it to handle bursty traffic. Unlike most other data packets, the ATM packet is a fixed-length cell containing 5 header bytes and 48 bytes of data. (In comparison, X.25 packets can consist of several thousands of bytes.) The fixed and predictable packet length makes it possible to switch ATM cells in hardware—there's no need for each switch to parse the contents of every packet. The fast hardware switching allows ATM networks to maintain the high data rates that are required to support connection-oriented data and applications in a switching environment.

ATM isn't the best of both worlds—standard data communications works best with large packets, while real-world data types prefer dedicated connections—but it is the best available compromise. The hype is not just hype; ATM is a tsunami that will transform the face of networking. To find out when and where the wave will break, read Peter Wayner's article "On the Road to ATM."

Despite its wonders, ATM presents one intriguing difficulty: its name. What are people going to call all those user-unfriendly machines that dispense cash at all hours of the day and night?

Mammals into Dinosaurs

Network+Interop is the most important networking and data communications trade show on the planet. While attending the June get-together in Las Vegas, I heard a number of people refer to the need to "upgrade legacy LANs" or "integrate legacy LANs into future networking architectures." Excuse me, but isn't the term *legacy* an adjective you use to describe lumbering mainframes and archaic SNA (Systems Network Architecture) implementations? When did Ethernet become a dinosaur?

Such questions brought benign (condescending?) smiles from the networking cognoscenti, who patiently explained the shortcomings of today's LAN technology in the face of tomorrow's multimedia applications. No need to rip out such legacy systems, I learned with relief; there's nothing wrong that a liberal dose of switching can't see you through. John Bryan explains it all in "LANs Make the Switch."

ISDN, Anyone?

The more organizations depend on LANs, the bigger becomes the issue of how you provide remote access to LAN services. Jeffrey Fritz—who in real life provides networking services to thousands at West Virginia University—discusses in the article "Digital Remote Access" how digital technology is being brought to bear on the problems of remote access. Remember all those "Year of the LAN" proclamations during the last decade? Soon, someone is going to have to declare a "Year of ISDN." It looks like it's finally going to happen.

Digital services are becoming more accessible and ubiquitous, but analog technology (i.e., modems) also has much to offer in the remote-access realm. For example, at Networld+Interop, Dayna Communications announced a new remote-access server that uses PCMCIA modems to connect the outside world with AppleTalk—and soon IPX and TCP/IP—networks. PCMCIA technology eases physical configuration problems and provides hot-swapping to boot.

Setup times make analog solutions inappropriate for LAN-to-LAN connections, but the modem still has its place in single-user access to LANs. Given the advance of digital technology, however, I wonder how long it will be before I start hearing solutions to the problem of "legacy modems"?

The Collapsing Backbone

The net effect of the new and evolving networking technologies described here is difficult to predict in the short run. Certainly, there will be confusion as router vendors, such as Cisco Systems, invade the hub arena, and hub vendors, such as SynOptics Communications, get into routing. ATM simply adds another flavor of spice to these mixtures.

The long-term picture is clearer. The internetworking functions you need to perform will increasingly take place in a single box. Your multiprotocol network will be multiprotocol in one place only, the switching hub, thus making your network backbone more accessible and manageable than ever. ■ **—Bob Ryan, Senior Editor**

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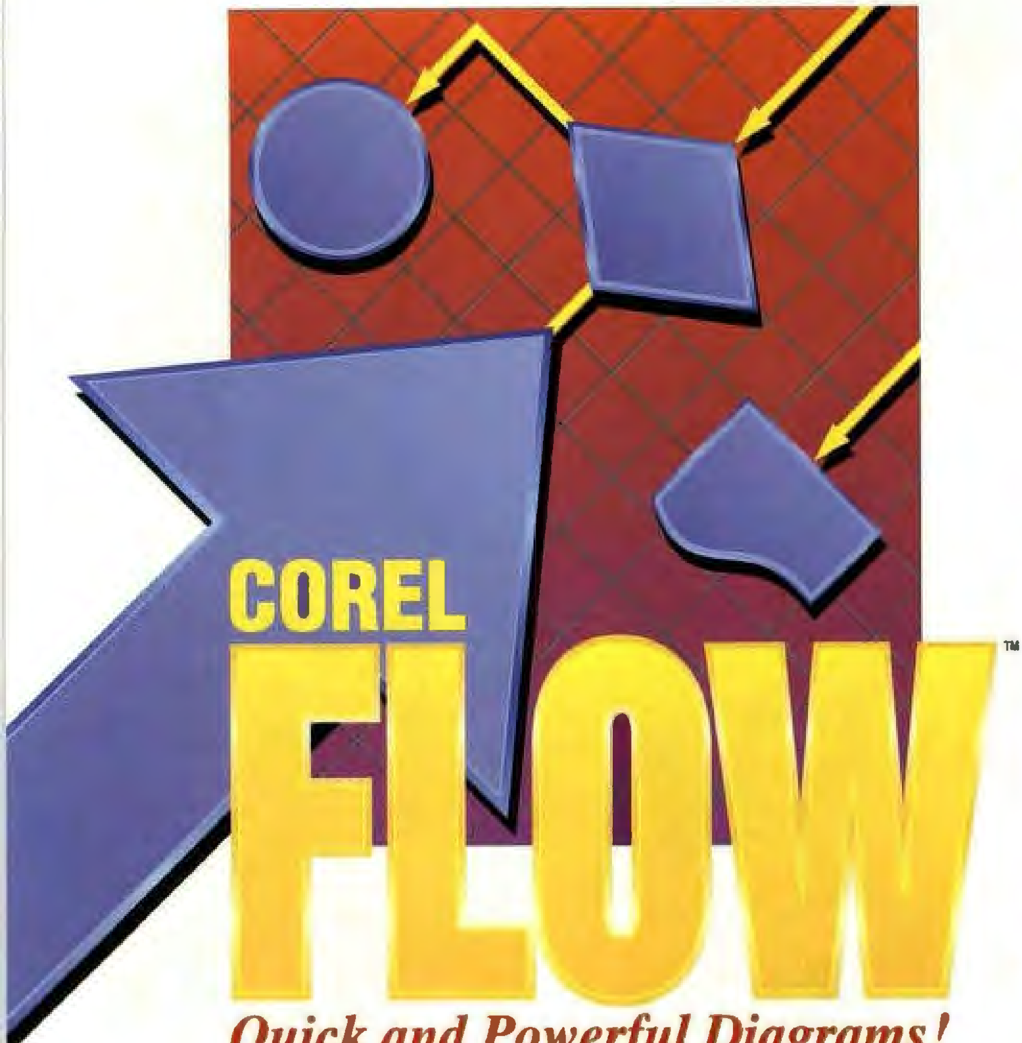

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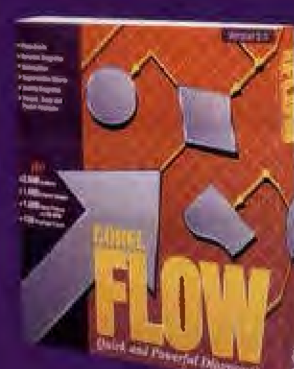

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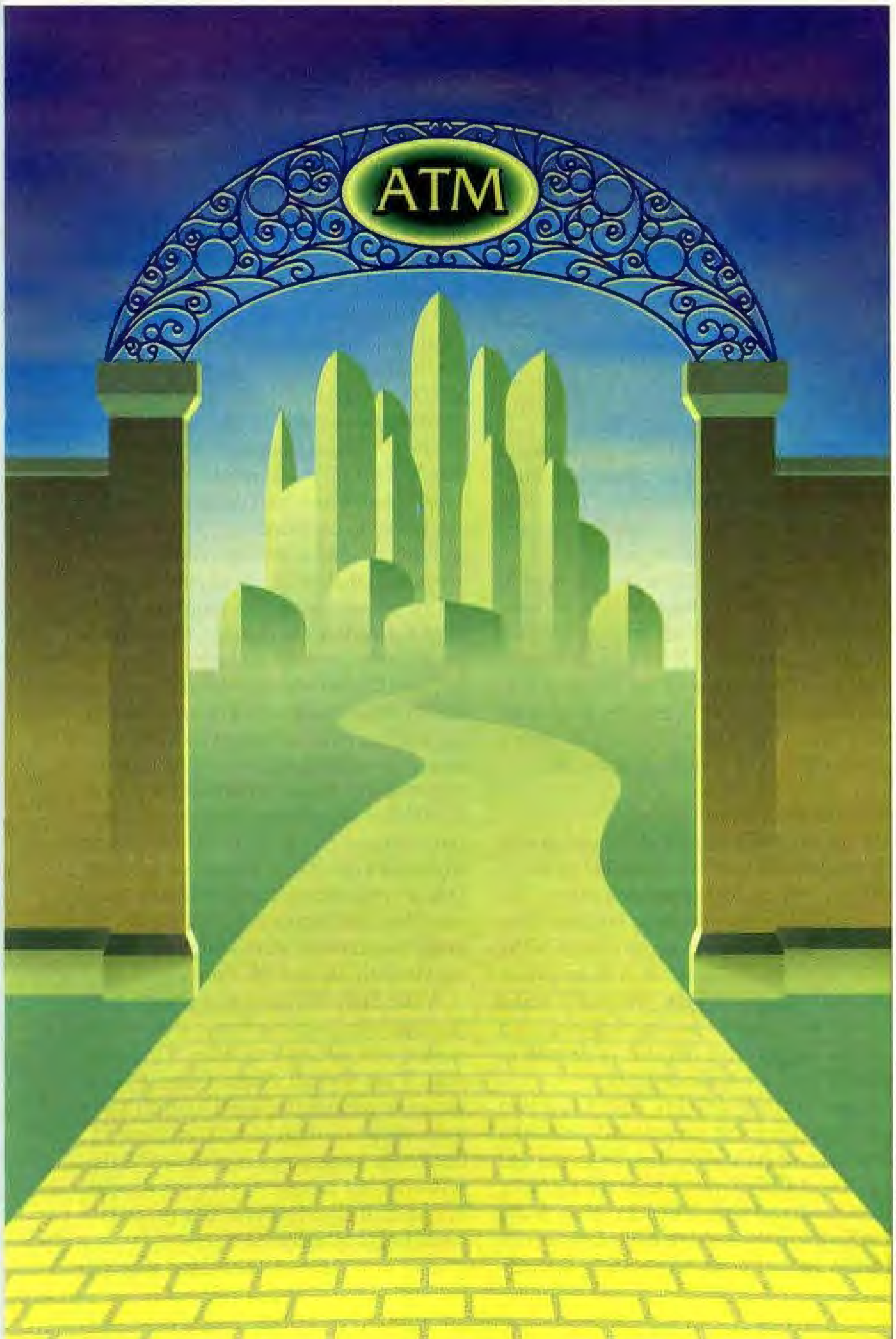
ON THE ROAD TO ATM

With its ability to move large blocks of data quickly, ATM brings networking nirvana a step closer

PETER WAYNER



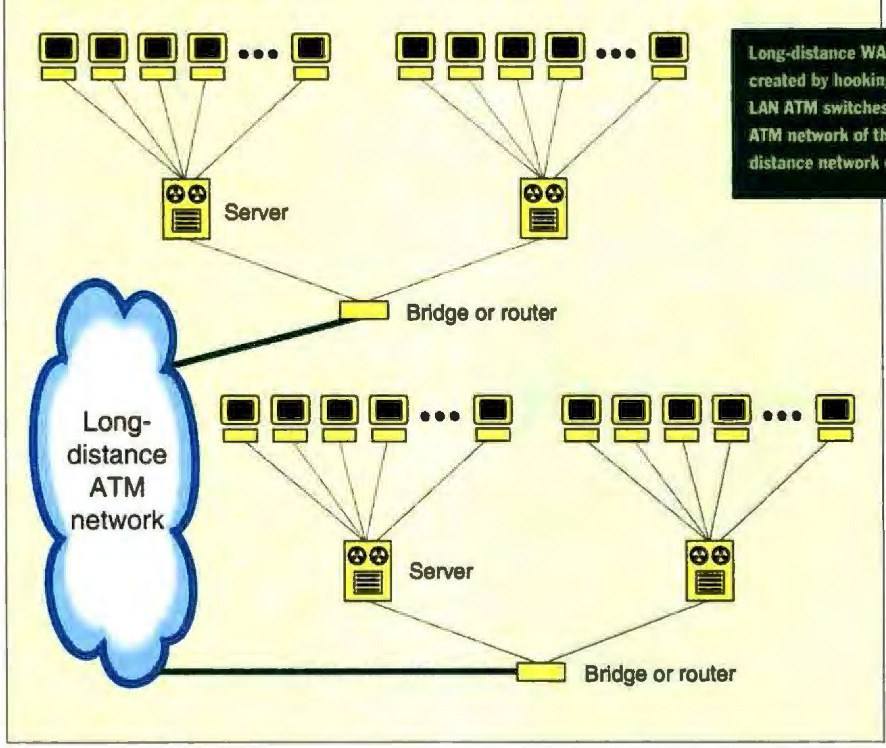
CHRIS LOCKWOOD © 1994

For the last several years, the networking world has been promising the average PC user that networks sporting ATM (Asynchronous Transfer Mode) would provide the tantalizing option of "bandwidth on demand." But no matter how often each of us said "Please," it was still hard to find and buy such systems. This is quickly changing. The manufacturers of routing switches and NICs (network interface cards) are rolling out product after product. The major providers of long-distance network infrastructure—including AT&T, MCI, and RBOCs (regional Bell operating companies) like Ameritech—already have limited ATM networks operating or in the final stages of testing. Clearly large segments of the network world believe that ATM is the Emerald City—and they need to get there fast.

But the journey to a fully functional, ATM-based network that links computers throughout the country will take years to complete. Although the destination sounds clear and most of the standards are set, many details are sure to change as companies define *in practice* the capabilities they will actually build into the ATM infrastructure. The service providers, hardware manufacturers, and users (e.g., LAN operators, WAN [wide-area network] operators, you, and I) are dancing a complicated jig, and no one is taking the lead. Vendors are trying to judge how much bandwidth to offer and how many features will be in demand, while users are trying to figure out just how much they need to buy.

In the end, the interaction between the network-service providers and users will define the overall shape and cost structure of the ATM-based network. Although the same basic standard protocols will unify the entire network, there will still be significant differences in what will be available. Some service providers will invest heavily in an approach that might be more suited to, say, transmitting video, and this will let them offer that service relatively

Linking LANs via ATM



Long-distance WANs can be created by hooking the local LAN ATM switches to the ATM network of the long-distance network operators.

cheaply. Others will invest in another approach that might allow them to price asynchronous data, such as E-mail, at a bargain-basement price. Everyone is guessing about the right mix of product and services and hoping that their hardware will match the market's future needs.

The wide-open nature of the market, coupled with the regionalized structure of the phone business, means that you may well see a fragmented market that will seem strange to everyone used to the modern homogeneity that has been brought by worldwide corporations such as Coca-Cola. Some services may end up being less expensive in Los Angeles than in New York, simply because the local phone companies make different choices when they install their switches. These kinds of differences on the information highway will make life, at the very least, exciting for network managers trying to optimize their decisions. However, the differences are bound to smooth out after a few years, as everyone begins to get firm ideas on which ATM services will sell successfully.

The companies that manufacture the switches and routers used by LANs and WANs are hedging their bets. They stress the flexibility of their machines and use seductive terms such as *tariff arbitrage* to imply that users will be able to rework their network schemes to use the least expensive service available. This flexibility is one of the best features of ATM, even though users may grow to hate the array of choices that this freedom brings.

The bottom line is that users will need to pay attention to the details and make many choices about bandwidth, types of service, and other protocols. The one real advantage of ATM is that all the modern network-interface devices are driven by software, and it will often be easy to switch protocols just by switching software.

At the Desktop Level

For the time being, most of the action will be confined to networks installed in single offices and on corporate campuses. The switches, LAN converters, and interface cards that you need to set up a local ATM network are available today. You may have trouble finding software that would make it possible to use all the neat features, such as real-time video, but this is certain to change by the middle of 1995.

LAN administrators will have two choices: They can retrofit old networks with clever hardware that links the old LAN to ATM clients outside the LAN, or they can build new networks. New ATM LANs let users manage large amounts of bandwidth without overloading the network, but it costs much more for new cabling, interface cards, switches, and software. Retrofitting is cheaper and easier, because you can reuse old cable, cards, and software, but it does not provide much of the superior performance of ATM. It allows interoperability, but performance is limited by the old LAN.

The first groups to adopt local ATM networks will be small workgroups that need to move large blocks of data. Many ATM network manufacturers cite Wall Street traders and seismic prospectors at oil companies as prototypical examples. These workers need to move large amounts of data quickly. The oil companies, for instance, like to move large numerical simulations of drill sites to graphics workstations, where they can visualize the data. ATM networks are among the few solutions that offer this much raw bandwidth.

The prices for small networks like these are dropping. A basic ATM network linking about 15 workstations costs about $1500 to $2000 per desktop machine for the interface card, and about $20,000 to $25,000 for the central switch. Many manufacturers are already in this market (see the text box "Selected Sources for ATM Products"). This network would run over C5 twisted-pair wires and deliver 155-Mbps bandwidth to each machine. Servers would probably be allocated even more bandwidth because of their naturally higher demand.

Prices vary widely depending on the need for additional features and perhaps for different interface electronics. One significant difference between interface boards is in the amount of on-board buffering they provide. Under ATM, the most time-consuming task is breaking up every transmission into standard 53-byte packets and then reassembling them on the other end. Some interface cards rely on the host processor to do this work and save money. This savings, though, can be a false economy, because heavy network traffic can easily bog down a workstation by requiring virtually all its CPU time.

While high-end users will always drive the edge of new technology, the primary market will be low-end users. One company, First Virtual (Santa Clara, CA), is aiming to provide the world with 50-Mbps connections at a cost of $500 each per PC. Unlike the manufacturers of the 155-Mbps networks, the company is not yet shipping a product. It says, however, that production could begin in early 1995.

It is not clear at this time whether

delivering this price/performance point will be successful. The low cost will attract many users; however, the networks may be too slow to handle high-bandwidth applications such as desktop video. Much of ATM's ability to knit together real-time and bursting data will go to waste. Other manufacturers say that they plan to aim for the higher 155-Mbps standard, because customers need a solid reason to move to ATM technology and wide-open performance is their selling point. They offer hints that this level of service will be available for about $700 in 1995, but for now, they refuse to announce any products.

Many manufacturers will produce variations on the ATM theme. All the cards and systems will work together, but users will need to think carefully about the details.

Retrofitting LANs

If it weren't for budget constraints, most people would be using ATM- capable LANs today. Most users, though, won't need the speed or features of an ATM network until functions like videoconferencing become widespread. Even if you don't need to move large blocks of data quickly, however, you still might want to connect a LAN to a larger ATM WAN. This is why companies are making Ethernet LAN routers with an ATM backdoor. Some are making entirely new routers, while others are building gateways that plug into older routers with an FDDI (Fiber Distributed Data Interface) link. Both of these let you connect your old Ethernet LAN to the ATM world without replacing your old interface cards or software.

Connecting to ATM WANs will be especially attractive to firms that have workers with different needs. Programmers, for instance, often place heavy loads on networks when they compile. Workers who use word processors, however, usually place the greatest load on the network when they open and close files. Those workers with low network demands can stay with the old network and can use an Ethernet-ATM gateway to reach the rest of the network.

Network managers who choose this last path will gain a fair amount of flexibility. They can place an important file server in the ATM branch of the network, and the gateway will route the traffic correctly. More important, the flexibility of ATM will let the manager move the file server to different locations, including across the country. This flexibility may help protect systems against fire and other disasters.

Outgrowing LANs

ATM is not intended simply as a high-speed replacement for LANs. The strength of the technology lies in its ability to link many networks and to switch traffic among them. The same 53-byte protocol works throughout the network. This flexibility promises to let network administrators mix and match connections to adjust the throughput to meet changing needs.

For this reason, the next growth spurt in ATM networks will occur in campus environments where users can string up their own networks. The ATM Forum, a cross-industry standards group, recently accepted a formal standard known as the UNI (User-Network Interface) that specifies how different switches may communicate. Several equipment vendors demonstrated the robustness of this standard by linking the switches of many manufacturers at the 1994 Interop conference.

If you run a multisite network, you will have many different options for linking the switches. You can pull your own fiber-optic cable, run copper coaxial, or string up twisted-pair wires between buildings, if they are close enough. Or you can run the link through your local phone company's network by simply buying a connection for each machine. This approach can end up cheaper if the telephone company already has fiber installed in each building. Each network manager has to evaluate the cost of running the cable and compare it to the prices the local telephone network charges for the connection. The important fact is that the basic switches and software will work with either choice.

Top-Layer Players

The greatest confusion and activity seems to center around the highest level, as the service providers try to determine just how much service to offer in what areas. All the major long-distance carriers (e.g., AT&T, Sprint, Wiltel, MCI, and MFSNet) are committed to offering ATM services. Several of the local RBOCs will also offer local service and some—such as Ameritech—have unregulated segments that may compete anywhere in the country.

The phone companies are struggling to anticipate demand so that they can plan how much to spend on each part of the local phone switches. At the time this article was written, users could buy T3-class ATM service (45 Mbps) as a *permanent virtual circuit.* This is effectively a leased line that offers a few additional features for ATM users. You get bandwidth on demand, as long as you always demand and pay for 45 Mbps per month. There are still other advantages over pure leased lines. Your ATM switches will be responsible for breaking up all the 45 Mbps of transmitted data and assigning it to your own internal traffic. In some cases, you will also be able to send bursts of data that are larger than 45 Mbps.

By the end of this year, some companies will begin to offer T1-level service (1.5 Mbps) as well as OC3 (155 Mbps). This service will allow you to knit a 155-Mbps LAN on the East Coast with one on the West Coast without losing any speed.

The most exciting part of ATM long-distance service will be SVCs (switched virtual circuits), and these will not emerge until well into 1995 and 1996. They will provide pure nationwide bandwidth on demand, limited only by the speed of your own local service. You will pay only for the circuits as you use them. One of the barriers to the emergence of this service is the telephone companies' internal networking standard known as the BICI (Broadband Inter-Carrier Interface), which governs the way that telephone company switches exchange data and call-setup information for billing purposes.

When the BICI standard is finished, the companies will have no trouble linking their services. That means that an East Coast RBOC like Bell Atlantic will be able to join with a company that services only another region of the country; together they will be able to serve customers who need connections between the two locations.

The Transition

Today, many network integrators who need to link up a WAN successfully are making interim choices that can be changed later. Many of the switch manufacturers, for instance, make switches that can spit out packets in some of the older standards, such as Frame Relay. These switches use software to handle the protocol-level bundling, which means that you can upgrade them to ATM specifications when the time is right.

Some customers may never switch over to ATM, because they find that the fee structure for Frame Relay is better suited to their needs. They may never need to use the guaranteed bandwidth feature of ATM. This approach will probably be available only for the short run if ATM becomes popular. Supporting multiple standards costs money, and the most popular ones tend to drive out the others.

Paying the Pipe-er

It's still not clear how these switched virtual circuits will be priced, and the differences between the services offered by the different carriers is sure to be intriguing. This is one of the major ways that the companies will be able to differentiate their services. It is all too likely that they will come up with a welter of creative pricing plans that will make choosing a long-distance carrier for your home phone seem simple by comparison.

One option sure to emerge will be to pay for only what you demand on a pennies-per-megabit-per-second basis. In this area, there will probably be at least two major classes of services: Class A, for guaranteed continuous data (e.g., video), and Class C, for variable-rate data that doesn't need to get to the other end as smoothly. At this point, it is uncertain how carriers will structure their prices, but one estimate is that Class A data links could cost three times as much as Class C data links. This is based on the experience of network managers who have found that they can overbook, packing three Class C users into a single Class A.

> **Basic ATM service is as close to a commodity as it gets. Bits are bits, and they have to get from one place to another.**

This ratio, however, is bound to change. Some local networks may find that the demands for the Class C service are different from those in the past, and this would force them to lower the amount of overbooking. Alternatively, some carriers may find themselves with excess capacity in parts of their network and choose to lower the price on Class A service to encourage consumption. Off-peak pricing and other such features will add further complexity.

Another option that may remain popular is the flat-rate bill. This seems a bit stodgy for a technology that was developed to offer unparalleled flexibility. But it promises no surprises on the monthly bill, and this will be a big advantage for some people.

Options

The basic ATM service is as close to a commodity as it can get. Bits must get from one place to another, and that's that. The telephone companies are certain to invent as many features as they can, because they realize that highly competitive commodity markets are the enemies of profits. They are considering intriguing features. For example, Ameritech says that it will throw in Internet access with its ATM service. That means that if you happen to address your packets to an IP address, the Ameritech network will send them to the right location. The company also plans to offer offsite backup, which will allow you to store blocks of bits in their computer for a price.

Every company says that reliability standards will be an important feature. Connections with guarantees of lower downtime will cost much more than standard-rate connections. The companies will compile extensive statistics, and each user will be able to decide how to choose whether to pay extra for less downtime.

Taking the ATM Plunge

The transition to ATM promises to be exciting. The technology is proven. Manufacturers are shipping products. The potential applications are not written, but they are tantalizing. In essence, the table is set, the banquet is prepared, and now we need to see who comes to the party.

The speed with which people join the system will make a big difference. If everyone buys into the plan immediately, then the economies of scale will be wonderful. ATM lets you share your leased lines so well that many users may be able to get all the advantages of a leased line at a price that might be one one-thousandth of the price today. But this will happen only if the phone company can find 999 other people to share that line with you.

ATM is already likely to succeed on the corporate high end. But the market for ATM could really emerge if we see applications that engage the entire population. This service could become the equivalent of phone service in the future...if everyone wants it enough to justify the cost of laying fiber or C5 twisted-pair wires to each house in the country. The phone companies could provide video on demand with a service like this. The possibilities for games are endless. The only thing that is uncertain is whether the general public will become interested in such a high level of service. These questions need not be addressed for several years. Until then, ATM manufacturers will have enough work to do in satisfying the anticipated demand for network users. ■

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Selected Sources for ATM Products

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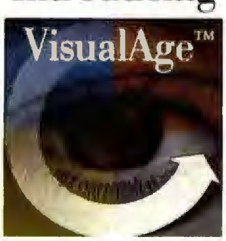

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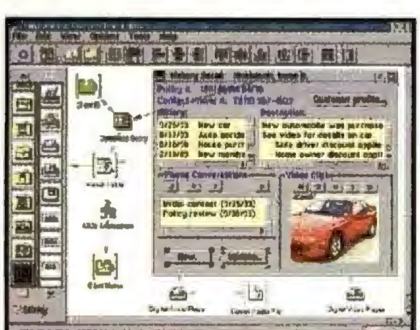

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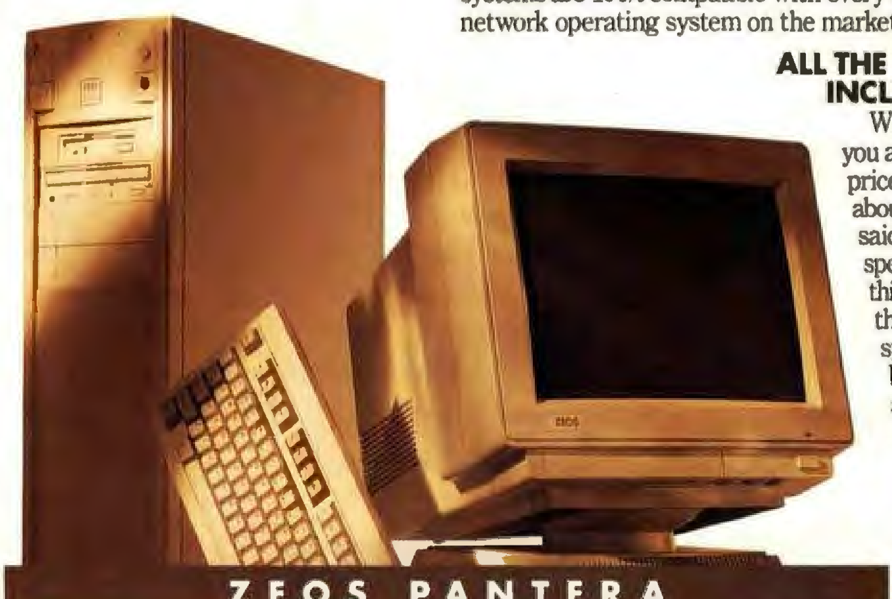

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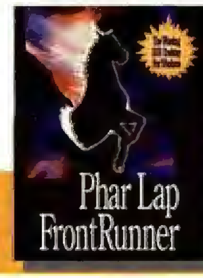

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State of the Art

LANs Make the Switch

The switching capabilities of bridges, routers, and hubs add new power to LANs and make it easier than ever to connect them to enterprise WANs

JOHN BRYAN

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As more people participate in client/server environments, the computing model shifts from a physical workgroup to a project orientation. In the project-oriented environment, there is a need for networks that satisfy the end user's demands for bandwidth, access, and security, while still providing management capability at the corporate level.

Currently, networks are generally expanded using router, bridge, and fast-backbone technologies. All enable more diverse network topologies and improve performance through segmentation and increased bandwidth. Routers and bridges have always used switching technology; only recently has the switching hub brought switching to the workgroup level.

Until now, LANs with access to shared media were standard. A 10-Mbps Ethernet network and 4- and 16-Mbps token-ring networks serve most business applications well, but they have inherent limitations. As more nodes are added, the available individual bandwidth decreases.

For example, in a 10-node 10Base-T network, each individual node can theoretically send or receive 10 Mbps but in practice have only 1 Mbps available. With little or no network traffic, there's no problem. But delays increase as nodes become more active or the network grows, as each node contends for a piece of the total bandwidth. With this example, if all 10 nodes are transmitting, total available bandwidth may be as low as 4 Mbps. The same is true for token-ring networks; the more nodes contending for the token, the less time any individual node has to transmit.

Of course, most LANs have more than 10 nodes. Burgeoning traffic volumes and graphical applications mean that changes must be made. At least two approaches have already been tried. The first was to increase network speed. FDDI (Fiber Distributed Data Interface) runs at 100 Mbps

What's on the Market

On the low end, *MicroAccess* (Fremont, CA) markets an Ethernet switching hub that is in their network servers. The hub is a six-port single ISA or EISA card with 10Base-T or BNC thin-Ethernet connectors. The card makes up to 60-Mbps total bandwidth available, and you can install multiple cards in the same server. The card has a built-in SNMP agent that enables all SNMP-compliant managers, including MicroAccess' own, to manage the card. At $2499, this product is eminently affordable.

NetWorth (Irving, TX) has several Ethernet/FDDI (Fiber Distributed Data Interface) PowerPipes switching products, from the Series 3000 TriSegment Stackable hubs to the Series 6000 Switching and Network Services hubs. PowerPipes is a 12-port Ethernet hub channeled into an FDDI connection to the server. An ASIC (application-specific IC) buffers and translates incoming Ethernet frames into FDDI frames. Outbound packets are FIFO (first-in/first-out) buffered so that frames don't stack up on the FDDI ring. A custom ASIC handles all switching logic. List price for PowerPipes is $7495 for single-attached copper and $8995 for dual-attached fiber.

Catalyst or Cut-Through

What one firm calls a shared-memory design, another may call a shared bus. *Cisco Systems* (Menlo Park, CA) labels as shared memory its Catalyst product, an eight-port LAN switch designed to give 10 Mbps to each of its connections. One of the ports can be configured as an FDDI or CDDI (Copper Distributed Data Interface) link, providing a high-bandwidth pipe to a network backbone. Catalyst lists for $9600; the FDDI option is an additional $1995, while the CDDI option lists for $995.

The Catalyst has 2400 2-KB buffers (300 per port), as well as 760 for each output port. The switch copies incoming data to the input memory buffers. At the same time, it sends the packet's MAC (media access control) destination address or other information to the switch logic, which moves the packet from input to output buffers and then to the port.

An IDT 3081 RISC processor sends the data across a 32-bit-wide, 20-MHz proprietary bus that, with 640-Mbps bandwidth, easily handles traffic from all ports simultaneously. This data-switching mechanism is called a store-and-forward process, because once the data frame is stored, it may be forwarded or copied to any designated destination port.

An alternative is the cut-through switch. Introduced by *Kalpana* (Sunnyvale, CA), the cut-through switch reads only the address header and immediately transmits the frame to its destination. This reduces switching time but can allow bad packets to pass through, causing problems down the line.

MAD but Smart

Another vendor, *Xedia* (Wilmington, MA) uses a shared-bus architecture it calls Smartswitch in its three MAD (media access device) products. The first product, MADswitch, is a six-port Ethernet switch with a slot for a 100-Mbps card, due later this year. This 100-Mbps connection may be Fast Ethernet, ATM (Asynchronous Transfer Mode), or FDDI. The Smartswitch architecture breaks incoming Ethernet frames into 64-byte packets or cells. You can use 512 cell buffers—enough for several Ethernet frames—for either input or output. Once the frame is converted to cells, it is transferred over the bus and the exit port, where the processor reassembles the message.

Each port has an IDT R-3000 RISC processor that handles port operations, including filtering nonvalid messages, cell reassembly, and transmission; each port can handle several different operations at once. The cell-transmission bus is a proprietary, 8-bit configuration, and Xedia has 16-, 32-, and 64-bit versions ready for the future. The MADswitch lists for just $2995, about half the price of most switched hubs.

Xedia's other products are MADswitch/PC and MADremote. At $2695, MADswitch/PC is a full-featured, single card that offers a 60-Mbps ISA interface port. MADremote is an ISDN-remote Ethernet switch that can interface with four ISDN B channels at various speeds.

As with Cisco's Catalyst, these products offer SNMP software for managing switches and nodes. However, not all switches offer this capability. When you research switches, look for software that is compatible with your environment.

ForeRunner

Fore Systems (Warrendale, PA) uses a shared-bus design in the contentionless time-division architecture of its ForeRunner ASX-100 ATM switch. Rather than a high-speed backplane, this "bus" is just four chips that are each capable of 622 Mbps and use TDM (time-division multiplexing) to pass data. This architecture gives the switch a much greater capacity than the sum of its ports' bandwidths; the ForeRunner's switch fabric supports 2.5 Gbps of bandwidth.

Fore's switch products include on-board ForeThought software to manage call connections and ATM routing without a dedicated workstation. This saves money on installation, provides higher performance, and offers greater reliability.

The ForeRunner will support up to 24 ATM devices or NICs (network interface cards), each transmitting at 155 Mbps. Modules for other interface speeds include 100-/140-Mbps TAXI, DS-3, and SONET (Synchronous Optical Network) OC-3. The ASX-100 also has a direct Ethernet interface and an FDDI port.

Each switch has a SPARC II RISC processor with 16 MB of RAM and a 120-MB hard drive. The processor controls bus access and sets up ATM circuits and operations. ATM permits two priorities of service, so 512 KB of buffer space at each port is configured in dual-priority RAM. Software handles setup, but data transfer occurs solely in hardware. Fore claims sub-10-microsecond latency in any data transfer, while setup takes less than 10 milliseconds. The ForeRunner ASX-100 starts at $23,995 for four ports, ranging up to a 24-port configuration for $34,000.

Multistage Matrix Switches

One area where matrix architecture may have the lead is in its capacity to expand to super-high-density port designs—switch systems with 1000 or more ports. This type of switch will seldom be used in LAN environments but will likely prevail in central office installations.

That said, LattisCell is a multistage matrix switch with what *SynOptics Communications* (Santa Clara, CA) calls a parallel ATM architecture. Each LattisCell is essentially a stand-alone switch, the various models differing primarily in how the 16 ATM connectors are apportioned.

SynOptics uses a number of techniques to reduce traffic contention. First, it distributes traffic over multiple paths. The matrix switch itself runs at twice the speed of the incoming ports, so there's plenty of bandwidth for each port. Buffering is available at each switch element.

When a cell enters the switch, Connection Management software reads its header—with information on the cell's origin, destination, and priority—then sets up the ATM's virtual channel throughout the span of switches. This software resides on a separate SparcStation that can control several LattisCell switches. The workstation only needs to be attached (via Ethernet) to a single switch; data for other switches is passed along a special ATM connector.

Prices begin at $27,950 for the 10115, a switch with 12 RJ-45 SONET/SDH connectors that support 155 Mbps over Category 5 UTP (unshielded twisted pair cable), and four ST-type (shielded-twisted) connectors for 155 Mbps over multimode fiber. The $31,950 10124-S has 16 fiber-optic ports: 12 100-Mbps ports used for 4B/5B encoding and four 155-Mbps SONET/SDH ports. Finally, the $35,950 LattisCell 10114 provides 14 155-Mbps SONET/SDH ports and two BNC 45-Mbps DS3 ports.

To link 10Base-T Ethernet to ATM, SynOptics has the $9995 EtherCell. Using the basic LattisCell architecture, the EtherCell provides 12 10Base-T ports and a single ATM port, either RJ-45 or fiber optic. This switch converts incoming variable-length Ethernet frames into fixed-length ATM cells and then handles all switching as in the LattisCell.

Token-Ring Solutions

M*adge Networks* (San Jose, CA) plans to introduce a token-ring switch early in 1995. This product will feature a shared-memory technology that Madge developed and Texas Instruments will manufacture and market. The device will handle switching between rings or individual nodes and provide a link to ATM or FDDI. It will offer full-duplex token-ring support, allowing a server to simultaneously send and receive 16 Mbps over the same connector. Token-ring NICs can be upgraded to full duplex via a software download; Ethernet NICs need a hardware change that would probably be as expensive as the original card.

Switching Packets and Cells

The MMAC-Plus from *Cabletron Systems* (Rochester, NH) provides over 500 ports of connectivity in a shared-bus design that handles both packet and cell switching simultaneously. This intelligent, fault-tolerant, modular hub has room on its backplane for up to 14 modules (connectivity or network services). Connectivity modules are available for all major network protocols, while network services modules provide distributed management and computer services.

ATM cells are switched as is; for non-ATM input, MMAC uses SFPS (secure fast packet switching). The system backplane has two system management buses (SMB-1 and SMB-10), a flexible network bus consisting of two dual FDDI rings, and the dual-channel INB (internal network bus), which is based on the IEEE standard for FutureBus. Finally, there is space for a cell-transfer matrix, due in 1996. This will offer a switching fabric capable of data rates in excess of 60 Gbps.

The dual-channel INB is governed, like Fore's ForeRunner ASX-100, by TDM. Each INB data channel is 64 bits wide, runs at 40 MHz, and can sustain a data rate of 2 Gbps or a burst rate of 2.5 Gbps, for a total of up to 5 Gbps. The TDM design can insert packets or cells on the bus for point-to-point switching, while signaling and bus arbitration occur on a separate 8-bit management and control bus.

The core design is powered by an Intel 960 processor. The Spectrum for Open Systems software (release 3.0) can manage networks of more than 10,000 nodes. Spectrum is compatible with Hewlett-Packard Openview for Unix and Windows, IBM Netview/6000, SunConnect SunNet Manager, and Novell NMS. Spectrum 3.0 lists for $15,000. MMAC-Plus starts at $11,500 without connection modules, which run from $3000 to $50,000; a typical average-cost-per-Ethernet connection is about $500 per port.

Fault-Tolerant Managed Switching

The LANplex 6000 is available in both four-slot and 12-slot chassis from 3Com (Santa Clara, CA). LANplex provides fault-tolerant switching, although it's less capable than Cabletron's MMAC. LANplex supports only Ethernet and FDDI; ATM modules are planned for early 1995. Current modules connect to one of three FDDI buses in the system. Future modules, including ATM, will connect directly to the High-Speed Interconnect Bus with sustained transfer rates of 3.2 Gbps.

3Com's starter kit includes the chassis, management module, power supply, and software. The management module hooks up via an integrated dual-attached FDDI backbone connection. The four-slot version is $16,073, while the 12-slot chassis kit starts at $31,900. An eight-port Ethernet switching module is $12,500. An FDDI six-port fiber module is $8500, and a 12-port FDDI module is $9950. The average price per port of the LANplex runs $1500 and up.

Forced Frame Relay

C*ascade Communications* (Westford, MA) offers several multiservice switches based on a common architecture. Its top-of-the-line B-STDX 9000 offers Frame Relay, SMDS, and ATM switching in a shared-bus architecture capable of data rates as high as 1.2 Gbps. If incoming data isn't Frame Relay (e.g., SNA/SLDC or X.25), the B-STDX encapsulates the data links and carries the data as Frame Relay. An Intel 960 RISC processor handles switching in each module.

B-STDX pricing starts at $30,000; a fully redundant, fully configured T3 system typically runs about $160,000.

but suffers from other problems, including cost and complexity (see "All-Terrain Networking," August 1993 BYTE). But shared access, even at 100 Mbps, will eventually lead to the same problems.

Another solution is to divide the network into separate segments connected by bridges or routers. Each segment is shared, but communications can occur simultaneously in different segments, easing congestion. This is the right approach, but network growth will eventually cause the same traffic problems. The logical solution is to reduce each segment to one node, and that's where switching comes in.

Switching in LANs is exciting because it reverses the bandwidth equation. In the earlier 10Base-T network example, 10 nodes got 1 Mbps each. However, with a switched hub, each node can realize its full 10-Mbps potential; the total segment capacity would be close to 100 Mbps. Except for some overhead, this relationship is maintained right up to the hub's bandwidth capacity.

As a result, segment traffic in legacy networks is greatly augmented without having to change NICs (network interface cards) or cabling. This has been the primary focus of switched hubs for LANs. In WANs (wide-area networks), the focus is more on reliability and efficiency.

Today, switching technology is being used for all types of network protocols at the LAN and WAN levels. Vendors offer switching products for Ethernet at 10 and 100 Mbps, for token ring at 4 and 16 Mbps, and for ATM (Asynchronous Transfer Mode). In addition, Fibre Channel is a switched technology being developed for high-end workstation use (see "Fibre Channel Speeds Up," August BYTE).

Bridges and Routers—How Switching Works

Switching is required whenever a network signal must move between carriers (e.g., Ethernet to X.25) or change speeds (e.g., 10-Mbps Ethernet to 100-Mbps FDDI). Two primary categories of switching are packet and circuit. Packet switching uses a fixed-length data cell (e.g., an entire Ethernet frame, packets of arbitrary size, or ATM "cells"). In circuit switching, the carrying element is switched, generally for the duration of an entire message.

Bridges use MAC (media access control) address information from the data-link layer of the OSI (Open Systems Interconnection) network model to determine an incoming packet's destination. When a bridge encounters an unknown MAC address, it sends that packet to all its ports; this is called *flooding*, and it can present both traffic and security problems. Bridges learn address/port relationships dynamically—if a new address is real, it gets added to the correlation table. But if a bridge hasn't yet assimilated a new address, packets may be sent to users who aren't supposed to receive them.

The MAC layer also reserves certain addresses as "broadcast" designators—packets that are supposed to go to everyone on the network. Unfortunately, this interrupts all other messaging. Used too frequently, the result is a broadcast storm that can thoroughly disrupt a network.

Routers take a different approach, using the OSI network layer, which establishes a different addressing scheme for each type of network protocol. To be compatible with

multiple standards, routers have more complex switching logic than bridges, with associated delays and added cost.

Neither the classical bridge nor the router is a connection-oriented switch, and this presents problems. Connectionless switches do not maintain an end-to-end link, thus eliminating the possibility of data streams and isochronous traffic.

What's in a Name?

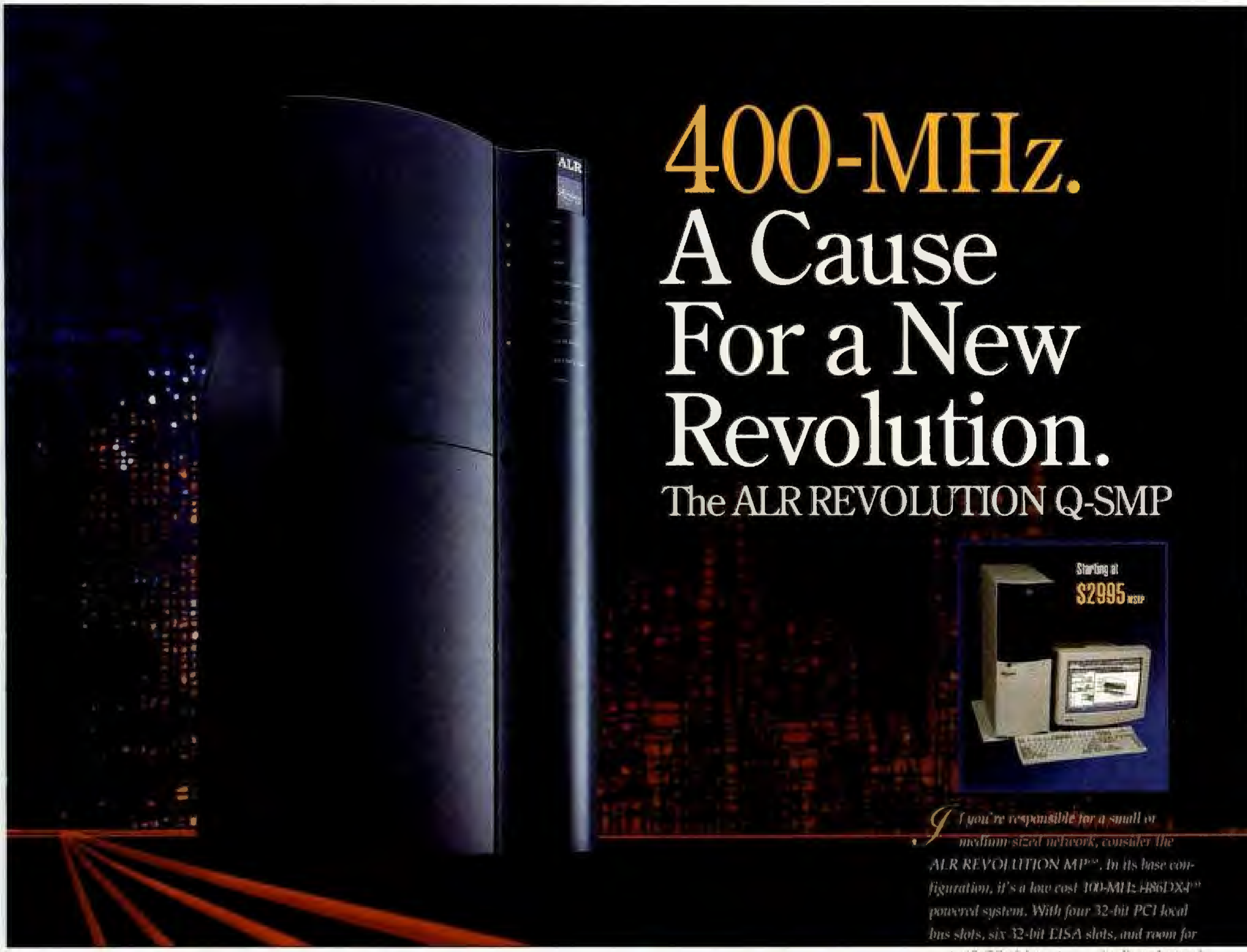
To allow each of its ports to operate at its maximum rate, a switch must handle the total potential traffic volume of all attached nodes, as well as switching overhead, the extra code bits assigned to each data-traffic unit. These traffic units might be variable-length Ethernet frames or constant-length packets, such as 53-byte ATM cells. Xedia's Smartswitch architecture, for instance, uses a 64-byte packet for Ethernet switching. For variable-length packets, software must determine the beginning and end; this introduces complexity and takes longer. Fixed-length packet switching can be implemented completely in hardware, which is faster.

Switch type can be defined by function, by the traffic units switched, or by hardware configuration. Most people are familiar with functional labels—bridge, router, and switched hub. The traffic-type label—Frame Relay, Ethernet, token ring, Fibre Channel, and ATM cell—tells you the intended use, but it gives no clue as to what's happening inside the box. What's happening inside the box determines the relative advantages and disadvantages, as well as the adaptability to future needs.

Several vendors produce so-called super hubs (or, as SynOptics Communications calls its Model 5000, Network Center Hubs)—switches that support some combination of Ethernet, token-ring, FDDI, ATM, and WAN connections. Cabletron Systems, 3Com, and others have products in this category, but only Cabletron currently supports all those topologies.

Approaches to Packet Switching

Generally speaking, there are three types of packet-switching hardware: shared-memory systems, shared-bus designs, and multistage matrix switches. But simple categories don't define all the products, and vendors' definitions don't adhere to any particular standard. No one design seems dominant for any given type of switch. As a result, a savvy network manager needs to assimilate an intimidating array of information before making decisions. In fact,



If you're responsible for a small or medium sized network, consider the ALR REVOLUTION MP™. In its base configuration, it's a low cost 100-MHz i486DX4™ powered system. With four 32-bit PCI local bus slots, six 32-bit EISA slots, and room for up to 12-GB of data storage, it offers plenty of room for high speed disk arrays, 32-bit LAN adapters, and other network expansion options. As your network grows, the DX4 processor module can easily be replaced with a 90- or 100-MHz Pentium processor. And when your needs increase even more, you can add a second Pentium processor, converting the Revolution MP into a true, symmetrical dual processing super server!

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price-per-port costs, even within a single category, range all over the place.

Shared-memory and shared-bus architectures have common elements. Both buffer I/O in memory that's connected to the switch logic by a bus. The shared-memory design generally relies on a logic-managed common pool of memory for switching between ports, while the shared-bus design uses a bus whose bandwidth is significantly higher than the accumulated demands of all attached ports.

A multistage matrix switch is an array of switching nodes, each with two inputs, two outputs, and a control line. Any input can be directed to any output. A number of ATM switches use the multistage-matrix-switch design. Because ATM cells are fixed-length, each node switch in the matrix can be a simple, fast, low-cost part such as an ASIC (application-specific IC) or FPGA (field programmable gate array). Xilinx (San Jose, CA), the leading FPGA vendor, has done extensive research on multistage matrix switches, such as a Banyan or Benes, implemented in a single FPGA.

ATM switches are not always based on the multistage-matrix-switch design. Fore Systems (Warrendale, PA) uses a variation on the shared-bus theme in its contentionless time-division architecture, and it has sold more ATM switches than anyone else—though that may also be a function of availability. Fore cites four advantages for TDM (time-division multiplexing): It is nonblocking, has a predictably low latency, provides integral multicasting without copying, and will support flexible interface speeds.

Nonblocking means it won't prevent an incoming cell from entering the switch fabric, because the fabric has greater capacity than any possible load. Multistage-matrix-switch vendors have reduced, but not eliminated, traffic contention in the switch fabric. Fore's ForeRunner ASX-100 offers the lowest latency times for any ATM switch, though matrix switches are almost as fast. To perform a multicast, a multistage matrix switch has to copy cells at appropriate switch nodes until it sends packets to the correct output ports; this adds traffic to the switching fabric. The ForeRunner sends only one copy of any cell onto its bus, and ports take it off as necessary.

WANs at Speed

Switching is an expensive proposition, though cheaper than replacing NICs and rewiring a network to gain speed. But for wide-area applications, limiting costs are not for hardware but for data transmission. For instance, maintaining a connection between Chicago and Minneapolis on a T32 link—a 32-Mbps link equivalent to T1 lines—costs close to $30,000 per month.

The trick is to provide bandwidth on demand at all levels. Currently, most WAN connections are provided through PVCs (permanent virtual connections), whose parameters—but not necessarily routes—are established in advance. On the other hand, SVCs (switched virtual circuits) provide resources as required, with billing according to use. SMDS (Switched Multi-Megabit Data Service) and Frame Relay vendors are expanding their SVC offerings, but some time-sensitive applications, like voice and full-motion video, really work best with the small cell size and short latency of ATM. Most WAN connections are supplied by routers, though the trend is moving from the circuit-switched router to the packet-switching variety.

Virtual Networking

One of the interesting and exciting possibilities of switch technology is virtual networking—using software to create network user segments regardless of physical location or connection type. The goal is to make participants appear local to each other to facilitate communication.

For a physical network, the network administrator can map out workgroups, establish connections, and collect management data. In a virtual network, this is not so simple. In fact, at this point, virtual networking seems to introduce more problems for both network managers and users than it solves. For instance, how do you maintain routing address conventions if a user belongs to two or more networks? For that matter, can a single node exist in two virtual networks simultaneously? How do you guarantee data security?

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John Bryan is a freelance technology writer and consultant based in San Jose, California. You can reach him on BIX c/o "editors."

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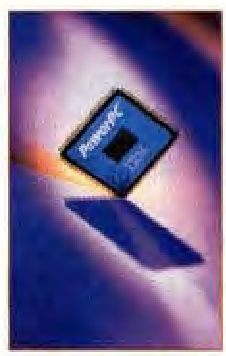

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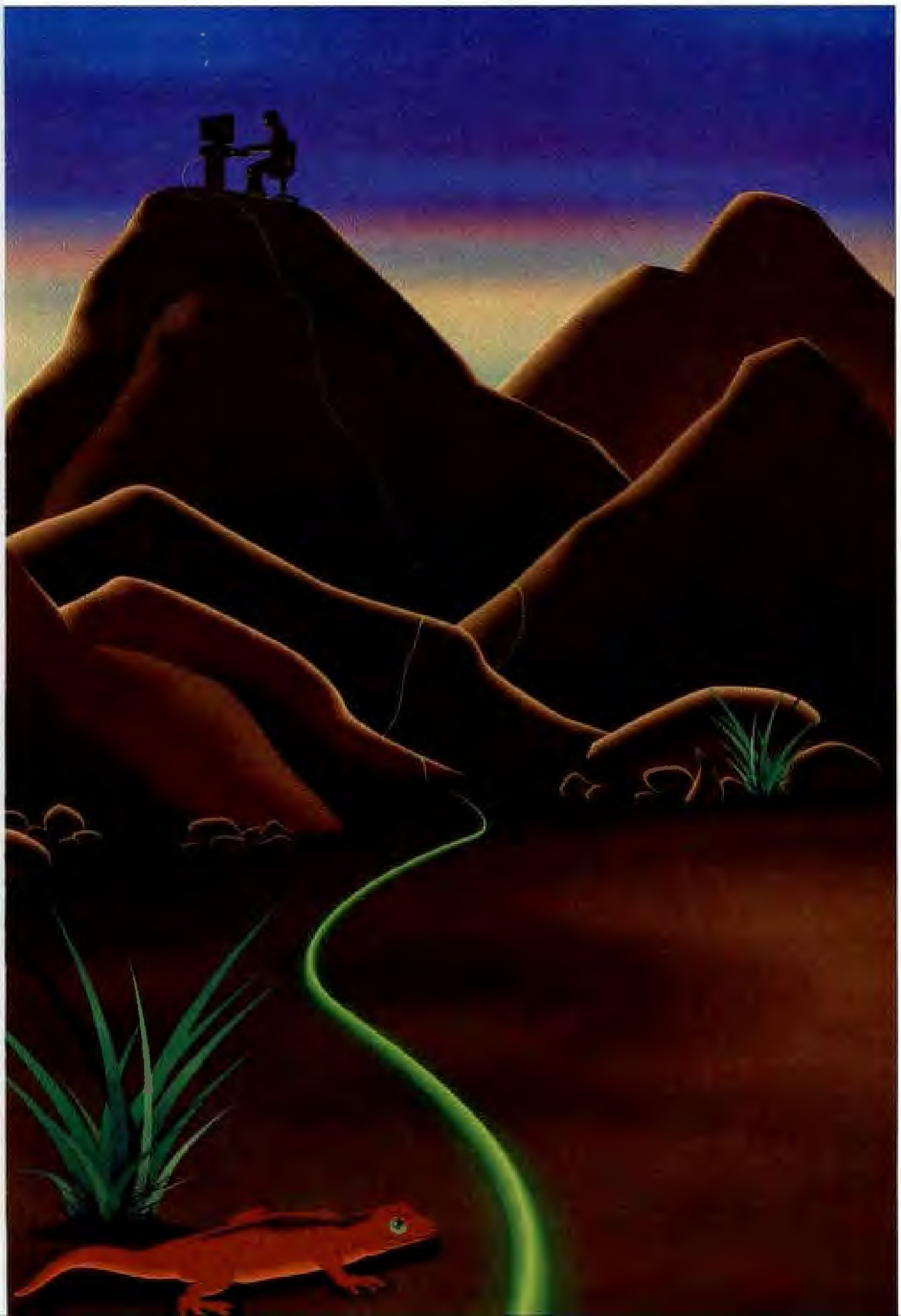
JEFFREY FRITZ



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Remote access to enterprise networks used to be in the same class with caviar, expensive limousines, and upper-class beach resorts—a luxury available only to a privileged few. Because connections to corporate computing services from offices or homes required a fair amount of engineering by the telephone company and MIS, they were neither easy nor cheap. Changes required issuing phone company work orders and were frequently out of the question. Eventually, even making new connections became difficult, as unused copper pairs in the telephone company's cables became scarce.

