WIN a Gateway Notebook! Enter BYTE's 20th Anniversary Poll - page 124

THE TRUTH BEHIND THE PENTIUM BUG

MARCH 1995

BYTE

20 Years 1975-1995

New CD ThinkPad

Hofstadter on Artificial Intelligence PAGE 45

Tough New Cross-Platform Benchmarks

THE MAGAZINE OF TECHNOLOGY INTEGRATION

7 NEW WAYS TO LEARN

From boardroom to classroom—how advanced technology is reshaping the way we think.

PLUS

26 Tape Drives Tested

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Apple, IBM, Motorola Fix PowerPC Standard

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Full client and server support for OLE 2.0 and DDE make Paradox the best database for use with other applications including PerfectOffice and Microsoft Office. For example, you can place a "live" Paradox table in a WordPerfect or Word document, edit the table in place, and your changes are automatically updated. *(This is not available in Access.)* And Paradox gives you record level locking, that provides enhanced productivity in multiuser environments. *(Access locks up your whole page!)*

Want to increase your workgroup productivity? Paradox's built-in Workgroup Desktop and new Mail Enablement make it easy to publish and subscribe the latest data, using your existing network or e-mail system. This makes it simple to get weekly or monthly updates like sales and expense information.

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New Paradox 5.0 for Windows has been tuned to give you better performance. It stores and retrieves data faster, and delivers answers to queries with more speed than ever before.

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Experts/Wizards to guide you step-by-step	✓	✓
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Built-in workgroup and mail capabilities	✓	
Quick Filter without query process	✓	
Power-user/Developer Features		
OLE 2.0 client and server support	✓	
Compatibility with applications from previous version	✓	
Superior network support	✓	
Transparent connectivity and scalability with database aliases	✓	
Record level locking	✓	
Full range of data types, including Time, Graphic, and Autoincrement	✓	
Graphical Integrated Development Environment (IDE)	✓	
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Parad

Paradox for Windows - [WorldOptics Order Entry System]

File Edit View Form Record Properties Tools Window Help

Customer

Contact Name : Loren Niday

Telephone: +44-71-123456

Company Name: The Camera Shop

WORLD OPTICS

Order

Order No	Date	Total Amount
2199	1-Jul-94	2,723.00
2286	12-Jul-94	1,235.23
2350	3-Aug-94	1,913.55

Status:
- (•) In Stock
- ( ) Back Ordered
- ( ) Discontinued

Ship via: Two day

Ordered by: Telephone

PO No.: M1209

Camera		
Qty	Unit Price	Total Price
2	1,195.00	2,390.00

Filters		
Qty	Unit Price	Total Price
2	19.00	38.00

Video Camera		
Qty	Unit Price	Total Price
1	1,565.00	1,565.00

Print Invoice

Upload Orders

WordPerfect [Paradox For Windows - Paradox 5] - FILTERS.DOC

File Edit View Table Record Properties Window Help

Andrew H. Broan
Executive Consolidated Enterprises
12345 East Seventeenth Street
Santa Ana, CA. 99979

WORLD OPTICS

Dear Mr. Broan,

We appreciate your giving our valued customers an opportunity to test your new product. Furthermore, we are very pleased that you will drop ship the filters directly to our customers, thus saving us the shipping and handling.

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2	Visuals	38, rue du Temple	Paris, France	75004
3	Cavagnari & Company	Rua Antonio, 187	Sao Paulo, Brasil	13206

Thank you for your cooperation. We look forward to working with you in the future.

Sincerely,

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▲ Paradox for Windows, an integral member of PerfectOffice Professional, has superior integration with suite applications. Thanks to OLE 2.0, you can place any "live" Paradox table directly into a WordPerfect or Word document and edit it in place. (This is not available in Access 2.0.)

February 1994

May 1994

June 1994

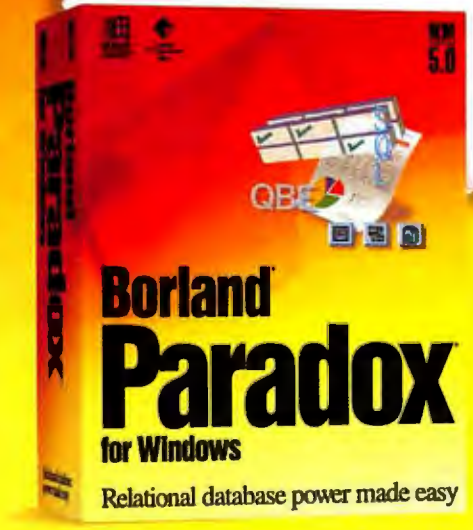
◀ With over 20 major industry awards for excellence, Paradox for Windows is the most award-winning Windows database on the market.

What makes Paradox the #1 Windows database?

(Everyone has their reasons)

"The hands down best Windows database... easier than ever."

—*InfoWorld* 7/18/94



Users say...

"The ease-of-use is a very key feature with Paradox for Windows."

—William Vannerson,
Blue Cross of Illinois

"It's one of the easiest databases, or any other computer product, I've ever picked up off the shelf."

—Timothy Riley,
U.S. Army Corp of Engineers

"There are plenty of new features in Paradox 5.0 for Windows that make it easier for clients to use, and lots of things about it for a developer to love."

—Greg Salcedo,
Para/Matrix Solutions

"Paradox is the best database on the market."

—Al Beckett-Lemus, Toyota Motor Sales

"With Paradox 5.0 for Windows, users don't have to sacrifice performance over ease."

—Dan Paolini,
DataStar International, Inc.

Reviewers say...

"With (new) Coaches and other ease-of-use features, Paradox's power can be put to practical purposes more easily than ever before."

—*Windows Magazine* 9/94

"I found the Experts (in Paradox 5.0 for Windows) more flexible to work with than FoxPro or Access wizards."

—*Government Computer News* 8/15/94

"A strong choice for standalone or workgroup development."

—*PC Magazine* 9/13/94

"If you need a powerful interactive database system and application development environment for Windows, then Paradox is an excellent choice."

—*DBMS* 1/1/94

"Paradox 5.0 solidifies position as the top Windows database."

—*InfoWorld* 7/18/94

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MARCH 1995 VOL.20, NO.3

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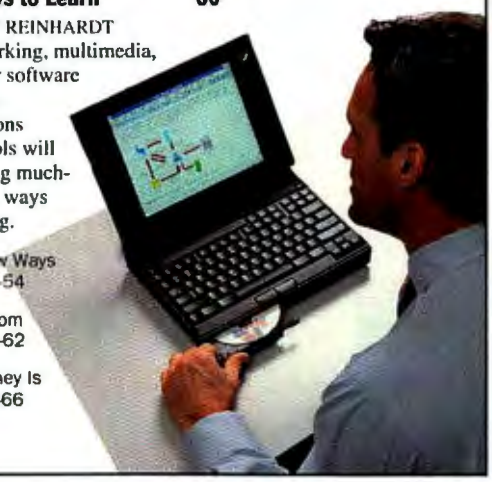

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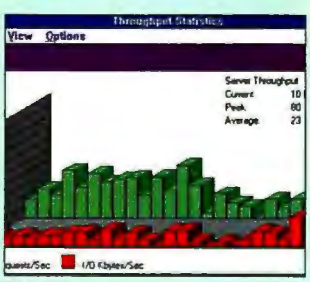

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BY STEVE APIKI AND RICK GREHAN

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BY REX BALDAZO AND STANFORD DIEHL

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BY STAN MIASTKOWSKI

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BY BARRY NANCE

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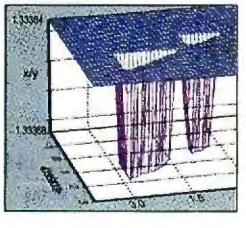

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BY PETER WAYNER

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The Net that Manages the Mail.....84
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Workgroup Conferencing..125
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Peer Power Upgrade.....135
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Roundup: Network Storage Economizers.....137
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The Truth Behind the Pentium Bug 163
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Workgroup Conferencing..125
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Peer Power Upgrade.....135
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Roundup: Network Storage Economizers.....137
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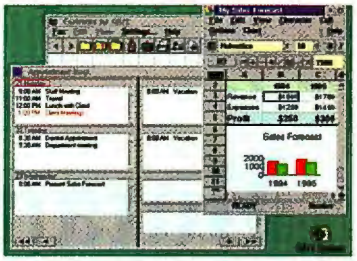

The BonusPak gives mobile users the applications they need.

As Mike puts it: "We use OS/2 on our headquarters' client/server systems. It's also installed in our 900 dealerships. But until now, we haven't been able to get OS/2 everywhere we need it – on laptops in the field. OS/2 Warp changes all that." OS/2 Warp is the 32-bit, multitasking, Windows™-friendly way to run a computer. With simple installation and proven reliability, OS/2 Warp is a total computing solution that performs ruggedly at every level.

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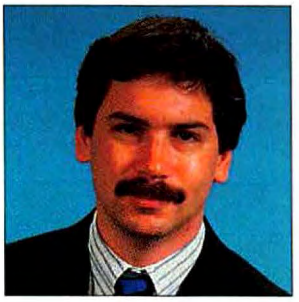

Would you trust your life to Pentium? How about a neural network?

I suppose, as the editor in chief of this magazine, somewhere in my job description there's a line that says, "...shall pontificate about every major screwup committed by Intel, IBM, or Microsoft." Of course, if I did that, I'd never have any time left to write about the things that computer companies get *right*, but nonetheless, I feel strangely compelled to say a few words about the dearly departed floating-point bug in the Intel Pentium.

So here it is, my advice to everybody who's been trying to figure out how serious the Pentium bug is, how Intel messed up, and whether we should be buying other chips like PowerPCs (or 486s) instead: Lighten up! Buy a Pentium if you want. At least now you know about one of its bugs. Really, what do you expect? The Pentium chip may look and feel like hardware, etched as it is in silicon, but it's just software that happens to have been pressed into hardware. And name me one complex program that doesn't have a bug.

Now, granted, we all learned a lot about the computer industry because of this bug. Mostly, we learned that no matter how minor or technical the error, once the popular media get hold of it, the company responsible is in serious public-relations trouble. Remember the ridiculous "unintended acceleration" fiasco that nearly sunk Audi in the U.S. a few years ago. For me, the exact time that the Pentium bug became part of the popular culture was one cold December morning. At 8:15 a.m., I heard a Chevys Mexican restaurant advertisement on the radio lampooning the chip's bug (Chevys' tortilla chips, it is claimed, are not in need of a recall).

The popular media may not be aware of it, but there are doubtless other undiscovered bugs lurking in the Pentium, not to mention its competitors. Can we ever expect these flaws to be eradicated?

Not really. Simulations are one thing, but we all know that there's no real way to run every possible combination of inputs into a CPU to find those that work right and those that don't.

From the pedestrian Pentium bug, I want to make a giant leap to another idea, one that has only a little to do with the Pentium but everything to do with the way new technology is designed today. Here goes: The nature of machine design means that each new machine can carry with it the inherent flaws of the generations of machines that came before it and contributed to its design.

It's pretty easy to tell when a simple machine built by a simple tool has a flaw (e.g., an off-kilter table built using a flawed level), but as machines get more complex, how do we make sure the chain of tools and designs runs true? Is it possible that we could be living with evil recessive lines of compiler code that will reach out and bite us sometime in the future, several generations of code removed from the original bug?

Fortunately, as we build new machines using older tools, we're also creating debugging equipment that can catch dormant problems because it's smarter than the last-generation designs—we hope. And even though I don't think the problem of machine evolution is serious at this moment, as we use more heuristic methods of programming and more neural networks and as we become satisfied with programs that do what we want *even when we don't know why*, we are just asking for trouble. Let me put it this way: Although you might be happy to entrust part of your stock portfolio to a neural-network algorithm that's outperformed the Dow, how would you feel if the airliner you were on was programmed using heuristic methods?

The Signal in the Noise. Speaking of trouble, I'm embarrassed to report that a number of readers noticed my improper use of the phrase "high signal-to-noise ratio" in last month's column. What I was trying to allude to was the high junk factor in broadcast data and Internet news groups, which is, of course, an illustration of a *low* signal-to-noise ratio. I stand corrected.

Finally, if you're interested in a thorough explanation of the exact nature of the Pentium bug, turn to "The Truth Behind the Pentium Bug" on page 163 for Tom Halfhill's excellent and frightening account of how the flaw came to be—and why it was so easy for Intel to correct it. ■

RAPHAEL NEEDLEMAN, EDITOR IN CHIEF
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Circle 130 on Inquiry Card (RESELLERS: 131).

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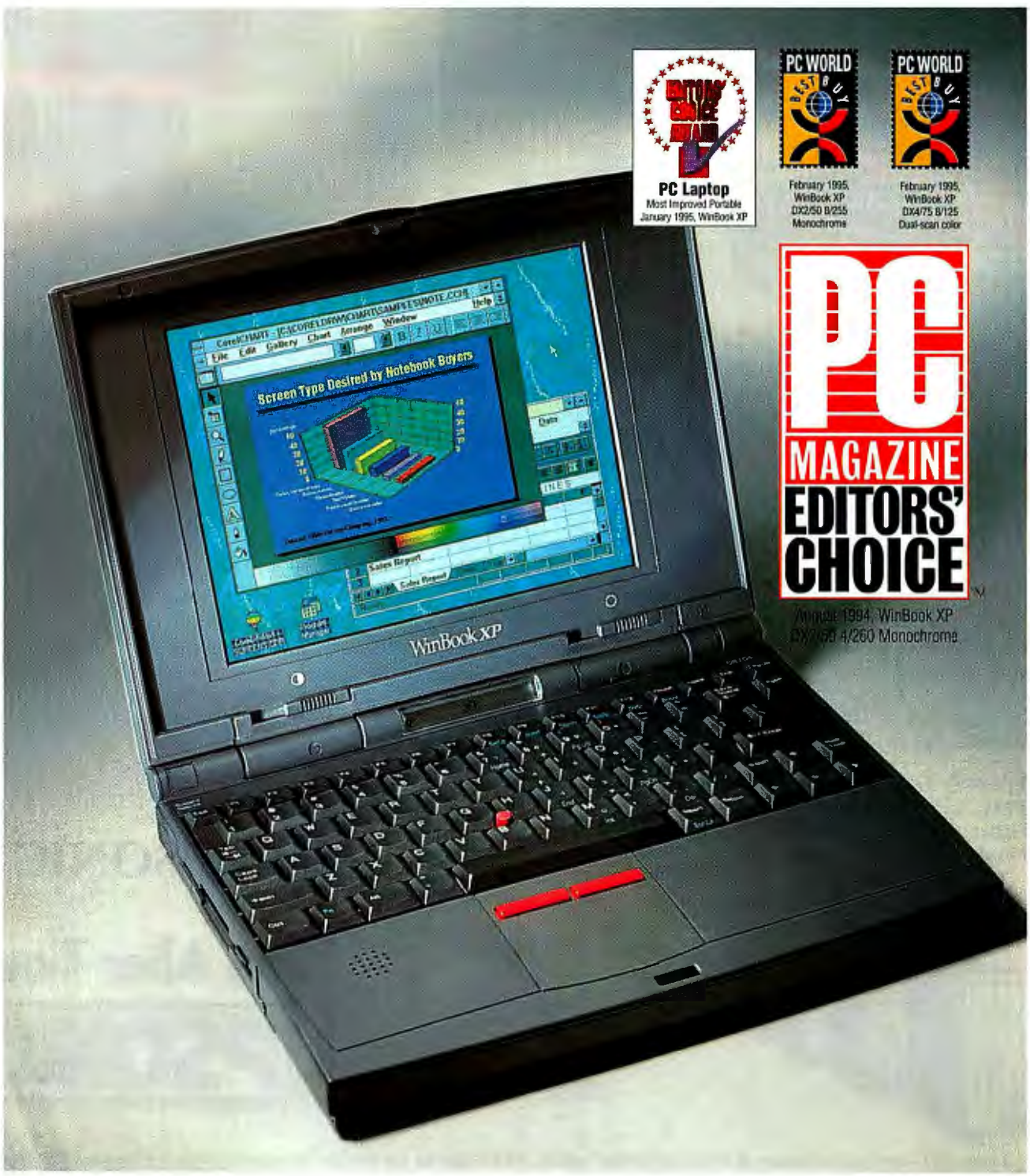

PC WORLD "Exceptional battery life, fast, lightweight, low price, modular design" *PC WORLD*, Systems Top 20, Feb. 1995

PC MAGAZINE "...the two DX4/100-based portables from WinBook Computer deliver three things that every buyer wants: attractive features, top performance, and a competitive price." "Both units posted extremely competitive scores in our tests." *PC MAGAZINE*, Cover Story: Color Portables. Jan. 1995

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PC MAGAZINE, Cover Story: Notebooks, Aug. 1994

PC LapTop COMPUTERS MAGAZINE "...WinBook has gone on to offer a notebook that everyone seems to want. The reason is simple: value."

PC LAPTOP, 1994 Editor's Choice Awards, Jan. 1995

"The WinBook XP is a color notebook that's designed well, feels sturdy and offers great value." *PC LAPTOP*, Review: WinBook XP, Dec. 1994

WINDOWS MAGAZINE "The WinBook XP represents the best kind of innovation in the rapidly changing field of notebook computers. It keeps the best of proven technologies, such as a sharp display, and complements them with new technologies, such as those employed to stretch battery life. The long battery life makes it a good choice for anyone who needs a basic notebook that also delivers solid performance."

WINDOWS MAGAZINE, WinLab First Impressions, Dec. 1994

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COMPUTER SHOPPER, PC Reviews, Nov. 1994

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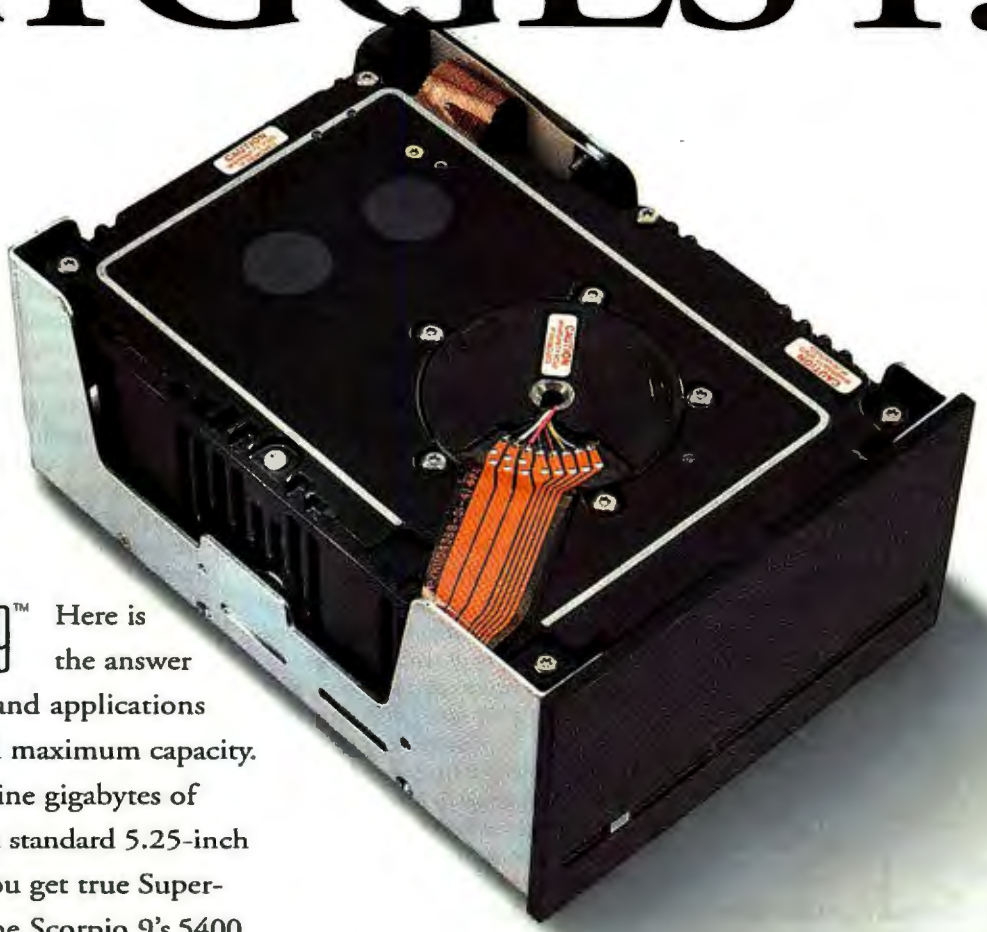

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Letters

Do We Overlook Apple's Innovations?

Tom Halfhill's cover story on Apple ("Apple's High-Tech Gamble," December 1994) accentuated the negative. He repeatedly told us that Windows 95—which isn't even released yet—will have wonderful innovations, such as preemptive multitasking. In a passing comment he says, "Mac users are fairly well served by the robust cooperative multitasking and crash recovery of System 7.x." However, nowhere does he remind us that the real reason "innovations" such as preemptive multitasking are critical to Windows users is because Windows is a fragile shell on an ugly and expert-tolerant (as opposed to user-friendly) DOS. Apple has "delivered the basics sooner," and these are the real innovations, not limitations, detailed in the article's time line.

Jon Muller
Carbondale, IL
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Formally Correct

I read John Cuadrado's "Teach Formal Methods" in your December 1994 issue with interest. Safety-critical systems must be made reliable through application of formal methods in their design and implementation. All software systems can be more reliable if the engineers who work on them have had some training in the formal derivation of correct programs.

Douglas Lovell
Wappinger's Falls, NY
dcl@pascal.acm.org

Micropolis Speedier Still

We appreciate the positive points made about the Micropolis 2217AV drive in the review "Speedy Data Delivery" (December 1994); however, we challenge the accuracy of your drive throughput results. We refer to the comment that the 2217AV "did not meet the expectations created by Micropolis." Micropolis uses a proven caching technique and stringent performance testing to ensure that our AV drives can deliver the sustained, uninterrupted data flow required in digital audio/video applications. Micropolis stands firmly behind its claim to an uninterrupted sustained data rate of 2.9 MBps for the 2217AV drive. (Our new 4.3-GB Capricorn AV drives provide an even higher guaranteed data rate of 4.0 MBps.) If you revisit your testing methodology, we are certain you will find Micropolis' stated throughput specifications are accurate.

Kumar Sreekanti
Senior Director of Engineering,
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Chatsworth, CA
kumar_sreekanti@microp.com

As technical editor of that review, I must apologize to Micropolis for a flawed test. First, the throughput test reset the drive, putting it into asynchronous mode (SCSI), thus reducing overall throughput. Second, the test did not adequately mimic audio/video applications in its timing of read requests, which led to pauses in data flow. After reconfiguring the test, I discovered that the 2217AV was capable of significantly higher throughput (average 3.7 MBps sustained) than we first reported. In addition, when read requests are paced at even intervals, the 2217AV delivers an uninterrupted data flow of 2.9 MBps. I also tested Micropolis' 4-GB Capricorn drive and verified that it provides a guaranteed sustained throughput of 4 MBps.

—Dave Rowell

Internetasaurus?

In "Who Needs the Internet?" (January Commentary), is Richard Jennings serious when he says that "the Internet is obsolete"? The proposition is simply alien; I hardly know how to reply.

Jennings says that in the past, he "used Internet mail to reach people who were always on the road, in the air, in meetings.... Most of these people have cellular phones now." Just today, I've received E-mail from Australia, Norway, the Czech Republic, Montana, Indiana, and Great Britain. There's no way I would have had telephone conversations with all those folks in 8 hours, but I do want to transact the business we share. Jennings writes gracefully and knowledgeably, but his opinion is so different from mine that I am left with no understanding of his larger message. Is someone pulling my leg?

Cameron Laird
Friendswood, TX
claird@Neosoft.com

Richard Jennings may have a point (January Commentary). Most of the legal and ethical squabbles of the present-day Internet stem from not knowing who is paying for the transmission of a message or what path that message may take. That's why there are problems with advertising, privacy, and pornography. A national, commercial communications infrastructure would change all that. Newsgroups in cyberspace already are being replaced by Web pages at specific sites. Perhaps what we require is a faster path to those sites rather than more of the present clumsy structure.

Michael A. Covington
Artificial Intelligence Center,
The University of Georgia
Athens, GA

Richard Jennings must have a great deal of money. Through the Internet, you get free access or at least a flat monthly rate for unlimited access to dynamic services. I no longer have to wait 20 minutes for toll-free technical support; I either access the World Wide Web, or I post a message on an appropriate newsgroup. Help desks aren't willing to spend time trying to get their products to work with "unsupported" hardware, but chances are that one or two news readers have done this before and can help. BBSes cost money; I have "free" consultants on the Internet.

Carl Jabido
CJabido@eworld.com

Kudos to Richard Jennings! When I'm asked, "How can I get plugged in to the Internet?", I respond, "What do you want to do once you're plugged in?" The responses vary from, "I'll surf, I'll send E-mail, I'll transfer files" to "It seems like it's time I became modern." I used the Internet extensively 10 years ago. However, currently I use it for E-mail only. Like Jennings, I

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Circle 81 on Inquiry Card (RESELLERS: 82).

rely on CD-ROMs to retrieve information. When asked if I've checked out the latest World Wide Web site, I usually respond, "What's on it and is there a CD-ROM yet?" So who does need the Internet? Perhaps it's not the Internet that's obsolete, but how we use it.

Bob Schlicher
Manager, Advanced Information Systems

Despite Jennings' claim of being a net vet, he seems to have missed the point that the Internet is really a community and that many people contributed all that useful information he benefited from. He describes no contributions of his own. But even if we recognize that Jennings considers the Internet merely a place to have played "gimmie" for 16 years, he still implicitly assumes that if *he* no longer needs the Internet, nobody does.

Lyle D. Gunderson
Pleasant Grove, UT
lyle.gunderson@m.cc.utah.edu

Safety First

Jerry Pournelle wanders a bit off-field when he argues against using "trillions of dollars" to research ozone depletion and global warming. Pournelle has stumbled into a key issue both in environmental questions and computing: safety first, often referred to as the *precautionary principle*. A network manager in charge of a critical system, for example, in a hospital or a stock exchange, would be foolish to balance the budget by cutting down on backups, UPSes, and antiviral software. Neither should responsible politicians limit spending on fighting ozone depletion and global warming just because the evidence isn't yet 100 percent conclusive. When it is, it might be too late.

Bjorn K. Bore
Oslo, Norway
bjoernb@oslonett.no

Big-Screen Monitors

Although I appreciate the information your January Lab Report on monitors provides, I have a few complaints. The first is about the "quality index" rating. Out of the 44 17-inch monitors, 33 of them received an "Excellent" rating and the remaining 11 received a "Good" rating. You might as well have had only two categories: "good" and "not as good."

This overall rating system was particularly bothersome to me because I value image sharpness and image quality far more than I value snazzy features, power consumption, and the like. Second, if you had provided the raw scores for image sharpness, distortion, and legibility, readers could have constructed their own ratings. Finally, I wish you had included more capsule summaries about the various monitors.

Steve Rinn
Campbell, CA
srinn@halcyon.com

Caller ID

I was really pleased to see Amine, Riggio, and Hill's article "Caller ID Goes to Work" (January). As system operator of an amateur BBS, the security issues you mention in the article are very important to me. On my system, I compare the number that a user enters with the number received from Caller ID to give me an idea about the new user's behavior.

The article also points out that Australia, Israel, the U.K., France, and Holland have announced that they will implement Caller ID in the near future. However, you have missed a country—Turkey. Caller ID has been in use in Turkey for about 9 months. Currently, it is implemented mostly in big cities, such as Istanbul and Ankara. The system is still being tested but will be in use in Turkey before the second half of this year.

A. Akin Koksal
Istanbul, Turkey

FIXES

January In our Lab Report on 17-, 20-, and 21-inch monitors, the vertical refresh rate for the Nokia 445X monitor at 1280 by 1024 dpi should have been listed as 85 Hz, not 70 Hz (page 220).

In "Curing the Windows Fax Blues," the caption on page 138 should have referred to Windows' cooperative multitasking rather than Windows' preemptive multitasking.

In "15 MB in a Matchbook" (News & Views, page 30), SunDisk is located in Santa Clara, California, not Burlingame. The main SunDisk number is (408) 562-0500.

December 1994 On page 165 in the review "SCSI Rides High on PCI," the toll-free telephone number for Future Domain is incorrect. The correct number is (800) 879-7599.

Pricing for two systems (page 206) do not reflect the "as-tested" configurations: As of press time, Hewlett-Packard's HP Vectra XU 5/90C has a list price of $6820 (estimated street, $6240). The $2830 price Hertz quoted us for the Hertz P90 is for a base system with 8 MB of RAM and no monitor, not for the system as tested.

November 1994 In the Lab Report on printers, the Hewlett-Packard DeskJet 540 does not support PostScript Level II, HP PCL5, or HPGL (Hewlett-Packard Graphics Language). ■

PC Magazine (UK), December 1994. Reprinted with kind permission of Ziff-Davis UK Limited.

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NexGen Chip Challenges Pentium Performance

PC WORLD, November 1994

System	CPU	RAM (MB)	Application test times (in minutes:seconds)
Nx586(VL) System	Nx586-P90	16	1:19 :37 1:08 1:23 1:27 1:19 1:16
Pentium System[1]	Pentium-90	16	1:15 :37 1:07 1:07 1:44 1:21 1:16

Shorter times are better.

0 1 2 3 4 5 6 7 8 9

Word 2.0 for Windows · Freelance 1.0 for Windows · 1-2-3 release 3.4 · Excel 4.0 · WordPerfect 6.0 for DOS · Paradox 3.5 · Paradox 1.0 for Windows

[1]Average score of six Pentium-90 systems.

Tests run on preproduction unit.
PC World Test Center application benchmarks.

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Addlict Computer
Tucson, AZ
602-294-7200

Adisys Corporation
Santa Clara, CA
800-423-4797

Alaris
Fremont, CA
800-317-2348

Allied Manufacturing Group
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Alpine Computer Center
Rockford, IL
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ASA Computers, Inc.
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Ballilo's Inc.
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Blackship Computer
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C Point
Huntington Beach, CA
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ICS Computer Systems Corp.
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M.E.C.
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404-447-1726

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Micro Simplex
Mesa, AZ
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National Micro Computers
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800-424-2983

NCA Computer Products
Sunnyvale, CA
800-964-1200

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Princeton, NJ
609-371-0003

Niotrix Corporation
Leonia, NJ
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PC Concepts
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PC Performance Centers
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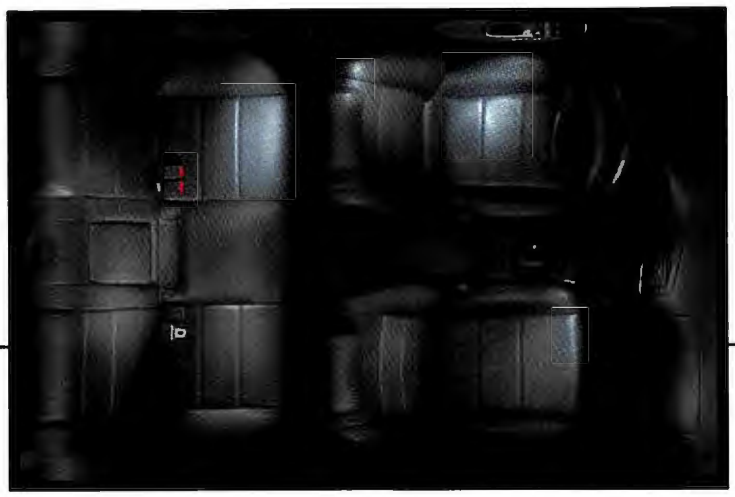

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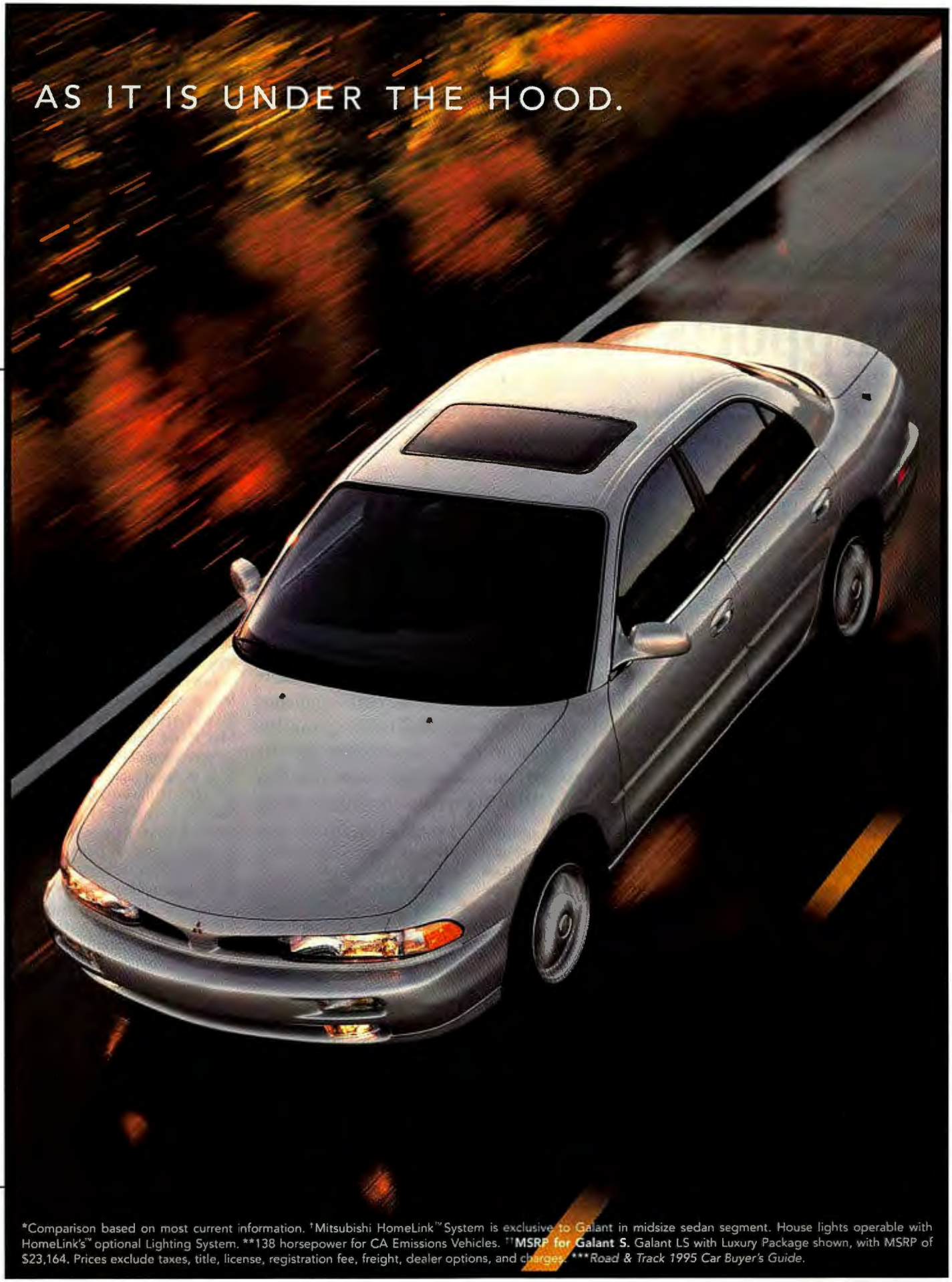

*Comparison based on most current information. †Mitsubishi HomeLink™ System is exclusive to Galant in midsize sedan segment. House lights operable with HomeLink's™ optional Lighting System. **138 horsepower for CA Emissions Vehicles. ††**MSRP for Galant S.** Galant LS with Luxury Package shown, with MSRP of $23,164. Prices exclude taxes, title, license, registration fee, freight, dealer options, and charges. ***_Road & Track 1995 Car Buyer's Guide_.

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New PowerPC Standard Supports Macs

Although still in its early stages, the new Common Hardware Reference Platform standard promises to let PowerPC systems freely use various operating systems

TOM THOMPSON

Apple, IBM, and Motorola recently disclosed technical details that were absent last fall when they announced a new standard for interoperability among PowerPC computers (including future Power Macs) and PowerPC operating systems. The CHRP (Common Hardware Reference Platform) standard, although still evolving, brings the PowerPC alliance closer to the goal it stated in 1991 to create a new standard for RISC-based computers that will let hardware vendors build a computer system for a specific audience by picking and choosing components. The disclosure at BYTE's PowerPC forum last December of details pertaining to cache, ASICs (application specific ICs), controllers, and other components portends an architecture that will let any CHRP-compliant computer cold-boot any CHRP-compliant operating system.

Part of the original PowerPC announcement included an ABI (Application Binary Interface) that would abstract low-level hardware so that Mac, DOS, and Unix applications would run on the same PowerPC system. While the ABI has been demonstrated several times over the years, none of the shipping PowerPC systems have used it. Instead, each uses its own PowerPC operating system: IBM's PowerPC systems and Motorola's new PowerStack computers run AIX, and Apple's Power Macs only run System 7. In the first quarter of this year, a PowerPC version of Windows NT 3.5 will become available for the IBM and Motorola systems.

The rift this creates in the PowerPC market is serious. Users must choose a system from a vendor based in part on what operating system the computer can run. This is the very problem that the alliance was trying to avoid.

The problem has its roots in the hardware itself. The memory organization that NT uses is different from that of AIX and the Mac OS (the Endian issue). This problem is further exacerbated by the hardware dependencies built into each operating system. For example, the Mac OS makes heavy use of custom ASICs for handling keyboard, sound generation, and video I/O.

IBM had circulated a draft PReP (PowerPC Reference Platform) document as early as November 1993, and version 1.0 of the standard was formally released in June 1994. PReP describes a system hardware standard to which all PowerPC systems should conform to provide a minimum set of capabilities (e.g., 16-bit CD-quality sound and 8-bit video) and host a variety of operating systems. Motorola's systems are PReP 1.0–compliant, as is the IBM RS/6000 Model 40P. Unfortunately, certain hardware features were never specified, and support for the Mac OS was lacking.

One notable facet of the November 1994 CHRP announcement was that vendors will be able to license the Mac OS and thus jump-start the Mac clone market for Apple. Says Gary Griffis, IBM's director of business development for Power Personal Systems. "CHRP is the next step, where the Mac architecture is merged into the standard. The end result is a platform that combines the best of PCs and the Mac."

Complete CHRP specifications are slated for release this spring. Prototype CHRP systems should appear in the second half of this year and ship sometime in 1996.

The conceptual block diagram "Common Hardware Reference Platform" shows that the core of a CHRP system consists of a PowerPC CPU, DRAM, and a bootstrap ROM, the same as in PReP 1.0. What's new is that the standard now suggests the use of a level 2 cache and a ROM SIMM socket. This ROM socket is for use by manufacturers who will build Mac clones (much of the Mac OS is housed in ROMs).

Jim Gable, Apple's Power Mac product line manager, says the fees Apple will collect from Mac ROM licensees will be comparable to DOS and Windows prices. (Radius and Power Computing have licensed the Mac OS and say they will build Mac OS–compatible systems.) If Apple keeps this promise, it augers well for the growth of a Mac-clone market.

Low-level support of the CHRP architecture will be accomplished initially using ASICs jointly designed by the alliance. Motorola will help develop the memory and PCI (Peripheral Component Interconnect) bridge chip, which will be a derivative of the company's Eagle chip. The new CHRP chip will support the PReP 1.0 and Mac OS memory maps.

Apple and IBM will develop other ASICs that offer I/O support, and these, too, will leverage off existing chip designs. IBM will use its Coral chip (an ISA bus interface and IDE device controller), and Apple will

use several ASICs as starting points in these chip designs.

Detailed CHRP specifications will be provided to a wide range of industry chip-set suppliers, according to Charlie Ashton, Motorola's PowerPC product marketing manager. "We will ensure that the core logic components for CHRP are available from a variety of sources, including suppliers of standard x86 chip sets and super I/O controllers," he says.

CHRP emphasizes the use of an ISA bus or a PCI bus, whereas the original standard only suggested their use. The ISA bus will provide compatibility with existing expansion card designs. The PCI expansion bus's throughput makes it suitable for high-performance applications. A big advantage of PCI is that it's a plug-and-play bus, which could make the job of adding expansion devices to a CHRP system easy.

Thanks to PCI 2.0 and Open Firmware, a CHRP system can host different operating systems while using the same expansion devices. The PCI 2.0 specification provides for multiple firmware images in the expansion device's firmware. And CHRP requires that PCI expansion devices use Open Firmware for the boot process.

Open Firmware, an evolving IEEE standard (P1275), specifies a processor-independent mechanism by which a system can interrogate expansion devices, configure them, and install device drivers. Open Firmware provides the mechanism by which a CHRP system configures and operates all its expansion devices as Mac peripherals under the Mac OS for one session and then configures and operates these devices as PC peripherals when the computer is restarted to run an NT or OS/2 session.

Apple is using Open Firmware to implement PCI expansion devices in PCI-bus Power Macs that will be introduced the first half of this year. Neither IBM nor Motorola have Open Firmware development tools at this time, but they plan to work with Apple and many third-party vendors in this area.

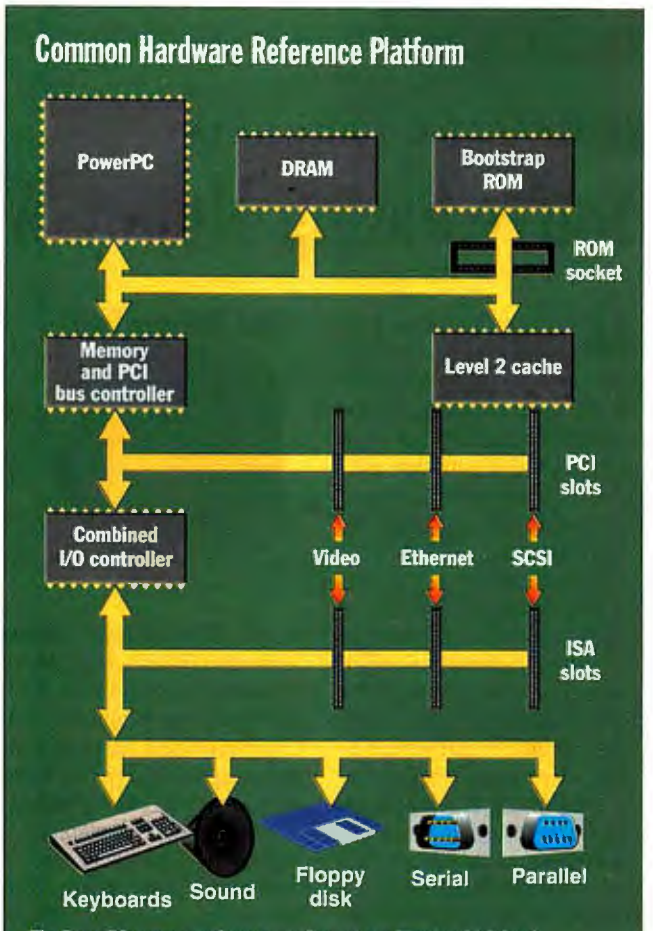
Each member of the alliance is responsible for porting a specific operating system to the new platform: For IBM, it is AIX and OS/2; for Motorola, NT; and for Apple, the Mac OS. Because the PowerPC processor can use little-Endian or big-Endian addressing, the memory organizations that the operating systems use are not an issue. Although CHRP will minimize some of the hardware dependency problems, all three companies agree that this area still needs work.

At the very least, all the operating systems will require rewritten device drivers. For example, modifications to NT's HAL and drivers are necessary for it to run on the CHRP platform. Apple says current Mac device drivers will also need modification, but at least the company has already laid the groundwork with Open Firmware on the PCI Macs.

Once this work is complete, the ability to seamlessly run different operating systems will be compelling. "CHRP Macs will run whatever OS is shipping in 1996," Apple's Gable says. "The hardware and software will operate as a no-apologies Power Mac."

Other vendors also find this capability valuable. Greg Galanos, president of Metrowerks (Montreal, Canada), a supplier of PowerPC compilers for the Mac, says that CHRP should make life easier for developers. "If CHRP is implemented as promised, a developer would need to buy only one CHRP system," Galanos says.

However, at the time of this writing, the CHRP standard is not complete. Vendors are free to attach devices or subsystems where it makes sense for their design. For example, a vendor might connect the video subsystem directly to the PowerPC system bus for performance reasons. The alliance has to balance flexibility for PowerPC system manufacturers with the danger that comes when too much leeway defeats the purpose of a standard (e.g., the original SCSI standard didn't precisely describe certain low-level details, and many early SCSI devices that complied with the standard didn't function with other SCSI devices).



The PowerPC common reference platform shown here is a high-level conceptual diagram. Actual implementation may vary as details are finalized and as manufacturers make their own decisions. What's new is a level 2 cache and a ROM SIMM socket, which is for manufacturers who will build Mac clones. The controller function blocks, particularly the I/O controller, might be implemented using two or more ASICs. System I/O support includes Mac and PC standards, such as SCSI, ADB (Apple Desktop Bus), Ethernet, serial, and parallel port standards.

The PowerPC alliance will have to resolve hardware details if the CHRP standard is to avoid a similar fate to that of the first SCSI standard. One such detail lies in the expansion bus. While the PCI bus lets expansion devices function with different operating systems, the same may not be true of a CHRP system that uses an ISA bus. By the time the standard is final, the ISA bus may be eliminated from the standard.

Another unresolved question is whether the CHRP boot process will support Plug and Play peripherals in either bus. Even the ROM socket that's crucial for the Mac OS is optional.

When selecting core logic components, vendors can unintentionally impact the use of their systems. For example, a PowerPC manufacturer might save costs by not adding the ROM socket and an ASIC that provides an ADB (Apple Desktop Bus) interface to its design. However, this decision disappoints users who expected to use the Mac OS on the CHRP system at a future date. The result: Users have to choose a CHRP system based on the operating system they want—which is the problem CHRP is supposed to solve.

However, this is just a snapshot of the situation while the CHRP standard is in its early stages. As the standard matures, the alliance is actively soliciting input from other PowerPC OEMs. "The original PReP 1.0 standard was too open," says IBM's Griffis. "We learned from that to narrow CHRP down to specifics."

SOFTWARE LICENSING

You're Saving Money When the Meter's Running

Software metering programs, which were originally designed to enforce concurrent licensing agreements and prevent liability for inappropriate use of software, are now being used to cut software costs. Already, companies are cutting licensing fees in half by exploiting a feature of metering programs that reallocates licenses across time zones. Reallocation lets a company get double duty out of licenses by passing them from, for example, U.K. users at the end of their day to San Francisco users as they start their day. While such use may be a short-lived phenomenon (applications vendors are already reexamining their license agreement terms to prevent this), it indicates the cost savings that companies can gain through a metering program.

Global reallocation among time zones represents the extreme of software license savings, where the costs are cut by 50 percent or more. However, the Personal Computer Assets Management Institute (Rochester, NY) estimates that corporations that inventory software, track its use, and reallocate licenses among departments can cut software purchasing costs by as much as 30 percent.

An immediate benefit of using metering tools is savings achieved through license reallocation when servers share licenses. Such savings are possible even in a modest-size organization, thanks to concurrent licensing agreements and the metering tools sold by vendors like the Elan Computer Group (Mountain View, CA), Frye Computer Systems (Boston, MA), McAfee (Santa Clara, CA), Microsoft (Redmond, WA), Microsystems Software (Framingham, MA), Saber Software (Dallas, TX), and Symantec (Santa Monica, CA). Many new metering programs dynamically redistribute licenses within an organization so that, for example, a purchasing department can use (and return when needed) an accounting department's 25 unused licenses for Word.

Metering tools offer other ways to save money. IT (information technology) departments can use a metering tool to log programs (i.e., track how often and how long a person uses an application), to bill software support costs to departments based on use. Support costs dwarf licensing fees—support is about three times more expensive over the lifetime of a typical software package, according to the Gartner Group (see the chart "Total Software Costs"). These support costs have, for the most part, been absorbed in IT budgets because corporations haven't had a fair way to assess charges.

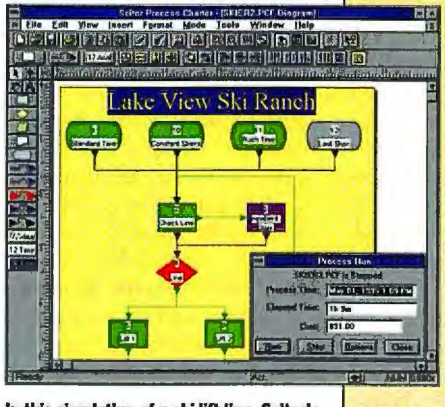
Corporations that track application use can achieve other cost savings. For example, it's not efficient to pay for 1000 copies of a special-purpose program like a flowchart application if only five or six people in the company are using the application at a time. But software vendors are reluctant to accept a concurrent licensing agreement that covers just a handful of simultaneous users when they sell to a large company.

One solution is to charge for software based on the amount of time it is used, not on the number of concurrent users. "It's the idea of the utility billing concept for software," says Nigel Spicer, president of Microsystems Software.

This type of software licensing option, while not common, is being discussed by vendors, according to Peter Beruk, litigation manager at the Software Publishers Association (Washington, D.C.). However, applications vendors will agree to this form of licensing only if a tool is in place to measure this use.

If companies demonstrate that this is possible by virtue of a metering tool, it will make several more applications available to corporations. Vendors will benefit by getting their products into markets from which they've been locked out due to high per-license pricing.

—Salvatore Salamone



In this simulation of a ski lift line, Scitor's Process Charter for Windows determined at what hours of the day a resort should commit resources to opening a second ski lift to reduce customer waiting time. You can step through a defined process and view the incremental cost as time elapses.

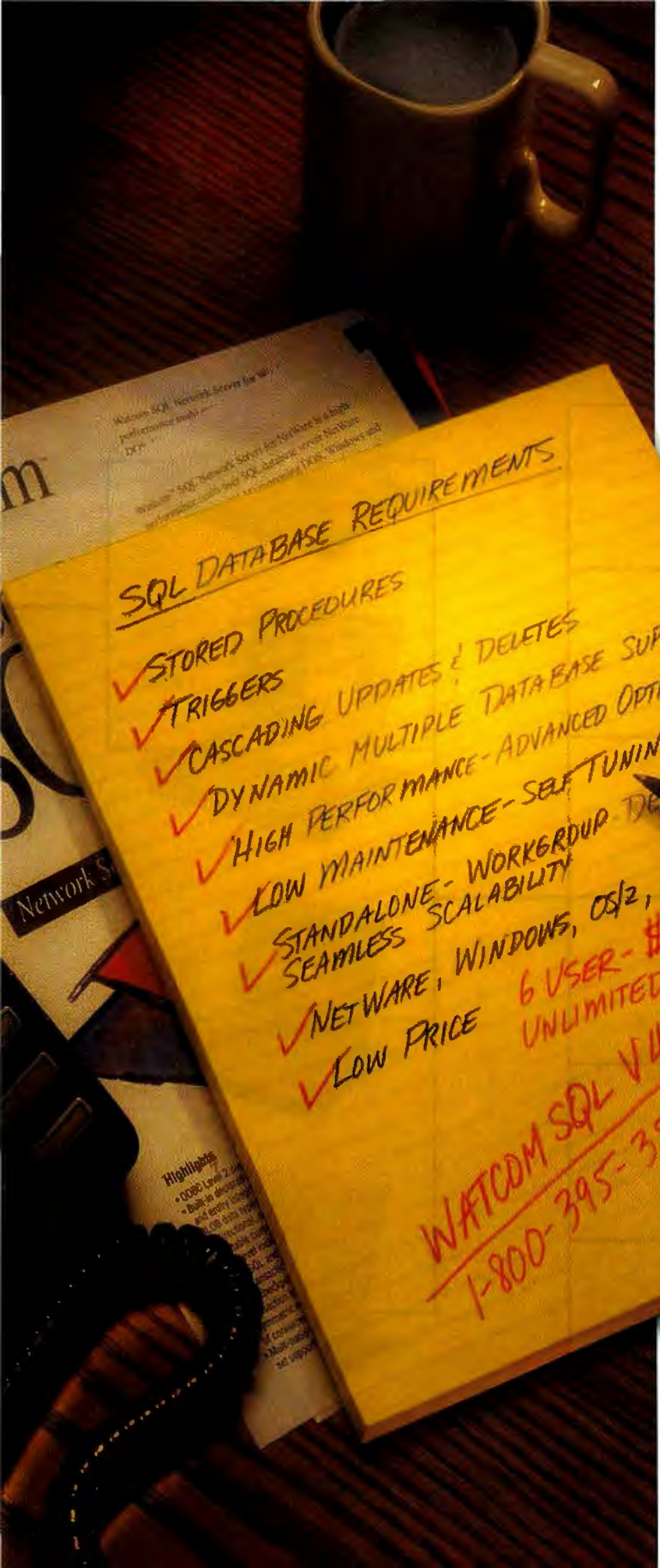
Flowcharts that Simulate Real Processes

Process reengineering tools can help you analyze costs and resources associated with a group of tasks. But if you have a complex group of interrelated processes, current flowchart and reengineering programs for desktop PCs like Micrografx's ABC Toolkit are not as helpful when you want to preview and simulate the effects of a process change on a group of interrelated tasks (e.g., the effects that ripple through all departments in a health care organization if one specific procedure in claims processing is changed).

Scitor (Foster City, CA, (415) 525-3270), a developer of project management programs, has released a program called Process Charter for Windows that addresses this issue. Process Charter combines flowchart tools with the ability to analyze processes through simulation. As with any flowchart program, you define the process structure using traditional flowchart symbols. Like other reengineering tools, you identify and assign the necessary resources required for the various steps in the process. The next step is Process Charter's most intriguing: You execute the process simulation and analyze the effects of process changes by studying the resulting charts and statistics the program generates. Other vendors of desktop reengineering tools are addressing process modeling. Micrografx (Richardson, TX) says ABC Flowcharter 4.0, expected to ship this spring, will integrate the functionality of ABC Toolkit and will support simulation through OLE Automation links to process modeling software from ProModel (Orem, UT).

Process Charter (estimated street price, $450) "gives you a greater likelihood that your design changes to a process will produce the results that you are looking for with less unintended consequences," says Mark Meade, a consultant to health care organization networks.

—Dave Andrews



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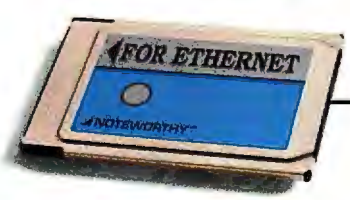

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ELECTRONIC PUBLISHING

Internet Publishing Tools Proliferate

Businesses wanting to publish information on World Wide Web servers will soon have at their disposal a variety of commercial products that let you generate documents in HTML (Hypertext Markup Language). The best tool for you depends in part on how often you'll need to update the information that you're publishing on the Internet.

Microsoft has introduced two add-ons that let users of the company's Windows word processor create HTML documents without having to learn a new editing package. The Internet Assistant for Word for Windows lets you create HTML documents. The second add-on, SGML Author for Word, has a conversion facility that converts Word text styles to SGML tags (or vice versa, if you import an SGML file). SGML Author for Word ($595) can generate documents for HTML and more complex DTDs (Document Type Definitions), like the ATA (American Transportation Association) DTD.

Avalanche Development's ((303) 449-5032) SureStyle ($495) complements Microsoft's add-ons. Slated for release by the end of March, SureStyle applies proper stylesheet elements to unstyled or incorrectly styled Word documents, making it easier to feed such documents to SGML and HTML authoring systems.

SGML Hammer is another Avalanche product that reads in SGML documents and outputs HTML, CD-ROM, word processing, and database formats. Avalanche's HTML Starter Kit allows authors to transform word processing and desktop publishing documents into HTML documents.

But the information in your electronic catalog may change often. "Conversion is just the beginning of the battle," says Philip Werner, product manager for Internet publishing at Interleaf (Waltham, MA, (800) 955-5323). "The real battle is in maintenance."

In addition to guiding you through the conversion of word processing and desktop publishing formats into HTML, Interleaf's Cyberleaf also maintains an internal database of all the hyperlinks within and among documents for a Web. When the content of source documents changes, Cyberleaf will automatically reinsert hyperlinks defined for the previous versions of the document into the updated version. Cyberleaf runs on most Unix operating systems ($795) and, in the first quarter of this year, Windows and Windows NT ($495).

Another approach to HTML translation is to do it on the fly, using source documents stored in the more robust SGML. Electronic Book Technologies' (Providence, RI, (401) 421-9550) DynaWeb is an add-on module to the SGML-based DynaText electronic publishing program. It translates SGML to HTML automatically on an "as-required" basis. The program should ship in the first quarter for many Unix platforms.

Information Dimensions' (Dublin, OH, (800) 328-2648 or (614) 761-8083) Unix-based Basis WebServer, which starts at $15,000, marries a relational database with HTML publishing. It has a repository that can manage documents in ASCII, word processing, HTML, and SGML formats. "Instead of the URL referencing a [static] hard-coded document, it can actually be a query against a database," says David Bayer, manager of electronic publishing at the company. This approach ensures that the information you publish is as fresh as your most recent database update.

—Steven J. Vaughan-Nichols

A VISION FOR A MORE SOPHISTICATED HTML

The WWW (World Wide Web) lets you publish documents with pages of text and graphics that are linked to other text and graphics stored locally or elsewhere on the Internet. These links are specified in HTML (Hypertext Markup Language), which is a simplified application of SGML (Standard Generalized Markup Language).

HTML and SGML use tags embedded in documents to identify elements, but HTML only provides for a limited number of tags, such as headlines, paragraphs, and the anchor codes that specify links. To address the needs of authors who want more control over a document's appearance and to increase the reusability of downloaded documents, committees are working on new versions of HTML. Meanwhile, other document formats (e.g., Adobe's PDF format) are appearing on the WWW, fueling the need for WWW browsers that can handle a variety of formats.

Eric Severson, executive vice president of Avalanche Development, foresees a scalable HTML that will ensure that any WWW user can read simple and complex WWW documents. In this vision, the WWW will use an object-oriented model: All browsers will understand the core classes (i.e., basic headings, paragraphs, and links), but more sophisticated browsers will utilize richer subclass distinctions. The analogy used is a black-and-white TV displaying a program, although the signal has color and stereo sound. —S.J.V-N.

Dialects of the Web

HTML 0.9 This early version of HTML (Hypertext Markup Language) is outdated, but some Web documents are still in this format.

HTML 1.0 Today's most popular Web document language focuses primarily on the anchors and links that compose the strands of the Web.

HTML+ This is a set of HTML specifications from a white paper by Dave Raggett of Hewlett-Packard. Some of the ideas from this paper, such as interactive forms, have been incorporated into HTML 2.0. Others, like support for tables, figures, and math, may be part of HTML 3.0.

HTML (NetScape) This popular HTML variant by NetScape Communications allows authors more basic control of their documents. For example, you can center text in these documents.

HTML 2.0 Recently blessed as an official standard by the Internet Engineering Task Force, HTML 2.0 defines a core set of features that all Web applications must support. It also defines the role of in-line images and adds a powerful interactive forms capability.

HTML 3.0 This HTML variation is expected to add more tags to make documents more accessible for information searching programs. Other proposals include tables, math, graphics and graphics/text objects, and methods to flow text around graphics.

SGML (Standard Generalized Markup Language) SGML is an ISO document format standard. DTDs (Document Type Definitions) identify structural items (e.g., chapter headings and footnotes) used in a class of documents. Tags indicate where the items occur.

PDF (Portable Document Format) PDF is Adobe Acrobat's document description format.

—S.J.V-N.

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3-D GRAPHICS

Developers Catch the 3-D Wave

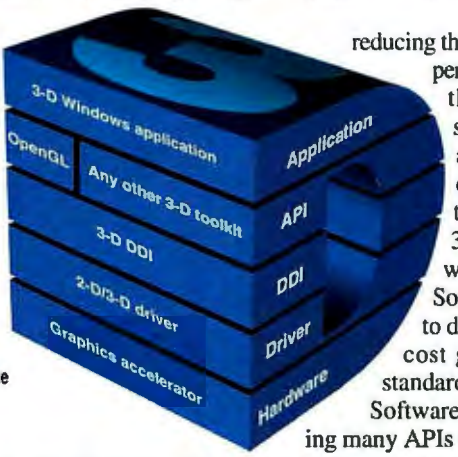
The computer industry is preparing to bring 3-D graphics capabilities that are usually associated with high-end workstations to desktop PCs by standardizing on new 3-D-enhanced video hardware, software APIs, and operating-system enhancements. PC games may never be the same.

The 3-D market demands superior numerical performance and blazing pixel manipulation. The processor must constantly compute how a full 3-D object will look from the viewer's perspective.

PCs based on CPUs like the Pentium or the PowerPC can handle the floating-point arithmetic necessary for calculating the sine and cosine that make up the equations that govern the lighting and movement of objects in 3-D. Game console vendors like Sony are introducing new game platforms like the PlayStation that feature 3-D-capable CPUs.

However, PCs will also need to change. An important addition will be a 3-D graphics acceleration card. Companies like 3Dlabs (San Jose, CA), Matrox (Quebec, Canada), ATI Technologies (Thornhill, Ontario), and Cirrus Logic (Fremont, CA) will release chip sets this year that will give low-end PCs substantial 3-D rendering capability.

- Developers write Windows applications using the API of their choice.
- The API translates higher-level applications calls into lower-level primitives (e.g., triangles and quadrilaterals).
- The 3-D DDI (and the device driver) takes the primitives and other information and accesses the hardware to perform the required drawing.



The more expensive boards using full-featured chips, such as the Glint chip from 3Dlabs, are able to replicate much of the power of the flashy high-end Silicon Graphics workstations with a video board costing about $2000. Newer boards will probably achieve the lower price point by reducing the number of bits used per pixel, which reduces the number of transistors in the chip and the amount of expensive VRAM that holds the image. 3Dlabs is working with Creative Labs, the SoundBlaster company, to develop a new, lower-cost game enhancement standard.

Software vendors are exploring many APIs that will let developers create programs for a variety of chip sets. For a time, the OpenGL API appeared to be an early default standard. Microsoft has incorporated OpenGL into Windows NT and the unreleased Windows 95.

But many companies prefer other APIs over OpenGL. Autodesk, for instance, uses the HOOPS graphics language in AutoCAD. And game software companies discovered that OpenGL was too large and took up too much memory.

A number of smaller APIs are available, including BRender from Argonaut (Menlo Park, CA), Reality Lab from RenderMorphics (London, U.K.), and Renderware from Criterion (Sunnyvale, CA). Each lets the programmer define objects as collections of polygons and choose the lighting and positioning needed to set the scene. They also include features like collision detection and interpolated motion that make game development easier. The more advanced features incorporated in OpenGL (e.g., those that render smoothly curved surfaces and other complex objects) are avoided.

Companies realize that the game market is huge and that people will pay top dollar for entertaining software with flashy effects. The games market, says Jeff Camp, product marketing manager for Windows multimedia at Microsoft, is potentially "illions with a *B* in front of it."

—Peter Wayner

3-D Hardware Vendors Anticipate Microsoft's 3-D DDI

Although Microsoft has incorporated the OpenGL API into Windows NT, the developers of hardware 3-D acceleration products are eagerly anticipating the release of the 3-D DDI (device driver interface) this year. "When Microsoft implements the 3-D DDI, it will provide a set of standard 3-D functions for a board to accelerate that are not specific to OpenGL," says Chris Smith, systems engineer for OmniComp Graphics (Austin, TX), which makes graphics accelerators, such as the 3 Demon 3-D PCI (Peripheral Component Interconnect) graphics acceleration card.

Microsoft has a DDI layer in place that offers a set of Microsoft-defined 2-D graphics functions that graphics hardware can accelerate. A vendor's graphics board driver can provide acceleration by implementing these functions in graphics hardware. "But in the current release of Windows NT 3.5," Smith says, "there is no equivalent 3-D DDI layer." That means that for the compute-intensive functions of OpenGL, there is no standard set of defined Microsoft functions for acceleration boards.

If a hardware vendor wants to accelerate Windows 3-D functions, the vendor has to invest considerable resources in writing its own proprietary low-level interface to its hardware that won't support other manufacturers' boards, says Carolyn De Bie, media relations representative for Matrox Graphics. To write such an interface, a hardware vendor needs to buy an OpenGL source code license from Silicon Graphics. For a board vendor, the $100,000 price tag for this source code can be cost prohibitive.

Microsoft says it expects to release the 3-D DDI at about the same time as it releases NT for the PowerPC. "We're gathering feedback, we're making sure we're getting it right," says Jeff Camp, product marketing manager for Windows Multimedia. Once Microsoft releases the DDI, says De Bie, "The user doesn't have to worry about incompatibilities between 3-D software and hardware."

—Dave Andrews

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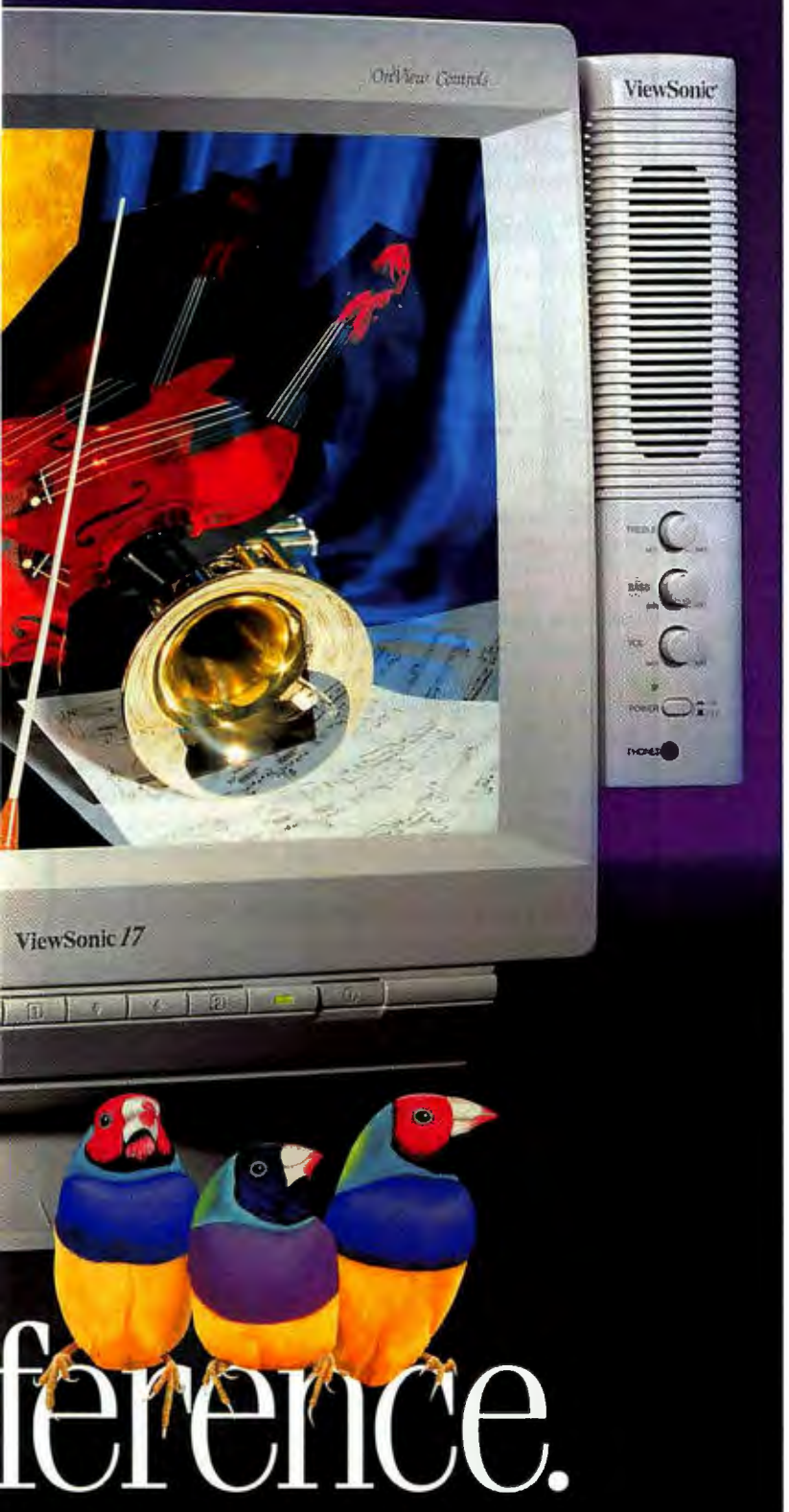

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NATIVE SIGNAL PROCESSING

Multimedia Goes Native

To improve the performance of the Pentium for hosting software-based real-time communications and multimedia applications, Intel includes a new PCI (Peripheral Component Interconnect) controller chip set and a 16-bit audio chip set on motherboards that the company makes for PC manufacturers. The new PCI chip set, code-named Triton, improves the PCI bus's ability to continuously deliver data from the outside world to the PC's main system memory so that the Pentium can quickly process it. The audio chips—the Yamaha 16-bit OPL3L FM synthesizer and two chips from Crystal Semiconductor (Austin, TX) (a D/A converter chip and a codec/controller)—deliver a Windows and DOS-compatible 16-bit stereo sound system on the motherboard.

By putting sound and a lower-latency implementation of PCI on its motherboards, Intel promotes its NSP (Native Signal Processing) strategy of migrating the processing of multimedia functions like software video playback/capture, stereo digital/audio, speech recognition, electronic MIDI instrument synthesis, and other functions off DSPs (digital signal processors) and add-in cards. Intel argues that the Pentium and the forthcoming P6 processor are powerful enough to handle many multimedia functions. Apple has a similar strategy with its PowerPC-based AV Macs.

Vendors like Gateway 2000 and AST say that they may release NSP-optimized systems this year, but they will have to wait until May at the earliest for another crucial component, which is the layer of software from Spectron Microsystems that communicates with Windows applications to deliver deterministic real-time access to the CPU and optimizes NSP. Spectron and Intel are porting Spectron's SPOX real-time system software to the Pentium. The new version, Intel Architecture SPOX (IA-SPOX), augments Windows 3.1 and Windows 95 with real-time capabilities. Bruce Thompson, marketing manager at Spectron, says you can expect the first audio and fax/modem products that support IA-SPOX to be released by midyear.

Some vendors aren't waiting for IA-SPOX availability to release data/fax modems that use the host CPU to perform certain functions previously performed by dedicated add-in cards. For example, ATI's ((905) 882-2600, ext. 1) Vigor fax/modem (list price, $89, up to 19.2 Kbps) eschews a modem controller, RAM, and EEPROM and emulates a 16550 UART using software and a 25-MHz 386 or higher CPU. But officials at Intel and Spectron say that the Pentium and the P6 will need a real-time system software component to adequately handle software videoconferencing.

The Pentium is powerful enough to take over some, but not all, of the tasks now handled by specialized hardware. Rick Olha, product manager for IA-SPOX and NSP at Intel's Architecture Labs, says, "We're not advocating yet that modem manufacturers take out the data pump, as placing that capability on the host takes too much of the Pentium performance." Nor does Intel say the NSP sounds a death knell for DSPs. Says Olha, "We're not trying to replace all DSPs, only when it makes sense."

Spectron's Thompson agrees with that last statement: "It will always be a leapfrog, there will always be new high-end applications that we don't imagine today that may require a DSP."

—Dave Andrews

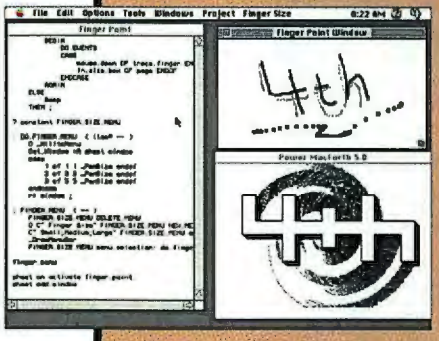
CODE TALK

RICK GREHAN

Forth Powers the Mac

First, let me confess that I have a soft spot in my heart for Forth. It's a language that has largely been misunderstood. I've seen it best described as an amplifier: Good programmers can do wonders with Forth, bad programmers produce hideous results.

Now from Creative Solutions (Rockville, MD, (301) 984-0262; fax (301) 770-1675) comes Power MacForth, descendant of the first Forth development system for the Mac. Power MacForth's ancestor was a 680x0-based, high-quality Forth programming system with lots of accompanying source code tools and libraries. As its name implies, Power MacForth runs on the PowerPC line of Macs.



With Power MacForth and four words, you can create a basic drawing package.

As development packages go, Power MacForth is surprisingly complete. It implements the core and extended core words of the relatively new ANSI Forth specification. The system provides its own form of cooperative multitasking. If you don't mind the postfix notation (and you can't, if you're going to work with Forth), it has a PowerPC 601–compatible assembler and disassembler. There's even a built-in source-level debugger; though, granted, it's really a BASIC-style "trace" capability.

Power MacForth is "direct-threaded," as opposed to the earlier 680x0 version, which was "token-threaded." With token-threaded code, execution of a single routine requires that the Forth inner-interpreter fetch a 16-bit token, resolve that token to the address of the code, and then transfer execution to that code. Token threading is memory thrifty, which makes it workable even on 512-KB Macs, but relatively slow. Meanwhile, direct-threaded code discards an inner interpreter. Tokens are replaced by CALL (or, in the case of the PowerPC, branch and link) instructions that call the routine directly. This change represents more a maturing of the Mac than a maturing of MacForth.