In addition, you needed a dedicated terminal to access corporate information systems; this equipment was installed in corporate offices and perhaps a few remote locations but was too expensive to place in employees' homes.

Today, as corporations move away from mainframe-based systems and onto LANs, terminals are being replaced by personal computers. PCs and LANs facilitate remote access to computing resources but don't, by themselves, solve the problems of remote connectivity. The key that unlocked the door to the remote office was the arrival of affordable, reliable digital telecommunications services coupled with inexpensive network hardware. A variety of digital telecommunications services now support remote connections to enterprise networks. Among the most common are Frame Relay, ISDN, Switched 56, and T1.

Frame Relay Initially designed as a barrier service for ISDN (which in turn was originally intended to be the front-end access to WAN [wide-area networks] and metropolitan Frame Relay networks), Frame Relay has become an independent technology based on the X.25 protocol. Normally, X.25 incorporates extensive error checking at every node in the circuit. Frame Relay's creators, assuming operation over reliable

THE ANALOG ALTERNATIVE

Not everyone has access to digital services yet. Several telephone service providers, particularly smaller, independent companies, have no immediate plans to implement digital-based services. Even in the larger RBOCs (regional Bell operating companies), digital deployment is spotty. Many users are located too far from the central office to be eligible for digital service.

While users have alternatives, however, they wait for the eventual deployment of digital services in their area. A variety of protocols have been designed to operate over analog modems. Protocols such as SLIP (Serial Line Internet Protocol) or PPP (Point-to-Point Protocol) are intended for remote TCP/IP network access.

Terminal servers, bridges, and routers are being equipped with PPP or SLIP capabilities that support modem access. Unfortunately, these protocols add some overhead, so faster modems—nothing slower than 9600 bps—should be used for the connection.

Some vendors are building remote-network access protocols into their products. Apple's AppleTalk Remote Access allows a remote Mac to dial into an AppleTalk network. Network modems, such as the Shiva NetModem, allow modem-based remote access to AppleTalk and Novell networks.

Although analog connections are slower and less reliable than digital connections, they can be a perfectly viable alternative if digital services are unavailable or too expensive.

digital links, removed the error checking to provide greater efficiency.

ISDN Most RBOCs (regional Bell operating companies—the offspring of the AT&T breakup) have considered ISDN to be, in one form or another, the mainstay of their residential and business telecommunications services. The problem is, they kept ISDN a secret, which has delayed its deployment and also confused users. The carriers generally believe that ISDN can meet the voice, video, and data needs of almost every user.

ISDN comes in two primary flavors: BRI (Basic Rate Interface) and PRI (Primary Rate Interface). BRI ISDN offers what's called a 2B+D service (i.e., it has two 64-Kbps B [barrier] channels and one 16-Kbps D [data] channel). PRI, at least in North America, has 23 B channels and one D channel; all PRI channels are 64 Kbps. Each B channel can support simultaneous and independent voice, video, or data connections. Therefore, one BRI can support voice plus two data calls; voice, video, and data; or multiple data calls. The choice is up to the user.

It's becoming easier to order ISDN, but it's far from one-stop shopping. Recently, I attempted to get rates from Bell Atlantic for an ISDN business connection. It took three separate calls to two different Bell Atlantic sales agencies before I had the information in hand—and I knew exactly what I wanted. I pity the poor user who doesn't know what to ask for.

Digital 56-Kbps Service Older than ISDN, digital 56-Kbps service is still popular. It comes in two varieties: dedicated and switched. Dedicated 56 is a hard-wired service configured much like older copper circuits. Changes require work orders and several days. As with ISDN, Switched 56 can place calls to a variety of destinations. The user dials the connection, uses the service, and then hangs up.

Switched 56 service has its flaws, including an intolerably long call-setup time. The telephone carriers' in-band signaling systems can set up only one node at a time. If multiple nodes are needed, setup can take a considerable amount of time (e.g., a coast-to-coast connection can take more than 13 seconds and in-state calls aren't much faster). This long delay is deadly to most network applications, which are likely to time out well before the connection is completed.

Digital 56-Kbps service provides connectivity, but it's expensive. Generally, 56-Kbps service costs more than ISDN and offers less than half the bandwidth and half the channels of a BRI. In some cases, 56-Kbps service can be nearly as expensive as T1 service. As a result, it is rarely used for residential connections.

T1 The digital mainstay for corporate networks, T1 service has a bandwidth of 1.544 Mbps and is commonly used to connect various enterprise network sites. A variant, called Fractional T1 is related to ISDN's PRI service; it breaks the T1 pipe into multiple channels. T1 lines are expensive and thus are rarely run to home offices and small businesses.

Personal Bridges

The appearance of low-cost network devices is radically changing the deployment of digital services. Until recently, bridging or routing equipment was expensive. Connecting a remote site required two bridges and a pair of CSU/DSU (channel service unit/data service unit) devices, or, for ISDN, a pair of terminal adapters. The total cost of all this gear was well over $30,000—far more than is to be spent for a single user.

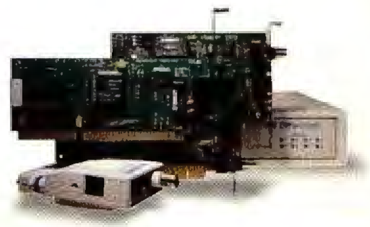
Today, full-featured ISDN Ethernet bridges, as well as internal PC cards that serve as bridges or routers, are available for under $2000. Single-user, "personal" bridges can be found for around $500—not much more than a high-speed analog modem costs—and that includes everything you require on the remote side, except for the PC, NIC (network interface card), and network software. This is a cost-effective way to connect homes and small businesses to the corporate or university enterprise.

Ramming 10 Mbps Down a 128-Kbps Pipe

It's important to maximize the efficiency of slower-speed digital links used for remote-network access. And let's face it, even 128 Kbps is slow when compared to typical network bandwidths.

We've all seen what happens during a heavy storm when rainfall exceeds the capacity of the storm drains—the streets get flooded and dangerous. The same holds for interLAN connections. LAN bandwidth is typically 10 Mbps for Ethernet and 4 to 16 Mbps for token ring. ISDN's 64-Kbps channel achieves only a fraction of those speeds and, at first glance, seems inadequate for connecting networks.

In practice, this isn't really a problem. Although 100 users may share a 10-Mbps Ethernet network, each uses only a fraction of the available capacity. The entire bandwidth of a 64-Kbps ISDN link, however, can be devoted to a single user. In addition,



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not all network traffic needs to use the slower-speed link. Most LAN traffic remains local. Only traffic going from one LAN to another crosses the link, and this is typically only a small percentage of the total. Keeping local traffic local is the reason you connect networks with bridges or routers in the first place.

Also, many existing network devices themselves—repeaters, bridges, concentrators, and NICs—act as bottlenecks to network speeds. Tests performed on production LANs at West Virginia University indicate that, on a 10Base-T Ethernet, user throughput is typically no more than 700 Kbps. On a busy Ethernet or on one using slower NICs, actual user throughput can drop to around 300 Kbps. Using data compression, ISDN bridges can provide throughput greater than 210 Kbps. Thus, the apparent difference in bandwidth isn't nearly as marked as it first appears.

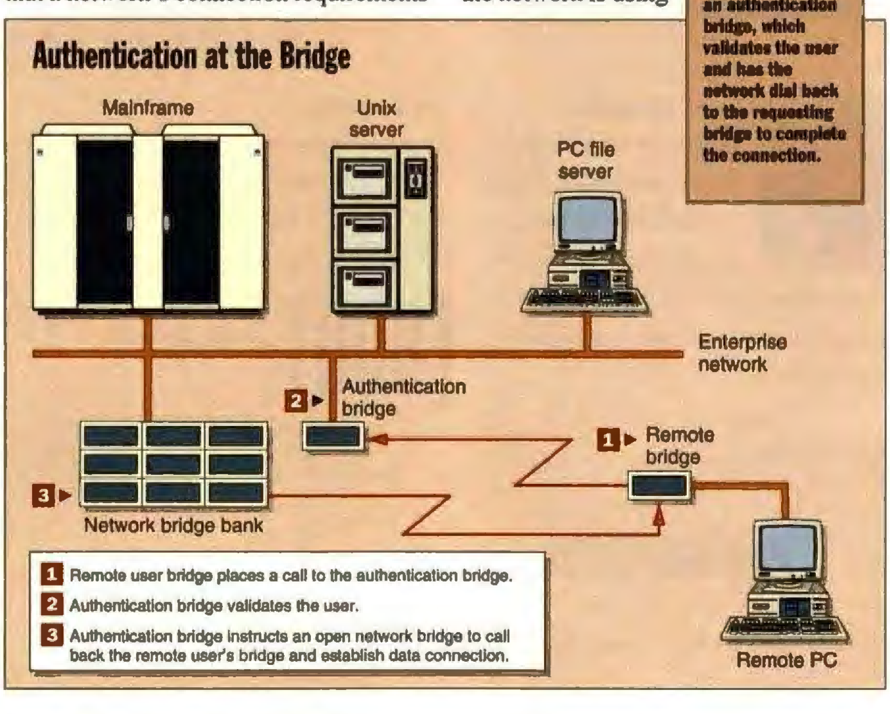
West Virginia University has networks in which 50 users are connected through a single 64-Kbps ISDN channel. Because the users perform interactive work (primarily database lookups) rather than file transfers, their traffic requirements are relatively light. The connection is so efficient that the users can't tell whether they are connected through ISDN or directly to the remote network.

Bandwidth on Demand

Bandwidth management is the key to successful operation of digital links. Suppose that a network's connection requirements change—for example, additional remote workstations are added or a remote workstation begins performing highly data-intensive tasks—and the single 64-Kbps connection no longer provides enough bandwidth. To support users' needs, you simply add bandwidth to the connection in the form of additional B channels.

ISDN network devices can aggregate multiple B channels into one virtual channel. For example, many ISDN Ethernet bridges combine the two BRI B channels to provide 128 Kbps of aggregate bandwidth. This is achieved behind the scenes, using techniques such as Multilink or BONDing (bandwidth on demand). Multilink is a software-based method for adding channels to the network connection. BONDing does much the same thing in hardware. It is more expensive and takes longer to set up or change than Multilink, but it has found favor in videoconferencing applications. Whether Multilink or BONDing is used, the result is the same—bandwidth is added as required. Users and network applications are none the wiser; all they see is a wider data-throughput path.

Multilink and BONDing are dynamic. If one channel is sufficient, only one channel is used. When the link needs to pass more traffic, the network device places more calls and adds channels as needed. When traffic demand falls off, the extra channels are dropped. Thus at any given moment, the network is using only the number of channels it requires to handle the traffic across the link. This minimizes connection costs.



Authentication can be handled by an authentication bridge, which validates the user and has the network dial back to the requesting bridge to complete the connection.

Filtering

One of the most important ways to equalize digital connections with higher-speed LANs is filtering, the elimination of unwanted network traffic. For an enterprise network operating with a wide variety of protocols, filtering can add up to 30 percent more effective bandwidth. If you don't need to transport multiple protocols across the link, it's better to filter them out on the enterprise side of the network.

Networks frequently contain multicast and broadcast packets, which are bad news for a narrow-bandwidth network connection. They consume considerable bandwidth and, in many cases, represent superfluous traffic. Every network device receives multicast and broadcast traffic, and many devices generate it. On a large network, this represents a lot of traffic that isn't necessarily relevant to the remote user. A server on the enterprise LAN may simply be looking for a local client when it sends out multicast or broadcast packets. These quickly add up and, on a large network, can become quite numerous. This isn't much of a problem on a 1.544-Mbps T1 link, but it can make a big difference for slower links like ISDN. There have been cases of networks with over 128 Kbps in multicast traffic alone.

While filtering can significantly reduce multicast and broadcast traffic, be careful not to eliminate them without first analyzing whether network services will be adversely affected. Some network protocols actually require broadcast or multicast traffic. For example, a network can age out a remote workstation that hasn't been heard from in a while. If there is subsequent traffic for that workstation, the ARP (Address Resolution Protocol) won't find it in the device table entries, and the network may have to send out a broadcast. Also, if broadcasts are carelessly filtered to the remote workstation, the network won't be able to locate the workstation.

Although not used as often as protocol filtering, address filtering can prevent packets from reaching particular devices on either side of the network. This might improve performance or add security options.

Security for Remote Access

There is an increased risk of unauthorized activity any time network access is given to more people. This problem is parti-

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cularly acute with dial-up connections. Unless appropriate controls are in place, anyone can dial into the network.

Remote network devices typically provide some form of security. The most common methods are ICLID (Incoming Caller Identification) and authentication. Digital services such as ISDN can automatically supply the telephone number of the calling party. Network devices can check the ICLID before accepting the call to determine if the call is coming from a legitimate user. If the number isn't recognized, the call is rejected. This simple security procedure isn't foolproof. It won't work if the call originates at a location that doesn't issue the calling telephone number, and it can be fooled by using call forwarding to route the connection through a second number.

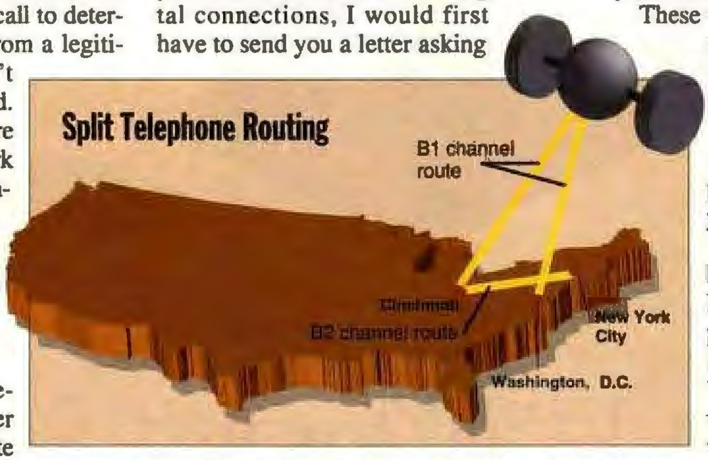
A better method of implementing security employs user authentication. Here the remote bridge sends a password or a random number called a *challenge*, depending on which authentication scheme is used. The network bridge compares the password with a stored string or performs a computation on the challenge. If they match, the user is authenticated and given access to the network.

A separate authentication bridge can be used. As can be seen from the figure "Authentication at the Bridge," the authentication bridge accepts calls from remote users. It verifies that the call originated from a legitimate bridge. The authentication bridge then finds an open bridge in the network bridge bank, instructs the open bridge to call the remote user back, and drops the original call from the user. This arrangement not only provides security but also makes it possible to perform call billing and charge-backs from a central location. (For a more complete discussion of network security issues and available control measures, see "Distributed and Secure," June BYTE.)

You Can't Get There from Here

The network side of the remote LAN connection is important. Digital services are of little value if there isn't anything to connect to on the other side. It's one thing to install an ISDN, Switched 56, or Frame Relay line. It's quite something else to provide real connectivity through the digital network. Whether it's the corporate operating system, the Internet, or the NII (National Information Infrastructure), there must be a destination to connect to on the enterprise side. For the Internet and the NII in particular, many questions are yet unanswered: Who will provide network access? How will they do it? At what cost?

How to coordinate network access is an increasingly hot issue. If normal telephone service was like these digital connections, I would first have to send you a letter asking you what kind of phone you have. I need to know because my phone will only work with equipment that is from the same manufacturer. If your equipment is different from mine, we can't talk.



A transmission is split and sent along two different routes, B1 and B2, but B1 takes significantly longer as B2, because it involves a satellite uplink.

Sounds ridiculous, doesn't it? Unfortunately, this situation is very common in remote-network access. Before we can connect, I must know the answers to a number of important technical questions: What equipment do you have—a bridge or a router? What vendor made the equipment? Which network protocol or protocols should be used? Can your phone network connect to my network? What network addresses can I use? Gathering all this information from every network you want to connect to would be a nightmare. This is a big problem with ISDN, which has many different flavors that don't all interoperate.

Happily, Bellcore, the research arm of the RBOCs, has developed a standard that addresses some of these issues. Called N-ISDN (National ISDN), it provides for a series of progressive interconnection standards for ISDN voice and data services. Currently, N-ISDN 1 and N-ISDN 2 have been widely accepted by switch vendors and service providers. Work continues on an even more robust version, N-ISDN 3, which is planned to be the final iteration.

Many vendors realize that interoperability is critical to sales. The Enterprise Network Data Interconnectivity Family of NIU-F (the North American ISDN User's Forum) will soon release an interoperability agreement that will allow any vendor's bridge to talk to any other vendor's bridge. A similar agreement will cover router-to-router communications. (Sorry, no router-to-bridge agreements yet—unless your router can pretend to be a bridge.)

These won't resolve all the interoperability issues, but they're a good start. With full device interoperability, national and international standards, and a simplified way to order digital lines, plug-and-play networking may yet be possible.

Packet Resequencing

Moving data between networks presents another interesting problem. Consider a network in Washington, D.C., that is linked via a multiple-channel connection to an enterprise network in New York City (see the figure "Split Telephone Routing"). The telephone network directs the call on channel two over a fiber route directly to New York. But the phone system sends the channel-one connection via a satellite link that goes through Cincinnati before it reaches New York. Strange as this sounds, it happens all the time. Two calls placed one right after the other may routinely be given very different routings. The routes aren't necessarily short, either; the telephone company network uses least-cost, not shortest-length, algorithms for routing call connections.

With the link in place, the Washington bridge is ready to send its traffic. The table "Putting Packets in Order" shows the sequence in which packets are placed on the two channels and the order in which they arrive at the destination. As the table shows, the bridge alternates channels, putting the first packet on channel one and the second on channel two. However, because of the longer transmission delay on channel one, packet number two will arrive well before packet number one. In fact, for much of the transmission, New York will see two packets arrive from channel two for every one that arrives from channel one. A very nasty situation.

Some network protocols (e.g., TCP/IP) aren't bothered by packets that arrive out of sequence; they just rearrange them in the proper order. Other protocols may

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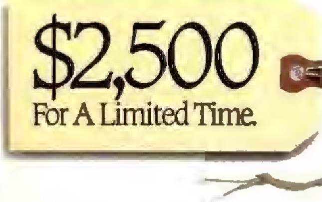

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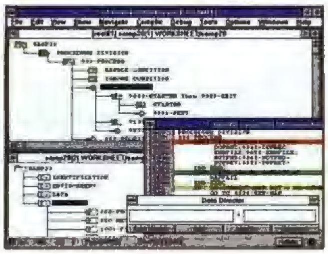

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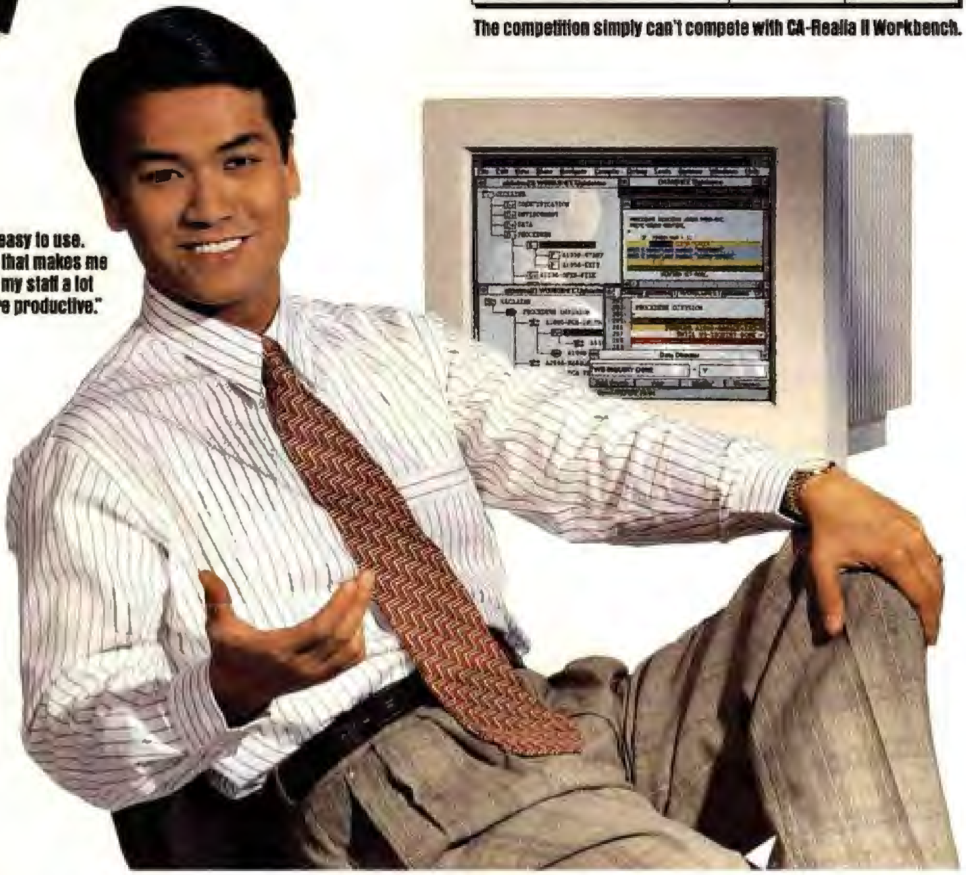

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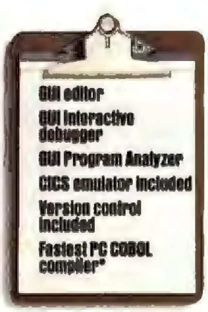

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PUTTING PACKETS IN ORDER

Splitting messages into separate packets sent along parallel routes with different transmission times may mean that they arrive out of order and thus require resequencing.

INPUT PACKET	PLACED ON CHANNEL	ARRIVAL PACKET SEQUENCE	OUTPUT PACKET (RESEQUENCED)	COMMENTS
1	B1	2	-----------	Waiting for packet 1's arrival.
2	B2	4	-----------	
3	B1	1	1	
4	B2	6	2	
5	B1	8	-----------	Delay waiting for packet 3's arrival.
6	B2	3	3	
7	B1	10	4	
8	B2	5	5	Packet 5 delivered just in time.
9	B1	7	6	
10	B2	9	7	Now all packets have arrived.
			8	
			9	
			10	

B1 transmission delay = 2 × B2

come unglued, however. Their designers simply never considered the possibility that networks would be connected by multiple links that can deliver packets out of sequence.

There are two ways to deal with this problem. One is to place each protocol on a single link. Routers, even when using multiple channels, allow protocols to be delivered on a single channel. If there are three protocols on the network, it uses a separate channel for each.

Resequencing the packets is more elegant, because it allows multiple links to exist behind the scenes, increasing bandwidth for all protocols. Any protocol's packets are sent over multiple links and then reassembled in sequence on the other side before being handed over to the remote LAN. This fools the protocol into believing it has a higher-bandwidth connection operating over a single link. And that makes every protocol happy. Many bridge and router products designed for digital links include internal algorithms that resequence the packets before releasing them to the network.

Whose Network Am I on Now?

Network protocols use numerical address schemes to determine where to send traffic. Each device on the network must have a unique network address, expressed as a number. If a computer runs multiple protocols, such as TCP/IP, IPX, and AppleTalk, it may require multiple addresses.

Addresses are generally associated with the network that the computer is connected to. With dial-on-demand, however, remote users may need to connect to multiple networks. They may link up with the corporate LAN to complete some work and then connect to a regional network to pass E-mail.

This can present problems, because the network addressing numbers and naming conventions will change from network to network. The address that was correct for the first network is wrong for the second. This is dangerous; bad addresses can wreak havoc on enterprise networks. They can confuse network devices, cause conflicts, generate additional traffic, and cause remote-user and network problems as devices argue over which naming convention or address number is really correct. Unfortunately, network numbers aren't easy to change; it usually means fiddling with a configuration file, something the casual user cannot and should not be expected to do.

The problem of network number assignments for dial-in users has yet to be solved. Until it is, you should be careful when connecting to multiple networks.

Bridge Loops

It's all too easy to create bridge loops. Suppose an office in Cambridge, Massachusetts, uses a bridge to connect to its corporate enterprise network across the river in Boston. A second bridge connects Cambridge to an office in Framingham, 20 miles away. One day, the folks in Framingham enhance their communications by installing a bridge link between Framingham and Boston. Unfortunately, neither they nor the Boston office mentions this to the Cambridge office. A triangle now exists from Boston to Cambridge to Framingham and back to Boston. Packets travel merrily around this loop, never dying. Because bridges don't expect to encounter a loop topology, they usually contain no intelligence to remove packets from the network. Therefore, the packets will travel forever around the circle. This condition is called *looping*, and it can be serious. Bridge loops can easily generate enough excess traffic to bring down an enterprise network.

A protocol called Spanning Tree can overcome this problem. Unfortunately, many remote bridges don't support Spanning Tree because it adds cost and complexity. In addition, it adds more traffic to the link.

Since remote bridge calls can be connected and dropped at will, bridge loops are difficult to spot. Network managers have to be extremely careful to coordinate their network topologies to avoid bridge loops. Fortunately, this is seldom a problem for networks using routers, which can deal with parallel routes and looping without difficulty.

Making the Connections

Despite these problems, digital services are now a viable means of providing remote LAN access. Generally, the most inexpensive form of digital telecommunications is ISDN. After years of unfulfilled promises and delays, it looks as if ISDN is finally beginning to flourish. A number of RBOCs have announced "ISDN Anywhere" programs that allow you to order ISDN services even if your local phone company's central office isn't equipped to provide it.

Clearly, our world is changing. Today there is more reason than ever to tie home-based and traveling workers to the corporate umbilical cord. Full network-service capabilities allow efficient and effective work to be done in remote offices, on the road, or at home. Digital communications services are—at long last—ready to provide remote access to a wide variety of networks. ■

ACKNOWLEDGMENT

My thanks to Robert Downs of Combinet for his assistance with this article.

Jeffrey Fritz is a telecommunications engineer responsible for the design and management of data communications for West Virginia University, including its ISDN Applications Lab. He is the author of Sensible ISDN Data Applications *(WVU Press, 1992). He can be reached on the Internet at jfritz@wvnvm.wvnet.edu or on BIX c/o "editors."*

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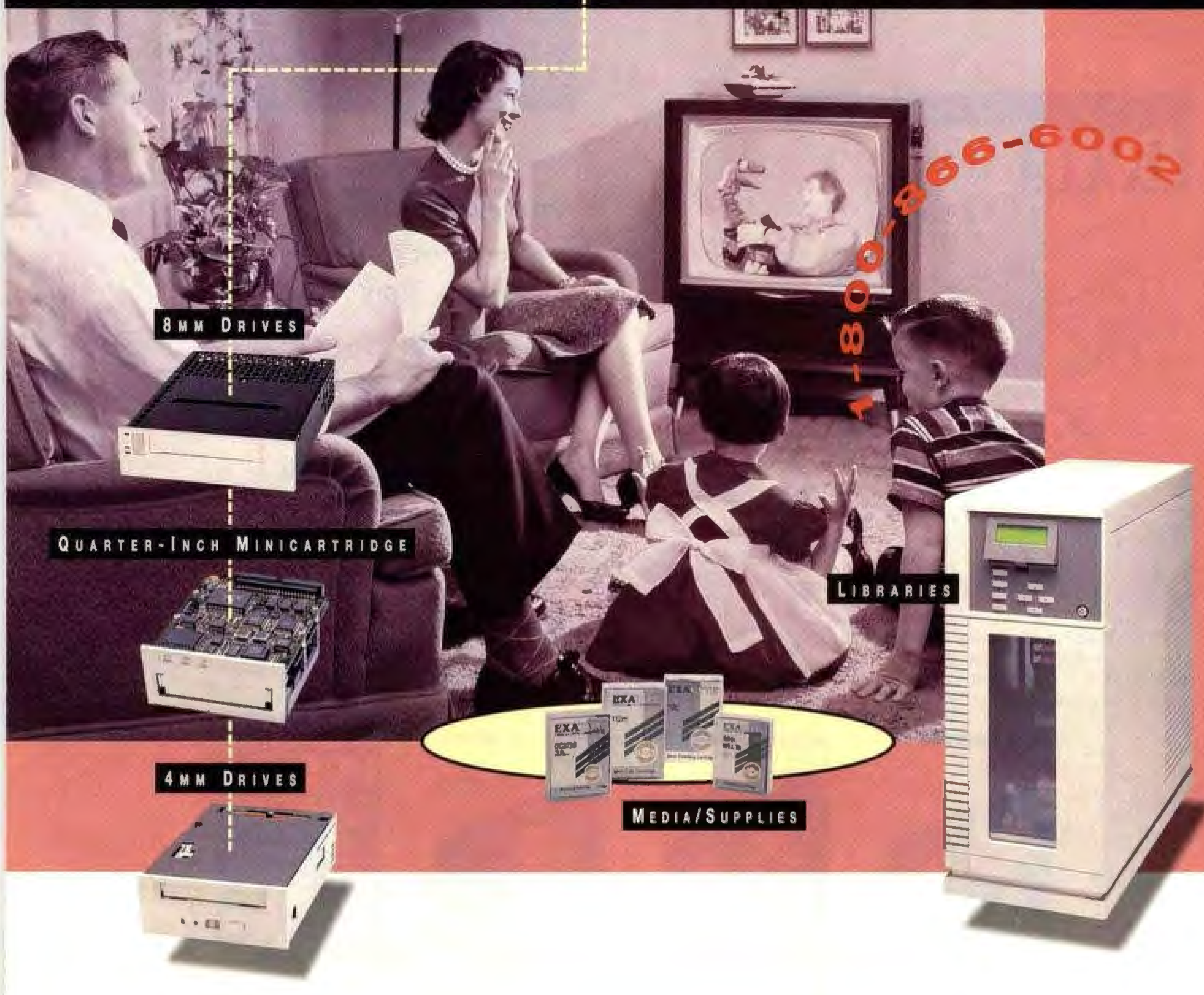

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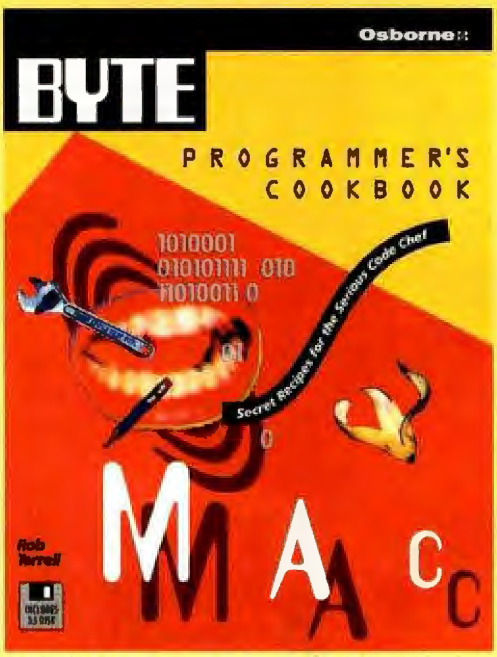

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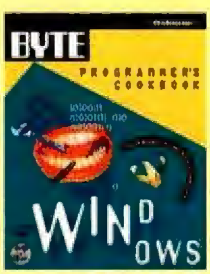

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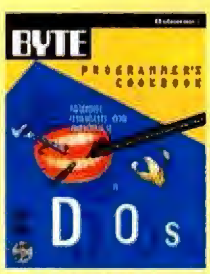

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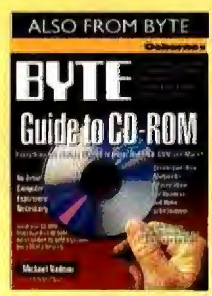

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Remote-Control Windows

NSTL evaluates six programs that let you control your PC remotely

Remote-control programs are a special category of communications application. They go beyond just connecting with another computer to actually taking control of it. Connecting through phone lines and modems or through LAN connections, these programs can put all the resources of one PC, usually called the *host*, at the disposal of a remote user's computer. The local PC screen (the *remote* or *viewer*) duplicates the host PC's screen: The keyboard enters characters directly to the host PC, and the mouse moves the host PC's mouse pointer. The local screen constantly receives data from the host PC screen, detailing every change in status. Likewise, the keyboard sends data to the host PC every time a key is hit. For all practical purposes, the remote user may as well be sitting in front of the host PC.

In the early days of remote-control software, most of us used these programs to access our office systems from home PCs. You could leave your office PC and modem on with the remote-control program running in host mode. You could then call in and take control from the home PC, perhaps running Excel to update a spreadsheet file or using Freelance Graphics to create charts. You could also transfer files from your office to your home PC. Companies could also provide technical support for PCs at remote sites via modem. Technicians could take control of a problem PC at a remote site, view the problem directly, and fix it without spending hours on the phone or traveling to the site.

A more recent use is to dial in (via modem) to a network-connected PC at the office, log in, and run network applications or update shared files on the network. Technical-support use of remote control has expanded to include connecting directly through the company LAN. Helpdesk personnel on the sixth floor of an office building can now use remote control through the network to fix a problem on an executive's PC on the eighteenth floor.

The Windows Connection

As Windows has grown in popularity, the demands made on remote-control communications have increased. A graphical interface such as Windows works with many times more screen data than older DOS interface programs—screen data that has to travel continuously over a relatively slow modem connection. Even with the faster modems now available, the response time for Windows applications over remote-control connections was not acceptable until remote-control programs written specifically for Windows emerged.

This report evaluates the six remote-control programs most widely used for running Windows applications. Carbon Copy for Windows, CoSession for Windows, Norton pcAnywhere for Windows, and ReachOut Remote Control are Windows applications that have taken over from previous DOS-based versions. Remotely Possible was introduced originally in Windows form. Close-Up is the sole DOS application we tested. Even though it is not Windows-based, it runs Windows applications and is positioned in direct competition with the other programs. For this issue, we did not consider programs that do not connect via modem.

Smart Screen Refresh

The bottleneck caused by modems can have a significant effect on the speed of remote-control operations. For the LAN versions of these programs, performance would be affected by the speed of a session link between two LAN workstations rather than a modem; however, since networks are many times faster than modems, this review concentrates on performance of remote control via modems.

To boost performance, remote-control programs try to minimize the amount of data that needs to be transmitted. In the past, remote control worked by sending and refreshing the entire image of the host PC's screen to the remote PC every fraction of a second. The constant rate at which the screen images were sent to the remote PC was called the *screen refresh rate*. The remote PC's screen accurately reflected the host PC's screen as changes at the host PC would be included in the next screen refresh.

Many times, a change is limited to a small section of the screen (e.g., moving the mouse pointer an inch, pulling down a menu, or highlighting an object), and only the changed data needs to be refreshed. The remote system can use the screen data it already has and just refresh the unchanged parts of the screen. By cutting out redundant screen-refresh data, a remote-control program can greatly increase the response time.

Smart screen refresh is implemented in one form or another in Close-Up, CoSession, pcAnywhere, ReachOut Remote Control, and Remotely Possible. It is not a standardized feature, which is to say that

OVERVIEW

NSTL RATING		VERSION	PERFORMANCE	VERSATILITY	QUALITY	EASE OF LEARNING	EASE OF USE	PRICE
★★★★	ReachOut Remote Control	4.0	▲	▲	▲	▲	▲	$199
★★★	CoSession for Windows	1.0c	▲	▲	▲	▲	▲	$199
★★★	Close-Up	6.0	▲	▲	▲	▲	▲	$199
★★★	Norton pcAnywhere for Windows	1.0	■	▲	▲	▲	▲	$199
★★★	Carbon Copy for Windows	2.0	■	■	▲	▲	▲	$199
★★	Remotely Possible/Dial	4.0e	■	▲	▲	■	▲	$199

KEY

★★★★★	Outstanding
★★★★	Excellent
★★★	Average
★★	Below average
★	Poor
▲	Good
■	Fair
▼	Unacceptable

some of the programs appear to filter out more redundant screen data than do others.

Caches speed the performance of hard drives and memory chips, and they also work well for remote-control programs. The idea behind a cache is to keep recently used data in a temporary storage area that is quickly accessible. If the data is soon needed again, it is much quicker to access it from the fast-access temporary storage area than to retrieve it from the original source. So, elements of a recently displayed screen are saved as a cache in extended memory. If the remote user returns to a recently displayed screen, the entire page redraws from the remote PC's screen cache, eliminating the need to transfer large amounts of data over the modem from the host. Screen elements that are often redrawn from a screen cache include bit maps, text, and fonts.

All the tested programs use caching to boost performance, although the effectiveness of the caching algorithms differs. The Page Redisplay performance test is a good example of a screen cache being employed to redraw a screen. Close-Up's Photographic Memory caching is especially effective.

Highlights

	Strengths	Limitations
Carbon Copy	Very easy to learn Excellent manual Automatic disconnect-after-transfer option	No remote printing No inactivity disconnect Limited choices for conditional file transfers
Close-Up	Fastest page redisplay Fastest remote printing No modification of system.ini and win.ini files	Very limited on-line help No background file transfers No support of SVGA resolutions over 800 x 600 pixels
CoSession	Drive redirection Fastest transfer of graphics file Fast video display	Setup features somewhat difficult Slowest remote printing
Norton pcAnywhere	Fastest overall file transfer times Largest number of programming features Best on-line help system	Slowest page-redisplay times No utility for modem customization No password encryption
ReachOut Remote Control	Fastest program overall Most versatile program No modification of system.ini and win.ini files	No message on a connection loss Limited script programming
Remotely Possible/Dial	Best quality overall Bidirectional file transfer Fastest transfer of compressed files	Lowest overall usability No programming features Slowest performance overall

Efficient Communication

Data transfer via modem is regulated by a communications protocol, which is a method for breaking the data stream into small packets and checking that each packet arrives intact. If a packet does not arrive intact (e.g., noise on the phone lines sometimes corrupts an individual packet), the protocol interrupts the data flow and resends the damaged packet.

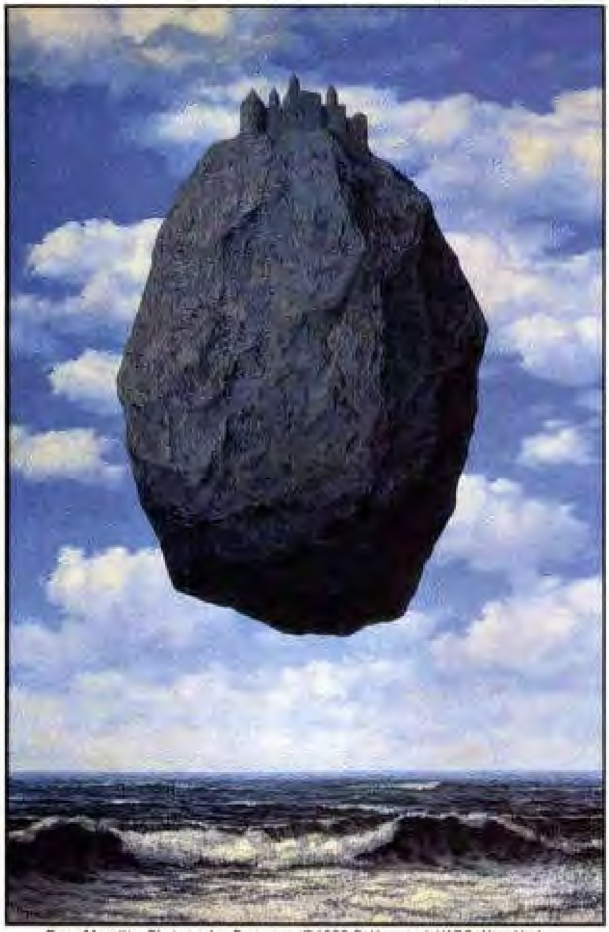
Each of the remote-control programs tested uses a proprietary transfer protocol, and the efficiency of the protocol has a significant effect on the speed of data transfers between modems. Packet size and error-checking methods can speed or slow data transfers, depending on how they are set. Larger packets, for example, provide better performance when there is little noise on the phone lines, because the protocol need not resend corrupted incoming packets. But they hurt performance when there are higher levels of noise on the phone lines, because the larger packets take more time to be retransmitted. Some protocols pause as each packet is checked; others do not pause, or pause less often, allowing an almost continuous transmission and providing significantly better performance. Again, with noisy phone-line conditions, this method can actually hurt performance.

Another feature employed to improve performance, specifically during file transfers, is to compress files as they are sent and uncompress them at the receiving system. Depending on the level of compression that can be attained, the time saved overall is more than worth the time it takes to compress and decompress the file. Carbon Copy, Close-Up, CoSession, pcAnywhere, and ReachOut Remote Control all use file compression.

If the file will not compress, the time spent trying to compress it is wasted and slows performance. NSTL's File Transfer performance test illustrates this point. In this test, a compressed file is transferred

ReachOut Remote Control, the top-rated program in the roundup, offers a strong set of features, including security options. ReachOut supports password protection, automatic dial-back, reboot on disconnect, and encryption.

Outstanding.



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For International Information circle 96. For Domestic Information circle 97, on Inquiry Card.

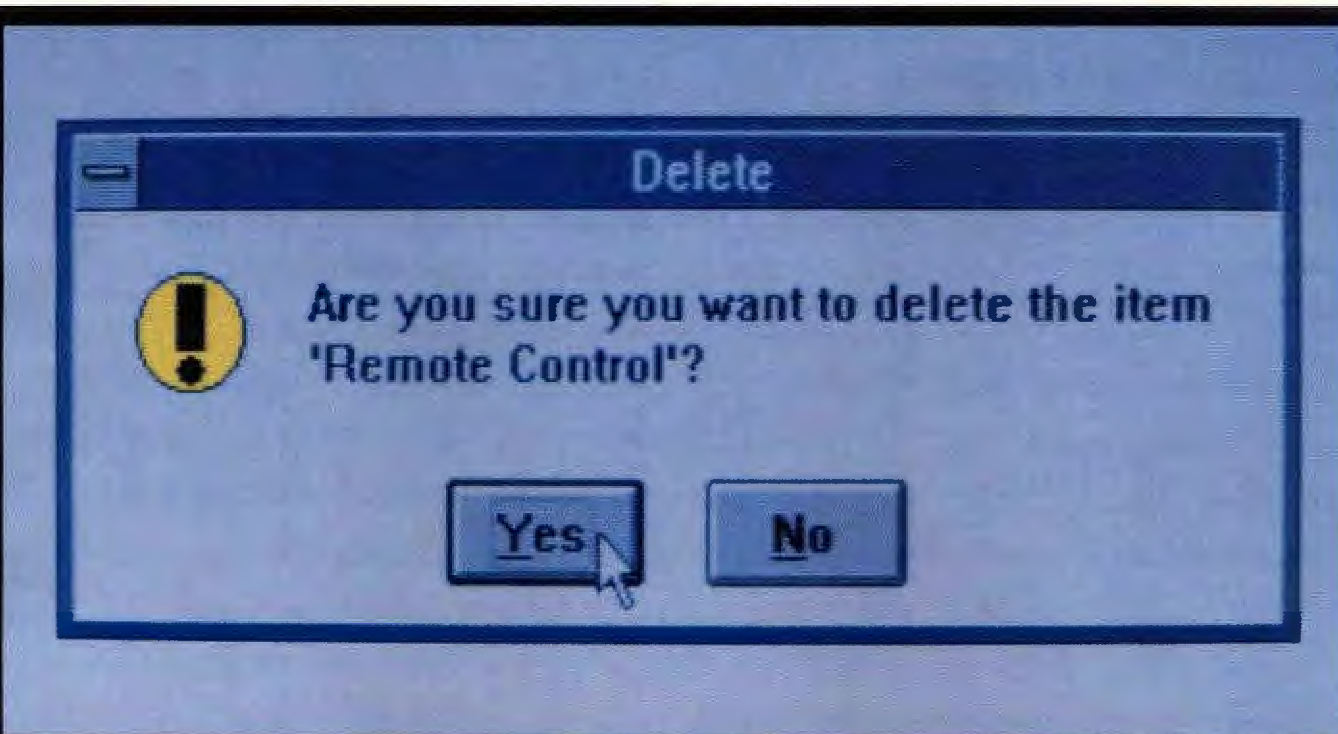
twice, once with file compression enabled and another time with it disabled. Carbon Copy, pcAnywhere, and ReachOut all have faster times with the feature disabled. CoSession and Close-Up appear able to turn off compression when transferring a compressed file and so achieve the same time for both tests.

Remotely Possible doesn't compress files, but it benefits from external compression because the V-series v.42 modems we use for testing compress data automatically.

continued

	CARBON COPY FOR WINDOWS	CLOSE-UP	COSESSION FOR WINDOWS	NORTON PCANYWHERE FOR WINDOWS	REACHOUT REMOTE CONTROL	REMOTELY POSSIBLE/DIAL
Configuration						
Load host program in upper memory	●	●	●	●	●	●
Unload host without rebooting	●	●	●	○	●	○
Access host within application	○	●	○	○	●	●
Exit to DOS on host	●	●	●	●	●	●
No modification of system.ini or win.ini	○	●	○	○	●	○
TSR not required for Windows-to-Windows connections	●	○	○	●	○	●
Operating-system support						
DOS 4.0x	●	●	●	●	●	●
DOS 5.0	●	●	●	●	●	●
DOS 6.0 or higher	●	●	●	●	●	●
DOS/Windows 3.0	①	●	○	●	●	●
DOS/Windows 3.1	●	●	●	●	●	●
Windows NT	②	②	②	②	②	②
OS/2 1.3	②	②	②	②	②	②
OS/2 2.0	②	②	②	②	②	②
OS/2 2.1x	②	②	②	②	②	②
Modems and optimization						
Remote uses screen-refresh data only	●	●	●	●	●	●
Remote uses "smart" screen-refresh data only	○	●	●	●	●	●
DTE rates to 115.2 Kbps	●	●	●	●	●	●
Operates at 230.4 Kbps (DTE)	○	○	●	○	○	●
v.32bis high-speed modems	●	●	●	●	●	●
v.42bis compression modems	●	●	●	●	●	●
Compression algorithm	●	●	●	●	●	○
Video						
DOS graphics	●	●	●	●	●	●
SVGA 800- × 600-pixel resolution	●	●	●	●	●	●
SVGA 1024- × 768-pixel resolution	●	○	●	●	●	●
Remote at higher resolution than host	●	③	●	●	●	●
Host at higher resolution than remote	●	③	④	●	●	●
SVGA 1280- × 1024-pixel resolution	●	○	●	●	●	●
Security						
User passwords	●	●	●	●	●	●
Setup screen password	●	●	●	●	●	●
Password encryption	●	●	●	○	●	●
Data encryption	○	○	●	○	●	⑤
Automatic dial-back	●	●	●	●	●	●
Host can place initial call	●	●	●	●	●	●
Disable host screen/keyboard/mouse	●	●	●	●	●	●
Disable remote screen/keyboard/mouse	○	○	●	●	●	○
Remote initiates host reboot	●	●	●	●	●	●
Inactivity disconnect	○	●	●	●	●	●
Lock out remote directory access	○	○	●	○	⑥	○
Intruder notification	○	○	○	○	●	○
Virus checking	○	⑦	○	○	●	○

● = yes; ○ = no.
① Windows 3.0a.
② May run as a Windows session, not as a native application.
③ Higher-resolution PC drops to match lower resolution in Windows.
④ If remote display is EGA or better.
⑤ At additional charge to comply with government encryption standards.
⑥ If viewer is restricted to Windows access only.
⑦ Checks its own executable files.



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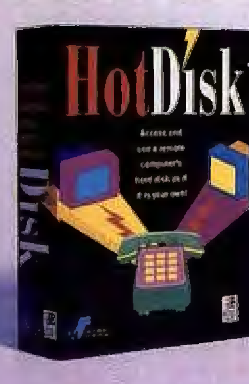


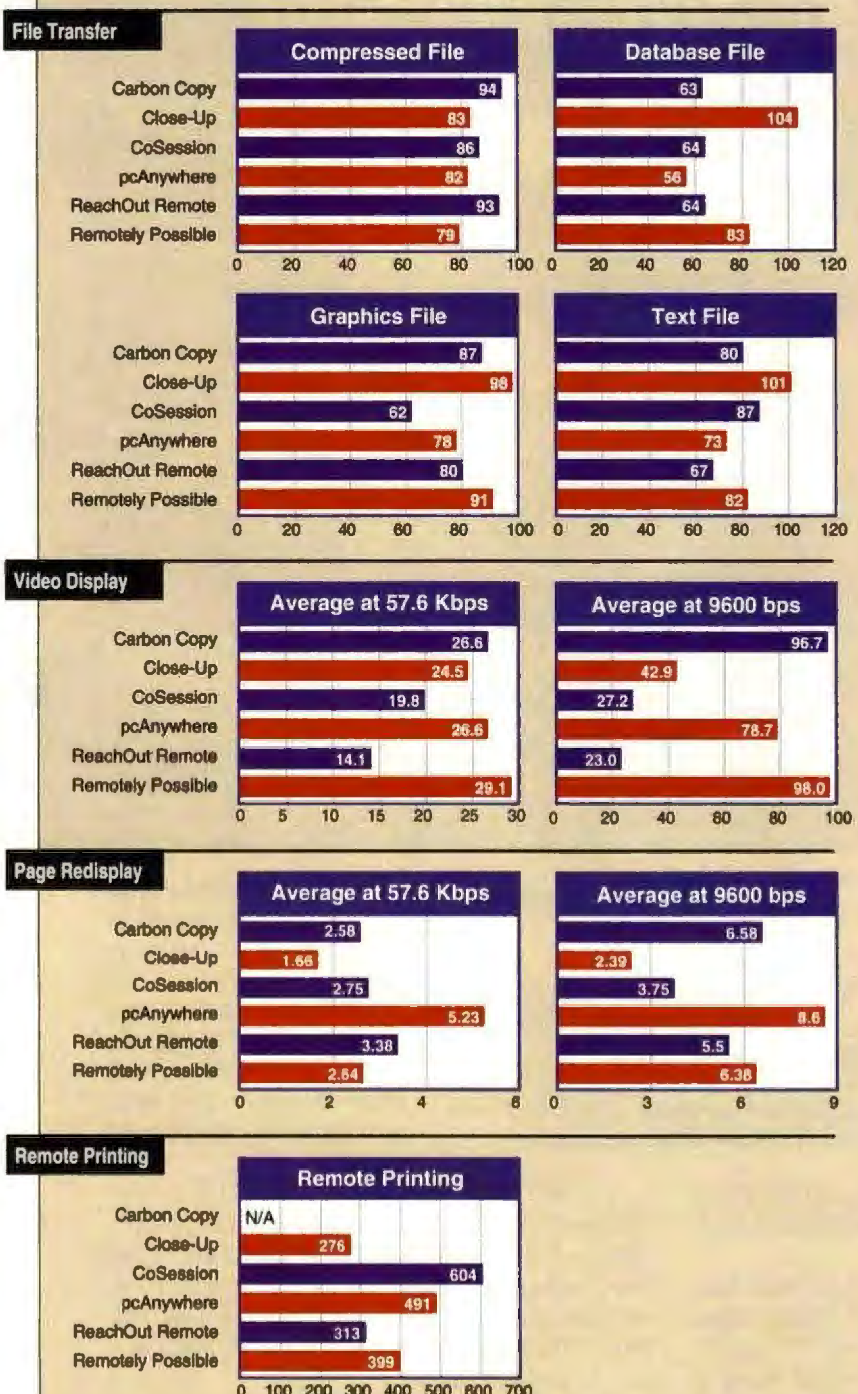
Circle 183 on Inquiry Card (RESELLERS: 184).

Reviews Software Roundup

	CARBON COPY FOR WINDOWS	CLOSE-UP	COSESSION FOR WINDOWS	NORTON PCANYWHERE FOR WINDOWS	REACHOUT REMOTE CONTROL	REMOTELY POSSIBLE/DIAL
File transfer						
Host full file transfer control	●	○	●	●	○	●
Remote full file transfer control	●	●	●	●	●	●
Bidirectional file transfer	○	○	○	○	○	●
Background transfer	●	○	●	●	●	●
Lock out remote file transfer	○	●	●	○	●	●
Lock out remote send function	○	●	●	○	●	●
Lock out remote receive function	○	●	●	○	○	●
Drag-and-drop transfer	●	○	●	●	●	○
Sort files by name	●	●	●	●	●	○
Sort files by date/time	●	○	○	●	●	○
Transfer protocols						
Proprietary	●	●	●	●	●	●
ZMODEM	○	○	○	●	●	○
YMODEM	○	○	○	●	●	○
XMODEM	○	●	○	●	●	○
Kermit	○	○	○	●	●	○
ASCII	○	●	○	●	●	○
Others	○	●	○	○	○	○
Communications session						
Remote can exit host Windows session	●	●	●	●	●	●
Single voice and data line	○	●	●	●	●	○
Phone directory	●	●	●	●	●	●
User-definable dialing prefix	●	●	●	●	●	●
Software chat mode	●	●	●	●	●	●
Modem customization utility	●	●	●	○	●	●
VT-100 terminal emulation	○	○	○	●	●	○
V-52 terminal emulation	○	○	○	●	●	○
IBM 3101 terminal emulation	○	○	○	●	○	○
TTY terminal emulation	○	●	○	●	●	●
Other terminal emulations	○	○	○	●	●	○
Programming						
Editable macros	○	○	○	○	●	○
Learn mode for creating macros	○	○	○	○	○	○
Scripting language	⑧	●	●	●	⑨	○
Scripts prompt for user input	⑧	○	●	●	⑨	○
Step through scripts for debugging	○	○	●	○	○	○
Check scripts for syntax errors	○	●	●	●	○	○
Variables	○	○	●	●	○	○
Subroutines with parameters	○	○	⑩	●	○	○
DO...WHILE loops	○	○	⑩	○	○	○
FOR...NEXT loops	○	○	⑩	○	○	○
IF...THEN...ELSE statements	○	○	⑪	⑪	⑨	○
Case statements	○	○	⑩	○	○	○
Event-triggered automated scripts	⑧	○	⑩	●	⑨	○
Time-triggered automated scripts	⑧	●	⑩	●	⑨	○
Script compiler	○	○	⑩	●	○	○
Miscellaneous features						
Display remote hardware information	○	○	○	○	●	○
Display host hardware information	○	○	○	○	●	○
Display host/remote connection information	○	○	●	○	●	○
Transaction logging	●	●	●	●	●	○

⑧ Using macros to access Carbon Copy as a DDE server.
⑨ During terminal emulation only.
⑩ Via add-on module at extra cost.
⑪ No ELSE.

Remote-Control Performance



All times in seconds; lower numbers indicate better performance.

We tested performance of the remote-control programs using Compaq ProLinea 4/25s systems as the host and remote. The systems were equipped with 8 MB of RAM, DOS 6.2, and Windows 3.1. For the file transfer tests, we transmitted four different file types, because transfer speed can be greatly affected by how well the transfer protocol and compression algorithm match with the format of the file being transferred. We used a two-page Word for Windows 6.0 document for the Remote Printing and Page Redisplay tests. The Video Display tests measure the programs' speed displaying a series of (mostly) graphical files. We made every effort during the testing to optimize the performance of these programs. We conducted the tests at DTE speeds of 9600 bps and 57.6 Kbps. All times are in seconds; shorter bars indicate better performance.

Modem compression, however, generally doesn't match software compression.

Resolving Resolutions

When a remote user connects to a host PC, the assumption is that the screen data from the host PC will exactly fit in the screen of the remote PC. That assumption will be challenged if both screens are not at the same resolution. With Windows supporting resolutions of up to 1280 by 1024 pixels, one system may well be running in a higher resolution than the other. Most of the programs support a variety of SVGA resolutions (Close-Up supports up to only 800 by 600 pixels), and all allow PCs with differing screen resolutions to connect.

The programs handle different screen resolutions in several ways. Where the remote PC is at the higher resolution, the host PC's entire screen fits into a small window on the remote screen. If the remote PC is at the lower resolution, the host's screen will be too big for the remote's screen. The remote then displays one area of the host's screen, and you access the rest by scroll bars, mouse, or arrow keys. Close-Up takes a unique approach, forcing the higher-resolution PC to drop to the resolution level of the other PC. The other programs take approaches that are reasonably similar to each other. ReachOut, pcAnywhere, and CoSession have scroll bars for moving around the host screen; Remotely Possible uses the mouse and arrow keys. Carbon Copy brings up a small box to represent the other screen.

Security

User passwords and a master password for the host PC are good precautions against unauthorized access. User passwords are individual passwords that remote users must enter during the initial connection to the host. The master password limits access to the screen where all the other user passwords are edited. Without a master password, anyone with a user password could open the password table and memorize or change the other individual passwords. All six programs support both user passwords and a master password.

Automatic dial-backs are the next level of protection. A dial-back number is associated with each log-in name and password. When someone logs in, the call is disconnected and the host calls back at the designated callback number. This keeps an unauthorized user with someone else's password from connecting unless the call is made from the legitimate password holder's phone (where the callback is received).

continued

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CoSession is a very strong program in nearly every category. Its speed is quite good, particularly in file transfer and video display tests, two very important performance categories. CoSession's feature set is extensive, and it will operate at a DTE rate of 230.4 Kbps, one of only two tested programs to do so. Some aspects of the program are difficult to learn.

The dial-back feature should not be confused with a roving callback, which will call the remote user at any number. Roving callback is a convenience feature primarily used to reverse long-distance charges incurred during a modem connection. All six programs support automatic dial-backs; Carbon Copy, Close-Up, pcAnywhere, and ReachOut Remote Control support roving callbacks.

Encryption is probably the ultimate level of security. Users worried about phone-line tapping or eavesdropping should choose a program with the ability to encrypt the log-in password upon log-in, or even all the data during the connection. A line tap would be able to intercept only gibberish, because it would not have the encryption key needed to translate the gibberish back into meaningful data. All the programs except pcAnywhere support password encryption. Data encryption is supported by CoSession, ReachOut Remote Control, and Remotely Possible, but because of strict federal regulation of data encryption products, users should arrange with their software dealer to make sure it is included with their purchase.

Remote-Control Choices

Close-Up, with support for more than 600 modems, includes more than three times the drivers of any other program. It provides excellent performance when redisplaying a screen on the remote system, thanks to its built-in Photographic Memory caching. Users will find this especially useful when moving through a multipage document. Usability is hampered by the absence of on-line help throughout most of the program and the lack of icons and windows such as the other programs offer. Close-Up is notable for its ability to work with third-party virus-checking programs.

CoSession is a strong program in nearly every category. Its speed is quite good, particularly in file transfer and video display tests—two important performance categories. CoSession's feature set is extensive, and it will operate at a DTE rate of 230.4 Kbps, one of only two tested programs to do so. It has excellent on-line help, but some aspects of the program are difficult to learn.

No other program matches the all-around excellence of ReachOut Remote Control. It delivers in almost every category, with the fastest overall performance, the highest usability rating, and the most features. Testers unanimously rate it number one in the general usability evaluation. ReachOut also offers a built-in virus checker. With its optimal mix of performance and power, ReachOut should handily meet any remote-control needs. ■

About the Products

Carbon Copy for Windows 2.0
Modem and LAN combined $199
Microcom, Inc.
500 River Ridge Dr.
Norwood, MA 02062
(617) 551-1000
Circle 1078 on Inquiry Card.

Close-Up 6.0
Modem $199
2-user LAN $395
8-user LAN $795
Norton-Lambert Corp.
P.O. Box 4085
Santa Barbara, CA 93140
(805) 964-6767
Circle 1079 on Inquiry Card.

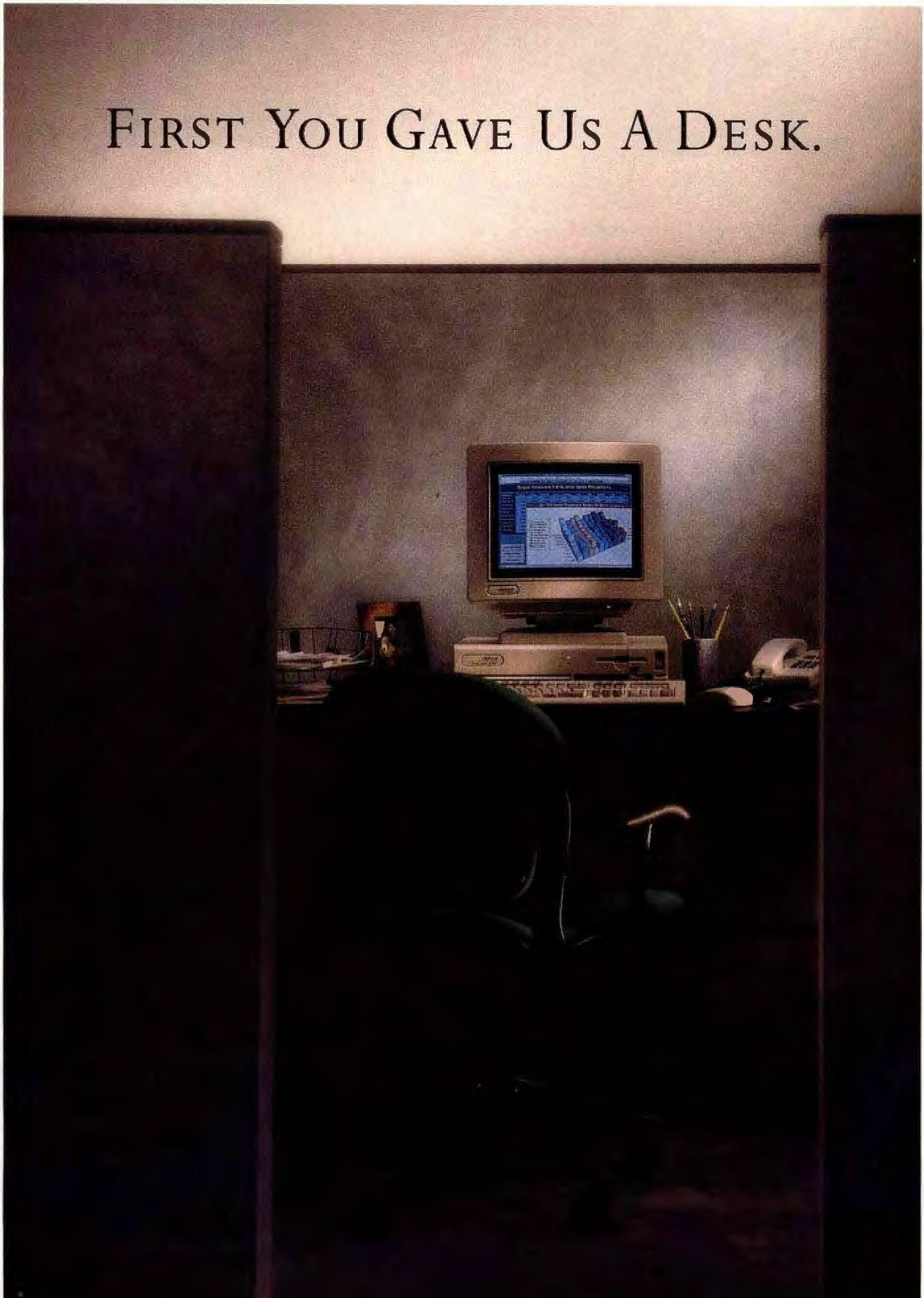
CoSession for Windows 1.0c
Modem $199
LAN (up to 25 workstations) $295
Triton
200 Middlesex Tnpk.
Iselin, NJ 08830
(800) 322-9440
(908) 855-9440
Circle 1080 on Inquiry Card.

Norton pcAnywhere 1.0
Modem and LAN combined $199
Symantec Corp.
10201 Torre Ave.
Cupertino, CA 95014
(408) 253-9600
Circle 1081 on Inquiry Card.

ReachOut Remote Control 4.0
Modem $199
4-user LAN $295
1-user add-on $195
10-user add-on $250
Ocean Isle Software
1201 19th Place
Vero Beach, FL 32960
(407) 770-4777
Circle 1082 on Inquiry Card.

Remotely Possible/Dial 4.0e
Modem $199
LAN (unlimited users at one site) $499
Avalan Technology, Inc.
P.O. Box 6888
116 Hopping Brook Pk.
Holliston, MA 01746
(508) 429-6482
Circle 1083 on Inquiry Card.

This report contains the results of The Software Digest Ratings Report, *a monthly publication from the National Software Testing Laboratories (NSTL). To obtain complete test results and in-depth analysis, contact NSTL (P.O. Box 551, Hightstown, NJ, 08520, (609) 426-7070, fax (609) 426-5434). BYTE and NSTL are operating units of McGraw-Hill, Inc.*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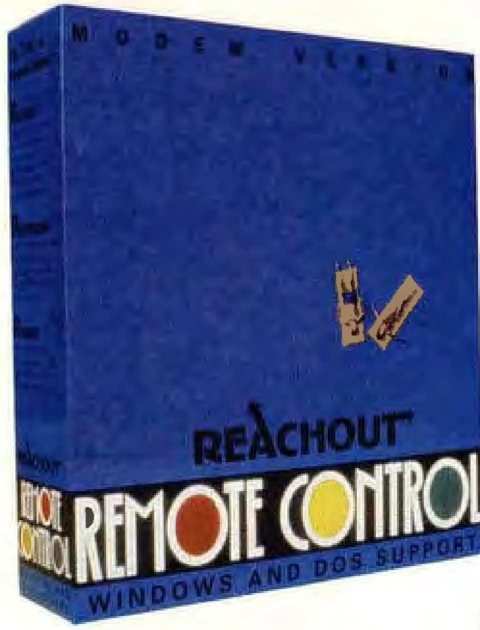

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INFO WORLD

ReachOut has earned three major awards in the past 18 months. The latest being "Product of the Year" for 1994 from LAN Magazine. Which goes to show that ReachOut is one powerful networking tool. InfoWorld proclaimed "ReachOut offers superb screen, mouse, and file transfer speeds and provides as many security options as Sing-Sing. Operation is as smooth as silk." InfoWorld rated ReachOut as #1 and awarded it their Buyer's Assurance Seal. And PC Magazine UK confessed ReachOut "was the only remote control program that worked right out of the box." They named ReachOut The Editor's Choice and called it a top notch value. The new ReachOut Version 4.0 for Windows continues the tradition of excellence with support for all high resolution monitors up to 1280 by 1280 with 256 colors. What's more, it makes no modifications to the Windows initialization files. And speed is as much as 40% faster than the version InfoWorld had reviewed.

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Circle 284 on Inquiry Card (RESELLERS: 285)

Big, Fast IDE Drives

The first high-capacity IDE drives show a lot of promise, particularly if you have a local-bus system that supports them well

DAVID ESSEX

The new generation of fast IDE drives with larger capacities is a good match for fast local-bus systems. Counterclockwise from left are the 1-GB Micropolis Taurus 4110A, the 1-GB IBM 0662 Model A10, the 540-MB Seagate ST5660A, the Western Digital Caviar AC2540, the 728-MB IBM DSAA-3720, and the 540-MB Quantum ProDrive LPS 540AT. Not included in the photo are Seagate's 1-GB ST31220A Medalist 1080 and Western Digital's 1-GB Caviar AC31000.

The need for fast, high-capacity hard drives has recently challenged the well-established popularity of the ATA (AT Attachment) interface used with IDE drives. The low cost and relative technical simplicity of IDE drives are little help when the data-storage requirements of workstations and multimedia machines push against a BIOS- and DOS-imposed 528-MB capacity limit. Further, on local-bus systems, ATA's 2- to 3-MBps data-throughput rate is no match for the nominal 5- to 20-MBps rates of the SCSI bus, putting IDE at a speed disadvantage in multimedia environments.

To meet this challenge, last year hardware and system software makers began updating the ATA standard—pushed somewhat by an Enhanced IDE standard proposed by Western Digital (see "IDE Takes Off," March BYTE). Parts of Western Digital's proposal relating to increased capacity (well beyond 528 MB) and higher ATA bus throughput were adapted by the SFF (Small Form Factor Committee), an ad hoc industry group. The resulting SFF proposal is now in the hands of ANSI, where it could pick up other enhancements, such as CD-ROM support, on its way to becoming known as the ATA-2 standard.

A few (540-MB) drives began implementing the SFF guidelines last year. This past spring and summer, larger, faster drives arrived, and they are the subject of this roundup. All offer burst data transfer rates over the ATA interface of at least 11.1 MBps. The performance story remains more complicated, however, as the data density of magnetic media, spin rates, and efficiency of read/write head movement continue to play major roles. The point is well illustrated by the varying throughput and seek speeds exhibited by the reviewed drives, which range in size from 540 MB to 1.08 GB.

In the Channel

The eight IDE drives reviewed here are representative of hard drive manufacturers' latest efforts to bring drive electronics up to speed with local-bus systems and improvements in the mechanical aspects of drive architecture. Standard ATA data transfers going over the typical ISA bus are limited to a bandwidth that cannot handle the faster stream of bits created by newer drives. Growing ever smaller, these drives have more densely packed platters with drive heads that are themselves getting smaller, lighter, and quicker, both mechanically and electronically. Even when matched with higher-throughput local-bus computers, IDE drives could not match SCSI rates, because the CPU's standard way of controlling throughput (called *Processor I/O*, or *PIO*) did not let it recognize when 100 percent of the shared local bus's bandwidth was available for data transfers.

The solution to faster PIO, implemented on all the reviewed drives, is called *flow control using IORDY* (the I/O Channel Ready line on the ATA bus). Flow control lets the drive electronics regulate the CPU's data transfer functions so the drive can reliably communicate with the bus at higher speeds. The SFF has standardized new ATA timings using flow control (called *PIO Mode 3*) at 180 nanoseconds per cycle. The result, in theory, is maximum internal transfer rates, or burst rates, of up to 11.1 MBps. That translates into at least a doubling of effective data transfer rates, a result more or less borne out by the BYTE benchmark tests. I measured sustained buffer-to-host rates as high as 7 MBps.

An alternative method, Fast Multiword DMA, uses the computer's DMA controller instead of the CPU to handle data transfers between the drive and system memory. SFF defines Mode 1 DMA transfers to allow burst rates of up to 13.3 MBps, roughly equivalent to PIO Mode 3. (A new PIO Mode 4 offers burst rates of up to 16.6 MBps and shows up here only on the 1-GB IBM 0662 Model A10 and Seagate ST31220A, although systems weren't available at review time to support or test these rates.)

Faster throughput was not the only IDE improvement I hoped to observe in the tested drives. The SFF proposal provides two translation schemes that let DOS-based systems break the 528-MB barrier. The first, CHS, involves a simple translation between the slightly incongruous cylinder-head-sector parameters in the system BIOS and those in the drive firmware.

The second scheme, LBA (logical block address), translates the CHS information into a 28-bit address that can be used by the operating system, device driver, and drive interface. All the reviewed drives support the more advanced LBA standard, but they use the simpler CHS in older systems with BIOS code that doesn't support LBA. Many newer systems also support only CHS, because it's more difficult to modify a BIOS to support LBA. The CHS scheme has an upper capacity limit of 8.4 GB—enough for now.

Small size and energy efficiency are two more benefits common to these drives.

continued

Drive Performance Results

Tests were done on a Compaq Deskpro XE 450 with a 50-MHz 486DX2 CPU and built-in local-bus IDE support. For all tests except the QBench Data Access Time, longer bars are better. The NSTL PLATT results are given as a geometric mean of weighted, indexed raw results.

Results from three different hard drive tests show a fairly consistent performance picture, with slight jostling of relative positions between tests. Bigger drives generally do better because they use the latest technology.

None is more than 1 inch high; Seagate's 540-MB ST5660A is only 0.75 inch high (it's also smaller than the others in length and width). These reduced dimensions will allow computer manufacturers to continue downsizing system boxes. In addition, the drives all boast low wattages, helping to meet federal government procurement requirements specified in the Environmental Protection Agency's Energy Star program.

Drive Testing

I used two PC systems to test the hard drives: a Compaq Deskpro XE 450 (50-MHz 486DX2) and a Zeos Pantera (60-MHz Pentium). Each system provided a built-in local-bus IDE connection and a BIOS that supports IDE drives larger than 528 MB. The Compaq was a year-old ISA system with a 170-MB Conner IDE drive; the Zeos was a more recent PCI (Peripheral Component Interconnect) design with a 425-MB Western Digital IDE drive. In both systems, the host drive was configured as an IDE master and the test drives as slaves, using the appropriate drive jumpers if necessary.

I used three tests: the file I/O parts of BYTE's low-level DOS benchmark, Quantum's QBench 1.30, and NSTL's PLATT (Page Level Availability Time Test) (see "Lab Report: 32 High-Speed Hard Drives," September 1993 BYTE). Each test takes its own read on the complexities of drive performance.

The BYTE file I/O test measures read and write I/O from the DOS file level. QBench works at the BIOS level, measuring sequential and random reads and writes. It produces a weighted average of access times and data transfer rates based on profiled DOS applications (65 percent sequential I/O, 35 percent random; 60 percent read, 40 percent write).

The NSTL PLATT benchmark is based on a profile of hard drive activity measured from Windows business applications running with Microsoft's SMARTDRV caching program. The access-time results from 12 tests, a mix of random and sequential read and write operations, are weighted and averaged according to the Windows profile. One part of the PLATT allows calculation of sequential throughput (dividing the 16-KB block size by the returned access time in milliseconds).

The age difference between the two test systems influenced drive installation and performance. While the Compaq automatically worked with the two Western Digital drives and the 1-GB Seagate, it required utility software such as OnTrack's Disk Manager (provided with many of the drives) to recognize the other drives, and it wouldn't work with the 540-MB Seagate unit unless set for 528 MB. The BIOS in the newer Zeos system recognized and worked with all tested drives, automatically configuring to their maximum capacity through a setup menu selection.

The Zeos, with its more sophisticated IDE controller, got much higher throughput rates in many of the tests, showing that the system can be a bottleneck with new, faster drives. Testing the five biggest drives on both systems showed that the 1-GB IBM 0662 Model A10 picked up the greatest throughput benefit from the faster system; the Micropolis Taurus 4110A, the 728-MB IBM DSAA-3720, and the Western Digital Caviar AC31000 showed intermediate gains. The 1-GB Seagate drive made smaller but still substantial throughput gains. The fastest measured throughput, 7 MBps, came from the 1-GB IBM drive on a PLATT sequential-read test that pulls most of its data from the drive's built-in buffer. The test system's ATA bus speed had no effect on access-time tests.

IBM DSAA-3720 and 0662 Model A10

Although the two IBM drives differ from each other substantially, both employ the magnetoresistive head technology invented by IBM. Magnetoresistive read and write heads require fewer copper coils and material layers than standard thin-film heads. The benefit, according to IBM, is smaller, simpler heads that allow higher data density and better durability. Both IBM drives also employ digital read channel electronics that allow reliable reading of more densely packed data (see "Digital Hard Drives," March BYTE).

These two IBM drives do, in fact, have some of the highest track density of the group (as high as 4300 tracks per inch for the 728-MB DSAA-3720), and the 1-GB 0622 claims a top-rated MTBF (mean time before failure) rating of 500,000 hours.

The 1-GB IBM drive's smaller, more efficient heads and higher data density do not seem to give it any overall performance advantage over the 1-GB Micropolis Taurus, however. The Micropolis makes up in access time what it loses in data transfer rate. In the file I/O test, the Micropolis drive bested the field and exceeded the 1-GB IBM unit's speeds by 3 percent to 13 percent. The IBM drive fared better in the NSTL PLATT benchmark, where its higher throughput slightly edged out the Micropolis drive's quicker access times.

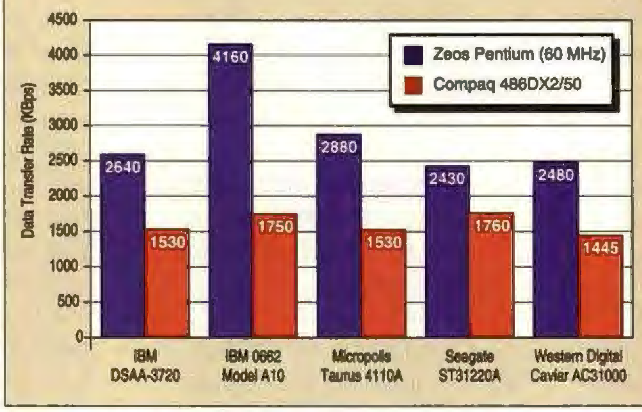
The IBM unit did slow down in the PLATT sequential test that accesses four areas of the drive simultaneously (an

indication of server capability), but it was still as fast as or faster than any other drive but the Micropolis Taurus in this test. Both 1-GB drives have a large (512-KB) buffer, so differences in caching algorithms are the most likely reason for the IBM drive's performance drop-off.

IBM's 728-MB DSAA-3720 has the smallest cache in the group (96 KB), and, at 4500 rpm, its rotation is slower than the 1-GB drives'. But it compares favorably to the 1-GB IBM drive for multimedia uses, because it doesn't have to perform TCAL (thermal recalibration), a periodic compensation for heat-induced mechanical changes that can translate into lost video frames. (Some of the other reviewed drives don't need to do TCAL, either.) IBM says it's preparing a workaround to mitigate TCAL's effects on the 1-GB drive.

The small cache may be one reason why the 728-MB drive has lower throughput than two of the smaller (540-MB) drives when, theoretically, its higher track and areal density would let it pump bits faster. In the file I/O tests, the 728-MB IBM drive generally falls slightly behind the 540-MB Quantum and Seagate units, although it passes two 1-GB drives on the Pentium QBench test.

On a Faster System



Running on a 60-MHz Zeos Pentium system with a more sophisticated IDE interface than the 50-MHz Compaq 486 Deskpro had, several of the drives improved markedly in throughput results, as shown here by the QBench test. The 1-GB IBM and Micropolis drives showed the strongest benefit.

Micropolis Taurus 4110A

As noted above, the 1-GB Micropolis Taurus performs slightly better than the 1-GB IBM drive even though it lacks the data density advantages of magnetoresistive technology. It avoids some of the downside of high capacity by employing five platters. It thus has two more than the three-disk IBM drive, giving it an edge when performing nonsequential seeks on large files (measured by the Short Seek and Long Seek tests in the PLATT benchmark).

The Micropolis can confine such files to a narrower range of cylinders (tracks that are the same general distance from the drive spindle) because the extra disks allow more capacity per cylinder. In other words, the more stacked up the cylinders, the shorter the distances the read/write heads must move when randomly accessing in a file.

Both IBM and Micropolis state that the 1-GB drives' 5400-rpm rotational speeds reduce latency time (the time it takes for the requested block to pass under the head once the head has arrived at the correct track) to 5.56 milliseconds. This is an easily proved mathematical verity and, coupled with the low average seek time (8.5 ms) claimed for both drives, should lead to quick data access. In those tests measuring random-access times in the Windows-oriented PLATT benchmark, the two drives did better than all the others, with the Micropolis generally faster than the IBM. In the DOS-oriented QBench test, however, the two Western Digital drives were fastest in data-access-time tests.

Using more disks contributes to the Micropolis's high $739 street price, but then Micropolis offers an industry-leading five-year warranty. (IBM offers a five-year warranty on its 1-GB IDE drive but not on the 728-MB unit.) Those looking to push the capacity limits of the IDE interface ought to seriously consider this drive.

Quantum ProDrive LPS 540AT

While the ProDrive LPS 540AT is larger than 528 MB and supports fast local-bus transfer modes, it won't be Quantum's fastest or largest IDE drive by the time you read this. Quantum's new 540-MB Lightning drive should be faster, and a 730-MB version of the Lightning will be larger. While relatively slow in the group reviewed here, the ProDrive LPS 540AT is still a fast drive with an attractive price. The drive supports PIO Mode 3 and Fast Multiword DMA, so the ATA interface throughput can potentially match the drive.

However, in both the access-time measures important for random file I/O and the throughput measures important for sequential file I/O, the drive placed well back

IDE HARD DRIVE FEATURES

Specs like these can give a good picture of a drive's capabilities, although they do not take into account one important attribute: the effectiveness of the caching algorithms for the drive's built-in cache. Larger drives get the best technology—for example, the higher (5400-rpm) spin rates for the 1-GB IBM and Micropolis drives. They also have higher MTBF ratings and the longest warranties.

DRIVE	CAPACITY (MB)	DISKS	NO. OF HEADS/ RECORDING SURFACES	SPIN RATE (RPM)	AVERAGE LATENCY (MS)	SEEK TIMES (MINIMUM/ AVERAGE/MAXIMUM; MS)*	CACHE/ BUFFER SIZE (KB)	TRACK DENSITY (TPI)
IBM DSAA-3720	728	2	4/4	4500	6.67	4/12/25	96	4300
IBM 0662 Model A10	1052	3	6/5	5400	5.56	0.6-2.5/8.5-10.1/16.5-18	512	4077
Micropolis Taurus 4110A	1057	5	10/9	5400	5.56	1.5/8.5/20	512	2756
Quantum ProDrive LPS 540AT	541	2	4/4	4500	6.67	4/12/23	128	2875
Seagate ST5660A	546	2	4/4	4500	6.67	3.5/12/30	256	3309
Seagate ST31220A Medalist 1080	1083	3	6/6	4500	6.67	3.5/12/25	256	4250
Western Digital Caviar AC2540	541	2	4/4	4500	6.67	4/11-13/25	128	3300
Western Digital Caviar AC31000	1084	3	6/6	4495	6.67	4/10-12/23	128	4000

*Track-to-track, including settling time; hyphen separates read and write values where necessary in the pack (though rarely last). Among the three 540-MB drives reviewed here, it placed second in sequential-access tests, behind the Seagate ST5660A. The ProDrive fared best in several of the simpler PLATT sequential tests, indicating that it may be a better drive for Windows than DOS, since that test is modeled on the use of hard drives in a Windows environment.

Two factors may have depressed the throughput results. Like the Western Digital drives, the Quantum ProDrive has a fairly small (128-KB) cache/buffer. And at 2875 tpi, it has the second-lowest track density of the group (the Micropolis Taurus 4110A has the lowest).

One final note: Quantum, like Western Digital and Micropolis, ships its drive with a specially licensed copy of OnTrack Computer Systems' Disk Manager to perform the CHS translation needed to get above the 528-MB DOS/BIOS barrier on systems with older BIOS code.

Seagate ST5660A and ST31220A

Seagate's mid-capacity entry has little that overtly differentiates it from the other 540-MB drives. When tested, however, the ST5660A showed seek and throughput speeds that put it not only at the top of the 540-MB group but in range of the 1-GB drives. For example, in the file I/O read test, the ST5660A's 559.4 KBps placed it fourth overall, behind three 1-GB drives. In the PLATT benchmarks, it jumped toward the top in the sequential tests.

Note that the Seagate was the only drive I couldn't configure for more than 528 MB on the Compaq test system. The Compaq's BIOS didn't automatically recognize it, and Seagate has no plans to offer its own or a third-party driver. That shouldn't be a

RATED MTBF (POWER-ON HOURS)	WARRANTY (YEARS)	PRICE
300,000	2	$435 (list)
500,000	5	$730 (list)
500,000	5	$739 (street)
300,000	2	$389 (street)
300,000	2	$379 (street)
300,000	3	$689 (street)
250,000	3	$349 (street)
250,000	3	$679 (street)

About the Companies

IBM Storage Systems Division
(DSAA-3720; 0622 Model A10)
Dept. 2W4
Rte. 100, P.O. Box 100
Somers, NY 10589
(800) 426-7299
fax: (800) 426-3395
Circle 1084 on Inquiry Card.

Micropolis
(Taurus 4110A)
21211 Nordhoff St.
Chatsworth, CA 91311
(800) 395-3748
(818) 709-3300
fax: (818) 709-3396
Circle 1085 on Inquiry Card.

Quantum Corp.
(ProDrive LPS 540AT)
500 McCarthy Blvd.
Milpitas, CA 95035
(800) 624-5545
(408) 894-4000
fax: (408) 894-3205
Circle 1086 on Inquiry Card.

Seagate Technology
(ST5660A; ST31220A Medalist 1080)
920 Disc Dr.
Scotts Valley, CA 95066
(408) 438-6550
fax: (408) 438-7852
Circle 1087 on Inquiry Card.

Western Digital Corp.
(Caviar AC2540; Caviar AC31000)
8105 Irvine Center Dr.
Irvine, CA 92718
(800) 832-4778
(714) 932-5000
fax: (714) 932-6498
Circle 1088 on Inquiry Card.

problem later on in the year, as the Phoenix BIOS, AMI's latest BIOS, and others designed to handle higher IDE capacities and LBA translation become more widely available. However, if you own an older system, you may not be able to access the ST5660A's top 12 MB without a utility like OnTrack Disk Manager.

The Compaq had no trouble with Seagate's 1-GB ST31220A Medalist 1080. Formatting nicely at over 1079 MB, the Medalist performed competitively with the 1-GB IBM and Micropolis drives on the Compaq, running neck-and-neck with Seagate's smaller 528-MB unit. Both Seagate drives did well on sequential tests, but not as well with random I/O. Read results were consistently behind writes for both Seagates (they use the same caching algorithms). On the Zeos Pentium system, the 1-GB Seagate fell significantly behind other 1-GB drives on throughput tests.

Western Digital Caviar AC2540 and AC31000
Although Western Digital, champion of the Enhanced IDE movement, has endowed its Caviar IDE drives with all the right high-speed protocol support—Mode 3 PIO and Mode 1 DMA—its efforts do not seem to have brought superior performance. The drives are fast, but not as fast as the others I tested. The 540-MB AC2540 and 1-GB AC31000 provided similar results in most tests, with the larger, newer drive coming out a bit ahead.

The Western Digital drives placed last or next-to-last in most throughput tests. For example, the AC2540's 495-KBps result placed it last in the file I/O read test. In the PLATT benchmark, the Western Digital drives placed in the slower group with the 540-MB Quantum and 728-MB IBM drives. QBench results were mixed: slowest in transfer time but fastest in access time. The QBench access-time result derives from both sequential and random operations, so the built-in cache helps out. The PLATT benchmark's seek tests, where the Caviars didn't do as well, are based on random I/O and more reflect the drives' mechanical abilities.

But keep performance in perspective. The Western Digital drives offer capacities and seek times that would have been unheard of in an IDE drive two years ago. If you have an older ISA system that you're upgrading for increased capacity, look at Western Digital's pricing, because you aren't likely to see great performance differences between drives without local bus.

With capacities over 1 GB and support for local-bus transfer rates, new IDE drives remain your best bet for desktop systems, where lower drive-interface overhead gives them a speed advantage over comparable SCSI drives. SCSI shines only in multitasking, multidrive situations and can provide multigigabyte capacities. Drive utility programs like OnTrack's let you use these drives on just about any system with IDE connectors, but newer systems that automatically recognize large capacities and provide local-bus throughput are where they belong. ■

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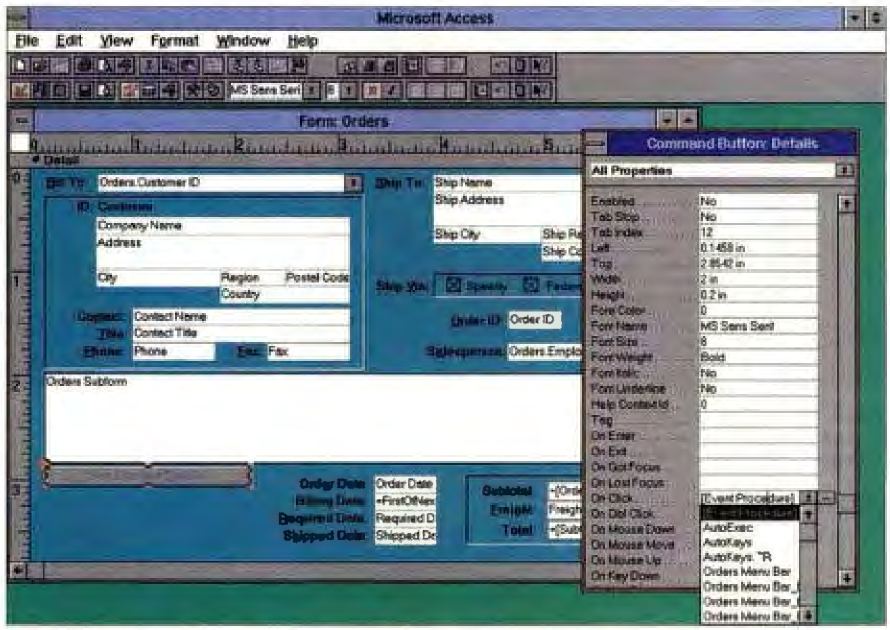
Access 2.0: The Best of Both Worlds?

With ease-of-use features and enhanced development tools, Microsoft's database manager aims at dabblers and developers

JIM CARLS

It's the holy grail of database vendors: building a database manager with the ease of use of a flat-file database and the power to satisfy demanding developers. Microsoft reached for this elusive goal with the initial release of Access and hopes to close in on it with Access 2.0. The new features and capabilities in 2.0 aim at the low-end user with ease-of-use improvements and at the database developer with enhanced connectivity and programming options. But the package can be intimidating and may leave the low end behind.



Access 2.0 is an object-oriented RDBMS. Objects in Access include data tables, reports, screen forms, controls such as input fields and buttons, and other elements. A property is a characteristic of an object and can range from input masks to validation rules to "what-happens-when" instructions for specific events (e.g., a mouse-click). The screen shows the properties assigned to the See Product Details button. The On Click option of the Properties window lists actions that can take place when the user clicks on the button. In this case, the mouse-click triggers an event procedure (a block of code). Clicking on the ellipsis next to the Event Procedure label brings up the snippet of code to be executed.

Objects Through Windows

Access 2.0, like 1.x, is an object-oriented RDBMS (relational database management system). Users new to this approach to data management will find a major difference between products like Access and traditional command-driven DBMSes: Instead of wrestling with a long list of commands and control statements whose behavior may be less than obvious, you wrestle with long lists of object properties whose meanings may be even less obvious.

An *object* is any item in the system that you can manipulate as a unit. Objects in Access include data tables, reports, screen forms, and controls such as input fields and buttons. A *property* is a characteristic of an object and can range from input masks to validation rules to "what-happens-when" instructions for specific events (e.g., a mouse-click). The properties available to the user for some objects can be alarmingly long. Still, object orientation can be such a superior way of organizing desirable programmed behaviors that it is well worth the effort to push yourself up and over the required learning curve.

Access also takes the Windows interface about as far as it can go: OLE 2.0, right-click menus, hover help, cue cards, and a host of wizards. And you can copy and paste objects (e.g., an entire table) as easily as you can manipulate highlighted rows and columns.

New and Improved

The previous version of Access was an accomplished data manager, but it could try the patience of anyone used to the kind of blazing speed you get with DOS-based databases. There were also some features of a finished database application that should have been easier to implement.

The new features in this version are extensive. Besides the additions covered in "A Few New Features in Access 2.0" on page 160, three other new features deserve notice. The first is the program's more comprehensive set of wizards. It is the function of a wizard to answer the question, "What on earth do I do with all these properties?" These programmed helpers can make a big difference in the ease and speed with which you set up the pieces (i.e., objects) in an application.

The next feature of note is the Solutions database. This bundled sample is a finished application as well as a storehouse of how-to information, including code samples, that help you climb the learning curve. I wish the Solutions database had been available when I was struggling with version 1. Finally, the Rushmore query-optimization technology purchased with the Foxpro acquisition may seriously cramp your coffee breaks.

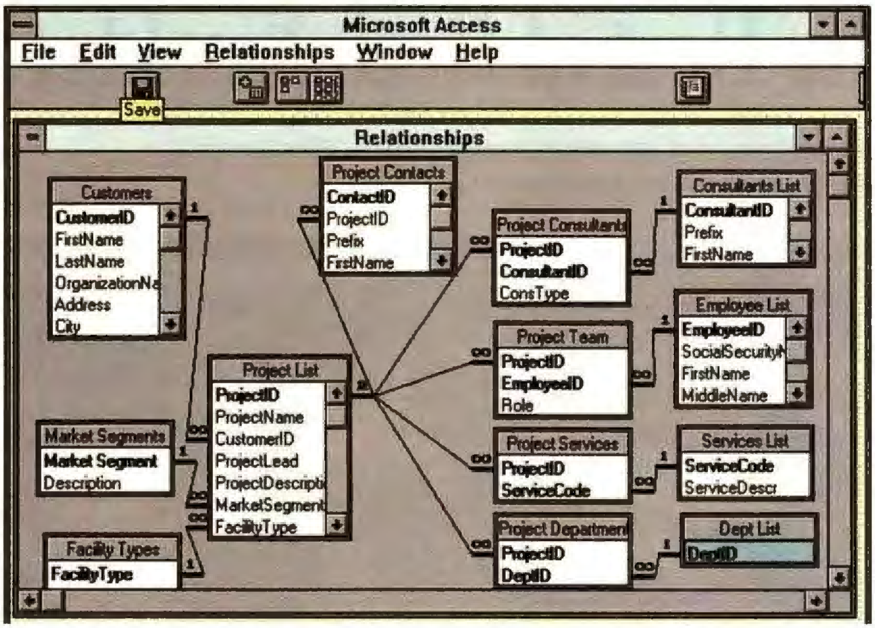
Space for Your Stuff

A full installation of the new version requires 22.4 MB of disk space. After including the space needed for Windows swap files and such, I squandered 2 hours on a search-and-compress mission to get the 30 MB I ultimately needed.

Space requirements are compounded for advanced 1.x users who have live applications. Changes and additions in the new version make it prudent to keep the old version alive until your applications prove themselves ready for 2.0. Even more prudent (don't say I didn't warn you) would be to read any readme files on Disk 1 before you install the new version. Tables created under previous versions will automatically convert to 2.0 format when you open the MDB file, but all other major objects must be opened and saved. This can be tedious for a complex application.

continued

Reviews Access 2.0: The Best of Both Worlds?



Access 2.0's new Relations Window makes it easy to define and edit relationships between tables. Notice that primary and foreign keys are easily visible. When defining relationships, you can specify whether to enforce referential integrity and whether to allow cascading updates or deletes.

A Sample Application

To get a feel for the new version, I created a project-oriented marketing database that might be used by any professional services firm, such as architects, engineers, or data-processing consultants. Many large professional firms must continually produce marketing aids, proposals, and government forms that present the firm's experience in a variety of ways, including cross-tabulated résumés for staff members. Since proposals are often custom-tailored to fit the job being sought, updating and collating this information can be tedious. I set out to create the basic table structure, input forms, and two reports: one for project information and another for a staff résumé.

The initial design for the system required 13 tables, organized around a list of Projects. Two categories of tables were needed. The first would include resource tables, such as lists of employees, regular consultants used by the firm, "approved" code lists, and so on. The second category of tables would define the intermediate relationships between the individual projects and the resource lists.

You can create tables manually or with a wizard. I discovered that the new Table wizard is most efficient if you've already created those tables that the wizard cannot. In my sample application, these would be the intermediate tables, which would consist of only two fields, both being primary keys of other tables. For example, the list of employees who had produced particular projects would be defined in a table called Project Team. I created this table manually with two fields, ProjectID and EmployeeID, which together would create unique keys. Creating the compound key was easy; I just highlighted both fields and clicked the Key icon on the toolbar.

As you work with each table field, a list of applicable properties (e.g., formatting and validation rules) appears below it. An important aspect of designing a table is to finalize, as much as possible, the properties for each field before creating queries and forms. Since the properties you include in the table design are inherited by the queries, forms, and reports based on them, this can save time. Although you can override these properties in other objects, it is more efficient to specify what you want at the table level.

To define the Project table and resource lists, I used the Table wizard. This function works best as a library of predefined tables. The Table wizard ships with over 50 sample tables. A library of tables helps enforce field-naming conventions from one development project to another, so macros and modules developed in one project are more easily usable in a new one. You can customize the default table list with your own; I recommend this, as some of the default fields are too generic.

The Table wizard also helps you define relationships between tables. You can choose an existing table, and Access will create the relationship to the new table, even adding a linking field if necessary.

You can define and edit relationships with the new graphical Relationships window, using point, drag, and click operations. When defining relationships, you specify whether to enforce referential integrity (preventing the entry of nonexistent foreign keys) and whether to allow cascading updates or deletes (where a change to the "one" of a one-to-many relationship also changes the "many"). One warning: The window can show either all relationships or only direct ones. I wasted an hour trying to change the original CustomerID field type, a modification the system refused to allow because the Customer table was "involved in one or more relationships." I was beginning to believe that the relationship was a bit too clandestine until I realized that I wasn't displaying "all" relationships.

Creating Forms

The heart of any database application is its interface, defined by its screen forms. Using the Forms wizard, it is fairly simple to set up basic forms from the four available types—Single Column, Tabular, Graph, and Main/Subform—and in one of five styles. Also, a new AutoForm form type creates best-guess forms based on the table or query selected. In addition to data-editing forms, you can build forms that use Access's rich macro capabilities to organize your application and control processing, eliminating much of the coding this normally requires.

My Marketing database makes heavy use of subforms within the main project form. These handle the data for project consultants, teams—anything with a one-to-many relationship. Data entry for subforms generally depends on first entering a valid ID from a related resource list (e.g., to enter a Project Team member, you enter a valid EmployeeID from the Employees table). This means that the subform will typically use either a list or combo box for data entry of the key field. Unfortunately, the Forms wizard does not set this up for you; there is a Control wizard for these types of controls. Using it, you can quickly set up one of these for your key field, but you will have to delete the original field, add the new control, and then make sure to edit the Tab Order to restore the original field sequence.

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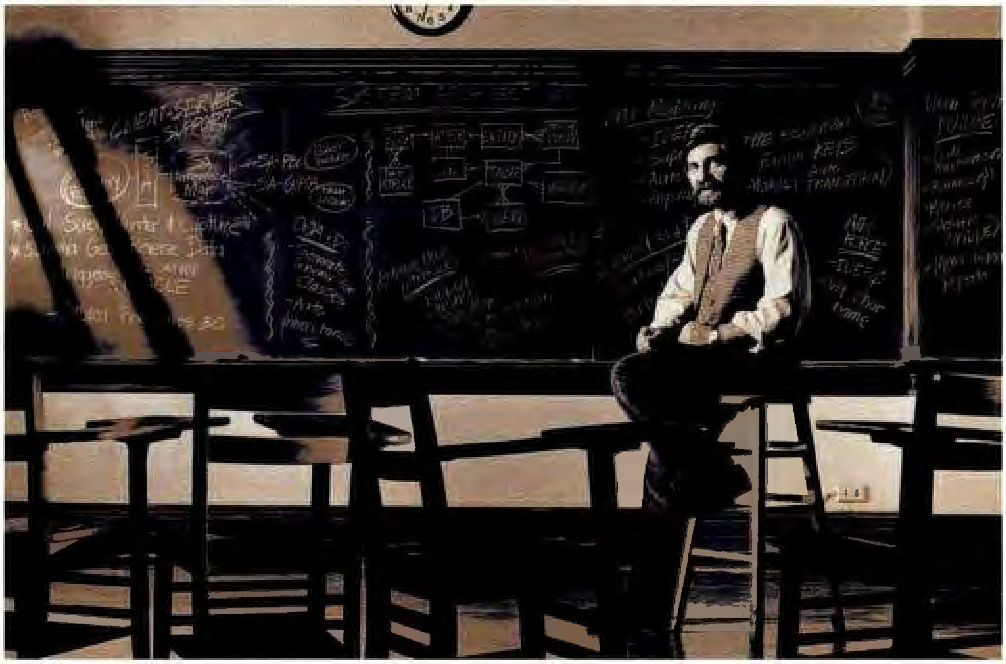

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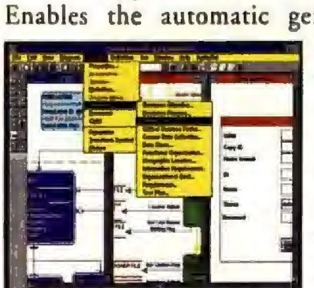

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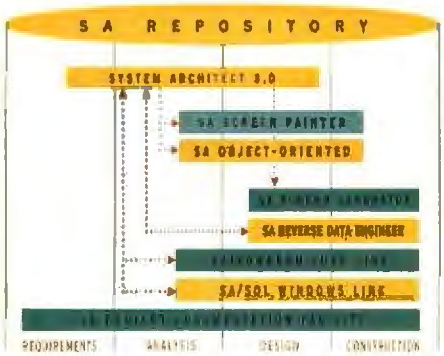

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A Few New Features in Access 2.0

Graphical relationships	Visually design the database and define table relationships
Expression Builder	Point and click from a list of common expression elements to quickly build complex expressions
AutoForm/AutoReport	Generate forms and reports automatically based on a table or query
OLE automation	Build a custom environment with Access objects and with objects exposed by other compliant applications
Cascading updates and deletes	Design unlimited levels of cascading updates and deletes to maintain consistency and integrity of data at the table and query level
Input masks	Apply input masks to automatically add formatting or insert special characters into each field or record.
New SQL features	Pass SQL statements directly to ODBC databases and create Union queries and queries that create, change, or delete objects in attached SQL tables.

Project Team, the person must already exist in the Employee List. Most well-designed databases let the user add a new record on the fly when the system detects a nonexistent foreign key. I was surprised to find that this is not possible in Access without some programming. Fortunately, the Solutions database includes a detailed explanation of how to do this (including sample code that you can copy).

Printing forms is only satisfactory, especially if you optimize the screen readability with specific color schemes. When installing a new application, you'll often need a data verification report that mimics the input screen, especially for complex tables. Although you can drop a form into a new report design, the result may be less than readable without further work.

Queries and Reports

Access has a healthy set of querying tools, including a new Query wizard that aids in creating some of the more complex types of queries, such as cross-tab queries and queries to find nonmatching records in a second table. Since most forms and reports are based on queries, this is an important feature. One major drawback of the previous version was the inability to export the results of a query to other data formats. Version 2.0 corrects this.

Access's reporting features are similar to the process of creating forms, both in concept and application—from using the Report wizards to the ability to drag an existing report from the report list and drop it into a report definition as a subreport.

Worthy Effort

Powerful? Certainly. Easy to use? Well.... The experience required to take full advantage of this powerful program depends not on the program's design but on the demands of complex data-processing systems. Access cannot design your database for you. Nor can it greatly reduce the tweaking needed for a maturing application as users begin to call for variations on the processing themes they see.

For professional developers, the range of object properties available means the end of a great deal of coding. For the average user, Access shortens the time that needs to be spent setting up a productive database and reduces some of the experience needed. But Access does not fill the niche for flat-file managers at the low end. For anyone with major data management needs who has the time or resources to implement it, this program can pay back the investment handsomely. ■

Jim Carls is a consultant and freelance writer in Memphis, Tennessee. He has over 14 years' experience in system design and user training. He provides custom software, training, and technical assistance to corporate clients, primarily in xBase languages such as Clipper. You can reach him on the Internet or BIX at editors@ bix.com.

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77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
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Inquiry Numbers 247–433

247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263
264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
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Inquiry Numbers 434–620

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Inquiry Numbers 621–807

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Inquiry Numbers 808–994

808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824
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Inquiry Numbers 995–1159

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Inquiry Numbers 1160–1324

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Inquiry Numbers 1325–1489

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SparcStation Overhaul

The new SparcStation 5 is a competitive low-cost workstation. The SparcStation 20 presents a more complex picture.

ERIC GARLAND

The SparcStation 5 (left) starts at $3995. The SparcStation 20M (right) starts at $14,590 and can run up to four SuperSparc processors.

In March, Sun Microsystems revamped its line of SPARC processor–based Unix workstations. Two new series are the multiprocessor-capable SparcStation 20 series, a redesign of the SparcStation 10 series that it replaces, and the SparcStation 5 series, low-priced workstations based on Sun's new MicroSparc II processor. The new SparcStation 20 series includes models geared toward multimedia and accelerated 2-D and 3-D graphics. Sun has discontinued the SparcStation 10 and lowered the price of its low-end model, the SparcClassic. Prices now range from $2995 for a no-frills SparcClassic to $29,995 or more for a four-processor model of the SparcStation 20.

The new SparcStations represent significant speed increases over previous models, but the workstation market is competitive. Hewlett-Packard's PA-RISC line and Silicon Graphics' Mips-based computers have tested faster than Sun's machines and are cutting into Sun's sales. Still, Sun held nearly half the workstation market last year, and many people will find the new systems of interest: There's something to be said for reliability and a large base of applications. With the SparcStation 20, you can also increase performance with multiple processors. In this review, I look at one of Sun's new high-end SparcStation 20 models and the more cost-effective SparcStation 5.

New SparcStations

Sun offers the SparcStation 20 with up to four 50-MHz or two 60-MHz SuperSparc processors (see the text box "Dual SuperSparcs"). The base system comes with one processor, a 535-MB hard drive, a 17-inch color monitor, and 32 MB of RAM for $12,195. You get your choice of 8-bit 2-D/3-D wireframe graphics or 24-bit accelerated graphics and imaging. I tested a SparcStation 20M, a model geared toward multimedia; it has the same components as other SparcStation 20 models but adds videoconferencing capabilities. The review unit arrived with a single 50-MHz chip. The $18,843 test configuration also included two 535-MB hard drives, 64 MB of RAM, 1 MB of RAM cache, and a 20-inch 1280- by 1024-pixel color monitor.

All SparcStation 20 models come with a microphone and 16-bit audio. The 20M adds accelerated video playback, video capture and compression, a video camera, videoconferencing software, and Photo CD support. The standard built-in networking combined with video and audio features makes the SparcStation 20M a prime platform for desktop videoconferencing. With the exception of the videoconferencing software, however, the package doesn't provide utilities or tools to take full advantage of the computer's multimedia potential.

The high-quality 20-inch monitor provides a very stable, readable image. A wireless remote control makes it easy to make all screen adjustments while staying a comfortable distance from the monitor—very elegant.

The SparcStation 5 base model was designed to be inexpensive. For the $3995 base price, you get a 535-MB hard drive, a 15-inch color monitor, and 16 MB of RAM. The $7745 SparcStation 5 I tested came with 32 MB of RAM, a 17-inch Sony monitor, and hardware and software for videoconferencing. The system I tested had a 70-MHz MicroSparc II processor. Higher-end models based on an 85-MHz MicroSparc II start at $9595 with 32 MB of RAM, a 17-inch color monitor, and 1 GB of hard drive storage.

Both new SparcStations come in the same well-designed case, and you can turn a SparcStation 5 into a SparcStation 20 with a simple motherboard swap. The SparcStation 20 system board has four 32-bit SBus expansion slots (two were free in the test machine) and two 64-bit MBus slots to hold SuperSparc processor cards. Each card can hold one or two processors. Using 64-MB SIMMs, you can put up to 512 MB of memory on the motherboard. The SparcStation 5 motherboard provides three SBus expansion slots and eight SIMM slots, each of which can hold up to 32 MB, for a maximum of 256 MB.

For either SparcStation, you open the case by removing two screws from the back, one of which is the grounding screw. This spring-loaded screw is held in place so that you can't lose it. When you attach a locking cable to the case, it blocks removal of the other screw, preventing access to the inside of the machine.

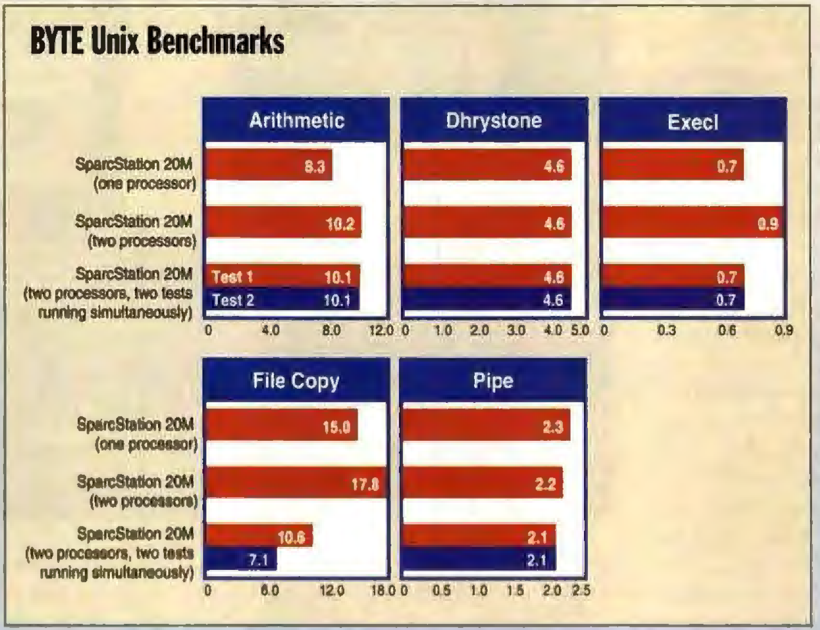
continued

Dual SuperSparcs

Sun tests show that a second SuperSparc processor improves performance by 20 percent to 40 percent for most existing Solaris 2.3 applications. Once available, programs tuned for multiple processors will do even better. Sun points out that you don't have to see a performance doubling to justify a second processor: If the percentage performance increase for your applications is more than the percentage price increase for the additional CPUs, you come out ahead. If you order your system with two processors on one CPU board, the additional cost for the second CPU is around $1500, or 12 percent, over the base model list cost. However, if you add it later, you'll pay a steep $4500, or 37 percent, of the base price for a second processor board.

Near the end of my review of the SparcStations, I received and installed in the SparcStation 20M a second 50-MHz processor board. Installation was simple because the system recognized and automatically worked with the new processor. Although I had no benchmarks ready to test multiprocessing, I did test around the edges of its potential using BYTE's Unix benchmarks. These tests are not multithreaded, nor are they designed to benefit from multiple processors, yet the second CPU provided an overall performance gain of around 12 percent. That fits with SPARC's higher estimates for more complex applications.

The best performance gain with multiple CPUs comes when you're running more than one application. With two tests running simultaneously (with a script), performance didn't differ markedly from when running one test with one CPU. As long as you run Solaris 2.x (which as yet has half the applications base of Solaris 1.x), a dual-processor system can run a fairly heavy-duty application in concert with other tasks with virtually no performance degradation.



The inside is well laid out, with room for two internal hard drives and two removable-media drives. The hard drives are cleverly mounted in plastic caddies that make upgrading simple. The caddy handle, when down, locks the drive into place. When you swing the handle up, it levers the drive out of its connector so you can simply lift it out. Sun offers external SCSI devices that can expand the storage capacity of the computer to up to 138.6 GB for the SparcStation 20 and 42 GB for the SparcStation 5.

Both SparcStations came with a full array of ports on the back panel, including ports for 10Base-T Ethernet (AUI [attachment unit interface] optional), SCSI-2, IBM/Centronics parallel adapter, serial (two), audio in and out, video input (two), S-Video input, and keyboard. The optical mouse plugs into the side of the keyboard, reducing cable tangle.