A beneficial byproduct of Power MacForth's direct-threaded structure is that it allows the compiler to use "in-lining" optimizations. A short Forth word of two or three instructions is copied wholesale into your code rather than being compiled as a branch.

The piles of source code tools and examples provide complete access to the Mac toolbox. In fact, there are two interfaces to the toolbox. The one that I found most interesting was a collection of files known as "MacIncludes," which are Forth-like counterparts to the universal C header files for the Mac.

The package is inexpensive: You get a complete PowerMac development system for $199. Of course, what a Forth programmer considers complete might seem skeletal to a C++ programmer. Still, you get the compiler, hordes of source code examples, an assembler and disassembler, and a debugger. Owners of 680x0 versions of MacForth can upgrade for $129. And the whole thing fits on one floppy disk.

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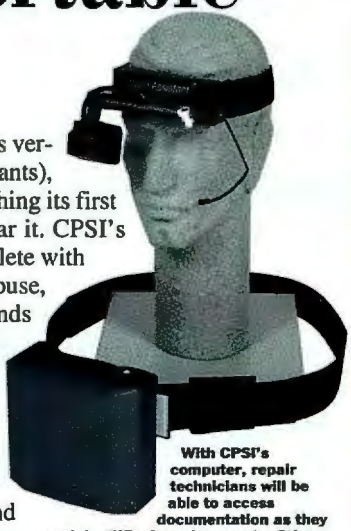
MOBILE COMPUTING

The Ultimate Portable Computer?

While users debate the merits and trade-offs of notebooks versus small notebooks and PDAs (personal digital assistants), information and systems integrator CPSI (Fairfax, VA) is finishing its first computer that represents the ultimate in portability: You wear it. CPSI's body-worn computer fits a 486-based 50-MHz computer complete with a 540-MB hard drive, dual PCMCIA slots, 16 MB of RAM, mouse, and voice recognition in a package that weighs about 3 pounds and is the size of a canteen. The company says the computer, which will cost about $10,000, will run continuously for 6 to 8 hours on lithium ion batteries.

CPSI selected Kopin's (Taunton, MA) state-of-the-art monochrome head-mounted display with VGA resolution that weighs only 6 ounces. CPSI does not plan to deliver end-user products, however. Instead, the company will work with VARs and manufacturers to develop and distribute products in targeted vertical markets worldwide. **—Chris Chinnock**

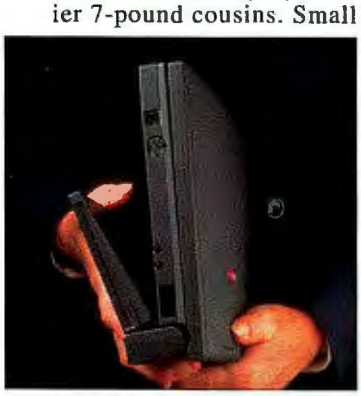


With CPSI's computer, repair technicians will be able to access documentation as they work in difficult environments. Other applications could include emergency medical diagnosis and treatment.

SMALL NOTEBOOKS

Stronger, Smaller Notebooks

Recent introductions by vendors such as Gateway 2000, DEC, and Hewlett-Packard of ultraportable notebooks have reduced feature discrepancy between notebooks that weigh about 4 pounds and their slightly heavier 7-pound cousins. Small notebooks don't yet deliver features such as built-in CD-ROM or SuperVGA resolution. But notebook vendors expect the feature set gap to decrease even more this year.



Small notebooks are becoming more capable thanks to better components and clever designs. DEC's HiNote Ultra features an optional floppy drive that docks to the underside of the portable. Other small notebooks like the HP OmniBook 600 and Gateway 2000 Liberty PC still use the older external floppy drive design, where the drive hangs off the side of the portable.

Subnotebooks that were released last year usually traded compromises (e.g., small screens, less-powerful processors, and low-capacity hard drives) for ultraportability. But now, says Bruce Stephen, an analyst with International Data (Framingham, MA), "The early design mistakes have been learned and corrected."

HP's OmniBook 600C (starts at $2800) features an 8½-inch backlit VGA color passive-matrix display, a 260-MB hard drive from Maxtor that fits in a PCMCIA Type III slot, and support for Windows enhanced mode. DEC's HiNote Ultra (from $2000 to $4999) offers 8 MB of RAM standard, up to a 340-MB hard drive, and a 9½-inch active- or passive-matrix color screen. Gateway 2000's Liberty PC notebook (starts at $2799), which weighs slightly more than 4 pounds, boasts a 10.4-inch dual-scan passive-matrix display. Look for more small notebooks to ship with 10.4-inch or higher-resolution displays, vendors say.

Shyam Jha, DEC's director of product management and marketing, expects the capacity of slim 12.5-mm, 2½-inch hard drives to increase from the current 340-MB maximum to 500 MB this summer and up to 700 or 800 MB by the end of the year. Tim Williams, R&D manager of HP's mobile-computing division, expects the capacity of rotating storage, 1⅓-inch PCMCIA hard drives to increase from 260 to 500 MB or more this year.

The compromises won't be eliminated, however. Today's CD-ROM drives, for example, are a little too thick and heavy for engineers to squeeze into a 4.2-pound package. **—Dave Andrews**

Whatever Happened to . . .

Project Xanadu?

The World Wide Web and hypertext are receiving attention these days, but the concept of distributed hypertext has existed for some time. It was in 1988 that BYTE reported on Ted Nelson's Project Xanadu, which was to be the basis of a global "docuverse" storing millions of documents accessible to millions of users—essentially the idea of the Web on the Internet but on a much grander scale.

Nelson's ideas were so intriguing that Autodesk founder John Walker decided to invest in Xanadu and started an Autodesk Information Business Unit, which included Xanadu and an Electronic Information Shopping Mall called AMIX (American Information Exchange) (see Microbytes, August 1992 BYTE, page 28). A preliminary version of Xanadu (version 88.1) was developed under Autodesk's auspices in 1988, but the project was eventually scrapped and Autodesk "divested itself" of Xanadu in 1992. Walker eventually moved on to other things.

Xanadu still has a phone number in northern California ((415) 331-4422), but Nelson is now in Sapporo, Japan, working with Professor Yuzuru Tanaka of Hokkaido University to develop a new version of the Xanadu Publishing System. According to Nelson, Tanaka has developed a "widget-based graphical interactive language," called IntelligentPad, which Nelson calls a "generalization of NextStep." IntelligentPad will be the "backbone" of a new version of Xanadu to be launched on the Internet's Web. Nelson's Internet address is ted@xanadu.net, but Nelson says he's a "reluctant correspondent" and rarely answers his mail. **—Nick Baran**

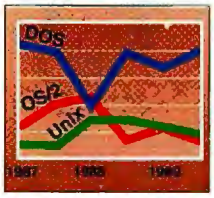
Blasts from the Past

DENNIS BARKER

VGA color monitors made the cover. They were getting to be inexpensive, starting at $399. We looked at 26 of them—very closely. The testers in the lab saw nothing but pixels swimming before their eyes for weeks after.

Machine of the Month: Compaq's new Systempro. "A reason to believe in EISA." This $16,000 33-MHz 386 server featured the Flex/MP architecture, which allowed for multiprocessing the Compaq way; all I/O, for example, had to be handled by the primary processor. Still, "a winner."

Which operating system will dominate the desktop? The BYTE poll at Comdex showed industry expectations for OS/2 falling faster than a mainframe dropped from the Eiffel Tower. In the spring of 1988, voters chose it as the operating system most likely to succeed. But by that fall, OS/2 was sliding, and DOS bounced back to the top. Even Unix, exotica for most Comdexers, surpassed OS/2 in votes. Our take: The practicality of staying with DOS outweighs the technical advantages of OS/2 and Unix. Only developers had Windows 3.0 then—but in a moment of shattering insight, we sensed it having a "negative impact on OS/2 acceptance."



The BYTE Unix benchmarks made their debut in this issue.

Life Within 1 MB. After those rich and famous 1980s—gas-plasma-screen/4-MB-of-RAM/386 laptops on the Côte d'Azur—it was time to think frugality. We devoted about 50 pages to the minimalist lifestyle: busting 640 KB, dealing with TSRs, multitasking DOS, compression programs, svelte integrated software, and Borland's VROOM.

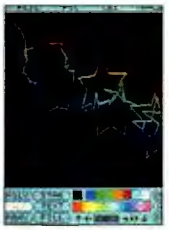
Reviews from the Past

NetWare 386: No more Netgen installation hassles.

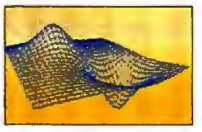
OS/2 1.2: Much improved, but "needs to go on a diet."

Mail-order 386SXes: From Gateway 2000 and PC Brand, "a great deal of power at very reasonable prices."

Autodesk Animator. In 1990, this is what an animation package for the ordinary PC user looked like. Glitzy it ain't, but, hey, it ran on a 640-KB machine. Not for generating *The Lion King*, but OK for *Beavis and Butt-head*.



Bargain Computing. We looked at low-cost and freebie ways to extend your PC's power: programming editors such as Vedit and Brief; a $35 program



called Surf, for generating 3-D plots; instructions for turning a Commodore 64 into an 80-column terminal; the $815 Slicer kit computer; public domain gems like Andrew Fluegelman's PC-Talk and Jim Button's One Ringy Dingy; and a tutorial on XLISP by its inventor and future BYTE employee David Betz.

IBM Japan introduced its PC for the local market. The JX crossed the PC and the PCjr: 4.77-MHz 8088, floppy drives, and two slots for software cartridges; the two expansion connectors would take only PCjr cards. The JX went up against more advanced systems from NEC, Sharp, and other giants.

> "One of the complexities of hacking is that we wanted a pure model. Now the world is more complicated. We have stock options and salaries to worry about."
>
> — Mac hardware designer Burrell Smith, quoted in our West Coast bureau's report from the Hackers' Conference

Flat-panel displays were a bit far out but showed "promise of eventually supplanting the CRT in several workaday contexts." We focused on the technology of gas-plasma and electroluminescent displays.

Steve Ciarcia advises two men at the local doughnut shop to "ease into 16-bit computing" with Intel's new 8088.

Articles on using a microcomputer to "explore the inner processes of a molecule"; solving problems involving variable terrain; simulating the landing of a jet-propelled craft; and operation codes of the 8080, 8085, and Z80.

Editorial director Carl Helmers recounted how he rigged up an Apple II and a Nikon camera to take photos of a solar eclipse. He was going to Kenya for the occasion, with a reader he'd met as a result of an earlier article on the subject.

They'd rejected Steve Wozniak's proposal, thus inadvertently helping to launch Apple, but now Hewlett-Packard had a PC of its own. The HP-85 looked kind of like a giant calculator: one piece, with a little display (5 inches) and built-in keyboard, plus a drive for tape cartridges and a thermal printer with paper only slightly wider than cash-register tape. The brain was a custom 8-bit processor. Cost: $3250.

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– *PC Magazine*, September 27, 1994

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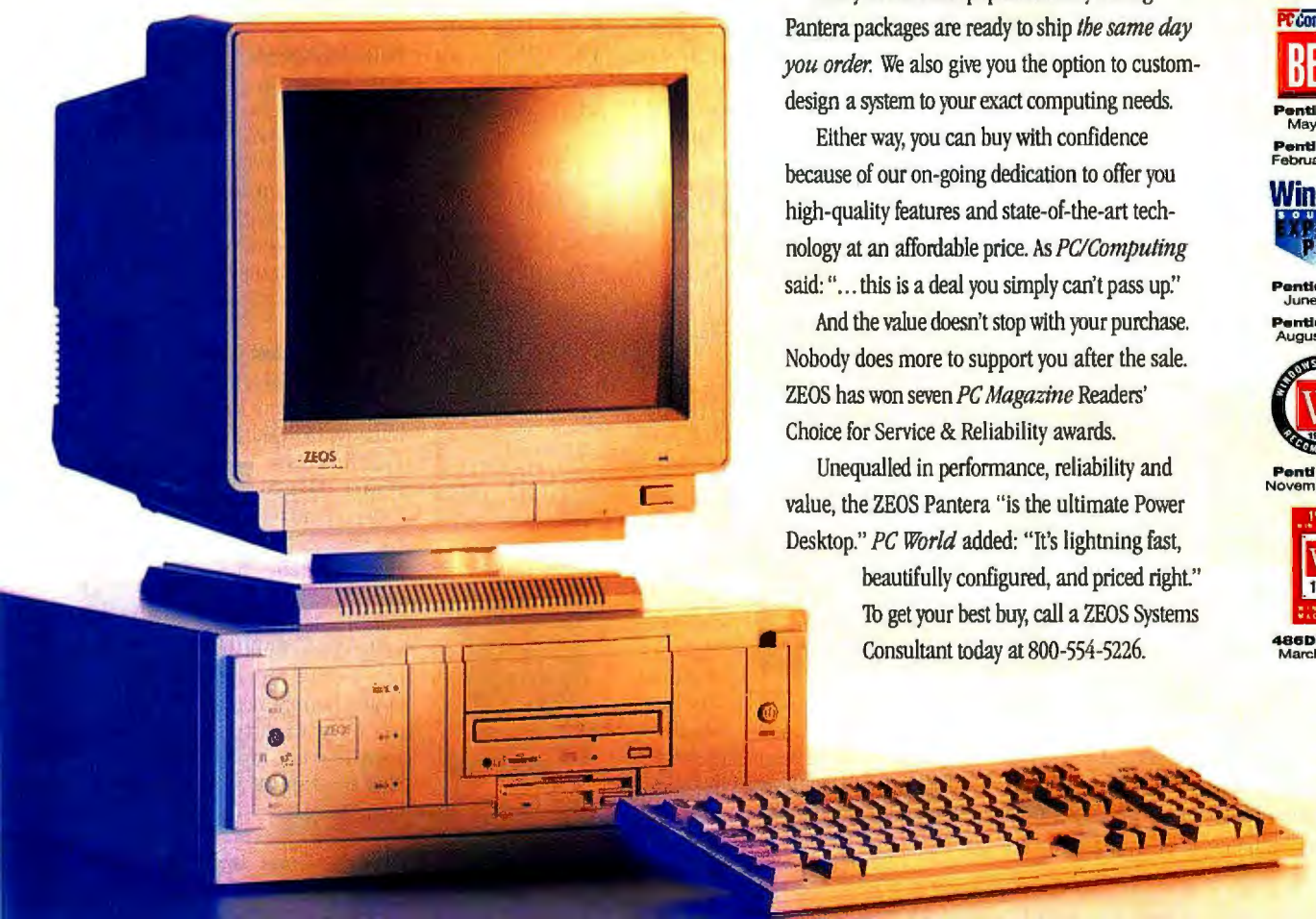

PC MAGAZINE EDITORS' CHOICE
Pentium-66 April 12, 1994
DX4-100 June 28, 1994

COMPUTER SHOPPER
Pentium-60 April 1994
Pentium-90 August 1994

PC WORLD BEST BUY
486DX2-66 January 1994, February 1994, March 1994, June 1994, December 1994, January 1995, February 1995
DX4-100 October 1994, November 1994, December 1994, January 1995
Pentium-60 December 1994, January 1995, February 1995
Pentium-66 June 1994, July 1994, August 1994, September 1994
Pentium-90 August 1994, September 1994, October 1994, November 1994, January 1995, February 1995

PC Computing BEST
Pentium-66 May 1994
Pentium-90 February 1995

Windows Sources EXPERTS' PICK
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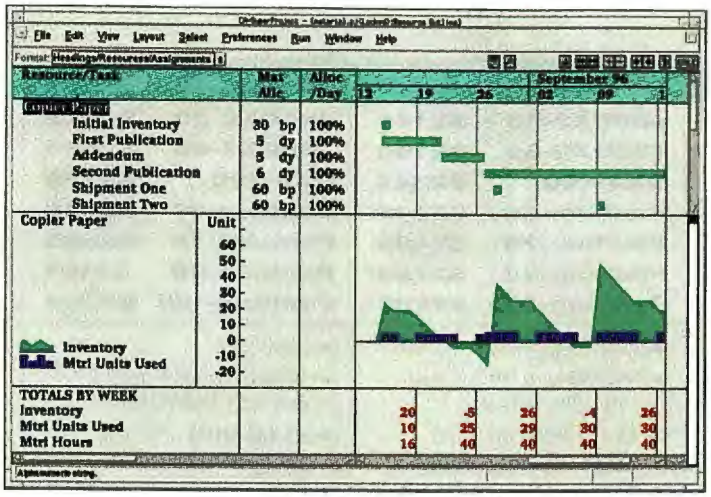

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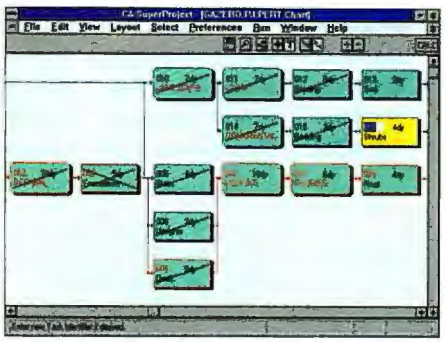

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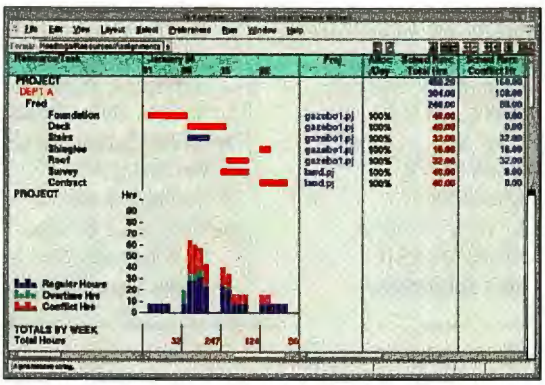

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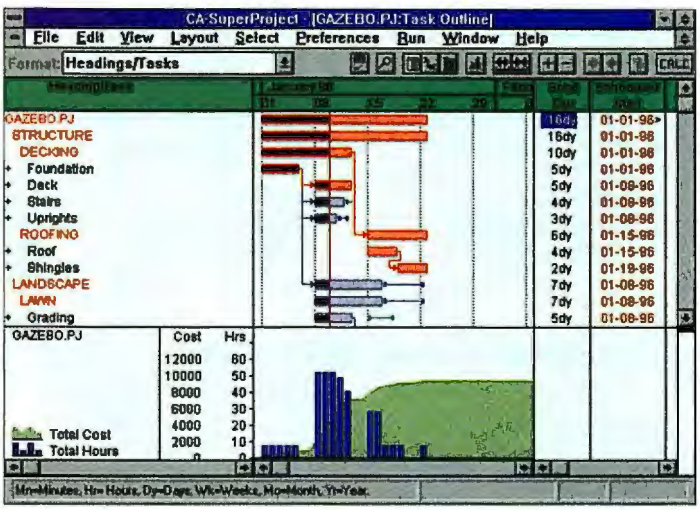

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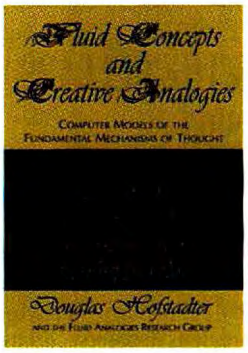


A Model for Future AI Research

JON UDELL

Fifteen years ago, *Gödel, Escher, Bach: An Eternal Golden Braid* exploded on the literary scene, earning its author a Pulitzer prize and a monthly column in *Scientific American*. Douglas Hofstadter's exuberant synthesis of math, music, and art, and his inspired thought experiments with "tangled hierarchy," recursion, pattern recognition, figure/ground reversal, and self-reference, delighted armchair philosophers and AI theorists. But in the end, many people believed that these intellectual games yielded no useful model of cognition on which to base future AI research.

Now *Fluid Concepts and Creative Analogies* presents that model, along with the computer programs Hofstadter and his associates have designed to test it. These programs work in stripped-down yet surprisingly rich microdomains. Here's one example from the Copycat domain: "Suppose the letter-string *abc* were changed to *abd*; how would you change the letter-string *xyz* in the same way?"

A shallow analogy emerges if you answer *xyd*. But that's unsatisfying, because it doesn't acknowledge features such as sequence, successorship, and the special roles of *a* and *z* as first and last. A more subtle interpretation yields the more satisfying answer *wyz*, in which the role of *d* as the successor to *c* in an ascending sequence anchored at the beginning of the alphabet mirrors that of *w* as the predecessor of *x* in a descending sequence anchored at the end of the alphabet.

The challenge for Copycat, the program built to solve this class of problem, was not only to be able to arrive at the answer *wyz* but to get there in the same way humans do. Hofstadter reports that just as human subjects usually answer *xyd* but are more satisfied when they sometimes discover *wyz*, so it is with Copycat.

Concepts? Discovery? Satisfaction? These are, of course, dangerously loaded terms. Here's how Copycat actually works: It uses one network, called the Slipnet, to model concepts, both literal (e.g., the letter *a*) and abstract (e.g., same, opposite, and successor). Links encode distances between pairs of concepts. The distances vary dynamically under the influence of another network, called the Workspace. This is where software agents assemble and tear down structures on various levels—bonds between adjacent letters, groups of letters, and correspondences between groups. Many agents are always running. They're chosen randomly from a larger population of agents scheduled to run. That randomness, governing interplay between conceptual (Slipnet) and perceptual (Workspace) activities, is what enables Copycat to sometimes "discover" *wyz*. The quality of structure and depth of concepts assembled in the Workspace are what measure Copycat's "satisfaction" with that answer.

Hofstadter boldly claims that Copycat captures fundamental processes of creative intelligence. That's radical enough, but what will make this book even more controversial is that he considers and violently rejects the models put forward by other cognitive scientists.

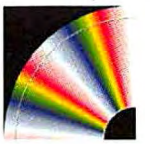
Hofstadter, like the competitors he denounces, must ultimately appeal to the performance of a computer program in some artificial-problem domain ("look, it finds *wyz*") as evidence of success. Thus, the Hofstadter-*über-alles* attitude can be justified only by compelling explanations of why a domain is meaningful and how a program's performance in a domain models real aspects of intelligence. I find the explanations compelling. Maybe you won't. But either way, the cards are mostly on the table. ■

FLUID CONCEPTS AND CREATIVE ANALOGIES: COMPUTER MODELS OF THE FUNDAMENTAL MECHANISMS OF THOUGHT

Douglas Hofstadter and the Fluid Analogies Research Group
Basic Books
ISBN 0-465-05154-5

$30

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



STAR TREK MEETS QUICKTIME VR

STAR TREK: THE NEXT GENERATION INTERACTIVE TECHNICAL MANUAL

Simon & Schuster Interactive, 1230 Avenue of the Americas, New York, NY 10020, (212) 698-7000, $69.95

When I heard about a CD-ROM published by Simon & Schuster titled Star Trek: The Next Generation Interactive Technical Manual, my first thought was "shovelware." In 1991, Pocket Books published *Star Trek: The Next Generation Technical Manual*. I suspected that the text of this book was just shoveled onto a CD platter. As it turns out, I was right and wrong: right, in that the book was used as a source of information; wrong, in that as the first multimedia product showcasing Apple's QuickTime VR (for virtual reality) this CD-ROM becomes greater than the sum of its parts.

QuickTime VR is an imaging technology that lets you examine a room through a full 360 degrees. Simple swipes of the mouse direct your field of vision to objects of interest. The stage sets used in the TV series have been captured in QuickTime VR format and are available for your inspection. You can sit in the captain's chair on the bridge and look about you, check out the length of the matter/antimatter reactor from floor to ceiling in engineering, and open drawers in the sick bay to examine some of the high-tech gadgetry.

An outside view of the *Enterprise* lets you see the spaceship from all angles, including the top and bottom (a full 360-degree view on two axes). It's like an outside tour of the ship, using the mouse to steer a shuttle.

The panning motion was very smooth on both a Power Mac 8100/80 at the office and a 33-MHz 68040-based Quadra 800 at home. Although QuickTime VR can do an acceptable job with 8-bit color, you'll get the best results viewing the scenes in 16-bit color, and a dual-speed CD-ROM drive is a must. Combined with background sounds and QuickTime VR's imaging magic, this CD-ROM makes the *Enterprise* an adventure game that you can wander about in and explore for hours—without getting mugged by a dwarf, no less. I certainly enjoyed it.

—Tom Thompson

SPELUNKING THE CELLARS OF WINDOWS 95

UNAUTHORIZED WINDOWS 95 by Andrew Schulman IDG Books, ISBN 1-56884-305-4, $39.99

Hacker/sleuth extraordinaire Andrew Schulman loves to spelunk in the dark and cobwebby cellar on which Microsoft's software empire rests. On two previous descents, chronicled in *Undocumented DOS* and *Undocumented Windows*, he compiled encyclopedic descriptions of what he found there. These books were much more than catalogs of technical trivia, though. Schulman emerged with important insights about the nature of DOS and Windows, the role of undocumented APIs and data structures, and the issues surrounding the use of that information by Microsoft and others.

Unauthorized Windows 95 carries on in the same great tradition. This time, his focus shifts to the architecture of Windows 95 vis-à-vis its predecessors. In particular, he attacks Microsoft's claim that Windows 95 eliminates the dependency on DOS that's widely regarded as the Achilles' heel of Windows 3.x. Schulman doesn't just refute that claim. He jumps on it with both feet and tramples it to a bloody pulp with an almost maniacal glee. The evidence just keeps piling up—we see Windows 95 issuing INT 21h calls, even on behalf of "pure" Win32 programs, to create PSPs (Program Segment Prefixes), get and set the time and date, and perform various other tasks.

After flogging this dead horse mercilessly, Schulman turns the argument on its head. Why shouldn't Windows 95 rely on certain DOS services, particularly when the code that supplies those services runs not in an x86 chip's real mode but in its protected V86 mode? Since version 3.0, he goes on to explain, Windows has really been two operating systems that are loosely coupled together.

The first of these, running at ring 0, is the VMM (virtual machine manager), which multitasks V86-mode sessions or VMs (including the special VM in which all Windows 3.x *and* Windows 95 programs run) and provides the execution environment for the VxDs (virtual device drivers) that Schulman aptly dubs "TSRs of the 90s." The second operating system, running at ring 3, is the set of 16-bit (or in the case of Windows 95, 16- and 32-bit) DLLs that directly support Windows programs.

To the VMM, virtualized DOS is merely a useful assistant that sees only those calls the VMM/VxD system chooses to reflect rather than consume. That consumption has steadily increased over time. In Windows for Workgroups 3.11, both disk and file access were handled entirely by the VMM/VxD system. The trend continues with Windows 95, which on the whole reflects even fewer calls to virtualized DOS (although, paradoxically, it does reflect some that WFW 3.11 did not, to be more compatible with third-party disk utilities).

Examining the fossil record, Schulman traces a continuous evolutionary series, from Windows 3.0 to 3.1 to WFW 3.11 to Windows 95. But while he ridicules Microsoft's claim that Windows 95 represents a clean break with the past, he denies OS/2 and NT supporters the opportunity to gloat. Windows 95's continuity with its admittedly checkered past, Schulman concludes, is a hugely bankable asset. ■

—Jon Udell

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12. Three words: Value! Value! Value!
13. It comes from AMD —the leading alternate source for 486 devices.
14. It puts 60MHz CPUs to shame.
15. Good luck finding a better value.
16. "The robust 486 is alive and well."— Michael Slater, Microprocessor Report.
17. Slater continues, "Enhanced 486 chips will play a major role in 1995."
18. Slater concludes "...an aggressively priced DX4 chip would be a great product."
19. 100MHz...cool!
20. Unlike some CPUs, it's good with figures.
21. Killer part. Killer speed. Killer value. Killer!
22. Certified 100% Windows-compatible by XXCAL. And they're really picky.
23. You don't have to upgrade all your existing software.
24. For all you chip-heads, we use 0.5 micron process technology for our 486 devices.
25. It's tried and true technology at a great price.
26. We were tempted to paint racing stripes on the side.
27. Try and find higher performance at a better price.
28. Runs MS DOS.
29. Runs OS/2.
30. Runs Novell NetWare.
31. Yes, even UNIX.
32. Runs Microsoft Word, without a hitch.
33. We'll say it again, it's 100% Microsoft Windows-compatible.
34. It's Windows NT-compatible, too.
35. And Microsoft Excel.
36. Microsoft Office.
37. Microsoft PowerPoint.
38. Pretty much everything Bill Gates has to offer, it handles flawlessly.
39. Don't forget Quicken.
40. You only live once.
41. Surf the internet @ 100MHz.
42. Runs CompuServe.
43. Runs America Online.
44. And Prodigy, too.
45. It runs everything you need it to, much faster.
46. My 486 is faster than yours! Neener neener neener!
47. It runs Lotus 1-2-3.
48. Lotus Notes.
49. Lotus SmartSuite.
50. And every other Lotus program you can think of.
51. 100MHz. Case closed.
52. Grease + lightning = 100MHz Am486.
53. Your 386 users will kiss you.
54. It's a smart move.
55. Runs WordPerfect.
56. Also WordPerfect Office.

57. And ClarisWorks, for that matter.

58. If you don't upgrade soon, your users will have you drawn and quartered.

59. Megahertz. 100 of them, to be exact.

60. We've invested over a billion dollars so we can keep cranking out tons of them.

61. Think you can pass up a deal this great?

70. Adobe Illustrator.

71. Adobe Photoshop.

72. Even AutoCAD.

73. You're incredibly smart when it comes to these kinds of decisions.

74. It's like driving in the commuter lane, all the time.

75. You sure know a great value when you see one.

82. It's at least worth a test drive, isn't it?

83. Look up "tight-wad" in the dictionary and there's a picture of your boss.

84. Without a doubt, the best value in 486 CPUs.

85. Runs PC Tools.

86. And Norton Utilities.

87. Also Norton Desktop.

92. Even the folks with big budgets will admire your business sense.

93. It's the most appropriate technology for the bulk of your users.

94. Now you can afford that cellular phone.

95. Compaq says, "100MHz 486 systems represent a significant market opportunity and we are delighted there will be an additional source of supply." — Jim Paschal, Vice President of Desktop and Corporate Engineering.

96. The mere thought of an AMD CPU somehow appeals to your rebellious side.

97. Can actually handle the rigors of complex calculations like *division*.

98. We've got ISO 9000 certification—in plain English, that means world class manufacturing facilities.

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66. It's tough to argue with 100MHz performance.

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89. Certified 100% Microsoft Windows-compatible. As if you didn't know.

90. Damn, it's fast!

91. Performance equal to a 60MHz Pentium.

Advanced Micro Devices

Cover Story

New Ways

As networking, multimedia, mobile technology, and better software converge, schools and companies are discovering new ways to improve learning, increase information access, and save money

The refrain is all too familiar: For the past decade, educators and employers have been crowing about the enormous potential for CBET (computer-based education and training), but nearly everyone acknowledges that this potential has yet to be realized. Computers in the schools have soaked up huge capital expenditures without providing any appreciable return on investment. In companies, investments in information technology have been used mostly to automate old learning processes instead of to enable new ones.

That picture is starting to change, however, as new technologies begin making their way into schools and training centers. "The old pattern of kids left in the corner to do flash cards on an Apple II is over," says Jeanne Hayes, president of Quality Education Data, or QED, a research firm in Denver, Colorado. Explosive growth in CD-ROM drives, LANs and Internet connections, multimedia, and collaborative software environments is fueling a new wave of better teaching tools. This generation of technology promises more than just an improvement in educational productivity: It may deliver a qualitative change in the nature of learning itself.

New approaches to educating workers and students are arriving just in time, in the view of many experts. The changing nature of companies and the work they do, especially with large-scale downsizing and the shift to an information-based economy, is requiring workers to be more flexible and better trained, especially in the use of technology. Businesses require schools to turn out students with a different set of skills than those emphasized in early-twentieth-century pedagogy. And employers themselves are using new technologies to educate workers. "Organizations are linking learning to productivity, rather than [training] in advance of the act," says Robert Johansen, director of the new-technologies program at the Institute for the Future in Palo Alto, California, and coauthor of the book *Upsizing the Individual in the Downsized Organization* (Addison-Wesley, 1994). "This is what we call 'just-in-time learning,'" he adds.

Tectonic shifts in computer-assisted teaching mirror those occurring throughout the computer industry—for instance, away from centralized, host-based systems to a networked, distributed model. They also echo a new way of thinking in education theory: Instead of a one-way information flow—typified by broadcast TV or a teacher addressing a group of passive students—new teaching techniques are, like the Internet, two-way, collaborative, and interdisciplinary.

"All the uses of information technology in the last decade—computer-aided instruction, networked information, distance learning—have had problems," says Carol Twigg, vice president of Educom, a Washington, D.C.–based organization for technology in higher education. "The problem with all of them is that they were bolted onto current in-

to Learn

SUMMARY

In the information economy, knowledge is power. However, traditional teaching is expensive and slow. New technologies make learning more productive.

- In companies, centralized training is now giving way to distributed, "just-in-time" learning. The result is increased flexibility, better retention, and lowered costs.
- In schools and colleges, students surf the Internet, use Lotus Notes, exchange E-mail, peruse multimedia CD-ROMs, and perform simulations. These techniques break down barriers, customize instruction, and make education more cost-effective.

structional methods." The convergence of new technology and modern teaching practices is finally breaking that mold, as each enables the realization of the other.

Of course, penetration of technology into classrooms dramatically redefines established teacher-learner relationships. Teachers change from omniscient leaders into tour guides for the infosphere. Instructional materials evolve from rigid textbooks into customizable software. Information becomes more accessible, users pick and choose what they want, and everyone is a content creator. "Education on demand, in homes and on the job, will be a far bigger business than entertainment on demand," asserts R. Wayne Oler, president and CEO of International Thomson Publishing's Education Group in Belmont, California.

Growing Infrastructure

Indeed, education is already big business. The U.S. spends $275 billion yearly for kindergarten through high-school (i.e., K–12) education, or roughly 5 percent of the gross domestic product, according to QED. Of that, roughly $2.4 billion was spent on educational technology last year, says the Software Publishers Association of Washington, D.C.

ANDY REINHARDT

In its July 1994 *K–12 Education Market Report*, the SPA says that "more than half the schools in the country now use computers in almost every discipline." Ninety-nine percent of schools have at least one computer, says the International Association for the Evaluation of Educational Achievement. Unfortunately, only one-third of schools have more than one computer for every 10 students; the national average is 12 students per computer, down from 22 in 1989, says QED.

Technology spending in higher education is harder to pin down (e.g., How do you categorize computer purchases made by students?), but a report from IBM Academic Consulting pegs institutional spending at more than $6 billion for 1994. According to the report, American institutions of higher education have spent an estimated $70 billion on computer-related goods and services over the past 15 years; of that amount, as much as $20 billion was for teaching and learning technology.

The amount of money earmarked for corporate training is also huge. *Training* magazine, in its annual industry survey, estimates that U.S. corporations with more than 100 employees budgeted $51 billion for training in 1994. Arthur Gloster, vice provost for information technology for Virginia Commonwealth University in Richmond, estimates the total spent per year by all companies and their employees at $90 billion to $100 billion.

New Learning

The common thread linking schools, colleges, and corporations is that all are facing budget pressures and are looking for ways to improve education's return on investment. "We're spending more and more on educational technology, but most of this spending is bolted onto our existing cost structure," says Bill Graves, associate provost for information technology at the University of North Carolina at Chapel Hill and director of the Institute for Academic Technology (Durham, NC). "We need to use the technology—use the network—to reduce costs and increase access," he adds.

Schools and companies are using similar technologies to address similar problems, because there is ample evidence that appropriate use of technology can boost retention rates, reduce boredom and misbehavior, and, in many cases, cut costs. The SPA's *Report on the Effectiveness of Technology in Schools, 1990–1994*, a summary of 133 studies, found that educational technology clearly boosted student achievement, improved student attitudes and self-concept, and enhanced the quality of student-teacher relationships.

Especially promising technologies were interactive video, networking, and collaboration tools. Computers are "amazingly patient teachers," says Jan Davidson, president and founder of software maker Davidson & Associates (Torrance, CA); they can spur creative thinking, promote enterprise, and whet curiosity.

But in study after study, another vital conclusion emerges: Technology alone is not the solution. Reaping the benefits of computers first requires extensive teacher training, new curricular materials, and, most important, changes to educational models. Modern educational concepts, derived from the work of scholars such as Swiss psychologist Jean Piaget, MIT researcher Seymour Papert, and Russian psychologist Lev S. Vygotsky, emphasize individualized, hands-on learning; teamwork; and guided discovery of information.

CHANGING EDUCATIONAL PARADIGMS

OLD MODEL	NEW MODEL	TECHNOLOGY IMPLICATIONS
Classroom lectures	Individual exploration	Networked PCs with access to information
Passive absorption	Apprenticeship	Requires skills development and simulations
Individual work	Team learning	Benefits from collaborative tools and E-mail
Omniscient teacher	Teacher as guide	Relies on access to experts over network
Stable content	Fast-changing content	Requires networks and publishing tools
Homogeneity	Diversity	Requires a variety of access tools and methods

All these concepts are not only well suited to technology assistance, but, given the economics of teaching and training, they are nearly impossible to effect without the help of computers. Says Britton Manasco, editor of the *Learning Enterprise*, a newsletter about corporate education, "We have to tailor [learning] to the individual student or employee, but there's no way we can afford to do this without technology."

Another problem with today's education "is that people are learning in a large group, and they're afraid to speak out because the culture makes them feel foolish if they make a mistake," says professor Roger Schank, director of Northwestern University's Institute for the Learning Sciences (Evanston, IL). "The greatest value of computers is that they will watch out for you and let you do stuff without fear of embarrassment," he adds.

Schank sees computers as electronic mentors. "They can provide built-in experts that are available on-line, looking over your shoulder," he says. "So, instead of today's model, where you have one expert at the front of the room talking to a lot of people, it's reversed: You have one user at a computer with hundreds of experts built in."

This permits—and makes economically feasible—the return of a very old educational model: apprenticeship. "Apprenticeship has always been the best learning model, whether from other people or simulations," Schank says. "Computers allow apprenticeship in fields where it's hard or impossible to do it in real life, like surgery or learning to fly an airplane."

The implications of this transformation affect both students and teachers. Instructors become more like coaches, while students are free to discover knowledge on their own. "There is more information about topics these days than anybody can handle, so teachers have to rely on technology to help," says Anita Best, editor of the *Computing Teacher* magazine, published by the International Society for Technology in Education (Eugene, OR), or ISTE. With computers, "teachers become facilitators, collaborators, and brokers of resources. The networks have the information, but the students need a guide."

Computers are also a huge aid in preparing course materials, whether through conventional tools, such as word processing, desktop publishing, presentation, or illustration packages, or as a means of access to far-flung resources, ranging from Internet news groups to shareware lesson plans on AOL (America Online). "Making it easier to prepare materials means teachers can focus on explaining information instead of conveying information," says Robert Cavalier, a senior faculty consultant at the Center for the Advancement of Applied Ethics at Carnegie Mellon University (Pittsburgh, PA).

New Technologies

The emerging technologies that are making the biggest difference in training and education fall into three broad categories: networking, multimedia, and mobility. Networking includes LANs, WANs, and on-line services (especially the Internet), as well as applications enabled by networks, such as audio conferencing and videoconferencing, E-mail, collaborative software, and instructional management. "Telecommunications will probably have the most long-term impact on teachers and students," says Dr. Greg Kearsley, a professor

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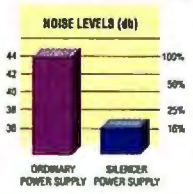

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of educational leadership at George Washington University, or GWU (Washington, DC), and a member of the Association for the Advancement of Computing in Education (or AACE), in Charlottesville, Virginia. "It's like word processing: It will become more a part of the infrastructure than an application in and of itself," he explains.

Networked applications run the gamut, from Internet survey courses to Lotus Notes–based collaborative projects. At the public schools in North Reading, Massachusetts, students use the Internet as a means of accessing authoritative sources, says Tom Hashem, a math teacher and the guiding light of the district's computer program. "It gives them access to timely information they couldn't find in the local library," he adds.

One high-school class studying an Amazonian tribe joined an anthropology list server and contacted ethnographers who were experts about the tribe. When they got contradictory responses, Dr. Maryanne Wolff, a teacher, says, it taught the students that informed sources sometimes

Seven New Ways to Learn

Carnegie Mellon University is changing the way in which teachers teach and students learn

DENNIS BARKER

Carnegie Mellon University (Pittsburgh, PA) buzzes like a playground during recess period—except its researchers aren't playing. Carnegie Mellon computer scientists, cognitive psychologists, education experts, and professors are working on projects that can change the way teachers teach and students learn.

Building on its historic strengths in speech recognition and AI, Carnegie Mellon is advancing education along seven broad thematic lines:

- Simulating real-life environments (e.g., the stock market or a hospital ethics team)
- Enabling self-paced learning
- Lowering the intimidation factor (i.e., fear of looking stupid)
- Reducing behavioral problems in the classroom
- Increasing one-on-one interaction
- Providing access to more information
- Implementing "situated learning"

The FAST Program

The FAST (Financial Analysis and Security Trading) program uses computers and high-speed communications to simulate the fast-and-furious world of the stock market. (It's part of the Graduate School of Industrial Administration's degrees in computational finance and industrial administration, which aim to produce information-technology-savvy graduates.) The program, as dean Robert Sullivan puts it, uses computers to "create a competitive trading environment, where students learn by doing."

In the FAST lab are pairs of Hewlett-Packard Unix machines and Windows PCs. On the PCs are trading tools, electronic textbooks, and portfolio management programs. The Unix boxes and PCs are hooked up to a real-time data feed from Reuters that shows what's happening on the stock, money, and options markets. Students use this live data to buy and sell real stock at actual current prices. "The system greatly accelerates our students' transition from the classroom to the real, live trading floor," says Sanjay Srivastava, Graduate School of Industrial Administration professor of finance and economics and co-developer of the FAST program. It teaches them "how to react in a real environment," he adds.

Reading aloud is less intimidating and more fun with a computer-based coach.

Carnegie Mellon has extended this trading environment, as well as the reach of its teachers, by connecting to schools in Mexico City, Tokyo, and other locations via a packet-switching network. The ultimate goal is to create a "virtual university" by adding more schools and using technologies such as videoconferencing to offer the programs to students in other locations. "All the concepts of distance learning [and] distributed learning that we are implementing in this program are applicable to education in industry," says Sullivan.

PUMP Algebra Tutor

The Mac-based PAT (Pump Algebra Tutor) takes students in the Pittsburgh Urban Mathematics Project through practice sessions at their own pace as a way of teaching them how to solve math word problems. The software is currently being used in three Pittsburgh high schools.

PAT is built around a cognitive model that tracks a student's performance and guesses at how well a student is learning a lesson. When the student appears to have the relevant skills nailed down, the program presents the next level of problems. When stumped, the student can ask the tutor for hints. The program doesn't give the answer; instead, it prods with suggestions (e.g., "Have you tried doing X?").

"Students are much more comfortable with computers when it comes to a problem they're having trouble with," says Ken Koedinger, a Carnegie Mellon researcher involved with the tutor program. "They don't feel embarrassed when they give the wrong answer to the computer-based tutor." Students are also more involved in their work and aren't goofing around. "Teachers don't have to spend 70 percent of their time dealing with discipline," says Jaclyn Baker Snyder, head of the math department at Langley High School.

Project Listen

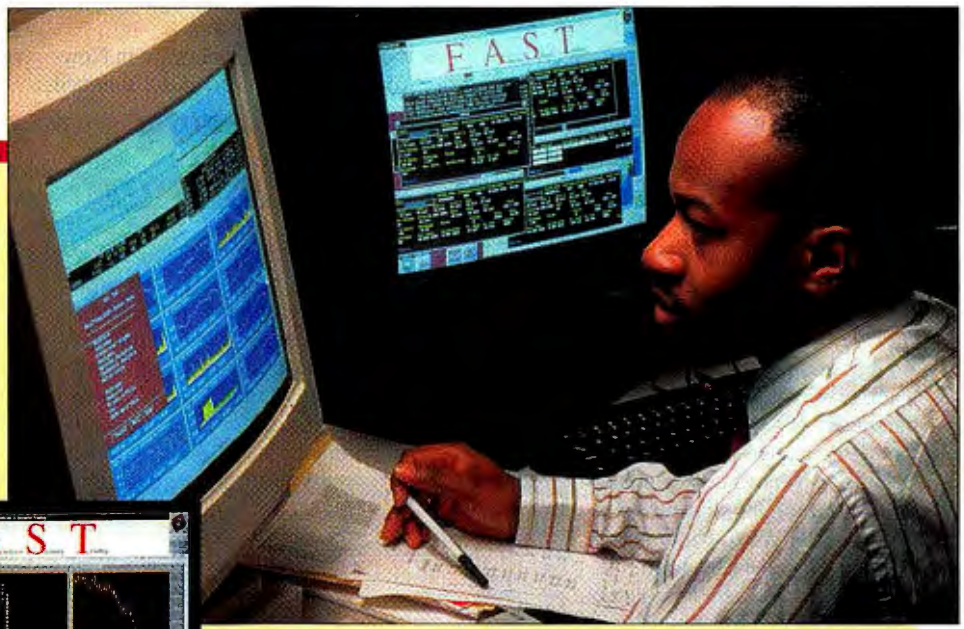
An AI-based coach program called Project Listen listens to kids read and then helps them out when they misread a word or apparently don't understand a sentence. The system, which is demonstrated on a Next computer equipped with a microphone, is linked to a speech recognizer developed at Carnegie Mellon, called Sphinx-II, that runs on an HP 735. It matches the spoken word with the text the student reads from and then highlights a problem word and pronounces it. "There's lots of software out there that tries to teach reading, but none of it is capable of listening and intervening," says senior research scientist Jack Mostow.

Eventually, he hopes, the coach will be smart enough to know what kinds of words a student has the most trouble with and then sprinkle them throughout the reading lesson. Although the coach is still "highly experimental," results have shown benefits. Preliminary experiments with a prototype showed that second-graders could read at a level six months higher, on average, while being assisted by the coach. Recent usability trials also suggest gains in com-

disagree. "Students begin to learn the need to dig into the background and perspectives of their sources," she notes.

At the John E. Anderson Graduate School of Management at UCLA, professor Arthur M. Geoffrion teaches a popular course on using the Internet and commercial on-line services in business. He teaches students how to use the basic tools of the Internet—ftp, gopher, search tools, and the WWW (World Wide Web)—and almost all class time is spent "in front of the tube," learning from doing.

Geoffrion asserts that "networking power" will become a new metric of professional skill. "Knowledge of networked-



Systems analyst Garfield Williams studies financial data at a FAST workstation. The system receives real-time data showing what's happening on the market.

PHOTOS: BILL REDIC © 1995

prehension, especially with more difficult material.

While Mostow concedes these results aren't earthshaking, it's progress nevertheless. "If we can provide an environment that makes reading less frustrating and encourages them to do lots of reading, then we'll see benefits," he says.

Center for the Advancement of Applied Ethics

Does a person have a right to die? Or to have medical treatments stopped? These issues are discussed in senior researcher Robert Cavalier's courses on ethics. To bring them to life, Cavalier uses a multimedia videodisc called The Case of Dax Cowart, based on the true case of a young man burned horribly in a freak accident. Rather than undergoing painful treatments and enduring a life of physical handicaps, he asked his doctors to let him die.

The disc gives students something other than words in a textbook; it includes video clips of Cowart's treatments and interviews with the patient, his mother, and his medical team. The multimedia presentation is designed to provoke discussion and philosophical reflection on the subjects of patients' rights, medical intervention, and assisted suicide. After students decide what they would do in Cowart's case, the disc shows them what actually happened.

"The traditional classroom doesn't convey these difficult situations," Cavalier says. Seeing and hearing from the patient and his doctors gives the student more information to draw from, as well as "the duress of counteropinions." The Center plans to put this kind of courseware out on the WWW (World Wide Web) and then have other real-life cases added.

Situated Learning

Phil Miller has taken the concept of *situated cognition*, or learning while doing, and applied it to teaching computer programming. A principal lecturer in computer science, Miller says, "straight lecturing puts people to sleep." Instead, he says, you teach people by "giving them something real to do."

To teach programming to students who perhaps couldn't care less about loops and stacks, Miller develops science courses that have programming lessons built in. For example, he gives biology majors a simulation of fruit-fly embryo development. Underlying that simulation, of course, are lines of code. Students can go into the code to either make changes to the simulation or learn what factors trigger certain events. "You want to change how diffusion works?" Miller asks. "Then hop on in there and change the code."

By working with the program, students consequently learn about data structures, algorithms, and other elements of software. In a similar way, business majors could tweak a sales-tracking program written in Visual Basic, or art students could work with a program that generates paintings. "Instead of just teaching programming," Miller says, "you give students a relevant context in which to learn programming—a context that interests them."

Informedia Digital Video Library

The Informedia project, which is still in prototype form, provides access to archives of videotape. But unlike video on demand, which can search only for titles (e.g., "Computer, find *The Wizard of Oz.*"), the Informedia system can search and retrieve on the basis of content (e.g., "Computer, find every clip in which there's a reference to *brain*, *heart*, and *courage.*"). It works by recognizing speech on the audio track and constructing an index from the text.

In a demonstration of the system, Carnegie Mellon vice provost for research computing Howard Wactlar asked about traveling to Mars. The system zeroed in on one of its "books"—a PBS documentary—and brought up film clips of Arthur C. Clarke and others discussing interplanetary exploration.

The material is more complete than the documentary shown on TV. The version in this library includes outtakes, so 30 minutes of the interview with Clarke et al. is available, not just the 2 minutes that survived the final editing for the program.

In another example, Wactlar queried about parallel processing. The system tapped into a group of videotaped lectures and brought up a clip of Thinking Machines' Danny Hillis explaining the basics of parallelism.

Ultimately, Carnegie Mellon envisions distributed libraries containing video on hundreds of topics. You'll be able to dial up and have the video blasted over the phone lines. "It will promote lifelong learning at work and at home," Wactlar says.

Dennis Barker is BYTE's chief of correspondents. You can reach him on the Internet or BIX at dbarker@bix.com.

based communications and on-line resources, how to use them, and the cooperative society of the Net all [improve] the creativity, productivity, quality, and quick responsiveness of professional work," he says.

Networked applications using NetWare are widespread in colleges and training centers, says Janet Perry, manager of technology transfer partners for Novell. Among the benefits she cites are ease of distributing information and course materials and improved communications, especially between students and teachers.

At the University of Delaware in Newark, Solaris-based servers store scanned color images for art, history, and botany classes. Students say they prefer these to black-and-white reproductions in textbooks, and not only because of the better quality. They can view them at their leisure, without regard to hours, location, or other people using the slides.

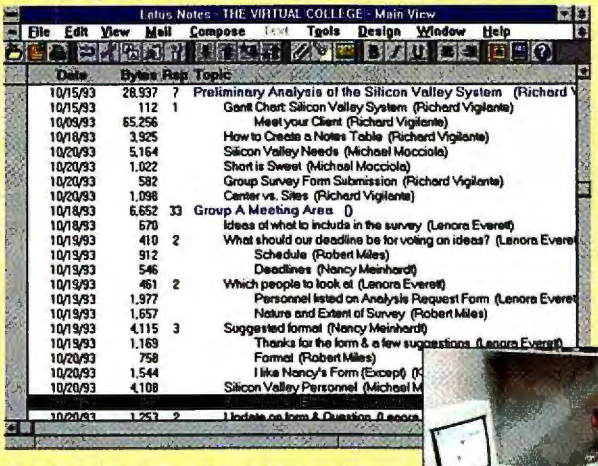
When you layer collaborative software

Building the Virtual College

NYU uses Lotus Notes to reengineer post-graduate studies

Is it possible to create a college, a curriculum, or even a student café entirely in cyberspace? Absolutely. The School of Continuing Education at New York University (New York, NY) has done just that, through a program that builds on Windows, NetWare, Lotus Notes, ISDN, and Indeo digital video.

Begun in 1992, the NYU Virtual College offers a small number of courses taught entirely in virtual classrooms. Each student owns a Windows-capable PC and modem. Through Notes servers accessed via toll-free dial-in lines, students receive electronic "lectures" that are delivered as multimedia presentations, obtain required course readings, contribute to discussion topics, and send E-mail to one another and the instructor. Participation in the program costs about $2000 per course.



NYU's Virtual College uses threaded Lotus Notes conferences for interactive "discussions" (above). At right is program head Richard Vigilante.

PHOTO: MARC YANKUS © 1995

Currently, the Virtual College is used mainly for midcareer training. "We needed to get away from the model of flying people to a place, putting them up in a hotel, and all the costs and lost productivity that go with it," says Dr. Richard Vigilante, head of the program. "Not to mention the problem of compressing into days something that might be better absorbed over weeks," he adds. Scheduled classes are especially impractical for busy mid- and senior-level executives who travel a lot; the Virtual College lets them "attend" classes anytime and anywhere, within the confines of the semester.

The program has an additional attribute that bears heavily on its success: The subject matter of the courses consists of applied IS (information systems) and virtual workgroups, so students are gaining not only theoretical knowledge of the topic but also practical, hands-on experience. Completing 16 course credits earns a student an advanced professional certificate, and an additional 16 credits of traditional graduate course work is enough for a master's degree in performance and IS auditing. "The students are using the very technologies [that] they may be implementing in their companies," says Rembert Aranda, a Virtual College faculty member.

Aranda says that the most surprising result of the program to date has been its effect on student participation. The amount of interaction among students, and between students and instructors, is an order of magnitude higher than that of a normal classroom, he notes. This is measured by observing how many questions students ask and the liveliness of the discussion threads. But it's possible that E-mail and BBS postings are merely filling in for the lack of face-to-face contact.

Organization: New York University

Technologies: Collaborative software; E-mail; digital video

Success factors: Customized curriculum; motivated students

Effects: Anytime/anyplace learning; high levels of interaction

Crucial Differences

Distance learning and learning on demand aren't new concepts. What makes NYU's Virtual College different from earlier, TV-based classes is its flat hierarchy, communications symmetry, and participatory nature.

Conventional televised courses, some of which offer remote students the ability to dial in for audio feedback, tend to penalize remote learners in favor of those present in the classroom. At the Virtual College, "everybody, even the teacher, attends the class on the same terms," Aranda says. And whereas night-school courses are available only to those who live nearby and have the time to attend, the Virtual College can draw students and instructors from anywhere. "You can get the very best people, regardless of time or space," Aranda says.

This spring, the Virtual College will inaugurate its first course to use digital video and new Video for Notes software from Lotus. Participating students will be given local ISDN service and loaned ISDN equipment; the video clips, compressed using Intel's Smart Video Recorder, can be viewed in real time (in quarter-screen size at 15 frames per second) or pumped across the wire for local storage and viewing.

"A lot of corporate training materials are already on video, and we wanted to tap into that," Vigilante says. However, video courses typically need reworking (e.g., the addition of hypertext links or supplementary text) to succeed as interactive tools. Doing so "makes them less lecture-like and more seminar-like," Vigilante adds.

Aranda and Vigilante acknowledge that the Virtual College works partly because the students are highly motivated. But both are convinced that it's a model with enormous potential for lifelong learning. "We had a sense that the cost of education, expressed in price/performance terms, hadn't been improving at the same rate as computers and telecommunications," Aranda says. Now that NYU has "reengineered" the classroom, he adds, "the degree of freedom is fantastic."

Will the P5-75 Family PC's new fax/modem call for help during the tumble in the rubble?

Will Anna buy her own Gateway P5-100 with a 1GB hard drive, quad-speed CD-ROM drive and 16MB RAM for only $2,999?

As the Hard Drive Turns

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Will the 4DX2-66 Family PC testify against Sheryl?

*Furs pictured are made from artificial materials.

Featured Gateway 2000 PC: P5-100XL with the new TelePath IIv fax/modem, 1GB hard drive and quad-speed CD-ROM at a new low price of $3,799!

Setting: Lawyer's Office

Characters:
Jonathan Mattison: Lawyer
Kiki: Young wife of Victor
Victor: Kiki's husband who was presumed dead

After the reading of the will, Kiki and Mr. Mattison lock in a passionate embrace. However, they're unaware that Victor wasn't killed in the accident, and he has just arrived in Gateville.

Victor: Kiki! What's going on here? Unhand her, you beast! I thought you really loved me, Kiki! Now Anna tells me you're having an affair with my lawyer and you plotted to kill me just so you could get my beloved Gateway 2000® PC!

Kiki: Why Victor! I thought you were dead! Anna lied! Victor you have to believe me. Of course I would love to have this potent PC with its powerful Intel® 100MHz Pentium™ processor, whopping 1GB hard drive, new TelePath™ IIv fax/modem, 16MB of RAM, ultra-fast quad-speed CD-ROM drive, ACS-31 speakers with heart-pounding stereo sound, 17-inch Vivitron™ color monitor, and Microsoft® Office Professional, Bookshelf® and Money *(inhale)* all to myself. But at its new low price of only $3,799 I could have easily bought it with my monthly allowance. Victor, your fall was an accident! We couldn't find you! We thought you were dead! It's been a whole week since you died. I thought it would be okay if I started dating again. I have needs, you know.

Victor: It was no accident! Some burly guy wearing a ski mask and a shiny three-piece suit shoved me off the cliff.

Mattison: Cool it Victor. Kiki and I had nothing to do with your accident. Anna bribed me to read the will. Man, was she steamed that you willed the P5-100XL to Kiki and she only got Fifi, the Yorkie.

Kiki: Yes Victor, I'm sure Anna hired the hit man.

Victor: This is terrible. To think my own daughter would have me killed. I must go rescue Fifi. And as for you two, I'll have you know Kiki, Mattison is your long lost twin brother! It would have only been a matter of time before you found out through the Internet.

Mattison: Now that you mention it, I do see a resemblance . . .

Kiki: *(faints)*

Featured Gateway 2000 PC:
The P5-75 Family PC with the new TelePath IIv fax/modem, 2MB of video memory and quad-speed CD-ROM for only $2,299!

Setting: Collapsed Office Building

Characters:
Julia: Successful Realtor
Trevor: Sexy Construction Worker

Julia and Trevor are lovers trapped in a collapsed office building. They could easily call for help with the PC's TelePath™ IIv fax/modem, but at the moment neither are in a hurry to be rescued. Julia is frisky, but Trevor's obsessed with her Gateway 2000® PC.

Julia: Trevor! How could you do this to me? You haven't paid any attention to me ever since we discovered my Gateway 2000 P5-75 Family PC™ multimedia system. Are you forgetting about our love child? Come on! Love in the rubble awaits us!

Trevor: Not now Julia! I've just discovered even more bodacious features on this PC! She has a hot new TelePath IIv fax/modem with a Messaging Center. We could really use her out at the construction site. She receives, plays and saves voice messages and even lets you access your computer remotely and check for new voice messages. The Messaging Center can send faxes from any Windows™ application that uses a print command and faxes can also be displayed, manipulated and edited, plus a ton of other really cool stuff!

Julia: Trevor, I never knew you were such a geek! Here we are, totally cut off from the rest of the world — it's the perfect time for love. Come to me you stud muffin!

Trevor: Hot damn! This PC is a beaut! She's been souped up with an ultra-fast quad-speed CD-ROM drive and 2MB of video memory — it's faster than grease lightning and a great value at only $2,299!

Julia: Why Trevor, you've made quite a discovery. These new features plus the powerful Pentium™ processor, an immense 730MB hard drive, 15-inch Vivitron™ monitor, 16-bit sound card and Altec speakers are remarkable. But if you don't get those rugged hands off that PC now, you'll regret it!

Trevor: We have to get out of here! I'll use the modem on the TelePath IIv fax/modem to call for help. I have to get to a phone to order an anchovy pizza *and* a PC from Gateway 2000! I need to ask how Bob's doing, too. Gateway is such a great company! I can't wait to get my own PC. I'll get a 30-day money-back guarantee and a three-year warranty on parts for my desktop PC and monitor. Gateway will provide me with technical support for the life of my PC, and on-site service is available during the first year in most U.S. locations. They'll even send me a free written copy of their warranty if I request it.

Julia: That's it! You'll need your own PC because this one is history!

Trevor: Stop! How could you even think of destroying this incredible machine?

Julia: Trevor, my biological clock is ticking. This may be our last chance! We can fax for help afterwards and then you can order your own Gateway PC.

Trevor: Geez... Julia. Okay, but you're kinda a mess.

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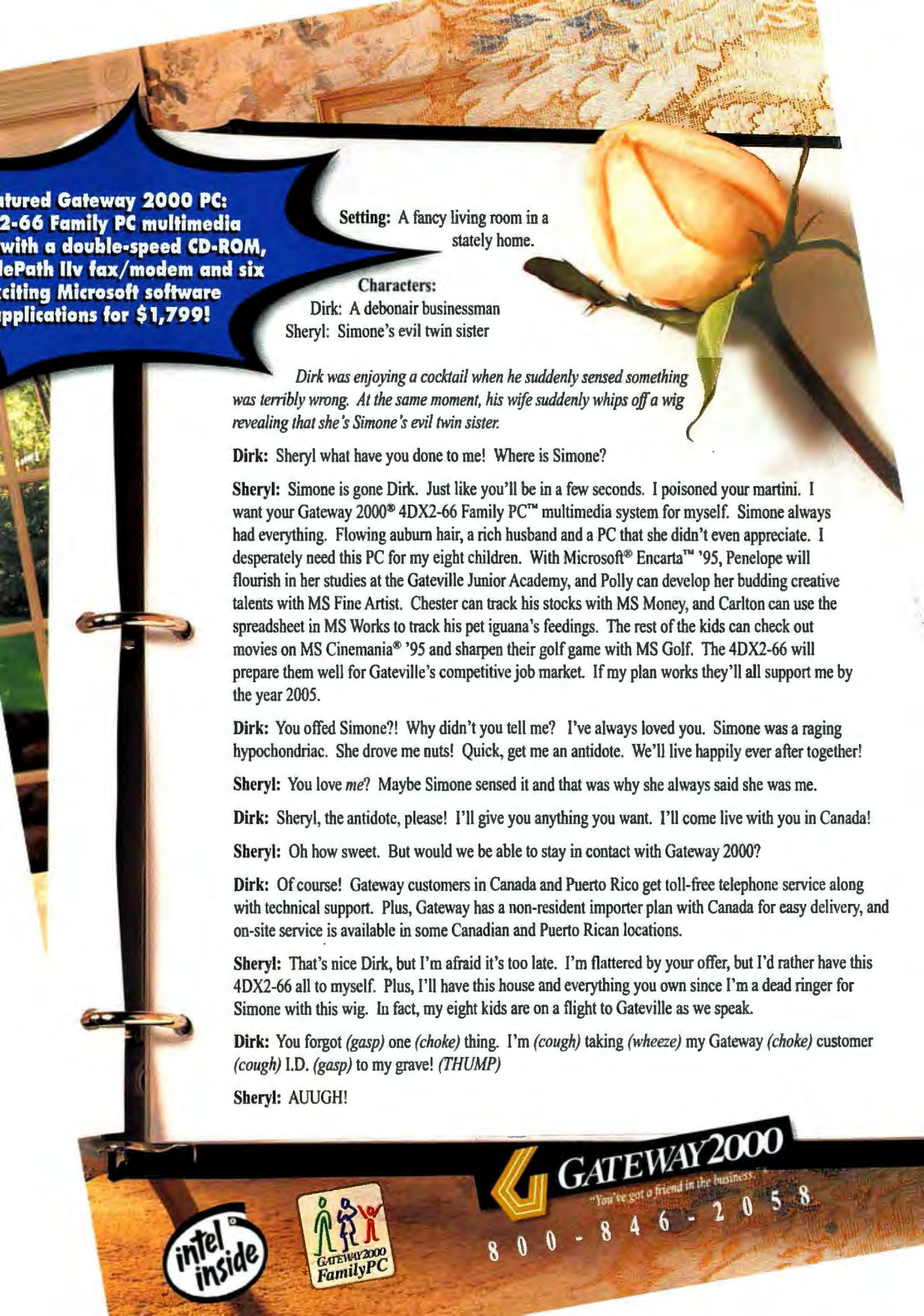

ıtured Gateway 2000 PC:
2-66 Family PC multimedia
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lePath IIv fax/modem and six
xciting Microsoft software
ıpplications for $1,799!

Setting: A fancy living room in a stately home.

Characters:
Dirk: A debonair businessman
Sheryl: Simone's evil twin sister

Dirk was enjoying a cocktail when he suddenly sensed something was terribly wrong. At the same moment, his wife suddenly whips off a wig revealing that she's Simone's evil twin sister.

Dirk: Sheryl what have you done to me! Where is Simone?

Sheryl: Simone is gone Dirk. Just like you'll be in a few seconds. I poisoned your martini. I want your Gateway 2000® 4DX2-66 Family PC™ multimedia system for myself. Simone always had everything. Flowing auburn hair, a rich husband and a PC that she didn't even appreciate. I desperately need this PC for my eight children. With Microsoft® Encarta™ '95, Penelope will flourish in her studies at the Gateville Junior Academy, and Polly can develop her budding creative talents with MS Fine Artist. Chester can track his stocks with MS Money, and Carlton can use the spreadsheet in MS Works to track his pet iguana's feedings. The rest of the kids can check out movies on MS Cinemania® '95 and sharpen their golf game with MS Golf. The 4DX2-66 will prepare them well for Gateville's competitive job market. If my plan works they'll all support me by the year 2005.

Dirk: You offed Simone?! Why didn't you tell me? I've always loved you. Simone was a raging hypochondriac. She drove me nuts! Quick, get me an antidote. We'll live happily ever after together!

Sheryl: You love *me*? Maybe Simone sensed it and that was why she always said she was me.

Dirk: Sheryl, the antidote, please! I'll give you anything you want. I'll come live with you in Canada!

Sheryl: Oh how sweet. But would we be able to stay in contact with Gateway 2000?

Dirk: Of course! Gateway customers in Canada and Puerto Rico get toll-free telephone service along with technical support. Plus, Gateway has a non-resident importer plan with Canada for easy delivery, and on-site service is available in some Canadian and Puerto Rican locations.

Sheryl: That's nice Dirk, but I'm afraid it's too late. I'm flattered by your offer, but I'd rather have this 4DX2-66 all to myself. Plus, I'll have this house and everything you own since I'm a dead ringer for Simone with this wig. In fact, my eight kids are on a flight to Gateville as we speak.

Dirk: You forgot *(gasp)* one *(choke)* thing. I'm *(cough)* taking *(wheeze)* my Gateway *(choke)* customer *(cough)* I.D. *(gasp)* to my grave! *(THUMP)*

Sheryl: AUUGH!

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environments, such as Lotus Notes, on top of a network, whole new modes of communication are unleashed. Debora Cole, academic marketing manager for Lotus, says that Notes permits "an extension of classroom learning, where you can make a contribution that others see and can respond to." It also offers rich media types, security, object-link maintenance, and other capabilities not well supported on today's Internet.

One of the most promising uses of Notes is in curriculum development. "Curriculum development is not an efficient process," Cole says. "Using collaborative software lets you work with faculty members on your own campus and worldwide to design and develop [a] new curriculum." Notes is also widely used in help-desk and customer-support applications, which often feed directly into training courses for support personnel.

E-mail among students and teachers, free exchange of curricular tools and content, consultation with on-line experts, and access to remote resources are all hallmarks of what ubiquitous networking will deliver to education. Concludes Kearsley of GWU: "The whole education community is ready to jump on the Internet full blast; Mosaic was the piece needed to make it work."

I Want My MTV

Multimedia has captured the imagination of educators more than any other technology. "It is really pumping adrenaline into the education market," observes Don Rawitsch, vice president of product development and support for software maker Jostens Learning (San Diego, CA).

Multimedia, as such, encompasses a range of data types, including analog and digital video, two-dimensional and 3-D animation, audio, and even hyperlinks and digital ink. It also includes delivery media, such as CD-ROM discs and drives, graphics display hardware (e.g., compression/decompression, acceleration, and codec cards), and sound cards. Specialized hardware devices, such as DSPs (digital signal processors) for speech and signal processing, are starting to appear in desktop systems and will play an increasing role in learning systems.

According to QED, 25 percent of school software budgets in 1994 were allocated to multimedia titles. Given the enormous growth of CD-ROM-equipped PCs in homes, multimedia could soon become the key "crossover" application to link the home and school markets.

Proof of the effectiveness of multimedia isn't yet conclusive, but early studies and many anecdotes suggest its great power as a learning aid. The SPA's 1994 report on technology effectiveness cites accounts of measurable improvements from the use of animation, video, laserdiscs, CD-ROM books, and hypermedia. "Studies show that we obtain 80 percent of our knowledge visually but retain only about 11 percent of that," says Howard Wactlar, vice provost for research computing at Carnegie Mellon. "We acquire a smaller percentage through hearing," he adds, but remember more of it. He says that a combination of the two is the most effective, boosting retention rates to 50 percent.

Applications for multimedia range from educational and entertainment titles, on disk or CD-ROM, from companies such as Broderbund (Novato, CA), Scholastic (New York, NY), and Davidson & Associates, to gigantic computational chemistry simulations that run on Onyx systems from Silicon Graphics (Mountain View, CA). "Multimedia lets you create a living textbook, versus a flat textbook," says Dr. Terry Crane, vice president and general manager of the education division at Apple.

One interesting multimedia application for the Mac, called CamMotion, is being developed by TERC, an R&D organization in Cambridge, Massachusetts, with funding from the National Science Foundation. It involves using visualization to learn about and analyze physical principles. A video camera lets kids capture and analyze motion on the computer. One group of students, for instance, used CamMotion to understand the difference in acceleration of a basketball when it was dropped and when it was dribbled. Textbook calculus would never have captured their interest in the same way.

Cutting Loose

Mobility is, in a certain sense, yet another outcome of networking, but it also comes about as a result of miniaturization. Schools and training centers all over the country are experimenting with giving students notebook computers to take home with them, setting up wireless LANs for instant virtual workgroups, or establishing dial-in services that permit anytime/anywhere access to course materials and fellow students. With networks and mobile access, "time and space dependencies are eliminated," says Steve Griffin, the director of technical services at the Institute for Academic Technology.

THE EVOLVING INSTALLED BASE

- Since 1992, the number of K–12 schools with CD-ROM drives has nearly tripled, from 13 percent to 37 percent. More than 50 percent of high schools are now equipped with at least one drive, says QED (Quality Education Data).

- The number of schools with modems has jumped from 22 percent in 1992 to 33 percent today; high schools weigh in at 50 percent, says QED. But only 12 percent of classrooms have a phone line, reports the SPA (Software Publishers Association), while others claim the number is as low as 5 percent. Among on-line services, 24 percent of K–12 schools say they have access to the Internet.

- Although only a quarter of all schools and half of high schools had LANs in 1994, says QED, those figures have risen from just 14 percent and 29 percent, respectively, in 1992. The leading NOSes (network operating systems) among K–12 schools are NetWare and AppleShare, with 73 percent and 59 percent usage, respectively, according to QED. In schools with LANs, says Market Data Retrieval, 49 percent use them to connect computers in a lab, 28 percent to connect between classrooms, and 20 percent to connect between buildings.

- A 1993 study done by the National Educational Association found that 62 percent of elementary school teachers had computers in their classrooms, versus 44 percent of high-school teachers. One explanation: Children spend most of their time in one room, whereas high-schoolers move from one class to another and computers are clustered in areas such as science labs or libraries.

- According to QED, 46 percent of the installed base of computers in grades K–12 are Apple IIs, 32 percent are DOS compatibles, and 15 percent are Apple Macs. In the 1993–94 school year, QED estimates, unit purchases were 61 percent Macs, 18 percent IBM-brand PCs, and 18 percent other DOS compatibles. The SPA found that 42 percent of the school districts it surveyed are testing or implementing Windows on their DOS systems.

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Distance learning, held out for years as a prime example of the potential of educational technology, benefits enormously from the combination of networking and mobile access. Instead of the conventional broadcast model of distance learning, which requires participating students to watch a live video transmission (via cable or satellite) or wait for days to receive a videotape in the mail, new schemes allow students to dial in at their convenience and partici-

Jason Frand (above) spearheaded a technology program for UCLA's Anderson School. Cables are pulled through individual conduits for easier upgrading (inset).

PHOTOS: MICHELE H. SMITH © 1995

Starting from Scratch

UCLA's graduate business school plans to completely reengineer its computer infrastructure

TOM R. HALFHILL

Ranked by *Business Week* as one of the top 10 business schools in America, the John E. Anderson Graduate School of Management at UCLA is on the verge of a rare opportunity to completely reengineer its computer infrastructure. In June, the Anderson School is scheduled to move into a new six-tower building that's custom-built to the school's specifications. Years of careful planning—and fund-raising—will culminate in new computer labs, classrooms, libraries, offices, conference rooms, and a centralized computing center—all tied together by a state-of-the-art "virtual network" that discards nearly 40 years' worth of legacy equipment and cabling.

UCLA's business school has had a long tradition of cutting-edge technology and business-oriented computer training. In 1957, IBM established the Western Data Processing Center at UCLA, a groundbreaking installation. The original "glass house" that enclosed the IBM mainframe still stands in the Anderson School's present-day building, and large parts of IBM's 360 operating system were written in rooms that are now occupied by faculty members and student computer labs.