About the Products

SparcStation 20M $18,843
(test configuration with 64 MB of RAM, two 535-MB hard drives, 20-inch color monitor, and videoconferencing options)

SparcStation 5 ....$7745
(test configuration with 32 MB of RAM, 535-MB hard drive, 17-inch color monitor, and videoconferencing options)

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2550 Garcia Ave.
Mountain View, CA 94043
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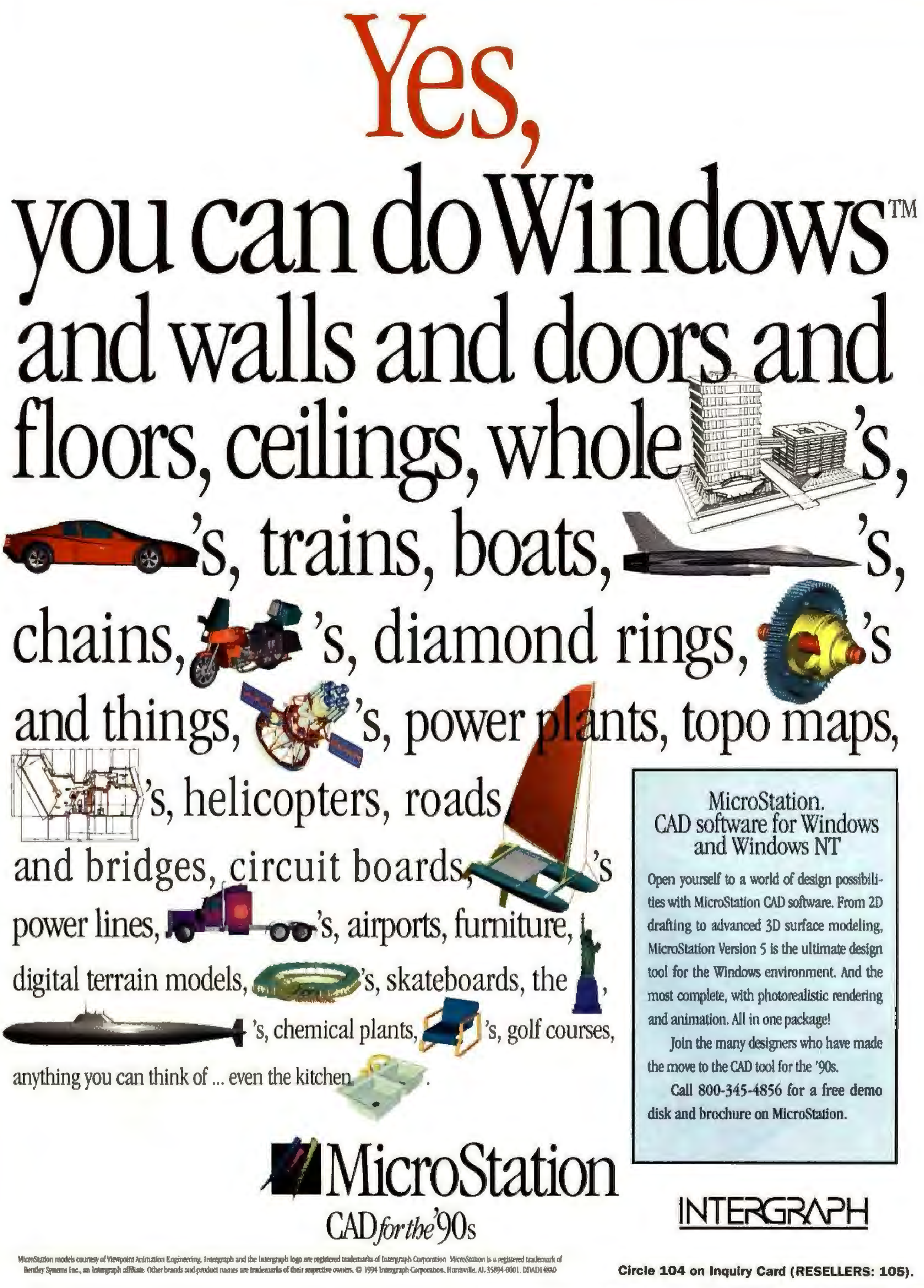
SPARC Performance

BYTE's Unix benchmarks provide a measure of Sun's CPU progress. The Arithmetic and Dhrystone results for the SparcStation 20 with a single processor showed that the new system had approximately five times the performance of the SparcStation 1+. File copy showed a dramatic improvement, with a speed index of 15; the improvement is somewhat due to better hard drive performance, but more so to caching. The Execl test actually ran slower on the SparcStation 20 than on the original SparcStation, due to the overhead inherent in Solaris 2.3. The Pipes test was the only other test to rely heavily on the operating system and thus showed only minor improvement.

SPECint92 results from Sun show the 20M test unit's 50-MHz SuperSparc processor scoring like a 90-MHz Pentium. The SuperSparc's SPECfp92 score is about 35 percent faster than the same Pentium. BYTE's native-performance benchmarks painted a dimmer performance picture, indicating that the SparcStation 20 had roughly two-thirds the integer performance and 50 percent better floating-point performance than a 66-MHz 486. Keep in mind that the native-performance tests are affected by the quality of the C compiler used for each platform. Still, these numbers put the single-processor SparcStation 20 at a performance disadvantage relative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BENCHMARK RESULTS

The Unix tests show that Sun's current SPARC systems are several times faster than the SparcStation 1+. The native performance tests indicate that they're hardly faster than a 66-MHz 486 system.

BYTE UNIX BENCHMARK

	SPARCSTATION 5	SPARCSTATION 20M
Arithmetic	5.9	8.3
Dhrystone	5.2	4.6
Execl	0.7	0.7
File Copy	12.4	15.0
Pipe	1.7	2.3

BYTE NATIVE-PERFORMANCE BENCHMARKS

	SPARCSTATION 5	SPARCSTATION 20
Integer index	0.67	0.72
Floating-point index	1.07	1.49

All benchmark results are indexed relative to the performance of a baseline machine. The Unix benchmarks are indexed to a Sun SparcStation 1+ running SunOS 4.1.3. The native-performance benchmarks are indexed to a 66-MHz 486. For each individual test, the baseline machine's index = 1.0.

to workstations based on DEC's Alpha, Mips's RS-4400, and HP's PA-RISC chips.

The SparcStation 5 did better than you would expect from the SPEC numbers for the MicroSparc II processor. The SparcStation 5 came out only 15 percent slower than the SparcStation 20 on the BYTE Unix benchmarks, in spite of the fact that the SPECint for the MicroSparc II is about 25 percent slower than that for the SuperSparc. The SparcStation 5 even pulled ahead in the Dhrystone portion of the test.

Solaris

SparcStations have a huge following of people who not only own the computers but know them inside and out. If you're not among them, the Solaris operating system that runs on the Sun computers is complex, with a steep learning curve. It has many intricacies that aren't standard Unix.

I was stumped, for example, when I tried to hook up an external Sun CD-ROM drive. The driver file for the CD-ROM drive didn't exist. After much head-scratching and searching with help commands, I discovered that I had to shut down the computer and, while outside the operating system, do a `BOOT -R` command. The system then rebooted, found the attached CD-ROM drive, and created the files necessary to access it. It's easy once you know how, but it's not nearly as convenient as on some other workstations I've used, where you plug in a SCSI device and turn on the computer, and it automatically mounts.

There are also two significantly different versions of Solaris, 1.x and 2.x. Solaris

1.1.1 is the most current of the former version and still ships with many Sun systems along with the new version, 2.3. There are good reasons for this. One is the 5000 or so applications written for the old Solaris that don't work with the new one. Another is familiarity. If you know the old Solaris, configuring the new one is painful because the operating-system data structures are different. The new kernel is also bigger than the old one. But 2.3 is a strong server operating system, supports multiprocessor machines, and can now claim 2500 applications, including all the biggies.

OpenWindows, the Solaris windowing system, is poorly linked to the rest of the system. With both SGI and HP workstations, you conveniently boot up right into the windowing system. With Solaris, you must boot up and log in through a full-screen text mode and then run OpenWindows on top of the text-mode session, much like the DOS/Windows combination. Worse, when leaving OpenWindows, you aren't warned if you have unsaved changes in some document—a fault common to other Unix systems.

Solaris's strong points are stability and a large applications base. Compared to its competition, however, Solaris has a long way to go as far as ease of use and integrating its windowing environment are concerned.

Solaris 2.4 should be out about the time you read this. According to Sun, 2.4 will provide easy-to-use graphical administration tools as well as a common environment for the 80x86-based Solaris and the Solaris that runs on the SparcStations, but it will provide little else in the way of significant features.

Still King?

Sun is still the king of Unix workstations. Although SparcStations don't have the processor speed of their competitors, don't count them out yet. Sun has made considerable advances in multiprocessor and threading technologies that will be the cornerstone of the distributed systems of the future—although the company is still proving their usefulness for today's applications. If Sun has fallen behind in speed, faster SPARC processors are right around the corner.

The SuperSparc II processor is sampling now and should ship early next year. Sun expects the 100-MHz SuperSparc II to be 85 percent faster than a 50-MHz SuperSparc, although it still won't be the fastest processor around. However, Sun's UltraSparc may be. This is a full-blown, 64-bit chip that should be more than three times faster than the 50-MHz SuperSparc. It should be available in quantity by the second quarter of 1995.

Considering its price, the SparcStation 5 is a good, fast machine and deserves consideration even for high-end use. The SparcStation 20 series provides more speed and expandability, but it's less competitive when you look at just price and performance. If you forgo Solaris 1.x applications, then running multiple processors under Solaris 2.3 can more than make up for the performance shortcomings of the SparcStation 20's CPU. How much more depends on your own particular mix of applications. ■

Eric Garland (Hancock, NH) has been using and programming computers for 12 years. He is currently enthralled by Unix. You can reach him on the Internet or BIX at editors@bix.com.

Reviews Software

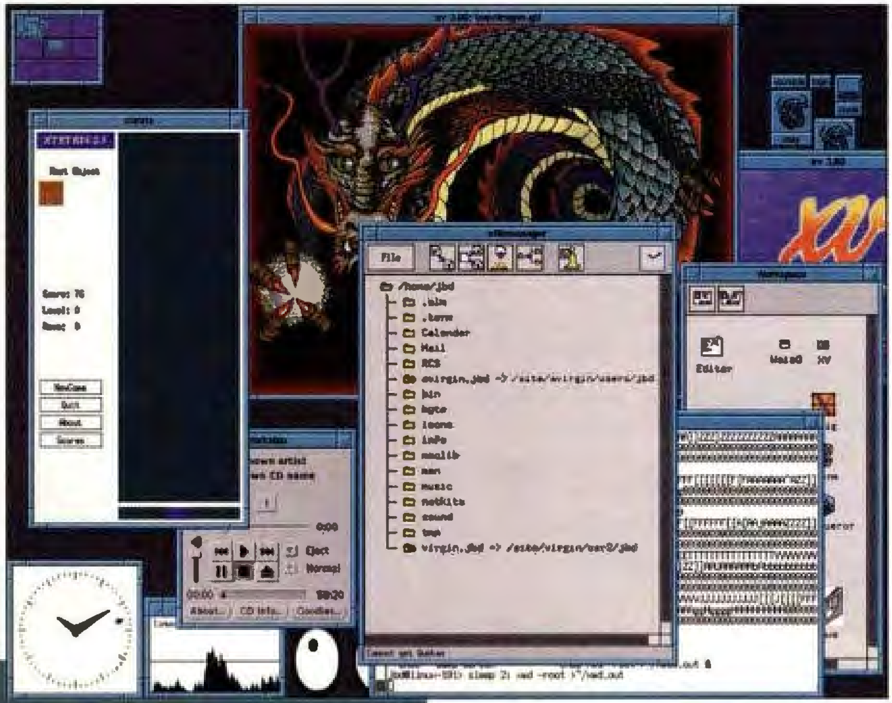
Power of Cooperation

Linux, a truly robust Unix clone, has evolved out of the Internet—and it's freely available

J. BRUCE DAWSON

Linux is not just another implementation of Unix. It's a complete rewrite, with an interesting history and some attractive features, not the least of which is its price tag: It has none. Linux is free—at least free from the more traditional license restrictions that come with commercial Unix. You can get it off the Internet from a number of sites for just the cost of the file transfers, or even on CD-ROM for a nominal price. And it comes with the source code.

In spite of its freely available nature, Linux is *not* public domain. Some of the code is bound by the Free Software Foundation's General Public License: You can copy and redistribute the associated software so long as the sources are readily and freely available. Other parts of the code have copyrights from external sources (e.g., BSD), but all these sources permit free redistribution.



When I logged in, most of the Unix commands I'm familiar with were available, and the X Window System came right up. X had been configured to use fvwm as the window manager. This wasn't one I was familiar with, but it looked very much like Motif's mwm. I could get around without learning too many new interface elements.

Family Tree

Unlike commercial versions of Unix, Linux was developed by a large number of unrelated individuals located all over the world (most of them are on the Internet). Contributors include the originator, Linus Torvalds (who lives in Finland) and the University of California at Berkeley (the originators of BSD Unix). The contributors all have differing interests, but they share a common goal: to create a freely available operating system and software that will serve the needs of power users.

A Unix look-alike, Minix, was Linux's physical ancestor, with Unix an obvious spiritual ancestor. But don't fall into the trap of viewing Linux as commercial software. Linux was developed in a somewhat anarchistic fashion by individuals working together to create a Unix that was free of the usual Unix licensing hassles; but the developers also wanted to do it "right," rather than just for profit. Not all of the work was a coordinated effort, and as a result there are several different Linux sources available, some better than others. The decision as to which Linux binaries (and sources) to use is not an easy one.

When I first heard about Linux, I was skeptical. Unix is just too complex a system, I thought, for a few people to put together and give away. Unix vendors want us to believe that it took thousands of labor years to put together their systems. Linux seemed like a fantasy that couldn't possibly be a serious solution.

Turnkey Linux

I simplified the processes of installing and configuring Linux by reviewing it on a system built and configured by Fintronic, a small company that specializes in assembling PC clones for Linux. The company claimed to have taken the best of the different implementations of Linux to build its systems.

I anticipated a lot of tinkering on my part just to get the system up and running, but everything worked surprisingly well right out of the box. Of course, things were not as well integrated as they would be in a commercial Unix. For instance, the documentation didn't always match what was installed on the system.

One of the problems Fintronic has had to deal with is a result of Linux's rapid flux: There have been new releases every few weeks, and tracking compatibility of the various component versions is time-consuming and tedious at best. A full Linux implementation is actually composed of software from many different development sites. There isn't a single point of distribution. Just tracking the source sites and juggling the file transfers can be a hassle. Fintronic must spend an enormous amount of time compiling and configuring each system with all its peripherals.

Fintronic had configured the system with a sound board, speakers, a CD-ROM drive, a 530-MB drive, a 4-mm DAT (digital audiotape) drive, 16 MB of RAM, a nice tactile-response keyboard, and a 17-inch ViewSonic display. Knowing of some problems with serial ports, I had ordered an upgrade to include the 16550A UARTs (universal asynchronous receiver/transmitters), and the system came with those already installed. The CPU was a 66-MHz 486 with 256 KB of cache memory. When I powered it on, the system asked if I wanted DOS or Linux. After about 10 seconds, it defaulted to Linux. The operating system came up in under 2 minutes (not including the operating-system prompt/time-out)—one of the faster Unix boots I've seen.

I logged in, made sure that most of the Unix commands I'm familiar with were available, and started the X Window System (using `startx`). There were no unhappy surprises—X came right up. X had been configured to use `fvwm` as the window manager. This wasn't a window manager I was familiar with, but it looked very much like Motif's `mwm`. I could get around without learning too many new interface elements. I started an `xterm` window (which was nearly instantaneous) and modified the window manager's initialization and configuration file for my account. I restarted the X server from the pop-up menu. No crashes. It was time to connect the machine to the network.

On the Network

In the process of learning about `fvwm`, I discovered that most of the `man` pages were included with the system. Unfortunately, not all `man` entries were accurate as to where files lived and which other software components were on the system. For example, the networking `man` pages assumed that many of the networking files lived within the Berkeley directory scheme, whereas Linux has a slightly different directory layout. Fortunately, I had enough Unix experience to guess where the files should be.

My first real problem was essentially that there is no real documentation other than the `man` pages and a small looseleaf binder Fintronic sent that contains some minimally out-of-date system administration information. The Linux administrator is expected to get documentation from conversations in the Usenet newsgroup comp.os.linux.

Again, Fintronic had done all the hard work of configuring the network card and establishing basic network operations. All I had to do was set up the IP addresses and host names. After configuring NFS (Network File System), I was able to mount remote disks on the Linux system and NFS-mount Linux disks on other systems. FTP worked without a hitch, as did Telnet. Even the PC-NFS server would start up and run. I could `rsh` to other systems, as well as `rlogin`.

It appeared that the network was operational. Well, not quite: I didn't get the name server properly configured, and I could not `rsh` or `rlogin` into the Linux system until I had both the full qualified name (including the domain of the host) and the host name for each remote system in `/etc/hosts.equiv`—a detail that would not be obvious to a neophyte Unix administrator, especially without documentation.

Linux isn't a bare-bones Unix clone. There is plenty of meat. In the process of getting all the facilities of Linux configured, I discovered that it has TCPD configured into its `inetd.conf` file. This is a nice feature that allows you to control incoming TCP access to your host. It was comforting to know that it was there.

Most of the features that I found on my Fintronic system (see the text box "Fintronic Linux Features") are widely available, but they're not necessarily all available from the same source. I ran BYTE's Unix Benchmarks on the Fintronic Linux system. The system (a 66-MHz 486 with 16 MB of RAM and a 530-MB hard drive) performed exceptionally well. There was some degradation on disk-access speed and pipe-based context switching when the system was normally loaded with more than a single user on it, but the unencumbered system performance was equivalent to that of a far more expensive RISC workstation.

FINTRONIC LINUX FEATURES

Here are some of the other features that Fintronic configures in its Linux systems:

- **DOS emulation. Note that this is still considered to be under test and not production quality, but it worked well enough for me (even though it doesn't run Windows).**
- **DOS file-system access. When Linux is running, users can access any DOS file systems that might be present on the system (e.g., hard drives and floppy drives).**
- **Most, if not all, of the GNU software; compilers, GhostScript, and so on.**
- **TeX and LaTex typesetting software.**
- **CD player software (WorkMan).**
- **SoundBoard drivers.**
- **InterViews—a library of X Window System functions and programs.**
- **OpenLook and XView—a library of X functions and programs.**
- **C-News—the NetNews server software (and several news readers).**
- **Shared libraries—makes executable files smaller by sharing common code.**
- **Dial-up IP and SLIP.**

Sold on System

On looking back at the start of this project, I find that I am now wearing the proverbial egg on my face. I'm not just favorably impressed with Fintronic's Linux system; I pulled out my credit card and ordered a Fintronic system for my personal use.

Some warnings, though: Unless you know a lot of Unix (and perhaps even have been following the Linux newsgroup discussions on the Internet's Usenet), you will need more documentation than is available, even if you obtain your Linux from a company such as Fintronic. As the "copy-left" rules state, the source code is readily available, here and there if not on your system. But if you need basic documentation, the source code isn't likely to help you much.

Linux has become what the Internet community wanted: a robust, freely available environment that has all the features of many commercial versions, but with the openness and cooperative spirit of the early days of Unix. It's anarchy at its best. ■

About the Company

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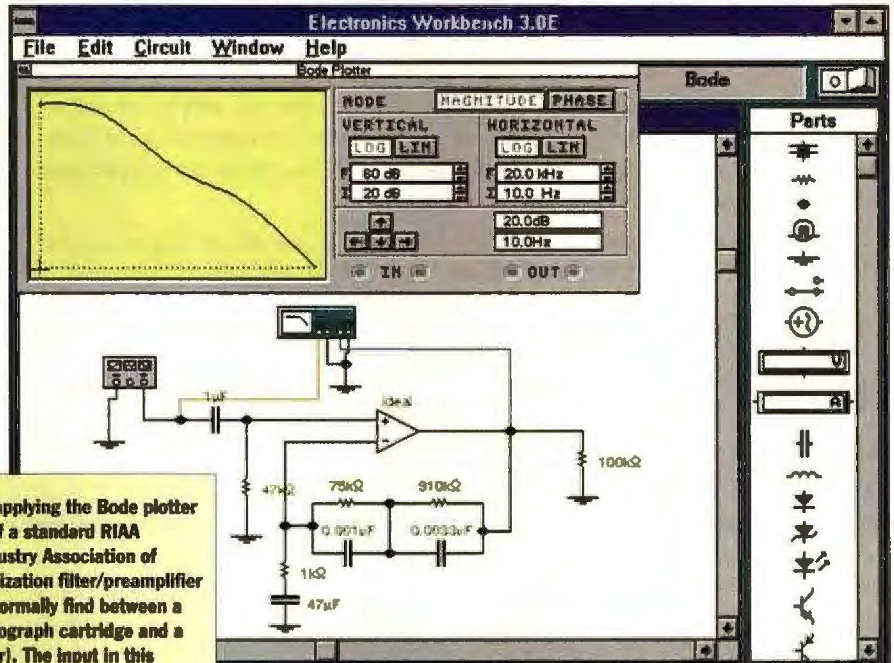
Low-Cost Simulation

Using a circuit simulator to test your designs can save both time and money

DANY DION

Sometimes a simulation can be better than the real thing. I design and build electronic control systems for a variety of automation tasks, and there are times when I would like to try out a circuit before building it. Electronics Workbench is a simulator that runs under DOS or Windows or on the Macintosh and provides breadboard and test facilities for analog and digital circuitry. I looked at the Windows version of Electronics Workbench 3.0.

Workbench is a medium- to low-end product, intended for electronics students and designers. The package includes both analog and digital schematic capture programs, with simulation and testing tools for each. Workbench is configured like some high-end simulators that cost $2000 or more (e.g., Spectrum Software's Micro-CAP or Orcad's Verification and Simulation Tools) in that the digital and analog portions are entirely separate functions. To get true mixed-mode simulation, you'd have to use a very expensive package like MicroSim's Design Center for Windows (about $8000 to $16,000).



The results of applying the Bode plotter to the output of a standard RIAA (Recording Industry Association of America) equalization filter/preamplifier (the kind you normally find between a magnetic phonograph cartridge and a stereo amplifier). The input in this example is a sine wave varying from 10 Hz to 20 kHz. After it passes through the filter, the Bode plotter shows the attenuation curve.

Inside Workbench

The primary interface to Workbench is a palette (or *bin*) of electronic parts (either analog or digital, depending on which simulator you load) and a selection of test equipment. To construct a circuit, you drag parts out of the bin (see the screen) and place them in the work area. Each part has one or more live connection points. Dragging a line between any two points makes a wired connection; the wires themselves are auto-routing. Double-clicking on a part in your design brings up a dialog box that lets you change the part's parameters (e.g., resistance and capacitance). Once you have connected all the components and attached the signal generators, multimeters, and oscilloscope, you click on the on/off switch to start the simulation.

Considering Workbench's reasonable price, I was impressed by how well it worked. My analog and digital control systems regularly include signal amplifiers, filters, bridge amplifiers with feedback and current limiting, stepper-motor controls, and sundry logic decoders. I entered some of my working designs into Workbench to see how well the simulation compared to the real thing. The fact that the analog and digital simulations are separate was a big problem, however; many real-world designs freely mix analog and digital circuitry.

Workbench's transistors won't properly bias because the simulator uses only ideal values. Real transistors don't work exactly like their descriptions in a textbook. I managed to get my working circuit to run on the simulator by changing some resistor values and removing some filter capacitors.

Troubles in Analog Land

The function generator can produce sine, triangular, or square waves at any frequency from 1 Hz to 999 MHz, with a duty cycle of from 1 percent to 99 percent. The analog simulator's oscilloscope is a dual-channel type with a time base of 0.10 nanosecond to 0.50 seconds per division.

The Bode plotter produces a graph of a circuit's frequency response. When connected to a circuit, the plotter generates a range of frequency over a spectrum selected from 1.0 MHz to 10.0 GHz. The result is a screen plot that shows how your circuit performs over the entire frequency-range sweep.

Workbench's op amps (operational amplifiers) may not work the way you expect, because the simulation drives them with standard voltage values (15 V DC) instead of the voltage sources you have elsewhere in your circuit. Op amps behave differently depending on their power-supply voltage.

Workbench transistors don't have limitations on voltage or current. In Workbench, you can use a small signal transistor, like a 2N2222, as a power transistor and sink 10 amperes at 120 V DC without causing an error. In real life, you'd get a rather spectacular puff of smoke. The frequency generator provides your choice of square, sine, or triangular wave output, but at only one frequency. Finally, some of the parameters use different measurements. AC voltage sources have peak values, while other components, like fuses and light bulbs, use rms (root mean square) values. You have to be careful to match these different voltage measurements.

The analog simulator comes with a library of 37 basic components, including connectors, voltage sources, current sources, ground, and other components. Designing circuits with the analog simulator can be difficult if you don't have enough working knowledge of real-world components. You have to hand-check every component for proper rating before building a real circuit from the design.

Digital Simulation

The parts bin in the digital simulator is filled with common logic design elements: logic gates, flip-flops, a half adder, and a seven-segment display. As with the analog simulator, you can select a region of a circuit and save it in your bin as a subcircuit.

The tools in the digital simulator are different from the analog simulator's. Since the digital simulator has no provision for analog circuitry, an oscilloscope or Bode plotter would make no sense; instead, you get a word generator, a logic analyzer, a voltmeter, and a logic converter.

The word generator stores a sequence of sixteen 8-bit words that can play back automatically (*cycle*) or one at a time (*step*), or play through once and stop (*burst*). Workbench's logic analyzer has eight input channels and can be triggered by an external signal, by the input channels themselves, or by a user-selected pattern.

I never did figure out what the voltmeter was good for. Since all circuits in the digital simulator are driven by 5 V and run at logic 0 and 1 levels (0 and 5 V), the voltmeter displays no more information than the simple LED probes that you can have any number of in your design.

The logic converter is far and away the most interesting part of the simulator. It can look at your circuit and tell you the truth table, convert a truth table to a Boolean expression, take a logic equation and simplify it, or build a circuit from a truth table or a Boolean expression. The logic simplification algorithm is the Quine-McKluskey method, instead of the more familiar Karnaugh mapping.

The Quine-McKluskey method begins by sorting the terms of a truth table according to the number of true conditions they contain. These terms are compared to find those that differ by only one variable, and that variable is eliminated. The process is repeated until no further elimination is possible. The grouped terms that remain are considered prime implicants. The final step is the elimination of redundant expressions. Since this method works with the binary representation of expressions, the Boolean expression is automatic.

The logic converter would be most useful for situations where you want to replace a portion of your design with a PAL (programmable array logic chip). Once you test the circuit, you use the logic converter to convert the finished circuit to a truth table for the PAL programmer. You'll have to live within the limitations of the package, though, and restrict your PAL designs to eight inputs.

IN THE WORKS

Good products just keep getting better. By the time you read this article, Interactive Image Technologies expects to have put the finishing touches on a new version of Workbench (available in October). According to the company, this new version will address many of the concerns our reviewer had with version 3.0:

- **Analog and digital simulators will be combined in one package, enabling mixed-mode simulation.**
- **Digital components will have propagation delays and other more realistic properties.**
- **There will be a choice between TTL (transistor-transistor logic) and CMOS parts.**
- **There will be multiple input gates and a larger array of standard parts, such as counters, RAM, ROM, 555 timers, SCRs (silicon-controlled rectifiers), and triacs.**
- **Op amps will have power-supply pins.**
- **Clock generators will support multiple frequencies.**

No price had been set when we went to press, but Interactive Image expects the price to be a bit higher than for version 3.0.

Alas, with its shortcomings, the digital simulator is as restrictive as the logic converter is enabling: Logic gates in the simulator are *perfect* and respond instantaneously. Without propagation delays such as you'd find in real silicon, high-speed circuits won't respond correctly and feedback loops are impossible. For instance, one popular way to create an inexpensive clock is to tie a number of logic inverters to themselves in a loop, with resistors and capacitors to control the speed. Without the analog/digital mix, you can't add the resistors or capacitors, and the simulator reports that the feedback loop is stuck in a race condition.

Pass the Breadboard

Perhaps the biggest shortcoming of the combined package—one that might stop me from trying to do real design work with either simulator—is that Workbench has no import or export capability. If you complete a design and want to produce a printed circuit board, you can't simply capture the final schematic and transfer it to a printed circuit board layout package. Anyone using a schematic capture program or simulator like Workbench is likely to be using printed circuit board layout software to produce boards.

It's a sure bet that Intel won't be using this software for designing the successor to the Pentium. I might be able to use it for designing simple circuits, but most of my work requires combining analog and digital circuitry.

I can easily see Workbench as a product for hobbyists or electronics students. Perhaps even small companies that can't afford more expensive, professional-caliber tools like Orcad's Verification and Simulation Tools or Spectrum's Micro-CAP would find it useful. While the manual and the included samples don't attempt to explain electronic theory in depth, they provide enough information to get anyone new to electronic simulation started. ■

About the Product

Electronics Workbench 3.0 ....$299
for Windows or the Mac
Interactive Image Technologies, Ltd.
700 King St. W, Suite 815
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HANDS-ON TESTING

24 CD-ROM DRIVES: DOUBLE-SPEED RULES

Today's mainstream CD-ROM drives offer faster performance at the most economical prices ever. We'll tell you which one is right for you.

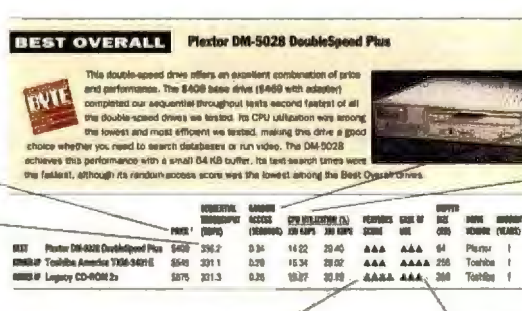
CHANDRIKA MYSORE

CD-ROM drives used to be a fancy option for your desktop system. Today, they're essential for loading new application software, viewing presentations, or accessing commercial and private sources of data. Recognizing this trend, many system vendors offer CD-ROM drives in "multimedia" bundles. As we went to press, Gateway 2000 announced that all its systems would include a CD-ROM drive standard.

But you don't have to buy a new system to take advantage of CD-ROMs: This lab report evaluates two dozen fast and easy-to-install external drives that can serve you well whether you use a PC or a Mac. We tested 20 SCSI-based, desktop drives and ranked the best for general-purpose, low-cost, and text-intensive applications. All but one of the drives was double-speed, with throughput scores of 300 to 350 KBps. The remaining drive was NEC's quadruple-speed MultiSpin 4X Pro, which was the most expensive drive we tested ($995) but also the fastest for throughput: 590.3 KBps. We also ranked four portable drives that connect via a SCSI and/or a parallel-port interface.

How to use this guide

Turn to page 179 for details on the double-speed drives that showed the best performance, features, ease of use, and price for Best Overall, Low Cost, and Text applications. The text box on page 182 ranks four portable drives.



Drive price, which doesn't include the adapter. Adapter prices for each drive are listed in the "Roll Call" on page 186.

Lower numbers indicate faster performance. This score represents how fast the drive can read data spread across the CD.

Higher numbers indicate faster performance. A measure of the amount of data a drive can transfer in 1 second.

Lower numbers indicate better performance. This shows the percentage of the time the computer's CPU was used by the CD-ROM drive during a sequential read at 150 and 300 KBps.

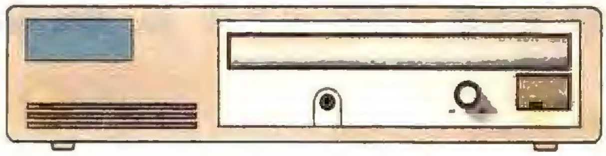
Better ratings indicate drives with longer warranties, a range of device drivers, and support for a greater number of modes, including CD-ROM XA (Extended Architecture), multisession Photo CD, and ISO-9660.

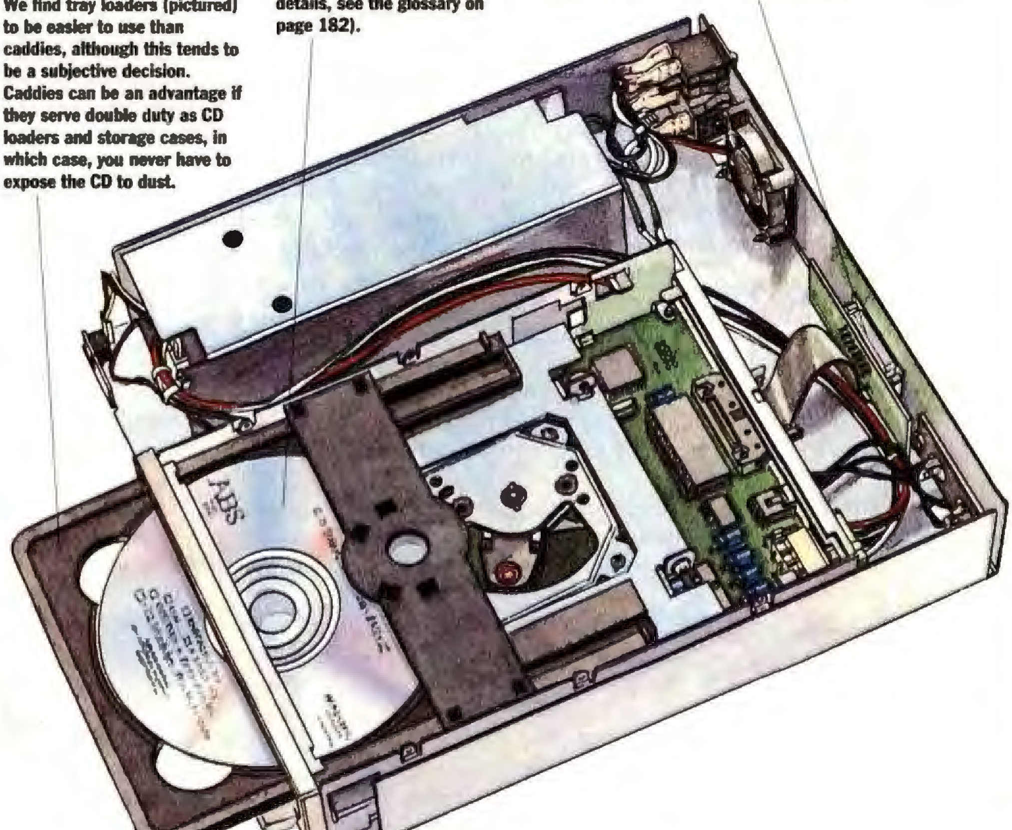
We considered the quality of documentation, installation, and user interface, among other factors.

PHOTOGRAPHY: CRAIG ALNESS © 1994

Choosing a CD-ROM Drive

Drive speed, the rate at which a drive can transfer data, is determined by a number of factors, including spindle rate and how effectively the drive uses its buffer. Double-speed drives are good choices for most general-purpose applications, and excellent models exist that range from about $300 to $500. Quadruple-speed drives offer faster throughput but sell for $1000 or more.





SEPTEMBER 1994 BYTE BEST CD ROM DRIVES

BEST

BEST OVERALL

Plextor DM-5028 DoubleSpeed Plus

An excellent combination of price and performance, this $409 drive was the second-fastest double-speed drive in our sequential-throughput tests, and its CPU utilization score was among the most efficient we tested. It also led the pack in the text-search tests.

PAGE 179

BEST LOW COST

Mirror CD ROM Drive

Sold primarily in the Mac market, this $259 drive can be a bargain for PC users, too, when it is matched with the right inexpensive SCSI adapter. No matter which platform, you'll see solid performance from this Toshiba-mechanism drive.

PAGE 179

BEST TEXT

CD Technology Porta-Drive T3401

This 3-pound drive achieved the highest overall performance score in our combined text, sequential throughput, and random-access tests. The Porta-Drive can run off of an external power supply, and the company supplies drivers for a wide range of operating systems.

PAGE 179

While this report focuses on external drives, you can gauge performance of drives offered by system vendors by looking at the "Roll Call" on page 186, which lists the basic drive mechanism used in each product.

Double-speed drives have claimed their place in the mainstream market because of price and performance that's fast enough for them to display full-motion video in some resolutions without dropping any frames. Less-expensive single-speed drives of the recent past offered only 150-KBps throughput with mixed reviews for video performance.

To rank drive performance, we used custom benchmarks to measure sequential throughput, random-access time, and CPU utilization of each drive. We also ran application tests, including a 912-frame video sequence to gauge if individual frames were dropped. Keyword and Boolean text searches helped us determine which drives were best for searching large text databases.

Although NEC's quadruple-speed drive was the only one available for our test cycle, you can expect several other vendors to offer these faster drives by the time you read this. Note that IBM also sells CD-ROM drives, but it didn't participate in this report because it expected to introduce a new model late this summer.

THE BEST DOUBLE-SPEED

CD-ROM DRIVES

Today's double-speed drives demonstrate sameness rather than distinction. The 23 double-speed drives we tested represent only eight different drive mechanisms. Toshiba's mechanism is the dominant one in this sample: 11 of the drives used either Toshiba's T3401 or T4101 model. Accordingly, performance varied only slightly across the entire sample (by approximately 10 percent), and the scores for the drives using the Toshiba mechanisms were almost identical. The T3401-based models produced sequential throughput of about 331 KBps, while the T4101-based models posted throughput of about 301 KBps.

Nevertheless, the exceptions to the Toshiba-mechanism rule often performed well. Our Best Overall drive, Plextor's DM-5028, uses a Plextor mechanism, and its throughput score was the fastest of the drives we ranked in that category.

The standard buffer size for double-speed drives is 256 KB, although we did see a handful with 128 KB or even 64 KB (including the Plextor). The buffer is especially important during times when the drive is waiting for the system to display an image on the screen: In such cases, the drive can read ahead and fill the buffer with data. However, the relatively small size of CD-ROM drive buffers (even when they're the larger 256-KB buffers) don't necessarily bring faster performance.

Firmware plays a prime role in how efficiently the drive uses its buffer. The system CPU stops every time it issues a read-ahead command to the CD-ROM drive. Too many such commands translates into noticeably slow system performance. CD-ROM vendors use two approaches for buffering. In circular buffer read-ahead, the drive continuously reads with just one interrupt from the main processor. This keeps the buffer full and improves throughput. Another approach is to copy the drive's table of contents or root-directory information into the buffer memory, which can reduce random-access time.

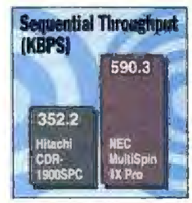
The interface adapter and the device driver also play an important role in drive performance, especially in CPU utilization. Several drive vendors, including Philips LMS, Reveal, Hitachi, and Plextor offer a standard bundle of an 8-bit SCSI adapter. Such adapters are handy if your system lacks SCSI and you are not planning to run multimedia applications. If you are buying a CD-ROM drive for video-intensive applications, consider a higher-performing 16-bit ISA or even an EISA SCSI adapter.

Some drives, such as Hitachi's CDR-1900SPC, come with a proprietary SCSI adapter, which provides a performance edge over drives that use a standard SCSI adapter. However, proprietary adapters can't support SCSI peripherals, such as a hard drive.

Test results for CPU utilization can be especially important for finding drives that won't drop video frames when playing video off a CD. All the SCSI-based drives achieve performance within the standard MPC Level 2 specification, which is 40 percent for 150-KBps transfers and 60 percent for 300-KBps rates. None of the SCSI drives we tested dropped frames when they ran our test video file at a resolution of 320 by 240 pixels. By contrast, none of the three parallel-port drives we tested met the MPC Level 2 specification for CPU uti-

Do You Need Quad Speed?

NEC's MultiSpin 4X Pro performed without flaws. This high-performance drive achieved 590.3-KBps throughput, or two times the rate of double-speed products. In addition, it comes in a well-designed housing with a rotating dust door and a clear control panel with an easy-to-understand LCD.



However, the price, with adapter, is \$1120, or almost 2½ times the price of our Best Overall winner. For most mainstream applications, quadruple speed is too expensive to justify, but if you need the fastest performance—and price isn't an issue—consider this drive.

MULTISESSION QUESTIONS

All the CD-ROM drive vendors that participated in this report say that their drives can read multisession CDs; however, when we tried to read a multisession CD, none of the drives succeeded.

The process of recording data and an associated table of contents is called a *session*. Whether it's a commercial CD-ROM title or your company's data that you've recorded onto CD-ROM, information is placed sequentially on the CD in spiral tracks. At the end of the recording process, a table of contents, listing the files and directory locations, is added to the CD.

To read multisessions, drives need some read electronics and a device driver that can identify more than one table of contents on the CD. Our problems centered around not having the latter component. Although each drive was capable of multisession reads, none was shipped with the proper driver.

JVC Information Products recently released a driver that can read OrangeBook multisessions on the CD. The price is \$200 for a 10-driver distribution pack; the company includes the drivers with its CD-recorder products. When we loaded this driver, the CD-ROM drives worked as advertised. In addition, Adaptec's EZ-SCSI adapter comes with a device driver to read Photo CD multisession CDs.

lization, and each dropped 80 percent or more of the frames (see "CD-ROM for the Road" on page 182).

This generation of double-speed drives is also similar in their ease of use. Installation was never more difficult than connecting the proper cables to the SCSI port and loading a device driver. Front-panel controls were also easy to use for all these drives. Each product came with an eject button, an emergency manual-eject hole, an audio jack, and volume control on the front panel. Nevertheless, we did have a few favorite interface implementations that offered more than the standard items. If the drive had indicator lights or an LCD, it helped us tell when the CD was loaded in the drive. But some drives, such as CD's T3401, Legacy's CD-ROM 2x, MacProducts USA's Magic CD Pro, Mirror's CD ROM, PLI's CD ROM MS, and Reveal's The Entertainer, had no indicator light to tell you if a CD was loaded or if the power was on. In these cases, we had to press the eject button on the drive to see if the CD was inserted.

A note about NEC's triple-speed drive: The first NEC 3X MultiSpin drive we tested produced throughput scores that were inconsistent with triple-speed performance. A second drive couldn't complete our tests. Neither we nor NEC technicians could resolve the problem during our test cycle.

KEY

Excellent ▲▲▲▲ Good ▲▲▲

Fair ▲▲ Poor ▲

BYTE BEST — CD-ROM DRIVES

For the best in price and performance...

BEST OVERALL — Plextor DM-5028 DoubleSpeed Plus

This double-speed drive offers an excellent combination of price and performance. The $409 base drive ($469 with adapter) completed our sequential-throughput tests second fastest of all the double-speed drives we tested. Its CPU utilization was among the lowest and most efficient we tested, making this drive a good choice whether you need to search databases or run video. The DM-5028 achieves this performance with a small 64-KB buffer. Its text-search times were the fastest, although its random-access score was the lowest among the Best Overall drives.

		PRICE [1]	SEQUENTIAL THROUGHPUT (KBPS)	RANDOM ACCESS (SECONDS)	CPU UTILIZATION (%) 150 KBPS	CPU UTILIZATION (%) 300 KBPS	FEATURES SCORE	EASE OF USE	BUFFER SIZE (KB)	DRIVE VENDOR	WARRANTY (YEARS)
BEST	Plextor DM-5028 DoubleSpeed Plus	$409	336.2	0.34	14.22	29.40	▲▲▲	▲▲▲	64	Plextor	1
RUNNER-UP	Toshiba America TXM-3401E	$545	331.1	0.29	15.34	29.02	▲▲▲	▲▲▲▲	256	Toshiba	1
RUNNER-UP	Legacy CD-ROM 2x	$575	331.3	0.26	15.27	30.19	▲▲▲▲	▲▲▲	256	Toshiba	1
RUNNER-UP	Mirror CD ROM Drive	$259	331.2	0.26	15.22	29.45	▲▲▲	▲▲▲	256	Toshiba	1
RUNNER-UP	DEC RRD44-DA	$549	331.9	0.27	18.40	35.58	▲▲▲▲	▲▲▲	256	Toshiba	3
RUNNER-UP	Peripheral PLI CD-ROM MS	$743	331.5	0.27	15.91	31.82	▲▲▲	▲▲▲	256	Toshiba	1
RUNNER-UP	MacProducts USA Magic CD Pro	$459	331.4	0.26	19.12	36.92	▲▲▲	▲▲▲	256	Toshiba	1
RUNNER-UP	FWB hammerCD	$749	331.4	0.26	15.22	29.04	▲▲	▲▲▲▲	256	Toshiba	2

Need low cost and fast speed?

LOW COST — Mirror CD ROM Drive

At $259, this drive known primarily in the Mac market easily met the under-$500 requirement for this category. It makes only minor compromises in speed compared to the Best Overall winner. If you're a PC user, you'll need to spend approximately $93 more for an ISA-based SCSI adapter and cable. For this still-economical price, you'll see solid performance from this Toshiba-mechanism drive: Its speed scores rank near the top of the more expensive Best Overall leaders.

		PRICE [1]	SEQUENTIAL THROUGHPUT (KBPS)	RANDOM ACCESS (SECONDS)	CPU UTILIZATION (%) 150 KBPS	CPU UTILIZATION (%) 300 KBPS	FEATURES SCORE	EASE OF USE	BUFFER SIZE (KB)	DRIVE VENDOR	WARRANTY (YEARS)
BEST	Mirror CD ROM Drive	$259	331.2	0.26	15.22	29.45	▲▲▲	▲▲▲	256	Toshiba	1
RUNNER-UP	MacProducts USA Magic CD Pro	$459	331.4	0.26	19.12	36.92	▲▲▲	▲▲▲	256	Toshiba	1
RUNNER-UP	CD Technology CD Porta-Drive T3401	$500	331.3	0.26	15.76	30.55	▲▲▲	▲▲	256	Toshiba	1
RUNNER-UP	Plextor DM-5028 DoubleSpeed Plus	$409	336.2	0.34	14.22	29.40	▲▲▲	▲▲▲	64	Plextor	1

Need to find data quickly?

TEXT — CD Technology CD Porta-Drive T3401

This svelte, 3-pound drive achieved the highest overall performance score in our combined text, sequential throughput, and random-access tests. A Toshiba-mechanism drive, the T3401 can run off of its external power supply. Note that the drive uses a proprietary SCSI connection, which can help performance but doesn't support other SCSI peripherals.

		PRICE [1]	SEQUENTIAL THROUGHPUT (KBPS)	RANDOM ACCESS (SECONDS)	TEXT SEARCH (SECONDS) ONE-WORD	TEXT SEARCH (SECONDS) BOOLEAN	CPU UTILIZATION (%) 150 KBPS	CPU UTILIZATION (%) 300 KBPS	FEATURES SCORE	EASE OF USE	BUFFER SIZE (KB)	DRIVE VENDOR
BEST	CD Technology Porta-Drive T3401	$500	331.3	0.26	15.23	15.08	15.76	30.55	▲▲▲	▲▲	256	Toshiba
RUNNER-UP	Legacy CD-ROM 2x	$575	331.3	0.26	15.2	15.42	15.27	30.19	▲▲▲▲	▲▲▲	256	Toshiba
RUNNER-UP	MacProducts USA Magic CD Pro	$459	331.4	0.26	15.35	15.37	19.12	36.92	▲▲▲	▲▲▲	256	Toshiba
RUNNER-UP	DEC RRD44-DA	$549	331.9	0.27	16.24	15.29	18.40	35.58	▲▲▲▲	▲▲▲	256	Toshiba
RUNNER-UP	Toshiba America TXM-3401E	$545	331.1	0.29	15.31	15.23	15.34	29.02	▲▲▲	▲▲▲▲	256	Toshiba
RUNNER-UP	Plextor DoubleSpeed Plus	$409	336.2	0.34	15.09	15.06	14.22	29.40	▲▲▲	▲▲▲	64	Plextor

[1] Doesn't include adapter price; see "Roll Call."

How We Tested

We rated the drives for speed, features, and ease of use. Our custom performance suite consisted of five components: sequential throughput, random access, CPU utilization, text searching, and video playback.

Our low-level CD-ROM tests were a portion of NSTL's InterMark performance benchmarks. In each test, drives were instructed to read data from inner, middle, and outer tracks of the CD. We accessed data from these three areas because CDs store information sequentially on a single track that's spiralled across the CD. Drives spin the CD faster when reading data from an inner track compared to outer tracks, and a drive's performance can vary depending on the location of the data on the CD.

The throughput tests measure the amount of data a drive reads into memory in a second. Data was read sequentially in a series of 16-KB blocks. In the random-access tests, drives read a single 16-KB block then skipped over a third of the CD to read a second 16-KB block. The CPU utilization tests measure the percentage of CPU resources used to sequentially read 16-KB blocks at a rate of 150 and 300 KBps.

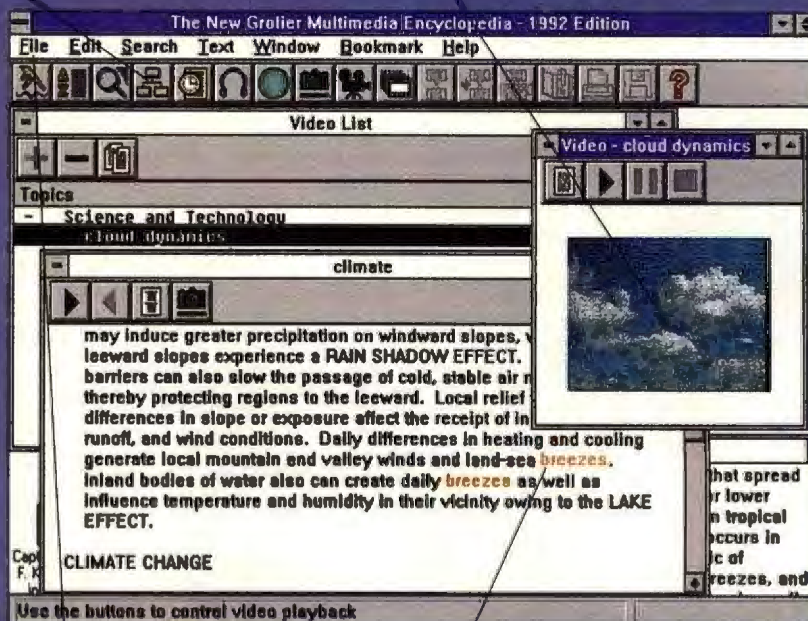
The text-search tests consisted of a single, keyword search and a Boolean search using Gofer, an information exchange protocol developed by the University of Minnesota. The text test data was "Project Gutenberg," electronic text of important English language documents published by Walnut Creek CDROM (Walnut Creek, CA). In the first text test, we browsed a 5-MB file for a keyword. The second test used a Boolean search phrase to locate two words.

In addition, we assessed each drive's ability to play video sequences using Microsoft's VidTest CD-ROM video tests. The drives ran an 8-bit, 912-frame file in resolutions of 320 by 240 pixels.

WHAT THE TESTS MEAN

RANDOM ACCESS
A measurement of how quickly a drive can read data stored across a CD-ROM (lower test scores indicate faster performance). This is important for interactive applications, including multimedia encyclopedias and electronic training programs, where data isn't easily prefetched in the buffer.

CPU UTILIZATION
An essential gauge for video applications. It measures how long the system CPU is used to transfer data from the drive buffer to system memory (lower test scores indicate better performance). Too much time devoted to data transfers results in dropped frames.



SEQUENTIAL THROUGHPUT
The single most important performance test for CD-ROM drives because data on CDs is stored sequentially (higher test scores indicate faster performance). Sequential throughput is important when copying large files, and loading software from a CD.

TEXT SEARCHING
An application-level test that measures how many seconds a drive takes to find one and two keywords in a large text file (lower numbers indicate faster performance). Along with sequential throughput and random-access scores, this test indicates real-world performance.

EASE OF USE

We considered the quality of documentation, how easy it is to install the drive's hardware and software components, and rated each drive's front-panel indicators.

The features that we considered most important were the length of the warranty, range of device drivers, MPC Level 2 certification, and support for SCSI-2 and fast SCSI. We also looked for the modes supported, such as CD-Audio, CD-ROM XA (Extended Architecture), CD-R (CD Recordable), CD-I (CD Interactive), and ISO-9660.

We ran the tests on a Compaq Deskpro 66M (66-MHz 486DX2) with a 500-MB hard drive and MS-DOS 6.2 and Windows 3.1. We disabled Smartdrive, and no swapdrive was used under Windows. We connected each drive to the test system using an Adaptec AHA-2740/42 SCSI (EISA) adapter and Adaptec EZ-SCSI 2.04. Three drives—Hitachi's CDR-1900SPC, MacProducts USA's Magic CD Pro, and Reveal's The Entertainer—use a proprietary SCSI connection; we used that for testing. Test files resided on the test computer's hard drive. Parallel-port drives ran from an AST PowerExec 4/25SL notebook with an enhanced parallel port, 8 MB of RAM, and a 200-MB hard drive.

Contributors

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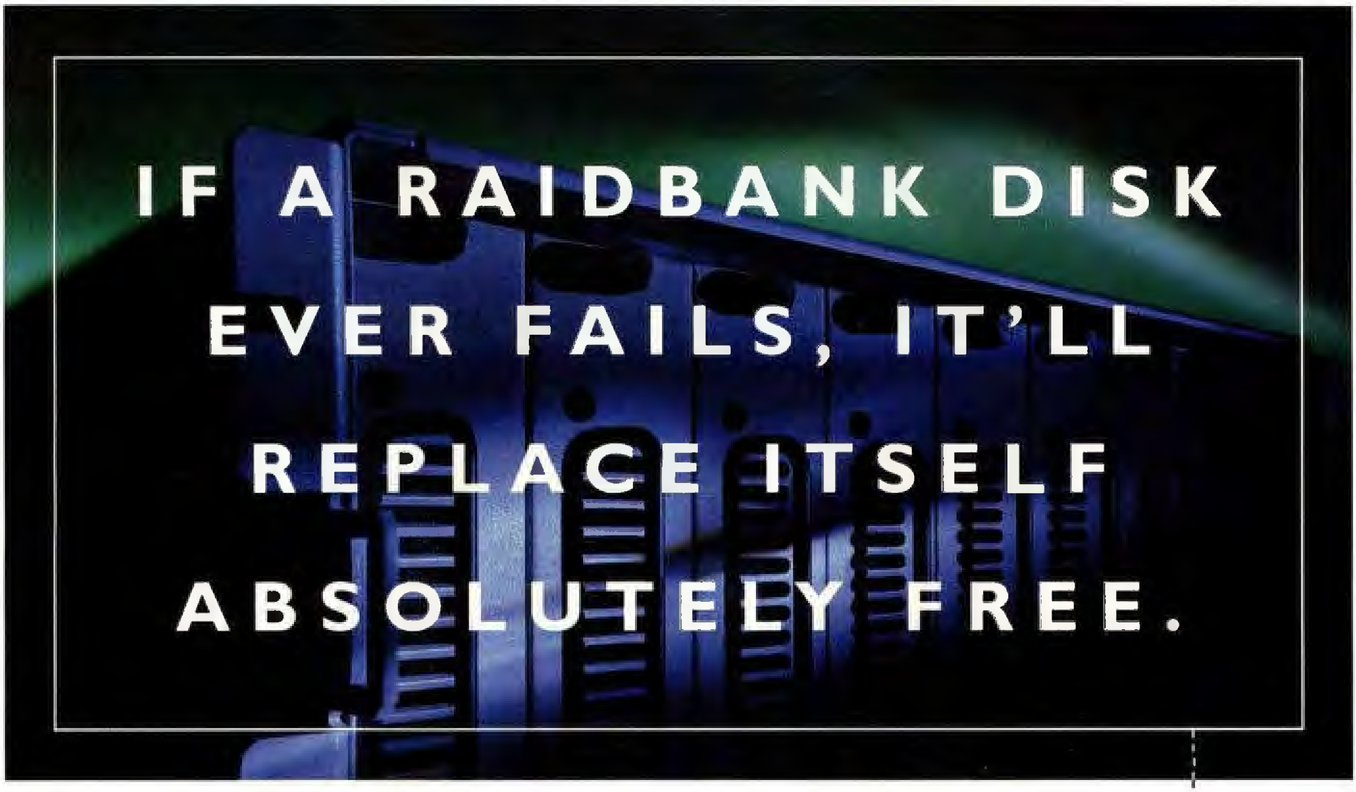

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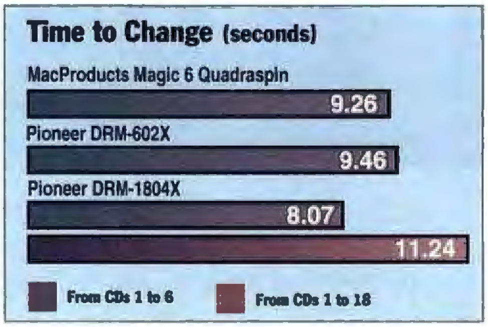
Fast Access to Multiple CDs

For fast access to data stored on numerous CDs, consider one of the changers now available that can hold up to 18 CD-ROMs. Three new changers are built using mechanisms from Pioneer New Media Technology. The Magic CD 6 Quadraspin is available from MacProducts USA. It sells for $1099 and can hold six CDs. It and Pioneer's $1845 DRM-1804X are quadruple-speed drives, although the Pioneer can handle 18 CDs. Pioneer's DRM-602X uses a slower, double-speed mechanism, and it's able to handle 6 CDs.

Pioneer's DRM-1804X can handle up to 18 CDs.

Device drivers identify multiple CDs in the CD changer through different drive letters. When you access a CD, the drive mechanism moves up or down to align itself with the desired CD, draws the CD into place, and locks it for reading. The amount of time changing CDs varies depending on the CD location in the CD changer. We measured the time to change from CD 1 to CD 6 and then displayed the directory on that CD (see the chart below). The quadruple-speed Pioneer completed this task fastest (just over 8 seconds), while the double-speed Pioneer and quadruple-speed Magic CD required 9.46 and 9.26 seconds, respectively.



Key Terms

CD-I (CD Interactive) A format developed by Philips for the playback of multimedia and interactive software.

ISO-9660 A pervasive file-format standard created by the ISO.

CD-ROM XA (Extended Architecture) XA-compatible drives offer multisession playback and synchronization of various media types.

MPC Level 2 The Multimedia Marketing Council's standard for minimum multimedia system requirements.

Multisession recording Recording data in more than one session, with a table of contents for each session.

Photo CD A standard specific to Eastman Kodak's Photo CD storage media.

Session Recording data and creating a table of contents on a blank CD.

Single-session recording Recording an entire set of data on a CD at one time. No more than one table of contents is allowed on the CD.

CD-ROM FOR THE ROAD

We tested three double-speed and one triple-speed drive for portable applications. Two used a parallel-port interface—Disctec's RoadRunner Express and Micro Solutions' Backpack. Liberty's 115 Series CDN-P and CD Technology's Porta-Drive T4100 support SCSI and parallel-port interfaces.

The heaviest of these drives, the Backpack and the Liberty 115, weigh 4 pounds, which is equivalent to some of the desktop drives we tested (although weights for the latter went up to 14 pounds for CMS Enhancements' Platinum II). But the parallel-port interface combined with relatively light weight recommends these drives for mobility.

The SCSI-based Porta-Drive T4100 was a wisp at only 1 pound.

Compared to the drives that supported EPP (enhanced parallel port) (all but the Backpack), the SCSI-based Porta-Drive T4100 provides marginally slower throughput and random-access speed. It shines, however, in CPU utilization by running within the MPC Level 2 specification at both 150 and 300 KBps. None of the parallel-port drives met the specification. (Note: The Liberty drive, which supports both EPP and SCSI, was tested using only the EPP interface.) This is borne out in our video tests: The Porta-Drive T4100 didn't drop any video frames in our test, while the three remaining portables dropped three quarters of the frames. If you travel to show presentations that include full-motion video, consider this drive.

Clockwise (from top left): CD's Porta-Drive T4100, Disctec's RoadRunner Express, Micro Solutions' Backpack, and Liberty's 115 Series CDN-P.

MODEL	PRICE [1]	SEQUENTIAL THROUGHPUT (KBPS)	CPU UTILIZATION (%) 150 KBPS	CPU UTILIZATION (%) 300 KBPS	SKIPPED FRAMES (8-BIT FILE)	FEATURES SCORE	EASE OF USE	BUFFER SIZE (KB)	DRIVE VENDOR	WEIGHT (LBS)	SUPPORT EPP
CD Technology Porta-Drive T4100 [2]	$400	300.9	19.13	49.79	0 of 912	7.9	8.3	64	Toshiba	1	✔
Disctec RoadRunner Express CD-2x	$499	301.6	58.79	73.83	774 of 912	5.8	6.4	32	Mitsumi	3.5	✔
Liberty Systems 115 Series CDN-P [3]	$649	311.0	45.83	94.34	854 of 912	8.2	8.3	256	Toshiba	4	✔
Micro Solutions Backpack	$499	112.3	99.22	99.22	897 of 912	5.6	6.1	32	Mitsumi	4	

[1] Doesn't include adapter price; see "Roll Call." [2] Drive tested using SCSI port. [3] Drive tested using EPP interface. ✔ = yes.

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HONORABLE MENTIONS

For SCSI information numbers at a glance, CMS Enhancements' Platinum II CD-ROM drive offers a unique front panel that displays the termination status and ID number (along with the power and "drive busy" indicators). The drive also comes with brackets for stacking multiple drives and a pedestal that positions the drive vertically.

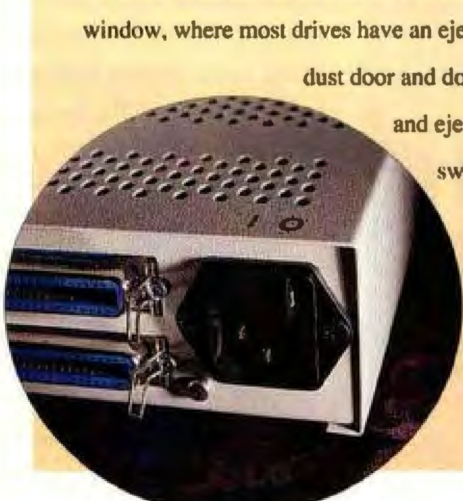
Kudos to the few CD-ROM drive vendors, such as CMS Enhancements, Hitachi, Todd Enterprises, and Chinon America, whose drives include a modest, but informative, "Disc Loaded" indicator on the dust door.

NEC Technologies' MultiSpin 4X Pro provides front-panel buttons that let you easily select fast-forward, fast-reverse, stop, and eject. Unique among the products we tested is this drive's audio-control buttons for audio-only CDs. Also handy is the amount of status information the MultiSpin provides. An LCD indicates CD loaded, CD busy, and the speed at which the drive is spinning.

▼

Dubious Achievements

The DEC RRD43-FB and Toshiba TXM-4101L drives have power buttons next to the caddy insert window, where most drives have an eject button (the eject buttons on the RRD43-FB and TXM-T4101L are below the dust door and don't have contrasting colors with the case). We found the proximity of the power and eject buttons to be frustratingly close together. Most CD-ROM drives' power switches are in the back or on the side, away from the front panel.



Is it On or Off? The Legacy CD-ROM 2x drive's power-switch indicators reverse the "0" and "1" on the top cover of the drive compared to what's indicated on the switch itself.

◀

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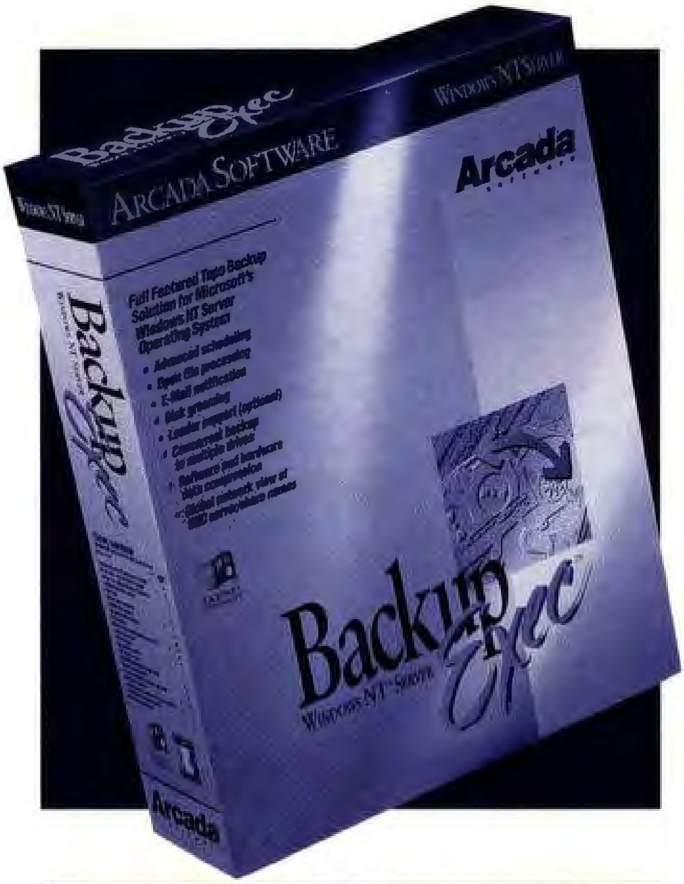

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ROLL CALL OF CD-ROM DRIVES

VENDOR	MODEL	DRIVE SPEED	PRICE	ADAPTER PRICE	DRIVE VENDOR	SEQUENTIAL THROUGHPUT (KBPS)	RANDOM ACCESS (SECONDS)	CPU UTILIZATION (%) 150 KBPS	CPU UTILIZATION (%) 300 KBPS
DESKTOP									
CD Technology, Inc.	CD Porta-Drive T3401	Double	$500	$120	Toshiba	331.30	0.26	15.76	30.55
Chinon America, Inc.	CDX-535	Double	$795	$100	Chinon	301.40	0.31	7.85	41.88
CMS Enhancements	Platinum CD-ROM	Double	$620	$400	Chinon	303.80	0.40	7.31	41.69
CMS Enhancements	Platinum II CD-ROM	Double	$809	$391	Chinon	303.80	0.31	7.29	41.69
Digital Equipment Corp.	RRD43-FB	Double	$473	$149	Toshiba	301.00	0.49	19.93	50.43
Digital Equipment Corp.	RRD44-DA	Double	$549	$149	Toshiba	331.90	0.27	18.40	35.58
FWB, Inc.	hammerCD	Double	$749	N/A	Toshiba	331.40	0.26	15.22	29.04
Hitachi Home Electronics	CDR-1900SPC	Double	$670	$112	Hitachi	352.20	0.35	18.03	34.71
Hitachi Home Electronics	CDR-1950S	Double	$670	$112	Hitachi	301.00	0.32	8.87	42.54
Legacy Storage Systems, Inc.	Legacy CD-ROM 2x	Double	$575	$199	Toshiba	331.30	0.26	15.27	30.19
MacProducts USA	Magic CD Pro	Double	$459	$199	Toshiba	331.40	0.26	19.12	36.92
Mirror Technologies	Mirror CD ROM Drive	Double	$259	N/A	Toshiba	331.20	0.26	15.22	29.45
NEC Technologies, Inc.	MultiSpin 4X Pro	Quadruple	$995	$125	NEC	590.30	0.26	8.67	17.57
Peripheral Land, Inc.	PLI CD-ROM MS	Double	$743	$175	Toshiba	331.50	0.27	15.91	31.82
Philips Laser Magnetic Storage	CM206/10	Double	$200	Bundled	Philips LMS	301.00	0.43	21.38	48.85
BYTE Best Plextor	DM-5028 DoubleSpeed Plus	Double	$409	$60	Plextor	336.20	0.34	14.22	29.40
Reveal Computer Products	The Entertainer	Double	$399	Bundled	Panasonic	301.70	0.42	23.60	49.63
Todd Enterprises, Inc.	TCDR2XMS	Double	$670	$75	Hitachi	301.40	0.34	8.11	41.69
Toshiba America Info. Systems	TXM-3401E	Double	$545	$155	Toshiba	331.10	0.29	15.34	29.02
Toshiba America Info. Systems	TXM-4101L	Double	$360	$155	Toshiba	301.50	0.52	19.75	50.08
PORTABLE									
CD Technology, Inc.	CD Porta-Drive T4100 [1]	Double	$400	$20	Toshiba	300.90	0.51	19.13	49.79
Disctec	RoadRunner Express CD-2x	Double	$499	N/A	Mitsumi	301.60	0.36	58.79	73.83
Liberty Systems, Inc. [2]	115 Series CDN-P	Triple	$699	N/A [3]	NEC	311.00	0.33	45.83	94.34
Micro Solutions, Inc.	Backpack [4]	Double	$499	N/A	Mitsumi	112.30	0.39	99.22	99.22

BYTE Best = BYTE Best [1] SCSI port [2] EPP (enhanced parallel port) [3] Price includes SCSI and EPP. Drive speed: Double ◎ Triple ◎ Quadruple ● N/A = not applicable.

FEATURES CONTINUE ON NEXT PAGE

VIDEO SKIPPED FRAMES 8-BIT FILE	TEXT SEARCH (SECONDS) ONE-WORD	BOOLEAN	FEATURES SCORE	EASE OF USE	BUFFER SIZE (KB)	DEVICE DRIVERS WINDOWS 3.1	WINDOWS NT	OS/2	MACINTOSH	OTHER	INTERFACE TYPE [b]
0 of 912	15.23	15.08	▲▲▲	▲▲	256				✔		SCSI-2
0 of 912	16.63	16.89	▲▲▲	▲▲▲▲	320	✔	✔		✔		SCSI-2
0 of 912	16.37	16.74	▲▲▲	▲▲▲▲	256	✔		✔	✔		SCSI-2
0 of 912	16.77	16.71	▲▲▲	▲▲▲▲	256	✔		✔	✔		SCSI-2
0 of 912	16.70	16.73	▲▲▲▲	▲▲▲	64	✔		✔	✔	Novell NetWare 3.x and higher	SCSI-2
0 of 912	16.24	15.29	▲▲▲▲	▲▲▲	256	✔		✔		Novell NetWare 3.x and higher	SCSI-2
0 of 912	15.76	15.33	▲▲	▲▲▲▲	256				✔		SCSI-2
0 of 912	16.86	16.76	▲▲▲	▲▲▲	128	✔		✔			Proprietary SCSI
0 of 912	16.76	16.75	▲▲▲	▲▲▲	256				✔		SCSI-2, optional EPP
0 of 912	15.20	15.42	▲▲▲▲	▲▲▲	256	✔	✔	✔		Novell NetWare 4.0	SCSI-2
0 of 912	15.35	15.37	▲▲▲	▲▲▲	256	✔	✔	✔	✔	Novell NetWare 3.11 and higher	SCSI-2, optional EPP
0 of 912	15.55	16.59	▲▲▲	▲▲▲	256		✔	✔	✔		SCSI-2
0 of 912	8.69	9.52	▲▲▲	▲▲▲	256	✔	✔	✔	✔		SCSI-2, optional parallel port
0 of 912	16.55	16.70	▲▲▲	▲▲▲	256	✔	✔	✔	✔		SCSI-2
0 of 912	16.84	16.85	▲▲	▲▲▲	64	✔	✔	✔			Proprietary SCSI
0 of 912	15.09	15.06	▲▲▲	▲▲▲	64	✔	✔	✔	✔	Novell NetWare 3.2 and higher	SCSI-2, optional EPP
0 of 912	16.76	16.76	▲▲	▲▲	64	✔					Proprietary SCSI
0 of 912	16.03	16.81	▲▲▲	▲▲▲	256	✔	✔	✔	✔		SCSI-2, optional IDE
0 of 912	15.31	15.23	▲▲▲	▲▲▲▲	256	✔	✔	✔	✔		SCSI-2
0 of 912	19.38	19.51	▲▲▲	▲▲▲	64	✔	✔	✔	✔		SCSI-2
0 of 912	17.06	17.53	▲▲▲	▲▲▲	64				✔		SCSI-2
774 of 912	26.79	36.08	▲	▲▲	32	✔					EPP
854 of 912	24.94	32.19	▲▲▲	▲▲▲	256	✔	✔	✔	✔		SCSI-2
897 of 912	39.53	44.62	▲	▲▲▲	32	✔		✔			EPP

Excellent ▲▲▲▲ Good ▲▲▲ Fair ▲▲ Poor ▲ ✔ = yes.

[a] Test via standard parallel; test drive would not run with EPP.

[b] SCSI-2 drives support SCSI-1 drives; EPP drives support standard parallel.

ROLL CALL OF CD-ROM DRIVES

VENDOR	MODEL	SCSI ADDRESSING	SUPPORT FAST SCSI	SCSI TERMINATION	SCSI ID SELECTOR	CD LOADER	MODES SUPPORTED: AUDIO CD	CD-ROM XA	CD-I
CD-ROM DRIVES									
CD Technology, Inc.	CD Porta-Drive T3401	8		External	Push button	Caddy	✔	✔	
Chinon America, Inc.	CDX-535	16		External	DIP switch	Caddy	✔	✔	
CMS Enhancements	Platinum CD-ROM	32	✔	External	Rotary switch	Caddy	✔	✔	
CMS Enhancements	Platinum II CD-ROM	32	✔	External	Push button	Caddy	✔	✔	
Digital Equipment Corp.	RRD43-FB	8		External	Jumpers	Tray	✔	✔	✔
Digital Equipment Corp.	RRD44-DA	8		External	Push button	Caddy	✔	✔	✔
FWB, Inc.	hammerCD	8		External	Push button	Caddy	✔	✔	
Hitachi Home Electronics	CDR-1900SPC	N/A		N/A	N/A	Caddy	✔	✔	✔
Hitachi Home Electronics	CDR-1950S	8- and 16-bit		Internal	DIP switch	Caddy	✔	✔	✔
Legacy Storage Systems, Inc.	Legacy CD-ROM 2x	8		External	Push button	Caddy	✔	✔	✔
MacProducts USA	Magic CD Pro	8	✔	External	Push button	Caddy	✔	✔	✔
Mirror Technologies	Mirror CD ROM Drive	8	✔	External	Push button	Caddy	✔	✔	✔
NEC Technologies, Inc.	MultiSpin 4X Pro	16	✔	Internal	Push button	Caddy	✔	✔	
Peripheral Land, Inc.	PLI CD-ROM MS	16	✔	External	Rotary switch	Caddy	✔	✔	✔
Philips Laser Magnetic Storage	CM206/10	N/A		N/A	N/A	Tray	✔	✔	✔
Plextor	**DM-5028 DoubleSpeed Plus**	**8**	✔	**External**	**Rotary switch**	Caddy	✔	✔	
Reveal Computer Products	The Entertainer	N/A		N/A	N/A	Tray	✔	✔	
Todd Enterprises, Inc.	TCDR2XMS	8	✔	Internal	DIP switch	Caddy	✔	✔	✔
Toshiba America Info. Systems	TXM-3401E	8		External	Push button	Caddy	✔	✔	✔
Toshiba America Info. Systems	TXM-4101L	8		External	Push button	Caddy	✔	✔	✔
CD-ROM PORTABLES									
CD Technology, Inc.	CD Porta-Drive T4100	8		External	Push button	Tray	✔	✔	
Disctec	RoadRunner Express CD-2x	N/A		N/A	N/A	Tray	✔	✔	
Liberty Systems, Inc.	115 Series CDN-P	16	✔	Internal	Rotary switch	Caddy	✔	✔	✔
Micro Solutions, Inc.	Backpack	8		External	Software selectable	Tray	✔	✔	

= BYTE Best   N/A = not applicable.   ✔ = yes.   Caddy   Tray

READ MULTISESSION	READ AUDIO CD AS DIGITAL	SINGLE-SESSION PHOTO CD	MULTISESSION PHOTO CD	ISO-9660	DIMENSIONS (INCHES) DEPTH	WIDTH	HEIGHT	FCC CLASS	WARRANTY (YEARS)	PHONE	TOLL-FREE PHONE	INQUIRY NO.
✔	✔	✔	✔	✔	9.0	5.0	2.0	B	1	(408) 752-8500	None	1105
✔	✔	✔	✔	✔	9.88	6.0	2.25	B	1	(310) 533-0274	(800) 441-0222	1106
✔		✔	✔	✔	10.50	9.75	2.25	B	1	(714) 222-6000	(800) 237-2707	1107
✔		✔	✔	✔	11.0	10.0	3.25	B	1	(714) 222-6000	(800) 237-2707	1108
✔	✔	✔	✔	✔	10.40	8.0	2.10	B	3	(800) 722-9332	(800) 344-4825	1109
✔	✔	✔	✔	✔	8.75	9.40	2.75	B	3	(800) 722-9332	(800) 344-4825	1110
✔	✔	✔	✔	✔	9.75	9.50	2.25	A and B	2	(415) 474-8055	None	1111
✔		✔	✔	✔	13.50	7.10	2.0	B	2	(310) 537-8383	(800) 369-0422	1112
✔	✔	✔	✔	✔	13.50	7.10	2.0	B	2	(310) 537-8383	(800) 369-0422	1113
✔	✔	✔	✔	✔	13.25	6.0	2.25	B	1	(508) 435-4700	(800) 966-6442	1114
✔	✔	✔	✔	✔	11.0	9.75	2.25	B	1	(512) 476-5295	(800) 622-8721	1115
✔	✔	✔	✔	✔	10.75	9.60	2.0	B	1	(612) 830-1549	(800) 654-5294	1116
✔	✔	✔	✔	✔	14.60	7.30	2.0	B	2	(708) 860-9500	(800) 632-4636	1117
✔	✔	✔	✔	✔	8.0	9.0	2.40	B	1	(510) 657-2211	(800) 288-8754	1118
✔	✔	✔	✔	✔	8.19	5.75	1.63	B	1	(719) 531-0188	(800) 593-4081	1119
✔	✔	✔	✔	✔	10.43	7.76	2.20	B	1	(408) 980-1838	(800) 886-3935	1120
✔	✔	✔	✔	✔	7.71	1.62	5.74	B	1	(818) 704-6300	(800) 669-3559	1121
✔		✔	✔	✔	13.75	6.0	2.13	B	3	(718) 343-1040	(800) 445-8633	1122
✔	✔	✔	✔	✔	9.80	8.70	2.70	B	1	(714) 457-0777	None	1123
✔	✔	✔	✔	✔	10.13	8.0	2.13	B	1	(714) 457-0777	None	1124
✔	✔	✔	✔	✔	8.0	6.0	1.0	B	1	(408) 752-8500	None	1125
✔	✔	✔	✔	✔	10.25	6.50	2.40	B	1	(407) 671-5500	(800) 553-0337	1126
✔	✔	✔	✔	✔	9.0	6.75	1.78	B	1	(408) 983-1127	None	1127
✔	✔	✔	✔	✔	10.50	6.0	2.25	B	1	(815) 756-3411	(800) 890-7227	1128

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Silicon for 3-D

The Glint chip brings inexpensive 3-D graphics processing to PCs

PETER WAYNER

The arrival of low-cost, high-power video chips capable of rendering complex 3-D scenes will, in the next three years, transform the average desktop PC into a sophisticated graphics workstation. The flat, 2-D components of today's user interfaces and applications will be replaced by fully functional 3-D objects that can move and rotate in any direction. Games, slide presentations, virtual reality—even spreadsheets—will never be the same.

One of the first inexpensive 3-D chips available to video board manufacturers is the Glint 300SX from 3Dlabs (San Jose, CA). The chip performs all the standard operations of the current GUI accelerator video boards and renders up to 300,000 Gouraud-shaded polygons per second. Such a level of performance isn't possible from today's CPUs alone. You can thus think of the 300SX as a specialized extension of your CPU dedicated to 3-D tasks.

3Dlabs estimates it will sell its chip at $150 apiece in suitable quantities. When the 300SX is bundled with relatively more expensive memory, you'll be able to add sophisticated 3-D graphics capabilities to a PC for well under $1000.

Inside Glint

At the highest level, the architecture of the 300SX is not much different from that of today's GUI accelerators. When the main processor needs to draw a triangle, for instance, it sends a list with the color and the three vertices of the triangle across the PCI (Peripheral Component Interconnect) bus to the 300SX. The compactness of this simple message allows the main processor to go on to other work while the 300SX interprets the message and changes the correct pixels on the screen.

The 300SX, like GUI accelerators, relies on an efficient memory interface to a frame buffer that contains the values of each pixel on the screen. The chip uses the interface to stream large sections of the screen image through its pipeline. The faster this is done, the more responsive a screen is.

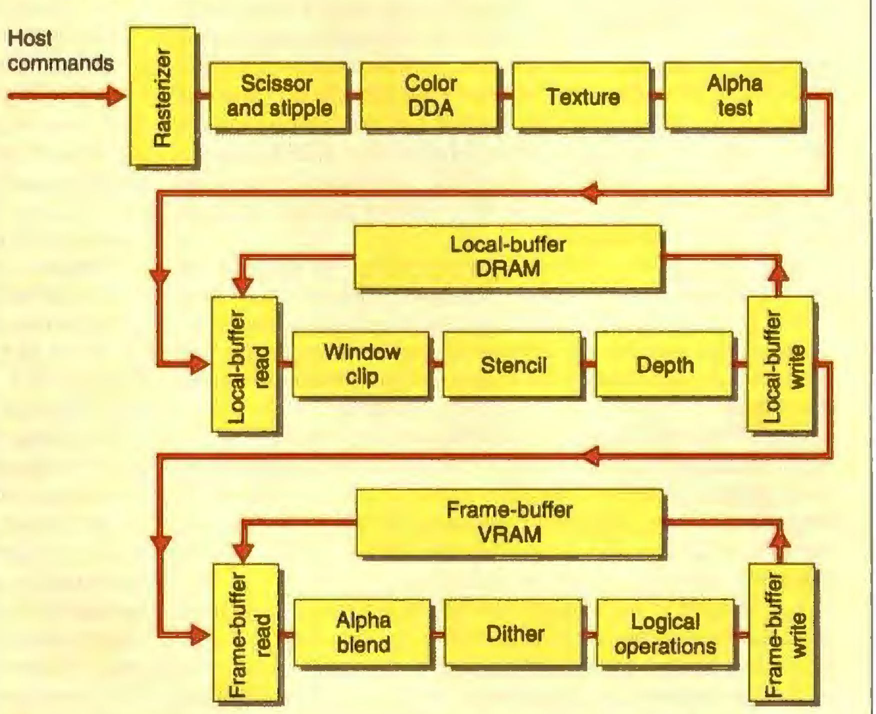
But the similarities stop at this level. Most GUI accelerators can draw only lines and rectangles as well as copy parts of a screen from one section of the memory to another. This is good enough for 2-D work, but not for 3-D applications. The 300SX, however, can do more. In addition to 2-D manipulations, it can draw properly shaded polygons in a 3-D environment. It achieves 3-D realism by making sure that only the closest polygon to the screen remains visible to the user. The rest disappear. The chip can also add special effects, such as fog.

The Local Buffer

The 300SX has access to two different buffers for constructing an image. The main buffer holds a description of the color of each pixel on the screen. It can contain up to 32 bits per pixel: 8 bits each for red, green, and blue, and 8 bits for an alpha-blending constant used for transparency. This buffer is usually stored in fast VRAM, which contains two ports so that the image can be sent to the monitor at the same time the 300SX is changing it.

The other buffer, called the local buffer, contains up to 48 bits of additional information for each pixel. Up

The 300SX Pipeline



At the front of the pipeline, the rasterizer creates a list of pixels for each primitive received from the host system. Each pixel thus generated visits the various stages, where it is shaded, given texture, checked for visibility, and written to the frame buffer. Using the information in the frame buffer, the display system outputs the rendered scene to the screen.

to 32 bits of this buffer is used as a z-buffer, which contains the depth of the last pixel drawn at a particular location. When each primitive is drawn by breaking it into pixels, the depth (or z-coordinate) is compared with the depth of the pixel that is already drawn in the frame buffer. If this new pixel is closer to the viewer, then it is drawn into the frame buffer. If it is farther away and effectively eclipsed by the previously drawn object primitive, then the new pixel is ignored.

The rest of the bits of the local buffer can be used to block out parts of a screen through stenciling masks. A common use of this technique is to draw cutout letters and render a scene that is visible only through these cutouts. In this case, the description of the letters is placed in the local buffer, and this controls the appearance of the scene. When the 300SX attempts to render a pixel, it checks with these bits to see if the pixel will be visible.

The Graphics Pipeline

The features of the 300SX are implemented by functional units arranged in a long pipeline through the chip. These units operate relatively asynchronously and are linked by buffered channels that route the information from one unit to another. The various steps in the pipeline are shown in the figure "The 300SX Pipeline."

At the beginning of the pipeline is a rasterizer, which takes the description of the graphics primitive (e.g., the three corners of a triangle) and converts it into a list of pixels. The 300SX will also antialias a primitive by computing the partial area covering a pixel, breaking the pixel up into either a 4- by 4- or an 8- by 8-subpixel grid. The chip uses this fractional information to better determine how much color to apply at the boundaries of the primitives. In effect, it blurs the edges slightly to reduce their jaggedness and to smooth animation.

Each pixel then travels to each functional unit along the pipeline. The first unit performs two functions: the scissors test, which checks to see if the pixel fits within the absolute boundaries of the frame buffer, and the stipple test, which checks to see if the pixel lies on predefined dashed lines or meshes. Next in line, the Color DDA unit computes the correct color of the pixel based on the colors at the corners of the polygon. The 300SX uses the Gouraud-shading model to average the color based on the position of the pixel in the polygon. This ensures that two adjacent polygons meet smoothly.

After color shading comes texture mapping. The hardware in this unit draws a texture onto the polygon by determining which spot in the texture pattern is to be drawn at each particular pixel. Texture maps are often digitized photographs that, when mapped onto a 3-D surface, lend a great deal of realism to rendered scenes. A complete 3-D model of every pebble, bump, and rough spot in a tree, for example, is just too complicated to be rendered by today's technology. Instead, a rough polygonal approximation is used, and the texture is projected onto it. The 300SX computes the correct texture color by interpolating among eight different versions. A later version of the chip, the 300TX, should provide true perspective correction for tilted planes.

At this point in the pipeline, the 300SX uses the information from the local buffer to remove hidden pixels. If the z-buffer shows that a pixel would be covered by a previously drawn pixel, then the covered pixel disappears from the pipeline. Similarly, pixels that may be blocked by a stencil or a window mask are also removed.

After the local buffer is accessed, the pixels are ready to be drawn into the frame buffer. There are three steps that control how a pixel is added to the frame buffer. The alpha value (i.e., the last 8 bits of the 32 bits assigned to each pixel) determines the transparency of the pixel and is used to blend the new pixel into the previously existing pixel in the frame buffer. The 300SX can also dither the pixel by finding two or more colors that approximate the desired color if it is not available in the current palette. Finally, the basic logical operations of OR, AND, and XOR are used to control the drawing of new pixels into the frame buffer.

Division of Labor

The 300SX does many things for the rendering of polygons, but it is important to recognize what it does not do. Although it draws shaded polygons and uses a z-buffer to determine which parts of the polygons are visible, this is only half of a 3-D graphics system. The chip does not actually compute the locations of a polygon's corners or do any of the lighting model calculations necessary to convert an image into the list of shaded polygons.

In graphics parlance, the 300SX provides the back end—the rendering half—of a 3-D graphics pipeline, leaving the host CPU to perform geometry calculations. This is the same tack taken by Hewlett-Packard in its 3-D graphics systems.

The 300SX does not perform geometry calculations for a number of reasons. First are the practical ones. Although a graphics pipeline that does both geometry calculations and rendering is usually faster than one that performs only rendering, it is also much more expensive to implement. Besides, most of the computations necessary to rotate, scale, and project objects are easily accomplished by standard CPUs. The calculations normally involve heavy floating-point arithmetic, which is best provided by a general-purpose CPU. The high-speed frame-buffer juggling that the 300SX performs is not necessary at this level. A final practical advantage of letting the host CPU perform geometry calculations is that it allows 3-D performance to scale along with the performance of the CPU.

The 300SX also leaves geometry to software to avoid political problems. While most 3-D companies agree on the basic steps needed to draw 3-D objects on a screen, they do not agree on the format or on many of the geometric models used to represent 3-D objects. OpenGL is a popular standard developed by Silicon Graphics and adopted by companies including IBM, DEC, Intergraph, and Novell. Microsoft, in fact, has made OpenGL the standard 3-D graphics API for Windows NT and other versions of Windows. Sun Microsystems and others, however, have other ideas about graphics APIs.

By leaving the geometry calculations to software, the 300SX avoids all API wars. Any graphics API can use the rendering capabilities of a 300SX on the back end by first using its own software-based geometric engine to convert the scene into a list of shaded polygons and lines and then passing this list to the 300SX. Such a system also lets the geometry engine evolve in the event that more complicated lighting models or other improvements are developed.

By providing both 2-D and 3-D acceleration, the 300SX is positioned to work with today's GUIs as well as tomorrow's virtual reality–based interfaces. As chips like the 300SX become more common in video display adapters, software vendors will become bolder in incorporating 3-D capability into their products. The time is not too distant when 3-D graphics will be as common as GUI accelerators. ■

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

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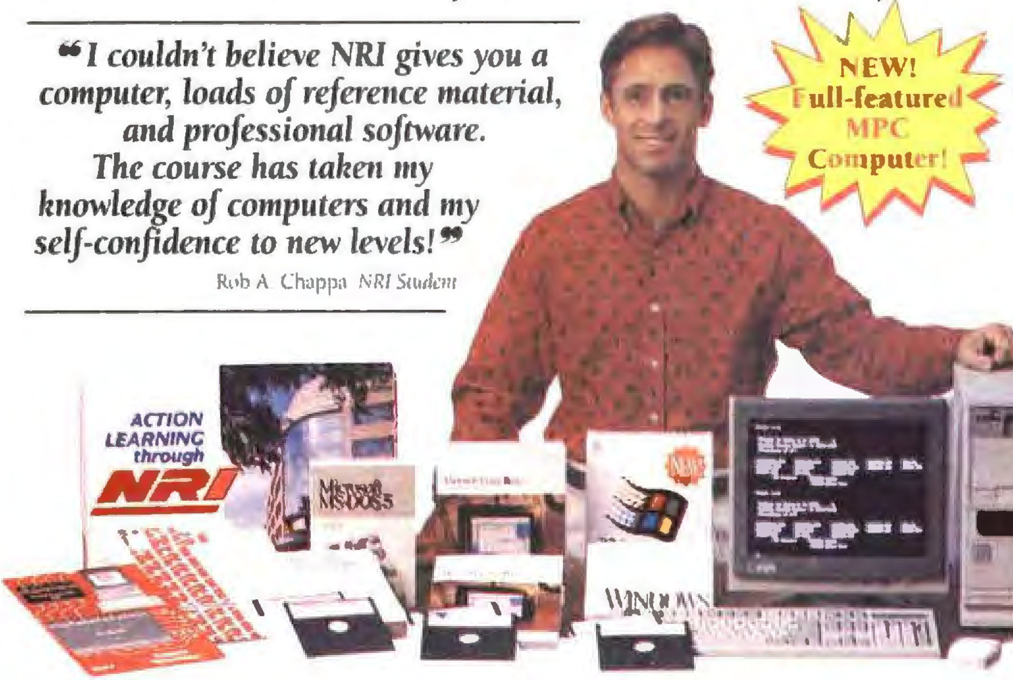

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The Fix Is In for Chicago

Microsoft has added many robust features to the successor to Windows 3.x

JON UDELL

Chicago's new shell will likely capture the lion's share of attention when the product finally ships. But ultimately the shell is just one—admittedly crucial—Win32 application. If you'll be deciding whether, or how rapidly, to upgrade hundreds or thousands of Windows 3.1 seats to Chicago, you can treat the shell as an à la carte item. Users who find its features easily discoverable can jump right in; users who don't can be weaned gradually from the tried-and-true Program Manager, which, like any Win16 application, should run just fine on Chicago.

Decision makers won't justify the inevitable pain of the most radical Windows upgrade ever solely on the basis of a better shell. They'll need convincing evidence that Chicago will be a stable, compatible, multitasking, manageable, networkable successor to Windows 3.x. To address these concerns, Microsoft has built a lot of new plumbing into Chicago. Here are some of the highlights.

Stability

The key point is that Chicago, like NT, separates Win32 applications (and some supporting subsystems) into private address spaces. What Win32 applications? That's a fair question, given that even Microsoft has yet to step up to the plate with Win32 (or even Win32s) versions of Word and Excel. But Chicago will be able to run on many more machines than Windows NT can, so it's reasonable to expect to see a significant move to Win32 during 1995.

Chicago systems running Win32 applications should prove much more stable than Chicago or Windows 3.x systems running mostly DOS and Win16 applications. Initially, however, Chicago *will* have to support lots of DOS and Win16 applications. These should run more stably, too, for several reasons. Chicago tracks resources such as memory, file handles, and GDI (Graphical Device Interface) objects on a per-thread basis and runs each DOS and Win16 application on its own thread. This arrangement means Chicago can reclaim these resources when a legacy application goes belly-up. If a DOS application crashes, reclamation occurs right away. If a Win16 application crashes, cleanup is deferred until all running Win16 applications quit: Windows 3.x lacks memory protection, and some Win16 applications grab resources owned by others, so aggressive resource recovery won't work.

There's also nice improvement for plain DOS multitasking. As with Windows 3.x, multiple DOS boxes share the VM (virtual machine) that runs the DOS system code. Corruption of that VM's memory in Windows 3.x was a disaster for Windows itself and for all other DOS VMs. In Chicago, Win16 and Win32 applications are no longer vulnerable if—as is recommended—you don't use any real-mode drivers. While DOS boxes are still vulnerable, you can opt, at some cost in performance, to guard the memory they share using read-only page protection. For a valid write, the system temporarily switches the protection of the destination page to read-write.

What about VxDs (virtual device drivers)? These scary denizens of ring 0, which is the highest privilege level on an 80x86 CPU, play an even bigger role in Chicago. They handle caching, installable file systems, networking, communications, and much more. Like NetWare NLMs (NetWare loadable modules), but unlike Win32 applications and system services, VxDs have full run of the machine and can get into trouble.

Windows 3.x Problem	Chicago Solution
Runs unstably	• separate the Win32 address spaces • clean up after failed applications • write-protect memory in DOS VMs • validate VxD parameters
Multitasks poorly	• schedule Win32 apps preemptively • avoid running with interrupts disabled
Display drivers are monolithic	• layer minidrivers on DIB engine
Hard to manage	• fully describe system in registry • RPC-enable registry viewer/editor • export registry data with SNMP or DMI
Works poorly with NetWare	• include 32-bit NetWare redirector • use IPX/SPX as default transport • support UNC for NetWare
Works poorly on WANs	• include 32-bit TCP/IP • support DHCP • support WINS

Microsoft's answer is that the debug version of the Chicago kernel will validate parameters passed to VxDs and so help developers spot trouble before VxDs reach the field. That's a start, but it won't flush out all the nasty interactions that can crop up in the field. Moreover, as developers rewrite their VxDs to make them pageable and dynamically loadable and unloadable, they're going to discover and want to use other new tricks VxDs can do in Chicago—such as calling Win32 safely in a special context known as *appy time*, or manipulating the scheduler.

To ensure that all the new VxDs that are bound to appear behave in an orderly way, Microsoft could offer to certify them, as does Novell with its NLMs. A complementary approach would be to give developers a flexible, comprehensive, safe framework for writing VxDs. This approach would also help make Chicago and NT drivers source code compatible—something that Microsoft promised but won't in all cases be able to deliver.

Compatibility

Microsoft says that Chicago will run any application or device driver that DOS or Windows 3.x can run. That's possible because Chicago includes the same components that DOS and Windows 3.x use to run those applications and drivers. It's a hybrid of 16- and 32-bit technologies, and some major pieces—notably printing and display—remain firmly rooted in the 16-bit world, a fact that raises legitimate concerns among critics.

But it's worth noting that, despite their mixed lineage, these Chicago subsystems in some ways surpass what the purely 32-bit NT offers today. In the new printing model, a stream of GDI commands spools to an *enhanced metafile* and then plays back through GDI on a background thread. This scheme ensures rapid return of control to the user. For developers, it will automate the most popular reason for using threads: to implement background printing.

The display subsystem features a DIB (device-independent bit map) engine that, when pointed at screen memory, can serve as a flat-frame-buffer display driver. Because the display drivers that ship with Chicago will use the DIB engine as a generic core, they should be relatively small and straightforward to implement, like NT's network card and storage *minidrivers*. As a result, driver developers can hook just the calls their hardware will accelerate. To create the fiction of a flat frame buffer when the graphics hardware is actually bank-switched, as are most SVGA-class cards, Chicago supplies a mapper to which DIB-engine-based display minidrivers can mate their bank-switching code. That the DIB engine is a 16-/32-bit hybrid, rather than the pure 32-bit entity the GDI team would have preferred to create, underscores Chicago's commitment to 16-bit compatibility. Given that constraint, the advances in printing and display are promising.

Multitasking

The most troubling aspect of Chicago's 16-bit compatibility is the Win16Lock, a semaphore that serializes access to the 16-bit code that Chicago inherits from Windows 3.x. Both Win16 and Win32 applications must acquire the semaphore to access the windows and GDI resources it guards, so both are vulnerable to delay should a Win16 application fail to yield. Win32 threads, since they're preemptively multitasked, hold the semaphore only briefly, so they shouldn't block other threads for more than a millisecond or so. But won't Win32 applications monopolize the semaphore during lengthy print jobs? Microsoft claims not, because the print spooler that feeds the enhanced metafile to GDI for rendering is a 32-bit, preemptively multitasked entity that grabs and frees the lock on a per-GDI-call basis.

Armchair operating-system designers may love to debate Chicago's multitasking design, but users just want results. One of the most wanted results is the ability, lacking in Windows 3.x, to handle demanding background communications. The migration of network and disk drivers to protected mode will help alleviate Windows 3.x's problems with high interrupt latency, Microsoft says, as will a concerted effort to identify and tune the parts of the system that were disabling interrupts for excessively long periods.

Management

Chicago's manageability flows from its deep and comprehensive support for Plug and Play. At boot time, Chicago enumerates

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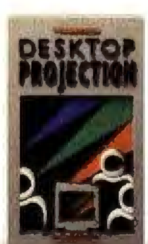

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all buses and devices on the system and records these in the system registry, so it knows a lot about the hardware it's running on, and that lays a good foundation for system management. The RPC-enabled (remote procedure call) registry editor will enable remote monitoring (and in some cases reconfiguration) of Chicago systems. The registry data will also be exportable to other management tools using SNMP, DMI (Desktop Management Interface), and potentially other protocols.

What's lacking, unfortunately, is an equivalent way to manage software. Chicago's performance-monitoring tools and procedures aren't yet on a par with their NT counterparts, and they may still not be when the system ships. The event-logging APIs that NT applications and drivers can use to record status and error information in the registry don't exist at all in Chicago. That Chicago sacrifices Win32 features such as Unicode, asynchronous I/O, and 32-bit GDI coordinates is troubling, but the loss of event logging is really tragic. Managing software is ultimately an even bigger problem than managing hardware. A golden opportunity to lay a foundation for software management is slipping through Microsoft's fingers.

Networking

Windows 3.x's poor network citizenship, particularly on NetWare LANs, has been an endless annoyance. Chicago will bring major improvements in this area, starting with a bundled NetWare redirector that integrates seamlessly with native Windows file- and print-sharing services. The separate NetWare dialog boxes of Windows for Workgroups 3.11 are no more, and UNC (Universal Naming Convention) works the same way for Windows and NetWare resources. New smarts in the redirector should end the maddening Windows 3.x propensity to hang upon losing contact with a NetWare server, Microsoft promises.

A further sign of Windows/NetWare détente is the fact that Chicago's default network protocol will be Novell's IPX/SPX. Chicago's internal peer server can also piggyback on the security services of both NTAS (NT Advanced Server) and NetWare servers. Thanks to *pass-through* authentication, you can share your C drive with user-level security, rather than the less-discriminating share-level security available in Windows for Workgroups 3.11. This nifty innovation leverages the user databases maintained by NTAS and NetWare.

Chicago also offers a systemwide log-in manager, called *master key*. It can transmit a single set of credentials, which may be validated locally by Chicago or remotely by NTAS or NetWare, to many password-protected services. The mail client will be the first to exploit the master-key API, but other applications can, too.

Although Chicago defaults to IPX/SPX, it will include the new TCP/IP features that are now (in June) available in beta form for Windows for Workgroups 3.11 and NT Daytona. Specifically, Chicago is a DHCP (Dynamic Host Configuration Protocol) client and a WINS (Windows Internet Naming Service) client. DHCP, which governs automatic, on-the-fly allocation of IP addresses, radically simplifies address management in large TCP/IP networks. WINS, which maps between network names and IP addresses, likewise simplifies the administrative effort required to support browsing for named resources on routed networks. The current plan is to offer DCHP and WINS servers only on NT. I hope these servers will show up on Chicago as well. ■

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

Object-Oriented COBOL

The great-granddaddy of procedural languages may soon be stepping out in its new object-oriented shoes

RICK GREHAN

COBOL may be, depending on your opinion of it, the Frankenstein or the Lazarus of computer languages. Either by its own inertia or by virtue of its structure, it is unkillable. Opinions aside, it is mere fact that there is a great deal of COBOL code out there being executed. Estimates run to billions of lines of code, representing untold programmer-years (possibly programmer-decades or even programmer-centuries) of work.

On the one hand, there's the force created by that mass of working code. It works, so common sense suggests that you leave it be. On the other hand, new technologies in hardware and software appear daily. Entrepreneurial sense suggests that an enormous benefit would be derived from adapting those existing programs to the new technologies. Such is the dilemma facing COBOL programmers as they survey the object-oriented landscape.

Cautious Steps

COBOL programmers face maintainability with more seriousness than other programmers. Viewing the learning cliff climbed by C programmers as they assault the C++ summit, COBOL programmers might reasonably argue that the C++ world spends all too much time looking forward and not enough looking back. Their complaint is not that C++ compilers are unable to support C code, but that no easy path is provided to turn a C program into a C++ program.

Because COBOL programs are running critical applications such as payroll and general ledger postings, they represent corporate activities that *cannot* die, lest they take the corporation with them. Hence, the community of COBOL programmers is willing to enter the object-oriented world only in a series of small, well-orchestrated steps.

Dan Clarke, Object Oriented Product Manager of Micro Focus, indicates that what the COBOL community wants is twofold. It wants some reassurance that there will be extensions to COBOL that will allow it to participate in the object-oriented game. Simultaneously, it wants lots of reassurance that existing code won't get broken in the move.

The Job

ANSI is putting together a specification for OO (object-oriented) COBOL. Currently, only draft documents exist, and the shape of OO COBOL is necessarily in flux as meetings of the Object Oriented COBOL Task Group (X3J4.1, in ANSI-speak) continue.

Presently, the draft documents provide good descriptions of what OO COBOL class and method definitions will look like. There appears to be indecision as to whether OO COBOL will support single or multiple inheritance, but all the fundamental object pieces are there: classes, messages, encapsulation, and polymorphism. I was surprised at how robust the draft specification appeared, given that COBOL lacks some basic facilities you need to build object orientation.

Take, for example, the entire notion of object references. COBOL doesn't have pointers. Remember, this is a language whose developers were more interested in modeling the goings-on of financial calculation and bookkeeping than in developing clever abstractions of CPU addressing modes. Implementing objects, however, demands some form of *handle* data construct—that is, a small, single data item that references a larger data structure, usually built as a pointer to a pointer. No such notion exists in current COBOL; it will have to be infused into the language (via the `USAGE` clause, a modifier placed on a data description entry).

This is just the tip of the iceberg, however. How, while remaining as true as possible to the spirit of the COBOL syntax, could you outfit the language with object-oriented notions such as inheritance, methods, and instance data?

A Glimpse

A sample of what object-oriented COBOL code might look like appears in the listing. The listing is based on object-oriented extensions to COBOL that are now available from Micro Focus and are based on a draft put together by ANSI's Object Oriented COBOL Task Group (X3J4.1). You can get still more information from Ray Obin's book *Object Orientation: An Introduction for COBOL Programmers*, available from Micro Focus Publishing; it includes a good description of Micro Focus's object-oriented extensions.

I cannot overemphasize this caveat: The code shown is based on draft proposals. Examine it with the understanding that there may be differences between what you read here and what will survive to the finalized specification (not due out until at least 1997). Nor do I intend to imply an endorsement of Micro Focus; I am using its extensions as a basis only, because they provide a snapshot of the current OO COBOL specification.

In any case, the listing shows an oversimplified definition of a savings account class, such as might appear in a banking application. The `CLASS-ID` phrase in the identification division not only names the class being defined but also indicates its superclass, if any, via the optional `INHERITS` phrase. In the listing, class `savings-account` is

Simple OO COBOL listing for a `savings-account` *class.*

```
IDENTIFICATION DIVISION.
CLASS-ID. savings-account INHERITS FROM account.
ENVIRONMENT DIVISION.
OBJECT SECTION.
CLASS-CONTROL
  account.
IDENTIFICATION DIVISION.
CLASS-OBJECT.
  DATA DIVISION.
  WORKING-STORAGE SECTION.
  01 total-number-of-accounts PIC 9999.
  01 savings-account-details.
    05 interest-rate PIC 99V9.
    05 minimum-balance PIC 9(6)V99.

  IDENTIFICATION DIVISION.
  METHOD-ID. reset-minimum-balance.
  DATA DIVISION.
  LINKAGE SECTION.
    01 new-minimum-balance PIC 9(6)V99.
  PROCEDURE DIVISION USING new-minimum-balance.
   P0001.
     MOVE new-minimum-balance PIC 9(6)V99.
     EXIT METHOD.
  END METHOD reset-minimum-balance.
END CLASS-OBJECT.

IDENTIFICATION DIVISION.
OBJECT.
DATA DIVISION.
  WORKING-STORAGE SECTION.
    01 interest USAGE OBJECT REFERENCE.
  IDENTIFICATION DIVISION.
  METHOD-ID. printStatement.
  DATA DIVISION.
  WORKING-STORAGE SECTION.
    01 displayInterest PIC -(9)9.99.
  PROCEDURE DIVISION.
  P0002.
    DISPLAY "Savings Account".
    INVOKE SUPER "printStatement".
    INVOKE interest "getValue" RETURNING tempInterest.
    MOVE tempInterest TO displayInterest.
    DISPLAY "Interest paid:" displayInterest.
    EXIT METHOD.
  END METHOD printStatement.
END OBJECT
END CLASS savings-account.
```

a subclass of class `account`. The `CLASS-CONTROL` paragraph, which follows, includes information that tells the compiler where it can locate implementation definitions of the `account` class. (Different OO COBOLs will use varying techniques to connect a class name to its implementation; in this case, I'm presuming that the compiler recognizes that there is only one `account` class, defined elsewhere in the source code.)

Notice that `CLASS-CONTROL` falls within the `OBJECT SECTION`, where class objects are defined. Don't confuse class objects with objects created by the class; only one class object exists per class. Data carried by the class object is *global data*—analogous to `static` data defined within C++ classes—accessible by all objects created by the class. In the listing, all savings accounts will have the same interest rate and minimum balance, so these data fields reside in the class object.

Similarly, methods defined for a class object manipulate only the class object's data. Again, the listing shows a `reset-minimum-balance` method that allows the program to set the `minimum-balance` field. Class objects also carry methods for creating and destroying instance objects, although none is shown in the listing. In this case, the compiler would create default methods for creating or destroying an object.

The definition of objects created by the class follows in the `OBJECT` paragraph. Data items in the `WORKING-STORAGE SECTION` are instance variables. In this case, the instance variable is a reference (a handle, if you will) to another object, an `interest` object. Note that data items that you would expect to find in all types of accounts—holder's name, address, social security number, and so on—will be defined in the parent object, `account`.

You can see some of the other elements of OO COBOL if you examine the `printStatement` method. First, you can create temporary variables (`displayInterest` in the example) that have lifetime and scope only within the method. Next, you can see that messages are sent to objects using the `INVOKE` verb. In the example, the `savings-account` object sends a `printStatement` message to its superclass and then sends a `getValue` message to the `interest` object. Finally, the invocation of the `getValue` method demonstrates how methods can return values. (The example doesn't show how values are passed into methods. You do this with the `USING` phrase, which you insert in the `INVOKE` command line prior to the `RETURNING` phrase. Ingoing arguments are listed after the `USING` gerund.)

Yet Unseen

There are more aspects of OO COBOL that I haven't covered here; they are nonetheless important. One is the notion of *interfaces*, a kind of inheritance mechanism that allows an object to present one set of methods to the outside world at one time and a separate set at another time. Interface definitions will also allow OO COBOL (with the help of translators) to provide a mechanism to produce an IDL (interface definition language) file. This is a necessary step for allowing COBOL objects to make themselves available to the outside world via, say, an object request broker as defined by CORBA (Common Object Request Broker Architecture).

At Boston's Computer Museum, upstairs in the People and Computers area, you'll find a bizarre exhibit that consists of a gray tombstone, the top of which has been sculpted to look like a sheep. Engraved on the tombstone is "COBOL"; it is dated 1961. According to museum employees, the exhibit was donated by someone who was working on the early specifications of COBOL and was convinced that the then-arguing members of the specifications committee (probably the CODASYL—Conference on Data Systems Languages—group) would never come to an agreement. Perhaps the donor thought the tombstone a joke; maybe he legitimately believed that COBOL would die early.

In fact, however, COBOL is no joke, and it's not dying. And if OO COBOL catches on, the language could be more alive than ever. ■

ACKNOWLEDGMENTS

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Optimizing Notes Replication

Proper scheduling makes a world of difference

DAVID YAVIN

Lotus promises that Notes will change the way companies do business, and judging by the product's explosive market growth, that promise is being taken very seriously indeed. But while Notes users enjoy increasingly pleasant user interfaces and sophisticated applications, network managers are discovering—the hard way—that running Notes efficiently is not always a simple task. In this discussion, I'll focus on an often-underrated cause of suboptimal performance: ineffective replication scheduling.

As a pioneer in distributed database technology, Notes may be the first and most visible product to suffer from large-scale scheduling woes. But with the advent of Novell's NetWare Directory Service and replication services for database servers from Oracle and Sybase, the issue of replication scheduling is moving to the forefront. Buyers and vendors alike should raise their level of awareness about this potentially critical issue.

From Concept to Reality

Today's global organizations need to provide their geographically distributed workgroups with the ability to access and manipulate shared information. But because of technical limitations and telecommunications costs, reliance on remote access to centrally located data is often not feasible.

Lotus Notes provides a conceptually simple and elegant solution to this problem: Identical copies of the shared Notes databases are distributed so that users do the bulk of their work on their local copies. What makes this solution work is the concept of *replication*, a process in which a pair of servers (or a server and a workstation) communicate to synchronize their respective copies of shared databases.

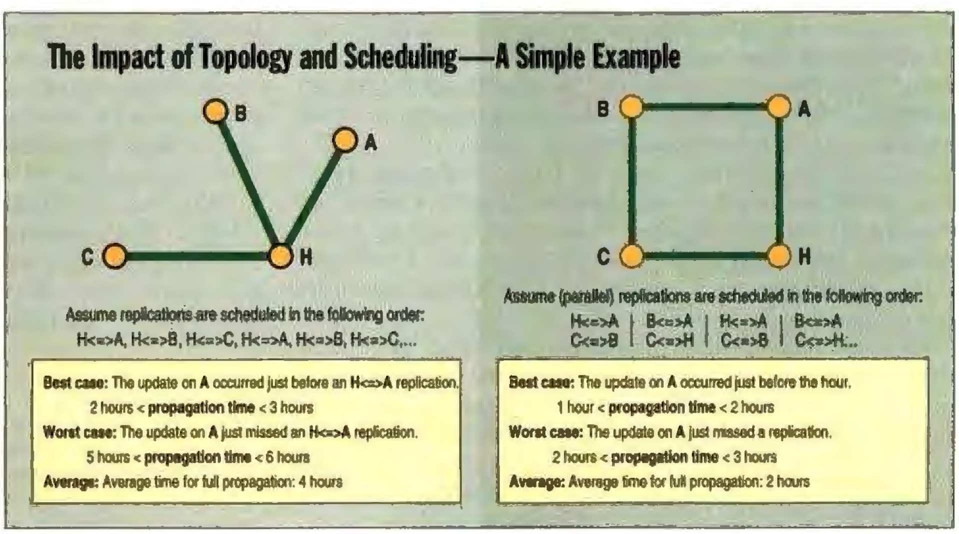
The concept is a simple one, but the road to effective implementation can be rocky. Notes is not immune to the usual WAN (wide-area network) ailments: international incompatibility of modems, unanticipated network congestion, and insufficient bandwidth. Fortunately, network managers know how to deal with these problems. But they've yet to acquire much experience with another problem that's critical to the health of a Notes network—replication scheduling.