As computers evolved, so did the business school. UCLA moved from punch cards to DECwriters to video terminals—and, in the 1980s, to microcomputers. In the mid-1980s, another IBM grant allowed UCLA to become one of the country's first totally networked business schools.

Additional grants from Hewlett-Packard and Apple allowed the school to set up labs with scores of PCs and Macs, all linked to an HP minicomputer running a custom E-mail system for the 1200 students, 100 faculty members, and 180 staff personnel. Today, a new HP 9000-H70 superminicomputer handles an astounding 350,000 to 500,000 E-mail messages per week, mostly internal.

Why so much E-mail? A major factor is that Anderson's MBA programs strongly emphasize team projects. In addition to the frequent break-out sessions associated with regular classes, second-year MBA candidates must complete a field-study project with a team of fellow students. "You deal with a client, you interface with them, and there's a lot of coordination that goes on between you and your teammates," explains Max Shoka, an electrical engineer and second-year MBA student. "We don't have any central office, we're doing a thousand things, and we need ways of passing information back and forth," he adds.

Anderson's current patchwork of 10 servers (variously running HP-UX, NetWare 3.12 and 4.01, AppleShare 4.0, and OS/2 1.3) and about 400 client machines is straining under the load of this traffic. Most users access the E-mail network over 9600-bps serial lines; only a minority have 10-Mbps 10Base-2 Ethernet connections.

Organization: John E. Anderson Graduate School of Management, UCLA

Technologies: Ubiquitous high-bandwidth networking; remote access

Success factors: A wealthy patron; a network built from scratch

Effects: Virtual networks; team projects

The network is further stressed by students dialing in from the outside. About 80 percent of them have their own computers, including 420 executive MBA students who work full-time jobs and connect remotely from university-supplied PowerBook 170 and 540c notebooks. Next fall, every Anderson student will be required to own a computer; in the fall of 1996, they may be required to own a laptop.

Future Vision

To cope with this wired environment and allow room for growth in the future, the new 280,000-square-foot building is a network manager's dream. The school's aggregate network bandwidth will be 30,000 to 50,000 times greater than before, and the entire network has been redesigned from scratch.

Every seat in every classroom, library, and office—2462 locations in all—will be wired with power outlets and 10Base-T Ethernet connections. Small break-out rooms will be wired so that teams of students can set up ad hoc networks with their laptops. Each classroom will have a computer built into the instructor's podium and a video projector suspended from the ceiling, so any screen in the room can be displayed to the whole class. New labs will be equipped with dozens of PCs, Power Macs, and multimedia gizmos, including scanners, video-capture boards, camcorders, and color printers.

Everything will be tied into a central computer room over a backbone of fiber-optic cables and ATM (Asynchronous Transfer Mode) switches. David VanMiddlesworth, the network manager, says ATM was chosen because it has great bandwidth, can handle isochronous transmission, and is relatively easy to reconfigure on the fly.

Profuse networking and a highly computer-literate student body will let the school deliver lessons that require students to browse the Internet and analyze information from diverse sources. "That's what life is going to be like for the MBAs when they leave here," says VanMiddlesworth. "We have to give them the tools to do that."

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

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pate in a class asynchronously. While it isn't in real time, the opportunity for feedback and participation is enhanced by rich two-way communications channels.

New York University's School of Continuing Education has pioneered a Notes-based distance learning application (see the text box "Building the Virtual College" on page 56), and others are not far behind, including California Polytechnic and the New Jersey Institute of Technology. Collin County Community College, of Plano, Texas, is exploring the idea of creating a virtual college at which its students could learn from graduate students at a university. The transport will likely be via E-mail messages over the Internet.

The Training Imperative

But "the fastest-growing segment of education is within industry," says Robert Sullivan, dean of the Graduate School of Industrial Administration at Carnegie Mellon. "Industry is faced with the question of how to keep the work force up to speed."

One answer, known as "training on demand," involves bringing information to employees at their workstations. "It's just not feasible to put employees in classrooms," says *Learning Enterprise* editor Manasco, who adds that classroom training is enormously expensive and notoriously inefficient in terms of retention and recall.

Hewlett-Packard has harnessed one such solution to cut some of its sales-training costs from $2 million to $200,000 per year. Previously, the company brought a conventional dog-and-pony show to 12 different cities, which took four to five weeks per quarter. Now, through an interactive satellite network, training sessions require just two days, and nobody has to travel. Furthermore, the message and delivery are more consistent, and there's a much shorter lag time between distribution and utilization of information.

Through the use of advanced simulators, Burlington Northern Railroad, in Fort Worth, Texas, has boosted its training productivity by 15 percent per year and improved quality, according to Edward Butt, assistant vice president of technical training. In the past, new engineers had to spend most of their training time in locomotives, which presented logistical challenges and limited the range of experiences encountered during training. Now, with images generated on Silicon Graphics workstations and a program from Hughes Electronics, engineers experience a full range of real-world scenarios, including emergencies and varying weather conditions.

Manasco, Schank, and Johansen all ar-

When Money Is Plentiful

The Peddie School pushes the envelope in secondary education

SALVATORE SALAMONE

The Peddie School, in Hightstown, New Jersey, enjoys an unusual distinction among private secondary schools: In 1993, alumnus Walter Annenberg gave it $100 million, the largest sihgle donation ever made to a prep school. The gift launched Peddie into national prominence and afforded it the opportunity to implement an ambitious technology program. While its wealth is by no means typical, Peddie has certainly blazed a trail by demonstrating what technology can do when resources are relatively unconstrained.

Rather than simply computerizing traditional teaching methods, Peddie has used computers to change the entire educational process. Students complete their course work using E-mail, an electronic library, and unlimited Internet access, all of which can be accessed from PCs in dorm rooms or from one of 60 public PCs connected to the school's campus network. Peddie features a student-centered learning environment in which teachers are guides to information resources, rather than imparters of canned material. In fact, teachers are as likely to be other students as they are faculty members; this redefinition makes students more responsible for their own educations.

Organization: The Peddie School (Hightstown, NJ)

Technologies: E-mail; Internet; digital library

Success factors: A wealthy patron; new instructional models

Effects: Reduced barriers to communications; increased student enterprise

Quick Start

The process begins on a student's first day at Peddie when, as part of orientation, he or she is given an E-mail account and is taught—by other students—how to use the E-mail system. "E-mail is presented as a common thing: Here's the library, here's the cafeteria, here's your E-mail account, and here's how you use it," says Patrick Clements, a teacher and program director.

Students in Peddie's multidisciplinary Principio Project discuss their work with program director Patrick Clements.

E-mail has become a way of life for the 500 Peddie students and 70 faculty members: There are, on average, 2400 log-ins per day to the mail system. (Peddie uses Lotus cc:Mail with a gateway to the Internet.) While E-mail is certainly used for mundane chores such as distributing homework assignments, its real value lies in the way that it changes the student-teacher relationship. Outside of class, students can ask instructors questions without having to make an appointment or swing by the teacher's office. And they can ask questions when they think of them, instead of waiting until class meets the next day.

E-mail is especially useful for foreign students or students who are reluctant to speak up in class. Students who don't formulate quick questions in the classroom find they have plenty of time to pose inquiries over E-mail.

Good teachers take advantage of this. For example, Clements says he once received a message from a quiet student concerning a question about *Huckleberry Finn*; after responding with several observations, Clements asked the student the same question in class the next day and solicited his feedback. In this way, Clements was able to draw out the student; he's convinced this wouldn't have happened without E-mail.

Tools of the Trade

Peddie students are trained in Internet access and the use of an electronic library, which includes an on-line card catalog, the full text of several years' worth of the *New York Times*, citation indexes, and other resources. Students learn the basics of using these services so that other courses can draw on common skills.

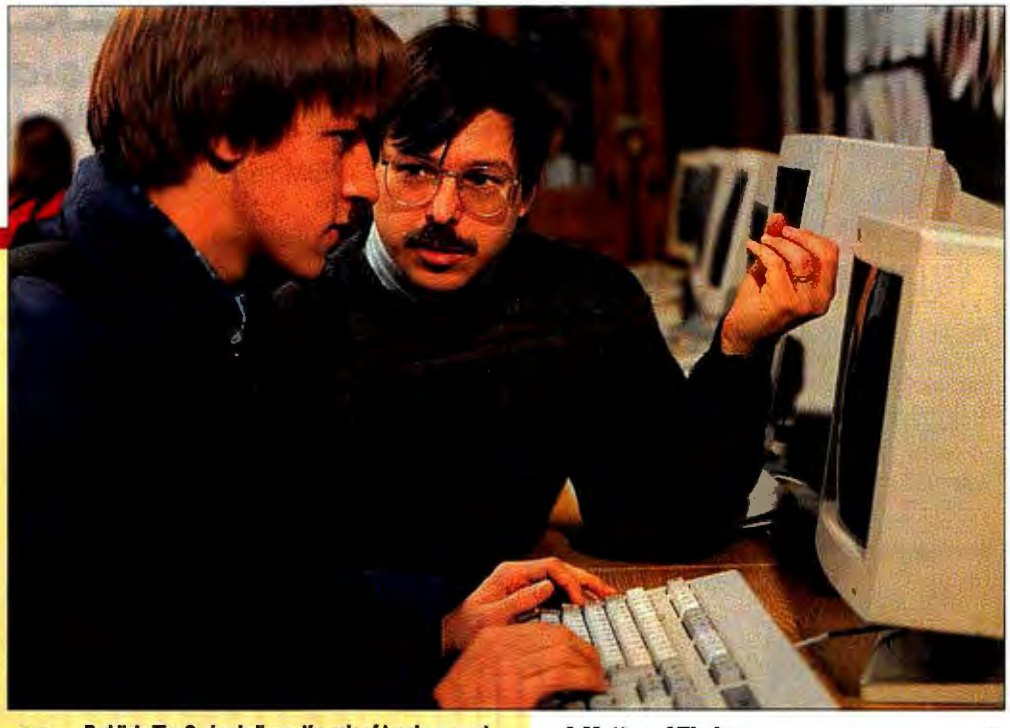
One difference at Peddie is that there are no "classes of usage" for most information on the network, says Tim Corica, director of academic computing. "If something is made available on the network, it is available to everyone," he explains. This philosophy typifies a shift in the teacher-student relationship that's designed to transfer more responsibility to students. "They must now go out and find answers to questions. And, more important, ask

gue that the traditional training department is out of step with the times. "The paradigm of training as a separate, centralized department is dead," Manasco says. "The new model is learning while working. Businesses are moving to decentralize training services and make them distributable to the desktop," he adds.

Several factors are at work here. Training departments are often among the first victims of layoffs because they're seen as overhead. Yet, at the same time, the changing nature and growing diversity of the work force require new kinds of training in cultural sensitivity, communications skills, and remediation. Employees are more geographically dispersed than in the past, and turnover is higher because companies and employees are less loyal to each other. Technology is evolving so quickly that skills require frequent refreshing.

The result is that rather than teaching employees fundamental skills (especially since workers sometimes bolt to competitors), companies are instead trying to link learning to the job itself. This can take the form of expert systems integrated into the work area or even hand-held computers connected via wireless communications to a constantly updated infobase. Steve Linsk, former product marketing manager for multimedia tools at Asymetrix (Bellevue, WA), suggests another scenario: putting self-paced employee-orientation materials on a network server instead of printing up a book.

Professor Schank is the high priest of just-in-time learning. "Anything not just-in-time is probably useless," he says. "People learn [a skill] at the moment they need to know it. It's like learning to ride a bike; if you fall off, you don't need your parents to give you a lecture about the physics of motion and gravity. You need instruction about righting yourself."



Peddie's Tim Corica believes the role of teachers must change to that of being a guide to resources instead of being a conveyer of facts.

PHOTOS: MIKE PETERS © 1995

their own questions," says Corica.

In one Peddie course, students must demonstrate proficiency at using a dynamic-modeling program. In traditional teaching, the class might be given specific homework assignments that use the model, meaning that everyone does the same thing and all the answers come out the same.

Without such constraints, one Peddie student chose to model population growth as his project and built a model involving birth rates, death rates, and assumptions about current population levels. Using the Internet, the student found census data, plugged in parameters, and ran his model.

This was enough to satisfy the requirements of the course. But then he went further, locating on the Internet results from other population models to see how his simpler version compared. Contrasting the different models became part of the project. In the end, the student had learned not just about the assigned software program but also about the science of population modeling.

Preparing for Life

Peddie's faculty members strongly believe in multidisciplinary studies to mold students who can tackle challenges in the real world. After all, business problems aren't parsed into neat little subjects where you only have to think about one thing at a time. To address this issue, last fall Peddie started a course called the Principio Project, which aims to break down traditionally fragmented approaches to learning.

Directed by Clements, the Principio Project centers around the constant use of a laptop by every student and faculty member in the program. Thirty sophomores started this year in a pilot project with an academic focus on Western culture. So far, they've struck up E-mail conversations with students living in the countries they're studying, and they're conducting research through a WWW site at the University of Granada in Spain.

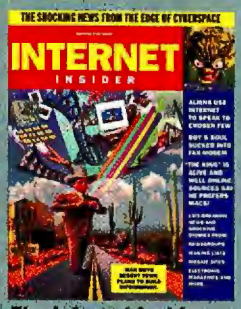
If the Principio Project is as successful as other efforts at Peddie, the school will have shown yet again how computer technology can be used to change education. The best news is that not all of this technology is wildly expensive. But the cost of doing it right is a lot more than just buying the hardware.

Salvatore Salamone is a BYTE news editor based in New York. You can reach him on the Internet or BIX at ssalamone@bix.com.

A Matter of Timing

Why is a paradigm shift in education happening just now, and not earlier? "I don't think education was really ready for this more than a year ago," concludes Donavan Merck, manager of the Educational Technology Office for the California State Department of Education. In the not-so-distant past, he says, most of the pressure to implement computers in schools came from the district level, from technology specialists who tried to push technology into the classroom. Teachers "looked at equipment such as videodiscs and software and felt that there wasn't enough there to justify the cost," Merck says.

Now, falling system prices and the wider use of networking are helping to make the shift more feasible. "The better quality of learning materials available from companies is helping a lot," Merck says. "Now it's the teachers who are going back to the district and saying they need this stuff." The shift from top-down to bottom-up adoption is making a huge difference in



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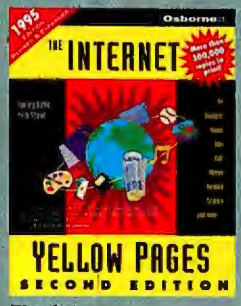

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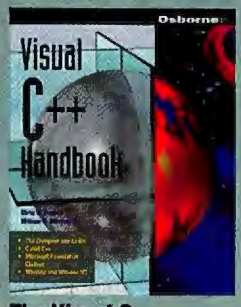

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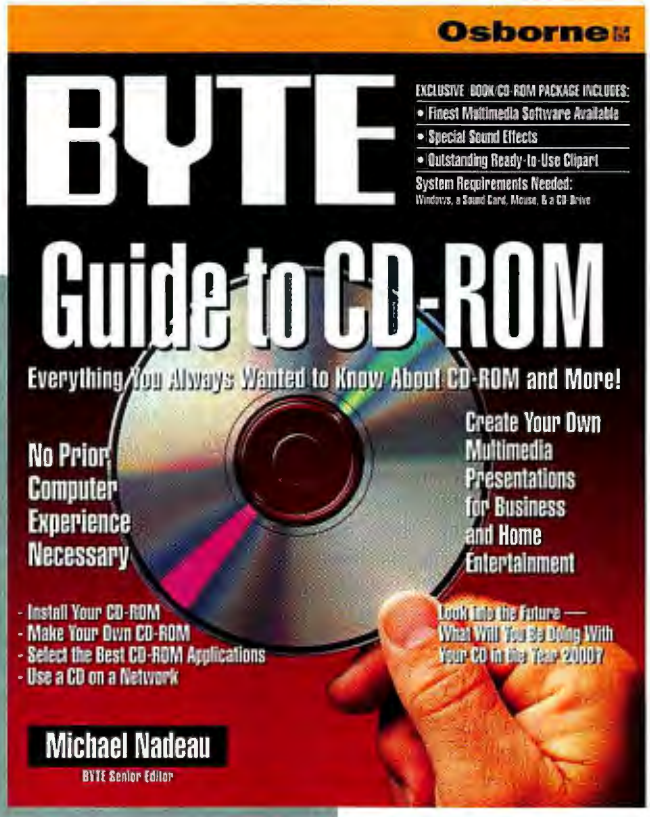

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how willing and eager instructors are to make the leap to educational technology.

Another major factor is the rapidly evolving computer environment outside the classroom. Many parents work in companies where computer technology is prevalent and sophisticated; they're starting to ask why schools lag behind, because they want their children to be trained in essential computer and information-gathering skills. Pressure from parents is starting to force school boards to spend more on technology.

Nonetheless, there are many problems still to be solved before learning technology can be successfully applied in schools and companies. Some skeptics point out that new learning models rely too much on the presumption that students are curious and have initiative, plus the social skills and attention span required for them to cooperate and work in teams. The behavioral problems many teachers witness today and the knowledge gaps many companies are being forced to fill are evidence that more fundamental issues need to be addressed.

Schank criticizes organizations for investing too heavily in distance learning and collaboration, which he thinks miss the point of educational technology. "It leaves out the core problem, which is that people need to be able to experiment without fear of embarrassment and with experts looking over their shoulders," he says.

Another problem is that technology can widen the socioeconomic gap between information haves and have-nots. A significant shortage of powerful, easy-to-use tools for creating curricula continues to suppress both the application of educational technology and its enormous potential for the future. To succeed in the market, educational technology requires the same sort of grass-roots army of do-it-yourself programmers that drove Lotus 1-2-3 and Microsoft Visual Basic into corporations. Kearsley of GWU believes the breakthrough may be the WWW, which he likes to refer to as "the network equivalent of HyperCard."

According to Asymetrix's Linsk, 50 percent to 70 percent of people who buy multimedia authoring tools, such as ToolBook, use them to develop courseware of one sort or another. Unfortunately, the cost of doing so is significant: A 1994 study of computer-based training found that the mean number of hours required to create a single hour of courseware was 228, Linsk says. At a conservative rate of $100 per hour, that works out to more than $20,000 per hour of courseware.

On the other hand, that's significantly less expensive than transporting employees to a central location, putting them up in hotels, and forfeiting their lost productivity—all to stuff their heads with information they'll largely forget. "If you distribute the material, students can learn it themselves," Linsk says. "There's a measurable ROI in dollars saved, increased retention, and decreasing learning time."

Linsk and others contend that the quality of development tools has greatly improved, such that teachers with no programming knowledge can now create their own courseware. But this raises a question: Just because teachers of the previous generation knew how to write didn't mean they created all their own textbooks, so why are we to assume they will develop hypermedia software?

A report by IBM Academic Computing confirms this problem and highlights how little incentive teachers are offered for making the extra effort. Among the 1000 colleges and universities surveyed in 1993 by the University of Southern California, 86 percent had no policy of rewarding faculty for developing courseware or any royalty-sharing program for faculty-developed courseware. Sixty-five percent had no formal projects for developing instructional software at all.

Sane Solutions

The solutions to these problems will come from the public, private, and nonprofit sectors. The ISTE, for instance, has developed a set of proposed standards for institutions seeking accreditation to teach educational technology. Now approved by the National Center for Accreditation of Teacher Education, the standards dictate minimum equipment and course offerings. Executive officer Dave Moursund says that the ISTE is also working on a set of guidelines for the use of technology in K–12 education, including basic skills, use of technology within a subject matter, baseline equipment standards, and evaluation and assessment methods. Pilot studies are under way, although a draft of these specifications may not be ready for several years.

In the public sphere, legislation and changes in regulations will be needed to boost educational technology. Educom is spearheading an effort called the National Learning Infrastructure Initiative—a conscious play on the official name of the data highway, the Na-

APPLYING TECHNOLOGY CAN RESULT IN:

- Boosting of curiosity, creativity, and teamwork
- Changed role of the teacher
- Reemergence of the apprenticeship model
- Reduced intimidation and frustration among students
- Reduced behavioral problems and improved concentration and self-image
- Access to more information (i.e., background on demand)
- Richer information environment to penetrate "media overload"
- Breaking down the walls of the classroom, integrating home, town, and world

FIVE GOLDEN RULES

1. Computers should be used to enhance, not replace, the teacher and supplement, not supplant, traditional teaching methods. Corollary: Computers should be used for the things they're good at, and people should be used for the things they're good at.
2. No more than 50 percent of the total information-technology budget should be spent on hardware: 30 percent should be spent on software, and at least 20 percent should be spent on support. Don't skimp; buy as much horsepower as you can afford, because it won't become obsolete as quickly.
3. Find local partners to help with purchasing, and especially with support. Some computer and software companies have adopt-a-school programs (even if the companies aren't local, employees are willing to support their alma maters). In addition, many corporations extend support to local educational institutions (in part out of enlightened self-interest, and in part because they can use the facilities after hours for their own training).
4. All computers should be networked with outside access. Don't let a renovation project at your school or company occur without taking the opportunity to rewire.
5. The best pilot classes for any new technology are those that teach teachers to use the technology upon which a class is based. Thus, it's wonderful to use a distributed Notes network to teach students about setting up and managing Notes installations or other client/server infobase products. Perhaps less appropriate: testing your new Notes-based teaching system on a course about thirteenth-century Chinese vase decoration.

tional Information Infrastructure. The former aims to ensure that the latter includes a significant major educational component.

To penetrate all schools—not just the ones with technology champions—technology vendors need changes to be made in state purchase policies so no one has to sneak in software under textbook budgets. And somebody, probably the federal government, needs to pick up the tab for the estimated $8 billion to $9 billion cost to connect every school in America to the data highway.

Dr. Linda Roberts, special advisor to the U.S. secretary of education and director of the Office of Educational Technology, points out that she is the first such advisor the Department of Education has ever had. The department is pursuing a variety of programs, including challenge grants for developing compelling educational technology and direct grants to the states for technology planning. The good news, she points out, is that even with today's minuscule technology budgets, there's enough revenue potential to support good products from private industry.

"The bad news is that education as a share of the whole market is still pretty small," she adds. "So, we need some stimulus from the public sector to push for the advances that can make a real difference." One such program, which is a classic case of innovative public/private partnership, is Vital Links, a joint development of the Los Angeles County Office of Education, Davidson & Associates, and publisher Addison-Wesley (Reading, MA). The package will consist of a year-long U.S. history course for children who have limited proficiency in English.

To help defray costs and ensure a market for the product, the state education departments of California, Florida, and Texas are each kicking in $400,000 of development funding in exchange for a royalty stake. California has also funded several development projects by San Ramon–based educational software supplier Decision Development.

The ultimate boost for educational technology may come from the data highway. "Everybody is excited by the idea of kids using the same materials at home and at school," notes Don Rawitsch of Jostens Learning. He speculates that Jostens "might team up with somebody like a cable [company] or a telco" to deliver educational materials directly into the home.

Enthusiasm for educational technology, always high, has reached new levels because of the growing use of home and business multimedia, the high profile of the Internet and data superhighway, and the continuing pressure to work and learn more efficiently. Nirvana isn't here yet, and substantial hurdles remain, but there is a growing commitment from teachers, trainers, managers, and vendors to make better use of the technology that's already here. "We don't know yet whether everybody learns better with this stuff," says Dr. Miriam Masullo, a researcher with IBM in Hawthorne, New York. "But," she adds emphatically, "we can't find out until we try it." ■

ACKNOWLEDGMENTS

Additional reporting was provided by BYTE chief of correspondents Dennis Barker, senior editors Ed DeJesus and Tom R. Halfhill, and news editor Salvatore Salamone.

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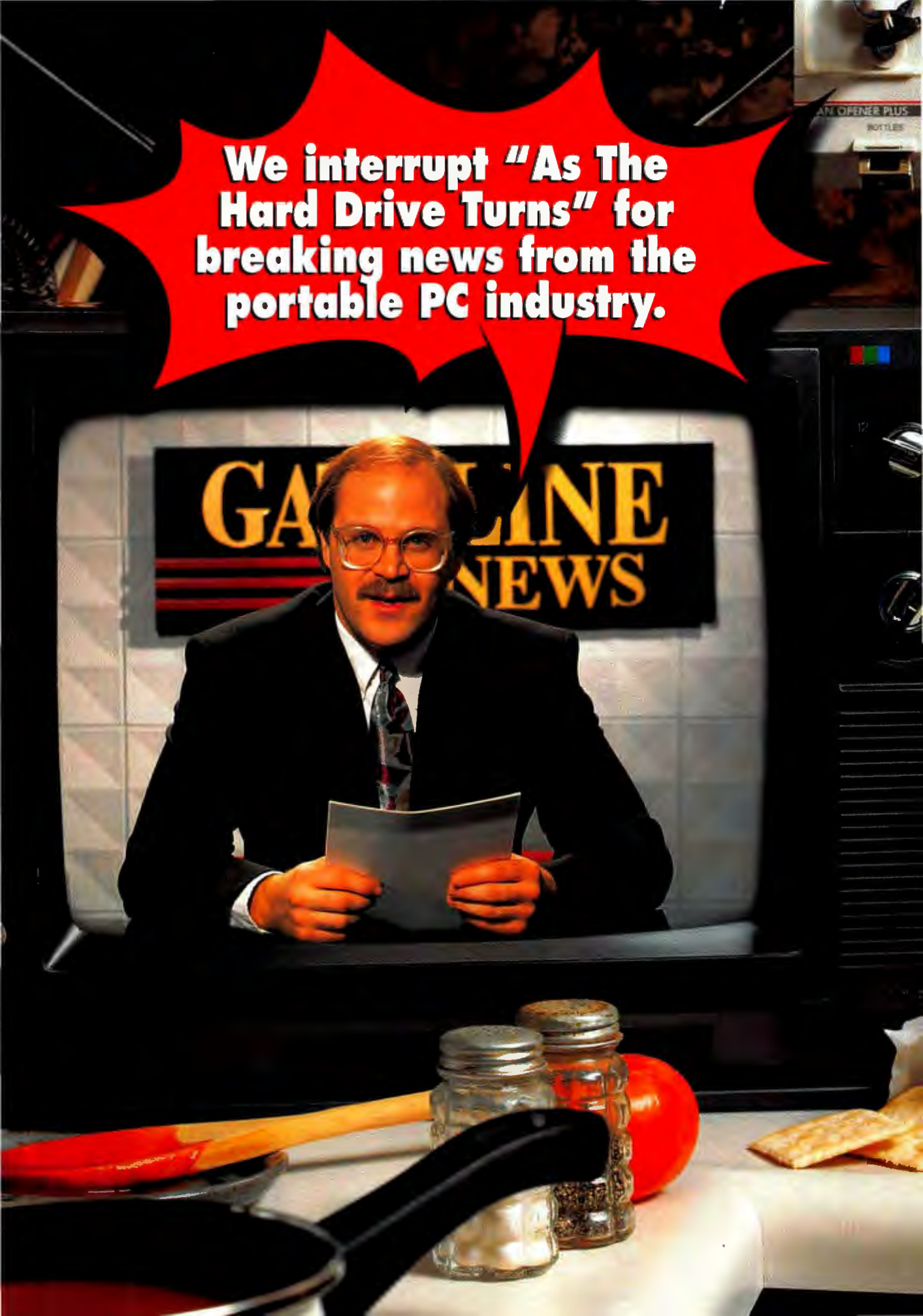
We interrupt "As The Hard Drive Turns" for breaking news from the portable PC industry.
NEWS


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Reporter: We have an exclusive interview today with a person who wishes to be identified only as John Doe. Now tell me John, is it true you purchased a portable PC from one of those "other" companies?

John Doe: Yes sir, I'm afraid it is. I'm so foolish. I settled for a portable PC with a tiny 8.4-inch screen, a 250MB hard drive and minimum software applications. It sounded good at the time, but that was before I knew about the 4.2-pound Liberty™ from Gateway 2000.® Its impressive 10.4-inch screen has 53 percent more active viewing area than the 8.4-inch screen and it features amazing infrared technology that lets you use many cool IR features including wireless transfer. I'll still be transferring files with those darn cables while Liberty users can simply beam files back and forth between their desktop PC or another Liberty. Plus, the Liberty DX4-100 Best Buy has a powerful 100MHz processor combined with a massive 720MB removable hard drive, 24MB RAM, a TelePath™ 14.4 XJACK® fax/modem, leather carrying case and Microsoft® Office Professional. How could I have been such a sap? I relish the thought of having a Liberty for about the same price. Now I have to enroll in the Portable PC Protection Program and start a new life. If only I had gotten the Liberty from Gateway 2000!

Reporter: Well, there you have it. This is just one of many portable PC buyers distraught because they bought a PC from one of the "other" companies. Remember, the Liberty is the latest and greatest development in portable computing. Unless you want to end up like this poor fellow, don't settle for anything less than a Liberty from Gateway 2000. Call them today! We now return to "As The Hard Drive Turns."

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BYTE's New Benchmarks

RICK GREHAN

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Our new algorithm-based Native Mode suite tests processor performance and FPU capabilities for a variety of CPUs

These days, a question asked by many IT (information technology) professionals is: "On what platform do I build my computing enterprise?" The answer is no longer just a choice from among the different versions of the x86. Users now face an array of 486 CPUs from a variety of suppliers, plus DEC's Alpha, Intel's Pentium, various offerings from Mips, and two different flavors of the PowerPC—not to mention AMD's K-5, NexGen's 586, and Sun's UltraSparc, which are all set to debut in the near future.

For many years, system evaluators have relied on benchmark tests to help them sort through the computer-performance claims of competing manufacturers. While benchmarking technology has for the most part matured for single platforms, users today need tools that can measure performance differences among competing platforms.

To that end, BYTE has released the latest version of our cross-platform Native Mode benchmarks, which are designed to be processor- and operating-system-independent. Built on the foundation of well-known algorithms, they are not purely synthetic; that is, each test actually does something more than simply hand the processor a stream of ADD operations and call it a math test. In addition, many of the algorithms are more than merely academically interesting. For example, one of the tests actually uses an up-and-coming data-encryption algorithm, IDEA (International Data Encryption Algorithm).

Let's be clear up front: The Native Mode benchmarks are specifically designed to test CPU and FPU performance, although they also serve to exercise cache and system memory. But they are by no means the only benchmarks we'll be using here at BYTE. The Native Mode benchmarks will be followed shortly by our Application Simulation benchmarks and our cross-platform GUI benchmarks. In addition, we have at our disposal the InterMark suite, a significant new set of processor-independent tests from our sister organization, NSTL (see the text box "NSTL's New InterMark Suite" on page 80).

What's the Point?

The Native Mode benchmarks are the continuation of the algorithm-based testing we started over a year ago at BYTE. This was a departure from our previous CPU benchmarks, which were far more synthetic; some had little to do with real-world applications. For example, the old String Move benchmark was, on Intel processors, simply a series of `REP MOVSx` instructions nestled in a tight loop.

We've extended our algorithm-based tests by adding more routines; there are now 10 in all. This variety is important. All programs are not alike; a program is not just a few instructions that are repeated over and over. The mix of instructions found in a

spreadsheet program, for instance, is different from the mix you'll find in a word processing program. Having a larger collection of tests lets us examine a given system from a variety of angles. (For a description of all 10 tests in the Native Mode suite, see the text box "What the BYTE Benchmarks Test" below.)

The Pros

BYTE believes that these new benchmarks are significantly superior to those we have produced in the past. Some of their advantages include the following.

First, the algorithms are well defined in the sense that we can get a good idea of what a computer is doing at the source level; that is, it's spending this much time in a tight `for` loop and that much time in a `switch` statement. With profiling, we can also get a pretty good idea of what a computer is doing at the machine-code level.

This allows us to home in on particular aspects of the system that is under test. For example, you can use the String Sort benchmark to explore how rapidly the processor (and the cache and memory system) moves blocks of data that may be aligned on arbitrary address boundaries. Similarly, the Fourier Coefficients benchmark exposes the performance of the coprocessor's (or, in some cases, the math library's) trigonometric functions.

The second advantage is that the algorithms are manageable; this is just a polite way of saying that the programs are small. This means that, if you want to port these benchmarks to new platforms, you stand a good chance of succeeding in a reasonable amount of time. From the perspective of a magazine that must test boatloads of systems coming in from all points of the compass, this is not a trivial advantage.

Third, we wanted these benchmarks to be useful across as wide a variety of systems as possible. We also wanted to give them a lifetime that will last beyond the next wave of new processors. To these

What the BYTE Benchmarks Test

The Native Mode benchmarks represent a collection of 10 diverse algorithms. With the exception of the Numeric Sort and String Sort tests (which both use the same algorithm, but not the same code), each test is significantly different from the others. Hence, the system being benchmarked is exposed to a variety of code profiles: There are sorts, searches, matrix operations, compressions, encryptions, and more. Here is a description of the 10 benchmark tests.

Numeric Sort. The Numeric Sort benchmark measures the time it takes to sort a one-dimensional array of signed long integers. It's built around the well-known heapsort algorithm. This is a good, general-purpose test of processor horsepower, since sorting is a fundamental operation that's found inside applications ranging from databases to word processors to operating systems.

String Sort. Like the Numeric Sort, the String Sort benchmark has at its heart a heapsort algorithm. However, this test juggles strings of bytes rather than fixed 32-bit integers, thereby putting pressure on the system's ability to move arbitrarily long blocks of bytes to and from arbitrary address boundaries (something, for example, that word processors must often do).

Bitfield. The Bitfield benchmark exercises a system's ability to manipulate single bits. The test is actually constructed as a type of simulation. Specifically, the test mimics what might happen inside an operating system that uses a bit map in memory to keep track of the allocation of disk blocks.

Emulated Floating-Point. This test is fairly self-explanatory; it performs fundamental math operations—addition, subtraction, multiplication, and division—with an IEEE-compliant floating-point package that makes no use of the math coprocessor. (Although the number format that we use is not strictly IEEE-compatible, it would be trivial to write translation routines to convert to and from true IEEE numbers.)

Fourier Coefficients. This benchmark calculates the first *n* Fourier coefficients for a cyclic waveform constructed using a logarithmic function. This algorithm exercises a system's trigonometric functions.

Assignment Algorithm. The Assignment Algorithm benchmark has a direct application to the business world. Basically, it solves a simulated resource-allocation problem, and in doing so it performs a variety of operations on two-dimensional integer arrays.

Huffman Compression. This benchmark executes the well-known Huffman-method compression algorithm, which is still in use, in one form or another, within some graphics file formats. The routine combines text processing, management of complex data structures (i.e., the benchmark constructs a kind of binary tree in memory), and bit-manipulation operations.

IDEA Encryption. The IDEA (International Data Encryption Algorithm) is a relatively new and powerful algorithm for encrypting digital data. IDEA is a block cipher that operates on a group of 16 bits at a time. The benchmark test measures how quickly a system can encrypt and decrypt a byte stream.

Neural Net. The Neural Net benchmark test is based on a simple back-propagation neural network, as presented by Maureen Caudill in her article "Expert Networks" (October 1991 BYTE). The neural net is taught to recognize a number of ASCII characters. The resulting test is primarily a floating-point benchmark that makes heavy use of the exponential function.

LU Decomposition. The LU Decomposition benchmark is constructed around an algorithm of the same name that can be used to—among other things—solve systems of linear equations. This benchmark primarily measures a system's fundamental floating-point capabilities: addition, subtraction, multiplication, and division.

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ends, we incorporated dynamic work-load adjustment. A complete description of this concept appears later, but in a nutshell, it allows the tests to expand or contract, depending on the capabilities of the system under test, while still providing consistent results so that accurate and fair comparisons are possible.

The fourth advantage is that the benchmarks are written in ANSI C. Consequently, we are able to port them across a wide range of processor and operating-system families. To date, we've run the benchmarks on 486s, 680x0s, Pentiums, Mips chips, PowerPCs, and DEC Alphas; we've also executed the tests on a variety of Unix flavors, DOS, OS/2, Windows NT, and even the Mac OS.

The algorithms are manageable; this is just a polite way of saying that the programs are small. This means that, if you want to port these benchmarks to new platforms, you stand a good chance of succeeding in a reasonable amount of time.

The Cons

Now that we've blown our horn, it's time for some honesty. The BYTE Native Mode benchmarks represent a significant addition to the benchmarking phyla, but they do have their limitations. What follows are some specifics.

First, the benchmarks are written in ANSI C. (Funny, isn't it? We just cited this as an advantage!) The problem is, because the tests are written in C, the results are at the mercy of the available C compilers. A lousy compiler will yield a lousy benchmark score. In our defense, we're in the same boat as all the other developers who want to build as much portability as possible into their products. In the past, we skirted this problem, first by using our own version of the well-known Small C compiler, and later by hand-coding the tests in assembly language.

However, in the current world of multiple RISC processors paddling merrily through a stew of operating systems, those approaches were ridiculous to even contemplate. We can promise that, as compiler technology continues to advance, we'll pass the benchmarks through all the C compilers we can lay our hands on, and we'll make those results available to all who ask.

Second, the benchmarks are designed with a "small-code, large-data" structure. The executable code portion of each test occupies less than 16 KB of machine code. It can be argued that this gives only a partial picture of, say, cache performance, because an entire benchmark's code (and, in some cases, the associated data) will fit inside at least the secondary cache of modern processors.

Once again, in our defense, this is really the way that a good program *should* work. Code should exhibit *locality*—that is, the program should spend the majority of its time executing instructions that are close together (preferably following one another) and relatively little time jumping across large address distances.

Of course, as much as a programmer might wish for this ideal, some applications simply won't work that way. We've heard of at least one large server application that, when profiled, followed an erratic execution path that spanned megabytes of memory. Also, it's likely that, as more multithreaded applications appear, programs will exhibit less and less locality. This is because, from the processor's standpoint, code will appear to jump all over memory space. Even though each thread may have considerable locality, the effect on the processor is definitely nonlocal.

Third, the benchmark routines are single-threaded. This is not intentional; producing even a modest multithreaded application that is portable to such diverse systems as Extended DOS, Windows NT, OS/2, Unix, and the Mac OS is not a simple undertaking. Nevertheless, we're currently working on multithreaded versions of the benchmarks for those operating systems that provide such support.

Dynamic Work Loads

We've incorporated some new tricks into the benchmarks that not only improve their accuracy but also increase their useful lifetime and make them easier for an average user to deal with. One problem that we encountered with our earlier benchmarks was trying to keep them up to snuff with the relentless advancement of computer-system technology. Each test in the benchmark suite performed a fixed amount of work; consequently, as processors got faster, we were forced to either increase the work load of the test or seek a more accurate clock.

The former meant recoding and recom-

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piling the benchmarks, something that had to be done carefully to permit continued comparison with already-gathered data. The latter was difficult to do on standard PCs, where the clock updates only 18 times per second (the faster a test ran, the larger the error of the recorded time was). This problem led us, with our most recent DOS benchmarks, to incorporate a high-resolution clock that depended on reprogramming one of the system's timers. As nice as that was, it was completely nonportable.

Our new benchmarks employ the aforementioned *dynamic work-load adjustment* system to deal with fast-executing systems. In principle, this simply means that if a test runs so fast that the system clock can't time it accurately, the benchmark increases the test work load—and keeps on increasing it—until enough time is consumed to gather accurate and repeatable results.

For a specific example, here's how the Numeric Sort benchmark adjusts itself. A global variable—we'll call it `globalminticks`—holds the minimum number of clock ticks that the benchmark will allow a test to take. The first step of the Numeric Sort benchmark is an adjustment phase in which the program creates a randomly shuffled array of long integers, sorts it, and measures how long it takes the sort to execute. If that time is less than `globalminticks`, the program then makes two copies of the array and tries again. This process repeats until the point where the program has made enough work for itself so that the test takes longer than `globalminticks` clock ticks.

A machine with a less accurate clock will be forced to sort more arrays at a time, but the results are always reported in arrays sorted per second. In this way, fast machines, slow machines, machines with accurate clocks, and machines with less-than-accurate clocks can all be tested with the same code.

This same principle is applied throughout all the benchmark programs. Furthermore, you can adjust the value of `globalminticks` to account for the accuracy (or lack thereof) of whatever clock routine is available on the operating system that is under test.

Test with Confidence

Another important new feature of the Native Mode benchmarks is built-in statistical controls. Each separate test (e.g., Numeric Sort, String Sort, and Assignment Algorithm) is run five times. For each test, the benchmark system averages the five scores, determines the standard deviation, and calculates a 95 percent *confidence*

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NSTL's New InterMark Suite

ANDREW J. FRONING

The InterMark suite, a new approach to testing systems, uses innovative technology from NSTL (National Software Testing Laboratories) and is based on Windows NT. It thoroughly tests standard system hardware, such as hard disks, CPUs, video adapters, CD-ROM drives, sound cards, and network adapters, and also incorporates tests for peripherals, such as printers, monitors, and modems.

The suite is based on platform-independent code that's compiled to run under Windows NT for each of the major platforms; therefore, it can cover the key computing platforms, and its tests are portable. The tests themselves are statically linked, so they remain independent of the user interface. The resource files and the artwork are constructed to allow users to tailor the test environment without affecting the execution of the tests. This ensures that the tests execute in the exact same manner on each platform, providing truly comparable results, where only the computers' architecture and their subsystems affect the outcome.

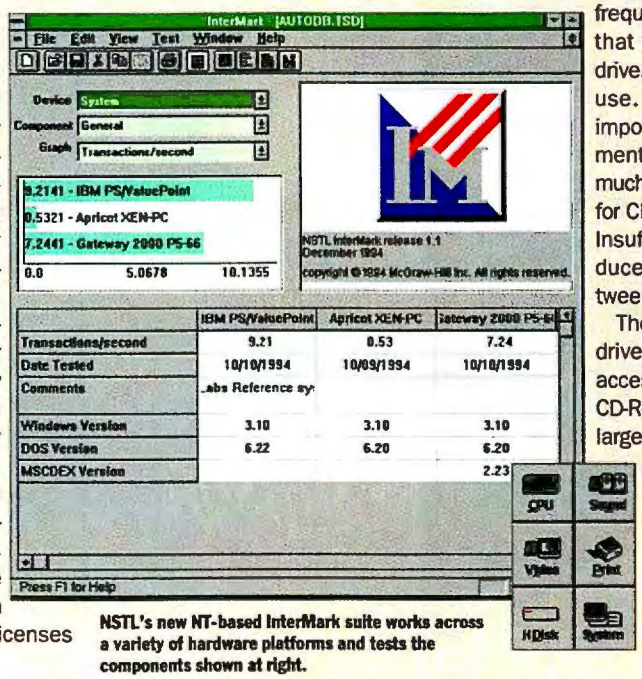
InterMark also provides the framework for high-level application tests. Specific test scripts provide instructions that drive the applications directly. (Of course, a user must have the appropriate licenses to run the applications.)

But the true strength of the InterMark suite lies in its ability to measure a system's performance at its lowest levels. To reduce the time needed to produce accurate statistics about performance, these tests use a precision event timer to measure system-response time for each task. Measuring response time also represents a real-world way to view system performance, because the tests judge the time needed to perform the many tasks that make up the operations of a program.

The suite is also highly customizable. Using a system of plug-ins, the benchmarks can be upgraded to accommodate new tests. These plug-ins are accessible through a distributed PostScript-like language, TestScript, that controls operations. As this article went to press, NSTL was using versions for Alpha, Intel, and Mips processors. By the time this article sees print, an IBM PowerPC version should be ready.

InterMark's Test Suites

The InterMark CPU test suite measures the performance of the CPU and FPU by performing extensive 3-D point transformations in double-float space and integer space. The test returns the number of 750-point transformations that can be performed per second. (A single-point transformation is equivalent to nine multiplication and nine addition operations.)



NSTL's new NT-based InterMark suite works across a variety of hardware platforms and tests the components shown at right.

The hard disk suite tests the speed of the hard drive during reading and writing. The tests simulate sequential, constant-rate sequential, random, localized random, and segmented activity in varying block sizes. The tests also measure the average response time, worst-case response time, and CPU utilization of the hard drive and provide a strong indication of whether write-caching has been enabled.

The video suite tests primitive GDI (Graphical Device Interface) operations, as well as the display of entire pictures generated by common applications, such as CorelDraw, Excel, Freelance Graphics, OpenGL, PowerPoint, Word, and others. All tests are done by drawing into memory, as well as drawing directly to screen.

InterMark also provides extensive testing of BITBLT operations. The suite tests bit maps in sizes of 160 by 120 and 320 by 240 pixels. InterMark also tests the bit maps in native-format and monochrome (4-, 8-, 16-, and 32-bit) device-independent bit maps. Other primitive operations tested include PATBLT, line draw, polygons, and ellipses.

The sound-card tests play WAV files in both 8- and 16-bit formats and at varying frequencies; they report the time that files spend blocked in the driver as well as background CPU use. The level of CPU usage is important in multimedia environments, since it determines how much processing capacity remains for CD-ROM and video operations. Insufficient CPU power could produce faulty synchronization between sound and video.

The CD-ROM test suite probes drive performance by measuring access time and CPU use. Since CD-ROMs are widely used to store large amounts of graphical data, such as photographs, the tests measure the drive speed during sequential reads (or writes, for CD-ROM writers) in designated parts of the disk. The tests also measure the amount of CPU resources required to transfer data at 150 and 300 KBps. Again, multimedia applications are especially sensitive to CPU use because they require synchronization between sound and video images stored on CD-ROM.

Finally, the InterMark suite provides testing benchmarks for peripheral items, such as printers, modems, and NICs (network interface cards). Using additional test scripts, InterMark also supports tests for file servers, SQL servers, bridges/hubs, and other computing systems.

Andrew J. Froning is managing editor of PC Digest *and* Software Digest, *comparative reports published by NSTL. You can address questions about the InterMark suite to imark@nstl.com.*

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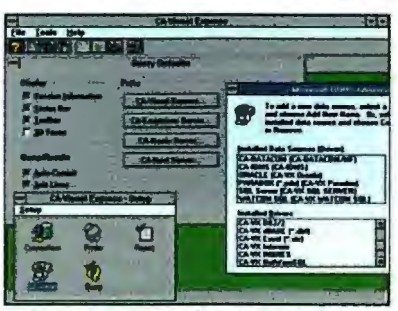

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half-interval for the mean. If this half-interval is within 5 percent of the calculated average, the benchmarking stops. Otherwise, a new iteration of the test is run, and the calculation is repeated.

Want to Use the BYTE Benchmarks?

If you want to use the BYTE Native Mode benchmarks yourself to evaluate system power, contact Lisa O'Neil at BYTE or, preferably, send your request via E-mail to editors@bix.com.

The upshot is that, for each benchmark test, the true average is—with a 95 percent level of confidence—within 5 percent of the average reported. By *true average*, we mean the average that we'd get if we could run the tests over and over an infinite number of times.

Users can request that each benchmark test report its associated statistics, including the mean, standard deviation, and number of tries the system attempted before the confidence half-interval criterion was satisfied. This helps you to spot situations where some activity outside the benchmark—a network-service daemon running in the background, for example—skews the timing results. You can then take the necessary steps to neutralize the problem and rerun the test program.

What's Next

As important as we believe our Native Mode benchmarks are, BYTE recognizes that other organizations in the computer industry have spent considerable resources developing benchmarks of their own: BAPCo, SPEC, SysWin, TPC, WinMark, and WinTach, to name a few.

We at BYTE applaud the efforts of the programmers and developers who built those benchmarks. There is considerable diversity as well as overlap in the areas of system performance that each benchmark suite seeks to measure. We'd be foolish if we didn't recommend that you investigate them as well. What's important is that you choose benchmarks that provide consistent, objective results and yield the kind of information you need. A CAD benchmark won't do you much good if you run a database shop, for example.

Having said that, what kind of results do the new BYTE benchmarks give? For a first look, check out the review "Shoot-Out at the NT Corral" on page 115, where seven widely different high-end systems are put through the tests.

As mentioned earlier, BYTE's benchmarking efforts haven't stopped here. We will be following our Native Mode benchmarks with a collection of Application Simulation benchmarks, which will be constructed with the same goals of portability and repeatability. They will be different from the algorithm-based tests described here in that their core will be built on public domain versions of common applications: databases, image processing, spreadsheets, and word processing. In addition, we will have NSTL's InterMark benchmark suite at our disposal, as well as a variety of application benchmarks and tests for all sorts of peripheral hardware, ranging from monitors to disk drives. Stay tuned. ■

Editor's note: *InterMark is a registered trademark of NSTL (National Software Testing Laboratories), Inc., an operating unit of McGraw-Hill, Inc.*

Rick Grehan is a senior technical editor for BYTE reviews. He has a B.S. in physics and applied mathematics and an M.S. in mathematics/computer science. He can be contacted on the Internet or BIX at rick_g@bix.com.

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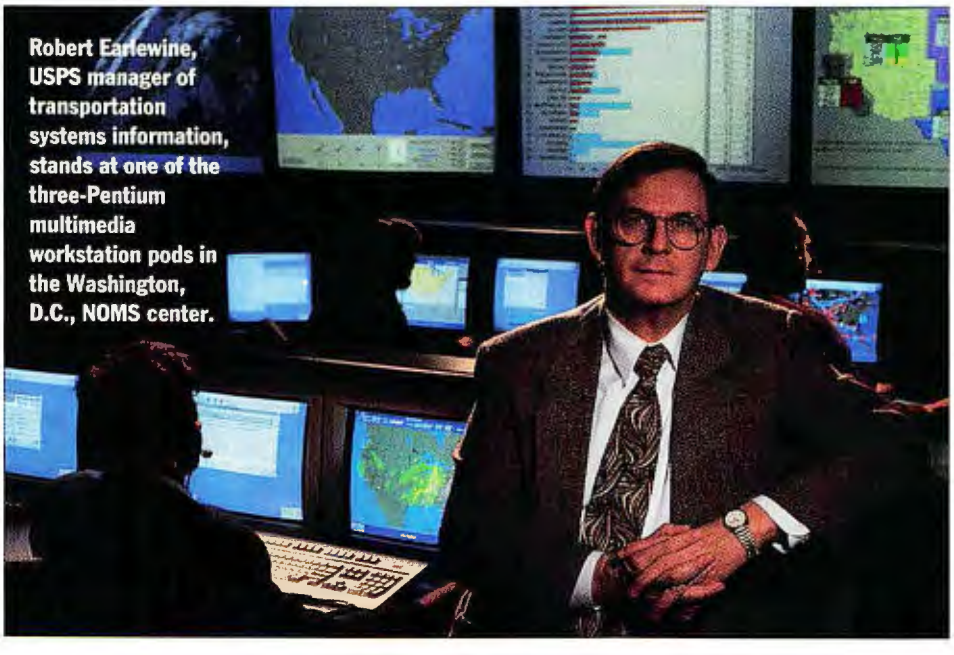
The Net That Manages

RANDALL D. CRONK

Not rain nor sleet nor snow will stop today's U.S. Postal Service from delivering the mail. A new network of multiprocessor workstations finally enables contingency and traffic planning on the basis of real-time information.

Since its seventeenth-century beginnings, the USPS (U.S. Postal Service) has relied on after-the-fact contingency planning. A mail backlog was fixed after it occurred, not anticipated by monitoring mail flow across a network on a computer screen. But for today's system, which moves 580 million pieces of mail daily among 125 million locations, a failure to plan can lead to disaster.

In many ways, the USPS typifies the problems of running a business in real time. Like many companies, it is struggling to catch up with new, geographically dispersed competitors that use the latest technology. To do this, it needs up-to-the-minute information about all its own operations 24 hours a day, seven days a week.



Robert Earlewine, USPS manager of transportation systems information, stands at one of the three-Pentium multimedia workstation pods in the Washington, D.C., NOMS center.

MATTHEW BORKOSKI © 1995

To get this real-time information, the USPS has had to rely on production systems designed only to move letters and packages (with no support for contingency planning). The USPS must extend these legacy systems without breaking them or even slowing them down. Such an undertaking means integrating production data with information from hundreds of sources—including weather reports, phone calls, and faxes—into a work environment that facilitates clearheaded decision making.

The USPS's answer to this challenge is called NOMS (Network Operations Management System). It's the critical first step of a plan that the USPS hopes will transform the organization with real-time, computer-assisted management. NOMS is a client/server application in which Windows NT–based agents extract information in real time from legacy mail-transportation systems and feed it into a unique client environment. Each client, called a *pod*, integrates three computers into a single workstation that uses state-of-the-art technology for decision support, GUIs, and CTI (computer telephony integration).

Last fall, the USPS installed the first NOMS test site at its headquarters in Washington, D.C. Remote sites were established in Indianapolis (which is the Express Mail hub) and Chicago. The initial cost of these three NOMS sites, plus the development work that went into creating them, was $1 million.

There are six pods in Washington, D.C., and one each in Indianapolis and Chicago. For the pilot phase, the Indianapolis and Chicago pods are networked to Washington, D.C., for their server processing. During 1995, each site is slated to get dedicated servers.

NOMS serves three principal functions. First, it's the "eye in the sky" that gives the USPS an overview of what's going on, answering such questions as: Where are the logjams? Where is there any extra capacity? What routes are available? Second, NOMS is an automated decision-support system that helps managers ask the right questions and suggests appropriate solutions. Third, it's a communications hub that puts crisis managers in immediate contact with operations personnel at airports, mail hubs, and transportation-contractor sites. For the first time, the USPS can make a contingency decision, such as whether to roll out another 747 jet, based on accurate information about mail volume, facility considerations, weather conditions, and equipment availability.

The primary NOMS site in Washington, D.C., (see the photo above) is the nerve center of an enormous transportation organization encompassing a dedicated fleet of 25 aircraft, contracts with 70 air carriers, and 14,500 ground-transportation contrac-

the Mail

tors that cover over 2 billion highway miles per year. Inside the NOMS control center, four 67-inch high-resolution display panels look down on the six command and control pods.

These pods are true multimedia workstations: They integrate telephone and fax capabilities and an interactive GUI into a virtual desktop comprising three 21-inch touchscreen monitors. The system architecture is such that a user can drag objects across physical screen partitions and perform all fax, telephone, and computer functions within a single virtual workspace.

And just as no logical barriers exist among the video screens, none exist among applications, either. For example, the system's software-based VRU (voice-response unit) is compatible with any PBX sold in the U.S.; it can handle IDMS (Integrated Data Management System) or VSAM (Virtual Storage Access Method) records from a back-end mainframe as easily as it can handle telephone numbers from its own automated Rolodex.

Design Decisions

NOMS was created under the direction of Robert Earlewine, USPS manager of transportation systems information, with the help of consulting firm Arthur D. Little (ADL, Cambridge, MA). The technical design and implementation were done by Edgewater Technology (Wakefield, MA).

For the NOMS developers, the main order of business was to create a desktop that would provide an organized, unified context in which many different appliances, technologies, ways of communicating, and modes of transportation could work together. The ultimate goal was to achieve a single view of any contingency. Some of the principal challenges are listed below.

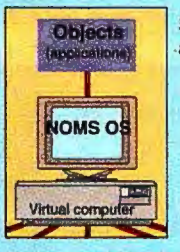
- Take legacy mainframe applications that think in terms of modes of transportation (e.g., rail, air, and truck) and get them to present information in terms of point-to-point delivery.
- Access, through a common interface, data from mail-transport systems that use a heterogeneous mix of platforms, database managers, communications protocols, and applications.
- Unify all user-interface environments, such as phone, fax, and computer, within a common touchscreen metaphor.
- Extend computer-integrated telephony in the following ways: Migrate all "smart" functions to the LAN from the PBX; integrate telephony, LAN functions, and back-end mainframes; provide Rolodex-assisted calling of key contacts based on problem criteria; and pass along the current software context of any phone call (i.e., what the calling-pod user has on-screen) to any other pod.

Altogether, the 14 programmers working on the NOMS project developed over 200,000 lines of new code. This work included constructing the universal VRU, building a work-flow manager, and creating a distributed, object-oriented operating system. Development work began in March 1994, and the first pod was installed during Labor Day weekend. Full installation at the three pilot sites was completed by December 1.

THE USPS'S NEW NETWORK MANAGEMENT SYSTEM

Goals

- Provide a real-time overview of mail and traffic flow within the USPS system, identifying trouble spots, unused capacity, and available routes.
- Support automated decision making to help managers ask the right questions and to suggest appropriate solutions.
- Function as a communications hub that puts crisis managers in immediate and direct contact with operations personnel at airports, mail hubs, and transportation contractors anywhere along the USPS network.

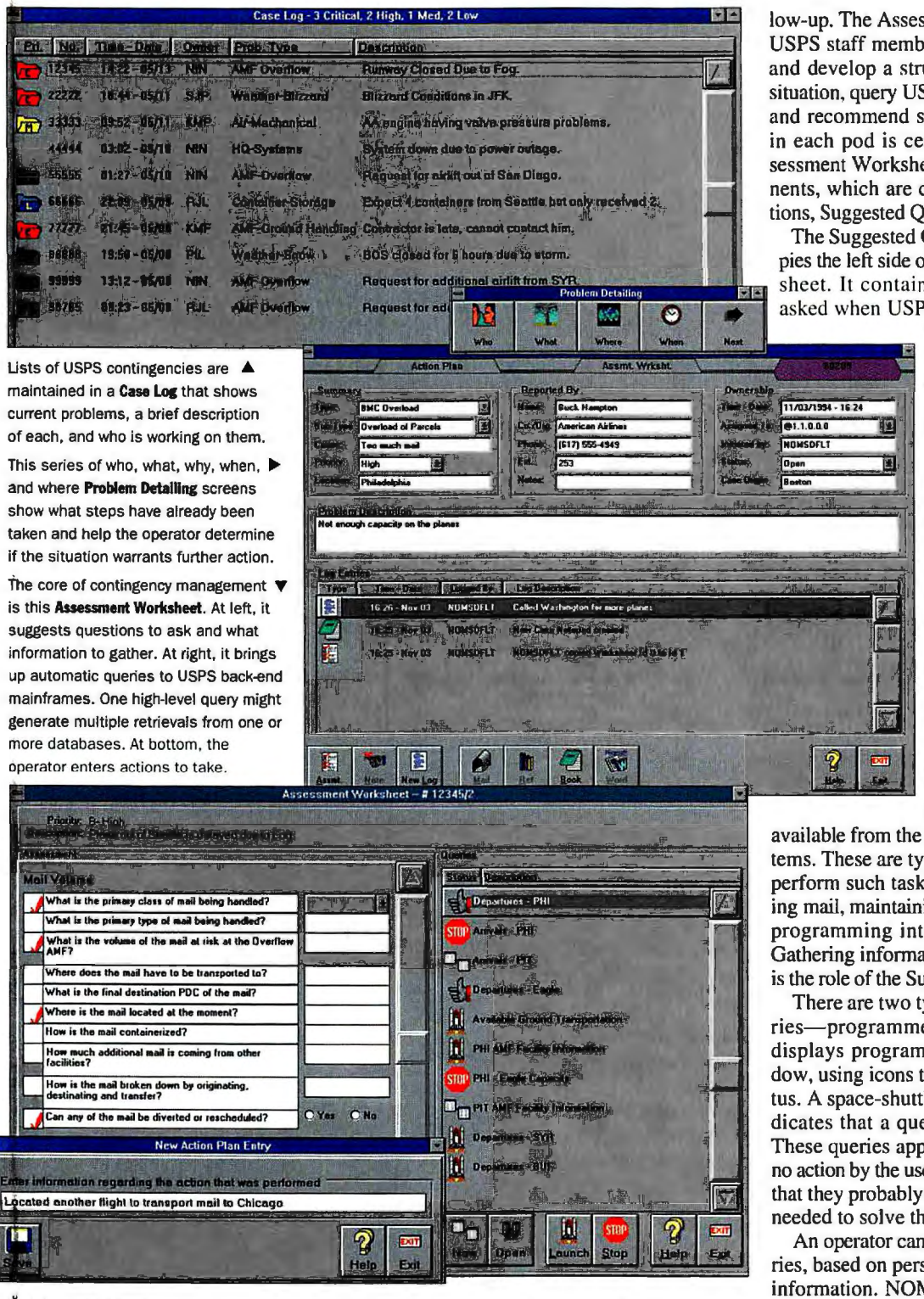


Software Architecture and Implementation

- NOMS functions as one large client/server application in which clients and servers alike can be multiple-CPU systems.
- The system integrates a largely hardware-independent voice-response unit, a work-flow manager, and a distributed, object-oriented operating system.
- Telephony integration (both voice and fax) was achieved in software by emulating analog phones usable with any PBX system; thus, it doesn't require the proprietary hardware characteristics of digital phone switches.
- Servers use Windows NT for improved portability and consistency across systems in addition to a large number of available off-the-shelf products. Clients use Windows for Workgroups 3.11.
- All functions call a middleware layer that provides a consistent API. NOMS treats Windows, telephone boards, and NetWare IPX stacks as distributed objects that simply plug into known, standardized APIs.

Multimedia at Work

- Multiple display screens enable operators to view and manage multiple types of data from multiple sources.
- At the Washington, D.C., NOMS site, four 67-inch high-resolution panels display weather, traffic loads, and other systemwide information.
- Each pod workstation uses three Pentium-based computers, each with its own separate 21-inch monitor, as a large virtual desktop; data can be moved across monitor and machine boundaries via a single keyboard and mouse.



Lists of USPS contingencies are ▲ maintained in a **Case Log** that shows current problems, a brief description of each, and who is working on them.

This series of who, what, why, when, ▶ and where **Problem Detailing** screens show what steps have already been taken and help the operator determine if the situation warrants further action.

The core of contingency management ▼ is this **Assessment Worksheet**. At left, it suggests questions to ask and what information to gather. At right, it brings up automatic queries to USPS back-end mainframes. One high-level query might generate multiple retrievals from one or more databases. At bottom, the operator enters actions to take.

Solving Problems

NOMS's main task is to help people decide what to do when problems occur with mail flow, such as when a bulk-mail center becomes overburdened or a piece of equipment breaks down. When a problem occurs, NOMS receives a call or fax over a WATS line from someone in the field or an alert is generated by one of the USPS's automated mail-handling systems. NOMS has three main resources for looking at USPS contingencies at any time: a Case Log, Problem Detailing, and an Assessment Worksheet (see the screens above).

The Case Log is a list of messages and problems to be logged in, assigned, worked on, and resolved. Problem Detailing comprises a series of screens that provide operations experts with a structured way to determine whether a situation warrants follow-up. The Assessment Worksheet helps USPS staff members evaluate a problem and develop a structured analysis of the situation, query USPS production systems, and recommend solutions. Most activity in each pod is centered around the Assessment Worksheet and its three components, which are called Suggested Questions, Suggested Queries, and Action Plan.

The Suggested Questions section occupies the left side of the Assessment Worksheet. It contains questions that were asked when USPS centers faced a similar problem in the past. Questions relating to the same topic are put together under headings such as Volume at Risk, Transportation, Mail Equipment, Service, and Operations. Sample questions: What is the primary class of mail being handled? Can any of it be delivered or rescheduled?

Some questions can be answered by calling or sending a fax to operations personnel; this is a major reason for NOMS's extensive CTI capabilities. Other answers might be available from the USPS's production systems. These are typically mainframes that perform such tasks as scanning and routing mail, maintaining flight schedules, and programming intercity delivery routes. Gathering information from these systems is the role of the Suggested Queries section.

There are two types of Suggested Queries—programmed and ad hoc. NOMS displays programmed queries in a window, using icons to show the queries' status. A space-shuttle icon, for instance, indicates that a query has been launched. These queries appear automatically, with no action by the user; experience has shown that they probably contain the information needed to solve the problem at hand.

An operator can also launch ad hoc queries, based on personal experience or new information. NOMS keeps track of what queries were made in regard to which problems so that the list of recommended queries can be updated. At present, this part of the system is updated manually by operations experts. But the USPS is considering building a learning algorithm into NOMS that will update the recommended queries automatically.

A key benefit of NOMS is that it facilitates the retrieval of information from

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back-end legacy systems. Operations personnel don't have to know how data is organized—for example, which fields in what tables of which databases need to be examined or how retrieved values need to be manipulated—to satisfy the original high-level query. Nor do users need to know the specific syntax required to pull data from certain systems. They only have to know how to ask an operational question, such as: Do alternate routes exist for mail headed through a particular airport?

Typically, one high-level query results in a number of so-called *atomic* queries being launched against individual databases dispersed throughout the USPS. These can be retrievals against one database or from multiple databases. Sometimes, when a back-end system cannot deliver the requested information, the NOMS expert software will automatically apply workarounds or attempt to get the information from alternative sources. One of the NOMS development team's important roles, in fact, was to ascertain which systems could supply which parts of a high-level query and to then choreograph the necessary sequence of atomic queries.

The third part of the Assessment Worksheet, the Action Plan, is a set of alternatives for action, drawn from historical records of how NOMS has solved problems in the past. Action Plan items are updated manually by experts who review logs to see which items are used in which contingencies. And, in the future, reviews

and updates could possibly be done automatically by NOMS.

Needed: Flexible Technology

The USPS's development plan was to have the first three NOMS centers on-line for Christmas 1994, to evaluate that experience and make any necessary changes to the system, and then to deploy NOMS to perhaps 10 other sites around the U.S. during 1995. To meet the USPS's requirements, several key decisions were made up front. The most important of these was to focus on people, not systems.

"The philosophy behind NOMS is not to tell people how to do their jobs," says Bernard Markowicz, ADL's senior consultant on the project, "but to provide them with as complete a picture as possible of what the postal network is doing. Hence, the integration of telephones and production systems and an Assessment Worksheet that facilitates asking the right questions but is not cast in concrete."

Technical decisions were also driven by the need for flexibility, integration, and speed. The developers decided to use Windows NT rather than Unix on the servers and opted to implement all telephony functions in software rather than on proprietary hardware. And they chose an architecture in which all software functions work with a common middleware layer rather than calling other functions directly.

The NOMS developers decided to use Windows NT on the servers for two reasons: more consistency across major system platforms, and support by more vendors of off-the-shelf products than for any other operating system, including Unix. "Whenever anyone says 'Unix,' the next question always is: 'What flavor?'," says David Clancey, Edgewater Technology's technical director. "The best port gets you only 80 percent of the way there. We wanted something that would be supported by the most people with the least amount of rework." On the client side, Clancey chose Windows for Workgroups 3.11, for similar reasons. Visual C++ (including the Microsoft Foundation Classes) was the primary programming language used.

Integrating Telephony

The need for hardware independence also drove voice/data integration. Edgewater's developers chose not to implement computer-assisted telephony functions with an off-the-shelf telephony server that glues telephone lines into LANs. They decided against this because every existing VRU supports only a limited number of PBXes. Instead, the developers implemented these functions in software on the NT boxes.

A key decision was made to interface the functions to the PBX through analog ports. "The digital portion of a PBX is incredibly proprietary," says Clancey. "I cannot take an AT&T phone and plug it into an NEC or Northern Telecom PBX. But every PBX will take an analog phone. Because they all want to accept analog phones, they all accept commands entered using the flashhook interface." But Clancey notes that such commands vary from one PBX to another. For example, on one system, the flashhook-*-9 sequence will transfer a call, whereas on another system that same sequence will conference a call.

But NOMS can take such differences in stride. "All I need to do is change my config file, and I can talk to any PBX in the U.S.," Clancey adds. "I can even do it at run time—not that you would install a PBX with the system running."

NOMS employs Dialogics voice-processing boards installed in both the pod workstations (four lines per pod) and the

SYSTEM HARDWARE

The Washington, D.C., NOMS site has six pods; the Chicago and Indianapolis sites each have a single pod. Each pod uses the following hardware.

- **Three individual DEC XL90 Pentium-based workstations tied together using a single keyboard and mouse.**
- **Each has a Zynx PCI Ethernet card and a DEC S3928 video adapter with 2 MB of video memory hooked to an Electrographics 21-inch touchscreen monitor.**
- **Other hardware in each pod includes a Logitech sound board, a Dialogic Dialog/41D voice-processing board, a Hayes 28.8-Kbps external modem, and Altec Lansing Multimedia adapters and headsets.**

NOMS servers are configured as follows.

FILE SERVERS

- **DEC XL90 Pentium-based computers, each with 32 MB of RAM, 2 to 8 GB of hard disk storage, and a 17-inch DEC monitor.**

DATABASE SERVERS

- **DEC 2100 Sables, each with dual 190-MHz Alpha CPUs, 128 MB of RAM, and 12 GB of hard disk storage.**
- **Each server has a DEC CD-ROM and tape tower changer.**

NETWORK CONNECTIONS

- **One Dialogic AMX matrix switch per pod.**
- **One Kalpana Ethernet switch for connecting servers.**
- **One SynOptics 3000 hub using 10Base-T connecting pods with servers.**

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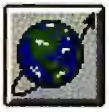

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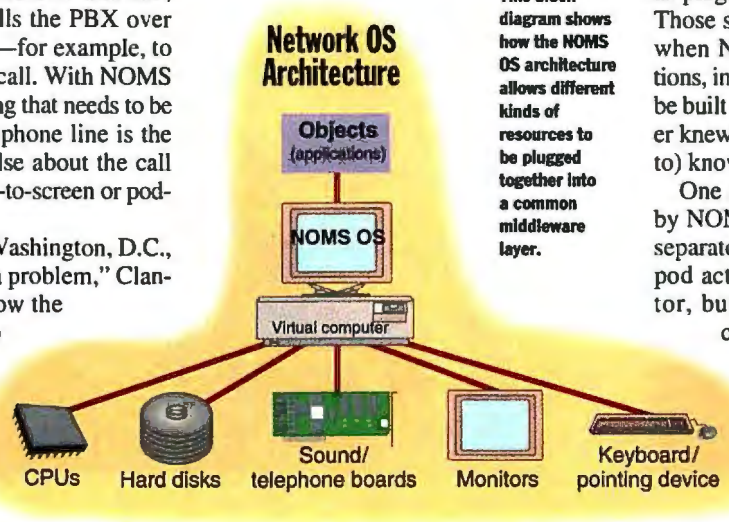
VRU. As an operator talks over one line, software in the VRU tells the PBX over another line what to do—for example, to transfer or conference a call. With NOMS in operation, the only thing that needs to be transferred over the telephone line is the call itself. Everything else about the call can be transferred screen-to-screen or pod-to-pod over the WAN.

"Let's say you're in Washington, D.C., and you're working on a problem," Clancey explains. "I can throw the whole problem over to Chicago. When they pick up the call, what I'm showing on my screen is now in front of the person in Chicago—the call, information about the caller, and the full context of the problem." This means that the person in Chicago doesn't have to ask the D.C. user to describe the situation simply because the two sites use different PBXes.



This block diagram shows how the NOMS OS architecture allows different kinds of resources to be plugged together into a common middleware layer.

Multiheaded Client/Server Architecture

Another technical decision made by the developers was the most important of all—how to tie everything together in a way that would allow pieces of NOMS to be built both independently and in parallel. "NOMS can be viewed as a single, large client/server application," says Clancey. "The only difference is that it spans multiple CPUs at both the client and server levels. Because objects may reside in different process spaces, an entire infrastructure that allows these objects to talk to each other had to be built." This is shown in the figure "Network OS Architecture."

The operating system, called NOMS OS, views such things as Windows, telephone boards, and NetWare IPX stacks as plugs in the sockets of a switchboard. Those sockets are APIs. Because of this, when NOMS was being built, all functions, including the operating system, could be built in parallel because every developer knew he or she had to provide (and talk to) known interfaces.

One of the gee-whiz features enabled by NOMS's middleware is that the three separate Pentium-based machines in each pod act as one; each has its own monitor, but a single keyboard and mouse control all three machines. The NOMS OS handles such things as moving the keyboard focus and sliding windows across screens. This three-in-one capability is similar to the DoD's (Department of Defense's) control pods. It was implemented in NOMS for the same reason it was chosen by the DoD—to multiply horsepower and screen real estate—but for NOMS it was developed at only a fraction of the price, because it used off-the-shelf components. (See the text box "System Hardware" on page 88 for a rundown of the NOMS system hardware.)

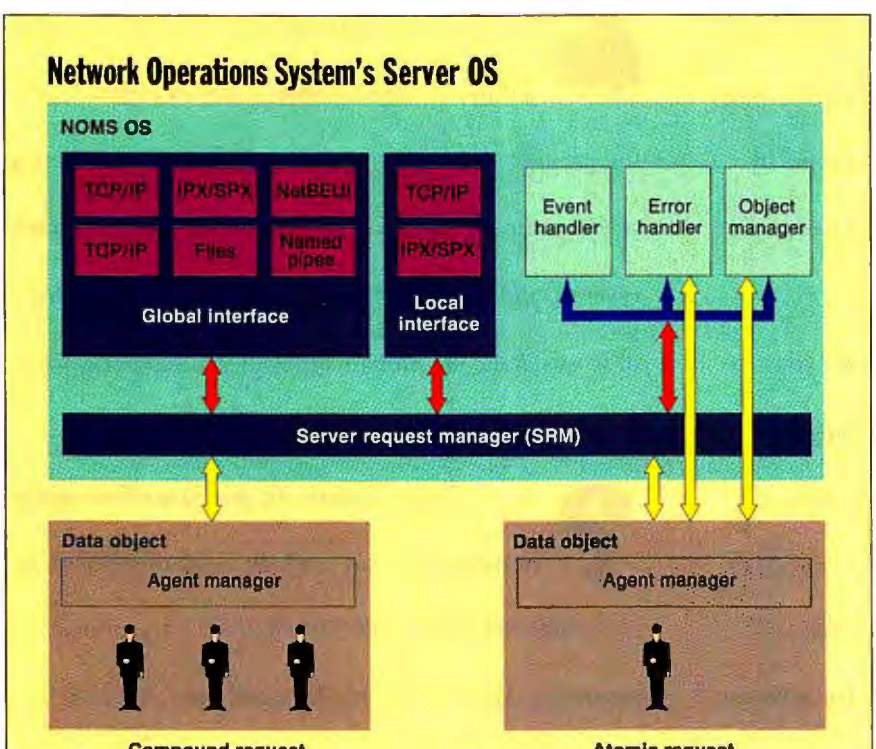
The NOMS OS is broken into pieces, called *stubs*, that reside on every machine within NOMS—clients and servers alike. These stubs communicate with one another and with applications by passing messages. Within each pod, one master stub is responsible for handling communications with the rest of the world. It knows where all objects in the pod reside, so when it's notified of an object event, it notifies all other affected objects. NOMS OS services, called *global* and *local* interfaces, whose underlying intelligence resides in a client-request manager, send and receive information to objects outside and inside the pod, respectively.

Two other pieces of the NOMS OS, currently resident on the client side only, are the *service manager* and the *object mover*. The service manager is a process that manages one physical resource, such as a telephone. The object mover allows the seamless transfer of objects from one display to another or from one pod to another.

Meanwhile, Back at the Servers...

The server side is similar to the client side. For instance, an SRM (server request manager) handles communications between each server's objects and the outside world (see the figure "Network Operations System's Server OS"). A request for production data is an example of an internal object that communicates through the SRM to a transport service, such as TCP/IP.

A server is likely to contain multiple



In the NOMS architecture, everyone has a specific job to do. In the server, back-end queries are performed by agents that in turn are choreographed by agent managers that are under the control of an SRM. Other jobs are handled by other processes; for example, talking to the correct transport service is handled by a global interface.

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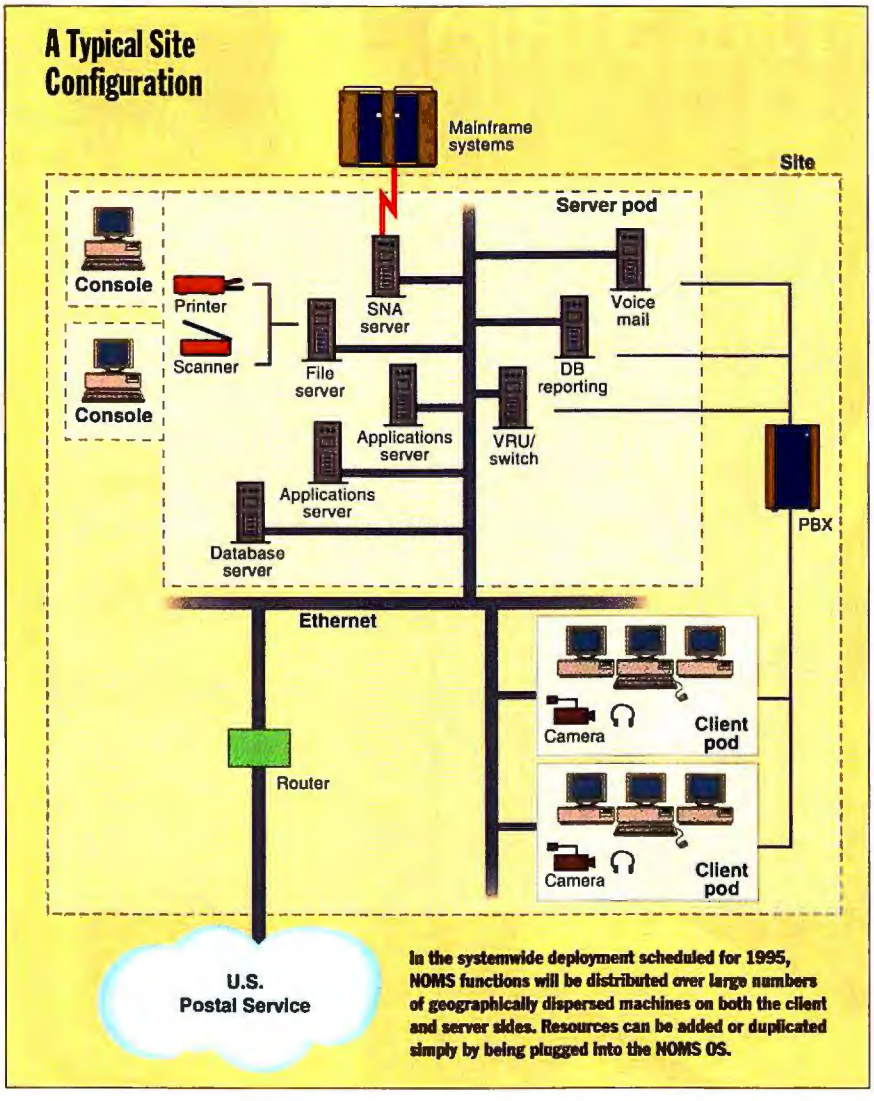

physical or logical processors, including a database server, an applications server, and a file server. In the pilot NOMS system, the database and applications servers run on one DEC 2100 Sable, a dual 190-MHz Alpha machine with 12 GB of hard disk storage. The file server is a DEC XL90 with 2 to 8 GB of hard disk storage.

The primary NOMS processor is called the APPS (applications server). An APPS machine is where data objects are created and destroyed, and it may be the sole provider of a particular service, such as faxing.

The principal job of the database server is to warehouse data retrieved from back-end systems for local manipulation by applications. The database server stores Case Logs, Action Plan items, and contact information for the Rolodex application.

The file server captures information before it's sent to the database server. This provides a place to buffer data received over the link and lets the DBMS—NT SQL Server—update the database at its own pace without tying up production systems.

Since data can reside in different locations and can be organized using different access methods, the server provides a helpful layer of abstraction between knowing what data to get and knowing how to get it. Knowing what data to get (e.g., which atomic queries to launch) is the job of the agent manager. Performing an atomic query (e.g., fetching a particular row from a specified table on a specified database) is the job of a process called an *agent*. For instance, an agent might invoke a 3270 "screen scraper," such as EDA/SQL from Information Builders (New York, NY), or its own SQL script.

Each agent is aligned against a particular back-end system. One of the NOMS back-end systems is the NTMS (National Traffic Management System), a COBOL application that runs on an IBM 3090 located in Memphis, Tennessee, and tracks the progress of mail being scanned through bulk-mail facilities around the U.S.

Minimizing the amount of time that clients spend communicating with production systems was a key element of NOMS planning. Another was to allow multiple machines to be instantiated in the applications-server and database-server classes to provide for load balancing, fault tolerance, and disaster recovery. As clients become active, they communicate mostly with a "sponsor" applications server that becomes their primary service provider.

When applications servers begin operation, they register themselves in a domain database, called the *server registry*, where they store information about the services they provide as well as their address. Applications servers also store a flag to inform the system when they are busy or lose particular services. A service-broker process is responsible for finding a sponsor server and a secondary server when a client becomes active. Once the client and the sponsor server establish a connection, all requests pass directly to that server. If the sponsor server becomes unavailable (e.g., due to a network problem or a system crash), the client can use the secondary server that it knows about or contact the broker for a new primary server.

Progress Report: So Far, So Good

NOMS provides a single information-workflow context in which USPS traffic data can be viewed, decisions can be made, and operations can be managed. Systems that view the mail differently, are programmed differently, have different interfaces, or run on different hardware are made to appear to NOMS operators as if they were designed from scratch to support unified contingency management.

As of last December, according to Earlewine, NOMS was working as specified. "So far, operations for the holiday period are better than they were last year," he notes. But he acknowledges the difficulty of assessing progress so early in the system's life. "Can we say that last year we had so many pounds of mail backlogged and this year we have 10 percent less?" he asks. "When I built the system, I didn't have that kind of benchmark in mind," is his reply.

"What the system is doing is capturing the systematic information in one place. Now we are in the process of expanding that coverage so that there's a duplicate NOMS in each of the [USPS's] 10 operations areas. That will allow managers in each area to do the same kind of contingency management, plant-to-plant, that we are doing across areas nationwide." ■

Randall D. Cronk is a Boston-based freelance writer. You can contact him on the Internet or BIX at editors@bix.com.

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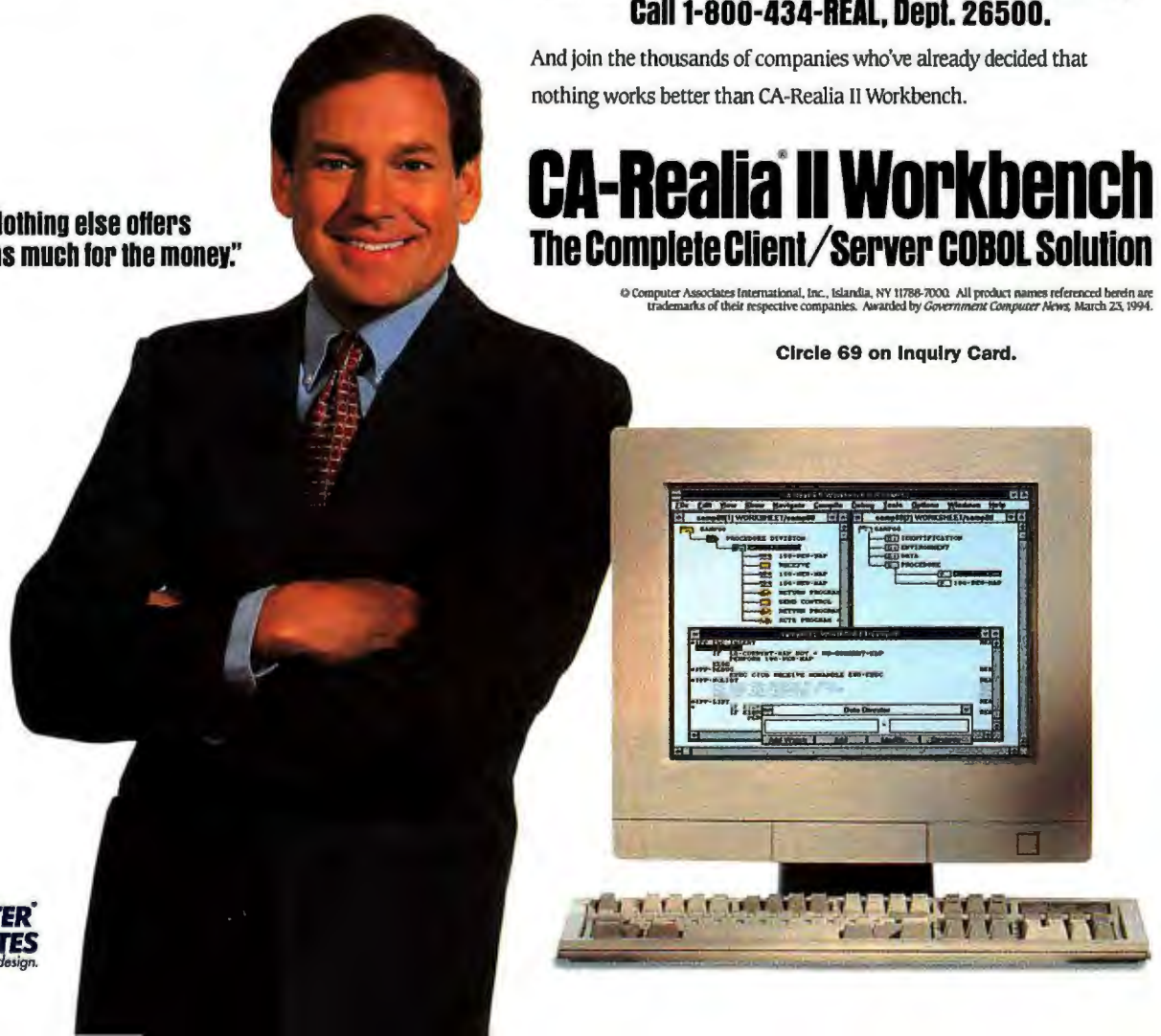

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AGENTS OF CHANGE

Beyond the hype, software is getting smarter at helping us solve real problems

The buzzword *agent* has been used recently to describe everything from a word processor's Help system to mobile code that can roam networks to do our bidding. The metaphor has become so pervasive that we're waiting for some enterprising company to advertise its computer power switches as *empowerment agents*.

Beyond the hype there is an emerging class of so-called intelligent software that eloquently solves business and scientific problems. It's this group of autonomous agents and "smart" software that we examine here.

The next two stories look at the subject from a variety of perspectives: Kurt Indermaur's "Baby Steps" puts the agent hype into perspective by detailing the most advanced implementations of agent technology today and telling you what to expect in the next two to five years. The story also looks at leading examples of smart software that doesn't travel the electronic world on our behalf but uses AI principles and embedded knowledge to help us in our work. Peter Wayner's "Free Agents" examines how agent-oriented operating environments are evolving to provide secure yet interoperable platforms for roaming software.

Be Careful Out There

Developments in these areas aren't happening in a static environment. An unstoppable force—symbolized by the explosive interest in the Internet—is pushing us to link our computers into broad networks, and we will need a common language that can join everyone. Today, machines on the network can exchange a bag of bits, but the value of that is limited. If two machines are going to do any sophisticated collaboration across these networks, programmers will need to write special software that ensures our machines are ready to interact with each other.

This interoperability is perhaps the greatest potential of autonomous software agents, which at their heart are mobile pieces of software that can run on any machine on a network. Some of the most promising agent software will establish a lingua franca for the network so that computers can exchange full-featured programs. These programs include both commercial systems, such as General Magic's Telescript, and freely distributed software, like Tcl, which is available on the Internet and will soon be distributed by Sun Microsystems.

The data packets distributed by these systems will contain complete programs that will execute on a remote machine, which takes you beyond programs that now just send data for another machine to interpret. The extra flexibility to use loops, conditional branches, and subroutines will free network programmers in the same way that macros liberated spreadsheet users.

Although autonomous software agents are just programs at their core, there are substantial differences between implementations that distinguish between secure and suspect agents and those that accept whatever software comes their way. After all, viruses are also autonomous packets of code, and developers of secure agent systems are going out of their way to ensure that an incoming agent can't do anything more than the host allows it to do. Agent systems can defend against the viruses with a well-structured language that keeps the agent from accessing protected memory or files. The agent's host can also include a layer of encryption and cryptographic authentication to keep track of an agent's origin.

While security is an underlying theme of the stories in this section, the complexities of agent interaction don't stop once authorization is established. Research to determine how agents interact when exchanging data or services tells us that agents need to have negotiation skills equivalent to those that people use to carry out business transactions.

During his research for "Baby Steps," Indermaur communicated at length with MIT's Media Lab, which conducts ongoing work on agent interaction. One project looked at how agents might be used in a commercial video-on-demand application, where agents recommend movies based on what you say you like and on your feedback from past movies an agent has recommended. Your agents might also communicate with other agents on the network to determine the favorite titles of viewers with interests similar to your own. Over time, your agent representatives learn and give preference to those outside agents that provide the most reliable recommendations for you.

The downside, as Media Lab researcher Pattie Maes points out, is that people may be unwilling to share their movie (or other) preferences with agents that can then pass along this information to the video-service company or perhaps anyone else with access to the network.

If you want to delve further into the issue of agent interaction, see Indermaur's description of the Stanford Logic Group's work in "Baby Steps." In addition, you also might read Jeffrey S. Rosenschein's and Gilad Zlotkin's book *Rules of Encounter: Designing Convention for Automated Negotiation Among Computers* (MIT Press, 1994), which uses the mathematical tools of game theory to design protocols for how autonomous agents interact with each other.

Back to Earth?

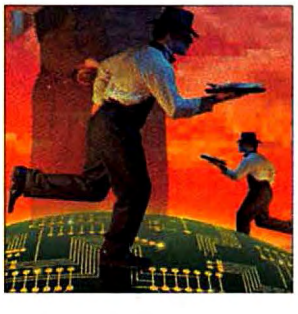
Although autonomous agents and smart AI-based software cast the most sparkle, some developers still believe that some more earth-bound tools, such as the scripting languages that underpin E-mail sorters, ultimately provide more utility to more people. Bob Balaban, systems architect, Lotus Notes Division, argues that most people don't need a "smart" agent to look over their shoulder, guess their desires (i.e., for message filtering), and proactively take action. "I know exactly what I want," he says, adding that he doesn't want an agent to try to learn from his behavior.

Consequently, the scripting language that is being added to the forthcoming version of Notes is the practical approach, according to Balaban. "This is where the rubber meets the road for commercial products. AI just isn't a slam dunk," he says.

—Peter Wayner, Consulting Editor, and Alan Joch, Senior Editor

Baby Steps

What agents will you use and create in the years to come? Look to today's fledgling examples.....97



Free Agents

Multithreaded agent operating systems are key to keeping users safe and commercial developers happy.....105

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BABY STEPS

They can't fly yet, but intelligent agents and smart software are beginning to walk. Here's how they can make you work smarter.

KURT INDERMAUR

ROB SCHUSTER © 1995

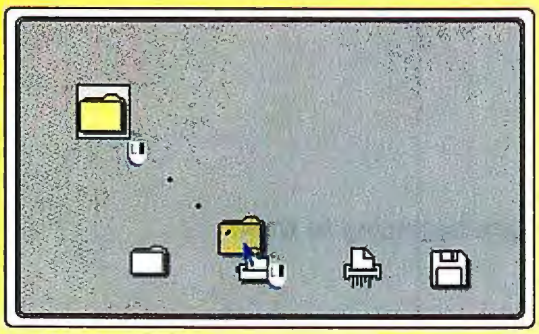
Think the idea of intelligent software agents is being oversold? Coach may convince you otherwise. Developed by Dr. Ted Selker at IBM's Almaden Research Center in California, this teaching assistant holds programming students by the hand as they learn the intricacies of Lisp. In a test using IBM programmers with no Lisp experience, student/Coach teams completed five times more training exercises involving database function calls than did students who didn't have the aid of an electronic tutor.

At the end of the training sessions, most Coach pupils said they liked Lisp; their untutored counterparts weren't so enthusiastic. Skeptics may scoff at agent hype—and the dearth of commercial programs—but if an agent can actually make using Lisp an enjoyable experience, maybe anything is possible.

Assisting in education and training has been a worthwhile aspect of agent research over the past decade. But the agents being developed and sold today cross a number of application boundaries. They're designed to filter and gather information from commercial data services and public domains like the Internet and to automate work flow. Because the range is broad, it helps to separate agents into three main categories: advisory, assistant, and Internet.

Advisory Agents

Advisory agents don't actually carry out tasks; like Coach, they offer instruction and advice to help you do your work. These agents are experts in a particular domain, but in the beginning, they have only rudimentary knowledge of you, your work patterns, and your preferences for managing your work life. As you go about your work, these agents learn such things about you as your level of expertise, your programming style, or your areas of personal and professional interest. Then, either



Coach uses AI techniques to help beginning programmers learn Lisp. Here, the icons along the bottom represent the "Big Picture": the main steps a programmer must follow to write database function calls. The dots trailing the file folder icon depict an animated image, which shows the user the actions he or she must take to move from one step to the next. This graphical shorthand keeps the agent small and fast and allows it to give advice unobtrusively.

when you ask, or when the agent decides it's time to chime in, it offers advice or information. The longer you work with an advisory agent, the better and more timely its advice becomes. At its best, such an agent could anticipate your goals and offer to complete a task the way you've done it in the past.

Selker, who is manager of USER (User Systems Ergonomics Research) at the IBM center, has been evolving Coach along these lines over the past decade. Coach, which is being converted from Lisp to C++, contains three independent but related sets of knowledge to do its work. The first is its user model, where the program builds and maintains information about a user's Lisp-programming proficiency, his or her mistakes (and the chosen fixes), and what worked and what didn't work in terms of coaching. Coach also tracks the rate of change in each user's proficiency (and whether it's getting better or worse), and for each learnable task, how long it's been since it was last used. If a user has done something correctly in the past and has trouble with it now, Coach can present an example from the user's own code.

The user model is persistent—it remains associated with a user from session to session. In a teaching environment, the user model could be made available to a teacher to help him or her understand just where a student might be having difficulties. In a commercial implementation, the coach agent might pass the user model onto a human customer-service representative if the agent determines a customer's problems are beyond the agent's capabilities.

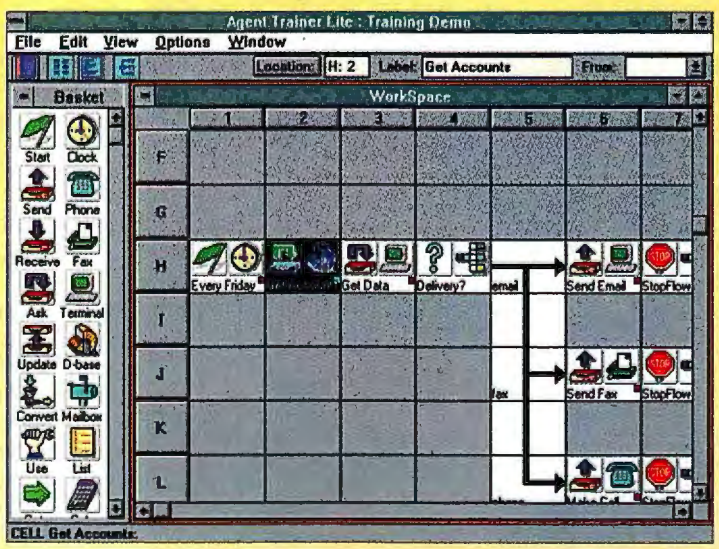
Second, Coach has knowledge about its subject matter. In the case of Lisp programming, Coach knows Lisp syntax, library functions, and concepts (e.g., evaluation, iteration, and recursion). This knowledge base grows over time, automatically incorporating user-defined functions into its repertoire. Such a facility would be a welcome addition to any programming environment, particularly in a team setting in which you're writing code for and using code from other programmers. Your agent might suggest using an existing function or object before you reinvent one yourself. Keeping the domain knowledge separate from knowledge about coaching has made it easy to apply Coach's framework to new domains. For example, Selker says Coach helped a summer intern inexperienced in programming create a Unix help system in just 10 weeks.

The third knowledge set consists of coaching rules that tie user knowledge and the domain together. These rules help Coach gauge a user's level of experience. Update rules determine when the program should refresh the user model to indicate that he or she has mastered a problem or when it's appropriate to present more advanced usage options for a particular feature. Consistency rules make sure that the user model doesn't contradict itself when the model is applied to related subjects. Finally, presentation rules determine how help will be presented to the user. For example, a user who's just starting out would want basic information, while an out-of-practice user may only need a reminder.

Assistant Agents

Assistant agents can be more ambitious than advisory agents because they often act without direct feedback from users. While this allows them to be much more powerful, it also raises a host of technical and even social issues that have yet to be resolved. The concerns you might have over privacy and stifled creativity with an agent that is only offering advice become much more acute when your agent is actually doing work for you.

Current commercial agents that assist users have more or less avoided these issues because they're designed for specific domains. Smart mailboxes (see "Smart Networks," October 1994 BYTE) and search engines are two well-known examples of these applications. In addition, Edify (Santa Clara, CA) offers products for human-resource and voice-response systems. Edify's Electronic Workforce is an agent-supporting environment with a development platform and applications. The electronic workforce has three components: the agents, a runtime environment, and a visual programming tool that's used to train agents. The product incorporates agents to automate human-resources queries and customer-service telephone support and handle the behind-the-scenes paperwork of an employee-review



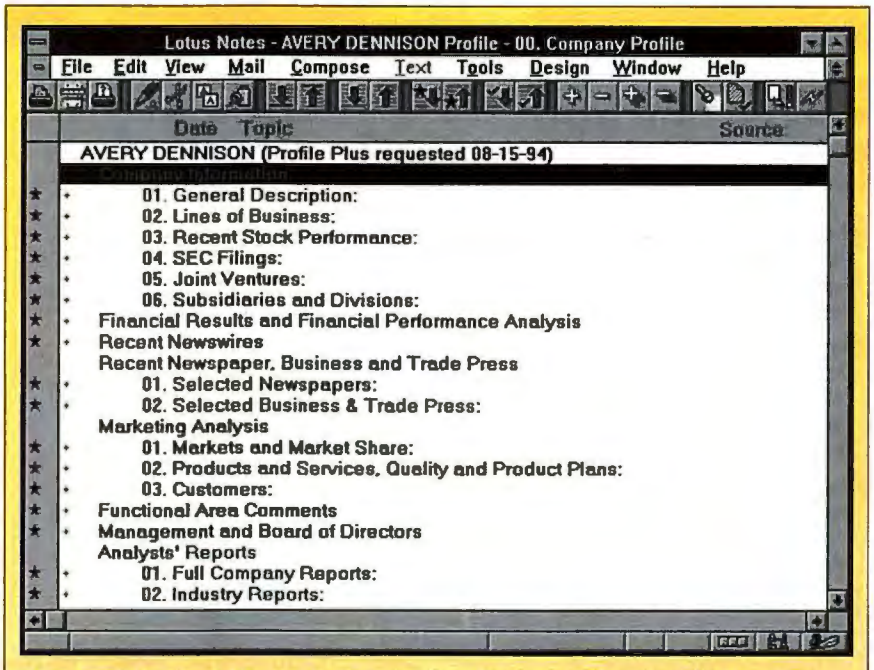
In the agent-trainer facility in Edify, you click on any of the graphical images to fill in details. For example, behind the clock image is a scheduling calendar, which in this case is set up to schedule an event every Friday.

process. Charles Jolissaint, Edify's chief technology officer, says that agents allow companies to augment traditional support applications with automated, 24-hour-a-day services. For example, banking customers can request that they be notified immediately (via fax, telephone, or pager) if their account balance drops below a certain amount, or buyers can be faxed a copy of the shipping manifest at the moment their order is shipped.

Edify's Workforce agents don't start life with specialized knowledge. Developers walk an agent through its paces to train, debug, and deploy it in the agent run-time environment. Because the program uses a visual programming environment, developers never have to drop down to an underlying scripting language. The database backend can be any database that supports OS/2 clients, and the run-time environment itself is an applications server that can be distributed over multiple OS/2 nodes.

The run-time environment includes a resource manager and a scheduler, which both optimize and prioritize the system's use of resources. The high level of system support and the capabilities of the operating environment mean that developers can focus on developing their own agents rather than worrying about contention for telephone lines or other resources. Operating-system support in the Electronic Workforce run-time environment makes agent development easier and, perhaps more important, reduces the risks of running an ill-behaved agent.

Another example of an assistant agent is a mailbox that can manage all your electronic communications, including telephone, fax, E-mail, and pagers. From the first day you use it, the mailbox would convert one message format to another, depending on the device you use to access your mailbox (e.g., convert voice mail or a WordPerfect document into plain text for your pager). Then, rather than (or in addition to) asking for explicit rules for handling your mail, your mailbox agent would observe how you process your messages and offer to set up rules of its own. Junk mail might automatically be routed to a low-priority folder, urgent messages could be forwarded to you at home, and your electronic inbox could be prioritized based on the source and content of the messages you receive.



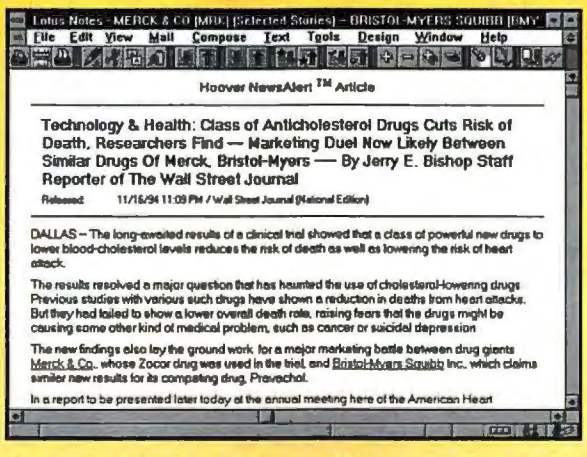
Hoover can find and report back information from Notes databases and commercial data services. This screen shows a custom company-profile template, which the program can fill in for a one-time ad hoc query or automatically on a regular basis if the subject is a company you track over time.

In the process of prototyping just such a mail agent, Pattie Maes, assistant professor and an agent researcher with MIT's Media Laboratory (Cambridge, MA) identified two important factors in the design of a good agent: competence and trust. To be competent, the agent must determine what tasks to do, when to do them, and the best way to perform the jobs. Maes observed that an agent that asks too many questions, interrupts too frequently, or does more than the user wants puts users off. To be trusted, an agent's actions shouldn't surprise the user. An agent should ask before acting if the task at hand is new or if an action might bring about unanticipated results.

While it's relatively easy to describe competence and trust, it's much more difficult to develop an agent application with those characteristics, Maes notes. These characteristics must be molded for each application, which requires extensive user prototyping to get the right balance between independence and intrusiveness.

Henry Lieberman, also with the Media Laboratory, recommends that agent programmers always give people control over their agents' intrusiveness. Some people want to know what their agents are doing all the time and to approve every action before it's begun. Other people are content to let their agents work without direct control. As people gain confidence in their agents' competence, they will likely want to change the degree of control they exercise over their agents.

Assistant agents can make users more productive by reducing mundane tasks; by nature, they can be



Hoover can also locate and retrieve news stories with topics of interest to individual users. Hoover's developers say that future refinements in the program will center on making the interface easier to use.

WWW AGENTS

Martijn Koster, of Nexor, a communications software company in the U.K., maintains a list of WWW (World Wide Web) agents (http://web.nexor.co.uk/mak/doc/robots/robots.html). This Web page also includes guidelines for agent developers and links to some of David Eichmann's work (see the main text). Most of the indexing agents make their indexes publicly available on the WWW. The list includes the following:

- **JumpStation/JumpStation II Robot**
  Constructs an index of documents by title, header, and subject. Author: Jonathon Fletcher (J.Fletcher@stirling.ac.uk).
- **Lycos**
  Research aid uses a finite memory model of the WWW to guide directed searches. Author: Dr. Michael L. Mauldin (fuzzy@cmu.edu) at Carnegie Mellon University.
- **NorthStar Robot**
  Another indexing/searching agent for the WWW. Authors: Fred Barrie (barrie@unr.edu) and Billy Brown.
- **Repository-Based Software Engineering Project Spider**
  A combination agent and indexer; traverses the WWW and indexes the full text of what it finds. Author: Dr. David Eichmann (eichmann@rbse.jsc.nasa.gov).
- **WebCrawler**
  Creates a content-based index of documents it finds on the WWW and satisfies specific user search requests. Author: Brian Pinkerton (bp@biotech.washington.edu).
- **W4 (World Wide Web Wanderer)**
  Measures the growth of the WWW. Author: Matthew Gray (mkgray@mit.edu).

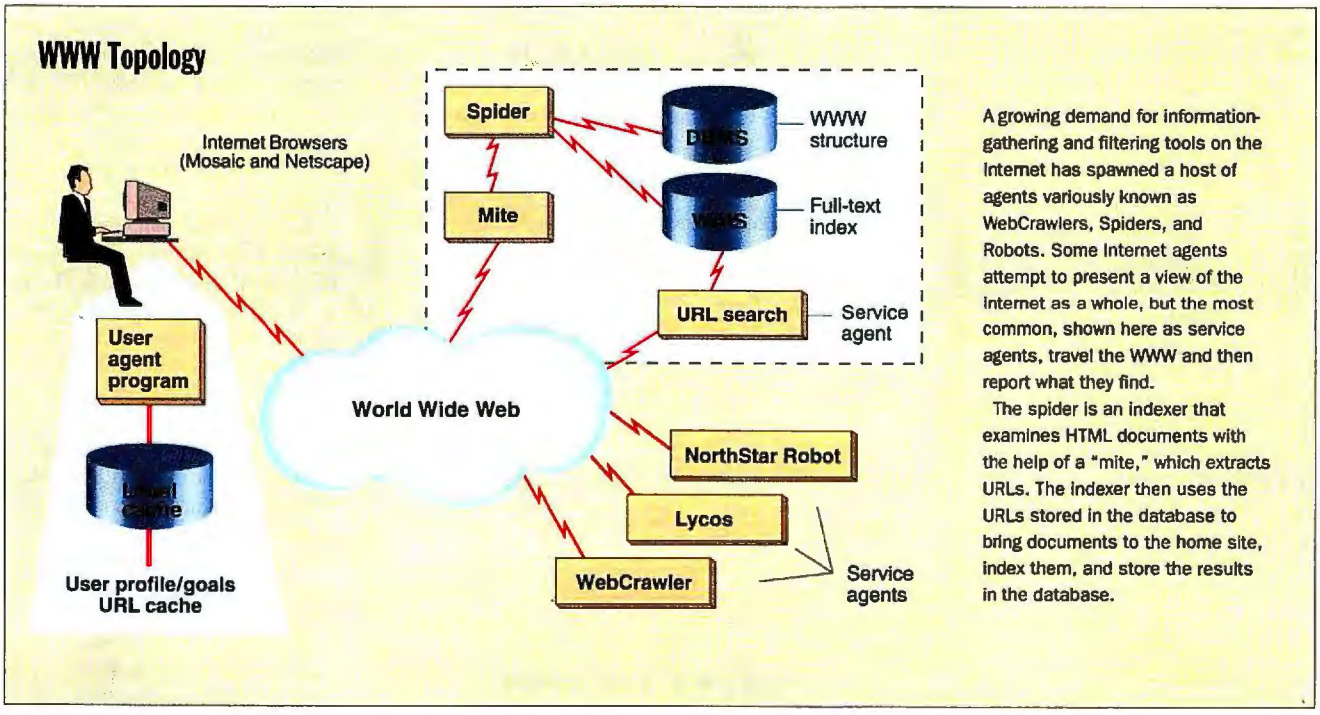
less intrusive than advisory agents. However, assistant agents' independence makes them more dangerous. We have less control over assistant agents but may still be responsible for their actions. As a result, issues of security, liability, and payment for services become important. Your agents may incur charges or do something you might have implied but did not explicitly approve, and you could be held accountable for those actions. As rapidly growing networks create more opportunities for agent software, they also increase the cost of an ill-behaved agent (for details about how agent-based operating environments are addressing security, see "Free Agents" on page 105). Users and service providers will want to be certain that agents remain under control.

SandPoint (Cambridge, MA) has grappled with the issues facing assistant agents in developing its Hoover search engine. This program works in conjunction with Lotus Notes to perform ad hoc or regularly scheduled searches of Notes' databases and commercial data services and then present the results to people in a Notes-format document. SandPoint has acquired access rights to commercial data sources, and it gives both systemwide and user-level control over how much money an agent should spend on given queries. Tom Henry, SandPoint vice president, says the biggest challenge now is to create a simple user interface so that information search and retrieval using software agents will become as natural for us as picking up the phone or reading a newspaper. Software agents will help accomplish this by knowing where to look and how to find information, according to Henry.

Internet Agents

Agents and their related issues are especially relevant on the Internet. Along with the explosive growth of the WWW (World Wide Web) has come the demand for tools to help us manage the vast amounts of available information, and agents (variously known as WebCrawlers, Spiders, and Robots) often fit the bill (see the text box "WWW Agents").

Some Internet agents attempt to present an integrated view of the Internet as a whole, but the most common to date are information gatherers (see the figure "WWW Topology"). These agents traverse the WWW and then report what they find to a home location. They collect information



A growing demand for information-gathering and filtering tools on the Internet has spawned a host of agents variously known as WebCrawlers, Spiders, and Robots. Some Internet agents attempt to present a view of the Internet as a whole, but the most common, shown here as service agents, travel the WWW and then report what they find.

The spider is an indexer that examines HTML documents with the help of a "mite," which extracts URLs. The indexer then uses the URLs stored in the database to bring documents to the home site, index them, and store the results in the database.

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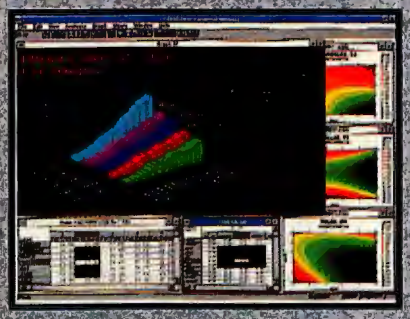
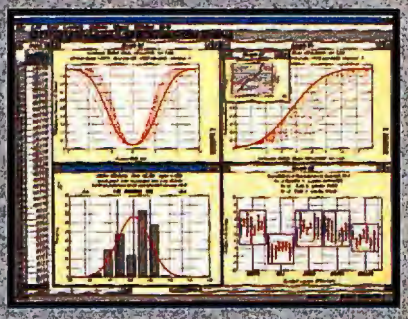
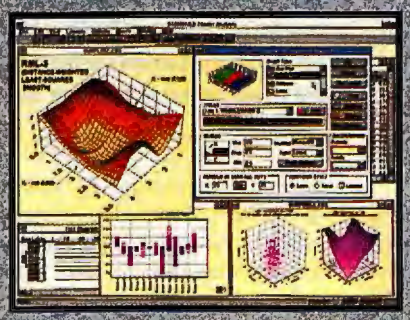
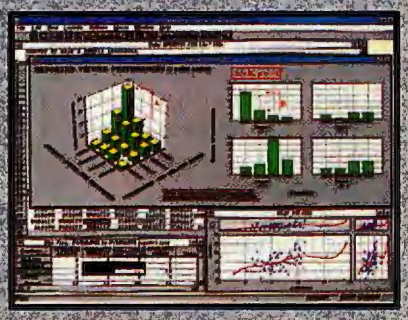
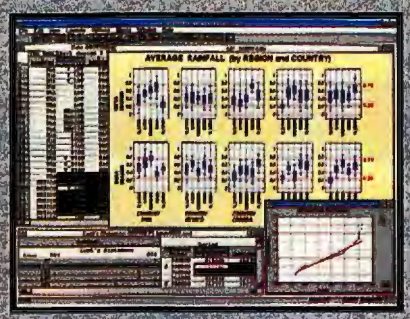
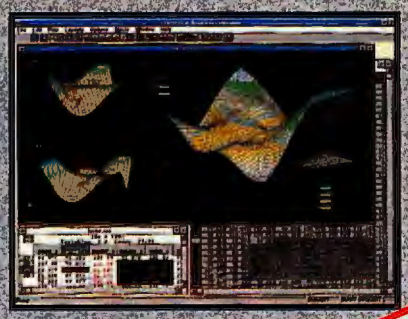
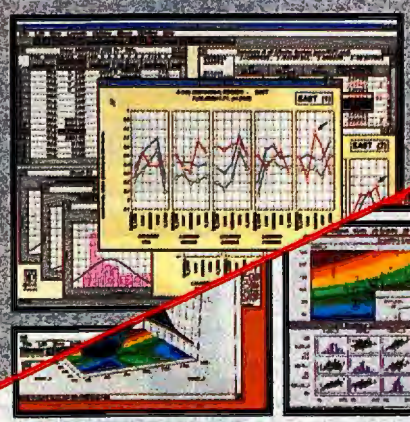
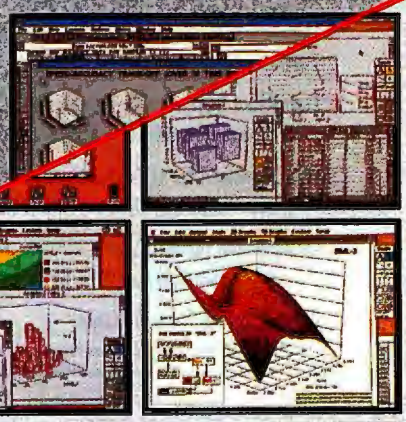
Windows, DOS, Macintosh

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about the WWW itself (e.g., topology or number of nodes), index the contents of remote sites to build an index at their home location, or simply execute a search request.

While the Internet agents don't share much of the advisory and assistant agents' user-interface sophistication, they have provoked a lot of discussion about what makes a well-behaved agent (see the text box "Agent Etiquette"). David Eichmann, assistant professor at the University of Houston–Clear Lake, has put his ideas about agent behavior into practice in his work for the RBSE (Repository-Based Software Engineering) program, for which he serves as R&D director. The RBSE agent balances the conflicting requirements of a low-bandwidth information gatherer with a two-part architecture—an agent and an indexer.

AGENT ETIQUETTE

As it gathers information in cyberspace, a well-behaved agent should obey the following rules of conduct:[1]

- **Identify itself**
- **Share its results with other servers**
- **Moderate the speed and frequency of its requests**
- **Limit searches to appropriate servers**
- **Respect the restrictions of other servers**
- **Determine the accuracy of the information it collects**

Although the Internet's openness as well as an agent's potential to mimic human behavior prevent enforcement of these guidelines, peer pressure has proven to be a strong force for cooperation on the Internet. A balance between the needs of service providers and service consumers may keep a steady stream of new, well-behaved agents in the pipeline.

[1]Source: David Eichmann, the University of Houston–Clear Lake.

The agent traverses the WWW, gathering information about the WWW structure, which it then stores in an Oracle database at its home site. It examines HTML (Hypertext Markup Language) documents with the help of a "mite," a smaller companion that extracts URLs (uniform resource locators), which combine multiple protocols and access methods for WWW browsers into a single specification. The agent limits its impact on individual WWW servers by restricting itself to breadth-first or limited depth-first traversals of the Internet. The indexer then uses the URLs stored in the database to retrieve documents to the home site, index them, and store the results in the database.

Communicating Agents

The Internet is, and will undoubtedly continue to be, a great place for developing agents, but developers must start from scratch when creating new agents. One result of this is that each agent reflects the design and coding idiosyncrasies of its author and is not likely to be able to interact with other agents. Such interactions might greatly improve an agent's efficacy—it could simply ask another agent for information instead of attempting to find information

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An interagent communications language is key to developing future agents.

on its own. But this would require agents to judge each other: Is this agent the agent I think it is? How reliable has this agent's information been in the past? In the future, agents may also have to negotiate payment for services as they satisfy each other's requests. Game theory plays an important role in modeling and studying agents' behavior in such an environment.

Researchers, including Michael Genesereth at Stanford's Logic Group, are investigating ways to create a common agent-communications language to facilitate interagent negotiations. Their KIF (Knowledge Interchange Format) and KQML (Knowledge Query and Manipulation Language) provide the foundation for interactions between agents. Each KQML message is one piece of dialogue, consisting of a communications type and one or more KIF expressions. KIF is an enhanced version of the language of first-order predicate calculus, which is used to declare information, information about information, and procedures. The communications type of a KQML message might be nothing more than a simple query or command, or it may be a more complex request for bids or a delayed request. Complete specifications of KIF and KQML, as well as source code for much of the Logic Group's work is available on the WWW at http://logic.stanford.edu.

Do What I Mean

While today's agent-oriented products point to the technology's potential, it will take more development work to produce wide-scale commercial applications. An interagent communications language will help negotiate one of the technical hurdles by reducing the time and efforts developers need to build an agent. We also still need to resolve some significant social issues, including agent security and who's responsible for an agent's deeds and misdeeds.

We have not created the general-purpose, intelligent agents of our imaginations, but we have taken the crucial first steps. Agents will someday make it possible for software to "do what I mean, not what I say." ■

Kurt Indermaur is a senior software engineer at Intuit, Inc. He can be reached on the Internet at Kurt_Indermaur@intuit.com or on BIX c/o "editors."

FREE AGENTS

How will we manage agents, whether friend or foe? Look to a new generation of operating environments that are extremely open and secure.

PETER WAYNER

ROB SCHUSTER © 1995

If you think slogging through dozens of E-mail messages each day is a challenge, just wait. Queues of automated software agents may soon bombard you with incoming packages of programs that wait eagerly to execute with the click of an icon.

Security is the most obvious problem: You will need to guard against wayward programs that install viruses, compromise the host, or pilfer your database. The flip side, however, is that agents must be free to perform valuable tasks and must be interoperable among a variety of computing platforms. This means a new generation of operating environments that are extremely open and secure.

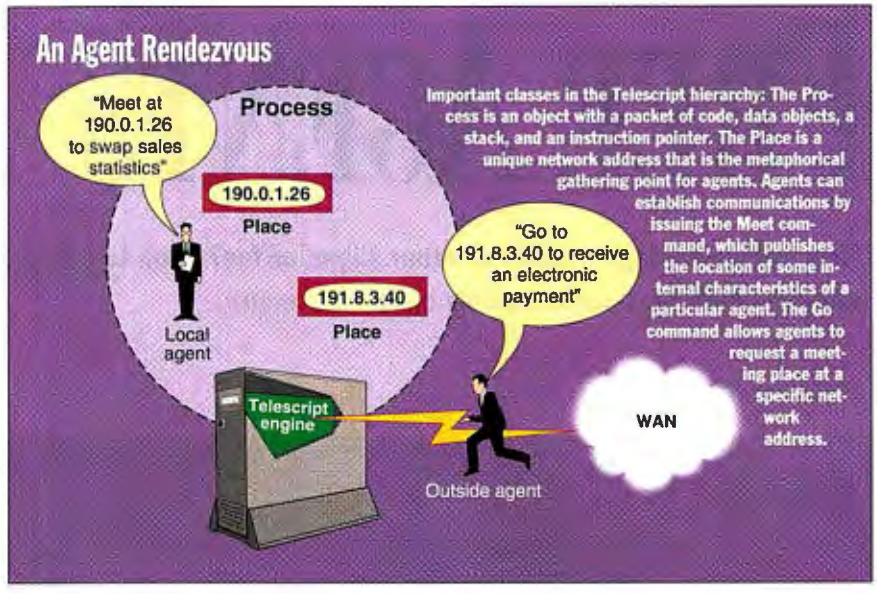
How do you build these environments? As evidenced by the first agent systems, it boils down to hard-core OOP (object-oriented programming), cryptographic algorithms, and lightweight, multithreaded kernels.

Refining Telescript

The preeminent agent operating environment to date is Telescript, which was created by Jim White at General Magic (Mountain View, CA). The company counts several large corporate backers, including Apple, AT&T, Fujitsu, Matsushita, Mitsubishi Electric, Motorola, Northern Telecom, Sony, and Toshiba. Presently, members of the "alliance" (as these companies call themselves) are implementing the technology on their proprietary networks. The first commercial product is the Telescript bundle in Sony Electronics' Magic Link PDA (personal digital assistant) (see "Agent-Enhanced Communicator," February BYTE).

The Magic Link implementation of Telescript presents an interface showing three buildings that represent a home, America Online, and the AT&T PersonaLink network. You click on the appropriate building to connect with the outside

Free Agents



world, or you click on the home icon to open your own files or applications.

Telescript lets Magic Cap users send executable programs in the form of agents through the network. We were able to test this when we opened an E-mail message and clicked on an installation icon: A software program automatically installed itself on our system, and the icon disappeared, all without our having to insert a disk and type `install`.

This implementation shows that Telescript isn't vaporware. However, developers who aren't part of the alliance can't yet tap into the language's full potential because a developer's kit and an API specification are not available.

Rogue-Agent Security

As of press time, General Magic continues to guard details about the core of Telescript, because the company says that publication could endanger licensing efforts. Nevertheless, insights into the internal details of the language continue to become available since our last look at the product (see "Agents Away," May 1994 BYTE).

At its heart, Telescript's development environment is much like Smalltalk's. Everything, from the data to the processes, is an object and part of the basic object hierarchy. Telescript is an interpreted language, and this provides much of its security. Each incoming agent can access only its own objects or other objects in the system that it is explicitly allowed to touch by the agent's creator. It can't write to system memory or to the disk, which is how many viruses do their damage.

Each Telescript agent has an identity that is cryptographically authenticated. In addition, each agent traveling on a network is encrypted using the RC4 data-encryption algorithm. Telescript uses technology licensed from RSA Labs (Redwood City, CA) to perform both authentication and encryption. Also, Telescript is flexible enough to use different methods, like the digital signature standard. Some people (e.g., end users and Telescript developers alike) may be forced to use weaker methods because U.S. export laws prohibit some encryption software from leaving this country.

The foundation class of Telescript's object hierarchy is the *process* (see the figure "An Agent Rendezvous"). This is an object with a packet of code, some data objects, a stack, and an instruction pointer. The Telescript engine on each network host runs multiple processes and preemptively switches between them. This allows the engine to host multiple agents that swap data and information.

Two important types of processes are the *agent* and the *place*, which have a symbiotic relationship. A place is a unique network address that is metaphorically the gathering place for agents looking for a particular type of information or solution. A Telescript engine on the network might support several places and services waiting to dispense information.

Procedures and functions at a place maintain the objects that exist within it. The method *entering* runs whenever a new object appears within a place. This is often an agent that arrives off the network or that a local programmer created. It could even be a different type of object

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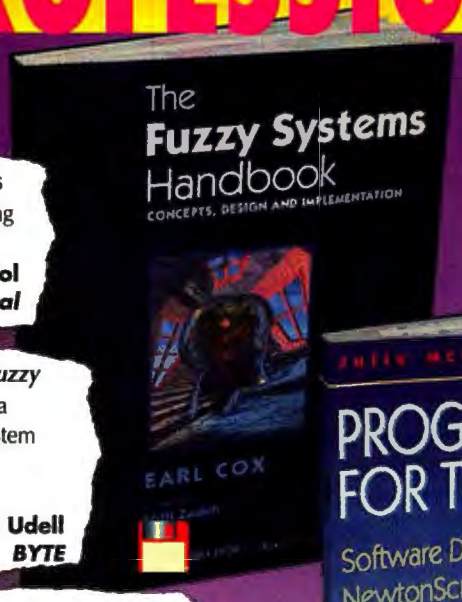

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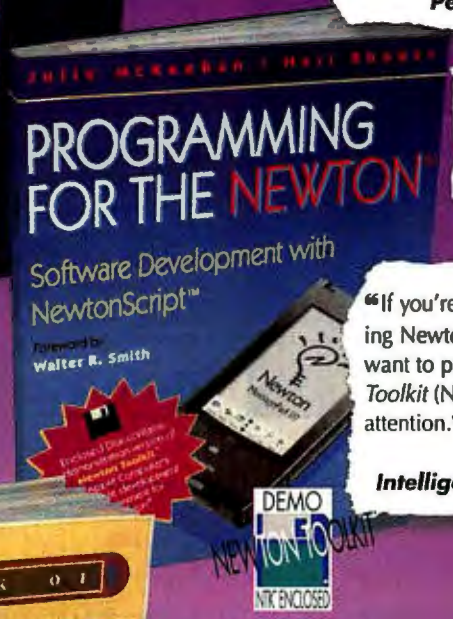

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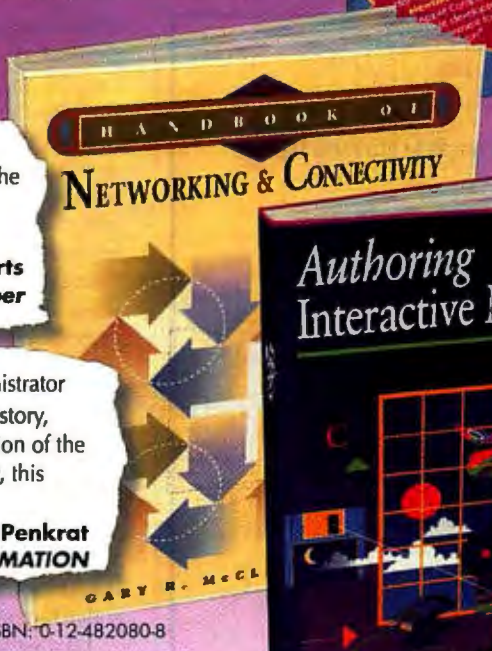

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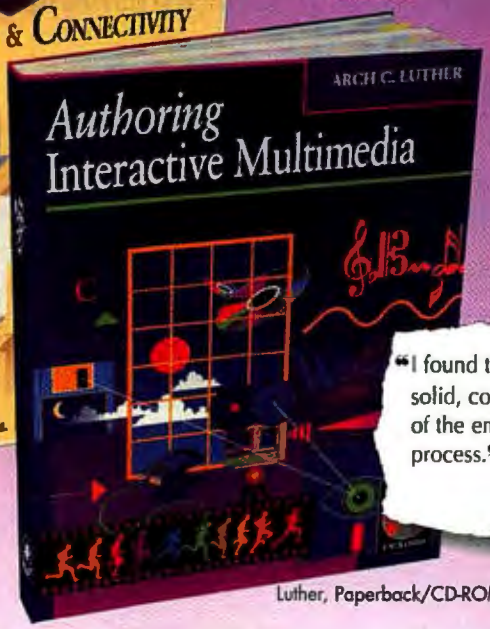

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or another subordinate place. The method *exiting* runs whenever an agent leaves the place.

Several agents can share the same place and set up communications between each other. An agent does this by issuing the Meet command, which effectively allows it to publish the location of some of its internal objects and methods to a particular agent. This allows the initiating agent to reveal parts of its internal state and exchange data without compromising all its information.

Telescript includes a command called Go, which lets an agent request a certain place by its network address. The Telescript engine that is running the agent is responsible for packing up the agent with all its data, stack, and instruction pointer into one package that travels off to the Telescript engine supporting that place. When it arrives, the receiving Telescript engine sets up the package as a local process and begins its execution at the next instruction. This one command makes it simple for programmers to create agents that roam the network because all the work is handled at the lowest level.

A Development System

General Magic expressly designed Telescript to handle network communications and make it simple for software to move and run successfully between machines. Quasar Knowledge Systems (Bethesda, MD) sells an enhanced version of Smalltalk, called SmalltalkAgents, that is intended to provide all the functionality of Telescript in a more traditional package.

SmalltalkAgents works as a distributed, preemptive operating system for computers that use Smalltalk. The main difference from Telescript is that SmalltalkAgents is a complete and extendible software development environment and layered operating system that comes with all the source code. All the tools necessary to create applications or to build distributed client/server code are available in SmalltalkAgents. Also, you can import Smalltalk code from other systems.

You would normally use Smalltalk to create objects that ran both on your machine and on computers that work together to do particular jobs. The structure of SmalltalkAgents makes it possible to change the internal system to run incoming agents in a protected manner to prevent any virus-like dangers.

Who might benefit most from SmalltalkAgents? Corporations large enough to

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AGENT EXPERTISE

Telescript

- Designed to handle network communications
- Moves executables among different machines
- Keeps incoming agents from writing to system memory
- Bars incoming-agent access to a host's hard drive
- Uses cryptographic authentication to verify agent identities

SmalltalkAgents

- A complete development environment
- Provides tools for creating applications
- Can produce distributed client/server code
- Runs untested agents in protected mode
- Offers scalable levels of security

Tcl

- Freely distributed on the Internet
- A high-level, machine-independent scripting language
- Enables you to develop code for Unix and Windows applications
- Includes tools to bind small C programs to larger applications
- Secure version is available

support custom applications are good examples of where a complete system like SmalltalkAgents can succeed. If you want to use the agent system to build software linking several machines inside your corporation, then this full-featured system may be a better approach than Telescript's.

SmalltalkAgents lets you attach as many security features to each agent as is necessary and raise security levels on agents if security needs grow. For example, you might write low-security agent applications that automate life in the corporation: orders, electronic time cards, and announcements could travel through the network without the need for a high level of security. Agents for such applications as expense accounts, salaries, check authorization, or withdrawals from petty cash could be created having a higher level of security.

A Layered Approach

QKS's AO/S (Agents Object System) is a layer that sits between the Smalltalk realm—where the agents work—and the host operating system. This layer of abstraction allows the agents to run on multiple computers from different companies. QKS plans to support the Power Macintosh and Windows NT early this year, and the company expects to roll out versions for Windows 95, OS/2, Silicon Graphics' IRIX, IBM's AIX, and Sun Microsystems' Unix systems later in the year. As of press time, the price for the 680x0 Macintosh version was $595; the Windows products are expected to range from $600 to $800.

A key feature of the system is its device-independent interpreter, which lies in the AO/S. The interpreter converts SmalltalkAgents into a simple language that can be read by interpreters running on the local machines. The process is analogous to a 680x0 emulator on Apple's PowerPC systems: The interpreter converts each instruction from this simple language into a set of instructions in the native machine code using a flexible table of replacement elements. This operates much like the trap mechanism on the Macintosh that lets developers call simple Toolbox routines by issuing a single instruction.

Because SmalltalkAgents supports a multithreaded operating system, it runs each agent as its own thread. It's important to note that each thread can have its own table of native machine code. You might run a safe agent with a full complement of instructions available in its table, or you might cripple an untrusted agent fresh off the network by assigning it a table with limited functionality. The instructions that would let it reach deep into the system or the disk files and cause havoc would either be deleted or replaced with null operations. For example, if an untrusted agent tried to execute a dangerous command (i.e., RM *.*, the Unix Delete command) the interpreter would intercede if you had instructed it to convert RM instructions into null operations.

Developers may find these security measures in SmalltalkAgents valuable, but

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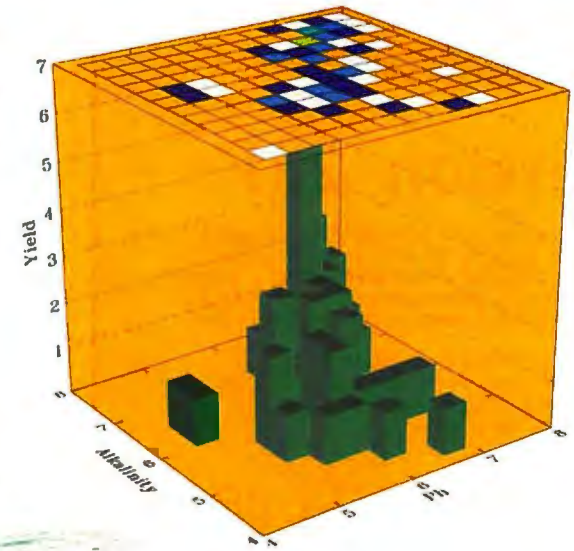

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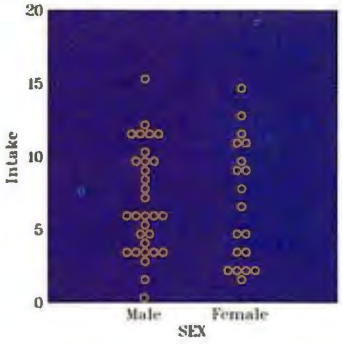

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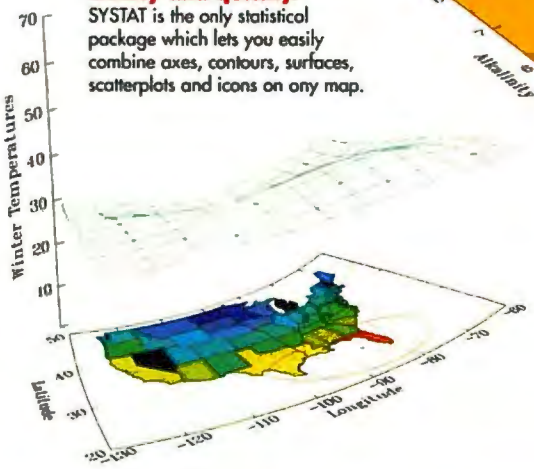

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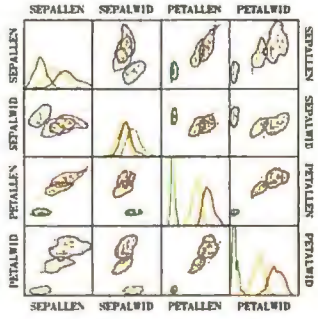

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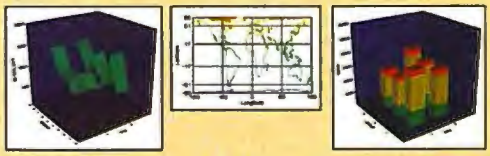

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Telescript's security structure is cleaner because the entire language was designed to run untrusted code. Each call to another agent or object must begin with a Meet command that explicitly allows the outsider in. By contrast, someone programming in SmalltalkAgents might be surprised by the number of calls to outside objects that they used in an unsecure system. Each of these would appear as the security was turned on. These problems can be avoided if the programs are written with a clear vision of where the security barriers will be.

The downside to Telescript, compared to SmalltalkAgents, is that it isn't designed to be a general computing environment. Telescript helps agents move about, but General Magic didn't intend for it to help a programmer deliver a new application.

Language of the Internet

A third agent-oriented language traces its roots to the Internet, where some people are converting a popular, public domain language into an agent system. Called Tcl (Tool Command Language), the system is a high-level language developed by John Ousterhout at the University of California at Berkeley. Many people are using the language to develop code for Unix and Windows applications because it offers a flexible way to bind small C programs (the tools) into a big application. The language itself was inspired by Apple's HyperCard, and Tcl acts the role of the HyperCard scripting language when people use Tcl to link Tcl's or your own sets of tools.

Ousterhout freely distributes Tcl so that others can build large applications with the language. The notion caught on, and now there is a good-size repository of code for other tools available through anonymous `ftp` at harbor.ecn.purdue.edu. Recently, Sun Microsystems (Mountain View, CA) hired Ousterhout to make Tcl the open scripting language for the Internet. His team at Sun is working on freeware versions of Tcl for Macintosh, Windows, and Unix machines.

If Tcl was developed as a flexible, machine-independent scripting language for linking tools, then it's possible that it can be a good language for letting agents roam the network. Nathaniel Borenstein and Marshall T. Rose, principals at First Virtual Holdings, created their own extension called Safe-Tcl and distribute it freely on the Internet (in the directory pub/code/other on ftp.fv.com).

The structure of Safe-Tcl is simple. The original Tcl is distributed as libraries that

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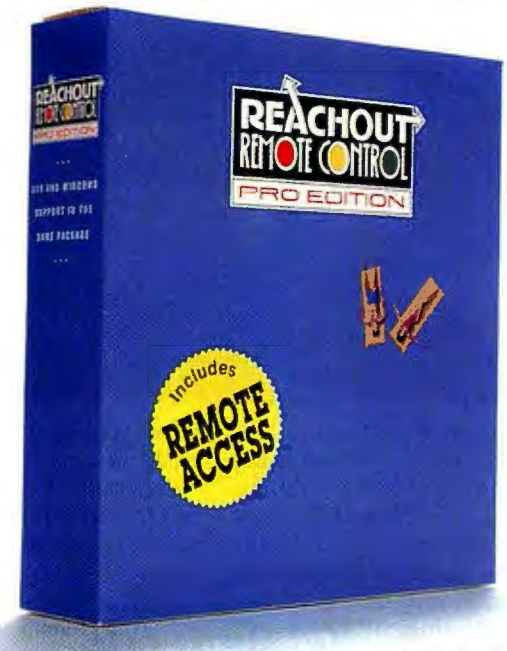

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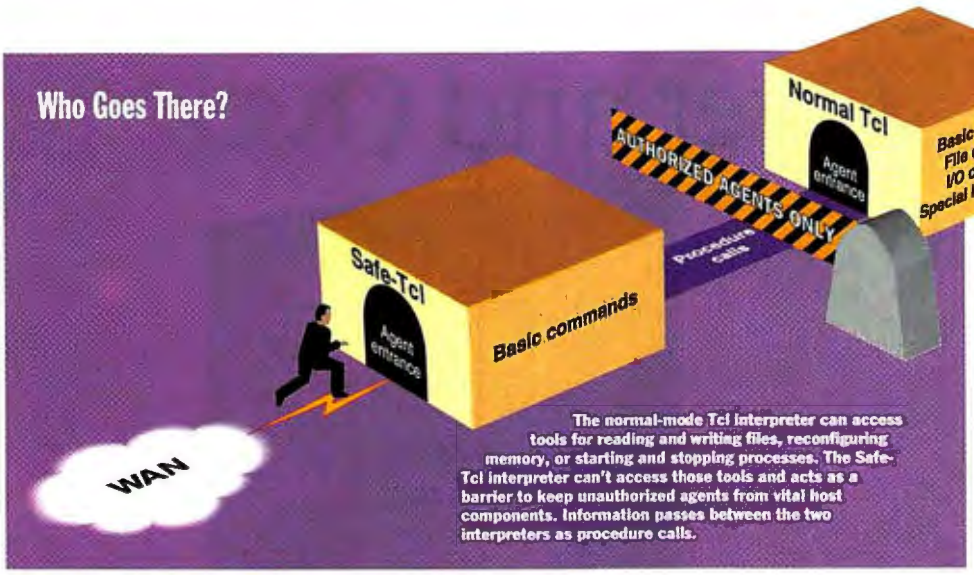

build a small interpreter for the language. You link one interpreter into your code, and it executes the code for controlling the basic tools that you've built in. Each tool responds to some of its own Tcl commands, and the scripting language is responsible for executing the code and sending off the commands to the tools. There are two Tcl interpreters in Borenstein's and Rose's Safe-Tcl (see the figure "Who Goes There?"). One is a local interpreter that has full access to the tools that do "dangerous" things, like read and write files, peek and poke the memory, or start and stop processes. The other is a crippled interpreter that runs the incoming agent written in Tcl.

If you wanted to create an information server that would respond to particular queries, you would build the tools for answering the queries in Tcl that would run in the local, unprotected interpreter. You would then create small instructions for the incoming agent that would be available in its protected space. This builds a fire wall to prevent any trouble from spreading. For more sophisticated protection against infinite loops or time-wasting agents, time management functions exist in the evaluation loop of the Tcl interpreter running the agent. This evaluator checks the time used by the agent before each instruction is interpreted and executed.

There are limitations to this approach. The scripts can run locally, but they cannot autonomously roam from host to host like the agents in Telescript. There is no way to save all the local data and the stack pointer, and there are no simple and clean ways to add these capabilities.

Cynics may point to the agent security threat as a sign of weakness in the Internet's structure.

Originally, Borenstein and Rose imagined that Safe-Tcl would be used for enhanced E-mail. The incoming mail message wouldn't be just a pile of text, an encoded image, or even a compressed application waiting to be run. It would be a Tcl script that you could execute in a safe mode. The script would display data on the screen and perhaps add functional buttons and other GUI devices, but it wouldn't be able to gnaw its way into the operating system like a virus. The system might distribute forms, surveys, or other interactive work.

The need for virus protection is illustrated by the Christmas tree virus, which made its way throughout the Internet a few years ago. The virus arrived as a shell script, and when it ran, the recipients would see a Christmas tree. However, the script also accessed the users local black book of E-mail addresses and sent a copy of itself to each of the entries. Most people who received the message believe it was mailed by a friend, so they executed it without taking any security precautions.

Ousterhout says that his group is folding many of the features of Safe-Tcl into the future version from Sun. The free nature of the product will allow many people to add even more functionality to their World Wide Web pages and Mosaic servers. Also, the language may become the lingua franca for agent interactions, because giving away software is a powerful way to colonize the world.

Cynics may point to the agent security threat as a sign of weakness in the Internet's structure. But the security measures are also a defense against old-fashioned software bugs, so these safe languages will ultimately be an impetus for better, more crash-proof systems.

Read the Script

Designing security structures for agents is challenging for engineers, but most users will not even be aware of the underlying actions. Users will be affected by the way the agents interact with general-purpose operating systems. The next generation of these systems will be designed to accommodate agents and agent-based operating environments. One example of this comes from Apple (Cupertino, CA), which recently introduced Apple Guide, a program that helps users of System 7.5 find their way around the operating system and accomplish tasks.

Although Apple Guide does not interact with the network or allow autonomous agents to come and go, it does illustrate how today's basic operating systems might expand to welcome active enhancements. Any programmer or user can write an Apple Guide script that will allow Apple Guide to walk a new user through a series of steps. Apple expects software developers and even corporations with custom software to write the scripts.

The Apple Guide scripts interact with the Mac OS using AppleScript and AppleEvents, two key pieces of programming technology that allow outside programs to manipulate the face that the Macintosh presents to the world. Apple Guide will, for instance, change the Empty Trash menu item to red if it is trying to tell you how to empty the trash. Apple Guide is just a small glimpse at the more flexible and protean GUI-based operating systems that will emerge in the near future.

Apple Guide is also a good glimpse at the effects that agents can have on the computers we use. Making operating systems open to the outside world allows us to work with others to structure our environments and the way that we work. ■

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Fastest NT Workstations

Windows NT 3.5 has inspired a diverse collection of midrange workstations based on Pentium, Mips, and Alpha CPUs. BYTE tests seven of the fastest.

STEVE APIKI AND RICK GREHAN

The talk among operating system illuminati is that Microsoft did it right with Windows NT 3.5 (a.k.a. Daytona). NT 3.5 delivers major networking enhancements as well as under-the-covers performance improvements (see the November 1994 BYTE, "Exploring Chicago and Daytona.") More important, anticipation of NT 3.5 has added significant momentum to the cross-platform movement NT 3.1 started. Here we have a mature 32-bit operating system that can run on systems housing one or more Intel, Mips, Alpha, or PowerPC processors.

Unix can claim a larger collection of processors only if you're willing to ignore the variation among Unix species. Meanwhile, NT on a Pentium is indistinguishable from NT on a Mips, which is indistinguishable from NT on an Alpha, which is indistinguishable from NT on a PowerPC. What's more, NT 3.5 has created a powerful downdraft that pulls RISC technology from pricey workstation heights closer to an affordable desktop system level.

Here we look at some of this NT diversity, testing seven of the most promising workstations from the three processor families (Intel, Mips, and Alpha) that were running NT at the beginning of the year. We also check out a PowerPC reference system (see the textbox "PowerPC: Late to the Party" on p. 118). NT should be available for PowerPC systems from IBM and Motorola soon after you read this.

Our test group included a trio of Alpha machines—a 275-MHz Action AXP275 from BTG, a 233-MHz DEC AlphaStation 400, and a 289-MHz Mach 2-289-T from NekoTech; a dual-processor 150-MHz Mips RISCstation 2000 from NEC and a uniprocessor 200-MHz Mips Fastseries MP from Netpower; and two dual-processor 90-MHz Pentium boxes—a TD-4 from Intergraph and a Dual-590EP2 from Polywell Computers. Processor speeds ranged from 90 MHz for the Pentium systems (though don't forget, both were dual-CPU boxes) to a cranking 289 MHz for the NekoTech system (with a single Alpha 21064 chip).

Seven fast Windows NT 3.5 workstations: (top, left to right) Intergraph's TD-4, BTG's Action AXP275 RISC PC, Netpower's Fastseries MP, (bottom, left to right) NekoTech's Mach 2-289-T, NEC's RISCstation 2000, DEC's AlphaStation 400 4/233, and Polywell Computers' Poly Dual-590EP2.

In spite of the CPU variety, we established some hardware equality by requesting a set workstation (not server) configuration. Every system came with 64 MB of RAM (except the DEC AlphaStation with 96 MB). All had a 1-GB SCSI hard disk drive and display hardware capable of at least 1024- by 768-pixel resolution in 256 colors—most had pixel area and color depth well in excess of that. In fact, the high-end graphics card in Intergraph's TD-4 operates *only* in 24-bit mode. All except the TD-4 came with a 17-inch display.

Hard drive and especially graphics systems are important for workstation performance. But with the commonality of built-in SCSI-2 and standard PC expansion slots (ISA, EISA, and particularly PCI [Peripheral Component Interconnect]), it doesn't take too much more than new device drivers to move graphics and storage components from one NT platform to another. With the exception of the TD-4's graphics card, it's processor architecture that raises big performance questions. To make sense of this ongoing CPU melee, BYTE pulled together a mixture of benchmark tests and ran each system down the digital gauntlet.

Benchmark Rollout

NT 3.5 comes in both Server and Workstation editions. Viewing our test machines as heirs apparent to the desktop, we used only the workstation version for testing. Our benchmark arsenal included a variety of synthetic and application tests. BYTE's new cross-platform Native Mode benchmarks, based on algorithms commonly employed by standard office applications, spearheaded BYTE's platform- and operating-system-independent benchmark suite.

Also platform-independent, NSTL's new NT-based InterMark tests provide comprehensive analysis that exercises a system's primary hardware components: processor, video, hard disk, and CD-ROM.

InterMark can also test other peripherals (e.g., printers), though we didn't use those components in this review. (See "BYTE's New Benchmarks" on page 73 for a more complete description of BYTE's Native Mode benchmarks and the InterMark.)

The PhotoMorph 2.0 multimedia image processing package from North Coast Software, Inc., leads our contingent of application tests. PhotoMorph served us well for two reasons: It runs on all the NT processor platforms (including PowerPC), and some key PhotoMorph functions take advantage of multiprocessor systems. Our PhotoMorph test is a "swirl" distortion that creates a 2.5-MB AVI (Audio Video Interleave) file. This particular image processing operation—the image looks like it's going down a whirlpool—is floating-point intensive and multiprocessor aware.

The remaining pair of packages in our applications tests are Micrografx's Picture Publisher 4.0, an image processing program, and Bentley Systems' MicroStation version 5.00.23, a CAD package. Both are driven by Microsoft Test scripts developed by NSTL. The Picture Publisher tests run several images through all the image processing effects available from the effects browser. Thus, the images are ground through a total of 22 processes that include blurring, distorting, and sharpening, as well as various "artistic" effects. The MicroStation tests load and render several CAD images (ranging from a 26-KB bridge to a 2-MB diesel locomotive), then perform hidden line removal and 3-D antialiasing operations.