Data propagation between servers is governed primarily by a fixed, network-wide replication schedule. That schedule, and the logical topology it implies, dictates how updates flow through the system. Organizations often underestimate the impact that the topology and replication schedule can have on the performance of Notes as an enterprise-wide application.

A well-planned flow, tailored to your specific infrastructure and usage patterns, avoids uneven server workloads and excessive network congestion. Topology and a replication schedule can be decisive factors in determining whether your Notes network can propagate shared information quickly enough to support the business processes that you want to automate. What follows is a scenario involving two organizations and their respective approaches to their replication problems.

Tales from the Trenches

Organization 1 is a round-the-clock operation. Its 75 offices, which are scattered around the world, are interconnected by the company's private network. Each office runs a Notes server. Rapid distribution of new information has always been crucial to many of the organization's business processes. *continued*



Given hourly replications that never last more than 1 hour, how long does it take to propagate an update from one server to the others? With a hub-and-spoke topology (left), the best case is between 2 and 3 hours, and the worst case is between 5 and 6 hours, yielding an average propagation time of 4 hours. But a square topology (right) is the optimal solution for four servers: The best case is between 1 and 2 hours, and the worst case is between 2 and 3 hours, for an average time of just 2 hours.

Organization 2 is a conglomerate of 15 loosely affiliated franchises located throughout Europe and the U.S. The franchises communicate over modems and rely on large volumes of shared (and frequently updated) information. Over time, several hundred Notes databases have evolved in this organization. Many of these databases are distributed to most or all of the servers, and some contain very large, frequently updated documents.

Organization 1 wanted a replication scheme that would propagate any update as soon as possible. Since replication between two servers transfers only those changes that have occurred since the two servers last replicated, and since communications costs on the private network were not an issue, organization officials figured they could replicate as frequently as they wished. They decided to use a hub-and-spoke topology. A central hub would initiate replications with all other servers every 45 minutes.

Organization 2 set up continental hubs, each one replicating with all the servers in its continent; the two continental hubs also replicated with each other. Replication scheduling was done more or less on an ad hoc basis, with no real master plan and no central control. The organization ended up with one daily replication scheduled between the hubs and some spokes, and two or three daily replications between the hubs and some other spokes. It was decided that the member of a pair of replicating servers to initiate the replication would be the one located in the office responsible for the phone bills.

Tips for Effective Scheduling

1. **Know the duration of your replications** to help avoid overly tight scheduling. Don't make unfounded assumptions concerning how long replications should take.

2. **Don't waste resources by replicating unnecessarily.** For instance, if you're a 9-to-5 operation, there's probably no point in having your New York server replicate with your Zurich server after lunch time (EST), since nobody in Zurich will generate or need information until the following morning.

3. **Seek to introduce parallelism**—that is, concurrent replications—into your scheme. Hub-and-spoke topology is simple, but it's also the least efficient method, since the hub can replicate with only one spoke at a time. The model of regional hubs that was implemented by Organization 2 shows one way of introducing concurrency. While the main hub is replicating with one regional hub, other regional hubs can simultaneously replicate with their spokes. To really appreciate the impact of topology and scheduling on turnaround time, see the figure.

Problems and Solutions

There was one basic problem with Organization 1's reasoning: the overhead involved in Notes replication. Replications—even empty replications that pull no data—are far from free. Both servers must expend a significant amount of time and resources just to identify whether any updates need to be pulled from the other server. It can easily take 30 seconds (and sometimes much longer) just to determine that nothing needs to be done, a burden when this process must occur more than 100 times per hour.

As a result, the hub was frequently failing to complete a calling cycle before it had to start a new round all over again, and some unfortunate spokes were consistently dropping off the end of the list and not getting replications. Moreover, all that replication activity put a significant strain on the hub and caused serious congestion.

Organization 2's replications were far from empty. Because of the large volume of data, the slow lines, and the replication overhead involved, a typical replication would last anywhere from 5 minutes to an hour, and sometimes longer. Insufficient awareness of the duration of replications throughout the system had caused many replications to be scheduled too close together; consequently, they were often lost or significantly delayed. Moreover, with replications being initiated by servers in five different time zones according to calling schedules that were not centrally coordinated—partly because Notes provides no tools for managing cross-time-zone scheduling—there were many scheduling conflicts; again, this resulted in lost or delayed replications.

Clearly, Organization 1 needed to cut back on the number of replications being made and take some of the load off the main hub. A comprehensive per-server and per-database analysis of replication showed that the highly active databases were not replicating to all the servers. The frequency of replications was therefore cut back wherever possible, and another hub was brought in to share the effort with the original hub.

Organization 2 needed a new, centrally planned schedule. A comprehensive analysis of the duration of replications with the various spokes helped indicate how large a window needed to be reserved for each replication to avoid conflicts. It also showed that the European hub could not efficiently handle replication with all its spokes, so regional hubs were introduced to help distribute updates more efficiently. The system was carefully mapped out, and, taking into consideration such issues as time-zone differences and usage patterns, a new, more efficient, and more reliable schedule was designed.

From Reliable Replication to Optimized Propagation

Successful tuning of a broken replication system is worth a pat on the back. But ensuring that updates get where they're needed is not enough. Updates must also arrive *when* they're needed. Again, the right topology and replication schedule are the key factors.

It's important to realize that design and maintenance of your replication scheme is neither a side issue nor a one-time thing. It is no less important than server administration, network management, and applications development.

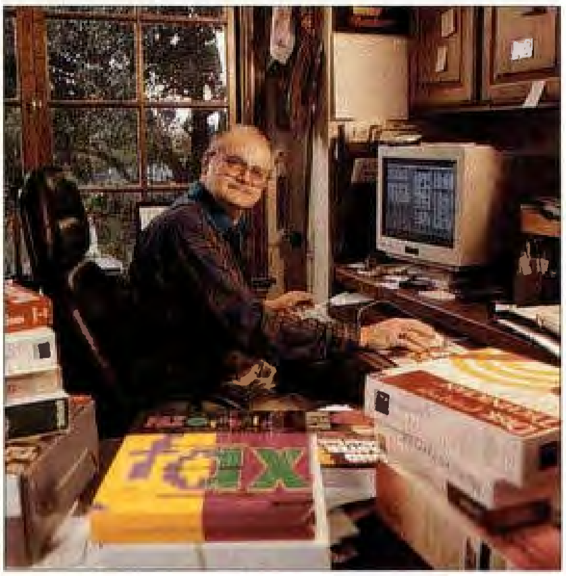
While you may need to seek outside help, especially for major overhauls, you should aspire to breed (or acquire) in-house expertise so that you can stay on top of your evolving Notes network. In addition, users of Notes and other distributed-data products have a right to expect much more powerful tools for analyzing and modeling data flows than are now available.

If your Notes network seems to be dragging its feet, it may be wearing the wrong topology/scheduling shoes. Custom-fit it with as good a pair as you can, and your organization and its Notes network just might start dancing to a smoother tune. ■

David Yavin holds a Ph.D. in mathematics from MIT in the fields of topology and combinatorics. Formerly a research fellow at the Max-Planck Institute of Mathematics in Bonn, Germany, he is president of DYS Analytics (Newton, MA) and has worked as a consultant to some of the world's largest Notes users on issues of topology and replication scheduling. He can be reached on the Internet as david@math.mit.edu or on BIX c/o "editors."

JERRY POURNELLE

Don't Blink



AMY ETRA © 1994

A wrestling match with a new Pentium machine and graphics card produces a winner: the fastest system yet at Chaos Manor

Pentafluge is back. This is the big Pentium system I wrote about in June. It features a DEC 3107 1.05-GB 9-millisecond SCSI hard drive, a Maxoptix T3-1300 optical drive, a Micronics Computers 60-MHz M5Pi motherboard, a Plextor Double Speed Plus CD-ROM drive, and a Distributed Processing Technology SmartCache III SCSI caching hard drive controller. It's all wonderfully fast. That's putting it mildly. This system is awesome, and you must understand I don't usually say things like that. This column is going to be full of superlatives. First, though, the problems.

Setting up Pentafluge was sheer frustration. If you're contemplating an act of penance, try SCSI. It took me two days; reading this may save you part of that.

Most of the problems were my fault in the sense that they were avoidable if I'd been more clever and had studied the situation better. However, I didn't want to spend my time studying badly written manuals. It was easier to just start in. Besides, systems work better after I've screamed at them.

My previous work left Pentafluge unable to find the optical drive and afflicted by mysterious glitches in the sound quality. I've since solved both problems.

The sound-quality glitches go away if you don't use Berkeley screen savers in Windows; if you must use them, set them up for internal speaker sound. When Berkeley screen savers try to employ high-quality wave-table sounds, they grab Windows resources and never quite let go of all of them. Over time, this degrades the sound in all your applications. At least one Berkeley technician claimed this was really a problem in the Creative Labs Sound Blaster drivers. I don't believe that, however, because I can get the problem when I'm running Logitech's SoundMan and ATI Technologies' sound-card system.

Pentafluge's early problems had more than one cause. There was shipment damage to the power supply and motherboard. It wasn't quite enough damage to have caused the problems, but we also had a bad SCSI cable, and apparently one of the devices wasn't properly terminated. SCSI systems are prone to termination problems, and the cable used for internal SCSI is subject to the problems of any ribbon cable, namely, that the connectors may not have been crimped on properly and aren't making full contact. We've had this difficulty since CP/M days. Contact enhancer liberally applied to the cable contacts seems to help. I've written about Stabilant 22—expensive but effective—before. This is another use for it.

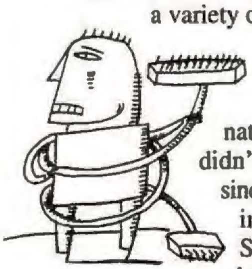
Wide ribbon cables can cause other problems. Big Cheetah (my 33-MHz 486DX/2 machine) recently developed screen flashes and other video glitches. When I opened him up, I found that the hard drive cable was blocking airflow to the video board. All my custom systems use PC Power & Cooling power supplies (see my June column), which have strong fans, but no fan can blow air through a cable. When you install SCSI devices, pay attention to cable routing.

One problem with setting up SCSI systems is that if something won't work, you don't know if it's the cable, or the termination, or the SCSI device itself. Fortunately, there's a remedy.

continued

Granite Digital makes a series of products, Active Diagnostic Terminators and Gold Diagnostic Cables, that let you diagnose cable problems.

For instance, you can connect one of your devices to the host computer using your own cable, terminate that device with one of their SCSIVue Terminators, and the blinking lights will soon tell you where the problem is. It's all explained quite clearly in the Granite Digital documents. If you're going to spend any time connecting external SCSI devices, you need these products. Granite Digital makes them in a variety of configurations for both Macs and PCompatibles. Recommended.



Granite Digital's terminators and diagnostic cables didn't help with my problem, since all my SCSI devices are internal. We replaced our SCSI flat cable with one known to be reliable and checked the termination resistors to be sure the hardware was reliable.

That didn't end my problems. The next difficulty was that CorelSCSI couldn't find the Maxoptix T3-1300 optical drive. This was odd, because that much of the system worked before I went off on a trip. The error messages indicated that the drive wasn't ready, but I had an optical cartridge in the drive. Not formatted, I thought, but the CorelSCSI formatting tools couldn't even find the drive! It reported the hard drive, the caching hard drive controller, and the CD-ROM drive, but nary a sign of the optical drive.

The next few hours are too painful to relate in detail. First, we didn't have all of DOS on the machine, so when I tried to edit the CONFIG.SYS file, EDIT would not work because QBASIC.EXE wasn't installed. LapLink took care of that, and I sent over Norton Commander for good measure. Commander is a great way to view and edit configuration files.

Once I had an editor, I tried literally everything I could think of, but nothing I did changed the situation. Finally, after hours of futile effort, I looked at the optical cartridge in the Maxoptix drive. It was a Pioneer cartridge.

We had originally planned to put a Pioneer internal optical drive in this system, and I had got a couple of Pioneer cartridges ready for that. Moreover, we have long had a Pioneer read/write optical drive as an external device on Little Cat C, the ancient Cheetah 386/25 that runs the Pioneer DRM-604X Minichanger CD-ROM drive and other network assets.

The problem is, Pioneer optical cartridges are compatible with nothing else. The Maxoptix drive uses standard optical cartridges, available from 3M and other sources as well as Maxoptix, but Pioneer drives read only Pioneer cartridges—which means nothing else can read the Pioneer format. I should have known that, and perhaps I did.

What caused me hours of rage and grief, though, were those error messages. If I'd used an unformatted Maxoptix cartridge, I'd have gotten a proper error message. Likewise, if there were no cartridge in the drive at all, the system would have reported it correctly; but the Pioneer cartridge fits right into the Maxoptix drive, and when that happens, the machine gets terribly confused.

My troubles still weren't over when I got the proper cartridge in the system. CorelSCSI, it turns out, has both DOS and Windows capabilities. I installed the DOS version of CorelSCSI before I installed Windows on Pentafluge, on the theory that you get it working with DOS before trying Windows. It wasn't a lot of trouble to do the Windows installation, but you can't interrupt the installation without starting over from scratch; there's no way to install without expanding and copying a zillion files from floppy to hard disk.

We now had both the CD-ROM and Maxoptix drives available to Windows; but there was only 400 KB of main memory left in the system. If you run mostly Windows applications this is no problem, but I've got a bunch of DOS applications that I need; and OS/2 solves that problem nicely. You can have all the memory you want in every DOS window, and even have different CONFIG.SYS and AUTOEXEC.BAT files for each of your DOS applications.

Alas, I'm not sure all this fast new hardware is OS/2-compatible; and if DOS and Windows setups are purgatory, OS/2 installations can be death and damnation. I wasn't ready to face that with deadlines coming. That doesn't mean I'm ready to abandon OS/2, which just keeps getting better; but one thing at a time.

The next step was to exit Windows and run QEMM 7.03's Optimize. If Optimize can't pack DOS and all your TSR programs into high memory, it offers to try Quarterdeck's Stealth technology. We had

Stealth working on Pentafluge the last time it was set up, but that was with QEMM 6. This time, QEMM reported it couldn't use Stealth because it couldn't find the INT 13 handler. I don't know what that means, but I told it to go ahead without Stealth.

It did, the computer booted up, I did some tests, and all was well. I had 570-KB DOS windows, not really big enough, but it would have to do. I went to bed. Next morning I wanted to button up the system, so I turned it off. When I turned it back on, it wouldn't boot. It would get to the part where it was supposed to load MSCDEX and hang up.

I booted up with my panic floppy disk. Clearly, we were having some kind of memory problem. I looked into CONFIG.SYS and found we were loading 40 buffers. Surely that was wretched excess for a system with 4 MB of hardware disk-cache memory? I cut that to 20 buffers and attempted to reboot. The machine hung.

Once again I'll pass over an hour of futile efforts. What finally gave me a clue was to boot while holding down the Alt key. That keeps QEMM from loading, and of course nothing will load high if you do that; but the system did boot. I then went through CONFIG.SYS and AUTOEXEC.BAT and removed all traces of previous attempts to load anything high.

I found that something had truncated the command string in AUTOEXEC.BAT that loads MSCDEX. In particular, the /E switch (for extended-memory use) was missing; and you can't load that high without the /E switch. I don't know what truncated that statement, but logic says it had to be QEMM's Optimize, because the /E switch was in earlier saved versions of AUTOEXEC.BAT. In any event, I restored that switch, stripped high loading off everything, and ran Optimize again.

Ron Sartore designed the Cheetah system and knows as much about systems architecture as anyone I know. He's currently working on PCI (Peripheral Component Interconnect) bus products. Ron thinks that SCSI ought to be carried out to the Mindanao Deep and thrown overboard. The La Jolla Trench wouldn't be deep enough.

There were times the past couple of days when I shared that opinion. SCSI can be complicated. On the other hand, it doesn't have to be. Apple proves that. Moreover, it will work with the PCI bus; it must, because Apple is moving to PCI in a big way, and they're sure not about to abandon SCSI. As I said last month after the SCSI Summit, fast SCSI is probably the wave of the future.

In my case, SCSI was frustrating as all get-out to get working properly, but I did manage to do it; and I now have a superfast system, with 615 KB of memory in DOS, 597 KB in DOS windows, and 597 KB with Norton Commander as a shell. That's plenty good enough. The Maxoptix T3-1300 optical drive works something wonderful, both locally and across the network. The DEC 3107 hard drive is the fastest one I have ever seen, and the Plextor Double Speed Plus CD-ROM drive goes like lightning. SCSI is hard to get going, but it sure works when it's going. I've always had fast disk operations at Chaos Manor, and I've *never* had anything like this. DPT, DEC, Maxoptix, Plextor, and Micronics make one heck of a Pentium system.

When Pentafluge came back from San Diego, where Larry Aldridge swapped out its motherboard, it had a #9GXE64 PCI local-bus video board from Number Nine Computer. I couldn't find the Number Nine distribution floppy disks, but I have the Windows drivers on another machine, so I didn't worry about it. I ran the board in standard VGA resolution of 640 by 480 pixels until I had Windows for Workgroups set up and Pentafluge connected into the network. I then brought over the Number Nine subdirectory from another machine.

Unfortunately, that did no good. You can't install the drivers without an installation program, and the installation program didn't copy into the Number Nine subdirectory when we did the original installation. There was no way I was going to test that #9GXE64 board.

The good news was that we'd just received ATI Technologies' Graphics Pro Turbo Mach 64. Despite the rather silly name—Mach numbers aren't very meaningful when describing video, which, after all, goes at the speed of light, and I don't think my computer has any turbines—it promised to be a very fast board indeed.

Installation of the Graphics Pro Turbo Mach 64 was extremely simple. Plug it in, turn on the machine, and run the installation program from floppy disks.

The ATI installation program told me that the board will operate at a resolution of 1280 by 1024 pixels and 16.7 million colors with the NEC MultiSync 5FGp monitor. I'm used to 1024 by 768 pixels and have found it good enough, so I began with that. At that resolution and 32,000 colors, I got an awesome 128.8 Win Tachometer reading at 32-bit pixels; at 16.7 million colors and 24 bits per pixel displayed, the reading was 227. This board is fast. Note, too, that we've now got enough colors to do some serious picture editing—and enough speed for serious video editing.

At a resolution of 1280 by 1024 pixels, we get Win Tachometer readings ranging from 132 to 246, depending on resolutions and color depths. I fear we've run past the capability of the Win Tachometer benchmark to discriminate. Once you get past 120, you're not likely to notice performance differences unless you're doing really big CAD displays. When we switched to dithered text, we got a Win Tachometer reading of 162, and the text is *beautiful*. The Wind Surfer Video for Windows sample AVI (Audio Video Interleave) floats through the air with the greatest of ease, and even full screen, while it's pretty grainy, the action is smooth.

It wasn't long ago that we thought getting the Win Tachometer reading up from 12 to 16 was a significant improvement. We also thought ATI's dithered Crystal Fonts were beautiful, but too slow to be used in daily work. Now we have an-order-of-magnitude better speed, even with beautiful fonts. The hardware performance increases aren't just more of the same; they give you capabilities you never had before. This machine is wonderful.

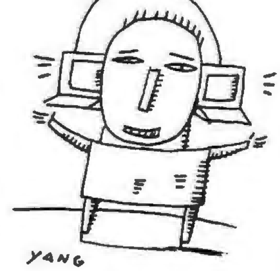
The 16.7-million color mark (24 bits per pixel, aka "24-bit color") is important, too. That's as many colors as the best PC scanners will recognize; the number is also close to the maximum the human eye can discriminate. For picture touch-up, say with the high-end Micrografx Picture Publisher, this is pretty much the standard. You can now buy a card, a monitor, and a computer capable of all the colors and resolution you need—and all for less than a king's ransom. In fact, you can buy such a setup for less than the maintenance on a professional photoretouch station of five years ago. That's real progress for you.

And remember: these new cards are still faster, courtesy of PCI and a galloping

technology, than "mere" 1024- by 768-pixel, 256-color jobs of two years ago.

So: what does a fire-breathing system like this cost if you put it together yourself? Micronics Computers' 60-MHz M5Pi motherboard, $1099. An Intel Pentium, $800, and that's coming down not long after you read this. Sixteen MB of memory, $800. The DEC 3107 hard drive, $1000. PC Power & Cooling's tower case, Turbo-Cool 300 tower-model power supply, Pentacool fan, and 110 Alert Plus alarm, $542. Plextor Double Speed Plus CD-ROM drive, $549. DPT SmartCache III, base $245, as configured here, add $555 for the caching module and $495 for 4 MB of memory. Northgate OmniKey Plus keyboard, about $100. The ATI Technologies Graphics Pro Turbo Mach 64 graphics card with 4 MB of memory, $699. The NEC MultiSync 5FGp monitor, $1175. That's $8059 for a system with serious photo- and video-editing capability.

Adding a sound system is easy: Creative Labs' Sound Blaster 16 SCSI-2 with the Wave Blaster works just fine. We already have a SCSI controller, so you can go for a sound card only. You can pay as much as you like for speakers. We have the Creative Labs Multimedia Kit with Labtec speakers, and it's about $450. Finally, the Maxoptic T3-1300 optical drive is $3495, but you've now got the capability for storing all the edited photos and video images you want to play with. Alas, 16 MB isn't quite enough memory for editing at really high resolutions; you should go to at least 24 MB, so add another $400 to the system cost.



The key software is Windows and CorelSCSI to get the system running and Micrografx Picture Publisher. You'll also need some CD-ROMs of pictures to play with.We're still just under $12,500 for a system with truly awesome capabilities.

Awesome is not too strong a word. Alex is in the other room running the Corel Professional Photos sampler CD-ROM. I keep hearing "Wow!" and similar expressions; and when I go in to look, I see why. The color displays on the NEC MultiSync 5FGp monitor set to a resolution of 1280 by 1024 pixels and 16.7 million colors with the Graphics Pro Turbo Mach 64 are as good as your standard drug store color enlargements, as good as the scanner that read them in, and they're digital, so they degrade in decades—and you can make perfect copies before they do. Wow!

Just after I wrote all that, the Number Nine software arrived, so I had to try it. Number Nine's setup runs only under Windows, meaning you have to use the Windows setup utility to change Windows over to plain-vanilla VGA before you can install the #9GXE64 board properly. Once that's done, everything goes smoothly.

The #9GXE64 board costs about $100 less than the ATI board. It's not as fast, but fast is a relative term at speeds like this. If you read in a big picture at high resolutions, the Number Nine board takes noticeably longer, but noticeable is a matter of a second or so. When using Corel Professional Photos as a screen saver (and it's so beautiful you'll probably want to do that), the picture changes take considerably less than a second with either board.

This #9GXE64 has only 2 MB of memory, so it won't do 1280 by 1024 pixels in millions of colors. That difference is quite noticeable. Having said that, I have to add that if we had started with the Number

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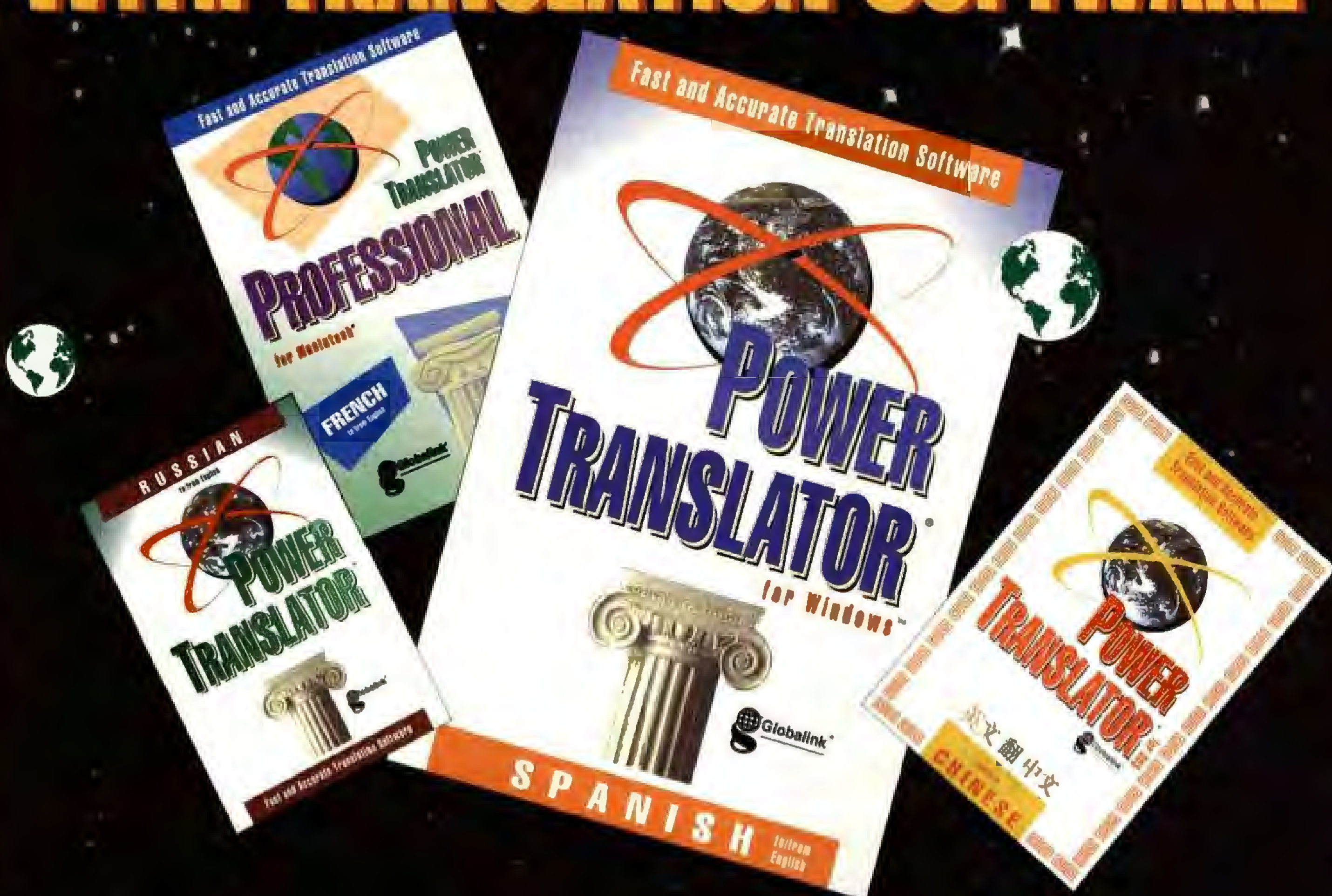

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Nine board, I'd have been so impressed I might not have gotten around to the ATI board this month. The images are very good, and the board is very fast. But the ATI board is clearly more so, and I must confess I went back to it after giving the #9GXE64 a fair trial.

If you want to save money—especially if you don't have a monitor that can take real advantage of the ATI board's colors and resolution—I recommend Number Nine's #9GXE64 as a lot more than good enough.

I also have Diamond's latest video board. Diamond has sworn never to be beaten in benchmark performance, so I'm prepared for anything. Next month, we'll do a comparison; but the ATI board is fast enough for just about anything you'd want to do, it sure is easy to install, and the color reproduction is awesome. Highly recommended.

We were in a hurry to look at video—this column is being done at breakneck speed because I'm past deadlines. Also, my son Phillip's ship leaves for deployment to Africa tomorrow morning, meaning we have to be in San Diego by dinnertime tonight. Thus, we grabbed the first image-editing software we saw in the pile. This proved to be Image Wizard from ImageWare Software.

Image Wizard is a moderately priced program for doing photo editing, and it does the job quite well. It doesn't have the resolution and features of Picture Publisher, and it seems to have some problems at very high resolutions—those may be due to our having only 16 MB of memory in Pentafluge—but it's quite easy to install and use.

If you're going to spend 12 grand on hardware, you'll probably want Picture Publisher, but if the notion is to get a good enough image-editing system and every dollar counts, Image Wizard is a very good way to go. It has features like independent object editing, various-size brushes, and sprays and fills, and the neat part is you can just install it and start using it. All told, a good package indeed.

A number of readers have, with various degrees of politeness, pointed out that the last time I talked about sound, I said something fairly dumb: I implied that adding Creative Lab's Wave Blaster to my system improved the quality of Mr. Spock's speech. Of course, that's wrong.

A few years ago, AdLib came out with inexpensive sound cards, and thus set a kind of de facto standard for low-end DOS sound; and most games still run under DOS rather than Windows. The AdLib cards used FM synthesis. This isn't a bad technology, and you can get surprisingly good quality with it. A number of games and other programs were written to use FM synthesis, and to this day, any decent sound card is AdLib-compatible. Of course, Creative Labs' Sound Blaster series sold so well that most competitors now claim to be Sound Blaster–compatible.

Most sound cards now, though, are actually at least two cards in one, and some like Logitech's SoundMan have what amounts to four cards aboard. A few cards are deliberately not game-compatible, because businesses told the designers they didn't want a game port and had no need for AdLib sound compatibility. These haven't sold very well.

Now comes the tricky part.

Say you want to create and play complex sounds on your PC. One way is simply to record an event and play it. The resulting file will have complete information.

continued

These are called *wave* files, and most of us have some that include the *Star Trek* characters saying things like "Most illogical" and "His brain is gone!" or excerpts from *Beavis and Butt-Head.* (My computer, I confess, now enters Windows with an announcer saying to stay tuned while Beavis and Butt-Head burn things and blow up stuff.) Since these are complete information files, the only sounds you'll hear from them are those already recorded.

There's another way to create sound. To make things simple, let's take a bugle call. I could get a bugler to play "Mess Call," record that, and include it on my system. Suppose, though, I wanted all the standard bugle calls, including the old combat commands like Squads Left or Right by Fours; complete information files are large, and I'd soon have my hard disk full of them. Suppose, instead, I take a sample of a bugle and record that; when I want to play a bugle call, I feed in the essential information about pitch and duration of notes, and let the computer synthesize the actual sound. This is called *wave-table synthesis*—you have a table of the "sound waves" from a number of instruments—and the important fact is that the computer synthesizes the sound from incomplete information.

A wave-table card—such as the Wave Blaster that piggybacks onto Creative Labs' Sound Blaster 16 card—contains, among other things, a set of "instruments": wave-table samples of things as diverse as bugles, guitars, and pianos. These are called *patches*, and those who are very much concerned about sounds evaluate the good and bad points of various *patch sets.* If you want to know more about that, I strongly recommend you get the latest copy of Rich Heimlich's Patch Set Review, which is available free from most BBSes where people talk about sound.

Note that in theory we could take samples of Mr. Spock talking, make him into an "instrument," and write software that would have him say almost anything we like. In practice, though, when you hear Mr. Spock on your computer, you are listening to a digitized recording of him actually saying that.

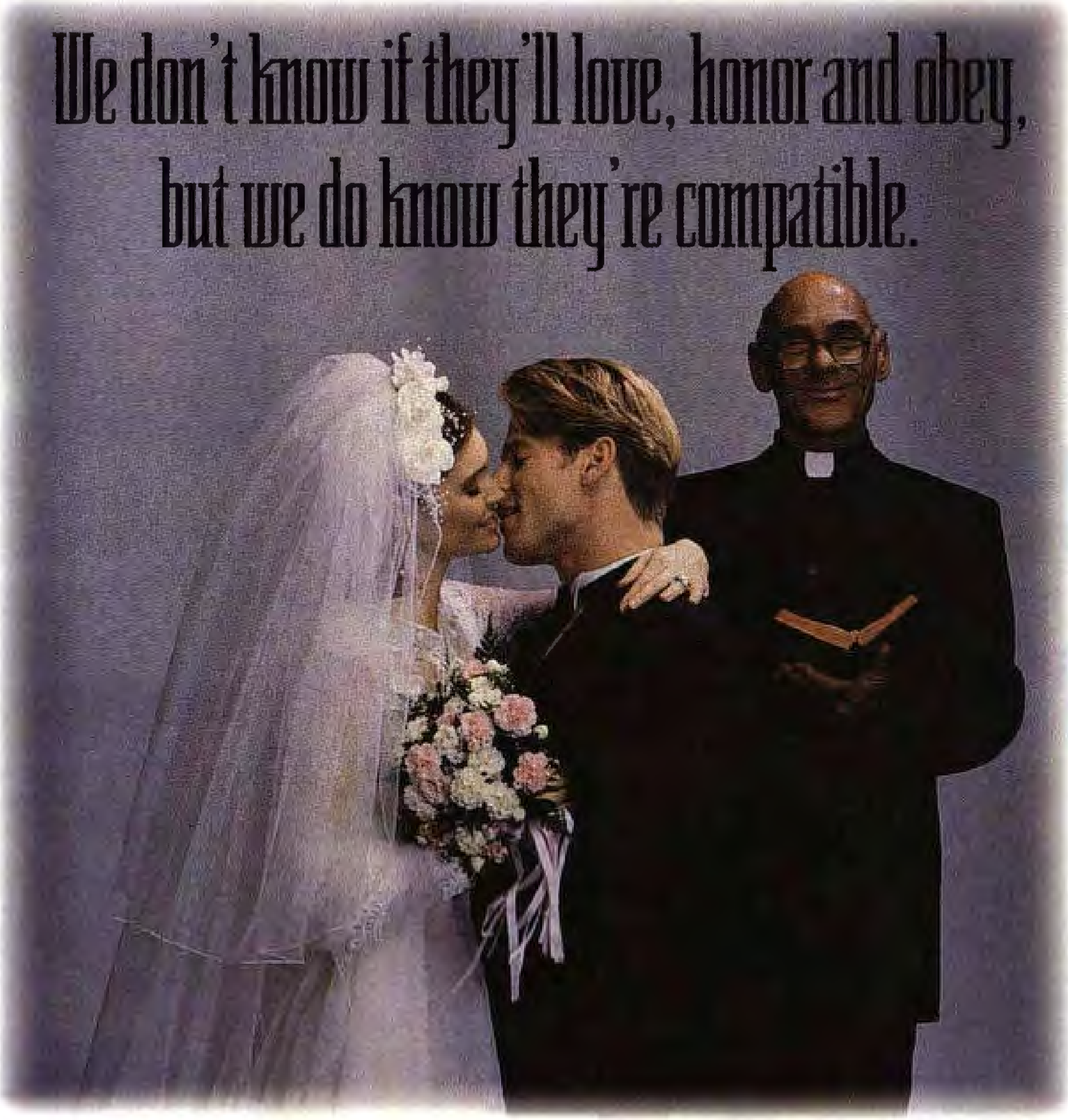
As a result of my earlier confusion, I have been required to learn more about the sound situation than I intended to.

For example: if I want the best synthesized sound quality, clearly the larger my sample table, the better job the computer will be able to do with the synthesis. Wave Blaster, like many wave-table cards, has 4 MB of ROM that contains the general MIDI-sound patch set. This includes a few sound effects and about 128 instruments, including the piano, trumpet, bass fiddle, violin, sitar, ocarina, koto, and agogo, and I don't know what those last two are either. The point is that all those must fit into 4 MB.

Suppose I want my system to play a Beethoven symphony. Even with a gigabyte hard drive, I won't want a complete recording of, say, the *Eroica*, so I'll want to have the system synthesize it. I'll have no need for an ocarina or a koto; I'd be better off if my patch set included better, meaning larger, samples of violins and trumpets. Maybe, instead of the standard instrument set in ROM, I'd be better off having RAM on my wave-table card and letting the computer load those with better samples of the instruments I need.

Then, too, if I want to blend a number of instruments into my sound, I'm likely to be compute-bound; perhaps I ought to have a processor on the sound card.

Things definitely get complex, and as



NSTL's compatibility and interoperability tests are the most rigorous in the industry. So when you see our Seal, you know the computer products you're buying will be compatible.

The following computer products* have recently earned the NSTL Seal.

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- Intel TokenExpress LAN Adapter EISA 16/4

Olicom USA, Inc.
- Olicom Token-ring Network ISA 16/4 Adapter

First International Computer, Inc.
- LEO DESIGNote 486 T33D-12

Intergraph Corporation
- TD2 Pentium Workstation

Telemecanique
- FTX 507.8c 486 Industrial Portable Terminal

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For more information about the NSTL Seal and what it takes to earn it, call 800-220-NSTL or (610) 941-9600. It's the first step toward a long and healthy relationship.

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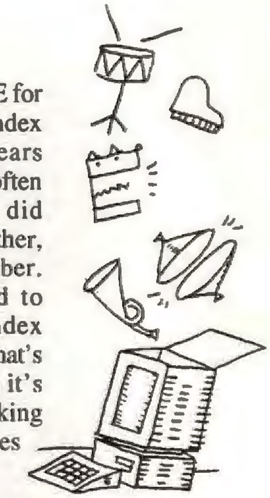
Circle 121 on Inquiry Card.

the hardware gets better, it's all changing like dreams. My advice is that for the moment, you get a cheap decent system. The Sound Blaster 16 or any card that will accept a Wave Blaster or other wave-table card is good enough, or if you need a CD-ROM drive, get one of Creative Labs' multimedia upgrade kits with a CD-ROM drive, speakers, and so forth (see my April column). Logitech makes good systems at reasonable prices. The important thing here is to get as good a price as you can.

You want a good price because truly awesome sound systems are coming. Think about that in conjunction with the image-processing capabilities high-end machines are capable of. You'll soon have a Moviola machine on your desktop, and you'll want really good sound.

For now, stay with good enough, and if you want to spend money on sound, buy good speakers. You can use them with the really great sound cards that are coming.

It's not generally known, but a small outfit called ESC has been publishing an index to BYTE for years. It's called Bindex and covers the years 1990–1994. People often ask me when we did some article or another, and I never remember. It's a bit awkward to search through Bindex one year at a time—that's how it comes—but it's sure easier than looking through the magazines themselves.



If you're doing documentation and you want to include pictures of key tops, you need RRKeyFonts. There are PC and Mac versions. You get both TrueType and PostScript Type 1 in each version. The fonts are attractive, very complete, and easy to use. Mouse buttons, function keys, arrow keys, cursor shapes, you name it, it's in there.

Anyone who ever used Windows Paintbrush to capture a screen picture of a key top and was dissatisfied with the printed result will want a copy. It also comes in German for the PC. Not everyone needs this, but if you do need RRKeyFonts, you need it bad. Recommended.

It's not too early to think about your taxes. Longtime readers will know I used to use MacInTax to do mine. For the past couple of years, I have used TurboTax for Windows from Intuit. I've learned to trust it: if it says there's a missing entry on a form, it's worth finding out what that entry is. The worksheet system on Schedule C businesses keeps track of those complexities. Mrs. Pournelle and I have "his, hers, and ours" businesses, and each gets a separate report. It handles Schedule K partnerships and Schedule E expenses.

Many of my friends have accountants, but I've found that by the time I have explained everything to an accountant, I could have done it using TurboTax. I'll remind you again next January.

I don't often need a rhyming dictionary, but now that I have one, I may make use of it. I used to like writing doggerel and once tried my hand at a classical ballad. In those days rhymes came easily, but as I get older, I have to think harder. It seems to be true that when you get to be my age the bin is full. For every new thing you learn, something you used to know drops out the other ear.

Fortunately, A Zillion Kajillion Rhymes takes care of the rhyming department. There are Windows and Mac versions, and

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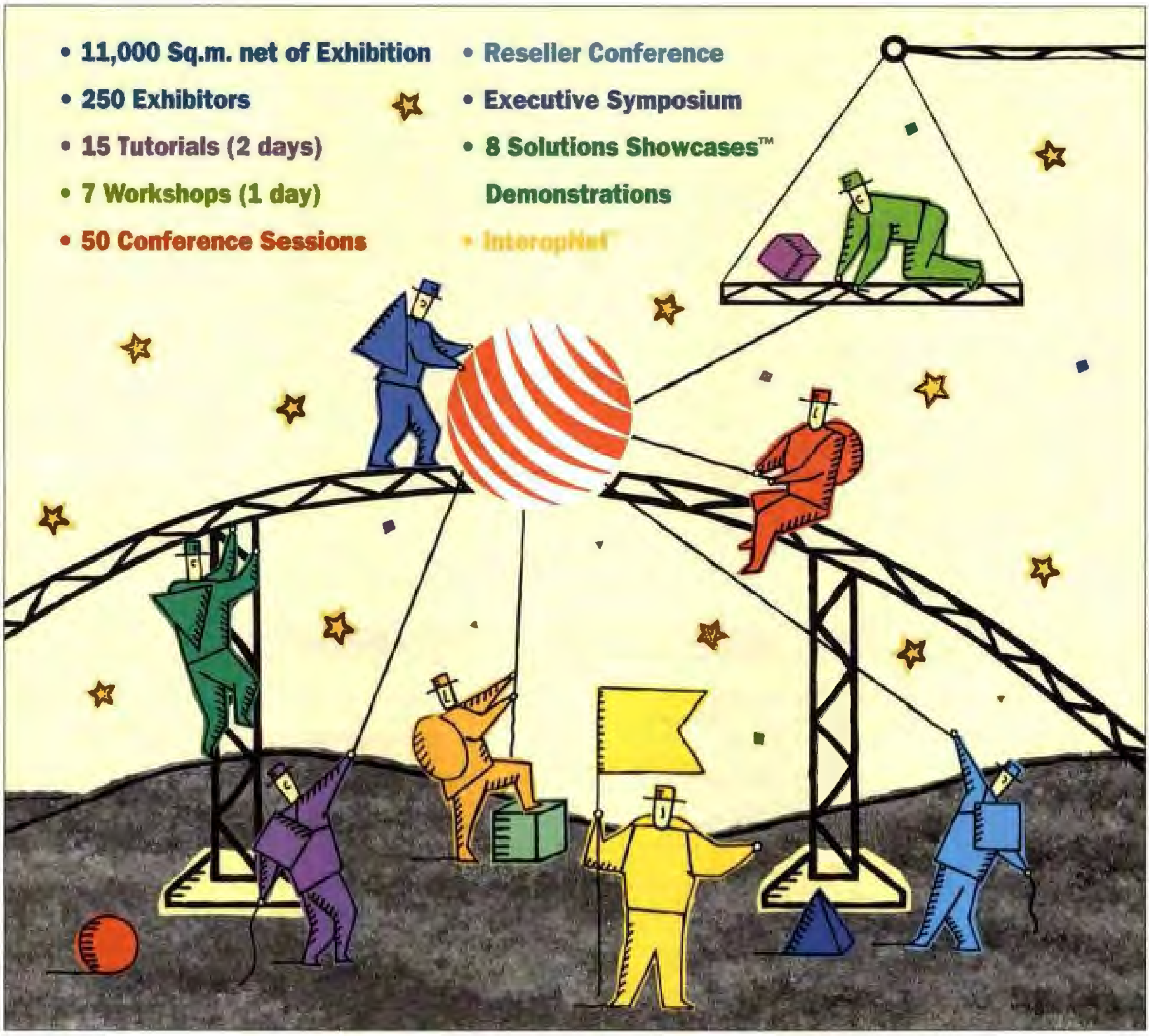

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THE EVENT YOU CAN'T AFFORD TO MISS

Circle 156 on Inquiry Card.

it's the easiest thing in the world to use.

Years ago when I was a kid, I saw a comic strip in which one of the characters claimed to be the only person in the world who knew a rhyme for the word *silver*. He could still be: at least this dictionary doesn't know one. He also said he could rhyme *orange*; the dictionary offers a dozen of those, including *derange*. I'll become deranged if I don't stop playing with this thing.

The company calls itself Eccentric Software. Its motto is "Software you never knew you needed," which is probably true enough for most of you, but if you do need it, this one works.

Fields of Glory remains interesting. Master of Orion (known affectionately as MOO) consumes all the time available and then some. If you're a MOO fan, you'll also want Master of Orion, The Official Strategy Guide, from Prima Publishing (P.O. Box 1260BK, Rocklin, CA 95677). If you don't have it, you're playing at a disadvantage.

I have a CD-ROM version of Betrayal at Krondor. If you have a CD-ROM system, this is the right way to play what is still the best fantasy role-playing game I've ever seen. One thing about Krondor: although the game tells you it's urgent to get to Krondor in Chapter One, it isn't. Take your time, develop your characters, and get the best weapons that you can find.

The book of the month is by Myron Magnet: *The Dream and the Nightmare: The Sixties' Legacy to the Underclass* (Morrow, 1993). It's a frightening analysis of why the good intentions of the war on poverty went wrong and the consequent moral challenge to the U.S. Highly recommended.

It's neither a game nor a book, but 3-D Body Adventure from Knowledge Adventure will probably teach your kids—and you—more about anatomy and physiology than you'd learn from both. Cruise around in your skull, see a body build up from a skeleton out, get inside your heart and see the valves working, all in 3-D if you like. This thing is amazing. Knowledge Adventure manages to combine both "content" and "technology," and I haven't seen anything they've done that isn't worth your attention.

As usual, there's more to write about than I have space for. For next month, we intend to try some high-resolution printing with Fargo's dye-sublimation printer, now that we have the image resolution. I have to make a speech this week, so I'll be trying out the new PowerPoint. Phillip is taking a wonderful new Zenith laptop on the ship; reports on that over the next year or so.

And I love that Pentafluge. ■

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future. Jerry welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply. You can also contact him on the Internet or BIX at jerryp@bix.com.

For More Information

If you're going to spend any time mucking about connecting external SCSI devices, you need Granite Digital's series of **Active Diagnostic Terminators** ($59), **Gold Diagnostic Cables** ($39 to $129), and **SCSIVue Terminators** ($59). Contact **Granite Digital**, Union City, CA, (510) 471-6442; fax (510) 471-6267. **Circle 1146 on Inquiry Card.**

Betrayal at Krondor ($69.95) is still the best fantasy role-playing game I've ever seen. Contact **Sierra-On-Line**, Oakhurst, CA, (800) 757-7707 or (206) 649-9800; fax (206) 562-4223. **Circle 1147.**

Bindex (index for 1990–1994, $49.95) makes it easier to find articles written in BYTE than looking through the magazines themselves. Contact **ESC**, Madison, WI, (608) 238-3970; fax (608) 238-4102. **Circle 1148.**

The **DEC 3107** hard drive ($1000) is the fastest one I have ever seen. Contact **Digital Equipment Corp.**, OEM Storage Group, Shrewsbury, MA, (508) 841-6439; fax (508) 841-5078. **Circle 1149.**

Fields of Glory ($59.95) is interesting. Contact **Spectrum Holobyte**, Alameda, CA, (800) 695-4263 or (510) 522-1164; fax (510) 522-3587. **Circle 1150.**

The **Graphics Pro Turbo Mach 64** (2 MB, $449; 4 MB, $699) is fast enough for just about anything you'd want to do, it sure is easy to install, and the color reproduction is awesome. Contact **ATI Technologies, Inc.**, Thornhill, Ontario, Canada, (905) 882-2600; fax (905) 882-2620. **Circle 1151.**

Image Wizard ($199) has features like independent object editing, various-size brushes, and sprays and fills, and the neat part is you can just install it and start using it. Contact **ImageWare Software**, San Diego, CA, (800) 842-4199 or (619) 673-8600; fax (619) 673-1770. **Circle 1152.**

The **Maxoptix T3-1300** optical drive (internal, $3495; external, $3995) works something wonderful both locally and across the network. Contact **Maxoptix Corp.**, San Jose, CA, (800) 848-3092 or (408) 954-9700; fax (408) 954-9711. **Circle 1153.**

Pentafluge includes the 60-MHz **M5PI** motherboard with a 256-KB cache ($1099). Contact **Micronics Computers, Inc.**, Fremont, CA, (510) 651-2300; fax (510) 651-5612. **Circle 1154.**

Its images are very good, and the **#9GXE64** PCI local-bus video board (with 2 MB of DRAM, $349) is very fast. Contact **Number Nine Computer Corp.**, Lexington, MA, (800) 438-6463 or (617) 674-0009; fax (617) 674-2919. **Circle 1155.**

The **Plextor Double Speed Plus** CD-ROM drive ($549) goes like lightning. Contact **Plextor**, Santa Clara, CA, (800) 886-3935 or (408) 980-1838; fax (408) 986-1010. **Circle 1156.**

If you're doing documentation and you want to include a picture of key tops, you need **RRKeyFonts** ($49). Contact **RoadRunner Computing**, Baton Rouge, LA, (504) 928-0780; fax (504) 928-0802. **Circle 1157.**

Creative Labs' multimedia sound cards tested on Pentafluge include the **Sound Blaster 16 SCSI-2** ($279.95) and the **Wave Blaster** ($249.95). We have the Creative Labs Multimedia Kit with Labtec speakers (**Discovery CD16 Multimedia Kit**, $449.95; **Edutainment CD16 Multimedia Kit**, $599.95; **Digital Edge 3x Multimedia Kit**, $999). Contact **Creative Labs**, Milpitas, CA, (800) 998-5227 or (408) 428-6600; fax (408) 428-6611. **Circle 1158.**

It's neither a game nor a book, but **3-D Body Adventure** (on floppy disk, $49.95; on CD-ROM, $69.95) will probably teach your kids—and you—more about anatomy and physiology than you'd learn from both. Contact **Knowledge Adventure, Inc.**, La Crescenta, CA, (800) 542-4240 or (818) 542-4200; fax (818) 542-4475. **Circle 1159.**

Many of my friends have accountants, but I've found that by the time I have explained everything to an accountant, I could have done my taxes using **TurboTax for Windows** (call for price). Contact **Intuit, Inc.**, Tucson, AZ, (800) 964-1040 or (602) 295-3110; fax (602) 295-3095. **Circle 1160.**

I don't often need a rhyming dictionary, but now that I have **A Zillion Kajillion Rhymes** ($39.95), I may make use of it. Contact **Eccentric Software**, Seattle, WA, (800) 436-6758 or (206) 628-2687; fax (206) 628-2681. **Circle 1161.**

What's New Hardware

PORTABLE 10BASE-T CONNECTION

Farallon Computing's EtherWave PCMCIA Adapter connects PC notebook computers directly to 10Base-T Ethernet networks. The adapter enables multiple computers to share one network outlet. This lets network administrators provide portable users with full 10-Mbps access to network printers and servers without requiring a dedicated hub-port connection. Able to fit into any Type II or Type III PCMCIA slot, the $299 EtherWave supports PCMCIA Card and Socket Services to enable hot-swapping of different PCMCIA products.

Contact: Farallon Computing, Alameda, CA, (510) 814-5000.

Circle 1318 on Inquiry Card.

HIGH-CAPACITY NETWARE STORAGE ▼

Available in EISA and Micro Channel configurations, the MonStor rack-mount storage system ($8640) supports scalable single-server capacities of 9 to 252 GB. From Storage Dimensions (Milpitas, CA), MonStor integrates up to four 9-GB SCSI-2 drive modules on the same SCSI bus; you can connect seven drive modules per host adapter and up to four host adapters per server. The system has a burst data transfer rate of 10 MBps and sustained rates of up to 8.1 MBps. MonStor ships with the LANStor Plus software driver.

Phone: (408) 954-0710.

Circle 1321 on Inquiry Card.

OFF-LINE NETWORK SENTRY

A hardware-based LAN management and security device currently available for NetWare 3.x and 4.x, Network Sentry ($3000) from Cyberlock Data Intelligence (Philadelphia, PA) connects to the server but operates off-line. When you install Network Sentry, the device creates a unique identifier for each executable file on the server and then checks the identifier each time a file is executed.

Phone: (215) 893-8833.

Circle 1322 on Inquiry Card.

STACKABLE HUBS

Designed for departmental 10Base-T networks, the KleverHub Stack K1016 ($895) and K1032 ($1685) stackable hubs feature 16 and 32 unmanaged UTP ports, respectively. The hubs support scalable port loads ranging from 16 to 132 ports. You can stack up to four of the Klever (Sunnyvale, CA) hubs in any combination or cascade them. A user-configurable port enables you to add an additional 10Base-T, 10Base-5, or 10Base-FL connection.

Phone: (800) 745-4660 or (408) 735-7723.

Circle 1323 on Inquiry Card.

PEDAL YOUR WAY TO PRODUCTIVITY

Consisting of three electronic foot switches, the Step On It Keyboard Control Pedals ($69.95) can be custom-programmed to assign or reassign any three keyboard keys to foot operation. From Bilbo Innovations (Madison, WI), the device comes with menu-driven software and a miniature external controller that plugs in between your keyboard and your PC.

Phone: (800) 203-0092 or (608) 233-6121.

Circle 1324 on Inquiry Card.

NOTEBOOK DATA ACQUISITION

The DAQ-19 data acquisition board (from $299) features 19-bit A/D capability on eight differential-ended or 16 single-ended channels, a 12-bit D/A port, an 8-bit digital I/O port, and source code for a Windows data acquisition program. Designed for use with notebooks, the parallel-port board is from ST Scientific (Chanhassen, MN).

Phone: (612) 361-6082.

Circle 1325 on Inquiry Card.

GIVE VOICE COMMANDS IN WINDOWS

The Timeworks Say It V-Command Voice Recognition System ($299) combines a sound card with voice-print capabilities to let you record messages under Windows. You use the system from Timeworks International (Northbrook, IL) by speaking naturally to your computer while using the Windows V-Command library; digitized compression uses only 4 KB for each second of speech. Timeworks Say It recognizes and executes commands regardless of variations in voice tone and emphasis.

Phone: (800) 323-7744 or (708) 559-1300.

Circle 1333 on Inquiry Card.

TRAVELERS' STORAGE ▼

A portable storage system that plugs into the parallel printer port of your PC, the Data Traveler DT200EX (from $585) has a capacity of 127 or 209 MB. The Kingston Technology (Fountain Valley, CA) unit has a parallel-to-IDE adapter, transfer rates of up to 1.2 MBps, a pass-through printer connection, an AC adapter, and a 3-hour battery. A QuickSwap feature enables disks to self-configure when they are inserted into the receiving frame.

Phone: (714) 435-2600.

Circle 1326 on Inquiry Card.

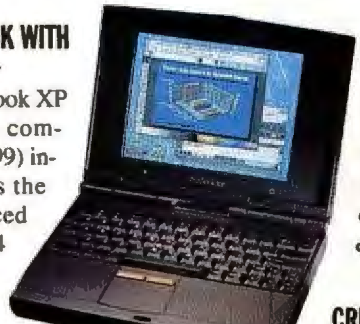
EXPAND CAPACITY QUICKLY

The SSI-5200 ($4995) 3½-inch SCSI-2 drive has a formatted capacity of 5.2 GB, an average access speed of 9.2 ms, and a media-to-buffer data transfer rate of 12.17 MBps. The drive, which has a magneto-resistive head, is from Storage Solutions (Stamford, CT).

Phone: (203) 325-0035.

Circle 1327 on Inquiry Card.

A NOTEBOOK WITH CHOICES ▶



The WinBook XP notebook computer ($1999) incorporates the SL-enhanced 486DX4 75-MHz processor and a dual-scan color screen. From WinBook Computer (Columbus, OH), the notebook comes with 4 MB of RAM (expandable to 32 MB), a removable 120-MB hard drive, and your choice of a Lexmark or Logitech pointing device. Optional 3.3-V L2 cache is also available.

Phone: (800) 468-2162 or (614) 481-8041.

Circle 1328 on Inquiry Card.

ERGONOMIC MONITOR

Compatible with Apple and Sun SPARC systems, MAG InnoVision's (Santa Ana, CA) MXP17F monitor ($1299) has a flat-square CRT with an Invar shadow mask and an antiglare treatment. Its ultrahigh resolution goes up to 1600 by 1280 pixels noninterlaced with refresh rates of up to 120 Hz and a dot pitch of 0.26 mm. Advanced Display Calibration via an RS-232 control port lets you use all the controls with a click of your mouse and locks out other users so that they can't disturb your settings.

Phone: (800) 827-3998 or (714) 751-2008.

Circle 1331 on Inquiry Card.

ROBOTS FOR UNIX

Driverless tape auto-loaders for Unix platforms, the Encore Plus Robotic Tape Handling systems (from $5995) have built-in robotic-control intelligence. The systems work with all Unix systems that have a SCSI bus, and they support all standard Unix tape utilities. From Andataco (San Diego, CA), the auto-loaders have backup and archive storage capacities ranging from 50 to 100 GB.

Phone: (800) 334-9191 or (619) 453-9191.