We ran the InterMark tests in 8-bit color depth only, except with the Intergraph TD-4, which supports only 24-bit color. We ran other graphics-intensive tests in both 8-bit and 24-bit color modes for those platforms that supported both, so you can see the effects of pixel depth on graphically intensive operations. (PhotoMorph, though an image processing application, is processor-dependent; its performance was independent of color depth.)

Unfortunately, the version of InterMark we used was new and unable to execute on the two Mips machines. Also, at the time of our testing, MicroStation was unavailable for Mips NT systems.

BTG Action AXP275 RISC PC ▲

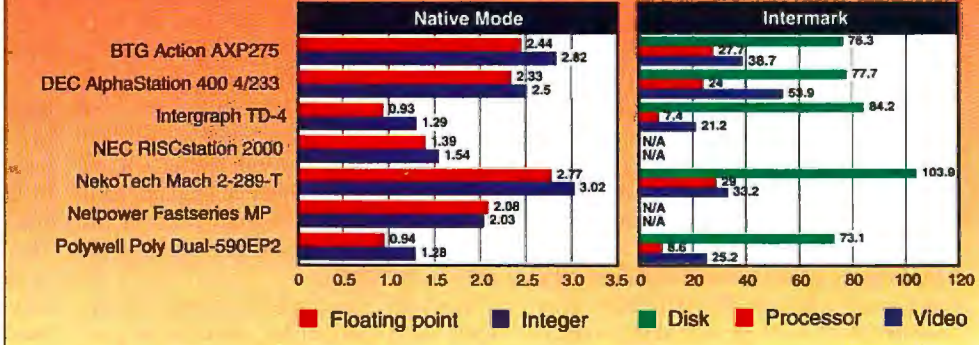
Of the seven workstations in this review, this Alpha-based system strikes the best balance between cutting-edge technology and mainstream pricing. The Action AXP275 finished a close second on our performance tests behind NekoTech's Mach 2, and it lists for $11,520 in our test configuration, making it the second least-expensive workstation we tested.

The Action AXP275 is built around a 275-MHz 21064A Alpha on an Aspen-designed motherboard. Except for clock speed, the Action AXP275 is similar in basic design to the NekoTech Mach 2, with 2 MB of secondary cache connected to 128-bit wide system memory. The Aspen board does supply some features that the Mach 2's DEC-designed unit does not, including 3.3-V power off the board, an extended capabilities port/enhanced parallel port interface, and three EISA and three PCI slots without a shared slot. These two systems set the top two marks on processor-intensive benchmarks, with the Action AXP275 generally behind the Mach 2 proportional to the 5 percent difference in clock speeds.

Video and disk subsystems are those you might find on any high-end PC: a graphics accelerator based on S3's 64-bit Vision964 and a 1.2-GB Seagate SCSI-2 drive. While helping to keep the price down, these components actually put the Action at a disadvantage compared to the other two Alpha-based systems, which boast either specialized video (DEC) or fast disk components (NekoTech). This is evident both from InterMark results and from Picture Publisher and MicroStation application tests.

While system construction isn't quite up to the level of DEC's AlphaStation, the Action AXP275 is solidly built and mounted in a standard PC case, and it certainly didn't give us any problems during testing. Top-shelf components like a quad-speed CD-ROM drive and an excellent 17-inch Nokia 447X flat-screen monitor round out the package.

BYTE NT Benchmarks



On the BYTE Native Mode and InterMark processor tests, the Alpha systems (BTG, DEC, and NekoTech) are faster than the Mips boxes (NEC and Netpower), which are faster than the Pentiums (Intergraph and Polywell). Within CPU families, these tests correlate with clock speed. The dual-processor systems (Intergraph, NEC, and Polywell) show their worth on the PhotoMorph test, which takes advantage of multiple processors. Otherwise, the PhotoMorph test mirrors floating-point performance. The Intergraph TD-4's GLZ graphics card made up for a relatively slow CPU on the Picture Publisher and MicroStation tests

DEC AlphaStation 400 4/233 ▲

Both the AlphaStation and the NekoTech Mach 2 are based on motherboards designed and built by DEC. However, the board in the AlphaStation 400 4/233 (with a separate processor module) is quite different from that in the Mach 2, as the Mach 2's board is based on a different DEC reference design.

The AlphaStation's 233-MHz clock makes it the slowest among the Alpha-based systems, but it still puts the AlphaStation well ahead of the Mips- and Pentium-based workstations we tested (we expect DEC to ship its own 275-MHz workstation this year). On BYTE's Native-Mode integer test, the AlphaStation proved itself about 25-percent faster than its nearest non-Alpha competitor, Netpower's 200-MHz R4400 machine.

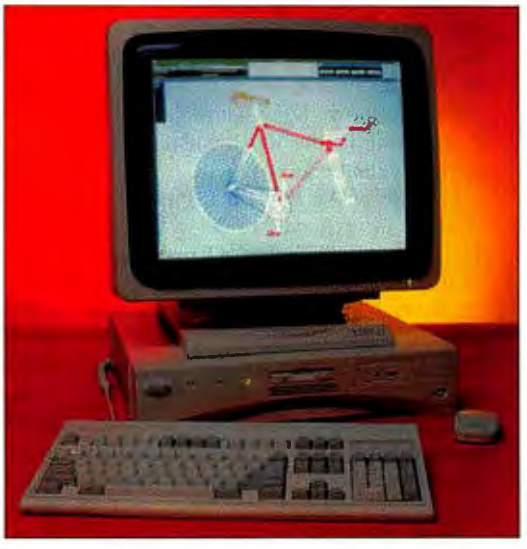
Its clock speed may be less than cutting-edge, but the AlphaStation's killer 2-D/3-D accelerator more than makes up for this lack on graphics-intensive tasks. DEC's ZLXp-E1 graphics card put the system well out in front on the InterMark video benchmark and while running Picture Publisher. Benchmarks aside, the AlphaStation also feels the most responsive when comparing systems side by side. On the downside, the E1 version of this card handles only 8-bit color. The E2 version does 24-bit color, and the E3 adds z-buffering.

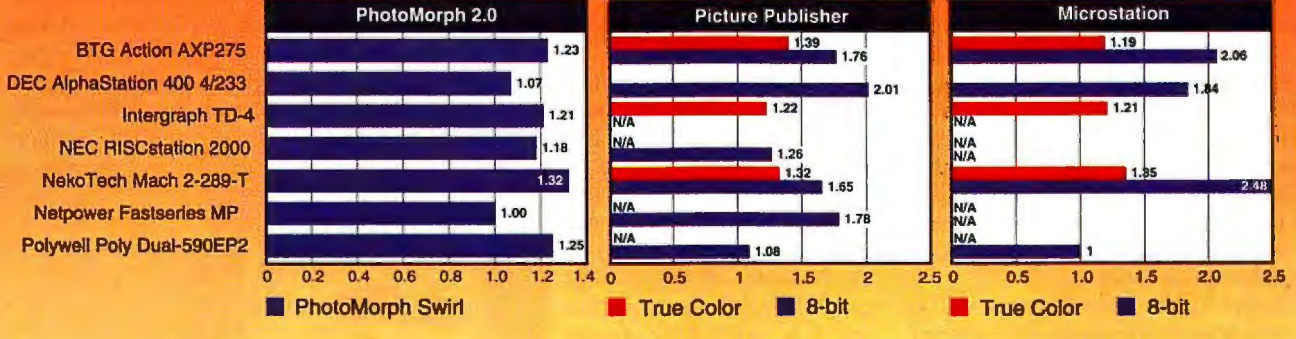
With a total price of $16,394, including 96 MB of RAM, a 17-inch monitor, and the graphics accelerator, the AlphaStation lands in the middle of the price range. This is a nicely built box with which we found few flaws. Its compact tower design mounts the CPU card and PCI add-in boards horizontally in the airflow of a large front-panel fan, keeping everything cool. If DEC can keep prices of the 275-MHz version of this system in line, it will be an outstanding NT machine.

Intergraph TD-4 ▶

Intergraph approaches the NT workstation market from an unusual angle. The TD-4 is no souped-up PC; it's a Pentium-powered workstation. From its specialized 3-D-accelerating graphics system and integrated Ethernet to its spacey 21-inch tube sitting atop a slimline case, the TD-4 instantly recalls machines of the Sun and Apollo genre. Unfortunately, its dual-Pentium design rarely keeps up with faster Mips and Alpha-based systems and the TD-4's pricing also owes more to the world of workstations than to that of PCs.

Intergraph's GLZ 3-D graphics system outclasses the graphics boards in the other machines. The dual-socket PCI board, outfitted with 24 MB of video memory, provides true-color images at all resolutions up to 1600 by 1280 pixels. Yes, it has 24 MB of video memory—enough to contain dual frame buffers and z-buffers with room for additional buffering. The GLZ supplies a rock-steady 76-Hz refresh rate at 1600 by 1280 pixels and is stereo capable. With





with 24-bit color depth. The DEC AlphaStation's graphics card also did well on these tests relative to the other Alpha systems. Results for Native Mode benchmarks are given as overall Integer and floating-point indexes. They are normalized against a DELL XPS P90 (90 MHz Pentium).

InterMark figures are reported in transactions per second. Numbers for PhotoMorph are iterations per second (an iteration being an execution of each project), normalized so that the lowermost score is 1. Similar techniques were used to resolve the Picture Publisher and MicroStation tests, with the addition that component test scores were combined using a geometric mean. Higher numbers are faster in all tests.

PowerPC: Late to the Party

DAVE ROWELL

We tested NT workstations at the start of this year. At that time, IBM and Motorola had agreed on the PReP (PowerPC Reference Platform) hardware that will run operating systems like Windows NT and OS/2, but systems hadn't shown up in retail channels. More important, Microsoft wanted to do more testing on systems based on 603 and 604 PowerPC chips, and thus delayed adding PowerPC support to Windows NT. That will happen by mid-year, if not sooner, with a minor upgrade called NT 3.51.

In spite of the late start, PowerPC systems are expected to do well relative to other RISC-based NT platforms. That's due to IBM's clout and the possibility that Apple, IBM, Motorola, and others will produce systems based on a CHRP (Common Hardware Reference Platform) that will run NT, OS/2, and an upcoming version of Apple's Mac operating system (see "New PowerPC Hardware Standard to Support Macs" in News & Views).

IBM, Motorola Computer Group, Tatung, Bull, DTK, FirePower, and other companies have demonstrated NT systems based on 601, 603, and 604 PowerPC processors. There is a PowerPC Windows NT 3.5 beta SDK (Software Development Kit) available, and several applications have been ported to PowerPC, including Excel, Word for Windows NT, SQL Server, WordPerfect, and PhotoMorph 2. By the time the first NT-running PowerPC systems ship this year, there may be as many NT applications for it as there are for Alpha-based systems.

Not wanting to leave PowerPC out of our NT workstation performance testing, we acquired a 601-based PowerPC prototype system from IBM. Though not as fast as 604-based systems will be, the 120-MHz PowerPC system we tested is representative of the first PowerPC systems you'll see. It arrived with 256 KB of L2 cache, 48 MB of DRAM, a PCI-based Diamond Stealth 64 graphics card, a 540-MB SCSI hard drive, and the requisite CD-ROM drive.

We compiled and ran BYTE's Native Mode tests on the PowerPC system using new hand-tuned floating-point libraries (beta) from Motorola. We also ran the PhotoMorph test, compiled with the beta NT 3.5 and freshly linked with the same Motorola libraries. The Native Mode test results (an integer index of 2.01 and a floating-point index of 1.87) put the performance of the 120-MHz 601 just below the 200-MHz R4400 Netpower system. Likewise, with the PhotoMorph 2 application test, which mirrors floating-point performance, the PowerPC system came in just below the Netpower system with an index result of 0.96. That puts our PowerPC test system at the bottom of the performance pile with this particular test, only because the systems with slower processors had two of them.

The PowerPC 601 chip appears to give similar performance to Mips chips running at higher clock speeds. The 604 should be significantly faster. Like Mips chips, PowerPC processors are relatively inexpensive, providing roughly twice the performance per dollar as Intel's Pentium chips. It's likely that PowerPC 601 workstation prices will be in the same range as are Pentium-based systems. Then the decision will come down to the PowerPC's faster performance versus Pentium's compatibility with legacy applications. ■

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Intergraph's 21-inch display, graphics performance is simply remarkable, both in speed and image quality.

The GLZ is also an OpenGL accelerator. OpenGL was not responsible, however, for the TD-4's doing better on the MicroStation CAD application tests than on any other benchmark. The TD-4 owes that result to an Intergraph proprietary high-level graphics language called MOGL. MicroStation is one of a few packages that support MOGL-capable hardware.

Except for the MicroStation test, The TD-4's benchmark results were generally disappointing. Dual 90-MHz Pentiums, individually between one-half and one-third the speed of the fastest Alphas, kept the TD-4 well off the pace that this fast group set. But only one of our tests—the PhotoMorph application—fully exploited SMP; on that test, the TD-4 scored almost as well as the Alphas. This is, once again, a machine built for CAD. If your application writes to OpenGL and is reasonably threaded, the TD-4 will perform better than our benchmarks show.

The TD-4's high-end video subsystem, including the high-performance 21-inch display, makes it the most expensive box we looked at—$23,150 in its test configuration. More expensive 3-D and less expensive 2-D acceleration options are available. Intergraph's G91 graphics accelerator card, for instance, would have provided similar performance on many of the tests but costs $6500 less. We'd heartily recommend this workstation for CAD or visualization applications, but it's too specialized to make a reasonable general-purpose system.

NEC RISCstation 2000 ▼

NEC's RISCstation is among the most mature of the non-Intel NT designs, and it has consistently been a top performer in the past. This generation of the dual-R4400 system will not remain the top workstation model, however. NEC has a 200-MHz version of

NT WORKSTATION FEATURES

Review systems with tested configuration

	BTG ACTION AXP275 RISC PC	DEC ALPHASTATION 400 4/233	INTERGRAPH TD-4	NEC RISCSTATION 2000	NEKOTECH MACH 2-289-T	NETPOWER FASTSERIES MP	POLYWELL POLY DUAL-590EP2
Price (as tested)[1]	$11,520	$16,394	$23,150	$14,160	$11,995	$13,980	$7900
Processor(s)/Memory							
CPU(s)	DECchip 21064A Alpha AXP	DECchip 21064A Alpha AXP	two Intel P54 Pentiums	two NEC VR4400MC Mips	DECchip 21064A Alpha AXP	R4400MC Mips	two Intel P54 Pentiums
CPU speed (MHz)	275	233	90	150	289	200	90
Primary cache (instruction/data, KB)	16/16	16/16	8/8	16/16	16/16	16/16	8/8
Primary cache design	direct-mapped	direct-mapped	two-way set associative	direct-mapped	direct-mapped	direct-mapped	two-way set associative
Secondary cache (KB)	2048	512	512	512 per CPU	2048	1024	512
RAM (standard/as tested/ maximum, MB)(ECC)	32/64/512, ECC	32/96/192, ECC	32/64/256	16/64/384, ECC	32/64/512	64/64/384, ECC	32/64/512
Storage							
Hard drive tested	1.2-GB Seagate ST11200N	1-GB DEC RZ26L	1-GB Conner CFP1060S	1-GB DEC DSP3107LS	1-GB Seagate ST31250N Barracuda	1-GB Conner CFP1060S	1.2-GB Seagate ST11200N
CD-ROM	Plextor 4Plex (4X)	Toshiba XM-4101B (2X)	Toshiba XM-4101B (2X)	NEC Multispin 3XI (3X)	Toshiba XM-4101B (2X)	Toshiba XM-3401B (2X)	Toshiba XM-3501B (4X)
SCSI	Built-in PCI, 8-bit Fast SCSI-2, NCR 53C810 Tolerant chip, internal connector only	Built-in PCI, 8-bit Fast SCSI-2, NCR 53C810 Tolerant chip, internal and external connectors	Built-in PCI, 8-bit Fast SCSI-2, NCR 53C810 Tolerant chip, internal and external connectors	Built-in, 32-bit local bus, 8-bit Fast dual-channel SCSI-2, NCR 53C700-66 chip, internal and external connectors	Built-in PCI, 8-bit Fast SCSI-2, NCR 53C810 Tolerant chip, internal and external connectors	Built-in PCI, 8-bit Fast SCSI-2, NCR 53C810 Tolerant chip, internal and external connectors	Adaptec 2940 PCI, 8-bit Fast SCSI-2 card
Drive bays	three accessible 5¼-inch, one internal 3½-inch	three accessible 5¼-inch, one internal 3½-inch, one 3½-inch floppy	one accessible 3½-inch, two internal 3½-inch, one 3½-inch floppy	three accessible 5¼-inch, three internal 3½-inch, one 3½-inch floppy	four accessible 5¼-inch, two internal 5¼-inch	two accessible 5¼-inch, one internal 5¼-inch, one internal 3½-inch, one 3½-inch floppy	eight accessible 5¼-inch, two internal 5¼-inch
Graphics							
Graphics card	Number Nine #9GXE64 Pro PCI	DEC ZLXp-E1 2-D/3-D 8-plane graphics card	Intergraph GLZ 3-D	VXL proprietary local bus	Diamond Stealth 64 PCI	Diamond Stealth 64 PCI	Diamond Stealth 64 PCI
Graphics processor	S3 64-bit Vision964	DEC 21030	n/a	NEC 64-bit Jaguar Graphics Chip	S3 64-bit Vision964	S3 64-bit Vision964	S3 64-bit Vision964
Video memory tested/ maximum (MB)	4/4 VRAM	1/1 VRAM	24/24 VRAM	2/4 VRAM	4/4 VRAM	2/4 VRAM	2/4 VRAM
Pixel clock maximum	220 MHz	135 MHz	220 MHz	110 MHz	135 MHz	135 MHz	135 MHz
Maximum resolution and refresh rate with 24-bit color	1152 by 864 (100 Hz)	n/a	1600 by 1280 (76 Hz)	800 by 600 (72 Hz)	1152 by 882 (90 Hz)	800 by 600 (76 Hz)	800 by 600 (76 Hz)
Maximum resolution (color depth, refresh rate)	1600 by 1200 (16-bit, 76-Hz)	1280 by 1024 (8-bit, 72 Hz)	1600 by 1280 (24-bit, 76 Hz)	1152 by 900 (8-bit, 60 Hz)	1280 by 1024 (16-bit, 76 Hz)	1280 by 1024 (8-bit, 76 Hz)	1280 by 1024 (8-bit, 76 Hz)
Monitor							
Model	17-inch Nokia 447X (Trinitron)	17-inch DEC VRT 17-HA (Trinitron)	21-inch InterVue-21	17-inch NEC 5FGe	17-inch DEC VRT 17-HA (Trinitron)	17-inch MAG DX17S (Trinitron)	17-inch ADI MicroScan 5EPI
Optimal resolution (refresh rate)	1280 by 1024 (75 Hz)	1280 by 1024 (72 Hz)	1600 by 1280 (76 Hz)	1024 by 768 (76 Hz)	1280 by 1024 (72 Hz)	1024 by 768 (70 Hz)	1024 by 768 (76 Hz)
Networking							
Interface	Cogent Data Technology PCI Ethernet card (thick, thin, 10Base-T)	DEC DE435 Etherworks PCI Ethernet card (thick, thin, 10Base-T)	built-in AMD PCnet AM79C790KC PCI Ethernet chip (thick, 10Base-T)	built-in local bus Ethernet (10Base-T)	built-in DEC 21040-AA PCI Ethernet chip (thin, 10Base-T)	ZYNX Ether-Action PCI Ethernet card (thick, thin, 10Base-T)[2]	ZNYX Ether-Action PCI Ethernet card (thick, thin, 10Base-T)
Expansion Interfaces							
Total slots	three ISA, three PCI	three ISA, two PCI, one shared PCI/ISA	two PCI, one shared PCI/EISA	three EISA	three EISA, three PCI, one shared PCI/EISA	two EISA, two PCI	three EISA, three PCI, one shared PCI/EISA

Notes:

[1] As tested price includes components listed plus Windows NT 3.5, keyboard, mouse, and 1.44-MB floppy disk.

[2] Tested with card listed. Built-in networking should be finalized by press time.

◀ NekoTech Mach 2-289-T

If 275 MHz just isn't quite enough for you, you'll appreciate the 5-percent boost the 289-MHz clock on NekoTech's Mach 2 generates. Otherwise, goosing the 275-MHz-rated Alpha in the Mach 2 to 289 MHz, while making the Mach 2 the fastest computer BYTE has ever tested, will probably look more like gimmickry than innovation. NekoTech's aggressive pricing ($11,995 as tested) makes this machine among the least-expensive, as well as the fastest.

This is essentially a 275-MHz Alpha machine with a few extra clock cycles—at its core is a high-quality DEC-designed motherboard with a swapped-out crystal. As such, the Mach 2 holds virtually all the latest performance records, with integer performance over three times that of a 90-MHz Pentium. It outperformed the next-fastest Action system (with 275-MHz Alpha) slightly on all processor-intensive tests.

The Mach 2's powerful processor was supported by a superfast Seagate Barracuda drive in the unit we tested. Video performance was also excellent, as the Mach 2 fell behind only the specialized accelerator in the AlphaStation and the Number Nine card in the Action AXP 275.

Engineers from DEC's systems group told BYTE unofficially that they didn't expect problems at 289 MHz, stating that they've tested selected chips themselves up to 330 MHz. The Mach 2 is housed in a tall tower case with plenty of cooling and includes a heat-sink fan on the CPU. Fit and finish are first-rate, so we don't expect any problems from shoddy construction.

the RISCstation in the works that should be in the channel by mid-year. Expect PCI slots and nonproprietary graphics.

The benchmark figures show the results for the shipping 150-MHz system. BYTE's Native Mode benchmarks, which test only one processor, rate the machine faster than only the two Pentium-based systems: the Intergraph TD-4 and the Poly Dual-590EP2. Except for the PhotoMorph application test (which uses both CPUs), other results follow suit. The PhotoMorph tests ran slightly slower on the RISCstation than on the dual-Pentiums. However, the RISCstation does beat out Netpower's single-processor 200-MHz Mips system on this test.

As a preview of the 200-MHz RISCstation to come, we also ran a few processor-intensive tasks on a 200-MHz NEC RISCserver, a dual-R4400 system similar in design at the CPU level (though drive and video options differ). The system scored BYTE integer and floating-point indexes nearly identical to those of the Netpower FAST MP and turned in a PhotoMorph rendering about 33 percent faster than the 150-MHz RISCstation (and faster than NekoTech's Alpha-powered Mach 2).

As an NEC system, the RISCstation 2000 comes with nice amenities like an NEC XE17 monitor (it was tested with an NEC 5FGe) and a triple-speed NEC CD-ROM. But at $14,160, it's a steady but not stellar performer, and the relative lack of software available for Mips systems is a strike against it.

Netpower Fastseries MP ▶

Like Intergraph, Netpower takes the "Workstation" part of Windows NT Workstation seriously. For Intergraph, that means CAD; for Netpower, that means high-performance systems designed for networked, distributed computing. Netpower offers a number of workstation applications (middleware) along with the Fastseries, including an NT port of SGI's OpenInventor Toolkit and a Netpower distributed make utility called NetCompile.

The Fastseries MP is an SMP (symmetric Multiprocessing) design that can support two R4400 processors. Netpower wasn't shipping a working dual-processor model as we went to press, however, so the unit we tested ran a single 200-MHz R4400—the first available system to do so.

CPU cards (up to two) fit into slots that rest behind a fan opening in the front panel. The interior layout is unusual in this all-Netpower design: SCSI and Ethernet controllers are built into the system board so only the video card requires an external PCI slot. The back panel connections come directly from riser cards which extend up from the motherboard. The most notable user feature in the Fastseries is its soft power switch. You can safely power down the machine from the NT desktop by clicking on the shutdown button.

The Fastseries turned in a good performance on our benchmarks, somewhat behind the Alpha systems and generally ahead of the RISCstation 2000, its Mips-based rival. Dual Mips processors could make up for slower-than-Alpha performance, depending on the application. When Netpower ships its two-processor system and NEC ships its 200-MHz Mips workstation, the Fastseries and the RISCstation should be close in both price and performance (the single-processor Fastseries sells for $13,980). However, Netpower's workstation orientation and ability to supply middleware will make it more attractive for technical environments.

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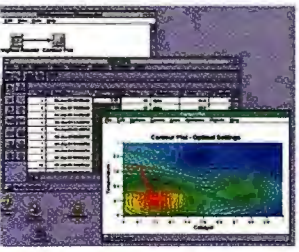

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Polywell Poly Dual-590EP2 ▲

At $7900 as tested, the Poly Dual-590EP2 is far and away the least expensive among these systems. If you're looking for a low-end entry into NT Workstation computing, the Poly Dual might be the answer. Compared alongside the thoroughbreds in this review, however, there's little beside price to recommend this dual-Pentium machine.

Like the TD-4, the Poly Dual was overmatched on all the benchmarks except the PhotoMorph application, where the Poly Dual brought its second processor to bear. In fact, there's little discernible difference between benchmark performance for the two systems on this CPU-intensive test. As the TD-4 supported only 24-bit color and the Poly Dual only 8-bit in this configuration, it's hard to compare application performance between the two systems. However, the TD-4 appears to have fared better against other 24-bit video machines than did the Poly Dual against its competitors.

The Poly Dual's huge tower case hides a baby-AT motherboard that crams two Pentiums alongside four PCI (all bus mastering) and three EISA slots. Putting four PCI slots on a board comes a little too close to the edge of the PCI loading specifications to make us comfortable, but we didn't have any problems with the system. Other hardware included typical high-end PC equipment like the Diamond Stealth 64 PCI board and a fast quad-speed CD-ROM drive.

If the performance of a single Pentium PC running NT doesn't cut it for you and you have applications that can take advantage of multiprocessing (e.g., SQL Server), the Poly Dual would be a good step up. It offers the processing performance of some much more expensive workstations at a bargain price.

NT Workstation Choices

NT's growing popularity makes choosing between several multiple-processor systems a real option; now you just have to pick from among a number of systems with a variety of strengths. Choices range from the high-end graphics but relatively underpowered CPUs of the dual-Pentium Intergraph TD-4 to the lightning-quick and moderately-priced NekoTech Mach 2.

If you have specialized requirements, you're choice is already made. With its high-end graphics system, Intergraph's TD-4 is the best system for 3-D and high-resolution, high-color video. And for 2-D graphics work, the AlphaStation is the best machine, combining fast floating-point processing with one of DEC's ZLXp graphics cards. The choice for a general-purpose workstation, however, is less clear-cut.

Currently, the Alpha processor is the way to go for supercharged NT performance, although dual 200-MHz Mips chips can compete with certain applications (depending on price). If you're looking for the tops in workstation speed, your choice is between the BTG Action AXP 275, the DEC AlphaStation 400, and the NekoTech Mach 2. While the AlphaStation boasts specialized video and the Mach 2 a slight clock-speed advantage, we lean toward the unit with the best blend of price, performance, and features. We recommend the Action AXP 275 as an excellent all-around NT workstation. ■

Steve Apiki is a BYTE contributing editor and senior developer at Appropriate Solutions, Inc., a Peterborough, NH-based consulting firm specializing in multiplatform development. Rick Grehan is BYTE senior technical director and developer of the BYTE Native Mode benchmarks. You can reach them via the Internet at apiki@apsol.com and rick_g@bix.com.

About the Companies

BTG, Inc.
(Action AXP275 RISC PC)
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(703) 641-9200
fax: (703) 876-1920
URL:http://www.btg.com
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Digital Equipment Corp.
(AlphaStation 400 4/233)
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Maynard, MA 01754
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(603) 884-6660
fax: (800) 723-4431
info@digital.com
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fax: (205) 730-2461
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NEC Technologies, Inc.
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sales: (800) 284-4484
(508) 264-8000
fax on demand: (708) 238-7800
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NekoTech
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fax: (714) 580-0060
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fax: (408) 522-2666
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BYTE's editors want to know what you think about industry issues. Your responses will help to determine who receives special recognition at our 20th anniversary celebration at Comdex Fall 1995. Return this form by April 21, and you will automatically be entered in BYTE's 20th anniversary sweepstakes. The prize is a Gateway Liberty notebook computer.

What is the greatest single challenge facing your company over the next five years?

- ☐ Client/server deployment
- ☐ Compatibility
- ☐ Customer service
- ☐ Internetworking
- ☐ Interoperability
- ☐ Legacy system migration
- ☐ Network management
- ☐ Remote access
- ☐ Technical support
- ☐ Training
- ☐ Upgrading systems/software
- ☐ Other _____

What desktop operating system will be dominant in the next five years?

- ☐ AIX
- ☐ Cairo
- ☐ Macintosh System
- ☐ MS-DOS/PC-DOS
- ☐ OS/2
- ☐ Other Unix operating system
- ☐ Solaris
- ☐ Taligent
- ☐ Windows 95
- ☐ Windows NT
- ☐ Windows 3.1
- ☐ Workplace OS
- ☐ Other _____

What CPU will dominate the desktop-computer market in the next five years?

- ☐ AMD K5
- ☐ DEC Alpha
- ☐ 486 clones
- ☐ Intel 486
- ☐ Intel P6
- ☐ Intel Pentium
- ☐ Mips
- ☐ Motorola 680x0
- ☐ PA-RISC
- ☐ Pentium clones
- ☐ PowerPC
- ☐ Sun SPARC
- ☐ Other _____

What three technologies will have the greatest practical impact on computing in your company over the next five years?

- ☐ CD-ROM
- ☐ Client/server
- ☐ Computer telephony
- ☐ Groupware
- ☐ High-speed networking
- ☐ Multimedia
- ☐ Object-oriented programming
- ☐ On-line/interactive
- ☐ Parallel processing
- ☐ Personal digital assistants
- ☐ Plug and play
- ☐ Software agents
- ☐ Speech recognition
- ☐ Subnotebook computers
- ☐ Videoconferencing
- ☐ Wireless communications
- ☐ Other _____

What three persons have contributed the most to the state of the art in computer technology over the last 20 years?

- ☐ Paul Allen
- ☐ Bill Atkinson
- ☐ Dan Bricklin
- ☐ Jim Clark
- ☐ John Cocke
- ☐ Douglas Engelbart
- ☐ Wayne Erickson
- ☐ Federico Faggin
- ☐ Lee Felsenstein
- ☐ Bob Frankston
- ☐ Bill Gates
- ☐ Adele Goldberg
- ☐ Jack Hawley
- ☐ Andy Hertzfeld
- ☐ Grace Murray Hopper
- ☐ Steve Jobs
- ☐ Bill Joy
- ☐ Philippe Kahn
- ☐ Mitch Kapor
- ☐ Guy Kawasaki
- ☐ Alan Kay
- ☐ John Kemeny
- ☐ Brian Kernighan
- ☐ Jack Kilby
- ☐ Gary Kildall
- ☐ Donald Knuth
- ☐ Thomas Kurtz
- ☐ Ray Kurzweil
- ☐ Steve Leininger
- ☐ Bob Metcalf
- ☐ Jay Miner
- ☐ George Morrow
- ☐ Ted Nelson
- ☐ Robert Noyce
- ☐ Ken Olsen
- ☐ Adam Osborne
- ☐ Chuck Peddle
- ☐ Jef Raskin
- ☐ Wayne Ratliff
- ☐ Dennis Ritchie
- ☐ Claude Shannon
- ☐ Michael Shrayer
- ☐ Charles Simonyi
- ☐ Clive Sinclair
- ☐ Bjarne Stroustrup
- ☐ Ivan Sutherland
- ☐ George Tate
- ☐ Ken Thompson
- ☐ Jonathan Titus
- ☐ Jack Tramiel
- ☐ John Warnock
- ☐ Terry Winograd
- ☐ Niklaus Wirth
- ☐ Steve Wozniak
- ☐ Other _____

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The contest is open to all U.S. residents 18 years of age or older. No purchase necessary. An individual may enter regardless of whether or not he or she chooses to participate in the survey. Entrants should fill out their daytime telephone number where indicated. Limit: one entry per person.

Entries must be received by April 21 to be eligible for the drawing. The finalist will be determined in a random drawing to take place at BYTE. The winner will be announced in BYTE's September 1995 20th anniversary issue and will be contacted by telephone during working hours upon publication of the issue. Personal contact with the individual specified on the entry card must be made for the finalist to be declared the winner. The winner shall be required to sign an affidavit releasing McGraw-Hill, Inc., from liability in connection with use of the prize.

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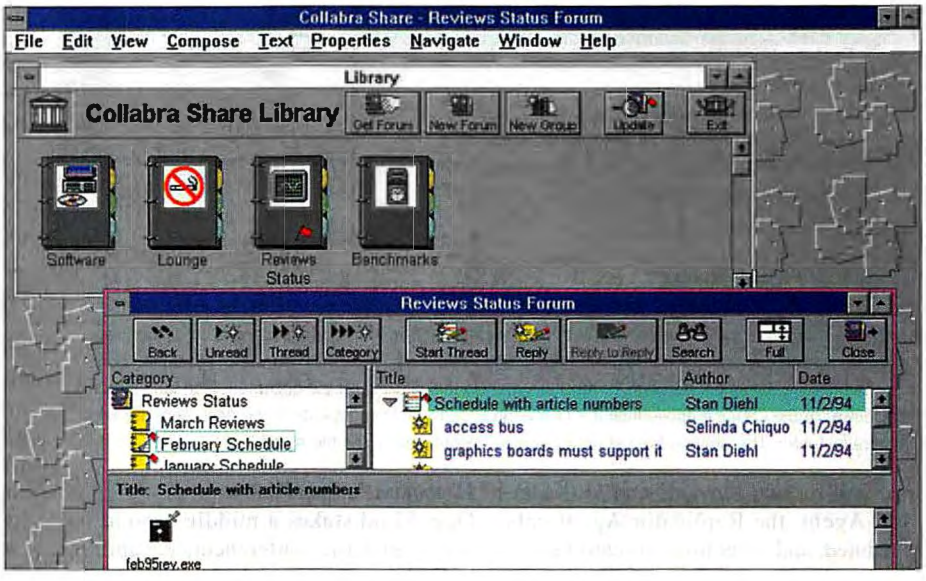
Workgroup Conferencing

Two new conferencing tools—Collabra Share and OpenMind—fill a niche between simple E-mail and Lotus Notes

REX BALDAZO AND STANFORD DIEHL



A Collabra Share Library. The notebook icons at the top of the screen represent forums. Double-clicking on the Reviews Status Forum opens the lower window. Discussion categories (e.g., March Reviews and February Schedule) appear in the upper left section of this window, with the threads from the selected category listed in the upper right section. The bottom section of the window displays the selected message. Double-clicking on the enclosure icon (labeled feb95rev.exe) launches the attachment. The red flags indicate unread messages.

E-mail is a great tool for person-to-person messaging, but it falls flat when you're coordinating a discussion among a group. Anyone who has ever cobbled together a group discussion using cc:Mail understands the problem: Traditional E-mail packages just weren't designed with workgroups in mind.

Two brand-new workgroup applications—Collabra Share and Attachmate's OpenMind—fill the gap, meeting workgroup-conferencing needs that aren't addressed by simple E-mail packages and for which Lotus Notes is overkill. Both Collabra Share and OpenMind build a structured environment for interactive discussions and information delivery. But the two products stake out different ground. Collabra Share delivers basic, easy-to-use workgroup conferencing over an existing LAN, while OpenMind offers a client/server platform for conferencing, document management, and customized work-flow applications.

We put Collabra Share and OpenMind to work across our editorial workgroup and gauged how well each met our own needs. The two programs differ in cost and functionality and represent two distinct alternatives to match specific workgroup requirements. If you demand even more from a workgroup platform, you should probably consider the Notes investment.

Collabra Share

Version 1.0 of Collabra Share delivers basic BBS-style conferencing over your existing network. It requires a DOS-file-compatible LAN operating system, such as NetWare or Windows for Workgroups, and runs on Windows 3.1; a Macintosh client is planned for this year. It doesn't support automated work-flow or document management features, but for such tasks as generating interactive workgroup discussions, refining ideas via collaboration and feedback, and distributing information across a department, Collabra Share is an effective, easy-to-use tool.

You set up various forums to hold related messages, and within each forum you can further group messages into categories (see the screen). Within a message you can put enclosures, such as a spreadsheet file or even an executable program. Double-clicking on the enclosure icon launches the appropriate application.

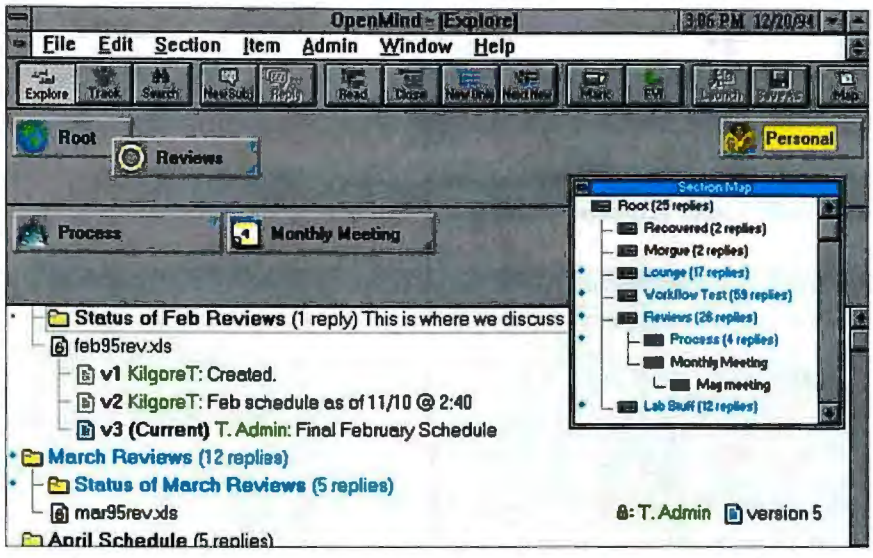
Collabra Share does not currently support application-specific viewers (a Word file viewer, for instance), so you can't view an attached file if you don't have the application it was created in. We got around this limitation somewhat by attaching Common Ground documents with viewers embedded in the file, but even a low-end conferencing system should include some standard viewers for the most popular applications.

The program has some convenient features for managing forums. You have the option of automatically deleting threads from a forum, based on either how old the threads are or when the forum exceeds a set size limit. This is controllable by forum, so each forum can have its own storage policy. And new participants are automatically prompted to join forums that are open to them.

Security is Collabra Share's weak point. Its forums must be installed in a full-access public directory so that all users have access. And the administration tools have no password protection, so the only security for those tools is what's provided by a local PC or the network. Collabra Software claims this problem will be remedied.

With Collabra Share's Enterprise Extension, you can extend your Collabra workgroup to participants beyond the reach of your LAN. You can join VIM (Vendor-Independent Messaging) or MAPI (Messaging API) E-mail users even if they don't license a local copy of Collabra Share. A Mail Agent checks any specified forum at an interval that you schedule. At the appointed time, the Agent checks the forum to see if new messages have been posted, and if so sends them out as mail messages to remote users. Any contributions received in the mailbox from those remote users is then posted to the forum.

A remote site can also establish its own Collabra Share workgroup and replicate



The OpenMind Explorer interface. Just below the toolbar are the section buttons. Below these are the subsection buttons (e.g., Process and Monthly Meeting). When you click on a section button, the lower half of the screen displays the contents of the section. Messages are contained within the folder icons. Note the multiple document versions of feb95rev.xls. Double-clicking on the document icon launches the Excel viewer or the creating application if it is available locally. Comments about the document are kept in a parallel folder. The Section Map at right gives an overall view of the hierarchy.

specified forums across E-mail. Like the Mail Agent, the Replicator Agent gets scheduled, and at set times it scans the forum, sending new messages to the remote Replicator. The remote Replicator does the same thing, so the two copies of the forum are kept synchronized.

Living with Collabra Share

We used Collabra Share for a couple of months and effectively managed some real work with it. We created forums for hardware testing, software reviews, benchmarks, and other key topics. We posted schedules, passed files, and distributed memos that normally would have gone out on paper. Of course, our lifeblood is generating articles for publication, so the lack of document versioning and control was a serious limitation for us.

We also noted some first-version immaturity. For instance, while Collabra Share allows the copying of threads both within a forum and among different forums, there is no move option, so after copying a thread you have to go back to the original and delete it. And when you delete a user with the administration tools, the identification file does not automatically get deleted, so the user can continue to participate in forums. You have to manually delete the user identification file.

The program's strengths are its easy setup, intuitive interface, and connectivity to remote sites. If you need a simple workgroup conferencing system, Collabra Share is an effective solution.

Attachmate's OpenMind

OpenMind stakes a middle ground between the basic conferencing capabilities of Collabra Share and the high-end groupware functionality of Lotus Notes. The OpenMind server currently runs only on Windows NT, and only Windows clients are supported, although a Mac client should be available by the time you read this.

OpenMind's conferencing interface takes some getting used to. Conference topics, called *sections*, can contain multiple levels of subsections beneath them. This can get confusing when you get a layered view of the sections you've traversed along with the subsections available from the current section (see the screen). The threads reside at the lower part of the screen and follow a familiar folder metaphor. Our workgroup found Collabra Share's interface more intuitive than OpenMind's.

As with Collabra Share, you can attach files to postings with OpenMind, but OpenMind supports a variety of viewers, allowing participants to view documents and spreadsheets without having the creating applications. If you want true document management, OpenMind tracks multiple document versions. You place a document in a folder, and it is stored on the server. You can then lock the document to make it read-only. When you update the document, a new version is created in OpenMind. The server stores only the changes to the original file, not multiple versions of the complete document.

You can also work on a file locally and then update the document from OpenMind. The document and discussions about it can all reside in the same parent folder. We found this structure an excellent vehicle for generating collaborative documents.

You can't extend discussions to E-mail-only participants, but OpenMind does let you replicate databases remotely to bring in other workgroups that license the OpenMind package. A publishing server forwards specified sections to a subscribing server. Any server can act as both a publishing server and a receiving server. You can connect to other servers via TCP/IP, IPX/SPX, NetBIOS, or a dial-in connection. A single user can also dial directly into the server for remote access.

If you need to create customized applications, OpenMind's support of OLE Automation puts it beyond Collabra Share and into closer competition with Lotus Notes. OpenMind Automation exposes 10 discrete objects, including the search engine or any specific section, folder, document, message, or attachment. An external program can then use OLE Automation functions to access and manipulate the objects.

For instance, the AddSearch function can launch the OpenMind search engine from an external program. You then use the Find function to return the results of the search. You can also use OpenMind's document-versioning capabilities to create a customized work-flow system out of

IF YOU NEED...	FOR EXAMPLE...	THEN BUY...
Basic group-conferencing capabilities with file attachments	A departmental workgroup requiring interactive discussions to generate ideas, solicit feedback, and distribute files and information	Collabra Share
Group conferencing with document management features	A product development team creating collaborative design specifications, manuals, and marketing materials	OpenMind
High-end workgroup features, including extensive knowledge bases	A technical-support department needing access to a variety of technical resources and a customized call-tracking system	Lotus Notes

Conceptual design by Robert P. Humeniuk and Jerry D. Flynn of McDonnell Douglas Space Systems

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other OLE-enabled applications.

Like Collabra Share, OpenMind suffers from some version 1.0 flaws. We found that users couldn't change a null password, for instance, and we couldn't get the SAP (Service Advertisement Protocol) to work; SAP advertises the SPX name to clients, so they don't have to know the server's address. And we experienced a couple of GPFs (General Protection Faults) on the Windows 3.1 clients. Fortunately, the NT server application was rock solid, so we never had to worry about losing data.

Groupware Alternatives

We found that OpenMind was not quite as inviting as Collabra Share for generating discussions within our workgroup, but many collaborative projects require the kind of document tracking and control that OpenMind handles well. You simply don't have document management features within Collabra Share or most other low-end conferencing packages.

OpenMind is an impressive release that we plan to keep up and running in the reviews department at BYTE. But if your applications require multiplatform clients; large, centralized databases; or integrated E-mail, you will have to step up to Lotus Notes. ■

Rex Baldazo is a BYTE technical editor who previously developed a workgroup system for collaborative documents. Stanford Diehl is director of BYTE reviews. You can reach them on the Internet or BIX as rbaldazo@bix.com and sdiehl@bix.com, respectively.

About the Products

Collabra Share 1.0
Workgroup Edition/10-user license.....$699
Enterprise Extension .....$899 per server

Collabra Software, Inc.
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True Multimedia Road Warrior

A big, bright color screen puts the best face forward on the full-featured multimedia ThinkPad 755CD

REX BALDAZO

If you've ever wondered how much functionality a notebook can deliver and still remain portable, IBM may have the answer for you. In a compact package weighing 7.3 pounds, the new IBM ThinkPad 755CD includes an impressive 10.4-inch color screen, an Mwave DSP (digital signal processor) for high-end audio functions, motion-video I/O ports, infrared ports, and a double-speed CD-ROM drive.

We got our hands on the newest ThinkPad for an extended evaluation, and while there are a few flaws, it is nonetheless a state-of-the-art portable for the power user. We were so impressed by an early look at the ThinkPad that we gave it the Best of Show award at Comdex last fall.

True Multimedia

The 755CD features an Intel 486DX/4 running at 100 MHz internal and 33 MHz external. It comes standard with 8 MB of RAM and a 540-MB hard drive. We ran the new BYTE Benchmarks (see "BYTE's New Benchmarks") to test overall performance and CDStone to test CD-ROM performance. The results show that the ThinkPad 755CD is a solid performer.

Video quality is outstanding. IBM calls its new display technology Black Matrix on Array, capable of 65,536 colors at a VGA resolution of 640 by 480 pixels. The ThinkPad also has a port to connect an external monitor.

The built-in Mwave DSP provides audio and telephony capabilities, including Sound Blaster emulation, audio recording and playback, modem (data and fax), and MIDI synthesizer. An adapter provided with the machine lets you connect standard MIDI devices, and it also doubles as a joystick port.

The double-speed CD-ROM meets MPC Level 2 specifications. On the CDStone tests, it posted respectable numbers for a double-speed drive. The CD-ROM's spring-loaded, rather than motor-driven, mechanism opens only when the ThinkPad is on; a smart feature that prevents accidental opening while the computer is stored.

Battery life was also respectable. Our Thumper 2 test, which simulates word processor use, managed a run of 4½ hours. But this does not utilize the CD-ROM. When we ran Rebel Assault, a CD-ROM arcade game that essentially runs the CD-ROM constantly, we managed a still-decent 90-minute battery life.

Front and rear infrared ports on the 755CD can communicate with another similarly equipped computer or peripheral (e.g., a printer). We tested them with Extended Systems' JetEye, which provides an infrared interface to most printers. The ThinkPad's infrared port must be pointed directly at and within a meter of the JetEye but it works well within those restrictions. No more plugging and unplugging cables to print from your laptop.

One of the more interesting features of the 755CD is the ability to capture or output NTSC and PAL video. An adapter that accepts either standard RCA or Super-VHS jacks plugs into tiny ports on the side of the 755CD. Audio is connected on the other side of the computer, through the Mwave DSP.

Presentations created on the ThinkPad can, in turn, be output to NTSC or PAL video. You can't use the ThinkPad for broadcast-quality video, but you can record presentations onto an ordinary VCR.

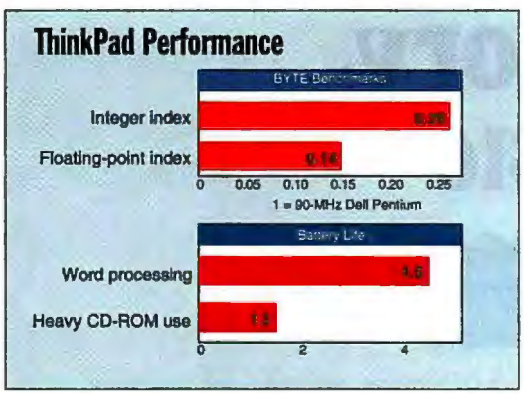
The IBM ThinkPad 755CD with removable CD-ROM and floppy drives.

The Art of Compromise

The ThinkPad 755CD comes close to replacing a desktop multimedia system, but you'll need to make a few compromises. You can remove the CD-ROM drive and replace it with the included internal 3½-inch floppy drive, but you can't have both. And installing the battery requires that you temporarily remove the CD-ROM drive. If the 3½-inch floppy drive is installed, the battery compartment is readily accessible. The extra overhang from the CD-ROM partially blocks the battery.

You lose some, you win a lot. At a suggested retail of over $8000, this isn't the portable for casual use. Except for its lack of a built-in network adapter, this machine is a capable desktop replacement and a groundbreaking integration of multimedia components into a truly portable computer. ■

Rex Baldazo is a BYTE technical editor. You can reach him on the Internet or BIX at rbaldazo@bix.com.



About the Product

IBM ThinkPad 755CD (8 MB of RAM)
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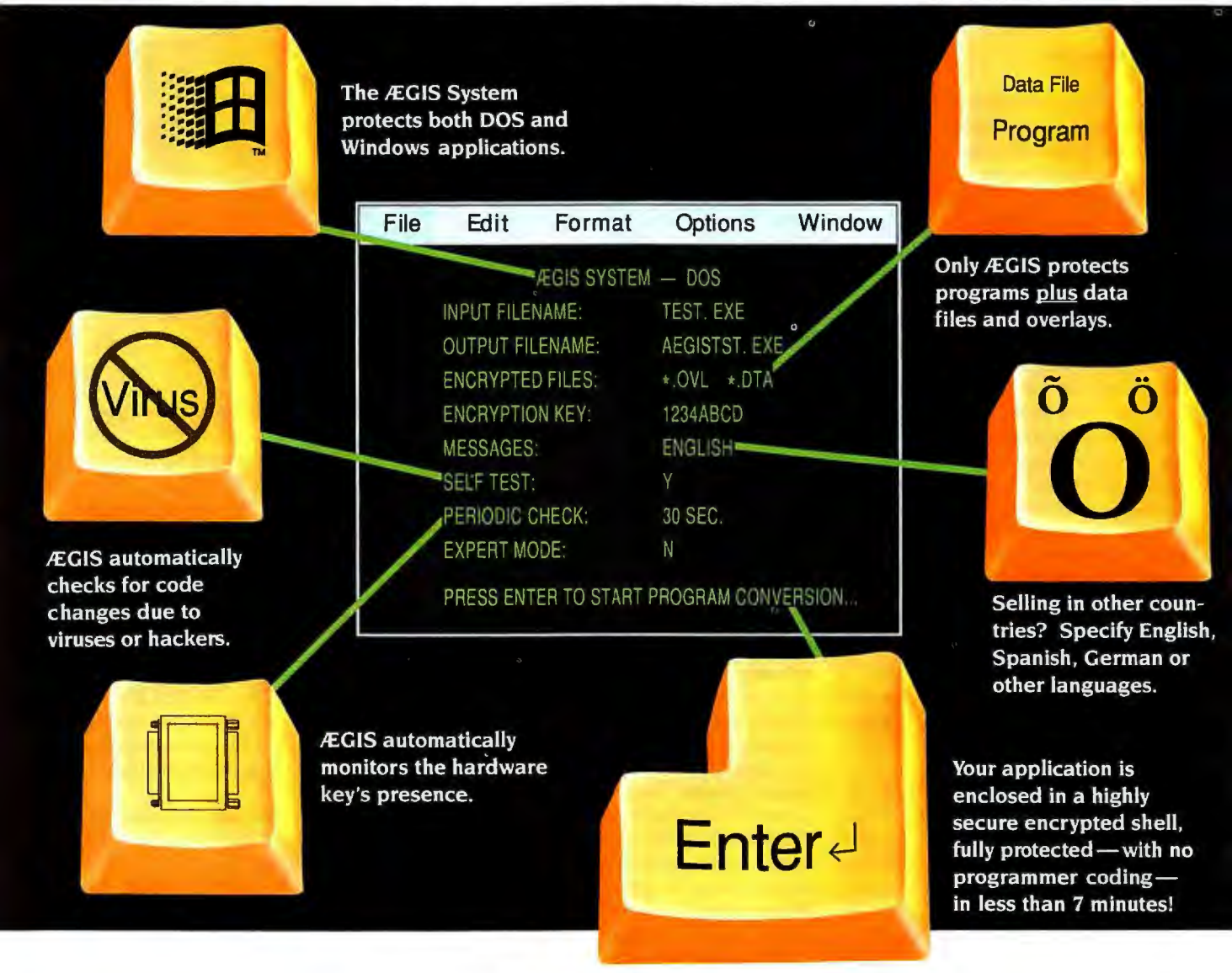

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Big Blue's Speed Trip

Fast, stable, and relatively easy to use, Warp is by far the best OS/2 yet. But is it good enough to displace Windows?

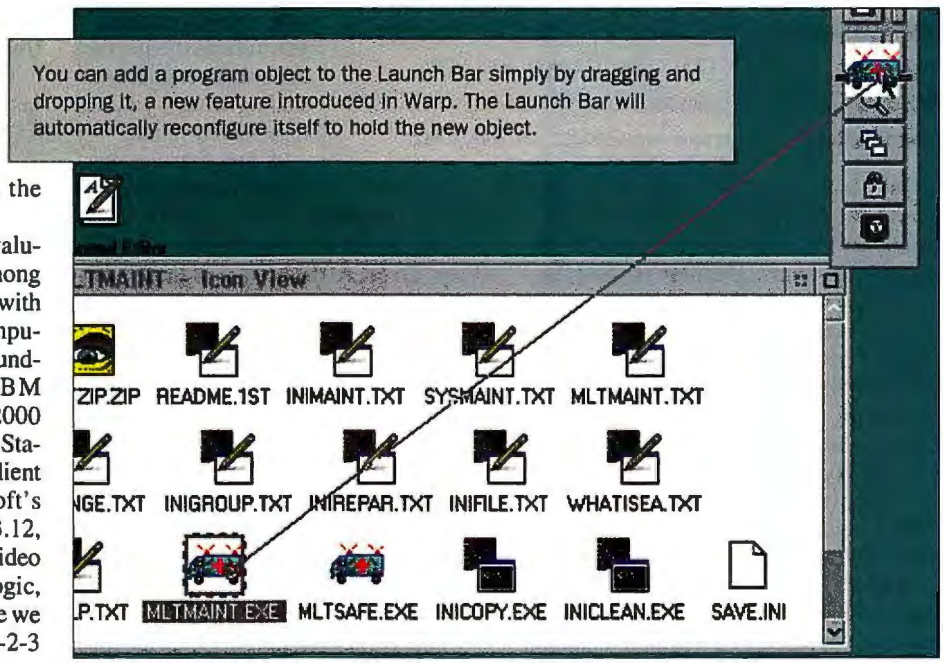
BARRY NANCE

A whirlwind of events accompanied the release of IBM's OS/2 Warp last October. Reports of bugs, recalls, and incompatibilities even reached the mainstream press.

To judge Warp for ourselves, we evaluated it on an even dozen computers, among them a Twinhead 486/33 notebook PC with 8 MB of RAM, an 8-MB 486/25 Compudyne equipped with a Creative Labs SoundBlaster card, a 4-MB 486/25 IBM PS/Value-Point, a 16-MB Gateway 2000 386/33, and a 32-MB 486/66 Zenith Z-Station 500. We networked Warp (using client software sold separately) with Artisoft's LANtastic for OS/2, Novell NetWare 3.12, and IBM's LAN Server 4.0. We used video adapters with chip sets from Cirrus Logic, Tseng Labs, ATI, and S3. The software we ran on top of Warp included Lotus 1-2-3 for OS/2, Microsoft Word for Windows, Microsoft Access, IBM's C Set++ 32-bit C compiler, IBM's DB2/2 relational database manager, Watcom's VX-REXX compiler, KnowledgeWare's Application Developer's Workbench, Datastorm's Procomm Plus, and the BonusPak applications that come with Warp.

With rare exceptions, we found Warp installed easily and ran applications, utilities, and development tools with great stability. During our testing, we also observed several important differences between Warp and previous versions of OS/2. Warp displays screen objects, especially the drives object, faster than before. Warp makes it easier than ever to avoid command-line sessions; a few minutes with the speedy new drives object encouraged us to switch to an object-oriented view of files. And Warp runs programs, albeit slowly, in low-memory situations in which earlier versions of OS/2 would have failed.

In fact, the few problems we had with Warp were caused by unsupported hardware or niggling bugs that we were able to work around easily. You should always be careful when adding a new video adapter, sound card, or other adapter to your computers: Device-driver support remains one of OS/2's few weak points.



You can add a program object to the Launch Bar simply by dragging and dropping it, a new feature introduced in Warp. The Launch Bar will automatically reconfigure itself to hold the new object.

BYTE Editor-at-Large Jon Udell examines the issue of Warp/Windows interaction and Warp's implementation of Win32 in this month's Core Technologies Operating Systems column, "A Warped Perspective."

A New Face for OS/2

Warp displays a configurable (and optional) "launch bar" that you use to start programs (see the screen). The launch bar can show text or just icons, be displayed horizontally or vertically, and hold the icons of frequently-used programs either on the launch bar or in drawers that you open and close. What's more, when you drag and drop a program's icon to the launch bar, the latter automatically configures itself. In general, Warp adds more drag-and-drop to OS/2's already object-oriented interface.

Warp changes the way OS/2 loads frequently-used DLLs into memory. Earlier versions of OS/2 refetched discarded code segments by loading and relocating functions from the DLL file. Warp, however, loads the DLL functions once and then pages them, with all address fixups and relocations already done, out to the swap file. Your SWAPPER.DAT file will be larger under Warp (in fact, you may want to preallocate the size of the swap file), but your system will be more responsive as a result. In addition, Warp offers a Windows fast-load option that you'll like if you frequently run Windows programs. The fast-load option tells OS/2 to initially run a small, do-nothing Windows program that gets Windows started. Thereafter, your Windows applications load without the overhead of first starting Windows. Unfortunately, OS/2 shut-down detects the do-nothing program as a still-running program and makes you manually close it before you can turn off your PC.

Warp lets you choose from a variety of new mouse pointers, and you can use Comet Cursor to make it easy to find and track the mouse pointer on monochrome displays. You set screen resolutions directly with the System object, so you don't have to open a command-line prompt to change resolutions. Additionally, Warp can automatically restart following an IPE (internal processing error) or CPU trap—a useful feature for file servers running LAN Server or LANtastic for OS/2.

A System Setup object can create a set of OS/2 bootable floppy disks for maintenance purposes. These utility boot disks

WARP-SUPPORTED VIDEO ADAPTERS AND CHIP SETS

ATI Technologies	ATI28800; VGA Wonder XL; Mach 8, 32, and 64
Cirrus Logic	CL-GD5422, -5424, -5426, -5428, -5430, -5434
Headland Technology	HT209
IBM	8514; XGA, XGA-2; VGA16, VGA256C
S3	86C801, -805, -805I, - 864, -928
Trident Microsystems	8900B, -C
Tseng Labs	ET4000, ET4000/32, W32, W32i, W32p
Weitek	Power9000, Power9100
Western Digital	Paradise and WD90C11, -24, -24A, -24A2, -30, -31, -33, -34

even have an option for removing OS/2 from your PC. A less drastic uninstall utility lets you remove portions of OS/2 from your computer. Each time it boots, OS/2 lets you press Alt-F1 to interrupt the boot process, at which time you can revert to an earlier CONFIG.SYS and INI file configuration, switch back to VGA resolution, or obtain a command-line prompt. If you modify your OS/2 configuration and then discover your PC won't boot, the new Alt-F1 behavior can save you from reinstalling Warp.

A new warp tool diagnoses such hardware problems as shared IRQs (interrupt requests). It displays a wealth of detail on IRQ assignments, adapter memory usage, SCSI addresses, and other system-level data. The Presentation Manager–based System Information Tool also displays such information, but not in as much detail.

Left to Your Own Devices

Warp includes drivers for more video adapters, printers, SCSI cards, and CD-ROM drives than earlier versions of OS/2 did. Unfortunately, the lists that pop up during installation are needlessly cryptic. The video list, for example, is still dominated by the names of chip-set manufacturers, not the video-card vendors with whom most users are familiar. The list of supported CD-ROM drives includes Chinon, Hitachi, IBM, Mitsumi, NEC, Panasonic, Philips, Pioneer, Sony, Texel, and Toshiba.

Many of the OS/2 complaints that IBM technical support handled center around video adapters, so the list of adapters supported by Warp is especially important. Warp comes with drivers for the products named in the table, "Warp-Supported Video Adapters and Chip Sets" on this page. Note, however, that Warp doesn't include drivers for some of these adapters' PCI (Peripheral Component Interconnect) versions.

SoundBlaster, Pro Audio Spectrum, and IBM sound cards work in Windows and OS/2 at the same time. However, you have to ignore the documentation on multimedia in the Information folder and leave the default settings alone, because if you follow the instructions about explicitly installing drivers, you will lose shared sound.

A few Internet messages complained about slow file transfers and dropped characters during serial communications under Warp. To get to the bottom of these problems, we talked to an acknowledged expert in OS/2 serial drivers, Ray Gwinn, a programmer based in Woodbridge, Virginia. Gwinn, who says he hasn't experienced the problems himself, offers a shareware replacement for IBM's COM.SYS and VCOM.SYS drivers called SIO.SYS and VSIO.SYS (in the IBM.OS2 conference on BIX), which offer better buffer support for 8250 and 16450 UARTs, the old but popular serial communication chips.

Under earlier versions of OS/2, the low-level printer support was interrupt driven, using IRQ7 for LPT1 and IRQ5 for LPT2. On the one hand, interrupt-driven print has low overhead and good throughput. On the other, IRQ conflicts with an 8-bit adapter (a sound card, perhaps), parallel cables that don't employ the pin-10 acknowledge line, and certain printers caused problems in previous versions of OS/2. Warp lets you choose between polled and interrupt-driven print, with polled the default. Some parallel ports and printers work acceptably with OS/2 polled printing, some do not. If you encounter this problem, you can add the IRQ command-line parameter to Warp's PRINT01.SYS device driver to control print modes.

Installing Warp

We recommend running Warp on at least a 386SX equipped with 6 MB of RAM (IBM says 4 MB), a mouse, VGA or some other supported video adapter (see the table, "Warp-Supported Video Adapters and Chip Sets"), 35 to 55 MB of hard disk space, plus up to 30 MB for the BonusPak components. Windows support requires use of the Windows 3.1, Windows for Workgroups 3.1, or Windows for Workgroups 3.11 distribution disks.

From floppy disk or CD-ROM, Warp installs on supported hardware easily and painlessly. It automatically and correctly detects most SCSI cards, video adapters, sound cards, and other system options. IBM publishes a list of computers and peripherals that work with OS/2 (you can download the list from FTP (file-transfer protocol) sites, such as ftp.cdrom.com). The list also contains drivers available from vendors and on-line sources.

Unfortunately, we found that the Warp install program incorrectly updated the CONFIG.SYS file on some PCs. On the Z-Station 500, for example, with the parallel port set to bidirectional, Warp wouldn't print unless we used the /IRQ command-line parameter in the BASEDEV=PRINT01.SYS statement (during a test of Warp's ability to reinstall itself, the install program had deleted the /IRQ parameter). The install program also insisted on inserting the Warp HPFS (High Performance File System) driver on a file server machine that was already running the LAN Server 386HPFS driver. The upshot is that it will sometimes be necessary to edit CONFIG.SYS after Warp has taken its best crack at configuring itself.

Running at Warp Speed

Technically, you can run Warp on a PC that has only 4 MB of RAM. However, in a low-memory environment, you won't be able to load Windows, multimedia software, or network software, and you won't be able to use the HPFS (which requires its own device driver and RAM cache). We found that a 4-MB machine could slowly run two and sometimes three DOS sessions, along with a small OS/2 program. With 6 MB or more, Warp begins to be useful and even speedy.

Warp multitasks nicely. You can run a Windows database program such as Microsoft Access in its own Windows session while you run other Windows programs in a separate session (if you have sufficient RAM). While Access is performing some long-running operation (e.g., table joins), you can switch to other sessions to continue working. Loading a Windows program can take a few seconds longer under OS/2 than under plain Windows 3.x, but once loaded, the programs run as fast as they would under Windows.

From Networking to Games

After installing Warp, we set up the Z-Station 500 as both a NetWare workstation (using the NetWare Client for OS/2 version 2.1) and a LAN Server 4.0 file server. ODINSUP, a requester module that comes

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Big Blue's Speed Trip

with the Warp NetWare client, lets both sets of network software use the Ethernet card; the computer shares its disk drives and locally attached laser printer at the same time it can access files on the NetWare server. As an added bonus, we were able to share the NetWare server's disk drives indirectly, via LAN Server 4.0, with workstations on the LAN. The workstations don't have to run NetWare client software to access the NetWare server (the access is slightly slower, however).

The OS/2 version of RPRINTER, a NetWare utility, services NetWare print queues, feeding jobs to the OS/2 print spooler. LAN Server also feeds its print jobs to the spooler. The OS/2 print spooler accepts and correctly manages print jobs from a variety of sources. In contrast, running the DOS-mode RPRINTER underneath regular Windows often caused Windows to crash.

About the Product

OS/2 Warp Version 3 .....$129
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At the other end of the computing spectrum, OS/2 runs game software rather well. One of our Warp users formerly had several DOS boot disks, each with a different EMM386 expanded/extended memory configuration, to run each of his games. Now, with OS/2, each program object in the desktop's Games folder can have its own memory and other settings. The user doesn't have to reboot to run a game and can run different games concurrently.

Apps? We Got Apps

The less-than-useful "productivity applets" found in earlier versions of OS/2 are gone, replaced by a set of Workplace Shell-enabled software called the BonusPak. The new BonusPak additions to Warp are true applications that make good use of object-oriented Workplace Shell features like pop-up menus, drag and drop, and templates. The BonusPak includes the following:

- **IBM Works** A word processor, spreadsheet, business charts, database, and report writer all in one package. It was previously a product called Footprint Works (from Footprint Software).
- **HyperACCESS Lite** A Presentation Manager–based, asynchronous terminal emulator from Hilgraeve.
- **Personal Information Manager** An integrated appointment calendar, to-do list, planner, and phone/address book. Formerly Arcadia's Workplace Companion.
- **FaxWorks** A send/receive fax application. FaxWorks can handle individual names or even distribution lists dragged and dropped from its phone book. The program is from SofNet, which is now part of Global Village.
- **IBM Internet Connection** TCP/IP over a phone line. Internet Connection uses SLIP (but not PPP) and a set of Internet tools that includes Gopher, NewsReader/2, an FTP client with drag-and-drop, and Telnet for both TTY and 3270 connections. A beta World Wide Web client, Web Explorer/2, should be an official part of the Internet Connection by the time you read this. You can connect to virtually any Internet provider with the Internet Connection, including IBM's Advantis network.
- **Multimedia Viewer** Extensions to MMPM/2 (Multimedia Presentation Manager/2), IBM's sound and video utility that has been bundled in previous versions of OS/2 for organizing and displaying GIF, PCX, and TIFF images. Web Explorer/2 uses the Multimedia Viewer.

Warp also comes with CIM (CompuServe Information Manager), IBM's MMPM/2 Video IN (based on Intel's Indeo technology), and a multiuser whiteboard-sharing product called Person to Person.

IBM's Best Shot

There's little doubt that Warp is a more mature operating system than the beta versions of its perceived nemesis, Windows 95. Unlike Warp, Windows 95 will have a hard time running in 4 MB of RAM. What's more, Warp lets you multitask 16-bit Windows applications in separate Windows sessions. Windows 95 still runs such programs cooperatively, not preemptively, so users will still be staring at the hourglass waiting, for example, for Excel recalculating to finish. And Windows 95 can't protect multiple DOS programs from crashing because it lets them share the same interrupt tables in memory, something Warp does not allow.

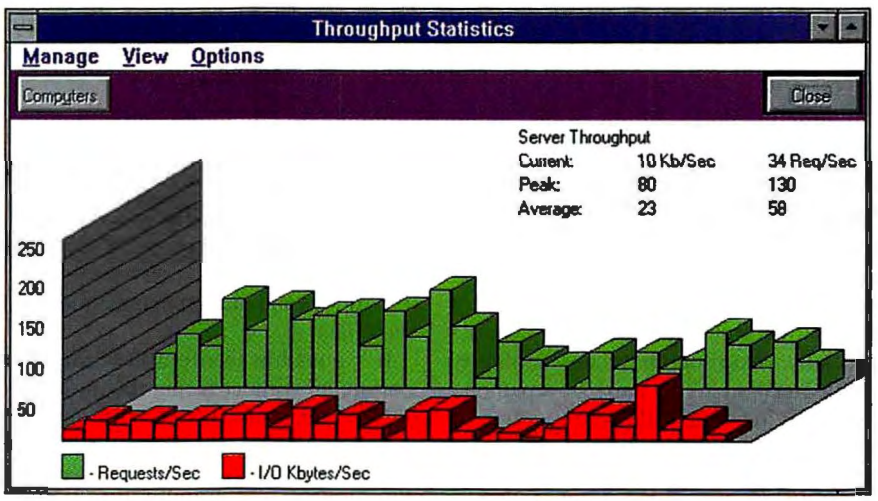
People already accustomed to DOS or DOS-plus-Windows and who have hardware that Warp supports will find it a refreshing, productive step up. ■

Barry Nance is a BYTE consulting editor and has been a programmer for 20 years. He is the author of Using OS/2 Warp 3.0 *(Que, 1994). You can reach him on the Internet or BIX at barryn@bix.com.*

Peer Power Upgrade

Tricky to install, CorStream extends LANtastic peer-to-peer networks by seamlessly integrating a NetWare 4.01 server into your installation

STAN MIASTKOWSKI



The CorStream server comes with a Windows-based monitor that displays server throughput graphically.

Peer-to-peer networks offer many advantages for small- to medium-size businesses. They're comparatively inexpensive and easy to install, and they don't require the expertise of a full-time system administrator. However, at some point, as businesses grow and network needs evolve, peer-to-peer users often find their networks start to slow down. When that happens, it's time to consider alternatives. Upgrading hardware or dedicating peer servers can improve things for a while, but they're usually only stopgap measures. Conventional wisdom says that for maximum network performance, you need a full-fledged, high-performance, server-based NOS (network operating system), such as market-leading Novell NetWare.

If you're already running LANtastic, one of the leading peer-to-peer networks, Artisoft offers CorStream, an alternative to starting from scratch with a new network installation. The heart of CorStream is a NetWare 4.01 run-time module that Artisoft licensed from Novell. It offers all the performance advantages of a true multitasking, multithreading 32-bit NOS. The kicker is that Artisoft has surrounded the complexity of NetWare with a Novell-certified LANtastic NLM (NetWare loadable module). This offers distinct advantages to both users and system managers. Users "see" the CorStream server as just another LANtastic resource that they access and use just like any LANtastic server.

In many ways, CorStream is a quirky product. While it offers impressive power and ease of use once it's up and running, it can be a bear to install. And if you want to use your CorStream server to go beyond the innate abilities of LANtastic clients (using readily available NLM-based software or hardware, for example) you may run into problems. According to Artisoft, a high-performance dedicated server was a logical addition to the company's product mix, because the majority of LANtastic users already dedicate LANtastic 6.0 machines as servers, and many asked for a more powerful alternative. That certainly makes sense, but at the same time, Artisoft seems unusually coy about providing the detailed information that's needed for both installing and administering a CorStream network. The documentation is sparse and often confusing, and it is missing both essential information and the type of background data that's essential to understanding what you're doing. If you're not familiar with NetWare—and CorStream is designed for people who aren't—it's easy to get confused during installation.

The Real World

We installed CorStream in an environment that badly needed more network power: a tax accounting office currently running 12 LANtastic 6.0 systems—10 workstations, one dedicated server and laser printer, and one combination server/workstation. Even with 486/50-based servers running caching controllers and SCSI hard drives, the heavy transaction processing and printing needs during the height of tax season caused unacceptable network response. This installation was an obvious candidate for a NOS upgrade, and because all users and the manager who administers the network were well-versed in LANtastic, CorStream seemed the obvious choice.

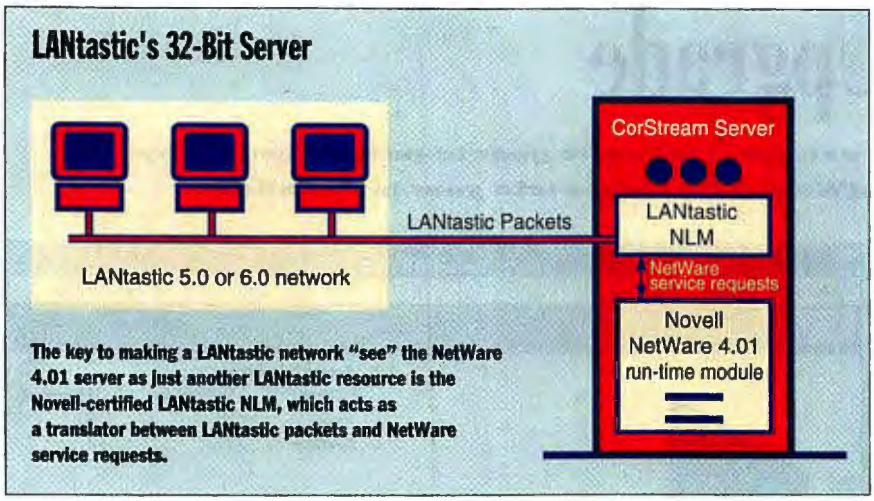
It goes without saying that to get the most from NetWare, you need capable hardware. But in the real world of small businesses, budgets are tight. CorStream comes packed with an EISA NIC (network interface card) from Artisoft subsidiary Eagle Technology, so an affordable EISA system (still the industry standard for file servers) was the logical choice.