Circle 1329 on Inquiry Card.

CREATE A SCSI DAISY CHAIN

The ParaSCSI Plus ultra-high-speed parallel-to-SCSI adapter ($216) supports up to seven daisy-chained SCSI or SCSI-2 devices. Compatible with any standard port or EPP (enhanced parallel port), the adapter has a pass-through to permit concurrent printing. From Linksys (Irvine, CA), the ParaSCSI Plus transfers data at 500 KBps; for EPP-compliant PCs, the data transmission rate increases to up to 1 MBps.

Phone: (800) 546-5797 or (714) 261-1288.

Circle 1330 on Inquiry Card.

POWERBOOK BATTERY ASSIST

A battery-charge extender for all 100-series Apple PowerBooks, the PowerAssist ($69) from Newer Technology (Wichita, KS) charges batteries in sleep mode and extends battery life by up to four times when plugged into an active PowerBook. The 1¾- by 2⁵⁄₁₆- by ¼-inch unit weighs less than 3 ounces and has a power output of 7.5 V at 1.1 amps.

Phone: (800) 678-3726 or (316) 685-4904.

Circle 1332 on Inquiry Card.

DATA ACQUISITION AND CONTROL

A data acquisition and control module with a serial-port interface, the JSL11A84 ($259) from Jasco Research (Sidney, British Columbia, Canada) has 11 analog input channels with programmable X1 or X10 gain on four channels. The serial-port connection is switch-selectable at rates ranging from 300 bps to 38.4 Kbps, and the module has a sampling rate of up to 180 Hz for one channel and 16 Hz for all 11 channels at 9600 bps.

Phone: (604) 656-0656.

Circle 1334 on Inquiry Card.

SEND YOUR NOTES THROUGH THE AIR

More than a pocket-size text pager, AirNote ($349) has its own Internet address, so you can receive Internet messages while you're away from the office. From Notable Technologies (Oakland, CA), AirNote also lets you receive E-mail, computer-typed messages, and phone messages. You can specify the maximum number of characters you want forwarded to the pager, and you can have AirNote Internet messages sent to your primary Internet E-mail address.

Phone: (800) 732-9900 or (510) 208-4400.

Circle 1335 on Inquiry Card.

FAX MODEM WITH VOICEVIEW SUPPORT

An internal multifunction fax board, the Connection Pro ($249) has built-in support for the Radish VoiceView protocol. From Digicom Systems (Milpitas, CA), the Connection Pro supports the Windows sound system and OLE, has full-duplex V.32terbo 19.2-Kbps data transfer, and can send and receive Group 3 faxes at speeds of up to 14.4 Kbps.

Phone: (800) 833-8900 or (408) 262-1277.

Circle 1336 on Inquiry Card.

MULTIMEDIA-READY MACS

With a built-in CD-ROM drive, a 66-/33-MHz 68LC040 processor, video- and TV-expansion options, and support for 16-bit stereo playback, Apple's 630 series of Macs (from $1199) are targeted toward users looking for a powerful entry-level multimedia system. The Mac LC 630, Performa 630 (shown in the photo), and Quadra 630 all come with 68030 LC PDS, communications, and video-in slots. An optional video-in card lets you view and cut and paste composite and S-video; another card accepts NTSC, PAL, and SECAM TV signals, letting you view them. An optional video-out solution allows you to "print" video to VCR tape. The communications slot accepts 10Base-T, 10Base-2, and AAUI Ethernet cards and a 14.4-Kbps fax/data modem.

Contact: Apple Computer, Cupertino, CA, (800) 767-2775 or (408) 996-1010.

Circle 1319 on Inquiry Card.

What's New Hardware

A Small UPS with a Large Attitude

Incorporating Deltec's large-system-engineering expertise, the PowerRite Plus UPSes protect stand-alone PCs as well as network nodes against power blackouts, surges, spikes, and power-line noise. An Advanced Battery Management feature in the units extends battery life, speeds recharge time, and provides advance notification of battery-service requirements. The UPSes are available with 250-, 400-, and 600-VA power ratings; the 400- and 600-VA models include a test switch and software-interface capabilities for operating systems such as NetWare, Windows, DOS, Unix, and OS/2. Prices start at $139.

Contact: Deltec Electronics, San Diego, CA, (800) 854-2658 or (619) 291-4211.

Circle 1320 on Inquiry Card.

SCSI Adapter

A bus-mastered SCSI-2 host adapter for VL-Bus systems, the BT-445C ($279) from BusLogic (Santa Clara, CA) has an on-board AutoSCSI Utility and dual-floppy support. The menu-driven AutoSCSI Utility resides in the adapter's BIOS and lets you configure the host adapter, a SCSI device, and BIOS-related parameters.

Phone: (408) 492-9090.

Circle 1337 on Inquiry Card.

Remote Windows Control ▼

A hand-held programmable remote control, the PowerControl ($195) allows you to control your Windows presentations from up to 30 feet away from your computer. You can assign a sequence of keystrokes or a mouse command to any of the buttons on the unit and activate complex software functions by pushing a button. The SoftMagic (Waltham, MA) infrared device supports packages such as PowerPoint, Harvard Graphics, and Freelance Graphics.

Phone: (617) 899-9966.

Circle 1340 on Inquiry Card.

Protection from Static

A small accessory that installs on your computer, UltraStat ($59.95) continually drains harmful static from your system and from you, according to its manufacturer, UltraStat (Colorado City, CO). The company says that UltraStat reduces the 10,000 to 20,000 V of static electricity typically emitted by a computer screen to less than 50 V.

Phone: (800) 460-7828 or (719) 676-4010.

Circle 1338 on Inquiry Card.

Integrate Multiprotocol Workgroups

The GatorRoute iR router ($2495) provides simultaneous routing of IPX, TCP/IP, AppleTalk, and DECnet protocols. The four-port module includes two Ethernet ports and expansion slots for either two serial ports or one serial and one LocalTalk port. From Cayman Systems (Woburn, MA), the router's built-in flash memory lets you easily upgrade your network software.

Phone: (800) 473-4776 or (617) 932-1100.

Circle 1339 on Inquiry Card.

A Keyboard with a Twist ▲

The Select-Ease Keyboard ($179) from Lexmark International (Lexington, KY) splits into left and right halves, each with an inverted-*T* cursor-key arrangement. You can change the position of either side of the full-function QWERTY keyboard by swiveling or symmetrically tilting the sides or by completely separating them.

Phone: (800) 438-2468 or (606) 232-2000.

Circle 1341 on Inquiry Card.

Flat-Square and 15 Inches

The Diamond Pro 15FS monitor ($535) from Mitsubishi (Cypress, CA) automatically readjusts image centering, size, and geometry when you select nonstandard resolutions. On-screen displays let you adjust display-setup parameters through an icon-based, on-screen control panel. The 0.28-mm dot-pitch monitor has preset color-temperature modes, as well as a user-definable setting, and a microprocessor-based 31.5- to 64-kHz auto-scan range. PC- and Mac-compatible, the Diamond Pro has a maximum resolution of 1024 by 768 pixels with a refresh rate of 76 Hz.

Phone: (800) 843-2515 or (714) 220-2500.

Circle 1342 on Inquiry Card.

The 2000DS monitor ($439) from Optiquest (Walnut, CA) includes the company's Opti-Green Software, which powers down the monitor to a maximum energy-consumption level of less than 3 W when it is not in use. The digitally controlled monitor adheres to MPR-II low-radiation standards. It senses the local AC power supply automatically and adjusts to between 90 and 264 V AC at 50 or 60 Hz with a maximum consumption of 100 W. Maximum resolution is 1024 by 768 pixels noninterlaced with a 76-Hz refresh rate and a 0.28-mm dot pitch.

Phone: (909) 468-3750.

Circle 1343 on Inquiry Card.

Gain Network Privacy

The Oncore Ethernet Private Line Card ($1995) is a daughtercard from Chipcom (Southborough, MA) that plugs into the company's Oncore Switching Hubs. The PLC's continuous auto-learning capability discovers all attached network users and then filters out any information they are not supposed to receive. Users can move from network to network and from hub to hub without losing communications.

Phone: (508) 460-8900.

Circle 1344 on Inquiry

"I oversee a
$24 million
budget and support
2400 users.
Every month
BYTE
helps me
evaluate
products & technologies that keep
Lincoln National Life
ahead of the
technology/productivity
curve."
Name: Skip Carstensen
Title: VP Product Administration Systems
Company: Lincoln National Life Insurance Company
Annual IT Budget: $24 million
BYTE Reader: 9+ years
BYTE
First PowerPCs
Apple's Power Macintosh and IBM's Power Personal Systems
CPU Wars:
Intel pushes the 80x86 envelope
BYTE readers set the agenda for corporate Information Technology purchases. Their recommendations can take your products to the top – or leave them at the door. Why? Because BYTE readers are the *technology experts*. They define the short list. They specify brands. They tell the buyers what to buy.
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BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

What's New Software

OPEN-ARCHITECTURE VISUAL DEVELOPMENT SYSTEM

ProtoGen+ NT, a fully integrated visual development workbench that streamlines the development of C and C++ applications for Windows and NT, supports Intel, Dec Alpha, and Mips processors. ProtoGen+ NT's object-oriented programming capabilities let you view and select, point and click, or drag and drop tool palettes and icons to reach menus, screens, and dialog boxes. A live, interactive test mode lets you test your application before you generate any code or compile the application. MDI support and Visual Coders for multimedia, MAPI, and OLE 2.0 are other prime features. ProtoGen+ NT is priced at $495.

Contact: ProtoView Development, Dayton, NJ, (800) 231-8588 or (908) 329-8588.

Circle 1271 on Inquiry Card.

OBJECT-ORIENTED IMAGING

A suite of object-oriented imaging development tools for Visual Basic and Visual C++, KIPP (Kofax Image Processing Platform) ImageControls (from $995) makes use of drag and drop to reduce the time needed to create production-level applications. From Kofax Image Products (Irvine, CA), the KIPP ImageControls package lets you add comprehensive imaging capabilities to new and established line-of-business applications even if you have no experience in document-image processing.

Phone: (714) 727-1733.

Circle 1275 on Inquiry Card.

PROCESS-IMPROVEMENT PACKAGE

Windows-based process-analysis and improvement software, Optima (single license, $1500) incorporates process-mapping, modeling, simulation, and reporting capabilities. From AdvanEdge Technologies (Tualatin, OR), Optima allows you to create a model of any process and run what-if simulations.

Phone: (503) 692-8162.

Circle 1278 on Inquiry Card.

DO SOME REAL-TIME THINKING

Designed for thinking in real time on the computer, Inspiration for Windows ($129) is a visual tool for planning and developing ideas. The Rapid Fire feature lets you quickly type related ideas into one symbol; the software then creates linked multiple symbols. The Point & Type feature pops a symbol around a random idea you have typed to hold it until you are ready to work with it. An outline view provides organization and writing capabilities. The visual tool is from Inspiration Software (Portland, OR).

Phone: (503) 245-9011.

Circle 1276 on Inquiry Card.

PUBLISHING-PRODUCTIVITY PROGRAM

A program for creating greeting cards, banners, calendars, signs, and stationery, PrintMaster Gold CD Bonus Pack ($79.95) provides verbal assistance via an audio interface. The MicroLogic Software (Emeryville, CA) CD-ROM can print PCX, TIFF, GIF, CGM, WNF, and BMP graphics in 24-bit color.

Phone: (800) 888-9078 or (510) 652-5464.

Circle 1279 on Inquiry Card.

A WORKSHOP FOR MULTIMEDIA

The Multimedia Workshop ($79.95) from Davidson & Associates (Torrance, CA) contains writing and video workshops to let you create multimedia presentations and published documents. The program's four multimedia libraries encompass photos, QuickTime movie clips, clip art, and sound effects and music.

Phone: (310) 793-0600.

Circle 1282 on Inquiry Card.

UPS-MONITORING SOFTWARE ▼

PowerEdge NetServer ($199) from CompuSci (St. Louis, MO) monitors any UPS and, in an orderly way, shuts down your computer's operating system before the UPS battery reserve is exhausted. Compatible with NetWare, SCO Unix, OS/2, DEC Alpha OSF, and HP-UX, PowerEdge NetServer allows multiple systems to be supported by a single UPS without the need for additional hardware. A status screen monitors UPS data, such as battery time remaining, battery voltage, charge status, and line voltage.

Phone: (314) 343-5022.

Circle 1277 on Inquiry Card.

FINANCIAL TOOLS

The Mathematica Finance Pack ($395) helps finance professionals to analyze numerical and statistical data, optimize mathematical models, display data graphically in 2-D and 3-D, and create animations. From Wolfram Research (Champaign, IL), the Finance Pack is designed to solve problems in areas such as interest rates, bonds, cash flow, options, and finance-calendar functions. It's available for the Mac, Windows, and the X Window System.

Phone: (800) 441-6284 or (217) 398-0700.

Circle 1280 on Inquiry Card.

EXPENSE REPORTS CUSTOMIZED

The Expense It for Windows program ($129.99) manages expense accounts for business travelers by providing customizable expense reports, rapid-receipt entry, foreign-currency conversion, and complete management and reconciliation of expense accounts. From On the Go Software (San Diego, CA), the program can consolidate the reports to include only the days that you incur expenses.

Phone: (619) 546-4340.

Circle 1281 on Inquiry Card.

CARRYING ON THE GENERIC CADD TRADITION

A $495 professional-level 2-D design and drafting program, Visual CADD works in Windows, so you can customize it through a macro language or any standard Windows programming language, such as Visual Basic or C++. Visual CADD's intuitive interface is based on design tools located in familiar, convenient locations; two-letter commands; and large drawing areas that are not obstructed by dialog boxes. Able to read and write Generic CADD GCD and AutoCAD DWG files, Visual CADD imports and exports data via DXF to share files with other CAD, CAM, and CAE software. The software features tracking and OLE 2.0 technology.

Contact: Numera Software, Seattle, WA, (800) 956-2233 or (206) 622-2233.

Circle 1272 on Inquiry Card.

INTEGRATE ON THE NEWTON

Developed for the Newton, TapWorks ($119) integrates text processing, spreadsheets, drawings, and graphs into a single application. The Avail Technology (Sunnyvale, CA) software improves the effectiveness of any document that you want to fax, print, beam, or mail from your Newton and provides WYSIWYG formatting.

Phone: (408) 730-6855.

Circle 1283 on Inquiry Card.

MULTISERVER AUDITING

A Windows-based multiserver auditing tool for NetWare, AuditWare ($595 per server) provides a look and feel similar to that of the NWADMIN NetWare 4 tool. From Preferred Systems (West Haven, CT), the version-independent tool has cross-server query ability for NetWare 2.1, 2.2, 3.x, and 4.x. The version-aware viewer allows the simultaneous auditing of multiple servers, regardless of the version of NetWare each is running.

Phone: (800) 222-7638 or (203) 937-3000.

Circle 1285 on Inquiry Card.

EASY BAR CODE PRINTING

A collection of bar code soft fonts, On-Tap/DOS (from $295) lets you print more than 13 different types of bar code symbologies and subsets. Available in a networked version, On-Tap/DOS lets you print the codes from within your applications. Integrated Software Design (Mansfield, MA) produces the software.

Phone: (508) 339-4928.

Circle 1298 on Inquiry Card.

INVESTMENT TRACKER ▼

Fundwatch Plus for Windows ($39) from Hamilton Software (Englewood, CO) has a spreadsheet-like tracking system that lets you maintain price data for investments at weekly or longer intervals. The software automatically incorporates dividend and distribution information. Flexible tracking and analysis methods let you directly compare a variety of investments and market indexes and identify the best times to buy and sell.

Phone: (800) 733-9607 or (303) 795-5572.

Circle 1292 on Inquiry Card.

EDITING UTILITY

A Windows utility that lets you cut any screen and deposit data in a customized file for reassembly, SuperCut ($79.95) is designed for the creation of multimedia and desktop publishing presentations. From Pacific Micro (Mountain View, CA), SuperCut also has features for general editing functions for applications such as word processors and graphics programs.

Phone: (415) 948-6200.

Circle 1287 on Inquiry Card.

POWERBUILDER QA

An automated software-quality system for conducting comprehensive QA and testing of applications developed using Powersoft's PowerBuilder, PowerRunner ($2850) employs Powersoft's standard PowerBuilder API. From Mercury Interactive (Santa Clara, CA), PowerRunner enables test reusability.

Phone: (408) 987-0100.

Circle 1289 on Inquiry Card.

Software Update

Excalibur EFS 3.5, Excalibur Technologies (San Diego, CA), is easier to integrate with third-party software, has a new API, and provides additional structured RDBMS indexing support. From $12,000.

Phone: (619) 625-7900.

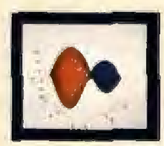
Circle 1303 on Inquiry Card.

FilePower MultiFiler/Finder 4.0, Optika (Colorado Springs, CO), adds OCR for automatic indexing; full text-retrieval and keyword-searching capabilities; multiple annotation features; internationalization; Oracle SQL database support; and multiple-page display. From $450.

Phone: (719) 548-9800.

Circle 1304 on Inquiry Card.

Minitab Statistical Software for Windows 10, Minitab (State College, PA), includes new



graph-editing capabilities; expands its exploratory data-analysis and statistical capabilities; and adds 3-D graphics, fully implemented DDE, and a session window that you can edit to generate reports from within the statistical package. $895.

Phone: (814) 238-3280.

Circle 1305 on Inquiry Card.

Aion Development System 6.4, Trinzic (Palo Alto, CA), improves development productivity on GUI workstations and integration in client/server environments. $9000 for the Windows and OS/2 Presentation Manager version.

Phone: (415) 328-9595.

Circle 1306 on Inquiry Card.

SQL Windows 5.0, Gupta (Menlo Park, CA), adds QuickObjects, workgroup integration, and the SQL Windows Compiler. $3395.

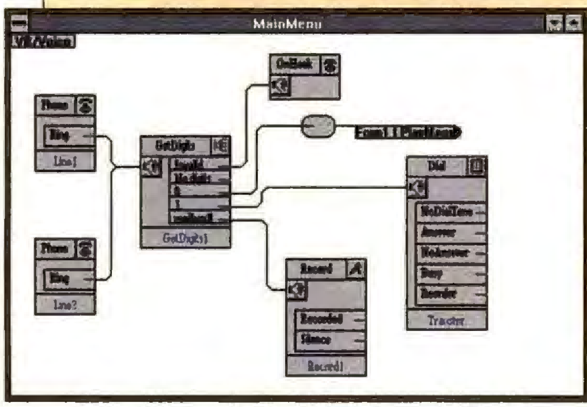
Phone: (415) 321-9500.

Circle 1307 on Inquiry Card.

What's New Software

A Graphical Voice System for Visual Basic

A voice and telephony integration package for Visual Basic, VBVoice is a complete graphical voice-application design tool. VBVoice creates a graphical environment in which you can design, develop, and test interactive voice systems within Visual Basic. The VBVoice/Tapi extension to the system allows you to recompile all existing VBVoice applications to use any telephony interface card that has a Tapi-compliant driver. For demanding applications, you can write code to respond to Tapi events to customize the controls, or you can create your own objects with the User control shell. Pricing for VBVoice/Tapi starts at $395; a fax option is $295.



Contact: Pronexus, Carp, Ontario, Canada, (613) 839-0033.

Circle 1273 on Inquiry Card.

ALPHA DEBUGGER

TotalView (single-user license, $975), a source-level debugger from BBN Systems and Technologies (Cambridge, MA), is available for DEC's Alpha AXP RISC workstation running the OSF/1 operating system. With TotalView, you can simultaneously view and debug all aspects of your applications, as well as debug applications that run on multiple workstations.

Phone: (617) 873-2634.

Circle 1288 on Inquiry Card.

DOCUMENT MANAGEMENT AID

With View Pro (from $395), you can simultaneously view, annotate, and mark up documents regardless of their original size and file format; document notes are automatically updated, and all comments and changes are linked. From The van der Roest Group (Santa Ana, CA), View Pro's vector support includes AutoCAD, CADkey, and CADAM. Its raster support includes TIFF, CALS, and PCX.

Phone: (714) 542-2201.

Circle 1301 on Inquiry Card.

MANAGE THE ISSUES

Issue- and problem-tracking software for Windows, Issue Manager ($49.95) provides a way for you to track issues, note their progress, and record when an issue is closed. From Winnovation (Ft. Collins, CO), Issue Manager tracks problems such as software bugs, maintenance requests, and quality-control support.

Phone: (303) 226-8682.

Circle 1293 on Inquiry Card.

DEVELOP CLIENT/SERVER APPLICATIONS

ObjectPro ($2995 per seat), an object-oriented development tool, is designed for programmers building client/server applications that have business objects programmed into them. All application components are stored as objects, so developers can take advantage of the benefits of inheritance and specialization throughout their applications. The Trinzic (Palo Alto, CA) software's interface lets you access and update a wide variety of databases.

Phone: (415) 328-9595.

Circle 1299 on Inquiry Card.

SOURCE CODE COLLECTION

A compilation of Mac source code and utilities on CD-ROM, Apprentice ($35) has working examples of applications, control panels, extensions, utilities, and more. Apprentice is from Celestin (Port Townsend, WA).

Phone: (206) 385-3767.

Circle 1290 on Inquiry Card.

WINDOWS NT MAKES THE UNIX CONNECTION

The eXceed/NT 32-bit X Window System server software package ($545) for Alpha- and Mips-based PCs enables you to use Windows NT to connect to and display network-based Unix/X and/or VMS applications simultaneously in windows on your desktop. The software is from Hummingbird Communications (Palo Alto, CA).

Phone: (415) 617-4560.

Circle 1291 on Inquiry Card.

DIAGRAM YOUR DATABASE

A reverse-engineering and documentation application for Oracle 6 and 7 databases, Database Illustrator (from $100) uses table, column, and constraint information stored in the data dictionary to produce an entity-relationship diagram with automatic entity layout and relationship routing. The application is from Ray Ontko & Co. (Richmond, IN).

Phone: (317) 935-4283.

Circle 1296 on Inquiry Card.

Software Update

IDL 3.6 for Windows NT and Power Macintosh, Research Systems (Boulder, CO), improves its user interface, enhances its numerical analysis and data handling, and adds new plotting techniques. $1500.

Phone: (303) 786-9900.

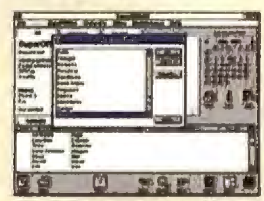
Circle 1310 on Inquiry Card.

Multimedia ToolBook 3.0, Asymetrix (Bellevue, WA), adds over 200 enhancements, including increased productivity, improved applications performance and text capabilities, better user interfaces and database support for applications, and comprehensive multimedia features. $895.

Phone: (206) 462-0501.

Circle 1311 on Inquiry Card.

SuperOffice 3.0, SuperOffice (Bedford, MA), offers calendar sharing between executives and secretaries and



group scheduling; interoffice E-mail; built-in PaperClip document imaging to let you link any type of document to a specific account; access to corporate databases; and linkups to employees in the field. From $295.

Phone: (617) 275-2140.

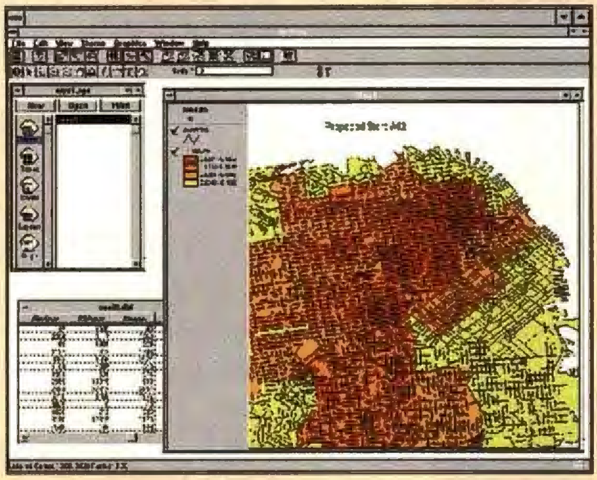
Circle 1306 on Inquiry Card.

askSam for Windows 2.0, askSam Systems (Perry, FL), adds a spelling checker, multiple fonts in the report writer, searching over multiple files, hypertext links, superscripts and subscripts, additional import filters, and an optional OCR module to scan text directly into an askSam database. $149.95; OCR module, $99.95.

Phone: (904) 584-6590.

Circle 1317 on Inquiry Card.

What's New Software



Add Geographic Analysis to Your Spreadsheets

A joint effort from Wessex and Environmental Systems Research Institute, First St. mapping software includes the core data from the U.S. Census Bureau, ArcView 2 software, and a set of 22 CDs with geographic and demographic data. ArcView provides GIS technology; desktop mapping; multimedia; and data-analysis tools, such as DBMSes, business graphics, and spreadsheets. First St. retails for $1995.

Contact: Wessex, Winnetka, IL, (800) 892-6906 or (708) 501-3662.

Circle 1274 on Inquiry Card.

TWO BEATS BEYOND A PIM

Using a concept called the Conducting Platform, SuperConductor ($99) allows you to organize your computers and information around the people (or companies or subjects) you ordinarily interact with rather than around your applications. You work from a central screen and six dependent screens to create a record for each person; then you organize all of a certain person's information—including documents—directly under that person's record. SuperConductor is from Four Corners Development (Sherman Oaks, CA).

Phone: (310) 780-3835.

Circle 1295 on Inquiry Card.

REMOTE ACCESS GOES LOCAL

TakeIt ($139.95) from G'Vosay (Provo, UT) provides access to your network files when you're away from the network. The software creates and maintains an electronic briefcase on your local hard drive; the briefcase emulates your network and allows you to access the files as if they were on the network, with identical drives and directory paths. TakeIt automatically synchronizes your files when you return them to the network.

Phone: (801) 374-1623.

Circle 1294 on Inquiry Card.

BATCH TILES

With Batch It ($199) from Gryphon Software (San Diego, CA), you can color-correct an on-screen digitized video clip by dragging the entire movie onto a color-correction tile instead of correcting it frame by frame. Once the movie is on the tile, the batching process begins. For two tasks, you connect the appropriate two tiles via a connector. The Mac software ships with 30 tiles.

Phone: (619) 536-8815.

Circle 1297 on Inquiry Card.

NETWORK MANAGEMENT

FreedomView NMS ($395) uses SNMP to manage Ethernet networks running under Windows. The software can diagram network topology, depicting different device types with built-in or user-defined icons, and it can automatically detect devices and create a network map, selecting icon types based on device queries. From Compex (Anaheim, CA), FreedomView NMS can poll devices at user-defined intervals and create event filters that trigger custom functions.

Phone: (714) 630-7302.

Circle 1286 on Inquiry Card.

ENTRY-LEVEL SPICE

A 32-bit analog and mixed-signal circuit-simulation system that employs Win32s extensions, ICAP4/Lite ($595) is based on ICAP/4Windows. From Intusoft (San Pedro, CA), ICAP4/Lite allows unlimited-size circuits; performs AC, DC, transient, and temperature analyses; and includes an integrated schematic entry program that produces a complete SPICE netlist.

Phone: (310) 833-0710.

Circle 1300 on Inquiry Card.

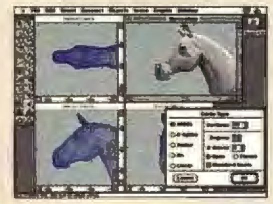
20 VOLUMES ON A DISC

A single-disk CD-ROM (from $1300) provides the full 20 volumes of the *McGraw-Hill Multimedia Encyclopedia of Science & Technology* as well as the complete fifth edition of the *McGraw-Hill Dictionary of Scientific and Technical Terms*. From McGraw-Hill (New York, NY), the Windows-based CD-ROM uses Online Computer Systems' Opti-Ware search-and-retrieval technology.

Phone: (212) 337-5961.

Circle 1302 on Inquiry Card.

Software Update



Sculpt 4.0, Byte by Byte (Austin, TX), features a new user interface; free-form modeling tools, such as b-spline, Bézier spline, and NURBS; and native support for Power Macs. From $1995.

Phone: (512) 795-0150.

Circle 1315 on Inquiry Card.

Collage 2.0, Specular International (Amherst, MA), supports the Power Mac and CMYK image files, is PowerPC-native, and has increased image sizes and an improved user interface. $395.

Phone: (413) 253-3100.

Circle 1309 on Inquiry Card.

Air Series 2.75, Spry (Seattle, WA), enhances installation, Telnet, mail, and news and adds PPP Windows Dialer and Mosaic. From $149.

Phone: (800) 777-9638 or (206) 447-0300.

Circle 1312 on Inquiry Card.

OPN:Office 7.3, OPN Systems (Fort Wayne, IN), includes a GUI that supports X Window System terminals and PCs running an X terminal–emulation package; adds a document-tracking system; and comes with PC Companion, OPN:Style, and OPN:World gateways. From $125 per seat.

Phone: (800) 676-1177 or (219) 455-2758.

Circle 1313 on Inquiry Card.

Catalog On Disk for Windows 2.30, Curtis Software (Torrance, CA), adds support for CD-ROM and the ability to distribute catalogs over dial-up services. From $1795.

Phone: (310) 320-2451.

Circle 1314 on Inquiry Card.

URGENT—YOUR INPUT NEEDED

Dear Reader—

The BYTE State of the Art section is devoted to delivering in-depth information about specific topics in computing on a monthly basis. Early next year, the State of the Art section will cover the technologies and strategies involved with Digital Video.

To ensure that our coverage is in tune with your needs, we request that you fill out the following questionnaire and fax it back to us. It will tell us about your needs and interests, and help us focus our coverage of Digital Video to best address your concerns. Please take a few minutes to fill out this form and fax it back to us.

Of course, questionnaires such as this are necessarily limiting. If you'd like to see other areas covered, or if you want to tell us your ideas about video on the desktop, please contact one of the SOTA section editors at the following E-mail addresses.

Thank you.

Bob Ryan, b.ryan@bix.com
Russ Kay, russellk@bix.com
Scott Wallace, swallace@bix.com

Digital Video

Please rate your interest in the following technologies and applications.

Not at all interested — Extremely interested

1 2 3 4 5

Applications

- ☐ Videoconferencing
- ☐ Video production for broadcasting
- ☐ Industrial video production
- ☐ Training videos
- ☐ Electronic publishing
- ☐ Whiteboard applications
- ☐ 3-D data visualization
- ☐ Other - please specify________________

Compression Schemes and Codecs

- ☐ Captain Crunch
- ☐ MPEG 1
- ☐ MPEG 2
- ☐ JPEG
- ☐ Cinepak
- ☐ MotiVE
- ☐ Fractal compression
- ☐ Huffman coding
- ☐ Other - please specify________________

Standards

- ☐ Indeo
- ☐ MWave
- ☐ Windows DSP Manager
- ☐ VCOS
- ☐ QuickTime
- ☐ H.261
- ☐ Px64
- ☐ Other - please specify________________

Transmission Technologies

- ☐ Switched LANs
- ☐ Full-duplex Ethernet
- ☐ FDDI/CDDI
- ☐ Fast Ethernet
- ☐ ISDN/Switched-56
- ☐ ATM
- ☐ Other - please specify________________

Comments:________________

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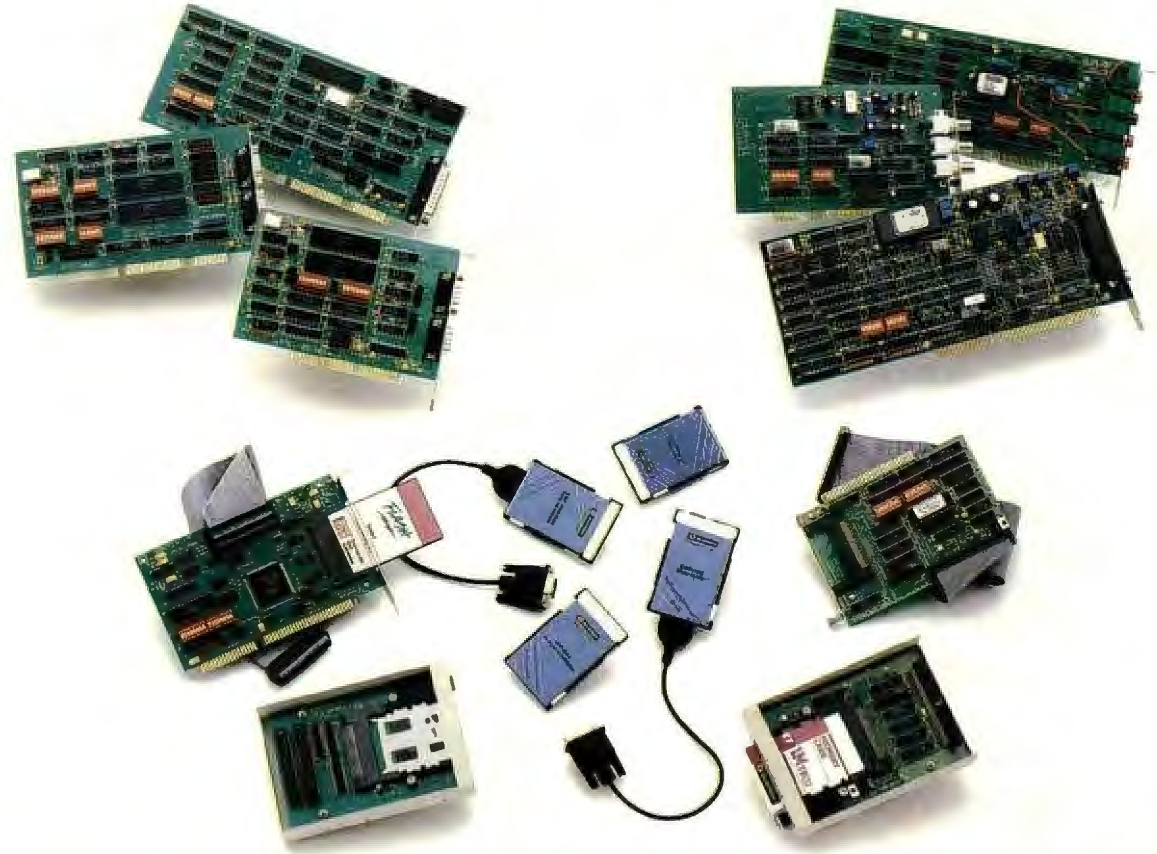

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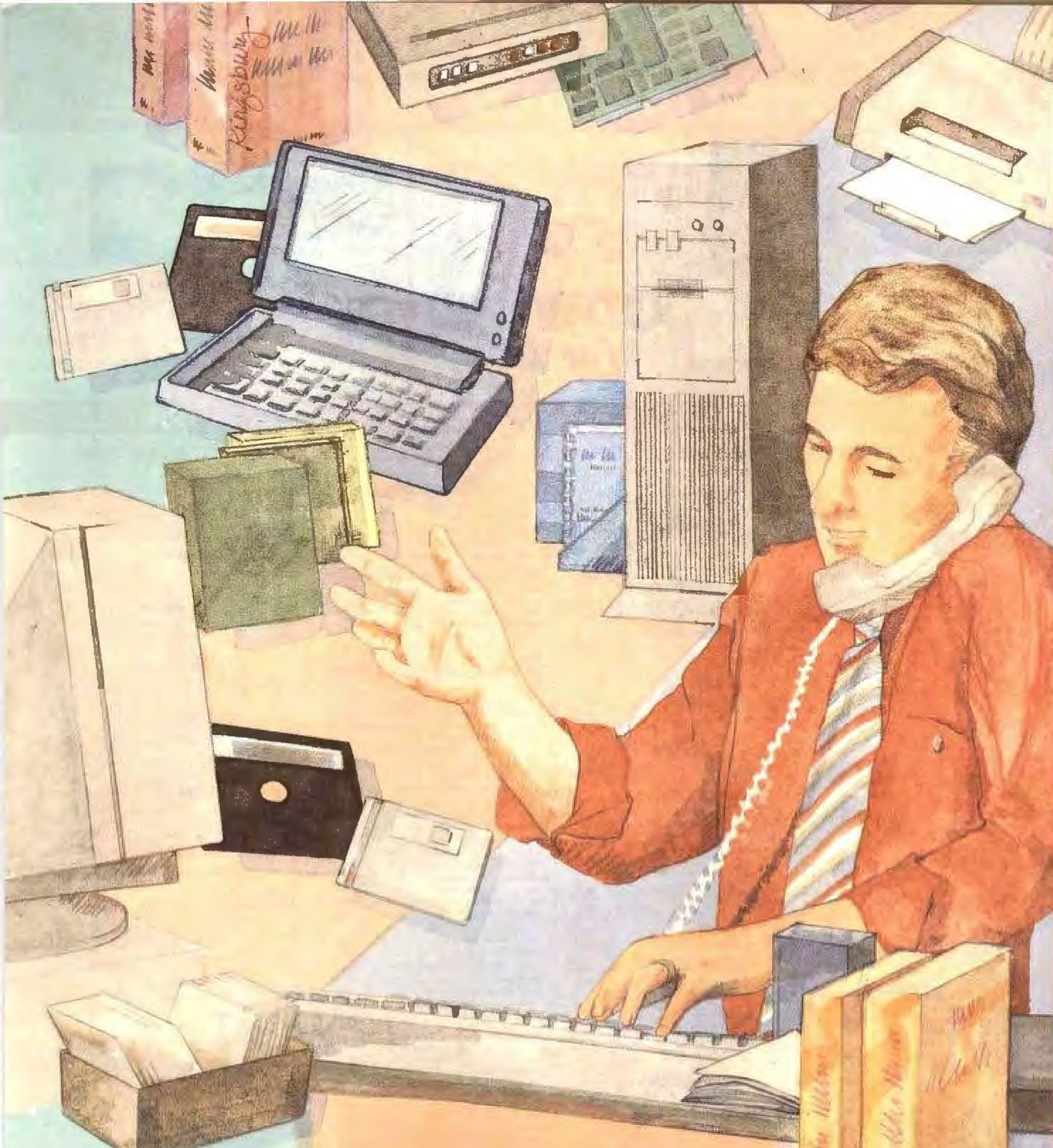

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EtherExpress 16 coax 20pk	1699.38
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Premium 486/33TE 486/25TE 33TE				
Premium Series Prem II 386SX/20 25				
Prem II 386/25 386/33 486/33 486SX/20	8Meg	500180-001	64 pin	189.00
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Prem II 386SX/20 25		500780-004		189.00
Premium 386/25 33 386/33T 386SX/16		500780-003		59.00
Prem II 386SX/20 25		500780-001		99.00
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Premmia	16Meg	501169-003		799.00
Premmia	32Meg	501169-004		1499.00
Premmia	64Meg	501169-005		3111.00
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DeskPro 386/33L, 486/33L	(Exp Bd)	116569-001	279.00
DeskPro 386/25, 386/20	1Meg Module	113131-001	79.00
	4Meg Module	113132-001	199.00
DeskPro 386S-16MHz	1Meg Exp Bd	113633-001	149.00
	4Meg Exp Bd	113634-001	279.00
	1Meg Module	113646-001	79.00
	4Meg Module	117534-001	199.00
DeskPro 386/20E	1Meg Exp Bd	113644-001	149.00
DeskPro 386/25E	4Meg Exp Bd	113645-001	279.00
	1Meg Module	113131-001	79.00
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DeskPro 286N, 386N,	1Meg Module	118688-001	59.00
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Port. 4 Series 486C	8Meg Module	178817-001	389.00
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T4400SX, SXC T6400, T6600	8Meg	PC-PA2005U	369.00
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AST Power Exec 4/33SL	4Meg, 16Meg	501318-001,002	194/769
AT&T Safari NSX/20	4Meg	PEC 37651	259.00
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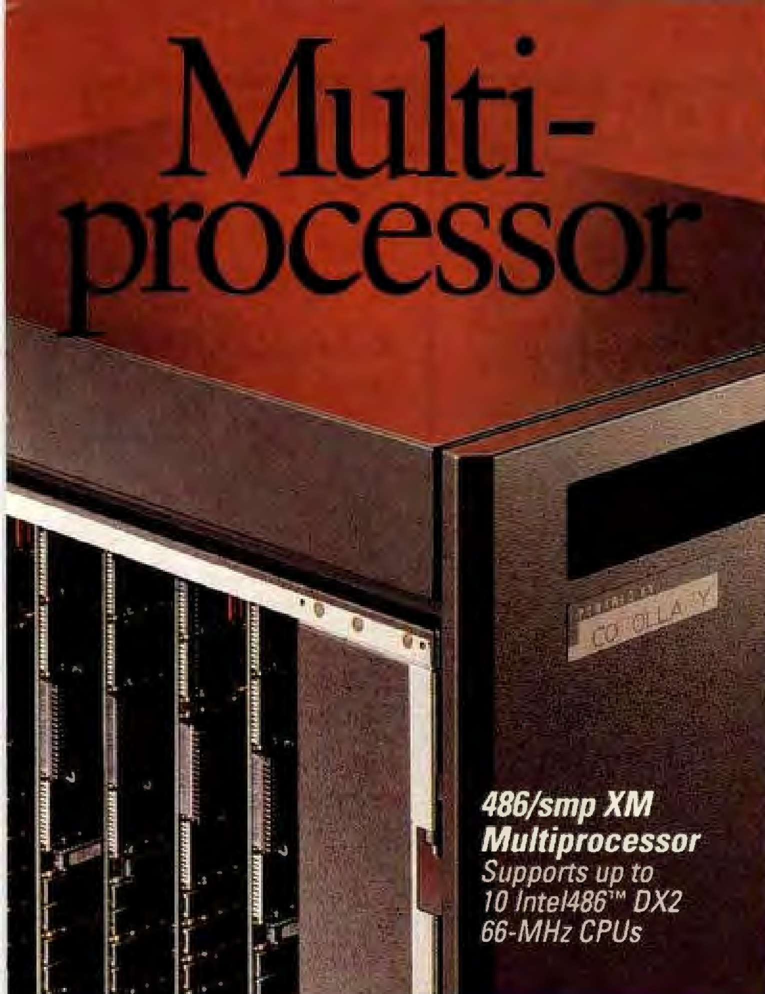

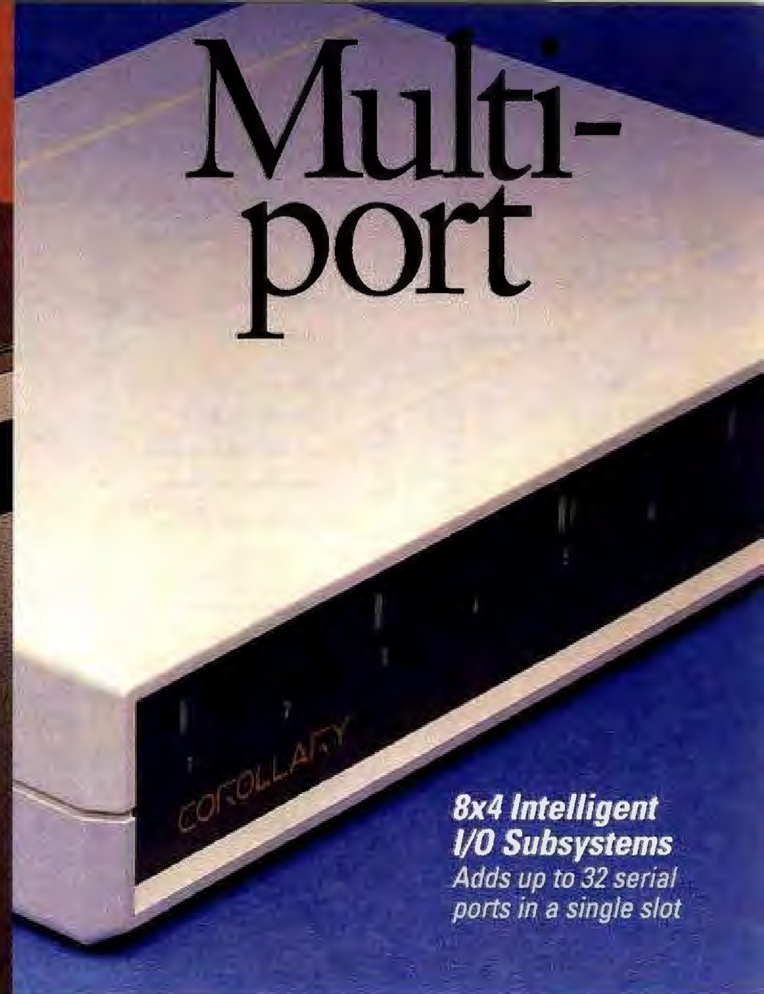

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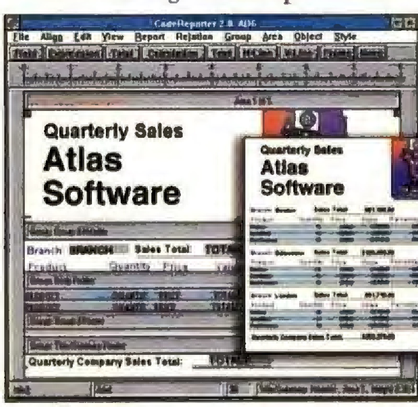

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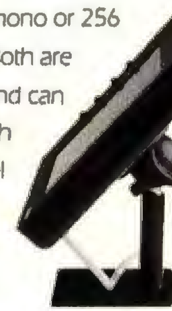

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ST31200N	1050MB	10MS	SCSI	$789

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MODEL	SIZE	SPEED	TYPE	PRICE
CFA210A	210MB	15MS	IDE	$198
CFA340A	340MB	12MS	IDE	$249
CFA420A	420MB	12MS	IDE	$288
CFA540A	540MB	12MS	IDE	$348
CFA810	810MB	12MS	IDE	$595
CFA1060A/S	**1060MB**	**10MS**	**IDE/SCSI**	**$678**

Maxtor

MODEL	SIZE	SPEED	TYPE	PRICE
7290A	290MB	15MS	IDE	$238
7345A	345MB	14MS	IDE	$258
7546A	**549MB**	**12MS**	**IDE**	**$368**

MICROPOLIS

2217 (3.5")	1750MB	10MS	SCSI/IDE	$1075
1548 (FH)	1748MB	14MS	SCSI	$1075
1926 (FH)	2100MB	11MS	SCSI	$1588
1936 (FH)	3300MB	11MS	SCSI	$2138
4110 (3.5")	**1050MB**	**10MS**	**SCSI/IDE**	**$788**

WESTERN DIGITAL

1210	212MB	13MS	3.5" IDE	$204
1270	270MB	12MS	3.5" IDE	$238
2340	340MB	12MS	3.5" IDE	$269
2420	**425MB**	**12MS**	**3.5" IDE**	**$258**
2540	**540MB**	**12MS**	**3.5" IDE**	**$408**

Quantum

LPS270A/S	270MB	12MS	IDE/SCSI	$243
LPS340A/S	340MB	12MS	IDE/SCSI	$308
LPS540A/S	540MB	12MS	IDE/SCSI	$398
LPS1080A/S	1050MB	10MS	IDE/SCSI	$748
LPS1225	1200MB	10MS	SCSI	$898

PROCESSOR UPGRADES

Evergreen Technologies

286 (6-16 MHZ)	EVER (IBM 486SLC2 50MHZ)	$288
386SX-16 & 20 (X2)	EVER (TI SXLC2-20/40 MHZ)	$248
386SX-25 MHZ (X2)	EVER (IBM SLC2-25/50 MHZ)	$328
386SX-33 mhz (X2)	EVER (IBM SLC2-33/66 MHZ)	$378
386DX 16 & 20 (X2)	EVER (TI SXL2 20/40 MHZ)	$278
386DX-25 MHZ (X2)	EVER (TI SXL2 25/50 MHZ)	$328
386DX-33 MHZ (X2)	EVER (IBM & LIGHTNING-33/66)	$498
386SX 16 MHZ (X3)	EVER (IBM & LIGHTNING-16/48)	$398
386SX-20 MHZ (X3)	EVER (IBM & LIGHTNING-20/60)	$478
386SX-25 MHZ (X3)	EVER (IBM & LIGHTNING-25/75)	$498
386DX 16 & 20 (X3)	EVER (IBM & LIGHTNING-20/60)	$398
386DX-25 MHZ (X3)	EVER (IBM & LIGHTNING-25/75)	$478
386DX-33 MHZ (X3)	EVER (IBM & LIGHTNING-33/99)	$698

Cyrix

386SX-20 MHZ (X2)	CYRIX (486SRX2 20/40 MHZ)	$248
386DX-16 MHZ (X2)	CYRIX (486DRX2-16/32 MHZ)	$238
386DX-20 MHZ (X2)	CYRIX (486DRX2-20/40 MHZ)	$268
386DX-25 MHZ (X2)	CYRIX (486DRX2-25/50 MHZ)	$308
386DX-33 MHZ (X2)	CYRYX (486DRX2-33/66)	$338
386SX-25MHZ (X2)	CYRYX (486SRX2 25/50)	$258

MOTHER BOARDS

486DX2/66.....$598
486DX W/O CPU.....$118
(3VL, 3-16BIT, 2-8BIT & ZIFF SOCKET)
We carry a complete line of motherboards, Call with your requirements!