The crucial component in planning a server is hard disk storage needs. Keeping in mind future storage demands, we settled on 2 GB of hard disk space. In NetWare, RAM requirements are closely tied to installed hardware, and one area where the CorStream manual is helpful is planning RAM requirements. You start with 10 MB for NetWare itself, then use the supplied formula to figure RAM requirements based on hard disk space. You also need extra RAM if you'll have a printer connected to the server, likewise for a CD-ROM drive. And the more extra RAM you have over and above the minimum, the better the performance: NetWare uses it for cache buffers.

We put together a complete system with an EISA motherboard, a 486/66 CPU, 32 MB of RAM, an Adaptec 2740 EISA SCSI adapter, and dual Micropolis 1 GB hard drives for $3600, a substantial savings over a prepackaged system.

Into the Fray

Installing CorStream isn't a job to do when you're under deadline, stressed out,



The key to making a LANtastic network "see" the NetWare 4.01 server as just another LANtastic resource is the Novell-certified LANtastic NLM, which acts as a translator between LANtastic packets and NetWare service requests.

or working at 3 p.m. on a Friday. There's no getting around that it's complex, especially if you don't have any familiarity with NetWare. You must sit down and carefully read the installation section of the manual before you begin. You'll also need to gather the right NetWare drivers for your hardware. A LANtastic 5.0 or 6.0 network must be up and running on the workstations that you'll be using with the CorStream server, and the server hardware must already be connected to the existing network.

At the end of the approximately 1-hour server installation process, NetWare boots up, and you must go to a LANtastic workstation elsewhere on the network to finish installing the server files. But we didn't get that far; the server locked up tight while trying to boot.

After nearly a week of work and hours of phone calls, the problem turned out to be the server motherboard, which wasn't NetWare certified. Installing a new motherboard immediately solved the problem. A painful lesson learned: Make sure all your components—NIC, hard drives, and motherboard—are NetWare certified.

In the Trenches

Once CorStream was installed, the new server immediately became visible to all LANtastic workstations on the network because the installation creates a default "wild card" account that allows all accounts to log into it. Running the standard LANtastic NET MANAGER utility enabled network security. The CorStream NLM has all the access and security features of LANtastic, allowing tight control over who gets access to what and when. ACLs (access-control lists) offer a great deal of versatility, letting the system manager control access to resources (e.g., drives and printers), directories, and even files.

It's possible to run and administer CorStream without facing the intricacies of NetWare. In fact, once CorStream is set up and running, you seldom have to venture into NetWare at all. There are exceptions, though. For example, shutting down CorStream requires entering the NetWare console and typing the `DOWN` command, and there are a few things you can't do from LANtastic. For example, although the CorStream installation sets up a default printer resource, adding another printer or changing the port requires the NetWare PCONSOLE utility.

Many users, though, will want to learn about how NetWare works. However, except for a section in the CorStream manual on NetWare's MONITOR utility, the manual says little about NetWare. Fortunately, Artisoft includes a CD-ROM that contains complete NetWare documentation in a searchable format.

Performance Power

Because the CorStream NLM acts as an intermediary between LANtastic and NetWare, translating LANtastic packets into NetWare service requests, you might expect a performance hit. But whatever extra overhead is added, it's more than made up for by the fast hardware and 32-bit NOS. Overall, CorStream server performance was nearly five times that of the LANtastic 6.0 server. That number, while impressive, isn't really surprising.

CorStream uses a NetWare run-time module, so some of the features of full-bore NetWare are missing. But they're generally those used by large installations, such as NDS (NetWare Domain Services), that allow single log-ins to multiple servers. For multiple disk installations, CorStream offers built-in disk mirroring, duplexing (mirroring using multiple controllers), and spanning (having multiple disks appear as one volume). CorStream also enables NetWare file compression. Any file that hasn't been accessed after a specified period of time (seven days is the default) is automatically compressed. If you call for it later, it's automatically decompressed.

NLMs are common in the NetWare world and are used for a wide variety of functions, such as adding a tape backup unit or management utilities. But one "gotcha" in CorStream is that not all NLMs work. Because the NetWare run-time module in CorStream is a two-user version, NLMs that track NetWare licenses won't work beyond two users. The same is true of NLMs that require the NetWare protocol stack on each workstation. A list of supported NLMs should be available by the time you read this.

Making Choices

Despite its complex installation process, CorStream is well worth looking at if you need more performance from a LANtastic setup, or even if you're not currently running LANtastic. (CorStream packages are also available with LANtastic 6.0, at a 10- to 30-percent premium, depending on the number of users.) On the other hand, if you're willing to wrestle with the daunting complexity of full-fledged NetWare and need enterprise-wide solutions with full NLM compatibility, a regular NetWare setup is a better choice. (LANtastic 6.0 comes with built-in NetWare client capabilities.) But at the bottom line, CorStream is a great value, delivering most of NetWare's functions wrapped in the easy and familiar LANtastic interface at about half the price of full-bore NetWare. ■

About the Product

CorStream
5 users, $749; 10 users, $1449; 25 users, $2399; 50 users, $3199; 100 users, $4449; *with LANtastic 6.0:* 5 users, $899; 10 users, $1599; 25 users, $2749; 50 users, $3499; 100 users, $5799

Artisoft, Inc.
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Tucson, AZ 85745
(800) 233-5564
(602) 670-7100
fax: (602) 670-7101
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Stan Miastkowski is a BYTE consulting editor and co-author of the Windows for Workgroups Bible *(Addison-Wesley, 1993). You can contact him on the Internet or BIX at stanm@bix.com.*

Network Storage Economizers

HSM is an increasingly popular way to control the cost of networked storage. Here's how three PC LAN-based products compare.

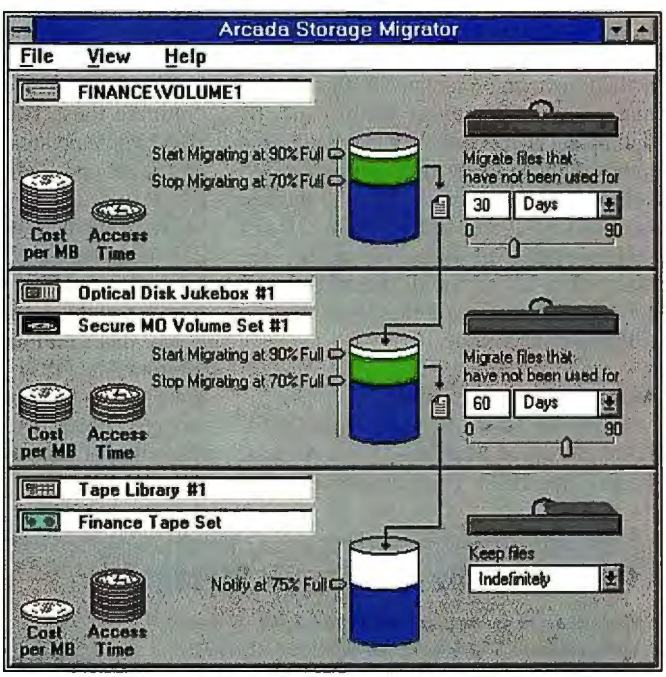
BARRY NANCE

While the cost of hard drives has dropped below 50 cents per megabyte over the past year, the cost of managing LAN data has, ironically, risen. The intangible cost of LAN data management is close to $8 per megabyte per year, according to Mike Peterson, president of research firm Peripheral Strategies (Santa Barbara, CA). Even if you discount so-called intangible costs and rely only on hard figures, the out-of-pocket cost of adding storage to a LAN can mean paying for a file-server computer, the server NOS (network operating system), a backup device for the server, and other components. These costs dwarf the price of the hard drive itself. To help reduce the cost of data management, manufacturers are beginning to offer a technology known as HSM (hierarchical storage management) on PC LANs.

Previously available on mainframes and Unix-based computers, HSM lets you automate the migration of LAN data to and from file-server hard drives to slower but larger-capacity devices. However, it is not a substitute for reliable backup procedures: You still must implement a backup/restore mechanism for the data on your LAN. Rather, HSM extends the storage capability of file servers. It moves older, infrequently used files from primary storage (the file server's hard drives) to secondary storage (optical read/write media and magnetic tape). The figure "The Hierarchy of Network Storage" on page 138 shows the price, speed, and capacity trade-offs for the different types of storage media.

To state the concept in different terms, HSM provides *on-line* storage of frequently used files and *near-line* storage of other files. It automatically and transparently moves files to and from near-line storage as it extends the storage capacity of file servers. A person at a LAN workstation who accesses a migrated file incurs a slight delay lasting a few seconds to half a minute while the HSM software "demigrates" a file. HSM is particularly well suited for situations involving many large files (e.g., images of documents) when only a subset of those files needs to be on-line at any one time.

These products are for serious LANs. Installation and setup time is hefty, and two of the reviewed products require multiple file servers with multiple volumes on each server. You might even need to install additional RAM in your file servers; NetWare doesn't offer virtual memory management, relying on physical RAM to hold all the programs running on the server.



HSM technology lets network administrators develop a customized strategy for tiered storage. The main control screen in Arcada's Storage Migrator lets you establish rules for file migration, such as high/low "watermarks" for each type of storage (shown here as cylinders) and the ages and sizes of files to be migrated.

Know Your Place in the Hierarchy

Peripheral Strategies has identified five levels of HSM that are widely accepted as guidelines by the HSM industry. Level 1 is simple automatic migration with transparent retrieval. Level 2 adds real-time, dynamic load balancing of free disk space based on predefined thresholds. Level 2 also can manage two or more layers of near-line storage (e.g., an optical jukebox and magnetic tape library). Level 3 provides for the management of three or more layers of storage hierarchy and

HOW HSM PRODUCTS COMPARE

	AVAIL'S NETSPACE	PALINDROME HSM	ARCADA'S STORAGE MIGRATOR
Demigration speed* (in seconds)			
• Optical jukebox	3.1	3.4	3.1
• Tape library	12.0	12.0	12.0
Temporary recall for browsing	▲	△	△
Temporary off-line storage	▲	▲	△
Requires dedicated server	▲	△	▲
Needs TSR to cause demigration	△	▲	△

▲ = yes △ = no

*In the demigration speed test, we forced a file onto the optical jukebox (using the same disk for each test) and then onto the magnetic tape library (the same tape cassette in the same position in the tape magazine). We then measured retrieval times.

dynamically balances the consumption of available space in each layer. Level 4 HSM products can migrate files based on data type and other criteria, through the use of policies (rules). Products that conform to level 4 preserve ownership, attribute, and location information about files, thus allowing multiplatform (DOS, Macintosh, OS/2) HSM. Finally, level 5 identifies HSM products that can work with database manager software, such as DB2/2, NT Server, or Oracle, to migrate portions of a database (rather than an entire file) to and from secondary storage. There are, as yet, no level 5 HSM products; the most advanced of the three reviewed here implements level 4 features.

Migrating old or infrequently used files onto inexpensive media such as removable optical disks or tape not only frees up primary storage space for more current files but also reduces the average cost of storage. Thus, instead of expanding your LAN in an on-line fashion, you can use HSM to begin expanding it in a more controlled, near-line manner. HSM can also increase overall network performance by optimizing access times for the data you're most likely to need. In a complex HSM setup, you might have ultrafast cached hard drives layered above slower 10-GB single-spindle drives, which are layered on top of a 20- or 40-GB optical jukebox for near-line storage, in turn layered above a 192-GB tape library.

About the Test Environment

We evaluated three HSM products for PC LANs: Storage Migrator, from Arcada; Palindrome HSM, from Palindrome; and NetSpace, from Avail. All three are actually NLMs (NetWare loadable modules) that run on a NetWare file server. Storage Migrator and NetSpace fit approximately into level 4 of HSM, while Palindrome HSM is a level 3 program. Further research revealed new HSM and HSM-like products you'll want to be aware of (see the text box on page 142), as well as a single-user HSM program reviewed in "A Smaller Version of Infinity" (page 140).

The NetWare 3.11 environment we created for evaluating HSM products included an ADIC 1200D DAT (digital audiotape) Autochanger, which holds 12 DDS (digital data storage) tapes with a total capacity of approximately 192 GB, and a 20-GB Hewlett-Packard 20XT optical disk drive. Both units feature hands-off operation and act as robotic librarians when retrieving files. The ADIC Autochanger and HP optical drive not only provided a good platform for HSM evaluation but are typically the hardware HSM vendors recommend to customers.

We used several criteria to measure and compare these HSM products. A good HSM implementation should support several layers of media hierarchy and offer hands-off media independence. HSM software should use a rules engine that understands capacity and time thresholds, exceptions by file type, and forced migration. It should also optimize migrations in a way that minimizes the need for remigration. And HSM software should demigrate files quickly, as fast as the secondary storage allows. All three products do all these things, but in different ways and to differing degrees.

Avail's NetSpace

The first HSM product for NetWare LANs, Avail's NetSpace 3.0, is primarily a collection of NLMs. These NLMs include an HSM Engine, a Server Monitor that displays system activity, a Media Maintenance Manager that allows changing of tape library magazines, a Device Maintenance Manager for changing near-line storage devices, a Database Recovery Manager for repairing NetSpace files after a server crash, a Backup Manager for scheduling the rotation of multiple NetSpace migration sets, and a Recall Initiator that recalls files from near-line storage.

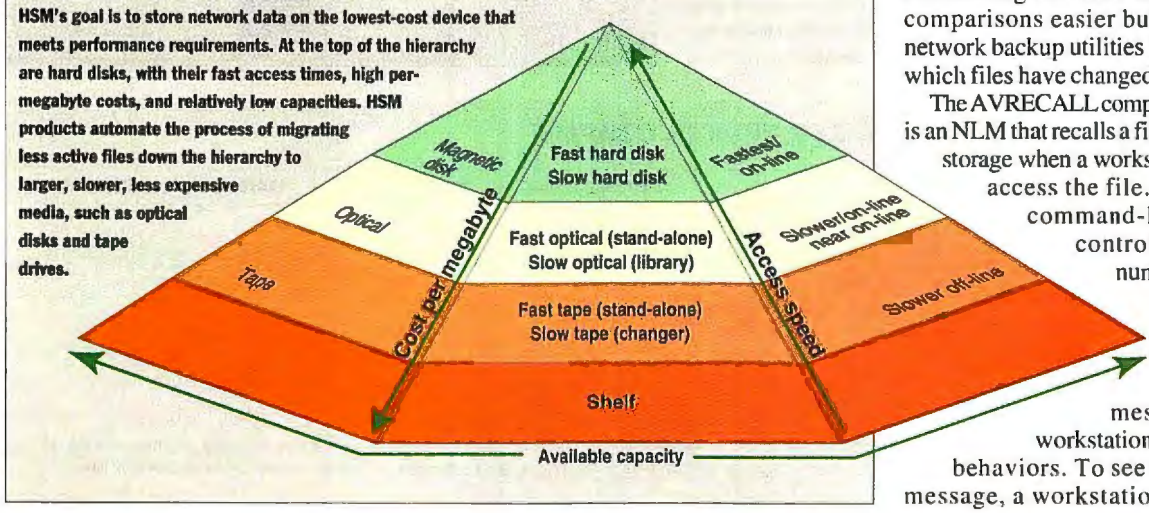
NetSpace requires a dedicated NetWare server (which it calls the Storage Server) with at least three same-size migration partitions, or NetWare volumes. A second NetWare server, termed the Domain Server, stores the NetSpace administrative programs and holds duplicate data files for the Storage Server. NetSpace stores migrated files on the Storage Server's hard disk and, optionally, on optical media and magnetic tape.

When NetSpace migrates a file from a file server it manages, it leaves a phantom file, or placeholder, behind. NetSpace stores a 420-byte link to the actual file in secondary storage in either the placeholder file or, if you load the NetWare name-space NLM and if the backup software supports name-space extended attributes, in extended attributes. At installation time, you choose whether NetSpace should change or preserve the last modified date attribute for the placeholder file left on the file server. Preserving the date makes directory comparisons easier but prevents some network backup utilities from recognizing which files have changed.

The AVRECALL component of NetSpace is an NLM that recalls a file from secondary storage when a workstation attempts to access the file. AVRECALL's command-line parameters control the maximum number of recalls per connection per hour, whether to send recall notification messages to the workstation, and other recall behaviors. To see the notification message, a workstation must load the

The Hierarchy of Network Storage

HSM's goal is to store network data on the lowest-cost device that meets performance requirements. At the top of the hierarchy are hard disks, with their fast access times, high per-megabyte costs, and relatively low capacities. HSM products automate the process of migrating less active files down the hierarchy to larger, slower, less expensive media, such as optical disks and tape drives.



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[1]Refer to minimum requirements. Some configurations may not be compatible. [2] For the name of an IBM Authorized Business Partner, call 1 800 772-2227. Hours of availability are M-F, 9:30 a.m.–9:00 p.m. EDT. [3]Dealer prices may vary. MB means million bytes. IBM and Options by IBM are registered trademarks and There is a difference is a trademark of International Business Machines Corporation. All other products and/or company names are trademarks or registered trademarks of their respective companies.

AVRSPND TSR program, which displays a message while demigration occurs. The TSR isn't needed to notify AVRECALL of an access to a placeholder. However, without the TSR, NetSpace users can't cancel a demigration operation once it's started.

NetSpace ensures that sufficient space always exists for migrated files and (like Palindrome HSM) can temporarily move files to off-line storage when file-server disk space runs low. NetSpace automatically queues the off-line data for a file-restoration operation when server disk space increases. NetSpace can also allow viewing, browsing, or searching (but not altering) of migrated files without permanently recalling those files to on-line storage. After the file browse or search operation, NetSpace returns the file to hierarchical storage.

Another NetSpace NLM, AVLOGMON, runs on managed file servers and allows backup utilities and virus-protection programs to open placeholder files without causing the actual file to migrate from secondary storage. AVLOGMON can also temporarily disable migration during backup and restore procedures, thus ensuring that a backup or restore operation occurs when the server's files are in a consistent state.

Palindrome HSM

Palindrome's Network Archivist (PNA) backup utility software is well known among LAN administrators, and the company's HSM product acts as an extension to PNA. Palindrome HSM 3.1a adds automatic file retrieval and multiple media-type support to PNA, which must be installed on the same server as the HSM components. However, the HSM component doesn't require a dedicated NetWare server.

Palindrome HSM consists of NLMs and DOS/Windows software. The Volume Monitor NLM, PALVMON, performs several tasks. It monitors disk-space use, maintains lists of files eligible for migration (Palindrome calls them *prestaged lists*), converts migrated files into placeholder files, and notifies an administrator of HSM error and alert conditions. The Volume Monitor delegates some tasks, such as the actual migration operation, to the HSM Engine NLM, PALVENG. Another NLM, the Recall Server (PALRECAL), receives requests to move files from secondary to primary storage. The Archivist Queue Server NLM, PALQSVR, performs the actual demigration of the file.

An administrator can configure Palindrome HSM to migrate files as soon as a NetWare volume begins to run out of space (a condition called Event Migration), and can specify the amount of disk space associated with the event. The default high watermark is 90 percent full. Migration continues until the prestaged

A Smaller Version of Infinity

STANFORD DIEHL

If you're not ready to spend thousands of dollars on full-blown networked HSM, there's an affordable way to test the concept on a small scale. Infinite Disk 2.1 ($129) from Chili Pepper Software ((800) 395-1812 or (404) 339-1812; fax (404) 513-7411) adapts the HSM concept to your personal desktop. As unused files age on your hard disk, Infinite Disk automatically migrates them to tiered storage.

The first level of migration is file compression. If you haven't used a file for a specified length of time (the default is 12 days), Infinite Disk compresses it onto the hard disk. If the file is still inactive after three months (or after any interval you specify), Infinite Disk removes it from your hard disk and stores it to off-line media, leaving a zero-length pointer behind. When you access the file, Infinite Disk automatically restores it to the hard drive.

It's a slick idea and a godsend for electronic pack rats who never seem to have enough disk space. Even if you're fairly diligent about deleting old files, you might need help winnowing out those obsolete files accumulating in your Windows directory. And Infinite Disk doesn't require endless disk management sessions. Installation is a breeze, and disk migration is fully transparent.

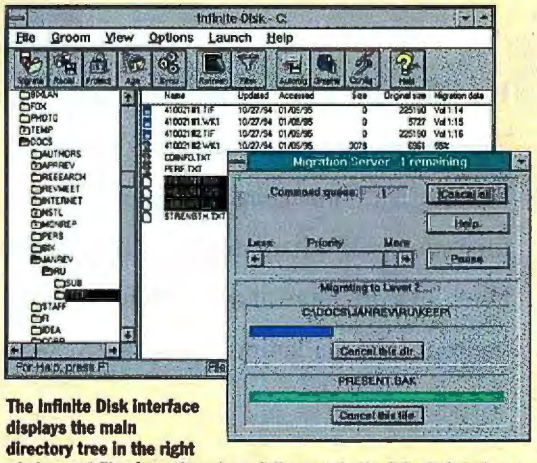
Chili Pepper designed Infinite Disk as a "hands-off" solution: You install the software and let it do its thing. Consequently, for the most part, you must buy into its philosophy of full automation. You can't, for instance, access the off-line archive directly to remove files from it. The archive simply keeps growing as files are moved into it, and there's no way to remove files except by first restoring them to your hard drive.

Infinite Disk supports any off-line device with a DOS drive letter assigned to it. However, one obvious off-line storage technology—streaming magnetic tape—is not directly supported. Infinite Disk Pro, which should be available by the time you read this, will support QIC (quarter-inch cartridge) tape drives. It also has a redesigned interface and will have a list price of $149.

The Limits of Infinite Disk

We tested the software with floppy disks, an Iomega 150 MultiDisk Bernoulli box, a MicroSolutions Backpack parallel-port hard drive, network drives, and a Pinnacle Micro M/O drive as off-line storage devices. We even got around the tape-drive limitation by using a slick utility from TapeDisk ((800) 827-3372 or (715) 235-3388, fax (715) 235-3818). The company's TapeDisk software can assign a DOS drive letter to most SCSI tape drives, making them visible to other Windows or DOS applications (including Infinite Disk).

We had some complaints about the software interface. Like Windows' File Manager, Infinite Disk displays the main



The Infinite Disk interface displays the main directory tree in the right window and files from the selected directory in the left window. Icons show files that have been compressed (level 1 migration) and archived (level 2 migration). Infinite Disk also installs as a menu option in the Windows File Manager.

list of eligible files is exhausted or available primary storage increases to a specified low-watermark level (the default is 80 percent).

The administrator can also direct Palindrome HSM to migrate files to secondary storage at a particular time of day on one or more days (a procedure termed Scheduled Migration). In this mode, Palindrome HSM begins migrating files without regard for how much disk space is left. Scheduled migration proceeds until the list of eligible files is exhausted or the amount of free space increases to the specified low watermark.

The administrator instructs Palindrome HSM to use one of three strategies in building the list of eligible files: least recently used, largest file, and most eligible. A file is most eligible if its last access date is prior to the last access date of other eligible files; most eligible status puts such a file near the top of the list.

During migration, Palindrome HSM by default leaves a zero-byte placeholder on the file server. Palindrome HSM's demigration of files (the recall process) uses a combination of workstation and server software; the workstation software intercepts a file access operation performed on a placeholder and sends a request to the Recall Server NLM running on the server. DOS-based workstations load an 11-KB TSR agent to intercept file operations, while Windows workstations use a Windows VxD (virtual device driver) to watch for accesses to placeholders.

The TSR can be a problem in memory-constrained DOS workstations (though Palindrome notes the TSR can be loaded high) and offers only a single DOS session on OS/2-based workstations. The TSR does, nonetheless, give impatient users a chance to cancel demigration of the file. Palindrome says it is working on a version of HSM containing an NLM that notices accesses to migrated files without depending on recall notification by a TSR agent. As of now, it's the only one of the three products reviewed that requires a TSR to handle demigration. (Regardless, you can optionally use Palindrome HSM's File Manager program to manually request demigration of files.)

directory tree in a left window and subdirectories and files in a right window. But we couldn't get Infinite Disk to alphabetize the main directory tree by name (as you can do in File Manager), so it was hard finding directories quickly. And you can't double-click on subfolders from the secondary tree (right window) to navigate through folders; you can open folders only from the main directory tree. This limitation can be annoying, especially if you're accustomed to working in File Manager.

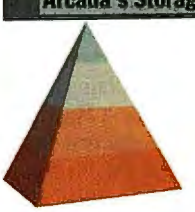
We also wanted to delete and move files from the interface, but there was no delete option. The DOS version supports file deletions, but the Windows version doesn't. If you're sifting through your hard disk looking for old files to migrate, you should be able to quickly delete files that you know are no longer needed. The good news is that Infinite Disk also installs as a menu item in the Windows File Manager, allowing you to migrate files, recall files, or protect files (preventing migration) directly from the File Manager interface.

Infinite Disk uses conventional DOS memory even when running in Windows (on the plus side, the program's TSR takes up about 30 KB of low memory, and the new version will require only 9 KB). During our evaluations on a 60-MHz Zeos Pentium, we had to free some conventional memory to get the software to work properly. On a few occasions, the software inexplicably bumped us out of Windows, dumping us to the DOS prompt. But we never lost data or had trouble accessing migrated files.

Automated Disk Maintenance

Infinite Disk is best suited for users who want a transparent solution to disk management. If you're running low on disk capacity but you don't have the time or temperament to clear away the usual jumble of unneeded files, Infinite Disk will do the job for you.

Arcada's Storage Migrator



Previously sold by Conner Peripherals as Conner HSM, Arcada's Storage Migrator 3.0 is a modified, earlier version of Avail's NetSpace. Arcada adds to Avail's software its own Infinet View graphical tool for tracking and managing migrated files across optical-disk and magnetic-tape media. InfiNET View provides administrators with information about file location, server use, and jukebox use (including remaining free space). The utility can show an administrator when files last migrated from one location to another, for example. Storage Migrator also includes some network management tools for producing reports and statistics on system storage operations.

As you'd expect from its ancestry, Storage Migrator is very similar to NetSpace in both architecture and daily operation. However, Storage Migrator lacks the ability to move files temporarily to removable off-line storage, and it also doesn't distinguish between mere file viewing (or searching) of migrated files and recall of a

About the Products

Infinite Disk 2.1 ..... $129
Chili Pepper Software
1630 Pleasant Hill Rd.
Suite 180-200
Duluth, GA 30136
(800) 395-1812
(404) 339-1812
fax: (404) 513-7411
Circle 1016 on Inquiry Card.

NetSpace 3.0 ..... $2749
Avail Systems
4760 Walnut St.
Boulder, CO 80301
(800) 962-8245
(303) 444-4018
fax: (303) 546-4219
Circle 1002 on Inquiry Card.

Palindrome HSM 3.1a $2995
Palindrome Corp.
600 East Diehl Rd.
Naperville, IL 60563
(800) 288-4912 ext. 375
(708) 505-3300
fax: (708) 505-7917
Circle 1003 on Inquiry Card.

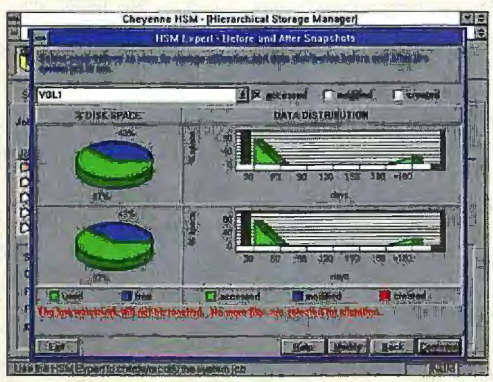
Storage Migrator 3.0 ..... $7500
(for two managed NetWare servers)
Arcada Software
37 Skyline Dr.
Suite 1101
Lake Mary, FL 32746
(800) 327-2232
(407) 333-7500
fax: (407) 333-7770
Circle 1004 on Inquiry Card.

TapeDisk $249.95
TapeDisk Corp.
85 Cove Lane
Oshkosh, WI 54901
(800) 827-3372
(715) 235-3388
fax: (715) 235-3818
Circle 1017 on Inquiry Card.

The Emerging Faces of HSM

The three products highlighted in the accompanying review aren't the only ones that take advantage of HSM technology. A recent boom in HSM introductions includes stand-alone products from major storage management vendors as well as backup programs with HSM added. And makers of medium-specific storage management software are adding HSM or alternative technologies.

Cheyenne has announced Hierarchical Storage Manager 1.0, a product that should be available by the time you read this but wasn't ready in time for the review. Like the three products we evaluated, Cheyenne's HSM software will consist of a collection of NLMs that allow a NetWare file server to become part of an HSM environment. Cheyenne says the new product will let administrators define a variety of migration parameters, including available server disk space, as well as file use, age, type, owner, and size. The software won't require a TSR agent, which means it should be able to work with files that DOS, OS/2, Unix, and Macintosh workstations create. Cheyenne also says Hierarchical Storage Manager will be able to demigrate files temporarily for browsing and searching.



Lotus Development, in conjunction with Kodak, offers the Lotus Notes: Document Imaging product (LN:DI, commonly pronounced "Lindy"). LN:DI is a set of client/server tools for managing image files, which are often good candidates for HSM. LN:DI includes Windows client software that performs basic imaging functions (e.g., scanning documents, compressing/decompressing files, and zooming, panning, and rotating). The server component, which runs on an OS/2-based PC, manages an image database with integrated HSM. Before LN:DI, Lotus Notes treated document images like any other type of file and replicated those files indiscriminately, a practice that could bring a WAN to its knees. With LN:DI, Notes stores images centrally and references the files via 100-byte pointers in distributed Notes databases.

Kodak also worked with Novell to produce a version of NetWare 4.x that has special support for image files. The two companies created Image-Enabled NetWare, a set of client components, NLMs, and APIs that implement storage management, server-based imaging, and a document management front end. Kodak wrote the storage management modules, which consist of optical media drivers (collectively called the High Capacity Storage System) and HSM capabilities (Mass Storage Services) for NetWare 4.x.

Alphatronics offers Inspire Migrator, which works in the NetWare 4.x environment and relies on the built-in data-migration API of NetWare 4. Alphatronics has much experience building HSM products for the Unix environment but is relatively new to PC LAN HSM. For now, Inspire Migrator can only use optical disks, but Alphatronics says it is working on a version that will support magnetic tape libraries. The program also lacks tools for monitoring hierarchical storage. If NetWare 4 becomes widely popular and if Alphatronics adds the planned features, Inspire Migrator will likely become a contender in the HSM arena.

Micro Design International offers EZ-Express, which uses the concept of SSM (Simplified Storage Management), rather than HSM. EZ-Express doesn't migrate and demigrate files for access by workstations, but instead lets workstations on the LAN treat secondary storage as mappable NetWare volumes. This approach, says MDI, allows transparent, direct access to the data stored on secondary volumes. The secondary storage can be any model of SCSI Express optical devices.

Another partial list of HSM solutions is Watermark Software's Watermark HSM, which adds support for optical storage to the company's Image Server software.

Hewlett-Packard has said it may develop a full-featured HSM product. HP's move would be a natural one, because the company manufactures a popular line of high-capacity magnetic tape drives and optical jukeboxes.

file for update purposes.

Arcada plans soon to release an upgrade that won't require a dedicated server and will add integration with the company's Backup Exec software.

Assessing the Early Crop

HSM is an emerging technology for PC LANs, and these products show the immaturity of HSM in the PC environment. As yet, NetWare-based HSM products don't take into account data management on application servers or workstation hard drives. Many HSM products lack sufficient file-by-file migration rules and don't offer centralized management of backup, HSM, and archiving procedures (excepting backup programs such as PNS, that have recently added HSM features). More practically, perhaps, applications such as Microsoft Word for Windows can take hours to retrieve and display summary information when listing demigrated files in File Open dialog boxes.

Avail's NetSpace is the best HSM implementation of the three products we evaluated. Unlike Palindrome HSM, NetSpace doesn't require a TSR recall notification agent, does a good job of supporting extended attributes (NetWare name spaces), and is easy to administer. However, if you already use the popular Network Archivist product from Palindrome, you might want to buy Palindrome HSM; it's a natural extension of PNA. But NetSpace is the clear winner if you want to use near-line storage to augment on-line storage that's growing by leaps and bounds. ■

Barry Nance is a consulting editor at BYTE and has been a programmer for 20 years. He is the author of Using OS/2 Warp 3.0 *(Que, 1994),* Introduction to Networking *(Que, 1994) and* Client/Server LAN Programming *(Que, 1994). You can reach him via BIX or the Internet at barryn@bix.com.*

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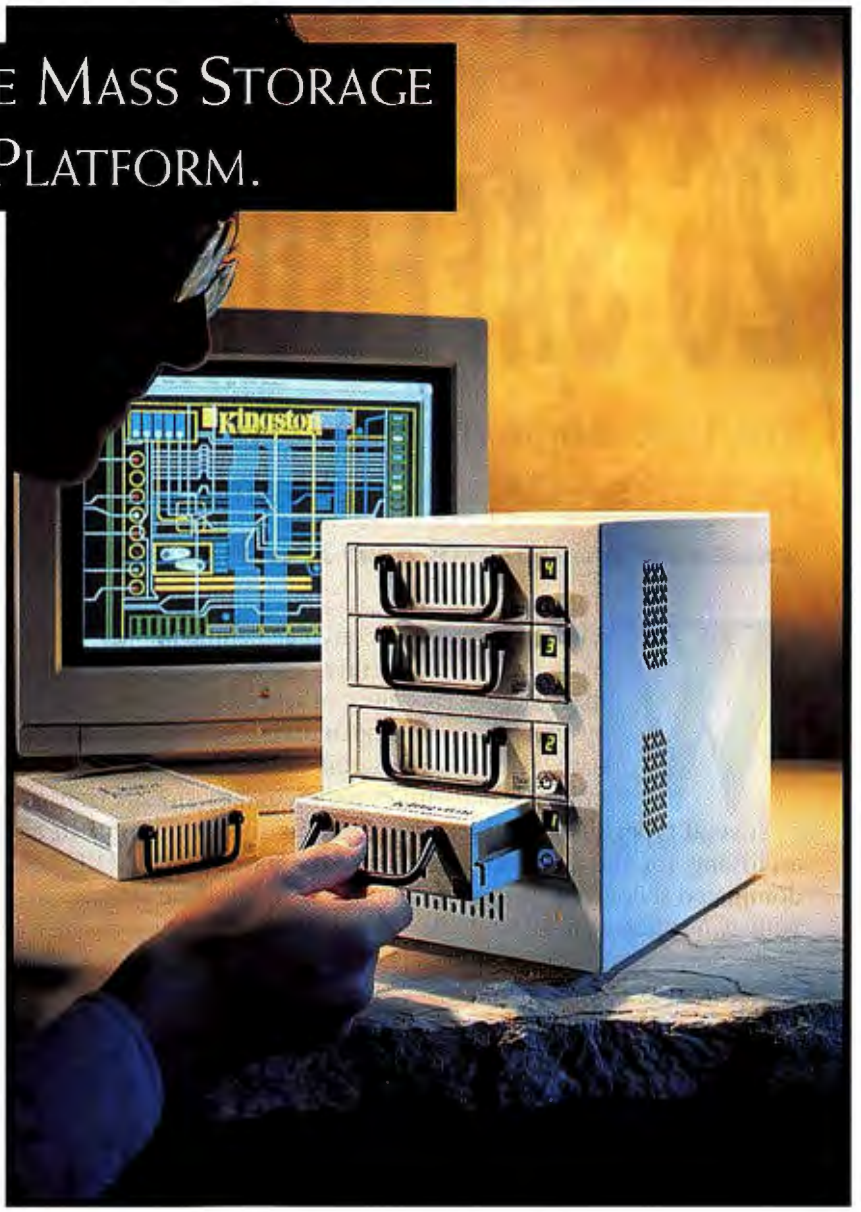

Data Express: Rugged Removability

Data Express, a family of durable removable carriers, houses a hard disk or DAT (Digital Audio Tape) device, adding up to 36GB plus the many benefits of storage removability to your PC or workstation. Data Express is available internally; mounting into your computer system drive bay, or externally; housed in steel enclosures and equipped with a fan and power supply. Data Express boasts an industry leading 25,000 insertions for long lasting removability. Constructed of steel and equipped with superior ventilation, Data Express provides the peripheral cooling needed when using large capacity devices.

Data Silo: Durable External Housing

Kingston's Data Silo is a family of stand alone external storage enclosures for half-height or full-height 5.25" or 3.5" SCSI peripherals. Data Silo is available in versions to house one, two, four, or nine SCSI devices simultaneously providing the utmost flexibility for storage expansion, disk array environments, and peripheral integration. Each Data Silo is equipped with its own power supply and fan and constructed of 100% steel, making Data Silo the most durable external storage enclosure available today.

Storage Versatility

Kingston's Data Silo four and nine bay units provide ideal drive stacking features for use in disk array environments. Data Silo also houses Kingston's Data Express products, which provide all the benefits of storage removability including data security and portability.

Industry-Leading, Five-Year Warranty

Every Data Express and Data Silo comes equipped with a comprehensive five year warranty and free technical support. Designed specifically for PC and workstation users, Data Express and Data Silo provide unsurpassed storage flexibility and quality.

Every Product 100% Tested

Kingston guarantees the highest quality available by testing every product prior to shipping.

Information At Your Fingertips

To get the facts on Data Express and Data Silo, call our convenient RAMFax fax on-demand service toll-free and request document number *8310*. For immediate assistance, contact Kingston's Storage Products group at:

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26 SAFEGUARDS AGAINST

We test single-medium tape drives for backing up midrange networks—DAT, QIC, 8-mm, and DLT

TADESSE W. GIORGIS AND JOHN MCDONOUGH

We no longer need to convince people to back up critical data. Now it's a question of how to back up data efficiently. Today's stand-alone systems and network servers, with on-line mass-storage capacities of several gigabytes, require high-capacity backup and archiving subsystems. For many businesses, the primary objective of backing up data is to guard against data loss. In the long run, however, the finite capacity and nonremovable nature of desktop systems' hard drives put secondary storage right up there with death and taxes—it's a must.

Several types of streaming-tape recording media continue to be the backbone of computer backup and archiving for the LAN market. Since the early 1980s, QIC (quarter-inch cartridge) tape drives have dominated secondary-storage solutions for stand-alone systems and LANs. However, QIC drives compete with two other tape technologies from the consumer electronics market: 4-mm DAT (digital audiotape) drives and 8-mm videocassette tape drives.

As storage requirements grow, DLT (digital linear tape), originally developed by DEC for use on midrange and high-end computing systems, is gradually gaining market share in the LAN segment of the industry. Compared to DATs and QIC tapes, DLTs have higher capacities and are faster. Quantum acquired the DLT technology last October, when it purchased DEC's Avastor OEM tape and disk storage business unit.

Based on the videocassette recording technique and using the DDS (digital data storage) specification advanced by Hewlett-Packard and Sony, DAT technology offers recording capacities ranging from 1 to 5 GB of uncompressed data on a 4-mm minicartridge. The 8-mm helical-scan videocassette tape (presently sourced only by Exabyte) offers from 2 to 5 GB of uncompressed data.

DLT drives can achieve up to 20 GB without compression. We tested systems based on the DEC DLT2000 drives, which can store 20 GB of compressed data; we did not test units based on the higher-capacity DEC

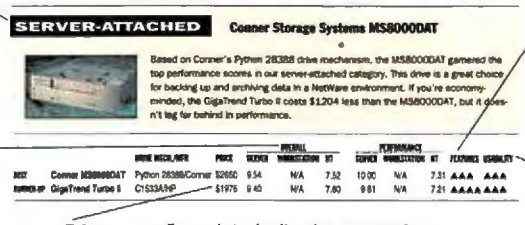
How to use this guide

To find the right tape-backup device for your needs, follow the main headings until you come to the appropriate category.

Then look for the subsystem that is most relevant to your network environment and specific backup and archival needs.

The tested tape-backup devices are grouped first by configuration (e.g., server-attached or workstation-attached) and by technology: 4-mm DATs, 8-mm helical-scan tape subsystems, half-inch DLT drives, and QIC drives.

Ratings for overall winners from each category are picked by taking a weighted average of the backup and restore performance score (75 percent), the features score (15 percent), and the usability score (10 percent). Using a scale of 1 to 10, 10 is best.



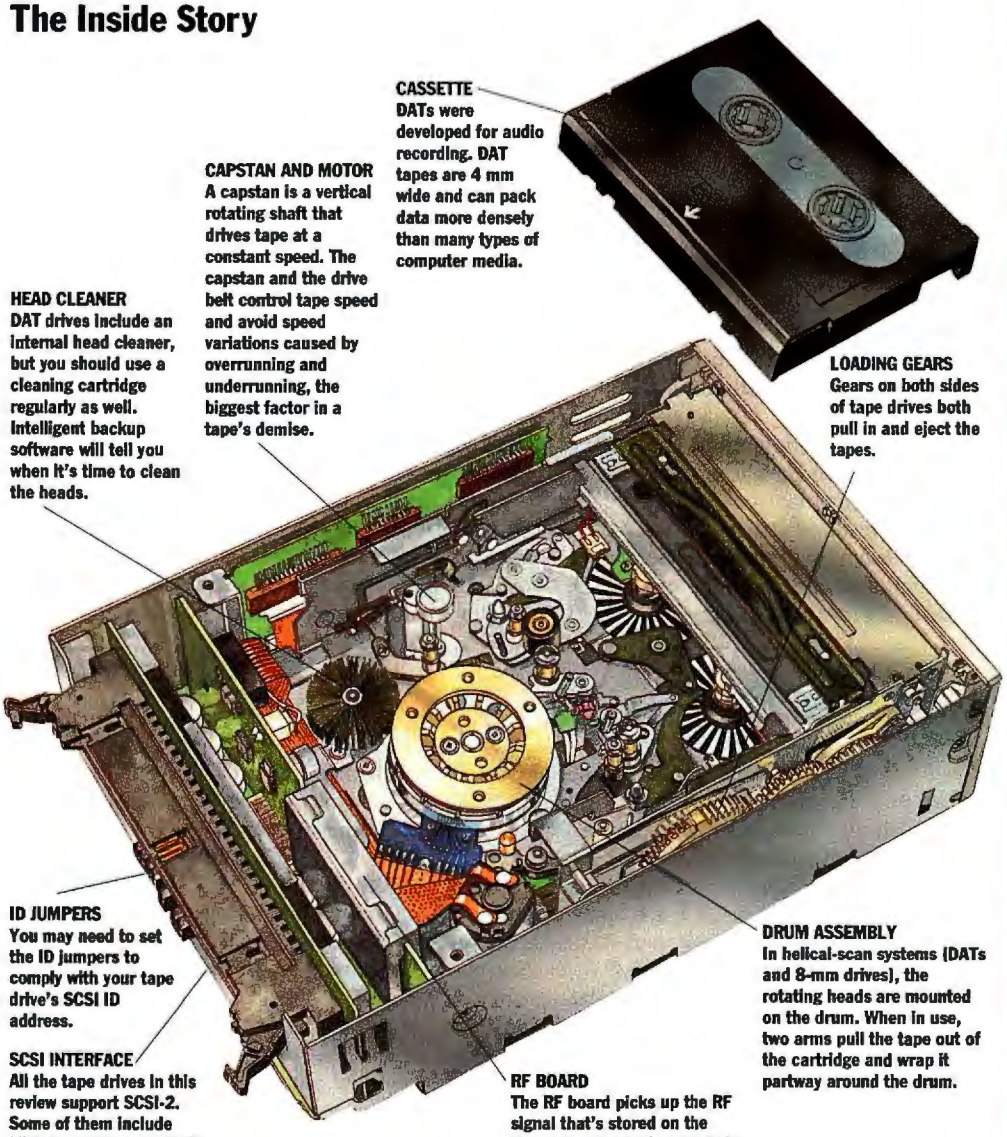
Price as configured; typically, the cost varies based on the bundled software and the interface hardware.

The features score rates how well the tape-drive subsystem is adaptable to a particular computing environment, including hardware platform support, backup software support, and desktop and NOS (network operating system) compatibility.

This rates how well the documentation simplifies installation and use of the tape drive.

LAN Data Loss

The Inside Story



DLT4000 drives, which can store up to 40 GB of compressed data.

Rewritable optical drives, WORM optical drives, and rewritable CD-ROMs (see "CD-R Backup Systems Compete with Tape" on page 146) are also alternatives for secondary storage.

We tested 26 tape-backup subsystems ranging in capacity from 4 to 10 GB native format (i.e., without compression). Their prices range from the truly affordable Sony SDT-5000 internal DAT drive to the high-priced CTS-2110 DLT drive from TTI.

BEST

DAT DRIVES

SERVER-ATTACHED

Conner Storage Systems MS8000DAT

This was the fastest DAT drive in our server-attached category. It provides a complete high-performance backup solution for a small business or workgroup. **PAGE 147**

WORKSTATION-ATTACHED

Storage Dimensions TDB-8005

The Storage Dimensions DAT drive and SCSI card topped the charts for workstation backup. **PAGE 147**

WINDOWS NT

Hewlett-Packard HP JetStore 6000e

The HP JetStore 6000e is a speedy drive that's bundled with ARCserve 5.1 backup software, data-recovery utilities, and JetSafe diagnostics. **PAGE 147**

NT PERFORMANCE

Hewlett-Packard HP JetStore 6000e

For raw performance without considering bundled hardware, bundled software, or price, the HP JetStore 6000e was the fastest drive under Windows NT. **PAGE 147**

QIC DRIVES

Legacy QIC 10

Of the two 5-GB native-capacity QIC drives, we preferred this. It has a faster sustained transfer rate and higher performance than the Tecmar drive. **PAGE 150**

8-MM DRIVES

Exabyte EXB-8505XL

The Exabyte EXB-8505XL posted the highest NT performance scores and tied for the shortest access times. **PAGE 152**

DLT DRIVES

Quantum DLT2000

Quantum's DLT2000 rose to the top in this closely knit group of DLT drives. **PAGE 154**

ILLUSTRATION: BRUCE SANDERS © 1995

THE TECHNOLOGY BEHIND

4-MM DAT DRIVES

Helical-scan technology used on 4-mm DAT drives records large amounts of data on very-slow-moving tape. Magnetic read/write heads are mounted on a rotating drum, with an axis of rotation at 6 degrees from the perpendicular (see the figure "Helical Scan"). DAT drives have two heads for reading and two for writing. The tape wraps 90 degrees around the drum's circumference, and the heads move in a spiral motion from the bottom to the top of the tape. The drum rotates at 2000 rpm, and the 4-mm tape moves slowly in the same direction at 8.15 millimeters per second (or 0.32 inch per second). The diametrically opposed heads describe portions of a helix on the tape.

With helical-scan technology, each new track overlaps the previous one, wasting no tape between tracks.

Each track is written diagonally from top to bottom. The heads are wider than the written tracks, so each new track overlaps the previous one, wasting no tape between tracks. Overlapping tracks would normally result in cross talk between adjacent tracks when reading data from the tape, but the device minimizes cross talk by angling the heads 20 degrees relative to the data track (the azimuth angle) and in opposite directions from each other.

When data is read from the tape, the read head receives a much stronger signal from data written to the same azimuth angle. Angling permits very close packing of tracks and very high data densities. ATF (Automatic Track Finding) circuitry keeps the head centered on the track by balancing the weaker signals from adjacent (i.e., off-azimuth) tracks.

In the early days of DAT's evolution, DAT devices used one of two proposed low-level formatting standards: DDS, developed jointly by HP and Sony, and Data/DAT, developed by Hitachi. DDS offers slightly more storage capacity and faster sustained transfer rates than Data/DAT. DDS devices write data sequentially, appending data to the existing information, and they can read data randomly, beginning at any point. Data/DAT drives can overwrite existing data files in place, reducing the inefficiencies of multiple copies of the same file. However, the market appears to have standardized on DDS and a few extensions of DDS.

DDS: The DDS format represents a modification of the DAT technology. Unlike the continuous data stream that's

CD-R BACKUP SYSTEMS COMPETE WITH TAPE

A new competitor has moved into the backup market with the emergence of affordable CD-R (CD Recordable) drives. Given the present capacity limitations of recordable CDs, CD-R will not challenge tape backup in large enterprises that have sophisticated tape management systems in place. CD-R cannot yet support unattended backups beyond 650 MB (although multidisc changers will address that limitation soon), and sophisticated backup software is still geared to magnetic media.

The price of CD-R, both in terms of cost per megabyte and initial hardware investment, remains relatively high. However, it is falling fast. Pinnacle Micro ((800) 553-7070 or (714) 727-3300; fax (714) 727-1913) has dropped the price of its RCD-1000 recordable CD-ROM drive to $1995. It sells recordable media for $29 per disc, a cost per megabyte of about 4 cents. In fact, Pinnacle markets the RCD-1000 as a replacement for tape backup, bundling in backup software that works just like standard tape-backup solutions.

Superior access speed and versatility make CD-R a compelling option in the right environment. Unlike streaming-tape drives, CD-R devices support fast random access to data. In addition to being a CD recorder, the RCD-1000 is also a standard double-speed CD-ROM reader, so you can retrieve any archived file at full double-spin access speed (300 milliseconds average).

For a full tape restore, sequential tape is efficient, but retrieval of a selection of files from a tape set can be slow; you must first open the tape and then access the file sequentially. With CD-R, single-file retrieval is as fast and simple as taking a file from a desktop CD.

The CD-R solution also gives you an effective data-distribution tool. CD-ROM readers are now a standard component on most desktops, so CDs are becoming a universal transfer medium. You could pass along a set of archived images simply by handing off a CD or mailing it to a remote site. Or you could run off a few copies of a contact database and distribute them across an organization. For large-scale distribution, you send the CD to a duplication service and pass out or sell copies. The Pinnacle Micro RCD-1000 can write to ISO 9660, HFS, CD-Image, and audio formats.

—Stanford Diehl

ADVANTAGES

CD-R BACKUP	TAPE BACKUP
• Fast random-access retrieval	• Lower cost per megabyte
• Effective data-distribution tool	• Larger storage capacities
• Longer shelf life for medium	• Greater backup software support
• Versatile applications	• Mature market

produced by the DAT format, DDS constructs a sequence of fixed-capacity groups on the tape. DDS packs up to 2 GB on a 60-, 90-, or 120-meter tape running at the same speed as DAT. The best-case scenario for a DAT recording is a sustained transfer rate of 183 Kbps to fill a tape during 2 hours of transfer time.

DDS-2: This was developed to allow data transfer to occur in SCSI-2 burst mode. DDS-2 doubles the density of DDS, but it maintains full DDS functionality and ensures backward compatibility.

DDS-DC: Similar to DDS-2, DDS-DC was established to include a data-compression standard. It allows uncompressed data to be stored in a way that maintains full DDS functionality and ensures backward compatibility with existing DDS drives.

The types of drive mechanisms in the DAT drives we tested differ widely; they are sourced by HP, Conner, Wang-DAT/Rexon, Sony, and Exabyte. In general, DAT drives based on HP's C1533A drive mechanism provide superior performance when compared to DAT drives from the other major drive manufacturers. In fact, the HP JetStore 6000e's NT performance is so fast that it ties for third place with TTI's CTS-2110, which is based on DEC's DLT2000 drive mechanism.

Conner-manufactured drive mechanisms also perform well. The Conner MS8000DAT achieves its best performance when tested in a server-attached configuration using the vendor-supplied 16-bit AT SCSI adapter, even surpassing the performance of drives using 32-bit bus-mastering SCSI controllers. Using a specialized hardware interface with an optimized device driver appears to be the major factor in the excellent performance of the MS8000DAT in the server-attached configuration.

KEY	
Excellent ▲▲▲▲	Good ▲▲▲
Fair ▲▲	Poor ▲

The best LAN solution

SERVER-ATTACHED — Conner Storage Systems MS8000DAT

Based on Conner's Python 28388 drive mechanism, the MS8000DAT garnered the top performance scores in our server-attached category. This drive is a great choice for backing up and archiving data in a NetWare environment. If you're economy-minded, the GigaTrend Turbo II costs $675 less than the MS8000DAT, but it doesn't lag far behind in performance.

				OVERALL			PERFORMANCE				
	DRIVE MECH./MFR	PRICE	SERVER	WORKSTATION	NT	SERVER	WORKSTATION	NT	FEATURES	USABILITY
BEST	Conner MS8000DAT	Python 28388/Conner	$2650	9.54	N/A	7.52	10.00	N/A	7.31	▲▲▲	▲▲▲
RUNNER-UP	GigaTrend Turbo II	C1533A/HP	$1975	9.40	N/A	7.60	9.61	N/A	7.21	▲▲▲▲	▲▲▲

For local backup...

WORKSTATION-ATTACHED — Storage Dimensions TDB-8005

The top three drives for local backup employ HP's C1533A drive mechanism. These OEM tape drives—Storage Dimensions' TDB-8005, Optima Technology's MiniPak F8000DAT, and MicroNet Technology's SS-D16000/EISA—all excel at local backup, but the more expensive TDB-8005 takes the crown. Storage Dimensions' drive and the MiniPak F8000DAT both feature 4-to-1 (16 GB to 4 GB) compression. The SS-D16000/EISA supports 16 GB of data and has a 2-to-1 compression scheme.

				OVERALL			PERFORMANCE				
	DRIVE MECH./MFR	PRICE	SERVER	WORKSTATION	NT	SERVER	WORKSTATION	NT	FEATURES	USABILITY
BEST	Storage Dimensions TDB-8005	C1533A/HP	$2315	N/A	9.31	8.18	N/A	9.45	7.95	▲▲▲▲	▲▲▲
RUNNER-UP	Optima MiniPak F8000DAT	C1533A/HP	$1879	N/A	8.97	8.68	N/A	9.26	8.87	▲▲▲▲	▲▲▲
RUNNER-UP	MicroNet SS-D16000/EISA	C1533A/HP	$2585	N/A	8.74	8.68	N/A	8.69	8.61	▲▲▲▲	▲▲▲

Outstanding NT performance

WINDOWS NT — Hewlett-Packard HP JetStore 6000e

The HP JetStore 6000e is second to none when it comes to backing up and restoring files on Windows NT. It is a speedy backup solution that is bundled with Cheyenne Software's ARCserve 5.1 backup software, as well as data-recovery utilities and the JetSafe set of diagnostic tools.

				OVERALL			PERFORMANCE				
	DRIVE MECH./MFR	PRICE	SERVER	WORKSTATION	NT	SERVER	WORKSTATION	NT	FEATURES	USABILITY
BEST	HP JetStore 6000e	C1533A/HP	$3714	8.41	N/A	9.19	8.29	N/A	9.34	▲▲▲▲	▲▲▲
RUNNER-UP	Ariel-DAT ADE-8500	C1533A/HP	$2399	8.85	N/A	8.73	8.86	N/A	8.71	▲▲▲▲	▲▲▲
RUNNER-UP	MicroNet SS-D16000/EISA	C1533A/HP	$1828	N/A	8.74	8.68	N/A	8.69	8.61	▲▲▲▲	▲▲▲

Raw-speed leader

PERFORMANCE — Hewlett-Packard HP JetStore 6000e

The NT/HP marriage worked again when we tested tape drives solely on their raw performance while backing up on Windows NT. Five of the top six drives are originally manufactured by HP. The only non-HP NT backup device that breaks into the winner's circle is IBM PC Co.'s IBM 4/10 GB 4-mm drive, the first runner-up to the HP JetStore 6000e.

				OVERALL			PERFORMANCE				
	DRIVE MECH./MFR	PRICE	SERVER	WORKSTATION	NT	SERVER	WORKSTATION	NT	FEATURES	USABILITY
BEST	HP JetStore 6000e	C1533A/HP	$3714	8.41	N/A	9.19	8.29	N/A	9.34	▲▲▲▲	▲▲▲
RUNNER-UP	IBM 4/10 GB 4-mm	4326NP/RP/Conner	$1699	N/A	8.31	8.55	N/A	8.61	8.93	▲▲▲▲	▲

How We Tested

We tested the 26 tape-backup subsystems using a hierarchical file structure with five directories and three subdirectory levels. We evenly distributed about 100 MB of test data. File sizes in each subdirectory are randomly distributed and range from 3072 bytes to 3072 KB, with compression ratios ranging from 10 percent to over 85 percent.

We used two Compaq Deskpro 66Ms (486/66 EISA), each with 16 MB of RAM and an IDE hard drive. We installed NetWare 3.12 on one system to act as a file server. We installed MS-DOS 6.2, Windows 3.1, and Windows NT Workstation 3.5 on the other system to act as a workstation.

If the vendor supplied a SCSI card, we used it; otherwise, we used an Adaptec AHA-2740 SCSI controller. For those units supporting parallel-port backup, we used the parallel port only if the vendor did not supply a SCSI adapter and the bundled software was intended for parallel-port use.

TEST METHODOLOGY

Our test procedure consisted of two distinct phases. In the first phase, we tested every entry using the vendor-supplied hardware and software. If the supplied software was an NLM (NetWare loadable module), we attached the tape drive to the file server and created the file structure on the server volume. After we backed up the data in overwrite mode, we restored it to the server. If the vendor-supplied software was a workstation product, we attached the tape subsystem to the workstation and created the file structure on the workstation's local disk.

If no software was supplied, we used Cheyenne Software's ARCsolo 3.02. We chose ARCsolo for its ubiquity in the marketplace and its use of a nonproprietary database (Novell's Btrieve) for tape library information. However, the same traits that make ARCsolo almost universally compatible also limit it: Advanced features such as record keeping and error-correction control are not supported.

The backup tests ran once with hardware compression disabled and once with it enabled. After the initial backup and restore, we backed up the new directory and restored it down a different path. For each drive, we repeated the tests until the variation between runs was reduced to under 5 percent. To reduce backup and restore time, we disabled such features as backup and restore verification and NetWare bindery file backup/restore options.

The second phase of testing used the same data tree locally on the NT machine, with NT drivers and backup software. We used an Adaptec AHA-2740 SCSI controller for the Windows NT tests, whether the vendor supplied interface hardware or not. Because the NT tests all used the same software and SCSI controllers, differences in performance can be attributed to the drives themselves.

FEATURES AND EASE OF USE

To evaluate ease of use, we examined the documentation and the use of LED indicators for tape operation and fault isolation. We considered ease of use during both setup and configuration.

The features score reflects the range of supported software and hardware platforms, controls, and other options.

Our overall ratings combine performance scores with usability and features scores. Higher scores are better.

HP PUSHES AUTOMATED NETWARE

HP worked with Legato Systems, Novell, and Palindrome to develop HP LABS (Low Admin Backup for Servers), a specification for automated backup under NetWare using auto-loading magazines and "intelligent" data management software. As long as the data on your LAN will fit on a single cartridge, a six-cartridge auto-loader can hold five weeks of data administrator-free.

To become LABS-compliant, backup software must meet eight criteria involving installation, configuration, automation, performance, and the upgrade strategy. LABS software must include the following features:

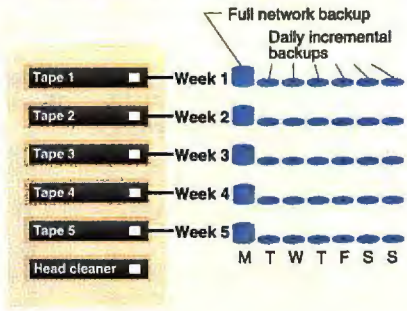
- **Predefined installation and configuration routines**
- **Completely unattended backup procedures**
- **Automatic error recovery**
- **Self-monitoring and status communication**
- **End-user restore**

The hardware component to LABS must include the following features:

- **Read-after-write verification**
- **Three levels of error correction**
- **Random access for data recovery**
- **A sustained data transfer rate of 1 MBps (compressed)**
- **A high-capacity auto-loader with a minimum of six cartridge slots**

—John McDonough

HP LABS Tape-Rotation Strategy



A schematic representation of the HP LABS system. The server performs full backups one day a week and incremental backups on the other days. Cleaning occurs as scheduled or as needed.

Contributors

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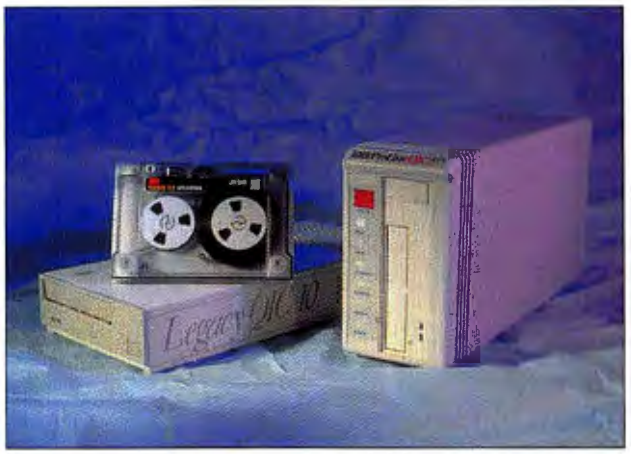
QIC Drives



The two QIC drives we tested (from the left): Legacy's Legacy QIC 10, and Rexon's Tecmar Proline CX QIC 10. A 6- by 4-inch cartridge is pictured; smaller minicartridges are popular.

The many standards of the QIC-based recording technology write data to tape using a complex multihead assembly. The drives record data by running tape past a stationary-head assembly at up to 120 inches per second serially on a straight track using the GCR (Group-Coded Recording) encoding method. GCR is used on many magnetic tapes as well as on Apple II and Mac 400- and 800-KB floppy disks. The tape then reverses direction and records data on a parallel track in a serpentine pattern.

The attraction of QIC drives centers on high capacity, low medium cost, and fast file access. However, QIC drawbacks are high drive costs, low data transfer rates, and incompatibility between different manufacturers' drives and data-recording formats. Originally, the only thing standard about QIC systems was the medium. Manufacturers varied the number of tracks per tape, the density of data, and even how the drives connected to computers. Each system was proprietary. In 1982 vendors formed the QIC Committee to form standards. Increasingly since then, QIC drives are gaining backward compatibility.

The QIC technology, developed and marketed by 3M, claims close to 10 million installations. Advances in materials technology and polymer chemistry have contributed to the medium's performance, capacity, and longevity. Improvements in medium formulation (i.e., high coercivity and cobalt-modified gamma ferric-oxide pigments), better tape substrate and binders, and improved mechanical design (i.e., a double-textured drive belt, corner-roller and hub, and better lubrication) gave rise to data cartridges with capacities in excess of 5 GB. QIC drives use hardware compression algorithms that enable them to transfer compressed data at a rate of 1.6 MBps (or 1 GB in 11 minutes). QIC, Inc., the QIC development standards association, also specifies a fast-search capability that matches that of the DDS-2 format and is twice as fast as the fast-search capability of 8-mm tape drives. The quoted MTBF (mean time between failures) of QIC-drive mechanisms is 200,000 hours. The length of QIC tapes can vary from 300 to 1200 feet, so the capacities vary as well. Data can be recorded on up to 44 tracks along the tape, usually in a serial, serpentine pattern. Although there are almost two dozen QIC recording formats, QIC, Inc. is working to ensure backward compatibility.

QIC Drive Winner

The Legacy QIC 10 is the better of the two QIC drives we tested because of its overall score and competitive price.

Advanced design features for QIC cartridges include a mirror mechanism and position sense holes for tape position sensing, a write-protect plug, and a tape cover door to protect the magnetic medium from contaminants when not in use. These all contribute to the longevity QIC drives have enjoyed in the PC market.

Yet the QIC-drive technology, despite new initiatives for higher-capacity standards (see "Low-End QIC Gets a Capacity Boost" on page 156), is falling behind advances in hard drive capacities that seem to increase by the day. This is helping high-capacity tape-drive technologies such as DLT earn market share in the LAN market.

We tested only two QIC drives: the Tecmar Proline CX QIC 10 and the Legacy QIC 10. Both use Rexon's Wangtek 9500 drive mechanism. The Legacy QIC 10 provides better performance than the Tecmar drive and costs $649 less. However, both drives' test results were significantly slower than the over 400-MB-per-minute transfer rate that is claimed for the QIC 10 drive. But remember: We tested them in overwrite mode rather than letting them append to existing data. QIC 10 drives usually perform much better in sequential append configuration than in overwrite mode.

TABLE OF QIC FEATURES

	PRICE	SERVER OVERALL	NT OVERALL	PERFORMANCE SERVER	PERFORMANCE NT	FEATURES	USABILITY
Legacy QIC 10	$1800	7.56	6.68	7.56	6.38	▲▲	▲▲▲
Rexon/Tecmar Proline CX QIC 10	$2449	7.27	6.23	7.14	5.75	▲▲▲	▲▲

(Both QIC drives use Rexon's Wangtek 9500 drive mechanism.) **Key:** Excellent ▲▲▲▲ Good ▲▲▲ Fair ▲▲ Poor ▲

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8-mm Videocassette Drives

As in 4-mm DAT drives, helical-scan technology constitutes the basic recording technique for 8-mm videocassette tape drives. Magnetic read/write heads are mounted on a rotating drum, with an axis of rotation at approximately 5 degrees from the perpendicular. Unlike 4-mm DAT drives, 8-mm drives use a three-head drive configuration (read head, write head, and servo head) around the drum and a separate erase head.

The tape wraps a quarter of the distance around the drum's circumference between the read and write heads, with the servo head situated midway between the two. The drum rotates at 1831 rpm, and the tape moves slowly in the same direction at 11.1 millimeters per second (or 0.44 inch per second).

Clockwise from the left: Storage Dimensions' TD1-10000, the IBM 5/10 GB 8-mm, the Dynatek Automation Systems HSB5.0, TTI's CTS-8510H (XL), and Exabyte's EXB-8505XL.

Of the five 8-mm drives we tested, the Exabyte EXB-8505XL provides the best performance for the price, followed by the IBM 5/10 GB 8-mm. The EXB-8505XL drive ranks tenth in our overall evaluation as a Windows NT backup subsystem among all the tape drives we tested (and second among the 8-mm drives). As a group, the 8-mm drives are outperformed by the DLT drives and the DAT drives based on the C1533A drive mechanism. But they are intermediate in cost and capacity between DLT and DAT drives.

8-mm Drive Winner

Exabyte holds the patent for manufacturing all 8-mm tape drives, and its EXB-8505XL was our price/performance favorite.

The physical structure of the 8-mm drives differs mainly in their external housing. The only 8-mm drive we attached to a file server was the HSB5.0 from Dynatek Automation Systems; it came with an Adaptec AHA-1540 SCSI controller and an OEM version of Cheyenne Software's ARCserve 5.01. As in all the tape drives, 8-mm drive performance is affected by interface hardware and backup software.

Once again, because our performance testing in the Windows NT environment uses consistent hardware and software, performance results under the Windows NT backup utility manifest differences of the drives themselves. However, if you are purchasing a solution, complete with a hardware interface and backup software, you'll also want to take a look at our overall scores, which incorporate results using the vendor-supplied components.

FEATURES OF 8-MM DRIVES

	PRICE	OVERALL SERVER	OVERALL WORKSTATION	OVERALL NT	PERFORMANCE SERVER	PERFORMANCE WORKSTATION	PERFORMANCE NT	FEATURES	USABILITY
Exabyte EXB-8505XL	$2800–$4500	N/A	6.72	7.57	N/A	6.18	7.32	▲▲▲▲	▲▲▲
Dynatek HSB5.0	$2830	8.15	N/A	7.23	8.02	N/A	6.80	▲▲▲▲	▲▲▲
IBM 5/10 GB 8-mm	$4005	N/A	6.74	7.56	N/A	6.22	7.30	▲▲▲▲	▲▲▲
Storage Dimensions TD1-10000	$3950	N/A	7.07	6.70	N/A	6.62	6.12	▲▲▲▲	▲▲▲
TTI CTS-8510H (XL)	$3995	N/A	7.43	7.28	N/A	7.14	6.94	▲▲▲▲	▲▲▲

(All 8-mm drives use Exabyte's EXB 8505 drive mechanism.) **Key:** Excellent ▲▲▲▲ Good ▲▲▲ Fair ▲▲ Poor ▲

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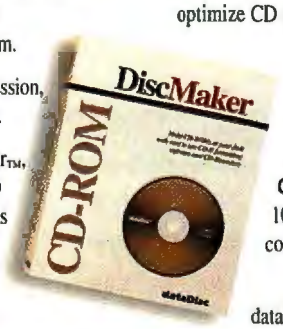

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DLT Drives

The outside cases of the three DLT drives we tested are virtually identical. All are manufactured by Quantum. Clockwise from the top: TTI's CTS-2110 drive showing its LED panel on the front (which the other drives don't offer), the back of Overland Data's DLT 2000 drive showing its SCSI ports and fan, and Quantum's DLT2000 drive.

The DLT technology is based on a high-capacity, streaming-cartridge tape that uses a dual-channel read/write head and DEC's proprietary data-compression and compaction schemes. We tested three drives in this category: the Quantum DLT2000, the TTI CTS-2110, and the Overland Data DLT 2000. Before Quantum acquired the DLT technology from DEC last October, DEC was the only manufacturer of DLT drives. These DLT drives offer an uncompressed capacity of 10 GB, compared to 4 GB for DAT drives and 5 GB for 8-mm helical-scan drives.

DLT drives offer several advanced features, such as full SCSI-2 command-set implementation, sophisticated LED indicators and built-in diagnostics, high data compaction with 2 MB of read/write data cache memory, and a high data transfer rate of 1.25 MBps in native (i.e., uncompressed) mode. These features make them suited to high-capacity network backup and archiving applications.

In contrast to helical-scan technologies, which place data in slanted stripes, DLT drives use a linear, serpentine recording method that places data in longitudinal tracks. The drives can read and record multiple channels of data simultaneously. This longitudinal recording method allows you to add parallel channels of read/write elements to the head to increase performance.

Assuming a 2-to-1 compression ratio, DLT drives can achieve data transfer rates of 3 MBps. The heads are stationary, which increases the life spans of both the heads and the tapes. The life spans exceed those of helical-scan technology tape drives. During read/write cycles, the tape runs past the drum at 100 to 125 inches per second. Fast-search rates are even higher. Quantum guarantees that its tapes will maintain their integrity for at least 500,000 passes, and the life of the heads is estimated at 10,000 hours. In comparison, 8-mm helical-scan tapes last only 2000 hours.

Twenty-five percent of the data on DLT drives is dedicated to error detection and correction. A custom chip based on the Reed-Solomon algorithm—and software—maintains strict data integrity. For every 64 KB of data, there is 16 KB of ECC (error-correction code). Sixty-four bits of CRC (cyclic redundancy check) error-detection code tag along with every 4 KB of data, and there's also an overlapping 16-bit CRC on each record.

The DLT drives we tested consistently outperformed all the other types of tape drives. Among the three DLT2000-based drives, the Overland Data DLT 2000 edged out the others, in both the Windows NT backup tests and the workstation-attached runs, with ARCsolo 3.02 backup software. The Overland Data DLT 2000 is the most expensive of the three drives we tested, but it posted solid scores in usability and features. All three drives are manufactured by Quantum and present excellent value. The Quantum DLT2000 has the lowest price, and its scores were solid—basically, it's the best buy for the money.

DLT Drive Winner

We selected the Quantum DLT2000 for its solid performance and good scores in features and usability. Its suggested retail price is also the least expensive among the DLT drives we tested.

TABLE OF DLT FEATURES

	PRICE	OVERALL WORKSTATION	OVERALL NT	PERFORMANCE WORKSTATION	PERFORMANCE NT	FEATURES	USABILITY
Quantum DLT2000	$4650	9.50	9.46	9.99	9.94	▲▲▲	▲▲▲
Overland Data DLT 2000	$6000	9.57	9.58	9.98	10.00	▲▲▲	▲▲▲
TTI CTS-2110	$4995	9.50	9.39	10.00	9.85	▲▲▲	▲▲▲

(All DLT drives use Quantum's DLT2000 drive mechanism.) Key: Excellent ▲▲▲▲ Good ▲▲▲ Fair ▲▲ Poor ▲

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Standards for Compatibility

SMS (Storage Management System) is Novell's standard architecture for supporting file systems under NetWare. SMS consists of a set of APIs for developing backup and storage management software in a heterogeneous environment. It helps software vendors by giving them just one interface to write to. SMS takes care of the operating-system and file-system protocols, reducing the amount of effort required by software developers to maintain NetWare compatibility.

Palindrome worked with Novell to port the SMS architecture to an easily adaptable set of standard C++ objects. These APIs will allow the integration of SMS into any operating system; originally, it was NetWare-specific.

SMS also protects end users' access to archived data by ensuring backward and forward compatibility. In the past, users were dependent on applications software vendors to provide support for every type of client workstation, server, and application.

SIDF (System-Independent Data Format) is based on SMS. It is a specification for an open-systems and media-independent logical file format, to provide multiplatform, multivendor data interchange. SIDF focuses on performance, extensibility, medium failure recovery, and flexibility. Besides tape, SIDF can be applied to WORM and rewritable optical discs, hard disk partitions, and floppy disks.

SIDF has three levels: media, transfer buffer, and data set. On each level, file-system information resides in blocks, each block containing a FID (field identifier) communicating to any SIDF-compliant system the type of information it contains. Essentially, FIDs enable SIDF extensibility. If incorporated correctly, SIDF compliance does not negatively affect performance.

SMS and SIDF compliance will ensure that a single manufacturer's products will work on different operating systems, as well as with its own earlier and future product versions. Users who purchase SIDF-compliant products will know that when they upgrade or change software, they will still be able to read their archived data.

Members of the SIDF Association (Arlington Heights, IL) represent leading vendors in the storage industry. They contract compliance testing to an independent company for certification under a variety of environments, including NetWare, Windows, OS/2, Unix, and Macintosh.

Last December, ECMA, a standards body in Geneva, Switzerland, voted to accept SIDF as a new international standard for file and label formats, properties, permissions, extended information, and international dates and language characters. It is the first international medium-independent file and label standard for tapes and optical disks since ANSI was recognized over a decade ago.

—Selinda Chiquoine

LOW-END QIC GETS A CAPACITY BOOST

A new family of entry-level QIC tape products will be released this year that can store up to 1.6 GB of uncompressed data on a single cartridge. The proposed Travan standard is an effort by QIC vendors to keep pace with the ever-increasing capacity of today's hard drives. However, even with a 400-foot QIC-3010 tape, which can hold up to 340 MB of uncompressed data, you can't back up all the data stored on a 990-MB hard drive without swapping tapes in and out of the tape drive.

More expensive QIC systems with larger capacities are still available. For example, Conner Peripherals' TSM4000R drive complies with the QIC-3080 standard and can hold 1.6 GB of uncompressed data. But it lists for $659, and many users like the low price tags of QIC-80, QIC-3010, and QIC-3020 drives. Colorado Memory Systems' Jumbo 350 and Conner Peripherals' TSM420R QIC-80 drives hold only 170 MB (native mode) and both list for just $199.

Before Travan, QIC vendors had increased the capacity of the original QIC-80 standard (see the chart) by increasing the tape's length. Also, the QIC-3010 and QIC-3020 drives, which have thin-film magnetoresistive heads, can handle higher bit densities than the older metal heads that were used in QIC-80 drives. And the QIC-Wide format, which specifies a 0.315-inch-width and 400-foot-length tape, was recently folded into existing QIC standards. Tape drives like Conner's Tape*Stor 420 can read older QIC-80 and QIC-40 tape cartridges in addition to writing to the QIC-Wide tape.

Travan, which industry experts expect will be up for approval this month at a QIC standards meeting, specifies tape that's 0.315 inch wide (compared to the previous 0.25-inch width) and 750 feet long. New Travan drives should be able to accept and read tape cartridges that comply to older standards.

The next move to make QIC more palatable to end users is to increase the backup speed. Backup rates of low-end systems with either floppy disk or parallel-port interfaces range from 2 to 10 MB per minute. Some tape drives with ATAPI (ATA Packet Interface) connections offer claimed data rates of up to 54 MB per minute.

—Dave Andrews

ENTRY-LEVEL QIC STANDARDS

	TAPE LENGTH, IN FEET[1]	COERCIVITY	CAPACITY, MB NATIVE	QIC-WIDE[2]	TRAVAN[3]
QIC-80	307.5/425	550	125/170	210	400
QIC-3010	400	900	340	425	800
QIC-3020	400	900	680	850	1600

[1] Older QIC tapes are 0.25 inch wide.
[2] QIC-Wide specifies a tape minicartridge format of 0.315 inch wide and 400 feet long.
[3] Travan, which is slated to be voted on this month, proposes a 0.315-inch-wide, 750-foot-long tape.

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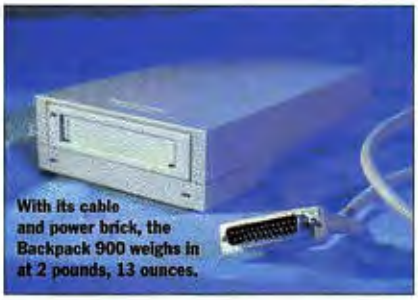
The Backpack Hits 900

Micro Solutions Computer Products ((800) 890-7227 or (815) 756-3411; fax (815) 756-2928) has introduced a new member of its popular Backpack series of parallel-port drives—the Backpack 900. As with all the Backpack drives, the Backpack 900 ($599) attaches to your printer port and supports printer pass-through, so you can easily share the drive across a workgroup or department.

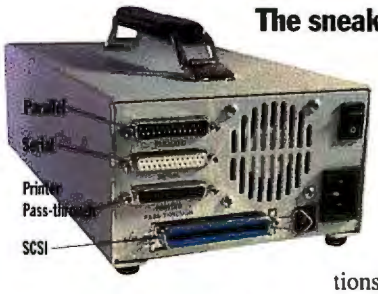
The new Backpack supports a maximum compressed capacity of 900 MB while retaining a compact housing (2 inches high by 4.75 inches wide by 8.37 inches long) and portable weight (1.5 pounds for the unit, 5 ounces for the detachable data cable, and 1 pound for the transformer). The Backpack's portability and enhanced storage capacity make it a viable single-tape solution for today's average desktop system. This is an especially attractive option for departments that don't have single-user tape drives installed on their local systems. Each department member keeps a backup tape, and the drive is shared.


With its cable and power brick, the Backpack 900 weighs in at 2 pounds, 13 ounces.

The Backpack 900 can read and write standard QIC-3010 tapes and read QIC-80 (250 MB) and QIC-40 (120 MB) tapes. To achieve the full 900-MB capacity, you'll need Sony's wide-tape minicartridge. The bundled Windows-based software supports multiple backups per tape, unattended backups, multitape backups, password protection, full or partial restore, and QIC-122 data compression. While the Backpack 900 is not the drive you'd pick for backing up a large network, it's an excellent choice for protecting mission-critical data that's stored on multiple workstations.

—Stanford Diehl

HONORABLE MENTIONS



The sneakernet era may be coming to an end, but network administrators may occasionally want to carry DAT drives to different locations because of no direct network link or a disruption in the communications line.

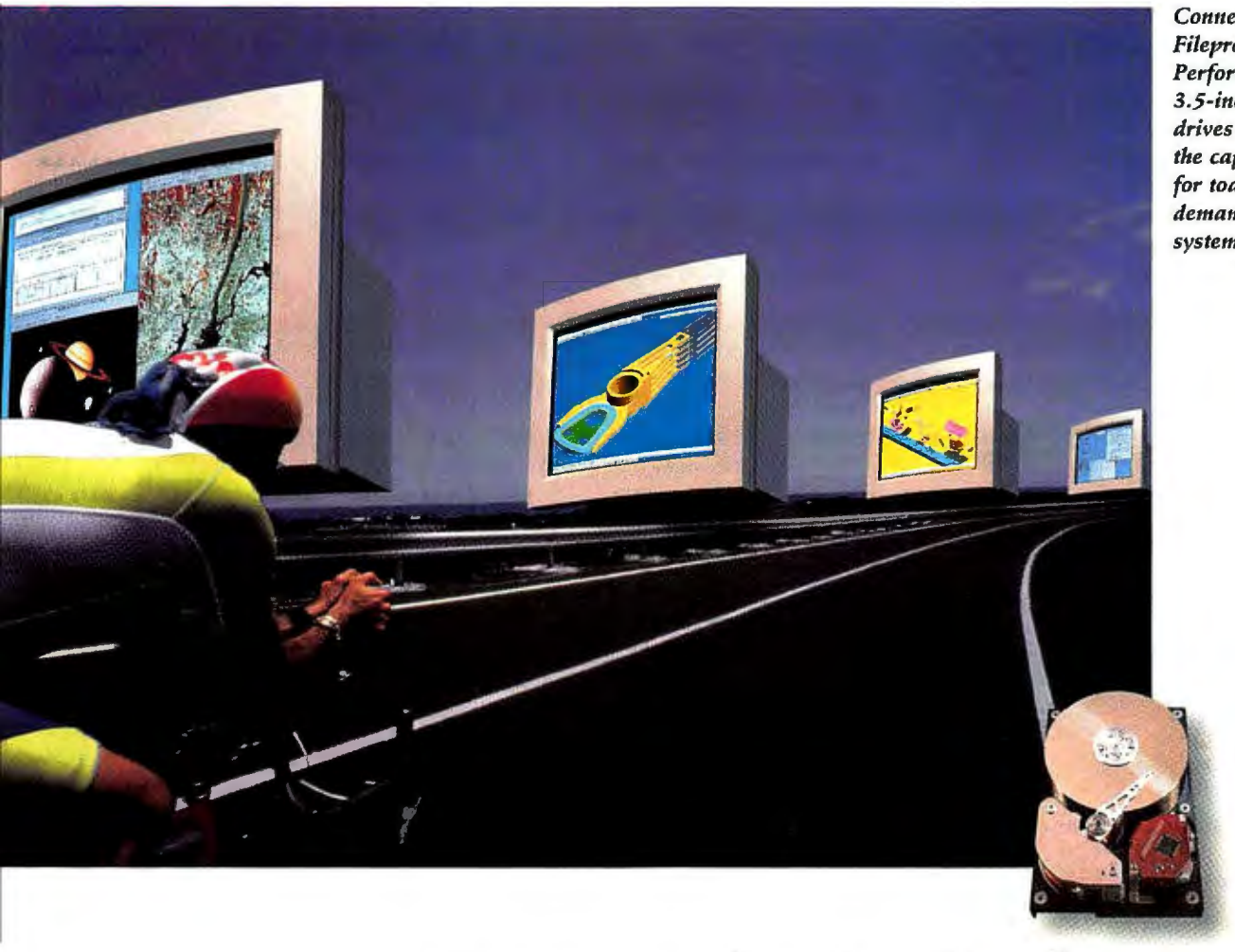
ADPI, Parallel Storage Solutions, and Valitek provide tape drives with handy (no pun intended) carry-on straps and parallel connection ports, in addition to the SCSI port. It's reassuring to know that you can attach your DAT drive to any computer on your network, even when you do not have a SCSI controller, to restore a badly needed file.

It is often difficult to pinpoint the specific problem when a SCSI device fails to be recognized. It can be as simple as an improper SCSI termination, or the terminator is not receiving the proper power signal. Having an LED indicator on the "active" SCSI terminators to show whether they are receiving the right amount of power eliminates the guesswork when there is a problem. The tape drives from Dynatek Automation Systems, FWB, Optima Technology, and Storage Dimensions come with terminator power LEDs. (The Optima's LED is on the back of the drive itself rather than on the terminator.)

Dubious Achievement

In addition to its internal command set, the beauty of the SCSI standard is the way physical connections have snap-on ease. However, the IBM 5/10 GB 8-mm drive caused us great ire before we could successfully test it—because of its nonstandard SCSI connection. The pin-outs on the unit are standard SCSI pin-outs, but you have to use a proprietary IBM SCSI cable, because the connection port is recessed into the unit with special screws to secure the connection. Not any standard 50-pin, Centronics-type SCSI cable will do. Furthermore, the termination is on the cable rather than on the drive unit.

Imagine a broad range of high performance drives for every systems' need.



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Conner Filepro Performance Disk Drives

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Interface:	Fast SCSI-2 Fast-Wide SCSI	Fast SCSI-2 Fast-Wide SCSI	Fast SCSI-2 Fast-Wide SCSI
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ROLL CALL OF TAPE DRIVES

DAT

VENDOR	MODEL	DRIVE MECHANISM/ MANUFACTURER	PRICE AS TESTED (MSRP)	OVERALL SERVER	OVERALL WORKSTATION	OVERALL NT	PERFORMANCE SERVER	PERFORMANCE WORKSTATION	PERFORMANCE NT	FEATURES/ USABILITY
ADPI (Analog and Digital Peripherals, Inc.)	One For All Model FT80	SDT-5000/Sony	$2095	7.46	N/A	6.72	7.22	N/A	6.24	▲▲▲▲/▲▲
BYTE Conner Storage Systems	MS8000DAT[1]	Python 28388/ Conner	$2650	9.54	N/A	7.52	10.00	N/A	7.31	▲▲▲/▲▲
Dynatek Automation Systems, Inc.	DAT8.O	SDT-5000/Sony	$1370	N/A	8.17	7.37	N/A	7.92	6.85	▲▲▲▲/▲▲▲
FWB, Inc.	HammerDAT 16G	WangDAT 3400/ Rexon	$1699	N/A	8.42	6.82	N/A	8.27	6.14	▲▲▲▲/▲▲▲
GigaTrend, Inc.	Turbo II	C1533A/HP	$1975	9.40	N/A	7.60	9.61	N/A	7.21	▲▲▲▲/▲▲▲
BYTE Hewlett-Packard Co.	JetStore 6000e	C1533A/HP	$3714	8.41	N/A	9.19	8.29	N/A	9.34	▲▲▲▲/▲▲▲
IBM Personal Computer Co.	IBM 4/10 GB 4mm	4326NP/RP/ Conner	$1669	N/A	8.31	8.55	N/A	8.61	8.93	▲▲▲▲/▲
MDI (Micro Design	SCSI Express 2000DF	C1533A/HP	$2095	8.80	N/A	N/A	8.76	N/A	N/A	▲▲▲▲/▲▲▲
MicroNet Technology, Inc.	SS-D16000/EISA	C1533A/HP	$2585	N/A	8.74	8.68	N/A	8.69	8.61	▲▲▲▲/▲▲▲
Optima Technology Corp.	MiniPak F8000DAT	C1533A/HP	$1879	N/A	8.97	8.68	N/A	9.26	8.87	▲▲▲/▲▲▲
Parallel Storage Solutions	PDS-4	WangDAT 3400/ Rexon	$2895	N/A	6.00	7.52	N/A	5.29	7.32	▲▲▲/▲▲▲
PeriffTech, Inc.	Ariel-DAT ADE-8500	C1533A/HP	$2399	8.85	N/A	8.73	8.86	N/A	8.71	▲▲▲▲/▲▲▲
Rexon, Inc.	Tecmar ProLine CX DAT 8	WangDAT 3400/ Rexon	$2399	8.54	N/A	7.61	8.41	N/A	7.18	▲▲▲▲/▲▲▲
Sony Electronics, Inc.	SDT-5000*	SDT-5000/Sony	$1078	N/A	7.90	6.72	N/A	7.91	6.34	▲▲▲▲/▲
BYTE Storage Dimensions, Inc.	TDB-8005	C1533A/HP	$2315	N/A	9.31	8.18	N/A	9.45	7.95	▲▲▲▲/▲▲▲
Valitek Corp.	PST2-DAT	EXB 4200c/ Exabyte	$1695	N/A	5.45	5.89	N/A	4.4	5.0	▲▲▲▲/▲▲▲

DLT

Overland Data, Inc.	DLT 2000	DLT2000/ Quantum	$6000	N/A	9.57	9.58	N/A	9.98	10.00	▲▲▲/▲▲▲
BYTE Quantum Corp.	DLT2000	DLT2000/ Quantum	$4650	N/A	9.50	9.46	N/A	9.99	9.94	▲▲▲/▲▲▲
TTI (Transitional Technology, Inc.)	CTS-2110	DLT2000/ Quantum	$4995	N/A	9.50	9.39	N/A	10.00	9.85	▲▲▲/▲▲▲

8-MM

Dynatek Automation Systems, Inc.	HSB5.0	EXB 8505/ Exabyte	$2830	8.15	N/A	7.23	8.02	N/A	6.80	▲▲▲▲/▲▲▲
Exabyte Corp.	EXB-8505XL	EXB 8505/ Exabyte	$2800-$4500[2]	N/A	6.72	7.57	N/A	6.18	7.32	▲▲▲▲/▲▲▲
IBM Personal Computer Co.	IBM 3445 5/10 GB 8mm	EXB 8505/ Exabyte	$4005	N/A	6.74	7.56	N/A	6.22	7.30	▲▲▲▲/▲▲▲
Storage Dimensions, Inc.	TD1-10000	EXB 8505/ Exabyte	$3895	N/A	7.07	6.70	N/A	6.62	6.12	▲▲▲▲/▲▲▲
TTI (Transitional Technology, Inc.)	CTS-8510H (XL)	EXB 8505/ Exabyte	$3995	N/A	7.43	7.28	N/A	7.14	6.94	▲▲▲▲/▲▲▲

QIC

BYTE Legacy Storage Systems, Inc.	Legacy QIC 10	Wangtek 9500/ Rexon	$1800	7.56	N/A	6.68	7.56	N/A	6.38	▲▲/▲▲▲
Rexon, Inc.	Tecmar Proline CX QIC 10	Wangtek 9500/ Rexon	$2449	7.27	N/A	6.23	7.14	N/A	5.75	▲▲▲/▲▲

BYTE = BYTE Best. [1]Internal drive [2]Depends on OEM/VAR/distributor N/A = Not Applicable **Key:** Excellent ▲▲▲▲ Good ▲▲▲ Fair ▲▲ Poor ▲

RELIBILITY (MTBF) 1000 HOURS	MAX. CAPACITY GB W/COMPRESSION/ NATIVE MODE	SCSI PORTS/ PARALLEL INTERFACE	MAX. NO. OF DAISY-CHAINED DRIVES	SUSTAINED TRANSFER RATE COMPRESSED KBPS	BURST TRANSFER MODE MBPS	BUNDLED SOFTWARE/ NO. OF LICENSED USERS	PRICE INCLUDES SCSI CARD?	TOLL-FREE TELEPHONE	TELEPHONE	INQUIRY NUMBER
80	8/4	1/Yes	5	35/732	3	None	No	(800) 758-1041	(513) 339-2241	1105
150	8/4	1/No	7	40/800	5	Backup Exec for NetWare/25	No	(800) 626-6637	(408) 452-3943	1106
80	8/4	2/No	7	35/732	3	Retrospect, ARCserve, ARCsolo/Unlimited	No	N/A	(416) 636-3000	1107
180	8/4	2/No	7	40/732	4	Retrospect Remote/3	No	N/A	(415) 474-8055	1108
200	16/4	2/No	7	30/1000	2	ARCserve for Windows/5	Yes	(800) 743-4442	(619) 931-9122	1109
80	4/4	2/No	6	30/1000	1.5	ARCserve 5.0/250	Yes	(800) 752-0900	(303) 635-1000	1110
350	10/4	1/No	7	30/804	5	NovaBack/Unlimited	No	(800) 426-2968	Call local IBM dealer	1111
200	8/4	1/No	7	20/1500	3	None	No	(800) 228-0891	(407) 677-8333	1112
200	16/8	2/No	7	20/1500	3	ARCsolo/1	Yes	(800) 800-3475	(714) 453-6000	1113
40	16/4	2/No	7	20/1500	3	None	Yes	N/A	(714) 476-0515	1114
180	8/4	2/Yes	0	40/732	4	SDB-Retrospect/ Unlimited	No	(800) 998-7839	(914) 347-7044	1115
200	16/4	2/No	7	40/1500	5	None	Yes	N/A	(216) 278-2070	1116
180	8/4	2/No	7	25/INP	4	ProServe CX 2.0/ Unlimited	No	(800) 422-2587	(216) 349-0600	1117
80	8/4	2/No	7	35/732	3	None	Yes	(800) 352-7669	(408) 432-1600	1118
200	16/4	1/No	7	20/1500	3	None	No	(800) 765-7895	(408) 954-0710	1119
50	8/4	1/Yes	7	20/466	5	Valitek Backup Software/Unlimited	No	(800) 825-4835	(413) 549-2700	1120
80	20/10	1/No	7	45/3000	3	ARCserve/10	Yes	(800) 729-8725	(619) 571-5555	1121
80	20/10	1/No	7	48/2500	5	None	No[3]	N/A	(408) 894-4000	1122
80	20/10	2/No	7	48/2500	10	None	No	N/A	(714) 693-1133	1123
40	10/5	2/No	7	43/1000	2.5	Retrospect, ARCserve, ARCsolo/1	No	N/A	(416) 636-3000	1124
160	14/7	1/No	2	43/1000	2.5	None[3]	Yes	(800) 392-2983	(303) 442-4333	1125
180	10/5	1/No	7	67/1000	1.5	NovaBack/Unlimited	No	(800) 426-2968	Call local IBM dealer	1126
160	28/7	1/No	7	43/1000	2.5	None	No	(800) 765-7895	(408) 954-0710	1127
80	10/5	2/No	7	85/1000	2.5	None	No	N/A	(714) 693-1133	1128
200	10/5	2/No	7	40/1560	7	None	No	(800) 565-9002	(508) 681-8400	1129
200	10/5	2/No	7	40/1200	7	ProServe CX 2.0/ Unlimited	No	(800) 422-2587	(216) 349-0600	1130

[3] No SCSI card is needed; controller is embedded in drive INP = Information Not Provided

The Truth Behind the Pentium Bug

An error in a lookup table created the infamous bug in Intel's latest processor

TOM R. HALFHILL

Anyone who doesn't rely on a computer or an accountant to handle their income taxes is all too familiar with the final ritual of paging through the tax table in the back of the 1040 book. "If your taxable income is greater than *x* but less than *y*, then your tax is *z*...." The 1040 tax table is a classic example of a *lookup table*: a matrix of precomputed values that saves you the trouble (and potential pitfalls) of doing the arithmetic yourself. Programs often contain lookup tables to avoid executing lengthy calculations at run time. As long as the values in the table are correct, the final results will be accurate.

It was this quest for speed and accuracy that led Intel to embed a lookup table in the Pentium's FPU, its fifth-generation x86 microprocessor. Stung by the superior floating-point performance of competing RISC processors, Intel wanted to endow the Pentium with an FPU significantly faster than that of any other x86 chip. This would allow Intel to promote the Pentium as a CPU for scientific and engineering applications, as well as the best engine for mainstream software that relies primarily on integer operations.

Genesis of an Error

Intel's goal was to boost the execution of floating-point scalar code by 3 times and vector code by 5 times, compared to a 486DX chip running at the same clock speed. To achieve that, the Pentium engineers had to improve on the 486's traditional shift-and-subtract division algorithm, which can generate only one quotient bit per cycle. They settled on a new method called the *SRT algorithm* that can generate two quotient bits per cycle.

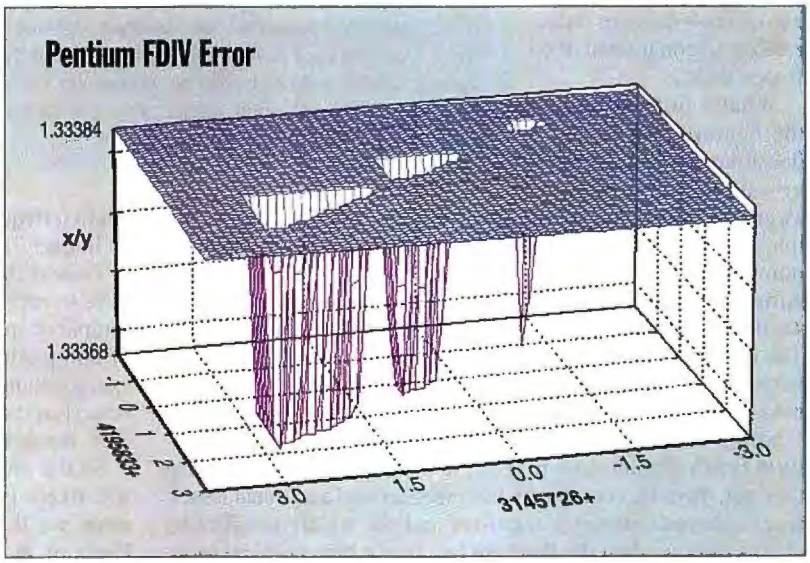
Named after three scientists who independently conceived it at almost the same time, the SRT algorithm uses a lookup table to calculate the intermediate quotients that are necessary for iterative floating-point divisions. As implemented in the Pentium, the SRT lookup table is a matrix of 2048 cells, although only 1066 of these cells actually contain values. For those that do, the values are integer constants ranging from –2 to +2. The algorithm uses the bit pattern of the divisor as an index into the table.

So far, so good. But here is where things went horribly wrong. An engineer prepared the lookup table on a computer and wrote a script in C to download it into a PLA (programmable logic array) for inclusion in the Pentium's FPU. Unfortunately, due to an error in the script, five of the 1066 table entries were not downloaded. To compound this mistake, nobody checked the PLA to verify the table was copied correctly.

These five cells are distributed along a boundary of the matrix and should contain the constant +2. Instead, the cells are empty. When the FPU accesses one of these cells, it fetches a zero. This throws off the calculation and results in a number that is always slightly less precise than the correct answer.

Because the SRT algorithm is recursive, the shortfall can accumulate during successive iterations of a division operation. At its worst, the error can rise as high as the fourth significant digit of a decimal number (but not the fourth digit to the right of the decimal point, as is commonly believed; the decimal point can be positioned anywhere in the binary floating-point number format). However, the chance of this happening randomly is only about 1 in 360 billion. Usually, the error appears around the 9th or 10th decimal digit. The chance of this happening randomly is about 1 in 9 billion.

Because the bit patterns of certain divisors lead to the corruption of quotients derived from certain numerators, the bug occurs only with certain *pairs* of divisors and numerators—no particular divisor always triggers the bug. The "buggy pairs" can be identified, however, and they



This graph is a 3-D plot of the ratio 4195835/3145727 calculated on a Pentium that has the FDIV error. The depressed triangular areas indicate where incorrect values have been computed. The correct values all would round to 1.3338, but the returned values are 1.3337, an error in the fifth significant digit. (Information courtesy of Larry Hoyle, University of Kansas.)

always result in a wrong answer on any Pentium chip manufactured before the bug was fixed.

Furthermore, the bug potentially afflicts any instruction that references the lookup table or calls FDIV, the basic floating-point division instruction. Related instructions include FDIVP, FDIVR, FDIVRP, FIDIV, FIDIVR, FPREM, and FPREM1. The transcendental instructions FPTAN and FPATAN are also susceptible, though no actual errors have surfaced. The transcendental instructions FYL2X, FYL2XP1, FSIN, FCOS, and FSINCOS were once suspect but are now considered safe.

Assessing the Damage

The basic facts about the Pentium bug are not in dispute, though they are often misunderstood. For instance, the Pentium does not suffer from a hardware defect in the same sense as a defective appliance or automobile. This is a software bug that's encoded in hardware, and it's the sort of bug any programmer can sympathize with. Users who tolerate a certain level of bugs in their applications and system software should recognize that the same kinds of flaws are inevitable in microprocessors. Unlike memory chips, which are little more than vast arrays of transistors, logic chips can contain complex software mechanisms—such as the FDIV algorithm—that are delivered on silicon instead of on floppy disks.

What's different about the Pentium bug is that it doesn't crash your computer—it yields wrong answers so subtle you might never notice anything amiss. But this raises another important issue, which is that binary floating-point math inherently lacks the precision of integer arithmetic. Although computers are still regarded as math machines, they are not really comfortable with floating-point decimal operations. The conversions between binary and decimal, coupled with inherent limits on precision, always result in small errors that are usually ignored.

Still, Pentium owners paid for a CPU that's supposed to perform floating-point math to IEEE standards, and that's not what they got. Instead, controversy has raged around additional issues: Intel's dismal customer relations and the wildly conflicting claims of how often the Pentium bug might bite a typical (non-scientific) user.

The court of public opinion has ruled on the former subject, but it's not so easy to judge the latter. Intel says a typical spreadsheet user might encounter the bug once in 27,000 years; IBM, which yanked its Pentium systems out of stores in December, says it could happen once every 24 days. Who's right?

Unfortunately, this argument will never be resolved to everyone's satisfaction because it hinges on key assumptions about users' behavior. How large are their typical spreadsheets? How often do they recalculate? How many FDIVs are executed? How often do buggy pairs occur?

Intel's 27,000-year estimate assumes that the average spreadsheet user will execute 1000 FDIVs per day and that buggy pairs happen randomly. IBM's 24-day estimate assumes 4.2 million FDIVs per day and that buggy pairs happen more often than random chance would suggest.

To back up its claims, Intel analyzed 510 spreadsheets from its internal departments (finance, sales/marketing, planning, treasury, product engineering, production control, and tax/customs). A special profiler counted floating-point operations during recalculations and also trapped for divisors containing the telltale bit patterns. Intel says the results confirmed its earlier estimates.

IBM insists that buggy pairs crop up more frequently than Intel claims because of a phenomenon dubbed "integer bruising" by Vaughan Pratt, a computer scientist at Stanford University. Pratt builds a formidable argument that common integers—distorted into slightly inaccurate values by seemingly innocuous floating-point operations—can lead to non-random frequencies of buggy pairs. (See textbox, "How to Bruise an Integer.")

To settle this dispute empirically, an independent party would have to replicate Intel's experiment across a statistically valid sample of spreadsheets obtained from a representative selection of companies. Even if such a party could get permission to examine hundreds of proprietary spreadsheets and record users' behavior, the data would take months to gather and analyze. By then, it would be of interest mainly to historians and lawyers.

So the ultimate question, "How serious is the bug, really?" will likely go unanswered forever. To paraphrase Albert Einstein, we'll probably never know if God plays dice with the Pentium. ■

How To Bruise an Integer

The "bruised," or truncated, integers Vaughan Pratt describes are numbers that should be integers and may appear as integers when displayed on the screen but internally are represented as floating-point values that fall just shy of a whole number. To see how this happens, try the following experiment using the Calculator program in Windows 3.1. This works on any PC, not just a Pentium.

1. Open the Calculator and select scientific mode from the View menu. Select decimal mode by clicking the button marked DEC.
2. Enter the integer 3.
3. Switch to binary mode by clicking the button marked BIN. Notice that Calculator correctly displays 11, the binary equivalent of 3.
4. Switch back to decimal mode and clear the display.
5. Enter 4.1 minus 1.1. Notice what appears to be the correct answer, 3.
6. Switch to binary mode. Calculator incorrectly displays 10, which is the binary equivalent of 2, not 3.
7. Switch back to decimal mode. The display now reads 2, not 3.

What happened? The floating-point subtraction in step 5 appeared to yield the correct result, but internally the number 3 was stored as a floating-point value that didn't quite equal 3 (probably 2.9999999...). When this "bruised integer" was converted to binary, Calculator evidently rounded down instead of up, causing an error in the displayed result. Microsoft corrected this problem in a new version of Calculator posted on various on-line services in January. However, the main point here is that the Calculator program illustrates how integer bruising occurs.

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A Warped Perspective

Warp's impressive control of DOS, Win16, Win32s, and OS/2 applications makes it an attractive choice for savvy integrators

JON UDELL

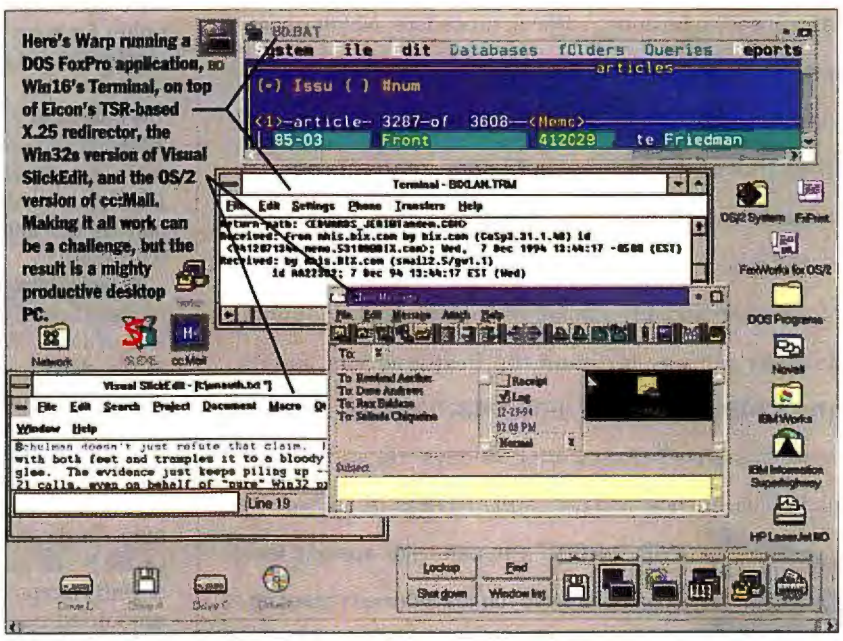
I'm dedicating this column to the folks at V Communications, whose excellent multiboot utility, System Commander, is enabling me to juggle DOS/Windows, Windows 95, Windows NT, and OS/2 Warp without dropping any of these balls. Who needs to perform this juggling act? Software developers and reviewers do, of course, but so do a growing number of system integrators and advanced users. The new 32-bit operating systems—Windows 95, NT, and Warp—use DOS and Windows as personality modules that support legacy applications. DOS/Windows isn't supposed to be the *dominant* personality, because these new systems are designed to host new breeds of applications. But the old code has a way of hanging around, and for Windows 95 and Warp in particular, effective use of it will be crucial.

Warp can be an amazingly effective integrator of legacy applications. Two of these that matter to BYTE are called `bixlan` and `bd`. The `bixlan` program connects users to the BIX conferencing system by a circuitous path that involves an INT 14 terminal emulator talking through an SPX network link to an Eicon X.25 card hooked to a 56-Kbps leased line. One variant of `bixlan` works in DOS, but reliably blows up when run in a Windows DOS box. Another variant, using an Eicon-supplied COMM.DRV replacement, supports Windows telecommunications software but precludes modem communications on the COM port that it uses. Both variants require either a TSR or a CONFIG.SYS driver, which eat up a big chunk of conventional memory. NT 3.5 and Windows 95 beta 2 won't run `bixlan`, but Warp handles both the DOS and Windows variants flawlessly. Because they talk to a virtual COM port in an OS/2 VDM (virtual DOS machine), they can't monopolize a physical port. And because the conventional memory hit is confined to that VDM, there's no impact on another homegrown program, `bd`, a FoxPro 2.0 application that tracks information about articles and authors. `bd` likes as much conventional memory as it can get, plus a big hunk of EMS memory, and while it can get these things from NT and Windows 95, it runs noticeably faster on Warp.

INT 14 and X.25? FoxPro 2.0 and EMS? You're right, these technologies are embarrassingly long of tooth. Of course, we'll be replacing `bixlan` with `telnet`, and `bd` with one of the cross-platform, client/server, component-based, buzzword-compliant solutions we keep experimenting with, just as soon as we find the time (translation: don't hold your breath waiting). Meanwhile, it's valid to avoid fixing what's not broken, and to extend the useful life of sunk investments (I'll bet you have a few skeletons in your closet, too). Particularly in vertical markets such as insurance and retail, investment in PC software is substantial, and Warp's ability to leverage those applications is a major strength.

Not for the Fainthearted

Warp can revitalize legacy code; however, it's not guaranteed to do so, and when it does, it's not quite in the way that IBM's marketing campaign envisions. The product is pitched, for the most part mistakenly, at end users. "Gordon, a lawyer in Halifax, Nova Scotia," a typical ad might say, "has Warped his PC, and now he's surfing the Internet while printing a mail merge in the background." To Warp your PC means to install the latest version of OS/2 for Windows on top of an existing DOS and Windows 3.x substrate. The resulting system boots OS/2, supplies its own version of DOS, and runs Windows system components (with some scary in-memory patches)



and applications (unmodified) in a VDM. IBM's marketing says that Warping is an end-user exercise that makes a PC more productive, which is very possibly true, but also simpler to use, which is generally false, because where Gordon formerly had two operating systems to contend with (DOS plus Windows), now with the addition of OS/2, he has three.

Consider Gordon's likely experience with FaxWorks for OS/2, the nifty fax software included in the Warp Bonus Pak. He installs it, tests it by faxing a document from the IBM Works word processor, another OS/2 application that comes in the Bonus Pak, and is delighted to find that it just works. Encouraged, he fires up Windows, connects to the FaxWorks queue on LPT3, then previews and faxes off a Winword document. This time, however, what rolls out of the fax machine is a page of hieroglyphics. Why? Winword is set up to print to Gordon's LaserJet, and the stream of PCL (Printer Control Language) it emits means nothing to FaxWorks, an OS/2 printer driver that (unbeknownst to Gordon) emulates an IBM Proprinter.

This problem can in theory be fixed in two ways—setting FaxWorks for PCL or installing the Windows Proprinter driver and telling Winword to use that instead of the HP driver. In practice, only the latter solution will work, because while a settings page in the FaxWorks driver tantalizingly lists PCL emulation, it won't actually let you select it. Now, this is not rocket science, but Gordon is only vaguely aware of what Windows printer drivers do, has never encountered an OS/2 printer driver, and is certainly not equipped to spot—never mind repair—a fumbled handoff from one to the other. However, once someone does straighten out Gordon's Warped PC, he is likely to be very happy with the results. FaxWorks can really crank, because it's native OS/2 software and because it's more streamlined than the ambitious but rather baroque E-mail-and-fax At Work technology included with WFW 3.11 and Windows 95.

The Integrator's Platform

IBM likes to call OS/2 the integrating platform, but I think it's more accurate to call it the integrator's platform. Beyond running DOS and Windows code side by side with OS/2 applications, here are two important things a savvy integrator might want to do with Warp:

❶ **Field distributed applications** On one of my Warped PCs, I'm running the Lotus Notes Server alongside the Notes client and a mixture of DOS, Windows, and OS/2 applications. As companies deploy database, fax, communications, mail, and other more specialized network services, the question becomes where to put them. Consolidation onto powerful servers, as exemplified by the Microsoft BackOffice strategy, presumes that services are few and clients relatively feeble. Distribution across a network of peers, on the other hand, might make more sense as services multiply—if the peer workstations can capably run those services. On the 8-MB workstations that Windows 95 and Warp (but not NT or Unix) can productively use, Win 95's bias is heavily toward the centralized model, but Warp (like NT or Unix on bigger hardware) can go either way. Warp's small footprint and its robust multithreading and memory management, plus IBM's network-capable SOM (System Object Model) technology, add up to a recipe for distributed computing.

❷ **Create customized user interfaces** Because native OS/2 applications are scarce, and because many that do exist (e.g., Lotus SmartSuite) are sadly out of date, the radical openness of Warp's Workplace Shell has gone largely unappreciated. The OS/2 version of cc:Mail, which uses customized WPS folders and provides a message

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template that you can drag from the Templates folder, only scratches the surface. DevTech's DeskMan/2 utility hints at the more pervasive customization that is possible. It alters the Workplace Shell's drag-and-drop behavior in a deep way, so that a Copy/Move/Shadow menu pops up when you release a dragged object. As a result, you needn't remember how pressing the Alt or Ctrl keys modifies the drag operation to perform these actions. A modest enhancement, but it shows how the SOM hierarchy that underlies the Workplace Shell can orchestrate systemwide, not just per-application, behavior.

Onward to Win32?

Warp runs Win32s applications handily. That might not seem like a big deal, because there are only a few such applications around today, among them SPSS, Mathematica, and one I use a lot, Visual SlickEdit. While reviewing Mathematica, BYTE technical editor Doug Tamasanis was intrigued to find that Warp ran the Win32s version of the program faster than did Windows 3.1, in some cases a whole lot faster. What's the future of Win32s? Some developers will bet on a slow uptake of Win 95 and NT and opt for the common-denominator Win32s API, sacrificing threads and advanced graphics to create a single 32-bit binary for all Windows platforms. Others will sacrifice Windows 3.x compatibility to exploit the richer Win32 APIs in Win 95 and NT. Win32s normally needs a VxD (virtual device driver) that, according Microsoft's documentation, provides exception handling, floating-point emulation, and memory management services. Enabling Warp to run VxDs was how IBM originally planned to support not only Win32s but also other VxD-based services, including the WFW 3.11 networking code. It didn't turn out that way, though. Warp doesn't run VxDs. Win32s works because Warp provides an OS/2 VDD (virtual device driver), W32S.SYS, that does the job of the Win32s VxD, W32S.386. The services that Win32s applications normally get from that VxD come, in this case, straight from OS/2.

Suppose IBM had instead delivered VxD support in Warp. VxDs normally run under Windows Virtual Machine Manager control, so Warp would have had to find a way to run (or emulate) that VMM, which in turn would run the Win32s VxD, which in turn would provide services to the other Win32s components. That would be the ring 0 analog to the way Warp now encapsulates the ring 3 Windows subsystem to run Windows applications on top of it. It's true that many of Win 95's Win32 features, including threads and linear memory management, are VxD-based. But OS/2 shouldn't require VxDs for services that it can supply natively. NT certainly doesn't. Like NT, OS/2 is going where no x86-specific VxD can go—onto the PowerPC. And on x86-based PCs, OS/2 runs well in half the RAM that NT requires. Finding ways to plug Win32 directly into the robust and capable OS/2 kernel is the smart play. The way IBM chose to implement Warp's Win32s support is a step in the right direction. ■

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OLE Controls from the Ground Up

The low road to OLE controls has its charms

STEVE APIKI

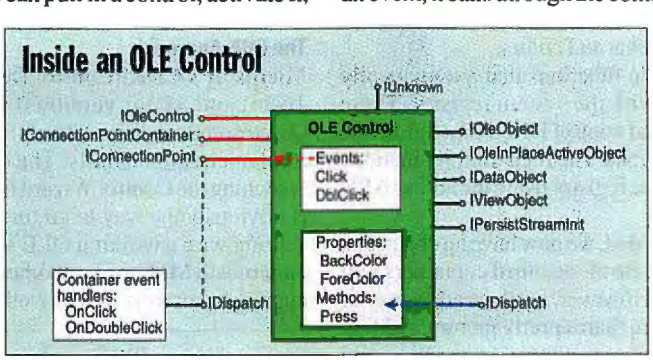
OLE controls are the heirs apparent to VBXes (Visual Basic custom controls), arguably implementations of the most successful component software model to date. OLE controls, like VBXes, are reusable, binary software objects with well-defined properties and I/O interfaces. Like VBXes, OLE controls make possible the rapid construction of sophisticated applications through the wiring together of component objects atop hosts like Visual Basic. Unlike VBXes, however, OLE controls can be built with 32-bit code; are based on COM (Common Object Model), a well-supported model; and are potentially portable beyond Windows and Win32 to the Mac OS.

Building an OLE control can be as simple as firing up Visual C++ 2.0, choosing Control Wizard from the menu, and instantly generating a new OLE control project. However, there's nothing magical about OLE control generation; in fact, if you've already built an OLE server that you want to convert to an OLE control, or if you don't want to be tied to Visual C++, you may want to consider implementing the control yourself.

The View from 10,000 Feet

Except for its intended use, an OLE control is nothing like a VBX (see the figure). At its core, an OLE control is an in-process OLE server that supports in-place activation (i.e., the ability to control the container's user interface elements). To this core, an OLE control adds layers of OLE Automation support and a few new interfaces to handle behaviors that are unique to controls.

The "embedding" part of OLE already provides most of the requirements for a drop-in custom control. It's the mechanism through which users can pull in a control, activate it, and edit it using the host's menus and toolbars. Supporting OLE embedding means building a COM object that exposes the OLE interfaces shown in black in the figure. These interfaces let the container place, activate, and store and retrieve the object, as well as mediate communication between control and container required for display updates and data access. The container also uses standard OLE models to locate the DLL in which the control resides (using the system registry) and to create an instance of the control (a `DLLGetClassObject` entry point in the DLL).



An OLE control equals an OLE in-place server DLL plus OLE automation interfaces for access to properties and methods plus a few new interfaces for mnemonic keystroke and event handling.

But a control is more than an embedded server. Controls have user-editable properties and user-callable methods. A button control might expose a color property, for example, or a "press" method that makes the control appear to have been clicked by a mouse. The types of these properties and the parameters of these methods must be made available to the container; the container also needs to know the names of these items so it may present them to the user. The `IDispatch` interface (the blue arrow in the figure) that forms the basis for OLE Automation accomplishes this.

`IDispatch` provides a way to obtain type information and access to properties and methods. Controls carry with them (usually bound in a resource) a binary object called a *type library*, which supplies a means to find the names, types, and parameters of the control's properties and methods. Containers find objects in the type library using the `IDispatch` interface.

OLE embedding or OLE automation interfaces don't address two key control behaviors: mnemonic accelerator support (e.g., Alt-key combinations in place of a mouse-click to activate a button) and a method for firing events. Mnemonics are handled through the new `IOleControl` interface (the red lines in the figure indicate new interfaces), which lets the container find accelerators associated with the control and call a handler when appropriate.

Event capability is the most radical OLE technology introduced with OLE controls. Events are calls to functions within the container (e.g., `OnClick`) in response to an external action (a mouse-click on the control). For the container to know which functions it must implement to support these events, the control exposes a description for a second `IDispatch` interface inside its type library. The container uses this description to build its own dispatch table that implements the required functions. When the control needs to fire an event, it calls through the container's dispatch interface to the user's implementation. This is a tricky point; the container must essentially implement an interface that is only described to it when the control is loaded. Making sure events get hooked up correctly is the responsibility of `IConnectionPoint` and `IConnectionPointContainer` interfaces introduced for OLE controls.

There is considerably more to an OLE control,

of course. It should present dialogs for editing properties (*property pages*), it must provide functions for self-registration, and it can support licensing features.

Firing an event (a mouse click) using new OLE control interfaces

```
...
hr = ppl->pIConnectionPoint->EnumConnections( &pEnum );
if SUCCEEDED(hr)
{   LPDISPATCH pSend;
    makeDispParams( &pparams, 2, VT_XPOS_PIXELS, &x,
                    VT_YPOS_PIXELS, &y);
    while( NOERROR == pEnum->Next(1, &cdata, NULL) )
    {   hr = cdata.pUnk->QueryInterface( IID_IDispatch,
            (LPLPVOID)&pSend);
        if ( NOERROR == hr)
        {   pSend->Release();
            hr = pSend->Invoke( DID_CLICK, IID_NULL,
                 ppl->lcid, DISPATCH_METHOD,
                 pparams, NULL, &einfo, &badarg);
        }
    }
    pEnum->Release();
    freeDispParams( &pparams);
}
...
```

Almost from Scratch

Building an OLE control from scratch is too involved a process to review in this space, so we'll start from where an OLE control begins to deviate from an OLE server supporting in-place activation. If you're starting with an OLE 2.0 server that's part of an application, you'll have to move the applicable code to a DLL, which is the only acceptable venue for an OLE control. You can also cut out any custom interfaces you may have implemented and any interfaces not related to those listed in the figure, as the container will never see them.

The first real step is to define the properties, methods, and events that your control will support. You do this by writing a script in ODL (Object Description Language), which you'll compile using Microsoft's MkTypLib. The ODL script describes both the dispatch interface (incoming) and the event connection interface (outgoing). If you've built OLE automation servers before, you'll notice that several ODL extensions have been added for controls, including specifying the events dispatch interface and new property attributes to support data binding. MkTypLib generates a type library that you'll bind to the application.

Although the type library describes two `IDispatch` interfaces, you'll only implement the incoming one. The container will handle the outgoing implementation once we add events. Most of the functions in the `IDispatch` interface can be relayed to default handlers inside the OLE DLLs, so building the incoming interface is mostly a matter of finding your type library and passing the information back to OLE. `IDispatch::Invoke` will relay calls from the container into functions inside the control.

We now have an OLE server that supports in-place activation and OLE automation and that contains custom properties and methods. To make it begin to look like an OLE control, we add an `IOleControl` interface. `IOleControl` primarily supplies a medium through which the container can notify the control of mnemonic keystrokes and of changes in the container's ambient properties. *Ambient properties* are those that describe the container's environment around the control, such as fonts and colors.

OLE control DLLs must include functions that automatically register and unregister the DLL with the system registry. These allow users to browse for additional control DLLs (not unlike the Visual Basic "Add File" menu option). The registration functions add keys describing the classes to the registry using the access APIs the SHELL library provides.

With the registration functions added, we now have an object that we can legitimately call an OLE control—control containers will recognize it and be able to load it. However, until we add a way to fire events, our control is little more than a pretty picture. Adding events requires writing the `IConnectionPointContainer` and `IConnectionPoint` interfaces and coding up the calls to make to the container when events occur.

Supporting `IConnectionPointContainer` is how a control demonstrates to the outside world that it has outgoing event sets. To establish event communication, a container first calls through `IConnectionPointContainer` to find the `IConnectionPoint` interfaces. Each connection point handles an entire event set, so your control will probably need just one or two connection points—one for your outgoing events and possibly one for data change notifications. Writing `IConnectionPointContainer` amounts to keeping track of these two interface pointers.

Once the container has found the control's connection point, it calls `IConnectionPoint::Advise` for each connection it wants to make to the control. The container hands this function a pointer to its implementation of the event dispatch interface that you described in your type library. Because the container can have multiple connections to a connection point, you need to maintain a list of these pointers and be prepared to enumerate them.

With the connection interfaces in place, we can now get a list of dispatch pointers to use when firing events off to the control. The listing gives an example of how you might actually fire an event (a mouse-click). The first step is to put the function call arguments into a form that `IDispatch` can understand (`makeDispParams`). Then we find each dispatch interface in the list we maintain (those that came from `IConnectionPoint::Advise`) and call the Invoke method to send the function. The ID we use to identify the function (DID_CLICK) and the number and types of its parameters (the arguments to `makeDispParams`) are those that we used when we built the event dispatch description into the type library.

To finish our OLE control, we need to add support for property pages. Property pages are COM objects that support a dialog window displayed when end users wish to browse or edit the control's properties. Supporting these requires adding an `ISpecifyPropertyPages` interface to our control and building the property-page objects. The interface contains a single function that hands back the class ID of our property-page object. The property page supports a single interface that allows the placing of the dialog within a property browsing frame window and updates properties that are changed.

The CDK Approach

Microsoft's CDK (Control Development Kit), bundled (in both 16-bit and 32-bit versions) with Visual C++ 2.0, uses MFC (Microsoft Foundation Classes) and a lot of built-in code to hide these implementation details. The steps above got us about as far as launching the Control Wizard from VC++ would have, so the CDK is obviously the way to go for most controls. However, if you're starting with a working OLE server, are curious about the wiring underneath MFC, or have other special requirements, a pure OLE approach can work just as well. ■

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Network-Ready Computers

The fastest networks will challenge desktop systems architects

PETER WAYNER

One of the biggest design challenges over the next ten years will be integrating desktop machines with the increasing power of networks. These new networks promise to deliver hundreds of megabits of data per second, and the traditional personal computer is built around an architecture that rarely has to handle more than a 14.4-Kbps modem. Ramping up the desktop machine will require more than just adding a faster interface card—designers will probably have to reengineer nearly every part of the desktop system to handle the flood of data.

Engineers and technicians involved with high-speed testbed networks are already facing some of these problems. Take, for example, the Aurora Project, one of several U.S. Government–funded Gbps testbeds for researching high-speed networking technology.

While the other Gb testbeds linked supercomputers and mainframes, Aurora concentrated on hooking up workstation-level machines to 600-Mbps ATM (asynchronous transfer mode) networks. The test network linked workstations at MIT (Cambridge, MA), IBM's TJ Watson Research Center (Yorktown Heights, NY), Bellcore (Morristown, NJ), and the University of Pennsylvania (Philadelphia, PA).

The folks involved in the Aurora Project are among the first that are encountering the problems that will eventually hit every desktop machine architect: Many different bottlenecks limit the performance of every part of the machine, from the hardware cards to the video apparatus to the software protocols that linked everything together. In fact, some members of the Aurora Project concluded that a RISC instruction set may be the only part of the computer that won't need to be redesigned.

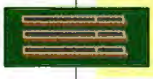
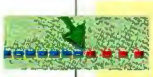
Related Bottlenecks

Everything from the desktop system's network I/O components to its operating system should be reexamined to attach the machine to a high-speed network (see the table, "Not Ready for Prime Time"). The Aurora Project uncovered some subsystem's limitations. For example, the I/O cards in their RS/6000 workstations could handle only 135 Mbps. Faster cards might be able to assemble the incoming data without balking, but they could not find a way to get the data to memory because the bus bogged down. Other data cards, such as those that link the hard disk, began to interfere with the bus traffic.

These problems are certain to cause grief for computer architects. Many users are quite familiar with the limitations that the old computer bus brought to video performance. Local buses that link the processor with the

NOT READY FOR PRIME TIME

Getting a desktop computer ready for high-speed networking means significant changes to some fundamental components.

Bottleneck	Problem	Possible Solution
 **Network adapter cards**	Cannot handle high-speed data flow I/O tasks	More on-board processing power and memory
 **PC bus**	Current bus architectures' low capacities and blocking nature	Higher-speed bus, such as PCI, and nonblocking architectures
 **CPU**	Processing power diverted to handling communications tasks	Processors on I/O cards that off-load some of the CPU's communications tasks
 **Operating System**	Many operating systems' single-tasking natures tie up a system when handling long data streams	Multitasking operating systems that allocate resources in real-time
 **Networking protocol**	Built-in features, such as error detection and handling, bog down systems	Newer protocols, such as ATM, that rely on higher-layer functions to deal with errors

video cards are now almost standard on many desktop machines. Adding a single, faster bus between the CPU and the video card is just a temporary maneuver that will speed up only one process. It is not possible to add another fast bus between the CPU and the fast network I/O card because this overloads the CPU.

One solution to this problem, the PCI (Peripheral Component Interconnect) bus, is becoming a standard for providing fast links between the CPU and other operations. This bus promises to offer enough speed to juggle several different parts that want to send information across the bus. The greatest danger will be long packets that bog down the bus. Devices on the bus cannot seize control of it until the packet is finished traversing the bus. This delay can be significant if the packets are large.

In the future, the possibility of packet delays could make the bus obsolete. The nature of the bus allows any device to communicate with any other one, but only two can communicate at one time. This might have made sense when there was one CPU that did all of the work. Now, though, any desktop system with a collection of I/O processors will have trouble letting them all work to capacity if they must communicate through a bus.

But remember that you can't make any change in a component without considering its interplay with other components. For example, distributing processing tasks to CPUs optimized for that particular task without changing the bus architecture will only yield an incremental gain in performance (which is limited by the bus' capacity to move the data between devices). Conversely, a high-speed bus that operates without regard to an attached device's ability to handle the data can be a performance disaster. For example, when a bus passes data faster than the device's buffers and processor can handle, they drop data or require that it be resent frequently.

Over the years, desktop systems have gone through bus changes, so another change to accommodate high-speed networks doesn't seem that drastic. The most radical overhaul will be the operating system. The current batch (MS-DOS, Windows, Mac operating system) emerged from an era when each application could assume that it had complete control over the machine. The latest versions provide a cursory amount of multitasking, but they can quickly break down when one application goes awry.

This application-centricism must change. As information pours in from the network, the computer must be able to handle it as a background task. Every few microseconds, the operating system must devote some time to processing the incoming information and making sure that it gets to the right place. If it fails often enough, the buffers will overflow, and the battle will be lost.

More modern operating systems like Windows NT, OS/2, and Unix offer preemptive multitasking. The operating system is capable of interrupting programs and allocating resources to another process. While this approach is a step in the right direction, it is not a complete solution. Too many processes can still bog these operating systems down because the operating systems treat all processes in the same manner.

The next round of operating systems will need to make decisions about allocating resources in real time. They will have to keep a list of essential programs and ensure that they get a guaranteed amount of time so that they can do the essential work. Real-time versions of Unix are already used in time-critical machines, like ATM network switches. These versions have a light-weight kernel that switches between processes based on real time. The designs in these machines will become more standard in desktop machines that step up to the challenge of handling multiple processes.

Using New Protocols

Even if the computers can absorb the information fast enough and the operating system can keep the data straight without bogging down, the computer still must pack up data correctly for conversing over the network. One of the biggest and most widely known standards for this is TCP/IP, a system that manages the data in blocks and stores it locally before giving it to the local application that requested it. One computer manufacturer reported that its machine would move a block of data around in local memory as many as four times to satisfy one network TCP/IP transaction.

Protocols like these won't function successfully at high speeds. Higher speeds mean bigger blocks of data, which require more memory and CPU cycles to handle these requests. The CPU will spend more of its time moving the data and less doing something with it when it arrives. When the TCP/IP protocol emerged years ago, many of the networks were much slower than the computers. Adding a layer of software that handled the incoming data made life easier for the applications programmer.

In the faster future, a more rational approach will require each application to bypass any local network protocol arbitrator and set up direct, virtual connections between itself and another machine. It will be important to remove any level of abstraction, such as TCP/IP's socket-based system, so the two applications bridging the network can shuffle packets directly.

The ATM standard has the potential to do this successfully. However, the standard covers only how the packets move once they enter the network. The software tools for exploiting this are still emerging.

Keeping Pace

The most likely casualty of all this change will be the imperial CPU that has long ruled the desktop computer. In recent years, it shed some of the responsibility for maintaining the display, as faster GUI-accelerator video cards became common. Now CPU design must change again to cope with the demands of faster network connections.

High-speed I/O controller cards will become increasingly common. The more powerful they are, the more viable they will be. Some manufacturers are currently offering cut-rate prices on ATM cards that require the host CPU to split each data transmission into 53-byte packets. This often bogs down the CPU and absorbs most of its time. The better cards come with their own I/O controller for handling the buffering and the network connections.

Desktop systems may even come with multiple CPUs that share a common memory space. Such machines are increasingly common in the workstation world. In a multiple-CPU design, one would maintain network connections while the other responded to the user's direct requests. This setup could become necessary if network protocols demand plenty of computational resources.

Eventually, the market might begin to list the network I/O capacity instead of the main CPU number as a measure of a computer's performance. The network I/O's speed will govern how well the system manages multiple video and data streams. Machines with fast network access can link up with remote services that offer virtual-reality graphics, video, and other real-time, data-intensive services. Then probably only writers and other isolated individuals who don't need high-speed interaction will be among the few still using the older, slower systems. ■

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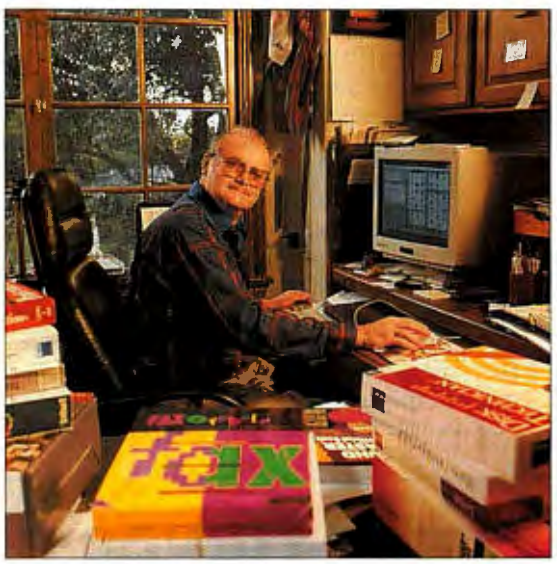
Unexpected Adventures



AMY ETRA © 1995

Intending only to update a simple BASIC program, Jerry winds up locked in combat with uninstallers, tape drives, INI files, and more

First a word of free advice to IBM. Get OS/2 on PowerPC systems fast, spend the money to get a simple and reliable installation program, and *give* a copy to everyone who has or gets a Power Mac. You don't even need to write software for letting the Mac and OS/2 installations talk to each other. Third parties will do that. But getting OS/2 on the PowerPC in general, and the Power Mac in particular, would really change the small-computer scene—if it's done quickly. Now back to your regularly scheduled column.

The book of the month in last month's column was Donald Norman's *Things That Make Us Smart: Defending Human Attributes in the Age of the Machine*. It's a great book that's well worth reading; but my theme this month is "things that make us feel stupid." Why do even the simplest things have to be an adventure? Why can't computers make you feel good instead of guilty?

It all started when I decided to update the DOS version of my wife's reading-instruction program, The Literacy Connection. (For more information, contact Mrs. Pournelle at rjp@bix.com.) The program is written in compiled Microsoft QuickBasic using Crescent Software's QuickPak Professional toolkit. It's quite elderly, having been written for CGA and monochrome PCompatibles. The graphics are simple line drawings, and, for that matter, when you log in, there's no real menu. The Literacy Connection works—it has taught thousands of kids (and adults, too) to read, including many diagnosed as dyslexic—but in this era of whizbangs, it looks like something out of the Stone Age.

That was made particularly clear when Roberta got the Macintosh version running. It has point-and-click menuing; color graphics, including some animation; and games kids can play when they're tired of the reading lessons. I didn't have the time to work on that, and I'm not a Mac programmer anyway, so she had Chris Innanen do most of that work. While I doubt it can teach reading any better than the clunky, old DOS version, it sure looks a lot better. The upshot is that I was shamed into trying to improve the old one.

I didn't intend anything fancy; just a way to take clip art—we have disks and disks of good stuff from T/Maker, Corel, and others—and throw images on the screen between lessons. Incidentally, one reason we have primitive graphics is that this program doesn't make the fatal mistake many educational programs do of having lots of fancy graphics for kids to look at when they should be looking at the lesson. Roberta's program flashes a few graphics images just long enough to get their attention and then goes to the lesson materials. I didn't want to change that; I just wanted to use better images.

The first thing was to go over the QuickBasic manuals on graphics. I soon learned that while QuickBasic has plenty of tools for *drawing* images, it has very little for taking an outside image and putting it on-screen. OK, the next step is to look at Crescent Software's toolkits; and they have most of what I need. The QuickPak Professional library has tools for doing fancy menus with or without mouse support and scroll bars. The Graphics QuickScreen library has both a paint program and a way to take outside files

ILLUSTRATIONS: CATHARINE BENNETT © 1995

and display them from within a QuickBasic program. Voilà!

Of course there was a catch. There always is. The catch in this case is that Graphics QuickScreen knows how to deal only with PCX-format files. Even that is a bit complicated, but Crescent provides examples—one of Pournelle's laws states that software publishers can't provide too many examples—and source code for demonstration programs. I had an early lesson in feeling stupid while getting the demonstration to run, but I managed it, and now I know how to get PCX-format images on-screen from within a QuickBasic program. Hallelujah!

Alas, at one time PCX was a popular format, but a search through several CD-ROMs showed me that nowadays there's not much clip art published in PCX format. The files are now all in TIFF, GIF, WMF, and suchlike. Clearly, I needed a program that can read in one of the more modern formats and write the file out in PCX format.

Well, that should be no problem. CorelDraw knows how to read almost all known graphics files and can write them out in PCX format. This should be a snap. I put the CorelGallery CD—10,000 images—into the local CD-ROM drive and invoked CorelDraw.

No joy. In fact, no program. I ran out of space on the local hard disk some weeks ago and moved some things around. Where CorelDraw had been was a note saying I had moved CorelDraw 3.0 across the network to another machine; it could be found on Windows for Workgroups network drive M. OK, go back to Program Manager, edit the file property to look for it at M, and try again. No joy. WIN.INI was telling the system to look at the C drive. Go into WIN.INI, find every reference to CorelDraw, edit to read M instead of C, exit Windows, reboot for good measure, and get back into Windows. Try again.

Still no joy. There's another INI file somewhere, because it still expects to find things on the C drive. I could have looked further, but I decided to move the whole mess back onto the C drive. There was only one problem with that. I didn't have room on the C drive for the Corel program.

Well, there was another possibility. I had CorelDraw 5.0 installed on Pentafluge, our test-bed Pentium system; I could use it to convert image files and send them across the network. Alas, that didn't work either; apparently one of the experiments we'd done on Pentafluge had clobbered CorelDraw 5.0. I now had three choices: reinstall CorelDraw 5.0 on Pentafluge, install CorelDraw 5.0 on the Big Cheetah 486/66 that is my main machine, or bring CorelDraw 3.0 back to Big Cheetah. The latter two required making some room on Big Cheetah's hard disk. That needed doing anyway, so I started with it.

My first move was to get out the new CleanSweep program from Quarterdeck. It's a Windows uninstaller, and a lot of people have said good things about it. Installation was easy enough with one exception: Quarterdeck programs have a serial number printed on the disk, and their installation programs want you to type it in. To do that, you must take out the disk. After you type in the serial number, if you hit Return before reinserting the disk into the drive, the installation program doesn't recover very well; you're better off starting over. Otherwise, it's simple.

On the other hand, I didn't find CleanSweep all that useful. It's easy enough to

use. It will look for big graphics programs that you may not need, and it will suggest other Windows files not used. It also looks for duplicate programs, but it's not smart about it. It will tell you that files of different sizes and dates are duplicates, when clearly they are not.

It's not all that smart in other ways, either. I used it to kill several obsolete program groups, which it did, but it did *not* go into WIN.INI and get all the references to the dead programs. More important, however, it didn't kill off the "dangling associations," which will drive you nuts when you double-click on a file (say in File Manager).

One of the programs I killed was iniExpert for Windows. I wrote about it in last August's column. The program was useful in examining my INI files and pruning out deadwood, but I found I wasn't using it, and I really did need disk space. I figured I could always get it back; after all, Palindrome's Network Archivist has saved it to DAT (digital audiotape).

I erased several other big program groups and moved a few more to a network drive. Then I exited Windows, turned the machine off, restarted DOS, and ran Golden Bow Systems' Vopt disk defragger. Vopt is fast, efficient, and—above all—safe. It won't run in Windows (nor should it), and it won't run if it finds lost disk chains, which it did. Norton Disk Doctor took care of that, after which Vopt ran fine.

Back to Windows, which was a disaster.

The first thing I noticed was that a number of program groups—ones I had *not* erased—were gone. Second, I couldn't size Program Manager correctly. Attempts to change its size met with extreme jerkiness. Third, Program Manager informed me that it couldn't load group C:\WINDOWS\I and wondered if it should keep trying in the future.

It was late at night, and nothing I could do seemed to help. I went to bed. The next day I probably could have experimented with the system until I found out what was wrong, but I called my friend Jeff Sloman for advice. Just describing the problem made it clear there was something horribly wrong with PROGMAN.INI.

The way to fix that is to "run" PROGMAN.INI, which should bring it up in the Notepad so it can be edited. Alas, that didn't work. RUN PROGMAN.INI did nothing at all. The association had been clobbered. Nothing for it but to bring up WIN.INI in SYSEDIT and look at it. Sure enough, the association of INI files with the Notepad was gone, replaced by an association with INIEXP.EXE—at which point the light dawned.

I had forgotten that iniExpert is supposed to watch all your INI files and make a record of changes as you make them. Clobbering the program group killed all that but left the association; moreover, the C:\WINDOWS\I group was likely the erased iniExpert group.

I edited WIN.INI to associate INI files with the Notepad and then brought up PROGMAN.INI. Sure enough, there was the reference to group I. There was also a lot of non-ASCII garbage. Because I was still on the phone to Jeff, I got assurance that PROGMAN.INI is an ASCII file, so I deleted all the non-ASCII stuff. Then go out to control panel and desktop, where the "granularity" in the sizing grid had been set to 16. I have no idea how that happened; I sure didn't do it. I have to conclude that one of the uninstallers managed to alter WIN.INI where that value lives. Anyway, I set it back to zero and exited Windows. For good measure, I shut down and restarted before loading Windows again.

That took care of the goofiness. Some of my groups were still missing, but creating the group again fixed that; the group files still existed, so all the programs were in them. I could have manually put their group filenames into PROGMAN.INI, but it was a little safer simply to create the group.

The upshot was that I had spent 12 hours getting back to where I started. I know more about WIN.INI and PROGMAN.INI, but not a lot more.

One of the morals of this story is that you should use a lot of caution with any program that can edit your INI files. That specifically includes uninstallers. I've about come to the conclusion that they are more trouble than they're worth, being just smart enough to get you in trouble but not smart enough to find out things, such as the changed association of INI from the Notepad to the iniExpert log program.

Meanwhile, I've had one more lesson in things that make us feel stupid.

While all that was going on, we quietly reinstalled CorelDraw 5.0 on Pentafluge. (We had probably used the option to let the program run right off the CD-ROM the first time; this time, we caused it to copy itself to the hard disk.) Whatever problem we'd had was cured, and we can bring in files of every known format and export them as PCX files, with as few as eight or as many as 16.7 million colors. Now I can get on with the job of jazzing up Roberta's reading-instruction program.

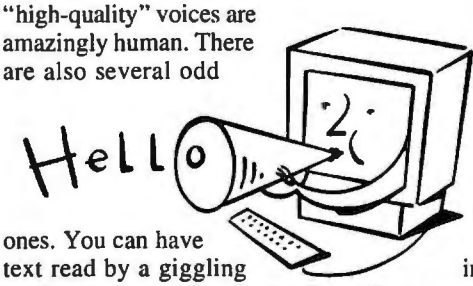
continued

Our next lesson in artificial stupidity involves Apple and Donald Norman himself.

When the 128-KB Mac came out amidst pronouncements that it would never need more memory or a hard drive, I said that it was a classy operating system attached to an overpriced toy computer. The MacTribesmen descended on me with fire and sword, and I got a reputation for hating Macs. That wasn't true, and, indeed, I bought an early Mac and upgraded it to a 512-KB "Fat Mac" with a 5-MB hard drive. I haven't been without at least one Mac since.

For the past few months, the main Mac user at Chaos Manor has been Roberta, who's working on the multimedia version of The Literacy Connection. Past versions have needed a human tutor, but she thinks MacInTalk is now good enough to support a stand-alone version. The goal is to have a computer teach reading with minimum human intervention. She's made considerable progress.

The key to this is MacInTalk, a program that reads text scripts aloud. The first MacInTalk was a third-party program not supported by Apple, and it was too crude to use. MacInTalk 2 is an Apple program and sounds much better. Now there's a new version, MacInTalk Pro, generated under research manager Kim Silverman. MacInTalk Pro uses models of the human skull to emulate natural-speech production, and it's remarkable. Three new "high-quality" voices are amazingly human. There are also several odd ones. You can have text read by a giggling maniac or by a cello-playing Peer Gynt, and if you haven't heard that, I can't possibly describe it to you.



Roberta has been doing most of her development with a Quadra and an old Mac IIfx, which we got back when it was the top of the line. Last summer the American Psychological Association held its annual meeting in Los Angeles. The convention bureau put up a billboard: "12,000 psychologists are coming to Los Angeles. How do you feel about that?" Anyway, Roberta presented a paper on using computers in education. It went well, and some of the psychologists thought they could use her program to teach reading to children with Attention Deficit Disorder. More on that when we know more.

Because the APA meeting was local, we took the Mac IIfx and our wonderful nView screen projector to the meeting so she could demonstrate the Mac version. That worked fine, but when we got back home, the Mac IIfx wasn't working properly. That was fixed by taking it apart and reseating the boards and cables, but it was annoying.

When we went to the Computer Users in Education conference, we discovered that the Mac AV stuff wasn't working properly. Since we flew there, we sure couldn't carry the Mac IIfx and nView. Thus, she couldn't show the Mac version of the program.

The result was new interest in a PowerBook. We'd had an early PowerBook 170, but it didn't have color, and we didn't use it a lot. Now we could use one that would let her work on the program at odd times and places and, more important, carry it to meetings for demonstrations. Apple sent us a PowerBook 540c with 12 MB of

URGENT—YOUR INPUT NEEDED

On: COMPUTER TELEPHONY

Dear Reader:

To improve BYTE's coverage of technology in the State of the Art section, we'd like to get your feedback about what topics, areas, and products we should be considering, and in what ways. Later this year, we're planning to update our cover story from last year on the ways in which telephony is being integrated into computer systems. We're considering such things as conferencing, simultaneous voice and data transmission, interfaces with phone systems and PBXes, and voicemail technology, to list a few items. But we'd like to hear your ideas, to find out about computer telephony applications we may not be aware of but should. Also, we'd like your help in identifying the people we should be talking to about this technology—users, vendors, researchers—you tell us. Finally, we're interested in hearing about what your organization is doing with telephony—how you're using the technology and what problems and benefits you've encountered.

To let us know what you think, please use the following as a template to send us, via E-mail, an ASCII text file with your comments. Please be sure to include the <FIELDNAMES> with their angle brackets, followed by your information and comments. And thanks very much for your help.

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memory, which made it both portable and more powerful than the Mac IIfx.

It's a very powerful machine, and it doesn't take long to get used to the little trackpad pointing device—Alex calls it a "mushpad." Otherwise, it works pretty much like any desktop Mac. There was only one problem: we couldn't get MacInTalk to install properly. We took the machine to the Hackers' Conference—hackers as in computer geniuses, not vandals who break into other people's systems—where some world-class Mac experts tried but couldn't get MacInTalk to install either.

One of the people who tried was Donald Norman, formerly professor of cognitive psychology at the University of California at San Diego and now an Apple Fellow. He has MacInTalk working on his PowerBook 540c, so he knew it could be done. After we got home and he got back to Apple, he called to see if he could help. The first thing we noticed was that the PowerBook had not come with System 7.5. Since that was what Norman had on his, Roberta's first task was to upgrade the operating system.

We got System 7.5 from Apple. Page 8 of the manual, called *Upgrade Guide*, says, "Insert the Before You Install disk and click on the Disk Tools icon to open it." She did that and got the error message "Not enough disk space available on the start-up disk to create a report. You need at least 150 KB of free disk space." The only problem was that the disk wasn't full; it was that the virtual memory manager was grabbing all the free disk space.

She went into the Control Panel to change that, after which the Disk Tool disk wouldn't eject. Unlike PCs, Macs have no manual eject button for floppy disks. She had to turn the machine off and use a straightened paper clip to get the disk out. Eventually, though, she got System 7.5 installed and running.