D-RAM CHIPS

DESCRIPTION	150NS	120NS	100NS	80NS	70NS	60NS
64 X 4	$1.95	$2.25	$2.45	$2.95		
256X1 STATIC				$1.95	$2.25	
256 X 1	$1.45	$1.85	$2.40	$3.00	$3.15	$3.20
256 X 4			$5.45	$5.95	$6.45	$6.95
1MEG X 1		$4.40	$4.90	$5.75	$6.45	$6.75
1MEGX1 STATIC				$4.95	$5.25	
1MEGX4				$26.00	$29.00	$34.00
256X16 VRAM				35.00	38.00	

CONTROLLERS

8 Bit	2 Hard Drives MFM	$49
8 Bit	2 Hard Drives RLL	$69
16 Bit	Hard and Floppy 1:1 Interleave	$34
SCSI	DTC 3280 (Supports 7 drives)	$139
SCSI	Adaptec 1742A 32 BIT EISA	$418
SCSI	Adaptec 2842 BLK (VLB)	$349
SCSI	Adaptec 1542 CF Bus Mastering	$214
ESDI	DTC6282-24	$149
IDE	Hard only 16bit	$9
IDE	**Hard and Floppy w/IO**	**$18**
Cables	Hard Drive	$9
Cables	Hard and Floppy	$14

MEMORY BOARDS

BOCA AT PLUS
16 BIT MEMORY BOARD FOR 286, 386
OK-$84.00 2MEG-$150.00
4MEG-$228.00 8MEG-$398.00

BOCARAM/2 PLUS
For PS/2 2 to 8MB (uses 1MEG SIMMS)
2MB-$198 4MB-$268 8MB-$438

2-8 MB FOR PS/2 50 & 60,
2MB $119, 4MB $188, 8MB $348

SIMM MODULES

30 PIN SIMM MODULES

DESCRIPTION	100NS	80NS	70NS	60NS	53NS	40NS
256X9 (30PIN)	$9	$12	$15	$17		
1MEGX3 (30PIN)		$37	$39	$44	$49	$64
1MEG X 9 (30PIN)	$34	$39	$42	$46	$64	$78
4MEG X 9 (30PIN)		$137	$139	$148		
16 MEG X 9 (36 CHIP)			$798			

72 PIN SIMM MODULES

512X36 2MEG (72 Pin)	$78	$84	$98
1X36 4MEG (72 Pin)	$158	$168	$198
2X36 8MEG (72 Pin)	$339	$348	$398
4X36 16MEG (72 Pin)	$648	$664	$738
8X36 32MEG (72 PIN)		$1475	$1575
16X36 64MEG 72 PIN		$2950	

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80386 MACHINES		8088 MACHINES	
80387 16MHz	$44	8087-3 5MHz	$44
80387 20MHz	$54	8087-2 8MHz	$48
80387 25MHz	$59	8087-1 10MHz	$78
80387-33MHz	$69	80286 MACHINES	
80387DX	$74	80287-6MHz	$19
80387 SX16	$48	80287-8MHz	$24
80387-SX20	$54	80287 10MHz	$49
80387 SX33	$84	80287 XL	$54
80387SL	$79	80287 XLT	$78

Cyrix

83D87-33MHZ... $28 83S87-25MHZ (SX)... $39
83D87-40MHZ... $58 83S87-33MHZ (SX) ... $58

CPU'S

intel

80486DX2/66	$298
80486SX/25	$78
80486SX/33	$98
PENTIUM 60	$698
PENTIUM 66	$798
PENTIUM 90	$976
80486DX/25	$188
80486DX/33	$264
80486DX4/100	$668
CPU COOLING FAN	$9

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Cyrix

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Cx486DRx2-16/32	$238
Cx486SRx2-20/40	$248
Cx486DRx2-20/40	$258
Cx486SRx2-25/50	$259
Cx486DRx2-25/50	$298
Cx486DRx2-33/66	$338

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IBM PS/2 Memory

MODEL	MEMORY	PART#	PRICE
AMBRA Enterprise 386, Hurdle 386, Sprinta 386 (all models)	2MB	N/A	$93
	8MB	N/A	$328
AMBRA Enterprise 486, Hurdle 486, Sprinta 486 (all models)	4MB	N/A	$178
	16MB	N/A	$648
PS/1 and 386/SX (2121)	2MB	92F9935	$80
	4MB	92F9694	$168
PS/2 30/286/25/286; Adpt Brd 1497259	512K	30F5348	$35
	2MB	30F5360	$80
PS/2 35SX, LS, 40SX, 70 E61; 061; 121, Adpt Brd 6450609; 34F3011; 34F3077, 502, 55SX, 65SX, P70, 55LS, 65LS X Station 120 & 130	1MB	6450603	$39
	2MB	6450604	$84
PS2 50, 50Z, 55SX, 60, 65SX	2-8MB	1497259	$198
	2-16MB	6450609	$368
PS/1 Consultant, Essentials & Expert models x43, x44 & PS/Valuepoint all models except Cxx series	4MB	96F9290	$194
	16MB	96F9291	$638
PS/2 70-A21; A61; B21; B61; PS/1 Consultant, Essential & Expert models x11, x13 & x14, PS/Valuepoint Cxx series	1MB	6450603	$39
	2MB	6450608	$89
PS/2 35SX, LS, 40SX, 55SX; LS, 65SX	4MB	34F2933	$178
PS/2 90 XP, 95 XP, P75 (Pairs) 56 57 (all) 76, 77, PS/1 Pro 2123	2MB	6450902	$80
PS2 90, 95 XP, P75 (Pairs) 56, 57, (all) PS/1 Consultant, Essential, Expert x11, x13 & x14, PS/1 Pro 2123, PS/6000	4MB	6450128	$174
	8MB	6450130	$338
PS2/2 35SX; LS; 40SX	8MB	6450129	$338
PS2 70's and 80's	2-8MB	6450605	$297
32 BIT BOARDS	2-14MB	34F3077	$225
32 BIT BOARDS	4-16MB	34F3011	$318
PS/2 80-A21; A31; A61	4MB	6451060	$188
PS/2 80-041	1MB	6450375	$78
PS/2 80-111; 311; 121; 321; 081; 161	2MB	6450379	$94

4010BSC/6000 (16MB) $768, 4033 (32MB) $1598, 4036 (64MB) $3298

IBM Laptop Memory

Thinkpad 300, Ambra Treka	2MB	33G9288	$128
	8MB	33G9289	$368
Thinkpad 350, 350C	8MB	60G0378	$358
	16MB	60G0379	$668
Thinkpad 500	4MB	53G6959	$228
	8MB	53G6960	$449
CL57SX	4MB	07G1420	$208
Thinkpad 700, 700C, 720, 720C	8MB	07G1421	$378
	16MB		$998
Thinkpad 710T, 750, 750C	4MB	N/A	$188
	8MB	N/A	$318
PS/Note N45SL	2MB	92F8804	$108
PS/2 Model N51, Notebook SLC, SX	2MB	07G1826	$98
	4MB	07G1827	$188
	8MB	07G1828	$418
Laptop N33SX, L40SX & PSNOTE 182	2MB	79F0999	$98
	4MB	79F1000	$184
L40SX, PSNOTE 182 ONLY	8MB	79F1001	$348

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MODEL	MEMORY	PART#	PRICE
T1000SE/LE/XE	1MB	PA8311U	$29
T1000 SE/LE/XE	2MB	PA8312U	$73
T2000/T2000SX	2MB	PA8317U	$93
T2000SX/T1000XE	4MB	PA8314U	$188
	8MB	PA8315U	$358
T1200 XE	2MB	PA8306U	$98
T1600	2MB	PA8307U	$98
T2000 SXE/T2200SX/T1800T1850, C	2MB	PA2000U	$94
	4MB	PA2001U	$188
	8MB	PA2002U	$358
T3100	2MB	PA7135E	$138
T3100E	2MB	PA8341U	$108
T3100 SX	2MB	PA8308U	$108
	4MB	PA8310U	$198
T3200 SX	2MB	PA8307U	$118
	4MB	PA8309U	$198
T3200 SXC	2MB	PA8318U	$108
	4MB	PA8319U	$198
T3200	2MB	PA7137U	$184
T3300SL	2MB	PA2006U	$118
	4MB	PA2007U	$238
	8MB	PA2008U	$234
	16MB	PA2009U	$698
T3400CT	4MB	PA2019V	$198
	8MB	PA2020V	$398
	16MB	PA2021V	$818
T4400 SX, SXC, T6400 SXC, DXC	2MB	PA2003U	$125
	4MB	PA2004U	$198
	8MB	PA2005U	$378
	16MB	PA2010U	$698
	32MB		$1999
T4500, T4600, T1900C 3.3VOLTS	4MB	PA2012U	$208
	8MB	PA2013U	$408
	16MB	PA2014U	$798
T5100	2MB	PA8301U	$94
T5200/T5200C/T8500	2MB	PA8304U	$109
	8MB	PA8313U	$418

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AST Memory

MODELS	MEMORY	PART#	PRICE
PREMMIA	4MB	501159-001	$168
	8MB	501159-002	$341
	16MB	501159-003	$734
ADVANTAGE 386SX/20, 25, PRO SX/25 BRAVO 3/33S	2MB	500962-001	$88
	8MB	500962-007	$348
BRAVO NB486	4MB		$198
	16MB		$798
ADVANTAGE PRO 486DX/33, SX/25, BRAVO LC 4/25S, 33, 33S, 50D, 4'66D	2MB	500987-001	$88
	4MB	500987-002	$178
	8MB	500987-003	$418
PREMIUM 386/25, 33, 33TE 386SX/16, 20, 25	1MB	500780-003	$48
	1MB	500780-002	$48
ADVANTAGE 486/25, 33, 33P, SX20, BROVO 4/33, 486/25, PREMIUM 4/25, 33TT, SE 4/33	2MB	500718-004	$84
	2MB	500780-005	$84
ADVANTAGE 486/25, 33, 33P, SX20, POWER PREMIUM 3/33, 4.33, 33S, 50D; 66D, PREMIUM 386/33TE, 486/25, E, 25TE, 33, 33TE, PREMIUM II 386/25, 33, 486/33, 486SX/20			
PREMIUM SERVER SE 4/33	4MB	500780-004	$178
	8MB	500780-001	$300
AST LAPTOP			
POWER EXEC 3/25SL, 3/25SL C, EL	4MB		$188
	16MB		$768
POWER EXEC 4/25SL	4MB		$178
	16MB		$768
PREMIUM EXEC 386, 386SX/20, 25, 25C	4MB	500814-001	$168
BRAVO NB486	4MB		$198
	16MB		$648

COMPAQ Memory

MODEL	MEMORY	PART#	PRICE
Deskpro 386/16	1-2MB	108069-001	$238
	2MB	108069/W71	$448
	4-8MB	108070-001	$398
Deskpro 286E; 386-20; 20E; 25; 25E	1MB	113131-001	$59
	4MB	113132-001	$178
Deskpro 386S	4MB Board	113633-001	$254
	4MB Module	112534-001	$178
Deskpro 386 20E; 25E	4MB	113645-001	$238
Deskpro 386/33/33I; 486/25, 33L, 50L; Systempro	2MB	115144-001	$98
	8MB	116561-001	$378
	32MB	116568-001	$1458
Systempro, Deskpro 6 SKT EXP BRD W/2MB		116569-001	$288
Compaq "M"	2-64MB	129160-001	$188
Deskpro 286N; 386N; 386SX/20, 20N, Portable 486c, DeskproM, Systempro LT Series 129160-001, Pro Signia	1MB	118688-001	$49
	2MB	118689-001	$84
	8MB	118690-001	$178
	8MB	128877-001	$348
Prolinea 3/25 & 25Z	4MB	141738-001	$88
	8MB	141742-001	$318
Prolinea 4/25s, 4/33, 4/50	2MB Module	141683-001	$94
	4MB Module	141684-001	$178
	8MB Module	141685-001	$338
Compaq Pro Signia	16MB	149230-001	$684
	32MB	149147-001	$1524
DeskPro 5/60, 5/66M	8MB	149911-001	$388
Prosignia PC Server, 486/33/66	8MB	141685-001	$348
	16MB	149230-001	$648
	32MB	149147-001	$1498
Prosignia 5/60	16MB	149949-001	$738
Proliant 1005/60	32MB	149912-001	$1398
Proliant 2000 4/30, 5/66	64MB	149913-001	$2698
Proliant 4000 4/50, 5/66	128MB	149914-001	$5600

Compaq Laptop & Notebook Memory

Concerto 486 4MB $198 8MB $388 16MB $798

Contura 320, 325, C	2MB	139497-001	$98
	4MB	139498-001	$174
	8MB	139499-001	$318
Contura 4/25CX	4MB	146520-001	$178
	8MB	146521-001	$328
	16MB	146532-001	$748
SLT/286	1MB	110235-001	$75
	4MB	110237-001	$218
SLT386	1MB	118303-001	$79
	2MB	118304-001	$108
	4MB	118305-001	$198
Lte 286	1MB	117081-001	$79
	2MB	117081-002	$99
	4MB	117081-004	$178
Lte 386S/20	1MB	121125-001	$98
	4MB	121125-002	$208
Lte Lite/20, 25, 25C	2MB	129769-001	$138
	4MB	129769-002	$208
	8MB	129769-003	$388
	16MB	129769-004	$808
LTE Lite 486/25C	4MB	142337-002	$178
	8MB	142337-003	$348
	16MB	142337-004	$768
Aero 3.3volt	4MB	190532-001	$218
	8MB	190597-001	$398

LAPTOP & NOTEBOOK MEMORY

MODEL	MEMORY	PART#	PRICE
AT&T Safari	4MB	37651	$248
Dec pc 320 Notebook	2MB Mod	FR-PCIMA-BA	$149
	4MB Mod	FR-PCIMA-BB	$298
	8MB Mod	FR-PCIMA-BD	$498
Epson NB-3 Notebook	4MB	A808511	$198
Epson NB-SL/	2MB Mod	A808771	$160
EPSON 25C Notebook	4MB Mod	A808781	$228
Everex Tempo LX, LX20	2MB	00160	$98
Everex Carrier	2MB	00263-00	$108
Gateway 2000 Nomad 425 DXL/SXL	4MB		$188
	16MB		$1475
Gateway 2000 486	4MB		$188
	16MB		$781
Grid 1500	4MB	52587	$238
Grid 1450SX	2MB	6200202	$148
Goldstar GS320, 386SX16	1MB	N/A	$98
	4MB	N/A	$298
NCR 3120 Notebook	4MB Mod	31204X104	$299
NCR 3170 Notebook	4MB Mod	31234X104	$399
Packard Bell, Magnavox, Mitsuba	1MB	N/A	$108
	4MB	N/A	$198
Panasonic CF170/270/370	1MB	CF-BA165	$64
Samsung Notemaster 386S	2MB	SN4002	$195
	4MB	SN4004	$395
Sanyo 17NB, 18NB & 27COS	2MB	MBC-NBMEM2	$98
Sharp 6220	1MB	CE-621B	$78
Sharp 6640, 6781, 6681, 6785	4MB	N/A	$198
Sharp 4700MZ 200	1MB	CE-471	$198
Sharp 8501 Calendar	2MB	N/A	$398
TI Travelmate 2000	1MB	2568034-0011	$78
TI Travelmate 3000SX, WINSX	2MB	2566996-0001	$84
TI Travelmate 4000, WINDX/25 SX/16, SX25, DX2/40	4MB	2581265-001	$188
DX2/50	16MB	AVAILABLE	$1298

Laser Printer Memory

MODELS	1MB	2MB	2MB	4MB	8MB	8MB
Canon LBP4, 4 Lite & 4+	$108	$144				
Epson Action Laser II, 8000	$108		$210		$268	
Epson + 6000 and many more	$128		$198			
Epson Action Laser 1000 & 1500	$138		$248			$399
Fujitsu 7100 & 7200	$199	$279				
HP Deskjet 500, 500C and 550C	$38 (256K)					
HP 2, 2D	$98		$164			
HP 3, 3D, 3P, 2P, 2P+	$98		$168			
HP Laser Jet 4, 111Si, XL300, 1200C	$84		$174		$348	
IBM Laser 4019, 4019E (3.5MB)	$114		$164			
IBM Laser 4029 ALL MODELS	$95		$155			
NEC 90, 290	$104					
NEC 95	$78					
OKI 400	$68	$88				
Packard Bell PB9500	$125		$208			
Panasonic 4410/4430	$118		$174			
Panasonic 4420/4450	$118		$178			
Panasonic 4450	$105					
Panasonic 4455	$179					
QMS 410	$119	$159	$249			
Toshiba Page Laser 6	$99		$168			
TIXL/PS17/PS35	$44	$98				

CACHE MEMORY

	15ns	20ns	25ns		15ns	20ns	25ns
8KX8	4.95	4.45	3.95	64x4	10.00	5.95	4.95
32KX8	7.95	6.75	6.35	16x4	6.95	5.45	4.95
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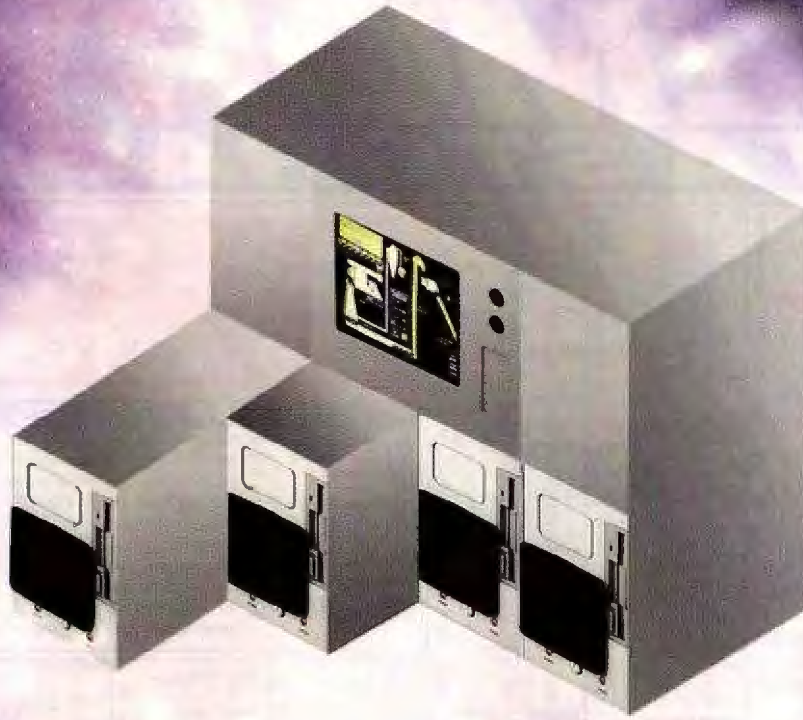

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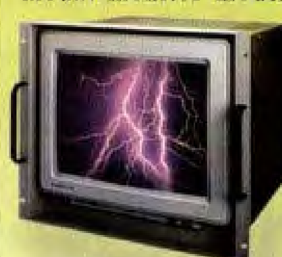

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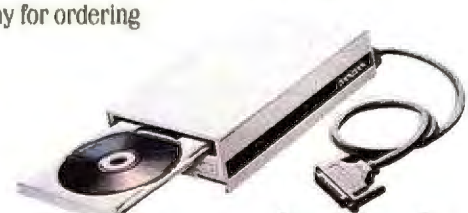

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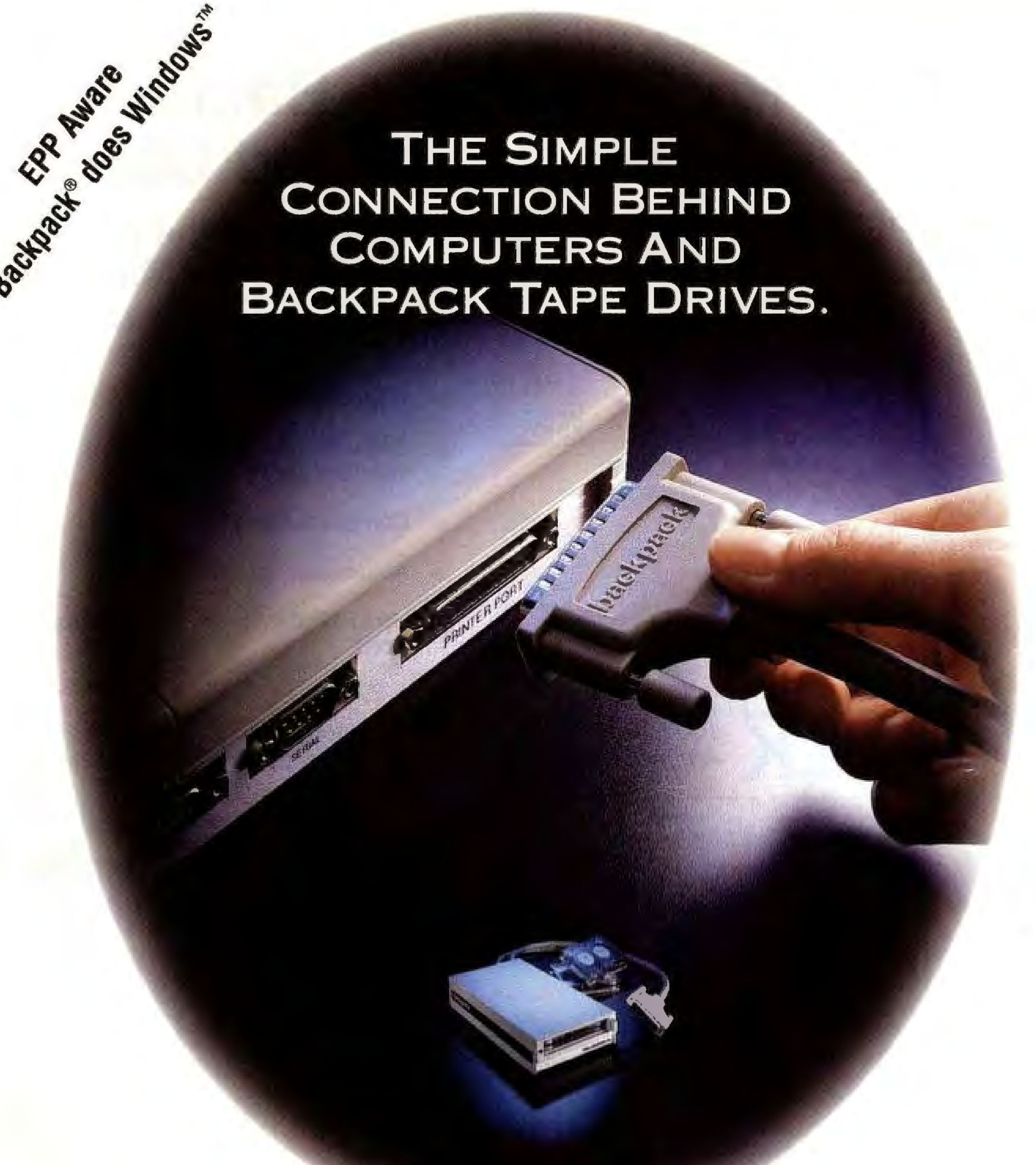

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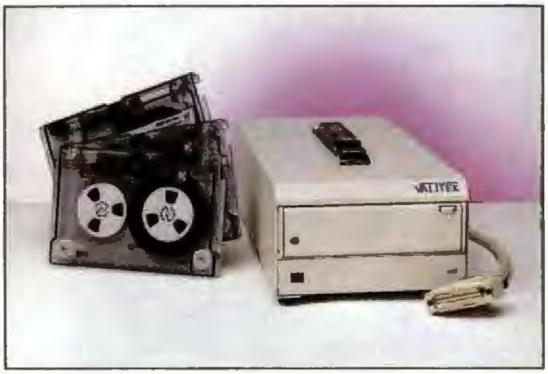

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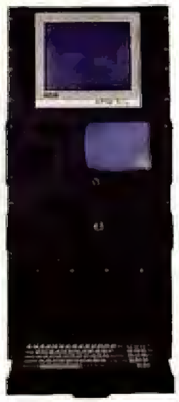

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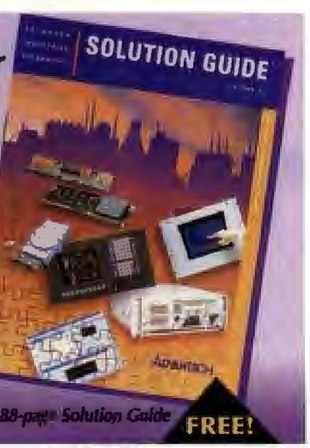

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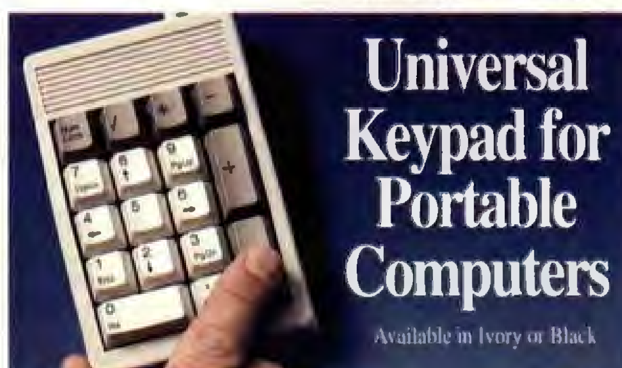

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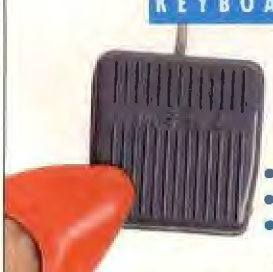

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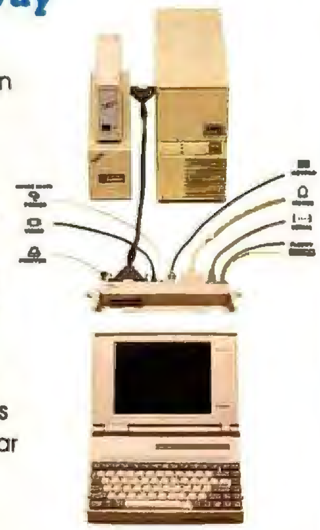

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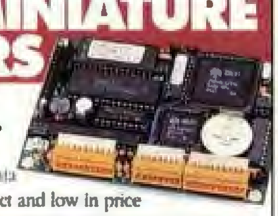

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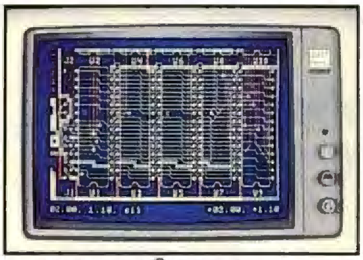

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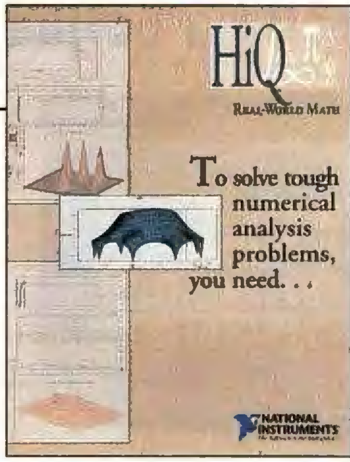

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99	IBM PC DIRECT	CII,1	800-426-7647
289	IBM POWER PC	122-123	800-POWER-PC
101	IBM C/C++ DEVELOPMENT TOOLS	21	800-342-6672
100	IBM S/W SOLUTIONS	109	800-IBM-CALL dept SM030
102	IBM RISC SYSTEM 6000 (N.A.)	28-29	800-IBM-6676 ext 633
264-265	IMAGRAPH CORP	261	508-256-4624
103	INTEGRAND RESEARCH	106	209-651-1203
558	INTEGRIX INC	40IS 21	805-375-1055
•	INTEL CORP	16-17	800-538-3373
•	INTEL CORP (N.A.)	16A-B	800-538-3373
104-105	INTERGRAPH	163	800-345-4856
106-107	INTERGRAPH (N.A.)	75	800-345-4856
235	IO TECH	262	216-439-4091
159-160	ITERATED SYSTEMS	164	800-437-2285
	J		
197	JAMECO ELECTRONICS	247	800-831-4242
•	JDR MICRODEVICES	255	800-538-5000
268-269	JNL COMPUTER PROD INC	261	800-283-5123
187-188	JSB	212	800-359-3408
295-296	JVC INFORMATION	190	714-261-1292
	K		
239	KEITHLEY METRABYTE	259	800-348-0033
108	KFC (N.A.)	170	800-253-2872

Inquiry No.		Page No.	Phone No.
236	KILA	258	303-444-7737
109-110	KINGSTON TECHNOLOGY	127	714-435-2600
111	KNOWLEDGEWARE INC (N.A.)	199	800-675-2100
518	KUO FENG CORP (INT'L)	121	+886-2-754-8498**
282-283	KUREO TECHNOLOGY, INC	264	604-433-7715
	L		
215-216	L A TRADE	234	800-433-3726
538-539	LABTAM	40IS 20	508-393-5780
237	LAGUNA DATA SYSTEMS	262	800-938-TAPE
112	LAHEY COMPUTER SYS	206	800-548-4778
535	LANSOURCE	40IS 18	+44-223-237778
238	LAWSON LABS INC	259	800-321-5355
519	LIGATURE LTD	40IS 4	+972-2-513553
	M		
520	MAGIC / MSE	40IS 5	+972-3-751-1901**
545	MANCHESTER EQUIP CO	240NE 1	516-435-1199
•	MAN IN THE CHAIR	240SO 1	
•	MAN IN THE CHAIR	240PC 4	
114-115	MANNESMANN TALLY (N.A.)	55	800-843-1347 ext 62
533-534	MARX DATENTECHNIK GMBH	40IS 22	+49-8403-1555
•	MCGRAW HILL NRI (N.A.)	192A-B	
•	MCGRAW-HILL ONLINE (INT'L)	209	
561	MEGADATA	40IS 24	516-589-6858**
209	MICRO 2000	248	800-864-8008
203-204	MICRO SOLUTIONS COMP PROD	239	800-295-1214
199-200	MICRO SOLUTIONS COMP PROD	251	800-295-1214
201-202	MICRO SOLUTIONS COMP PROD	253	800-295-1214
211	MICRO-INTERNATIONAL, INC	240	800-967-5667
256-257	MICROCAL SOFTWARE, INC	265	800-969-7720
297-298	MICRODATA	245	800-539-0123
117-118	MICRONET TECH	181	800-800-DISK
•	MICROSOFT CORP	8-9	800-370-8896 ext CN3
240-241	MICROSTAR LABORATORIES	259	206-453-2345
158	MINICOM / CLASSNET VIDEO	118	+972-2-637576**
523-524	MINUTEMAN	40IS 17	214-446-7363
553-554	MULTIPORT COMP-SYS (INT'L)	170	+49-991-29017-20**
	N		
119-120	NANAO USA CORP (N.A.)	51	310-325-5202
521-522	NATIONAL INSTRUMENTS	40IS 6	512-794-0100
242	NATIONAL INSTRUMENTS	264	512-794-0100
290	NEC RISCSERVER	12-13	800-NEC-INFO
156	NETWORLD + INTEROP 94	217	+33-1-46-39-56-33
157	NETWORLD + INTEROP 94 (N.A.)	213	800-338-6638 ext 1900
196	NEVADA COMPUTER	242	800-982-2925
559-560	NEWGEN SYSTEMS CORP (INT'L)	55	714-641-8600
273	NEWVOICE	258	703-448-0570
121	NSTL	215	610-941-9600
•	NSTL	246	610-941-9600
546	NYNEX MOBILE COMMUNICATIONS	240NE 6	800-996-DATA
•	NYNEX MOBILE COMMUNICATIONS	240NE 6A-B	800-996-DATA
	O		
284-285	OCEAN ISLE SOFTWARE	150	800-677-6232
516	OLIVETTI S.P.A. (INT'L)	148-149	(UK) +0800 44 77 99
517	OLIVETTI S.P.A. (INT'L)	28-29	(UK) +0800 44 77 99
530	ON TIME MARKETING	40IS 22	+49-40-437472
•	OSBORNE MCGRAW-HILL	134-135	800-822-8158
	P		
279	P.E. LOGIC CORP	257	800-345-SCSI
218	PACIFIC COAST MICRO	244	619-581-6040
255	PACIFIC SOFTWORKS	265	800-541-9508
122	PATTON & PATTON	207	800-525-0082 ext 114
280	PC PORTABLE MANUFACTURING	258	818-444-8144
123-124	PC POWER & COOLING	53	800-722-6555
125	PERSOFT INC	173	800-368-5283
243	PERSONAL TEX	264	800-808-7906
126	PHAR LAP SOFTWARE INC	112	617-661-1510
525	PHILIPS MONITORS (INT'L)	100-101	+31-40-73-39-83**
127-128	PINNACLE MICRO	7	714-727-3300
537	PIONEER HIGH FID (GB) LTD (INT'L)	81	
129	PKWARE INC	155	414-354-8699
303-304	PLASMON DATA SYSTEMS	216	408-956-9400
178-179	PLEXTOR	66	800-4PLEXTOR
130	POPKIN S/W & SYSTEMS INC	159	212-571-3434

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Title

Company

Address

City State Zip

Phone Fax

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

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

B. What is your level of management responsibility?

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

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

10 ☐ Yes
11 ☐ No

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

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

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

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

September 1994 91 96 99

Valid until November 30, 1994

Inquiry Numbers 60–246

60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110
111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127
128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161
162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178
179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195
196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212
213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229
230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246

Inquiry Numbers 247–433

247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263
264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297
298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314
315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331
332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348
349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365
366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382
383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399
400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416
417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433

Inquiry Numbers 434–620

434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450
451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467
468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484
485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501
502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518
519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535
536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552
553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569
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587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603
604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620

Inquiry Numbers 621–807

621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637
638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654
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723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739
740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756
757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773
774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790
791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807

Inquiry Numbers 808–994

808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824
825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841
842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858
859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875
876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892
893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909
910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926
927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943
944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960
961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977
978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994

Inquiry Numbers 995–1159

995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009
1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024
1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039
1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054
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1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159

Inquiry Numbers 1160–1324

1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174
1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189
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1310	1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324

Inquiry Numbers 1325–1489

1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339
1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354
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1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472	1473	1474
1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487	1488	1489

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- Diskettes/Duplicators 8
- Fax Boards/Machines 9
- Graphics Tablets/Mice/Pen Input 10
- Keyboards 11
- LAN Hardware 12
- Laptops & Notebooks 13
- Mail Order 14
- Memory/Chips/Upgrades 15
- Miscellaneous Hardware 16
- Modems/Multiplexors 17
- Monitors & Terminals 18
- Multimedia/CD-ROM 19
- Printers/Plotters 20
- Programmable Hardware 21
- Scanners/OCR/Digitizers 22
- Tape Drives 23
- UPS/Power Management 24

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- Data Acquisition 28
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- Entertainment 32
- Graphics 33
- Macintosh 34
- Mail Order 35
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- Miscellaneous Software 37
- On-Line Services 38
- Operating Systems 39
- Programming Languages/Tools 40
- Security 41
- Shareware 42
- Software Duplication 43
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163-164	PROXIMA CORP	195	619-457-5500
186	PSI	165	800-PSI-3031
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131	QNX SOFTWARE SYS LTD	2-3	800-363-9001 ext 101
244	QUALSTAR CORP	262	800-468-0680
132	QUARTERDECK OFFICE SYSTEMS	43	310-392-9851
133-134	QUATECH INC.	230	800-553-1170
	R		
135	RAINBOW TECHNOLOGIES	61	800-852-8569
266-267	RCI	258	908-874-4072 ext 71
551-552	RECOGNITA (INT'L)	133	+36-1-2018925
206	RECORTEC INC	249	800-729-7654
180-181	ROBERTSON-CARUSO & ASSOC	42	404-512-0600
137-138	ROSE ELECTRONICS	208	800-333-9343
	S		
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246	SEALEVEL SYSTEMS INC	257	803-843-4343
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247	SILICONSOFT, INC	260	800-969-4411
183-184	SMITH MICRO SYS & S/W	141	714-362-2345
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548	SOFTWARE PUBLISHING	240NE 5	408-986-8000
527	SOFTWARE SECURITY	40IS 9	203-329-7428**
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142-143	SYSTAT INC	153	708-864-5670
	T		
248	TALKING TECHNOLOGY INC	258	800-685-4884
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146	TEKTRONIX	69	800-835-6100 ext 32G
147-148	TEXAS INSTRUMENTS	44-45	800-TI-TEXAS
149	TOSHIBA AMERICA INC	22-23	800-457-7777
253	TRI VALLEY TECHNOLOGY INC	259	510-447-2030
	U		
541-542	UNISALES	40IS 10	508-393-5780
	V		
205	VALITEK INC	254	413-549-2700
249	VIDEX, INC	257	503-758-0521
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	W		
528	WALKER, RICHER & QUINN (INT'L)	75	206-217-7100
153	WATCOM VX-REXX OS/2	27	519-886-3700
152	WATCOM C/C++ DEVELOPMENT SYS	71	519-886-3700
174-175	WIBU (INT'L)	42	+49-721-377455**
174-175	WIBU (U.S.)	42	301-570-3497
250	WINTEK CORP	263	800-742-6809
208	WORLDWIDE TECHNOLOGIES	250	215-922-0116**
	Y		
185	YUAN YUAN ENTERPRISE CO LTD	210	+886-2-726-8845**
	Z		
251	Z-WORLD ENGINEERING	262	916-757-3737
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166-167	ZYXEL USA	203	714-693-0808

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Category No.
Inquiry No. — *Page No.*

HARDWARE

1 ACCESSORIES/ SUPPLIES

Inquiry No.		Page No.
212-213	ANTEX ELECTRONICS	254
247	SILICONSOFT, INC	260

2 ADD-IN BOARDS

Inquiry No.		Page No.
212-213	ANTEX ELECTRONICS	254
67	ATI TECHNOLOGIES INC	200
501-502	BOCA RESEARCH INC (INT'L)	58
82-83	CURTIS INC	156
193-194	DISTRIBUTED PROCESSING TECH	241
264-265	IMAGRAPH CORP	261
197	JAMECO ELECTRONICS	247
279	P.E. LOGIC CORP	257
133-134	QUATECH INC	230
246	SEALEVEL SYSTEMS INC	257
248	TALKING TECHNOLOGY INC	258

3 BAR CODING

Inquiry No.		Page No.
249	VIDEX, INC	257

4 COMMUNICATIONS/ NETWORKING

Inquiry No.		Page No.
557	ALTEX ELECTRONICS	240PC 2-3
230	GMM RESEARCH CORP	257
231-232	GTEK INC	257
561	MEGADATA	40IS 24
117-118	MICRONET TECHNOLOGY	181
158	MINICOM / CLASSNET VIDEO	118
273	NEWVOICE	258
546	NYNEX MOBILE COMMUNICATIONS	240NE 6
170-171	PRIMAX ELECTRONICS	214
186	PSI	165
266-267	RCI	258
137-138	ROSE ELECTRONICS	206
258-259	SIGMA TECH SOFTWARE	258
565-566	SOLID COMPUTER GMBH (INT'L)	147
248	TALKING TECHNOLOGY INC	258

5 COMPUTER SYSTEMS

Inquiry No.		Page No.
61-62	ADVANCED LOGIC RESEARCH	119
•	AMBRA COMPUTER CORP (N.A.)	40A-H
207	APPRO INTERNATIONAL INC	256
268	COMPAQ COMPUTERS (N.A.)	147-149
299-300	COROLLARY	235
192	DATALUX CORP	238
•	DELL COMPUTER CORP (N.A.)	CIII
•	DELL COMPUTER CORP (N.A.)	CIV
•	DELL COMPUTER CORP (N.A.)	83
•	DELL COMPUTER CORP (N.A.)	85
•	DELL COMPUTER CORP (N.A.)	87
•	DELL COMPUTER CORP (N.A.)	89
•	DELL COMPUTER CORP (N.A.)	91
•	DELL COMPUTER CORP (N.A.)	93
•	DELL COMPUTER CORP (N.A.)	95-97
531-532	ECG	40IS 19
•	GATEWAY 2000	64A-H
•	GATEWAY 2000	64I-L
•	GATEWAY 2000	65
99	IBM PC DIRECT	CII,1
102	IBM RISC SYSTEM 6000	28-29
558	INTEGRIX INC	40IS 21
•	INTEL CORP	16-17
104-105	INTERGRAPH	163
236	KILA	258
545	MANCHESTER EQUIPMENT CO	240NE 1
290	NEC RISCSERVER	12-13
121	NSTL	215
218	PACIFIC COAST MICRO	244
280	PC PORTABLE MANUFACTURING	258
206	RECORTEC INC	249
•	SILICON GRAPHICS	116
555-556	SOLID COMPUTER GMBH (INT'L)	147
253	TRI VALLEY TECHNOLOGY INC	259
155	ZEOS INTERNATIONAL	110-111

6 DATA ACQUISITION

Inquiry No.		Page No.
221	AMERICAN ADVANTECH	259
264-265	IMAGRAPH CORP	261
239	KEITHLEY METRABYTE	259
238	LAWSON LABS INC	259
240-241	MICROSTAR LABORATORIES	259
133-134	QUATECH INC	230

7 DISK & OPTICAL DRIVES

Inquiry No.		Page No.
252	ADAPTEC	260
275	COMPUSHARP INTEGRATED SERVICES	259
82-83	CURTIS INC	156
262-263	GRANITE DIGITAL	260
199-200	MICRO SOLUTIONS COMP PROD	251
201-202	MICRO SOLUTIONS COMP PROD	253
203-204	MICRO SOLUTIONS COMP PROD	239
117-118	MICRONET TECHNOLOGY	181
553-554	MULTIPORT COMPUTER-SYS (INT'L)	170
127-128	PINNACLE MICRO	7
537	PIONEER HIGH FID (GB) LTD (INT'L)	81
303-304	PLASMON DATA SYSTEMS	216
178-179	PLEXTOR	66
144-145	TEAC AMERICA INC	183

8 DISKETTES/ DUPLICATORS

Inquiry No.		Page No.
222-223	AXIOMATIC	264

10 GRAPHICS TABLETS/ MICE/PEN INPUT

Inquiry No.		Page No.
172-173	ARISTO GRAPHIC SYSTEMS	194
233	HI-TECH INSTRUMENTS	260
247	SILICONSOFT, INC	260

11 KEYBOARDS

Inquiry No.		Page No.
503	CHERRY MIKROSCHALTER GMBH	40IS 14-15
192	DATALUX CORP	238
228-229	GENOVATION, INC	260
234	HOOLEON CORP	261
268-269	JNL COMPUTER PRODUCTS INC	261

12 LAN HARDWARE

Inquiry No.		Page No.
501-502	BOCA RESEARCH INC (INT'L)	58
504-505	COMPEX INC	40IS 11
64-65	CYBEX CORP	117
507-508	CYBEX CORP (INT'L)	CIII
509-510	CYBEX CORP (INT'L)	CIV
117-118	MICRONET TECHNOLOGY	181
546	NYNEX MOBILE COMMUNICATIONS	240NE 6
123-124	PC POWER & COOLING	53

13 LAPTOPS & NOTEBOOKS

Inquiry No.		Page No.
•	AMBRA COMPUTER CORP (N.A.)	40A-H
224	AXONIX CORP	261
74	COMPAQ COMPUTERS (N.A.)	100-101
529	FIRST INTERNATIONAL COMPUTER	40IS 2
99	IBM PC DIRECT	CII,1
•	JDR MICRODEVICES	255
211	MICRO-INTERNATIONAL, INC	240
517	OLIVETTI S.P.A. (INT'L)	28-29
147-148	TEXAS INSTRUMENTS	44-45
149	TOSHIBA AMERICA INC	22-23
154	ZENITH DATA SYSTEMS	33
155	ZEOS INTERNATIONAL	110-111

14 MAIL ORDER

Inquiry No.		Page No.
544	ALTEX ELECTRONICS	240NE 2-3
549	ALTEX ELECTRONICS	240SO 2-3
557	ALTEX ELECTRONICS	240PC 2-3
•	AMBRA COMPUTER CORP (N.A.)	40A-H
•	AMERICAN LUNG ASSOCIATION	240SO 4
•	AMERICAN LUNG ASSOCIATION	240NE 4
190	COMPUTER DISCOUNT WAREHOUSE	232-233
191	COMPUTERLANE UNLTD	262
99	IBM PC DIRECT	CII,1
197	JAMECO ELECTRONICS	247
•	MAN IN THE CHAIR	240PC 1
•	MAN IN THE CHAIR	240SO 1
•	MCGRAW-HILL ONLINE SVCS (INT'L)	209
198	NEVADA COMPUTER	242

15 MEMORY/CHIPS/ UPGRADES

Inquiry No.		Page No.
195-196	FIRST SOURCE INT'L	236
289	IBM POWER PC	122-123
•	INTEL CORP	16-17
197	JAMECO ELECTRONICS	247
109-110	KINGSTON TECHNOLOGY	127
215-216	L A TRADE	234
206	WORLDWIDE TECHNOLOGIES	250

16 MISCELLANEOUS HARDWARE

Inquiry No.		Page No.
277-278	BILBO INNOVATIONS	261
182	CALIFORNIA PC PRODUCTS INC	120
103	INTEGRAND RESEARCH	106
218	PACIFIC COAST MICRO	244
123-124	PC POWER & COOLING	53
185	YUAN YUAN ENTERPRISE CO LTD	210

17 MODEMS/ MULTIPLEXORS

Inquiry No.		Page No.
501-502	BOCA RESEARCH INC (INT'L)	58
•	JDR MICRODEVICES	255
166-167	ZYXEL USA	203

18 MONITORS & TERMINALS

Inquiry No.		Page No.
80-81	CTX INTERNATIONAL INC	143
192	DATALUX CORP	238
108	KFC (N.A)	170
518	KUO FENG CORPORATION (INT'L)	121
119-120	NANAO USA CORP (N.A.)	61
525	PHILIPS MONITORS (INT'L)	100-101
139-140	SAMTRON DISPLAYS INC (N.A.)	63
536	SAMTRON (INT'L)	51
160-161	VIEWSONIC	73

19 MULTIMEDIA/CD-ROM

Inquiry No.		Page No.
212-213	ANTEX ELECTRONICS	254
161	CREATIVE LABS INC	36-37
264-265	IMAGRAPH CORP	261
295-296	JVC INFORMATION	190
553-554	MULTIPORT COMPUTER-SYS (INT'L)	170
163-164	PROXIMA CORP	195
•	SILICON GRAPHICS	116
144-145	TEAC AMERICA INC	183

20 PRINTERS/PLOTTERS

Inquiry No.		Page No.
•	HEWLETT-PACKARD	31
545	MANCHESTER EQUIPMENT CO	240NE 1
114-115	MANNESMANN TALLY (N.A.)	55
559-560	NEWGEN SYSTEMS CORP (INT'L)	56
516	OLIVETTI S.P.A. (INT'L)	148-149
170-171	PRIMAX ELECTRONICS	214
146	TEKTRONIX	69

21 PROGRAMMABLE HARDWARE

Inquiry No.		Page No.
169	BUFFALO PRODUCTS	255
86-87	DATA ACCESS CORP	189
226	DATAMAN LTD	262
260-261	DAVISON-WORTH CORP	262
89-90	ELIASHIM MICROCOMPUTERS	180
513-514	FAST HARDLOCK (INT'L)	63
235	IO TECH	262
•	JDR MICRODEVICES	255
533-534	MARX DATENTECHNIK GMBH	40IS 22
174-175	WIBU	42
251	Z-WORLD ENGINEERING	262

YOUR DIRECT LINK

PRODUCT CATEGORY INDEX

For FREE product information from individual advertisers, circle the corresponding inquiry numbers on Your Direct Link Card!

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Category No.
Inquiry No — *Page No.*

22 SCANNERS/OCR/DIGITIZERS

Inquiry No	Advertiser	Page No.
89-90	ELIASHIM MICROCOMPUTERS	160
519	LIGATURE LTD	40IS 4
551-552	RECOGNITA (INT'L)	133

23 TAPE DRIVES

Inquiry No	Advertiser	Page No.
72-73	COLORADO MEMORY SYSTEMS	19
91-92	EXABYTE CORPORATION (N.A.)	133
237	LAGUNA DATA SYSTEMS	262
203-204	MICRO SOLUTIONS COMP PROD	239
199-200	MICRO SOLUTIONS COMP PROD	251
201-202	MICRO SOLUTIONS COMP PROD	253
244	QUALSTAR CORP	262
205	VALITEK INC	254

24 UPS/POWER MANAGEMENT

Inquiry No	Advertiser	Page No.
•	AMERICAN POWER CONVERSION	56A-B
287	AMERICAN POWER CONVERSION	56-57
68-69	BEST POWER TECHNOLOGY	129
291-292	DELTEC / NSSI	107
523-524	MINUTEMAN	40IS 17
123-124	PC POWER & COOLING	53

53 SECURITY

Inquiry No	Advertiser	Page No.
513-514	FAST HARDLOCK (INT L)	63
174-175	WIBU	42

SOFTWARE

25 BUSINESS

Inquiry No	Advertiser	Page No.
165	CARDIFF SOFTWARE	196
274	DESIGNER CHECKS	262
293-294	GLOBALINK INC	211
122	PATTON & PATTON	207
163-164	PROXIMA CORP	195

26 CAD/CAM

Inquiry No	Advertiser	Page No.
65-66	AMERICAN SMALL BUSINESS COMP	64
172-173	ARISTO GRAPHIC SYSTEMS	194
104-105	INTERGRAPH	163
106-107	INTERGRAPH (N A.)	75
250	WINTEK CORP	263

27 COMMUNICATIONS/NETWORKING

Inquiry No	Advertiser	Page No.
254	BEAME & WHITESIDE SOFTWARE	263
162	BEAME & WHITESIDE S/W (N.A.)	35
540	CERBERUS SOFTWARE LTD	40IS 24
504-505	COMPEX INC	40IS 11
77	COMPUTER ASSOCIATES	131
98	HUMMINGBIRD COMMUNICATIONS	136
187-188	JSB	212
535	LANSOURCE	40IS 18
284-285	OCEAN ISLE SOFTWARE	150
125	PERSOFT INC	173
186	PSI	165
180-181	ROBERTSON-CARUSO & ASSOCIATES	42
183-184	SMITH MICRO SYSTEMS & SOFTWARE	141
169	SOFTARC	64
555-556	SOLID COMPUTER GMBH (INT'L)	147
541-542	UNISALES	40IS 10
528	WALKER, RICHER & QUINN (INT'L)	76

28 DATA ACQUISITION

Inquiry No	Advertiser	Page No.
242	NATIONAL INSTRUMENTS	264
521-522	NATIONAL INSTRUMENTS	40IS 6

29 DATABASE

Inquiry No	Advertiser	Page No.
225	COMPUTERWISE	263
86-87	DATA ACCESS CORP	169
111	KNOWLEDGEWARE INC	199
520	MAGIC / MSE	40IS 5
•	MICROSOFT CORP	8-9

30 EDUCATIONAL

Inquiry No	Advertiser	Page No.
293-294	GLOBALINK INC	211
520	MAGIC / MSE	40IS 5
•	MCGRAW HILL NRI (N.A.)	192A-B

31 ENGINEERING/SCIENTIFIC

Inquiry No	Advertiser	Page No.
104-105	INTERGRAPH	163
106-107	INTERGRAPH (N.A.)	75
159-160	ITERATED SYSTEMS	184
243	PERSONAL TEX	264

33 GRAPHICS

Inquiry No	Advertiser	Page No.
172-173	ARISTO GRAPHIC SYSTEMS	194
176-177	AT&T MULTIMEDIA S/W SOLTN	124
79	COREL FLOW	102
78	COREL SCSI	39
276	EMATEK GMBH	263
119-120	NANAO USA CORP (N.A.)	51
163-164	PROXIMA CORP	195
245	SCIENTIFIC ENDEAVORS	263
543	SOFTWARE PUBLISHING	240PC 1
543	SOFTWARE PUBLISHING	240NE 5

35 MAIL ORDER

Inquiry No	Advertiser	Page No.
190	COMPUTER DISCOUNT WAREHOUSE	232-233
506	COMPUTER QUICK	40IS 8
515	GREY MATTER LTD	40IS 12
113	PROGRAMMER'S PARADISE	76-77

36 MATHEMATICAL/STATISTICAL

Inquiry No	Advertiser	Page No.
243	PERSONAL TEX	264
141	STATSOFT	105
142-143	SYSTAT INC	153

37 MISCELLANEOUS SOFTWARE

Inquiry No	Advertiser	Page No.
530	ON TIME MARKETING	40IS 22

38 ON-LINE SERVICES

Inquiry No	Advertiser	Page No.
450	BIX	277
68	DELPHI INTERNET SERVICES	227

39 OPERATING SYSTEMS

Inquiry No	Advertiser	Page No.
131	QNX SOFTWARE SYSTEMS LTD	2-3
132	QUARTERDECK OFFICE SYSTEMS	43
180-181	ROBERTSON-CARUSO & ASSOCIATES	42

40 PROGRAMMING LANGUAGES/TOOLS

Inquiry No	Advertiser	Page No.
•	APPLE COMPUTER INC	11
70-71	BORLAND INTERNATIONAL	15
•	COPIA INTERNATIONAL LTD	194
276	EMATEK GMBH	263
75-76	GREENVIEW DATA	49
101	IBM C/C++ DEVELOPMENT TOOLS	21
100	IBM SOFTWARE SOLUTIONS	109
111	KNOWLEDGEWARE INC	199
112	LAHEY COMPUTER SYSTEMS	206
530	ON TIME MARKETING	40IS 22
126	PHAR LAP SOFTWARE INC	112
130	POPKIN S/W & SYSTEMS INC	159
168	POWERSOFT CORP (N.A.)	58
113	PROGRAMMER'S PARADISE	76-77
306	SEQUITER SOFTWARE INC	237
526	SIEMENS NIXDORF INFO	40IS 7
152	WATCOM C/C++ DEVELOPMENT SYSTEM	71
153	WATCOM VX-REXX OS/2	27

41 SECURITY

Inquiry No	Advertiser	Page No.
64	ALADDIN KNOWLEDGE SYSTEMS	46
63	ALADDIN KNOWLEDGE SYSTEMS	166
503	CHERRY MIKROSCHALTER GMBH	40IS 14-15
89-90	ELIASHIM MICROCOMPUTERS	160
511-512	EUTRON	40IS 16
513-514	FAST HARDLOCK (INT'L)	63
96-97	GLENCO ENGINEERING	139
533-534	MARX DATENTECHNIK GMBH	40IS 22
135	RAINBOW TECHNOLOGIES	61
527	SOFTWARE SECURITY	40IS 9
174-175	WIBU	42

43 SOFTWARE DUPLICATION

Inquiry No	Advertiser	Page No.
222-223	AXIOMATIC	264

45 UNIX

Inquiry No	Advertiser	Page No.
•	COPIA INTERNATIONAL LTD	194
95	FRAME TECHNOLOGY (N.A.)	81
75-76	GREENVIEW DATA	49
98	HUMMINGBIRD COMMUNICATIONS	136
538-539	LABTAM	40IS 20
541-542	UNISALES	40IS 10

46 UTILITIES

Inquiry No	Advertiser	Page No.
302	ARCADA (N A)	165
64	ALADDIN KNOWLEDGE SYSTEMS	46
210	ALLMICRO	243
116	CONNER (N.A.)	121
281	CONSOLIDATED SOFTWARE PRODUCTS	264
209	MICRO 2000	248
297-298	MICRODATA	245
129	PKWARE INC	155

47 WINDOWS

Inquiry No	Advertiser	Page No.
•	COPIA INTERNATIONAL LTD	194
•	FINSON	148
227	GAMMA PRODUCTIONS	265
106-107	INTERGRAPH (N.A.)	75
282-283	KUREO TECHNOLOGY, INC	264
256-257	MICROCAL SOFTWARE, INC	265
119-120	NANAO USA CORP (N.A.)	51
255	PACIFIC SOFTWORKS	265
126	PERSOFT INC	173
180-181	ROBERTSON-CARUSO & ASSOCIATES	42
543	SOFTWARE PUBLISHING	240PC 1
548	SOFTWARE PUBLISHING	240NE 5

48 WORD PROCESSING/DTP

Inquiry No	Advertiser	Page No.
95	FRAME TECHNOLOGY (N.A)	81
293-294	GLOBALINK INC	211
519	LIGATURE LTD	40IS 4

GENERAL

49 BOOKS/PUBLICATIONS

Inquiry No	Advertiser	Page No.
•	BUSINESS WEEK	185
•	BYTE READER	223
•	COMPUTER PROFS' BK SOC (N.A.)	209A-B
•	COMPUTER PROFS' BK SOC (N.A.)	209
•	NSTL	246
•	OSBORNE MCGRAW-HILL	134-135

51 MISCELLANEOUS

Inquiry No	Advertiser	Page No.
•	BYTE BACK ISSUES (INTL)	48IS 23
•	BYTE EDITORIAL SURVEY	229
•	BYTE EURODECK	199
•	BYTE FILLER	204
305	BYTE INTELLIQUEST	219
•	BYTE REPRINTS (INT'L)	213
•	BYTE SUB MESSAGE	198
•	DATAPRO	174-174
156	NETWORLD + INTEROP 94	217
157	NETWORLD + INTEROP 94 (N.A.)	213

EDITORIAL INDEX

For more information on any of the companies covered in articles, columns, or news stories in this issue, circle the appropriate inquiry number on Your Direct Link Card. Each page number refers to the first page of the article or section in which the company name appears. IS pages appear only in the International edition.

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Why IBM Should License Win32

Win32 is growing like a weed, sprouting new extensions as Microsoft takes Windows places it has never gone before

The millions that IBM sank into OS/2 bought a pearl of great value. Big Blue now owns an operating system that uniquely combines five key virtues: OS/2 is small, fast, modern, 80x86-tuned, and mature. Do you doubt the strategic value of such a thing? Microsoft doesn't. RISC machines running portable operating systems may be the future, but you can't wish away millions of 80x86 PCs.

Hence Chicago, which Microsoft claims will be small (4 MB), fast (Windows 3.1 or higher), modern (equipped with threads and preemptive multitasking), and 80x86-tuned. The ultimate OS/2 killer? Maybe not. What Chicago won't be, at least in 1995, is mature. Major parts of Chicago—including its file-system manager, memory manager, and scheduler—are, although inspired by Windows NT, otherwise brand new.

Is Chicago the ultimate OS/2 killer?

The comparable pieces of OS/2 have been solidly in place for years. While I believe that Chicago will eventually prove itself a great foundation for Win32 applications, I think OS/2 could be one, too. There's room in the world for both—and more as well. If Win32 dominates, as I think it will, more niches for compatible substrates will exist than any single company can occupy.

Sadly, OS/2 has a tragic flaw. It wears the "wrong" API. Presentation Manager, available since 1988, has been dead in the water since Windows 3.0 took off in 1990. That's a hard truth, especially since PM's imaging model was unsurpassed in the Windows realm until NT appeared, and it's a truth that continues to cloud OS/2's future.

IBM should ditch Presentation Manager.

I think IBM should swallow its pride, ditch PM, and license the Win32 API. OS/2 guru Michael Kogan, on the other hand, thinks Microsoft should swallow its pride and simply use the OS/2 kernel. Either way, we would not now be waiting for Microsoft to reinvent OS/2. Most Windows programmers would know how to build applications using thread synchronization, preemptive multitasking, and sparse virtual memory. Some of us would be using OS/2 to run those applications natively on mid- to high-end 80x86 PCs. Others would be using NT to run them on high-end RISC or 80x86 systems. Windows-on-DOS, minus some advanced APIs, could continue to serve the low-end 80x86 population.

In the real world, of course, the great divorce of 1991 did occur. Microsoft went on to build Chicago. IBM stuck with PM, failed to deliver credible Windows-to-PM conversion tools, and then embarked on a strategy to host Windows itself, rather than Windows applications, on OS/2. This bold hack has served more people far better than most outside IBM thought it could. It will grow bolder yet if, as promised, OS/2 gains mastery of the Windows VxD (virtual device driver) and, through it, Win32s.

But patching Windows in memory, as OS/2 for Windows does, won't take IBM far in the era of Chicago. Neither will a PowerPC-based Workplace operating system running an OS/2 personality that has few mainstream applications.

To survive as an operating-system vendor, IBM will need a credible Win32 strategy, both for OS/2 and Workplace. What to do? It has just two choices—convert Windows applications and components or assimilate them. Both strategies merit a second look.

Conversion tools like Microsoft's Windows Libraries for OS/2 and Micrografx's Mirrors and Oasis never amounted to much, but cross-platform toolkits for C, C++, and Smalltalk have come on like gangbusters in recent years. IBM's Visual Age, which is a Smalltalk-based development tool for OS/2 and (soon) Windows, exemplifies this new breed of product. Thanks to IBM's groundbreaking SOM (System Object Model), Visual Age will help build distributed systems made of reusable components. This class of tool could level the playing field as the first mainframe era and the twentieth century draw to a simultaneous close.

IBM doesn't need to fight in the PIM (personal information manager) and spreadsheet skirmishes. It needs to define a new era, the one in which PCs control the back room as well as the desktop. This is the company whose systems run banks and airlines. Its mission, often poorly articulated, is to move those systems onto modern hardware and software platforms and, while doing so, to improve and extend them. To play its intended role in that mission, OS/2 needs tools like SOM and Visual Age. But neither tool would be likely to flourish if it did not also support the volume platform, Windows.

The same holds true for OS/2 itself, and that's why cross-platform tools, while necessary, are not sufficient. IBM should bite the bullet and license Win32. Sure, that will cost something, but if Microsoft offers IBM terms less favorable than those offered to Insignia, the FTC and Justice Department might reopen their inquiries.

Win32 is growing like a weed, sprouting new extensions as Microsoft takes Windows places it's never gone before. Consider telephony. IBM's CallPath blazed the trail that TAPI (the Intel/Microsoft telephony API) and TSAPI (the AT&T/Novell telephony services API) follow. But today, IBM doesn't get to define these or other vital infrastructures. It should, given its experience with big, complex systems. And it could, with a Win32-equipped OS/2. An IBM/Microsoft détente seems farfetched, but so did the PowerPC alliance. I say go for it, IBM. ■

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

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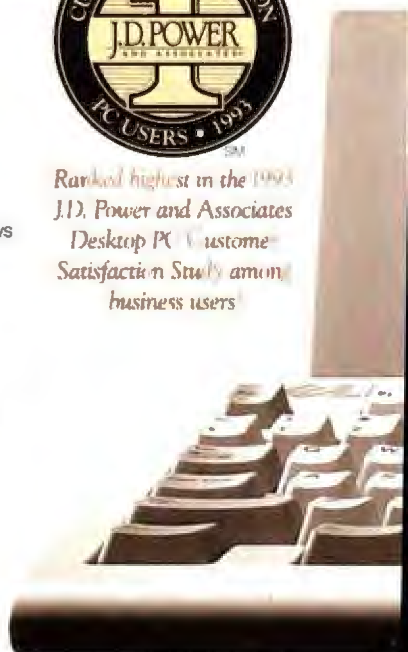

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