Now to install MacInTalk. It comes on the Developer's CD-ROM, so the first thing to do is get the PowerBook connected to a CD-ROM drive. There are two ways to do that. First, you can connect a CD-ROM drive directly to the PowerBook's SCSI port; that uses one kind of cable. Second, you can connect the PowerBook directly to another Mac that has a CD-ROM drive. That uses another kind of cable. Unfortunately, the two cables have no labels as to what they are for. They are identical except that one of them has all the pins and the other is missing one. Using the wrong kind of cable for the job just won't work and makes you feel stupid.

I won't describe all the attempts that Roberta made to install MacInTalk; there were a lot of them. Before it was over, she was talking to the Apple technical-support people daily for a week, to Donald Norman, and to Kim Silverman. That last conversation made her even more eager to get MacInTalk running, but it didn't help make it so.

The PowerBook would see the Chinon CD-ROM drive that installed MacInTalk on the Mac IIfx. Roberta would begin the installation of MacInTalk; and about a quarter of the way through, the system would just stop. The cute little fingers icon would count off, but nothing would happen, and the machine locked up. This happened over and over.

She tried using the Toshiba CD-ROM drive from the Quadra. The same thing happened.

Then someone suggested using the TechWorks Technet, which uses RJ-11

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jacks and telephone wire. Roberta bought two TechWorks adapters from CompUSA. Her diary notes: "At first, I did not see the tiny plastic terminator resistors in the corner of the plastic packaging under a red label. (Still feeling dumber than dumb!) They *must* be installed or the network does not know the location of things. Still no joy, as software from the Developer's CD would not completely install."

It was about then we decided there must be something wrong with the PowerBook and persuaded Keri Walker at Apple to swap machines. We asked for a PowerBook with MacInTalk already installed, but there wasn't one. Instead, Keri sent a 540c with System 7.5 and a known good cable. When it arrived, the cable was slightly bent, as if it had been wrested from the claws of a reluctant owner. Whoever sacrificed the cable, thanks.

When it arrived, the cable was slightly bent, as if it had been wrested from the claws of a reluctant owner. Whoever sacrificed the cable, thanks.

We returned the old PowerBook in the box the new one had come in and, armed with a known good cable, tried again. Once again the system locked up, but this time at a different place.

At this point I called the SCSI experts at Granite Digital. Granite makes diagnostic SCSI cables. They're not cheap, but they are extremely reliable. They have built-in red and green lights to indicate whether the SCSI setup is working properly.

Alas, they don't make cables for the PowerBook. However, they do make diagnostic termination connectors that will work on any SCSI string; and they were willing to spend some time explaining SCSI and termination power. It's a complex subject. "That's what keeps us in business," Granite Digital said.

A SCSI-bus system requires an active source of termination power. Many SCSI devices do not supply termination power; one device that doesn't is the PowerBook. At least one of the devices you connect to a PowerBook must supply that power. The SCSI string has to be terminated at both ends with the proper termination resistors. Each termination resistor uses about ½ ampere. Two of them will use ⅔ A.

A typical SCSI device will have the termination power fused to 1 A, leaving a 33 percent safety margin; but if the string ever gets three termination resistors on it, it's using 1 A, and there's no safety margin at all. A sneeze can blow that fuse. Now if you connect that device to a system—like the PowerBook—that doesn't supply termination power, there won't be any termination power.

Alas, SCSI systems will work, albeit unreliably, without termination power. It would probably be better if they didn't work at all. Worse yet, there's no external indication that the termination power fuse has blown.

The only way to be sure your PowerBook SCSI installation doesn't have termination problems is to put a diagnostic termination block on one end of the string and observe the lights. Granite Digital sent me one of theirs by Federal Express. If you do much SCSI work, a SCSIVue Active Diagnostic Terminator termination tester is a vital necessity. It helps to have one of their SCSIVue Gold Diagnostic Cables, too, since cable problems are the number one cause of SCSI failures.

As it happens, Roberta got things working before the Granite Digital termination tester arrived. In her words: "Plugged in the HDI-590-0718-A cable with all the pins, and it did *not* work. Talked to our Quadra again [She tends to personalize those machines even more than I do. JEP] and asked if he would mind lending the PowerBook his CD-ROM drive. Being the happy chap that he is, the Quadra agreed it would be for a good cause. Switched CD-ROM drives to Toshiba and changed the setting from 2 to 3. Upstairs on the Quadra, the CD-ROM drive used ID setting 3, so I changed the FWB CD-ROM Toolkit to reflect that setting (the brand name appears on the toolkit register).

"Changed cables (HDI SCSI system cable) were bent, but by forcing the shiny metal flange with the terminator, I made it fit. Inserted the terminator between SCSI cable and CD-ROM drive.

"In my haste to see if it operated, I tried to copy The Literacy Connection on an undersize disk to transfer to the PowerBook. Once I stopped hyperventilating and resumed talking aloud to myself, the copying worked. As I write this, the copying

to the PowerBook hard disk is taking place.

"Rebooted and tried SimpleText to see if MacInTalk Pro was functioning. There is joy in Mudville!"

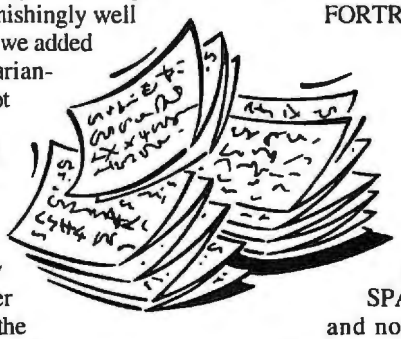
What happened was that the Chinon CD-ROM drive we normally use with the Mac IIfx no longer supplied termination power. As long as the Chinon unit was used with a device such as the Mac IIfx that does supply termination power, it worked; but because the PowerBook doesn't, it would work for a while and then fail. Using the Toshiba CD-ROM drive from the Quadra took care of the problem. The reason the Toshiba drive didn't work the previous time was that we also had a bad SCSI cable. Once we had System 7.5, a good SCSI cable, and a CD-ROM drive that supplied termination power, everything worked.

Actually, there was one more problem. The Mac installation program isn't very smart. It says it is removing all obsolete versions of MacInTalk, but it doesn't. Alex solved that problem by getting his mother to read off the filenames from the PowerBook and comparing each to what he saw on the Mac IIfx. Eventually they came to Voice Chooser. The new MacInTalk Pro doesn't use a Voice Chooser, and, indeed, if there is one in the System folder, MacInTalk won't work. Once all the extraneous older software was removed, everything worked fine. Of course, we all feel guilty for not having figured it out in the first place.

I really don't know what the moral of the story is, but we have an observation. Donald Norman thinks that computer systems shouldn't make humans feel guilty. We agree. Computers ought to be a source of help and support, not a means of demoralizing you. Unfortunately, software designers have a long way to go.

Meanwhile, note that the PowerBook 540c is as good a laptop as you can buy. We very much like the active-matrix color screen, the keyboard is very good, and the sound is astonishingly good. Once you get your software installed properly, it all works well. Roberta is looking forward to using it to demonstrate her program.

We ran a number of tests on MacInTalk Pro. The new version really is neat, and it's fascinating to play with the different voices. One test we devised was the sentence, "Though the rough cough and hiccough plough me through, I shall prevail!" It reads that astonishingly well in several voices. Then we added "antidisestablishmentarianism sucks rocks." It got that, too.



Indeed, it will read both those sentences one after the other in most voices; but if you have them both read by the cello-playing Peer Gynt, it works but then the machine locks up and must be reset with the Mac equivalent of Ctrl-Alt-Del. We haven't found any other bugs in MacInTalk Pro, and I have to admit not too many people will find that one.

A couple of years ago, I gave the keynote speech to a society of supercomputer users, and I took the opportunity to hang around at their meeting for a couple of days. I asked one supercomputer user what he actually did when he set out to solve a problem.

"I write about 80,000 lines of FORTRAN, and I can tell you, after you write 80,000 lines of FORTRAN, you don't much care about fluid dynamics."

Microcomputer users don't have quite that problem, but some of us still have to do hairy math computations. Although FORTRAN was one of the very first computer languages—I wrote a FORTRAN model of a U.S./U.S.S.R. nuclear exchange in 1963—it's still the weapon of choice for some mathematical problems.

If you have that kind of need, you definitely need to know about a DOS version of MATH77. MATH77 is an ANSI FORTRAN library of math routines, from random-number generators to Fresnel integrators to least-square curve fits. You get source code that will compile in any standard FORTRAN system; there are versions for Sun SPARC, VAX, and Cray—and now for the PC and the Mac. If you need it, you need it bad.

There are several ways to get on the Internet, and all Internet connections are not equal. Probably the simplest way onto the Internet is to subscribe to BIX. Founded by BYTE (it's now owned and operated by Delphi), BIX (in my judgment) has the highest signal-to-noise ratio of any of the

on-line services, as well as one of the best Internet tutorial and connect capabilities. If you want a simple excursion into Internet space, BIX is about as good a way as any.

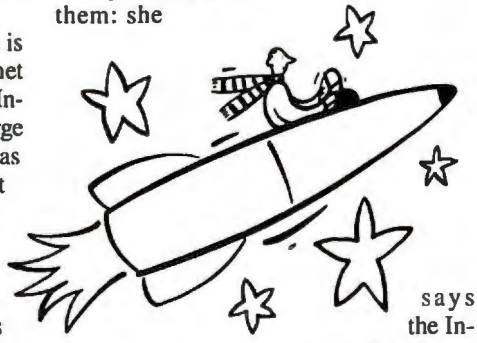
If you are one of the fortunate people who can get OS/2 Warp to work properly, a good Internet connection is provided by IBM in the Bonus Pack that comes with Warp. Because my every attempt to get Warped has failed—it either won't install on my equipment or won't work once installed—I can't say a lot more now, but I'll keep trying, because it's darned good when it works.

Then there's Internet In A Box. This is an easy-to-use front end for the Internet that includes a connection to the Sprint Internet connection system. The setup charge is included in the price of the software, as is an hour of connect time. Sprint isn't likely to be the cheapest Internet provider in your area, but it may be competitive. In any event, the Internet In A Box software can be used with other Internet service providers, which is what I'll be doing.

Most of my friends at the Hackers' Conference thought that Internet software, particularly Mosaic connections to the WWW (World Wide Web), would be the killer applications of the 1990s; several someones will get rich providing Internet software. Mosaic is an Internet front end, and WWW is a graphical interface and hypertext way of connecting to the Internet. None of this is going to mean much until you try it.

If you have a fast—at least 14.4-Kbps—modem, some free time, and a few bucks to spend, Internet In A Box is a painless way to find out what the Internet is all about. Sprintnet connections are $8.95 an hour; a hundred bucks' worth of Internet time will either hook you so badly you'll find a cheaper way to connect to the Internet or convince you that it isn't really worth the effort.

There are a few people who find the Internet a useful tool but don't get hooked on it. My wife's one of them: she



says the Internet is neat because it lets her do education research without having to wander through libraries. Fair warning, she connects through an education network. Internet searches can take a long time; even the simplest things can test your patience. My advice is if you do much Internet surfing, have a computer you can dedicate to it, as Roberta does. Alternatively, you can use OS/2, which is reliable enough to do Internet connections in the background, provided you can get it running at all.

We'll have a lot more on the Internet in months to come.

The book of the month is by Ian Bradley and Ronald Meek, *Matrices and Society: Matrix Algebra and Its Applications in the Social Sciences* (Princeton University Press, 1987). Yes, I know I've recommended it before; but it's worth reading again, and I just did. The computer books of the month are Neil Randall's *Teach Yourself the Internet: Around the World in 21 Days* (Sams, 1994) and Eric Gagnon's *What's on the Internet* (Peachpit Press, 1994). Actually, I got about 20 books on the Internet this month, and they're all pretty good.

The game of the month is Rules of Engagement 2. This is a space war game; the graphics are the screens you would see as a ship's commander. In addition to your own fleet, you generally have at least one other ship with you. The other fleet captains have different strengths and weaknesses. Some are just useless. If you get this game, be sure to get on CompuServe or another BBS and download the bug fixes; there are also a number of scenarios available. If you've ever wanted to command a starship, this is about as close as you'll get.

On that subject, at the request of some friends in Congress, I've been working with NASA officials. I believe we're about to see some significant developments in getting access to space for everyone, not just astronauts. Note that a general trend has been a hyperbolic increase in software instructions. However, the single-stage-to-orbit DC/X was controlled by adapting existing flight-control software rather than writing everything new, and that may have been one of the most important lessons we learned from flying the DC/X.

Next month, how readers have solved the problem of getting different kinds of network software to work together and the annual Chaos Manor Awards. ■

For More Information

CleanSweep ($59.95) is a Windows uninstaller, and a lot of people have said good things about it. Contact **Quarterdeck Office Systems,** Santa Monica, CA, (800) 354-3222 or (310) 392-9851; fax (310) 314-4217. **Circle 1146 on Inquiry Card.**

Internet In A Box ($149) is a painless way to find out what the Internet is all about. Contact **Spry, Inc.,** Seattle, WA, (800) 557-9614 ext. 26 or (206) 447-0300; fax (206) 447-9008. **Circle 1147.**

If you need **MATH77 4.1** ($99.95), you need it bad. Contact **Language Systems Corp.,** Sterling, VA, (800) 252-6479 or (703) 478-0181; fax (703) 689-9593. **Circle 1148.**

The **PowerBook 540c** (base price with 4 MB of RAM and a 320-MB hard drive, $4839) is as good a laptop as you can buy. Contact **Apple Computer, Inc.,** Cupertino, CA, (800) 776-2333 or (408) 996-1010; fax (904) 584-7481. **Circle 1149.**

QuickPak Professional 4.19 and **QuickPak Professional 3.22 for Windows** ($199 each) have tools for doing fancy menus with or without mouse support and scroll bars. **Graphics QuickScreen 1.12** ($149) has both a paint program and a way to take outside files and display them from within a QuickBasic program. Contact **Crescent Software, Inc.,** Ridgefield, CT, (800) 352-2742 or (203) 438-5300; fax (203) 431-4626. **Circle 1150.**

If you've ever wanted to command a starship, **Rules of Engagement 2** ($59.95) is pretty close. Contact **Impressions Software, Inc.,** Cambridge, MA, (617) 225-0500; fax (617) 225-0993. **Circle 1151.**

If you do much SCSI work, a **SCSIVue Active Diagnostic Terminator** (50-pin Centronics, $59) termination tester is a vital necessity. It helps to have one of their **SCSIVue Gold Diagnostic Cables** ($49 to $169), too. Contact **Granite Digital,** Union City, CA, (510) 471-6442; fax (510) 471-6267. **Circle 1152.**

Vopt 4.01 ($59.95) is fast, efficient, and—above all—safe. It won't run in Windows (nor should it), and it won't run if it finds lost disk chains, which it did. Contact **Golden Bow Systems, Inc.,** San Diego, CA, (800) 284-3269 or (619) 298-9349; fax (619) 298-9950. **Circle 1153.**

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.

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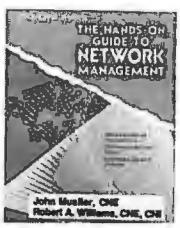

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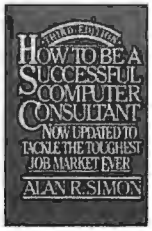

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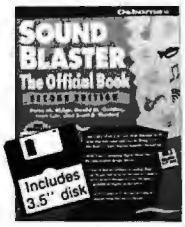

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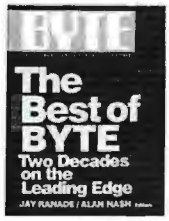

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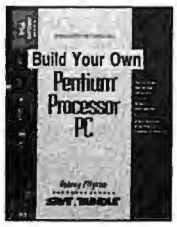

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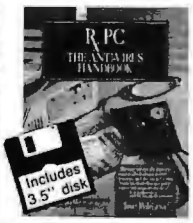

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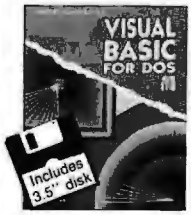

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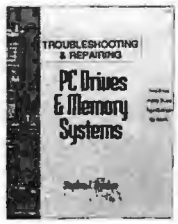

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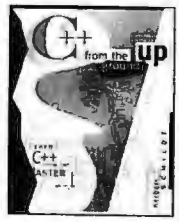

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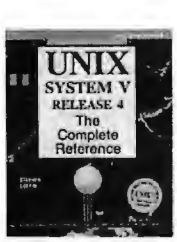

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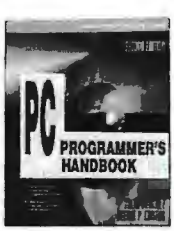

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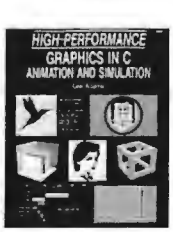

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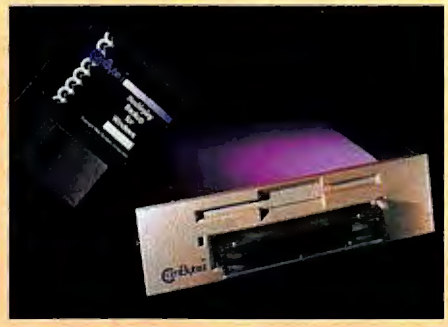
What's New Hardware

Double the Storage in Your Floppy Drive Bay

A two-in-one floppy and tape drive, the Doubleplay Series I ($229) fits into the computer bay usually occupied by the floppy drive alone. Because the floppy and tape drives share motors and electronics, the Doubleplay has increased reliability, according to developer ComByte. A single cable connection eliminates compatibility problems.

The Doubleplay stores files from your hard drive on industry-standard QIC-80 quarter-inch tapes and can transfer the equivalent of more than six floppy disks' worth of data per minute. With its long, wide tape and 2-to-1 compression, the drive can store up to 420 MB of data. The unit reads and writes 1.44-MB floppy disks at twice the speed of single-function devices; it can also copy and move files directly from your hard disk to either tape or floppy media via the Windows File Manager.



Contact: ComByte, Fort Collins, CO, (800) 990-2983 or (303) 229-0660.

Circle 1271 on Inquiry Card.

V.34 Modems

Packaged in a compact tower case, the ViVa 28.8 V.34 external modem ($335) can test line conditions and simultaneously adjust transmission rates before and during transmission. From Computer Peripherals (Irvine, CA), the PC-compatible modem transfers data at 28.8 Kbps and sends and receives fax transmissions at 14.4 Kbps. It incorporates V.42 error correction and V.42bis data compression and is equipped for voice communication.

Phone: (714) 454-2441.

Circle 1275 on Inquiry Card.

Available as the 2834F internal ($299) and the 2834FX external ($339) desktop modems, the V.34 data/fax modems from Best Data Products (Chatsworth, CA) provide 28.8-Kbps data and 14.4-Kbps fax transmission. The units, which include V.42 error correction and V.42bis data compression, are available for DOS, Windows, and the Mac.

Phone: (818) 773-9600.

Circle 1276 on Inquiry Card.

A Type II PCMCIA card, the Queen of Diamonds ($849) V.34 28.8-Kbps modem lets you simultaneously use audio applications and modem operations on your laptop. The Ositech (Guelph, Ontario, Canada) card has separate cable connections for the audio and modem applications, as well as direct cable connections to either the phone network or cellular phones. The unit's communications controller includes a 16-byte FIFO buffer to enhance high-speed fax or data communications.

Phone: (800) 563-2386 or (519) 836-8063.

Circle 1277 on Inquiry Card.

Skinny but Strong ▼

The DEC (Maynard, MA) HiNote Ultra CT 450 notebook packs power and TFT color into a 4-pound unit that's only 1.2 inches high. The HiNote Ultra has 8 MB of memory (expandable to 24 MB), 1 MB of video memory, 32-bit local-bus video, and a 340-MB hard drive. The basic unit contains two Type II/III PCMCIA slots, and an optional snap-on expansion dock contains PCMCIA slot enhancements and a 1.44-MB floppy drive. The unit has an integrated infrared interface, and its built-in business audio lets you run applications that have integrated audio and text. The active-matrix color display measures 9½ inches. The HiNote Ultra CT 450 costs $4599.

Phone: (800) 722-9332 or (603) 884-4304.

Circle 1274 on Inquiry Card.

Card Communications

PhoneWorks ($699), a dual-line communications adapter that supports the TAPI standard, enables you to make phone calls and receive faxes on your PC simultaneously. The card, which works under Windows 3.1 enhanced mode, integrates telecommunications capabilities such as fax and voice messaging, data communications, conferencing capabilities, intelligent call control, and a speaker/microphone for MCI-compatible stereo sound. PhoneWorks is from Connectware (Richardson, TX).

Phone: (800) 357-0852 or (214) 907-1093.

Circle 1278 on Inquiry Card.

Four-Faceted Fax Machine

Able to turn an ordinary fax machine into a combination fax, scanner, copier, and printer, the MFF-100 multifunction fax card ($249) continues working after you turn off your PC. The card fits into the ISA slot of your PC; it has two RJ-11 phone jacks that connect directly to a wall socket and the fax machine. From Castelle (Santa Clara, CA), the MFF-100 is compatible with existing Class 1 and Class 2 fax software applications.

Phone: (800) 289-7555 or (408) 496-0474.

Circle 1279 on Inquiry Card.

Personal Data Security

Based on the company's iPower data-security technology, National Semiconductor's (Sunnyvale, CA) PersonaCard 100 ($249) works with wired, wireless, secured, and unsecured networks. The PCMCIA card processes all security procedures directly rather than relying on the network to secure your data. Features include RSA Data Security's public-key-encryption-technology architecture; an SPU (security processing unit) that creates, stores, and manages the RSA keys and algorithms; an onboard 5-year battery; and an optional PersonaPort card reader ($209) for use with PCs without a PCMCIA slot. A silicon fire wall protects the SPU from electrical and physical hazards.

Phone: (408) 721-5000.

Circle 1280 on Inquiry Card.

Drive Supports Newest QIC Standards

The dual-format EXB-1500 QIC tape drive ($399) supports the QIC-3010 and QIC-3020 recording standards. From Exabyte (Boulder, CO), the drive stores 340 MB of data in QIC-3010 mode and 680 MB in QIC-3020 mode. With data compression, the drive's capacity reaches 680 MB in QIC-3010 mode and over 1.3 GB in QIC-3020 mode. The transfer rate varies from 2 to 4 MB per minute.

Phone: (800) 392-2983 or (303) 442-4333.

Circle 1286 on Inquiry Card.

WORKGROUP LAN SWITCH

Based on a five-slot high-speed backplane, the AmberSwitch workgroup LAN switch ($1995 for eight ports) provides up to 32 ports of switched Ethernet on 10Base-T lines. The packet bus in the AmberSwitch offers sustained throughput of more than 600 Mbps. The distributed packet processors on the modular switch manage local packet memory on each card and connect local network ports to the packet bus at wire speed. The AmberSwitch is from Amber Wave Systems (Acton, MA).
Phone: (508) 266-2852.

Circle 1281 on Inquiry Card.

LIGHTWEIGHT CD-ROM DRIVE ▼

A portable CD-ROM drive that weighs less than a pound, the Panasonic KXL-D720 ($399) connects to your notebook via the

provided Type II PCMCIA card or your PC's SCSI-2 connection. The Panasonic (Secaucus, NJ) drive has a 300-KBps transfer rate, a 250-ms access speed, and a 128-KB memory buffer. The unit operates on six AA batteries and provides up to 2 hours of data and 4 hours of audio.
Phone: (800) 742-8086 or (201) 348-7000.

Circle 1282 on Inquiry Card.

REMOTE-CONTROL UPS

The OnGuard Telephone Sentinel ($225), from Clary (Monrovia, CA), is a voice-prompted, remote-control system for use with the company's OnGuard LI series of UPSes. The system lets administrators use a standard Touch-Tone phone to dial into the UPS and turn power on or off, check UPS status, power on or off the attached computer or device, and activate or shut down software applications. Each system features user-modifiable, Touch-Tone password protection. Voice prompting guides the administrator through system functions.
Phone: (800) 442-5279 or (818) 359-4486.

Circle 1283 on Inquiry Card.

LOCK OUT INTRUDERS

The Modem Lock ($595) DES encryption device automatically provides a transparent user interface that does not require you to type a log-on. From Advanced Engineering Concepts (Seal Beach, FL), the device offers a throughput of 960 cps and a key that is field reprogrammable and stored internally. To ensure security, the key is not transmitted across unsecured phone lines.
Phone: (310) 379-1189.

Circle 1285 on Inquiry Card.

HIGH-SPEED DATA ACQUISITION

The CompuScope 250 ETS ($3995) XT-compatible ISA bus card performs an equivalent-time sampling rate of up to 4 billion samples per second on two simultaneous channels and a real-time sampling rate of up to 100 million sps on one channel. From Gage Applied Sciences (Montreal, Quebec, Canada), the card can store up to 8 million samples in on-board memory in real-time sampling mode; in equivalent-time sampling mode, 256 sample points are available.
Phone: (800) 567-4243 or (514) 337-6893.

Circle 1287 on Inquiry Card.

SWITCH POWER TO SAVE YOUR NETWORK

A combination hardware/software answer to eliminating network downtime, the PowerSwitch (from $1995) controls the switching between two servers and an external drive containing all production files. The dual-server design enables the backup server—which can be a workstation, an additional server, or a monitoring station—to be an active device on your network. The unit, from Applied Concepts (Wilsonville, OR), is controlled by the Alert Manager in IBM's NetFinity software.
Phone: (800) 624-6808 or (503) 685-9300.

Circle 1288 on Inquiry Card.

WIRELESS PRINTING

An infrared transceiver module, the JetEye ESI-9580A connects to your printer's parallel port to let you send documents to your printer from your infrared port–equipped portable computer. After you install the driver in the printer, you aim the laptop at the JetEye module to print, at 115 Kbps, any document you've created in DOS or Windows. A pass-through in the device's parallel port lets you maintain a printer connection with another PC or network print server. The JetEye costs $179.

Contact: Extended Systems, Boise, ID, (800) 235-7576 or (208) 322-7575.

Circle 1273 on Inquiry Card.

SYNCHRONOUS COMMUNICATIONS

A single-channel multiprotocol communications PCMCIA adapter, the MPAP-100 ($595) is compliant with the PC Card Specification 2.1 and employs a Zilog 85230 serial communications controller. From Quatech (Akron, OH), the MPAP-100 also supports asynchronous bit- and byte-oriented protocols. The adapter has two programmable baud-rate generators and combines surface-mount and chip-on-board technologies.
Phone: (216) 434-3154.

Circle 1289 on Inquiry Card.

FULL-DUPLEX FAST ETHERNET

Cogent Data Technologies' (Friday Harbor, WA) EM400 PCI Quartet adapter ($1395) for PCI servers is the latest in the company's eMaster+ Fast Ethernet series of networking products. The four-channel adapter supports full-duplex fast Ethernet on all four ports, which enables the card to supply 800-Mbps data throughput.
Phone: (206) 603-0333.

Circle 1290 on Inquiry Card.

PCMCIA STORAGE

The Type III PCMCIA More MB Drive ($499), from MiniStor (San Jose, CA), incorporates Stacker Anywhere data-compression software to double the 260-MB native capacity of the drive. The 520-MB More MB Drive also includes PRML (Partial Response Maximum Likelihood) technology for increased capacity and data throughput. The nitrogen-filled and sealed drive uses the company's Impac-Safe shock-sensor technology for improved ruggedness.
Phone: (408) 943-0165.

Circle 1291 on Inquiry Card.

What's New Hardware

EXPRESS CONNECTION

A single-port PCMCIA board, the ExpressPort ($249) provides connectivity for mobile and desktop peripherals via its bidirectional EPP (enhanced parallel port). The DOS- and Windows-compatible board plugs into a PCMCIA Type II socket for connection to such devices as portable drives, CD-ROM drives, tape backup units, high-speed EPP printers, and data acquisition products. From FarPoint Communications (Lancaster, CA), the ExpressPort includes a client software driver for automatic setup with socket services and a hot-swapping capability that lets you insert or remove the board while your system is running.

Phone: (805) 726-4420.

Circle 1292 on Inquiry Card.

RUGGEDIZED AND PEN-BASED

With an internal, solid-state IDE flash disk, the pen-based 486 K2000F computer (from $3395) eliminates the need for a rotating disk drive. The 3½-pound system has options for 10-, 20-, 40-, or 80-MB flash disks. From Kalidor (Upland, CA), the unit includes a ROM-based boot-and-recovery utility, an infrared port for host connections via the optional K100 docking station, a VGA pressure-sensitive display, and an optional 14.4-Kbps internal fax/modem.

Phone: (800) 252-5436 or (909) 931-3888.

Circle 1293 on Inquiry Card.

SECURITY FOR LAPTOPS

The C/DAS security system ($329.95) for laptop computers is compact enough to take on the road. From Rokan (Roswell, GA), the system uses a patented sensor device that you connect to your computer via a special adhesive pad that leaves no residue after it is removed. Once attached, the sensor is connected to a control module via a 3-foot cable. You then enter your personal four-digit code to activate the system, which emits a 110-dB alarm if anybody tampers with it or attempts to disconnect the AC power. To deactivate the alarm, you reenter your four-digit code and disconnect the cables.

Phone: (800) 228-5625 or (404) 740-1616.

Circle 1294 on Inquiry Card.

HEAVY-DUTY VIDEO

An EISA-based video card that offers full-size, full-motion, true-color video for Hewlett-Packard's HP 9000 Series 700 family of graphics workstations, the XVideo 700 ($7485) is targeted toward applications developers. The included Video Development Environment helps you create applications that are interoperable with applications developed for Sun workstations. From Parallax Graphics (Santa Clara, CA), the card includes hardware-assisted motion JPEG compression and decompression and the ability to display two live video streams simultaneously in two 640- by 480-pixel windows.

Phone: (408) 727-2220.

Circle 1295 on Inquiry Card.

VIDEO CAPTURE

The WaveWatcherTV-II ($429), from AITech International (Fremont, CA), features full-motion video capture with no video-motion artifacts, a built-in TV tuner and FM radio, and support of up to 1024- by 768-pixel resolution. The included software can capture and play back compressed AVI files in a full-screen display, and the card provides a scalable, resizable TV display in either a window or a full-size screen. WaveWatcherTV-II places no limitations on system RAM resources and can work with up to 128 MB of RAM installed in a system.

Phone: (800) 882-8184 or (510) 226-8960.

Circle 1297 on Inquiry Card.

HASP ON A CARD

A PC expansion card that combines a standard HASP software-protection key with a parallel port, the HASPCard (from $18) lets software developers enhance their HASP software protection by installing the key inside the PC. The expansion card, which interfaces to a standard ISA-compatible expansion slot, is functionally identical to regular HASP keys, so no source code changes are necessary. From Aladdin Software Security (New York, NY), the HASPCard is available as HASP-3, MemoHASP, and NetHASP keys.

Phone: (800) 223-4277 or (212) 564-5678.

Circle 1284 on Inquiry Card.

ADD CONTROL TO YOUR KEYBOARD

Belkin Components' (Compton, CA) OmniView keyboard-controlled switch ($349) is designed for system administrators, LANs with multiple file servers, test labs, and similar applications. The switch enables you to control as many as six PCs with a single monitor, keyboard, and mouse. When you boot each PC, OmniView automatically sends the correct signals to the keyboard and mouse port so that the PCs behave as if they were directly connected to the control hardware. This prevents the PCs from aborting the boot sequence if there happen to be any keyboard errors. After all the PCs are booted, you can then select the unit that you wish to control and view.

Phone: (800) 223-5546 or (310) 898-1100.

Circle 1296 on Inquiry Card.

PUSH A BUTTON TO DIGITIZE PAPER

An input device that acts as the electronic equivalent of an inbox for your PC, PageOffice manages the input of documents and images with a direct link to E-mail, OCR, image-editing, faxing, and document management applications. After importing the designated text or graphics into your computer, it automatically activates the appropriate application and processes the document into digital form. The PageOffice engine can scan entries at up to 300 dpi; the proprietary PageManager software comprises integrated drag-and-drop modules and icons that work with the hardware for integrated processing. PageOffice costs $499.

Contact: Umax Technologies, Fremont, CA, (800) 562-0311 or (510) 651-8883.

Circle 1272 on Inquiry Card.

The Fastest PC in the World

(and it doesn't make mistakes)

BTG's 275 MHz Desktop Personal Computer

Nothing compares to the computing power of the ACTion AXP275 RISC PC. The PCI-based ACTion System uses Digital Semiconductor's 64-bit 21064A Alpha microprocessor, with a cycle time of **275 MHz**–*the fastest processor available today!*

Capable of peak execution rates of 555 MIPS, its performance is equivalent to a supercomputer. Imagine what you can do with this much computing power!

With Microsoft® Windows NT™ installed, the ACTion Alpha AXP275 provides the same familiar user interface as the MS Windows operating system, and runs MS DOS and all 16-bit and 32-bit Windows applications.

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Networking by Cogent

To learn more about the ACTion AXP275 or any other of our ACTion System computers, including Pentium, call:

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digital business partner
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TOSHIBA
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ALPHA GENERATION

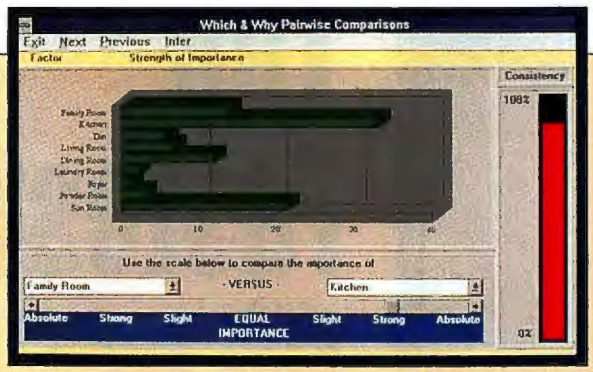
"The AXP275 offers the fastest Win32 performance we've seen..."
Windows Sources, February 1995

"All 16- and 32-bit Windows applications will scream on this machine..." PCWorld, February 1995

BTG MICROsystems
formerly ACT

Circle 162 on Inquiry Card.

What's New Software



Strengthen Your Decision-Making Skills

Intuitive decision-support and valuation software for Windows, Which & Why analyzes factual and emotional data to help you compare options, rationalize conclusions, and consistently reach the best possible decisions. The $349 package divides the decision-making process into four phases. First, it helps you organize your criteria and requirements. Then it prioritizes the criteria to establish the ranking of importance. Next, you input the options for evaluation against the preestablished weighted criteria. Last, Which & Why analyzes the input and recommends the alternative that is the best and most consistent with your needs.

Contact: Arlington Software, Baie D'Urfé, Quebec, Canada, (613) 746-1140.

Circle 1298 on Inquiry Card.

X Server for the Mac

AGE Logic's (San Diego, CA) XoftWare for Macintosh (from $295) lets Mac and Power Mac users concurrently access and display Mac and network-based Unix applications from a single Mac desktop. Developed in cooperation with Apple Computer, XoftWare for Macintosh is fully X11.5 compliant and includes XDMCP support, `rexec` and `rsh` remote log-in options, and single-button installation. The software is accelerated for the Power Mac and provides native support for the Motorola 601 PowerPC processor. It uses the Macintosh local window manager and supports remote window managers.

Phone: (619) 455-8600.

Circle 1302 on Inquiry Card.

Communicate with Objects in OS/2

An OS/2 general-purpose communications package with an object-oriented approach, RhinoCom 1.0 ($199) features native Presentation Manager code for a true OS/2 look and feel. From Rhintek Computer Engineering (Columbia, MD), RhinoCom uses multithreading and allows multiple sessions. A configurable status box attaches to the terminal window or moves independently. Supported transfer protocols include text, binary, XMODEM, YMODEM, and ZMODEM.

Phone: (800) 234-4546 or (410) 730-2575.

Circle 1303 on Inquiry Card.

Natural-Language Database Designer ▼

Database Designer 2.0 for Windows ($350), from SerraCorp (Kent, OH), lets you use English sentences to design and automatically build normalized relational databases. The databases can be used with Access, Approach, Clipper, and Visual Basic; DOS and Windows versions of dBase, FoxPro, and Paradox; DBMS formats that can use or adapt ANSI-standard SQL; and Oracle and Sybase. You can reverse-engineer existing databases and their data and then convert these databases to any of the DBMSes that the program supports.

Phone: (216) 677-1931.

Circle 1304 on Inquiry Card.

Manage Documents with Ease

A document management program, Kruse Control for Windows ($99) allows you to manage, view, and retrieve your engineering drawings, documents, spreadsheets, and digital images. You can then organize the data by department, project, date, or another category that you've defined. You can attach free-form comment fields to any document and conduct multilevel searches on any combination of fields that you desire. From Kruse (Downingtown, PA), Kruse Control is compatible with most networks.

Phone: (610) 269-8767.

Circle 1305 on Inquiry Card.

Fax Server for NetWare

Biscom's (Chelmsford, MA) Faxcom for NetWare (from $1495) is an NLM-based fax server that supports NetWare 3.x and 4.x, as well as such client operating systems as Windows, DOS, the Macintosh, and the Unix X Window System–based Motif GUI. The software, which off-loads all CPU-intensive functions from the file server, integrates with many NetWare-based E-mail products and provides automated inbound routing of received faxes. It also converts faxes to text with OCR integration and provides an interface to scanners so that you can fax paper documents.

Phone: (800) 477-2472 or (508) 250-1800.

Circle 1308 on Inquiry Card.

Gain Internet Access Anywhere ▼

Designed for use in the office, on the road, and at home, SuperTCP Pro ($595) transparently adjusts its TCP/IP networking engine and its Internet, TCP/IP, and X Window System applications for the environment you choose from the program's menu. From Frontier Technologies (Mequon, WI), the program has a multisession, multiprotocol browser that enables you to simultaneously access several Internet information servers, such as CSO Phone Book, Gopher+, WAIS, and WWW.

Phone: (414) 241-4555.

Circle 1307 on Inquiry Card.

Free Up Your Hard Drive

A personal storage management utility for DOS and Windows, NeverEnding Disk ($129) provides automated functions for compressing inactive files on your hard drive and archiving them to a floppy disk or other storage device. When you must access the files, NeverEnding Disk retrieves and decompresses them and then restores them to their original location. The storage utility is from Sytron (Westborough, MA).

Phone: (508) 898-0100.

Circle 1306 on Inquiry Card.

BUILD INTELLIGENT FORMS EASILY ▲

By simply asking a question, you can build forms that have intelligence built in when you use PerForm for Windows 3.0 ($129) from Delrina (Toronto, Ontario, Canada). The forms package includes DelrinaExperts, which automatically create the intelligent forms; extensive help demonstrations; and usability advancements that organize, in Tab dialog boxes, all the configuration options for a form object. In addition, you can fill out your forms on your computer and save the data that you've entered for later search and retrieval without previous forms-design experience or database knowledge.
Phone: (800) 268-6082 or (416) 441-3676.
Circle 1323 on Inquiry Card.

GLUE A NOTE TO WINDOWS WORK

Evergreen E•Glue ($69.95), from Evergreen International Technology (North Vancouver, British Columbia, Canada), lets you annotate Windows documents and applications with electronic stick-on notes that can contain text, sound, graphics, video, and animation. You can send the notes to other E•Glue users on your network and attach them to icons, sections of text, and screens without changing the original document or application.
Phone: (800) 667-4340 or (604) 986-6121.
Circle 1310 on Inquiry Card.

BUTTON UP YOUR WINDOWS APPLICATIONS

The Developer's Edition of SmartPad ($179) includes a SmartScript system, a set of tools for adding macroscript capabilities to Windows applications. From Softblox (Atlanta, GA), the software lets developers embed icons into these applications, which lets end users initiate multistep processes with a single mouse-click. SmartScripts are written in an extended BASIC language that is compatible with Visual Basic's syntax.
Phone: (404) 892-0202.
Circle 1309 on Inquiry Card.

CONVERT YOUR OS/2 FAT

For use with OS/2, PartitionMagic ($129.95) lets you convert between FAT and HPFS file systems and resize and move disk partitions with the click of a button. From PowerQuest (Orem, UT), PartitionMagic includes a 32-bit DOS executable.
Phone: (801) 226-8977.
Circle 1317 on Inquiry Card.

TAPE-LIBRARY TOOL

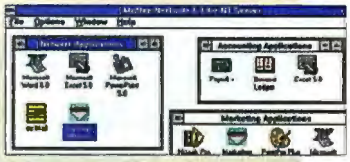
Video Librarian ($39.95) works in Windows to find any recording in a videotape library. From Denton and Associates (Fort Scott, KS), the program allows you to point and click to categorize recordings and then retrieve a recording in seconds. You can view a recording's location on your screen or print a listing of tapes and locations.
Phone: (800) 337-2039 or (316) 223-4846.
Circle 1318 on Inquiry Card.

CRUISING DOWN A VIRTUAL HALLWAY

More than a PIM or contact manager, Cruiser gives you control over your communications. TAPI-compliant, Cruiser combines communications media, such as real-time voice communications, faxing, E-mail, and file transfer. Using its correspondent-availability function, it defines availability by person, subject, time, or urgency, both for yourself and for others trying to reach you. Via the software's status and hallway features, you can glance down a virtual hallway to determine other users' availability and reachability and then contact or leave messages for internal and external correspondents. Cruiser's built-in conferencing feature lets you switch between voice and data during a call or schedule data transmissions for automatic handling later. Through rules that you define, Cruiser automatically sorts, prioritizes, and handles your mail, regardless of the electronic form used to send it. The package costs $199 per user.
Contact: Connectware, Richardson, TX, (800) 357-0852 or (214) 907-1093.
Circle 1299 on Inquiry Card.

Software Update

NetTools 5.1, McAfee (Santa Clara, CA), adds the IniTool INI-file-manager module and improves the AppMan menu



manager. From $40 per node. New is NetTools 5.1 for NT Server, also from $40 per node.
Phone: (408) 988-3832.
Circle 1326 on Inquiry Card.

Vision 2.0, Unify (Sacramento, CA), has a scalable RADD architecture and provides automated application partitioning, a comprehensive application model, cross-platform portability, and an object repository. Single-user development license, $4995.
Phone: (800) 468-6439 or (916) 928-6400.
Circle 1327 on Inquiry Card.

Concordance 5.40, Dataflight Software (Los Angeles, CA), adds a Windows GUI and advanced print-design functions; supports fuzzy logic; performs field group and field wild-card searches; and includes a table view, browse headers, KWIC printing, a report writer, and support for an image viewer. Single-user version, $995.
Phone: (800) 421-8398 or (310) 471-3414.
Circle 1328 on Inquiry Card.

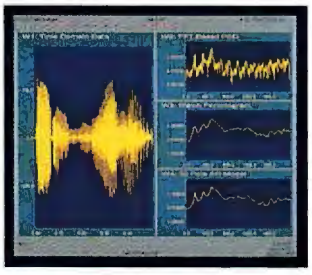
Facility Master II for Windows 1.01, Comsec (South Windsor, CT), adds the ability to make multiple reservations in 2-, 3-, or 4-week increments. From $489.
Phone: (800) 305-3496 or (203) 644-1817.
Circle 1329 on Inquiry Card.

DynaDesigner 3.1, Ditek International (Markham, Ontario, Canada), provides network capabilities; file locking; and security features, such as encryption. $399.
Phone: (905) 479-1990.
Circle 1339 on Inquiry Card.

What's New Software

ADVANCED DSP MODULE ▼

A complete, advanced DSP add-on module to DADiSP software, DADiSP/AdvDSP 1.0 (from $495) is fully integrated with the DADiSP worksheet. The many DSP algorithms in the module



include advanced FFT analysis, power spectral-density estimation, digital interpolation, and cepstrum analysis. Each routine is available via a fill-in-the-forms menu and also as a direct command-line function. The module is from DSP Development (Cambridge, MA).

Phone: (617) 577-1133.

Circle 1319 on Inquiry Card.

BACK UP ANY NODE

A program that lets network administrators and workgroup managers back up the hard drive of any node attached to a NetWare 3.x or 4.x network, DriveMaster (from $249 per server) establishes a peer-to-peer link between the backup machine and the node to be backed up. The link appears as a drive letter to the backup machine for compatibility with most existing backup programs. DriveMaster, which works in the background and supports all DOS file operations, is from NetAccess Development (Youngstown, OH).

Phone: (216) 759-7565.

Circle 1313 on Inquiry Card.

OFFICE EQUIPMENT FOR YOUR PC

E-Quip+ ($159), from Alacrity Systems (Hackettstown, NJ), adds the capabilities of a digital copier; plain-paper fax machine; electronic file cabinet for paper and fax documents; and OCR system to your Windows PC, page scanner, and fax modem. With E-Quip+, you can scan and store paper forms on your computer, fill them out using the keyboard and mouse, and then print or fax them.

Phone: (800) 252-2748 or (908) 813-2400.

Circle 1315 on Inquiry Card.

DATA INTEGRATION ON THE DESKTOP

The client-based ODBC Integrator ($400 per user) makes distributed ODBC data sources appear as one source and provides the capability to join data transparently among multiple data sources. Other capabilities include data access, data synthesis, data synchronization, and data warehousing. For PCs running Windows 3.1, ODBC Integrator works with all ODBC drivers and tools, according to the developer, Dharma Systems (Nashua, NH).

Phone: (603) 886-1400.

Circle 1312 on Inquiry Card.

DESKTOP DATA ACCESS

With its focus on analyzing data rather than simply producing reports, BrioQuery (from $595) is a full-featured desktop-query, analysis, and reporting tool for data warehouses. The Brio Technology (Mountain View, CA) program's ad hoc SQL query system is based on a multidimensional analysis engine that supports an intuitive, interactive DataPivot-style interface. Included in the Mac/PC tool are a graphical query-request builder; a flexible, one-step, band-style reporter; and high-level scripting for building desktop EIS systems. BrioQuery is available in three configurations.

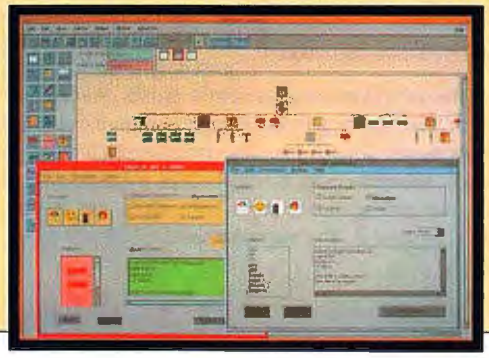
Phone: (415) 961-4110.

Circle 1314 on Inquiry Card.

NO PROPRIETARY CODE IN THESE INTERFACES

X-Designer 4, a cross-platform GUI builder for Motif and Windows applications, uses the MFC (Microsoft Foundation Classes) library as the Windows interface to ensure compatibility with all Windows versions. You can use X-Designer 4's Windows mode to ensure that only Windows-compatible Motif designs are created for future porting to Windows. In Windows mode, the program has the ability to generate MFC code, which can be compiled with native Windows tools, such as Visual C++. X-Designer 4 also indicates which Motif resources don't have an equivalent in Windows.

Developed by Imperial Software Technology (Reading, U.K.) and distributed in the U.S. by V. I., X-Designer 4 is now available on DEC, Hewlett-Packard, IBM, SCO, Silicon Graphics, and Sun platforms. X-Designer 4 costs $3500 for the first license.



Contact: V. I. Corp., Northampton, MA, (413) 586-4144.

Circle 1300 on Inquiry Card.

Software Update

CentaMeter 2.0, Tally Systems (Hanover, NH), adds suite metering, suite-license optimization, DOS-client support, software-version differentiation, and application-inactivity tracking. From $11.75 per PC.

Phone: (800) 262-3877 or (603) 643-1300.

Circle 1330 on Inquiry Card.

Chantal RAID Software for NetWare 5.0, BusLogic (Santa Clara, CA), includes support for the ASPI protocol and the ability to boot from the disk array. $695.

Phone: (408) 492-9090.

Circle 1331 on Inquiry Card.

GammaTech Utilities 3.0 for OS/2, SofTouch Systems (Oklahoma City, OK), adds more than 200 enhancements, including a disk map that displays the layout of FAT and HPFS volumes, graphical representation of the optimization process for FAT volumes, automated HPFS optimization, and formatted display of file-system structures. Single-user version, $99.

Phone: (405) 947-8080.

Circle 1332 on Inquiry Card.

High C/C++ 3.3 Compiler for Windows and Extended DOS, MetaWare (Santa Cruz, CA), includes fully implemented C++ exception handling, C++ namespaces for compatibility with third-party class libraries, new-style casting notation, and a Windows 3.x application development kit. $795.

Phone: (408) 429-6382.

Circle 1333 on Inquiry Card.

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Able to translate ordinary English database requests into SQL, English Wizard ($99) can enable any relational-database access tool to understand such requests. English Wizard automatically creates its own dictionary of English words and synonyms so that you can immediately begin to ask questions. Because the software supports multiple forms of input, you can type, point and click on a dialog box, or, if you're using English Wizard with a voice-input system, enunciate your request. The program determines the natural joins between tables in the database and uses the information to generate the optional join logic for each query. It then provides a graphical display of the resulting database map.

Contact: Linguistic Technology, Acton, MA, (800) 425-8200 or (508) 266-1818.

Circle 1301 on Inquiry Card.

Wireless E-mail

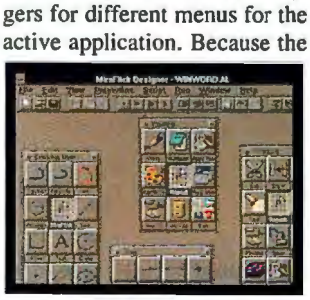
RadioMail Connection for Windows ($39) is a wireless communications application that provides Windows users with a mobile messaging capability. Developed by RadioMail (San Mateo, CA) in conjunction with ConnectSoft (Bellevue, WA), the application lets you exchange messages on public on-line services. It also provides wireless access to Internet E-mail, peer-to-peer messaging, wireless faxing, and an operator-assisted messaging service that operates like a paging service.

Phone: (415) 286-7800.

Circle 1322 on Inquiry Card.

Pop-up Icons ▼

A tool to enhance the Windows interface, MiraFlick ($79.95) pops up a menu of icons around the cursor, letting you choose a command with a directional gesture. From MiraTech (Palo Alto, CA), the tool has different triggers for different menus for the active application. Because the menus pop up only when you request them, they don't take up any screen space when you're working.



Phone: (800) 330-9816 or (415) 329-9816.

Circle 1321 on Inquiry Card.

Keeper of a Small LAN

The LANkeeper Company's (West Caldwell, NJ) LANkeeper ($249) offers effective LAN-administration capabilities to organizations that don't need a professional administrator to maintain a small network. A novice LAN administrator can use the LANkeeper program to automatically build a network map, spot potential problems, and track changing computer assets.

Phone: (800) 808-1626 or (201) 808-9272.

Circle 1320 on Inquiry Card.

Integrated Business Plan

Palo Alto Software's (Eugene, OR) Business Plan Pro ($149.95) lets you custom-build a plan for your business by selecting the applicable business option and then choosing the proper charts, tables, and text topics to reflect your approach. Options include a home office and a cash-only business; if you are planning a new business, you can factor in the inherent start-up costs.

Phone: (800) 229-7526 or (503) 683-6162.

Circle 1324 on Inquiry Card.

Navigate Through Your References

The Cross Reference Navigator ($195), from Synthetic Intelligence (New York, NY), lets you create and display relationships. Developed for Windows with Visual Basic, the program stores information—using headings such as ID, Title, and Description—in an Access database. It allows cross-reference connections to other records and permits chain searches.

Phone: (212) 685-7526.

Circle 1325 on Inquiry Card.

Picture It Personal

The Personalize It screen-saver package ($24.95 for one image; each additional image, $5.95) lets you select images to appear on your monitor's screen. The Zoom It add-on option ($10) enables the images to automatically zoom in and out from large to small and vice versa. The package is from Personal Screen Images (Fair Oaks, CA).

Phone: (800) 728-4397 or (916) 961-9773.

Circle 1316 on Inquiry Card.

Software Update

EZReport 2.7, Raosoft (Seattle, WA), expands the Intuitive Command Structure to support additional grouping and statistical commands, adds a one-word Summary command, produces instant repetitive statistical analysis for departmental or periodic analysis, automatically recalculates stratified sample data for population adjustments, and uses Gap analysis, among other enhancements. $149.

Phone: (206) 525-4025.

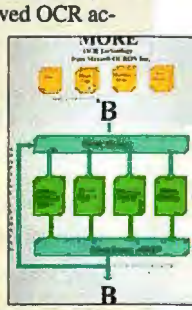
Circle 1334 on Inquiry Card.

Infinite Disk Pro, Chili Pepper Software (Atlanta, GA), adds a new user interface, the latest HSM technology, and support for quarter-inch data cartridges. $149.

Phone: (800) 395-1812 or (404) 339-1812.

Circle 1335 on Inquiry Card.

Business Card Reader 2.0, Maxsoft-Ocron (Fremont, CA), provides improved OCR accuracy via MORE technology; can read 11 foreign languages; has an Auto Scan feature, automatic orientation, a field verifier, and background-processing and batch-card scanning; and lets you call up the scanning function while you're working in most PIMs and databases. $99.



Phone: (510) 252-0200.

Circle 1336 on Inquiry Card.

Macola Progression Series 7.0, Macola Software (Marion, OH), adds more than 100 features, two modules, multinational and customization capabilities, and advanced windows functionality. From $995 per module.

Phone: (800) 468-0834 or (614) 382-5999.

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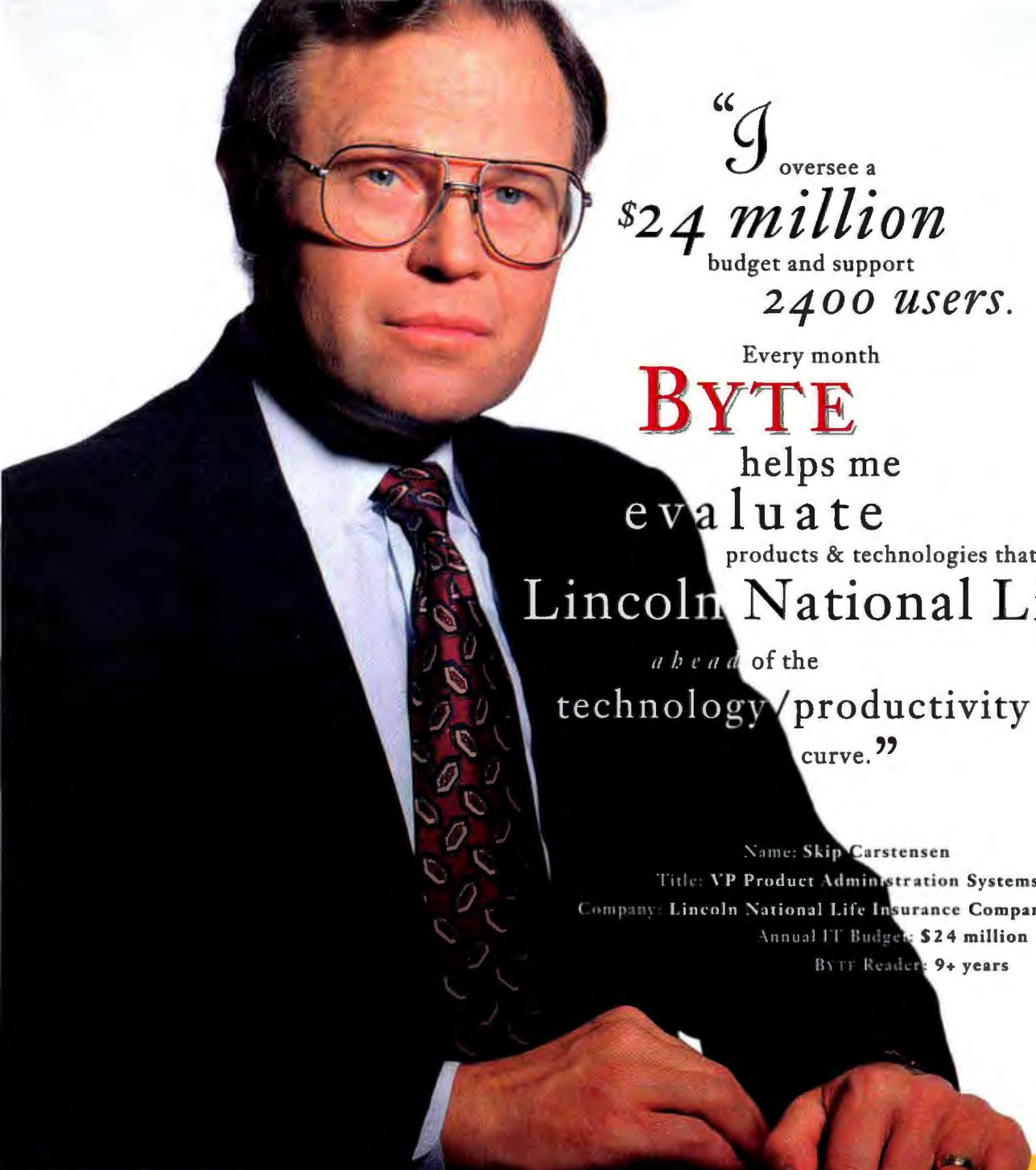

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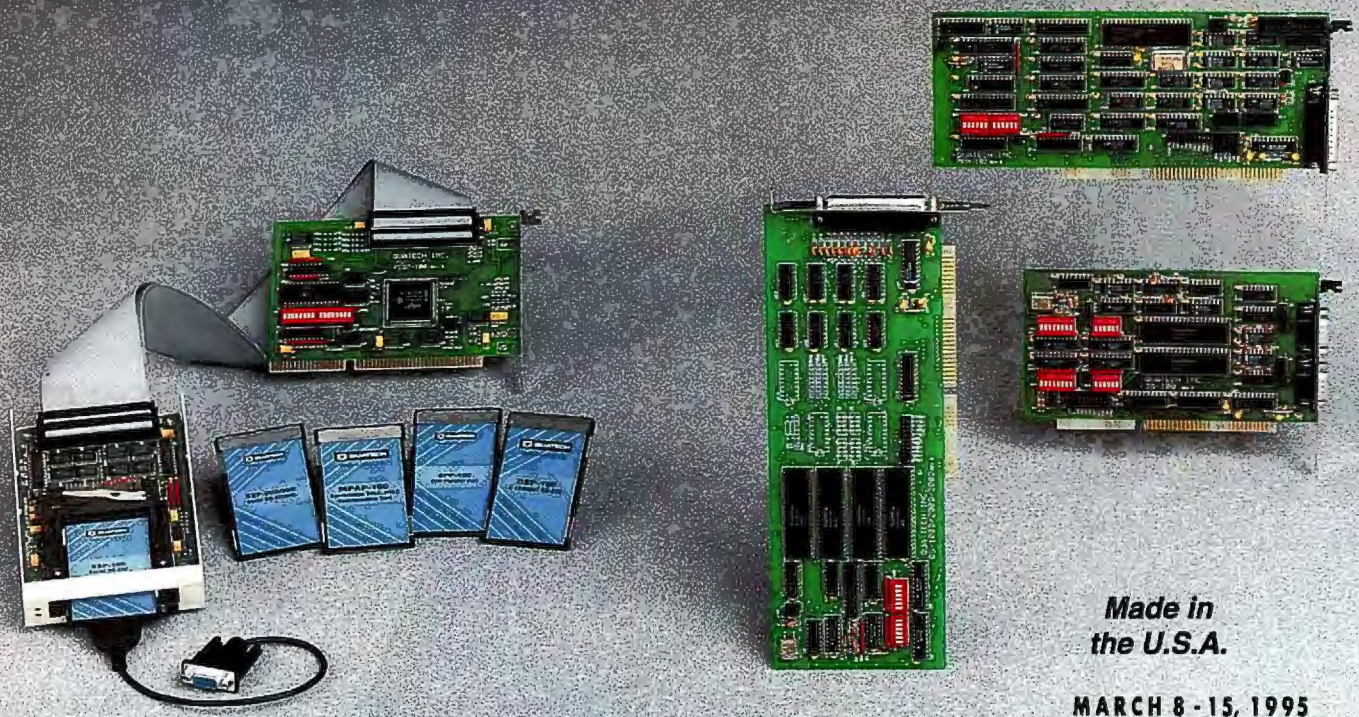

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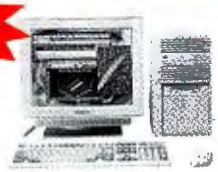

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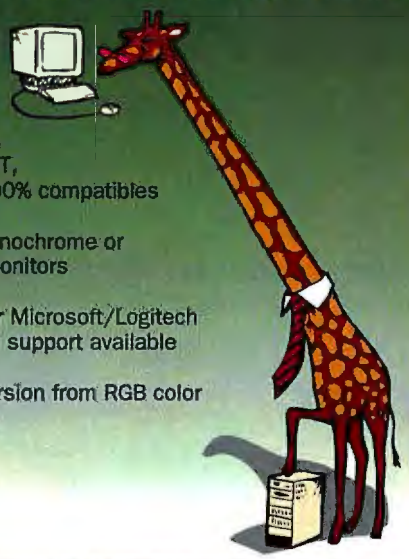

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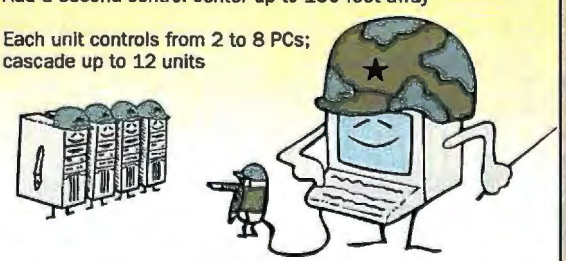

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4/50 Model 343W	9.5" Active	340MB	3629
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486DX4/75	540MB	9.5" High Res.	5099
486DX4/100	810MB	9.5" Active	5569
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Processor	Screen	Hard Drive	Price
486DX2/50	9.5" Dual Scan	250MB	$2499
486DX2/50	9.5" Dual Scan	340MB	2669
486DX2/50	9.5" Active	250MB	3199
486DX2/50	9.5" Active	340MB	3399
486DX2/50	9.5" Active	540MB	3779
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486DX2/50	10.4" Active	520MB	4839
486DX4/100	10.3" Dual Scan	340MB	4069
486DX4/100	10.3" Dual Scan	520MB	4449
486DX4/100	10.4" Active	340MB	5179
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486DX4/100	10.4" Dual Scan	540MB	5129
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486DX4/100	10.4" Active	340MB	6049
486DX4/100	10.4" Active	540MB	6429
486DX4/100	10.4" Active	810MB	6959
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486SL/33	9.5" Dual Scan	340MB	2659
486SL/33	8.4" Active	170MB	2489
486SL/33	8.4" Active	340MB	2779
486DX2/50	9.5" Dual Scan	340MB	2889
486DX2/50	9.5" Dual Scan	540MB	3259
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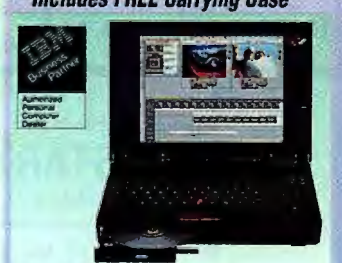

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Prem II 386/25, 386/33, 486/33, 486SX/20	8Meg	500780-001		398.00
Premium 386/33T, Prem. 386SX/16			64 pin	
Prem. II 386SX/20, 25	4Meg	500780-004		189.00
Premium 386/25, 33, 386/33T, 386SX/16,	1Meg	500780-003		59.00
Premia 4/33S, 4/33, 4/50D, 4/66D	8Meg	501159-002		379.00
Premia	16Meg	501159-003		789.00
Premia	32Meg	501159-004		1468.00
Premia	64Meg	501159-005		3111.00
AST Cupid 8d	0–32Meg	500818-001		179.00

ZENITH MEMORY MODULES

MODEL	AMT. UPGRADED	AST PART #	PRICE
Z386/33, 25, 20, 33E	1Meg	ZA3800ME	59.00
Z386/33, 25, 20, 33E, 486/25E	4Meg	ZA3800MK	180.00
Z386SX	2Meg	Z-605-1 modules	119.00

MAGNAVOX

286/386SX-16, 386SX-20, 486SX-20 & 386-33 *all are 72PIN SIMM:*

1MEG – 59.00 4MEG – 180.00 8MEG – 349.00 16MEG – 659.00

MEMORY BOARDS

IBM Compatibles & PS/2

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16 BIT MEMORY BD. FOR 286, 386 AT • OK-8Meg Bd. 4.0 LIM Compat. • New 5 Yr. Warr. Convent., Expnd. & Extnd. Memory • Supports DOS, OS/2, LIM/EMS & EEMS • Versatile Split Memory Addressing • Operates w/CPU Speeds to 33 MHz • Supports Desqview, Multitask operations • ***Bd. made by Boca Research, AT plus***

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• Expanded memory for XT • Lim 4.0 compat. 0-2Meg • Uses 256x1-100

0-K – **$99.00** 1Meg **$189.00** 2Meg – **$229.00**

IBM P/S2 32BIT EXPANSION BD.

0-16Meg, Ext. Expnd. Memory Bd. for P/S2 70, 80, 90, Lim 4.0

0Meg	2Meg	4Meg	8Meg	16Meg
$139.00	**$238.00**	**$319.00**	**$499.00**	**$859.00**

PS/2 MCA 0-8MEG EXPANSION BD.

0-8Meg Extended and/or Expanded Memory for all IBM P/S2 Models 50, 50Z, 60, 55SX, 65SX, 16 Bit, 4.0 LIM Compat.

0K – **119.00** 2Meg – **199.00** 4Meg – **283.00** 8Meg – **449.00**

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IBM PS/1, PS/2 MEMORY MODULES

IBM PART NO.	WORKS WITH MODEL NO.	PRICE
30F5348 (512K)	20-286	37.00
30F5360 (2Meg)	30-286, 25-286, 80 MTHR BD	104.00
64503751 (1Meg)	80-041	79.00
64503779 (2Meg)	80-111, 311-121, 321 061, 161	84.00
64510604 (4Meg)	80-A21, A-61, 80-A31, 80 111, 80-311	189.00
64506049/92G7196 (2Meg)	78-061, 661 121, 602, 55SX, 65SX, P-70, 55LS, 65LS, X-Station 120 & 130, 35SX, 35LS, 40SX	99.00
64506081 (2Meg)	78-A21, A-61 B 21, B-61, 35SX, 35LS, 40SX, Val Pt. 32ST	90.00
78X8955 (128K)	25	35.00
34F2933 (4Meg)	35SX, 40SX 55SX, 65SX, 53LS, 65LS	175.00
87F9977/92G7199 (4Meg)	55SX, 55LS, 65SX, 40SX, 35SX, 35LS	175.00
1057035 (512K)	P/S1-286	49.00
92F9935 (2Meg)	P/S1 & P/S1/386SX-2121	109.00
92F9694 (4Meg)	P/S1 & P/S1/386SX, Model-2121	189.00
92G7200 (4Meg)	PSI Expert, Consultant, Willow	175.00
92G7201, 73G1131 (4Meg)	Value Point Performance PC Server 4/66	175.00
73G3132/92G7203 (8Meg)	Value Point Performance PC Server 4/66	339.00
60G1622/92G7204 (16Meg)	Value Point Performance PC Server 4/66	609.00
92G7205 (32Meg)	Value Point Performance PC Server 4/66	1239.00
64509022 (2Meg)	56, 57, 57SLC 90, 95, P-75, 57SLC Value Point 77 486DX2, 486SX, SVR 85	90.00
64501289/92G7200 (4Meg)	57SX, 90, 95, P-75, 57SLC, 56, 56SLC, P/S1, 386SX, Mod-2123, 2133, 2155, Val Pt 77, 486DX2, 486SX, SVR85	175.00
64501299/92G7428 (8Meg)	35SX, 40SX	339.00
64501309/92G7202 (8Meg)	56, 57, 57SX, 90, 95, P-75, 57SLC Value Point 77 486DX2, 486SX, SVR 85	339.00
64511158 (4Meg acc)	486, 95XP, 56A (install in pairs)	198.00
64511159 (8Meg acc)	486, 95XP, 95A (install in pairs)	399.00
(16Meg acc)	9595 OPT	749.00

IBM NOTEBOOK & LAPTOP MEMORY

8189098 (4Meg)	Thinkpad 500, 510CS (3.3 volt)	209.00
8189099 (8Meg)	Thinkpad 500, 510CS (3.3 volt)	389.00
8189113 (16Meg)	Thinkpad 510CS (3.3 volt)	869.00
79F1900 (4Meg)	LX40, N33SX, PS Note	103.00
79F1000 (4Meg)	LX40, N33SX, PS Note, Thpd 350, 350c, PS Note 425	189.00
79F1201 (8Meg)	LX40, N33SX, PS Note	349.00
07G1415 (4Meg)	Thinkpad 750, 750c, 755 360, 355 340, 450	199.00
07G1416 (8Meg)	Thinkpad 750, 750c, 755 360, 355 340, 450	349.00
66G3094 (16Meg)	Thinkpad 750, 750c, 755 360, 355 340, 450	749.00
(4Meg/16Meg)	Thinkpad 755 Dxmm Modules & Acapter	299.00/849.00
(4Meg 16 Meg w-Adap	Thinkpad 755	313.00/999.00
07G1420 (4Meg)	CL57LSX LpTp, Thinkpad 700 700C, 720 720C	209.00
07G1421 (8Meg)	CL57LSX LpTp, Thinkpad 700 700C, 720, 720C	389.00
60G0378 (8Meg)	Thinkpad 350, 350c, PS Note 425	319.00
60G0379 (16Meg)	Thinkpad 350, 350c, PS Note 425	569.00
92F6804 (2Meg)	144SSL	109.00

COMPAQ MEMORY MODULES

MODEL	AMT. UPGRADED	CMPQ PART #	PRICE
DeskPro 386/33, 386/33L, 486/25, 486/33L, 486/50L, System Pro	2Meg Module	115144-001	109.00
	8Meg Module	116561-001	399.00
	32Meg Module	116560-001	1399.00
DeskPro 386/33L, 486/33L	(Exp Bd)	116569-001	279.00
DeskPro 386/25, 386/20	1Meg Module	113131-001	79.00
	4Meg Module	113132-001	199.00
	1Meg Exp Bd	113633-001	149.00
DeskPro 386S-16Mhz	4Meg Exp Bd	113634-001	279.00
	1Meg Module	113645-001	79.00
	4Meg Module	112534-001	199.00
DeskPro 386/20E	1Meg Exp Bd	113640-001	149.00
DeskPro 386/25E	4Meg Exp Bd	113645-001	279.00
	1Meg Module	113131-001	79.00
	4Meg Module	113132-001	199.00
DeskPro 286N, 386SX20, all "M" series, sytem LT series, all "i" series	1Meg Module	118598-001	59.00
	2Meg Module	118599-001	89.00
	4Meg Module	118690-001	169.00
	8Meg Module	128877-001	339.00
M Series Exp Bd	0-4Meg	129160-001	189.00
DeskPro 386/16	1Meg Kit	108071-001	99.00
	4Meg Kit	108072-001	299.00
	1-2Meg Exp Bd	108069-001	239.00
	4-8Meg Exp Bd	108070-001	437.00
DeskPro 286	512K Kit	113012-001	49.00
DeskPro 5/60, 5/66M, 5/66M ALL OF THESE MACHINES	8Meg Kit	149911-001	389.00
Prosignia 5/60	16Meg Kit	149949-001	699.00
Prolant 2000 4/33, 5/66	32Meg Kit	149912-001	1356.00
Prolant 4000 4/50, 5/66 ONE OF THESE MODULES	64Meg Kit	149913-001	2516.00
Prolinea 386 3/25S, 3/25ZS	128Meg Kit	149914-001	5739.00
	2Meg	141738-001	90.00
Prolinea 486 4/25S, 4/33, 4/50, 4/66, CDS Enhanced Prolinea, Prosario series	8Meg	141742-001	316.00
	2Meg	141683-001	95.00
	4Meg	141684-001	175.00
	8Meg	141685-001	339.00
Prosigma PC Server, 486/33, 486 DX2/66	8Meg	141685-001	339.00
	16Meg	149320-001	599.00
	32Meg	149147-001	1199.00

COMPAQ LAPTOPS & NOTEBOOKS

LTE/286	4Meg Bd	117081-003	179.00
LTE/386S/20	4Meg Module	121125-002	209.00
LTE LITE/20, 25, 25C	4Meg Module	129769-002	209.00
LTE LITE/20, 25, 25C	8Meg Module	129769-003	389.00
LTE LITE/20, 25, 25C	16Meg Module	129769-004	769.00
LTE LITE 425C/33C/25E/25L	4Meg Module	142337-002	189.00
LTE LITE 425C/33C/25E/25L	8Meg Module	142337-003	329.00
LTE LITE 425C/33C/25E/25L	16Meg Module	142337-004	639.00
SLT/286	4Meg Module	110237-001	199.00
SLT/386	2Meg Module	118304-001	109.00
SLT/386	4Meg Module	118305-001	213.00
Concerto, LTE Elite	4Meg	144790-001	183.00
	8Meg	144790-002	369.00
	16Meg	144790-003	699.00
Contura 320, 325	2Meg	139497-001	99.00
	4Meg	139498-001	189.00
	8Meg	139499-001	339.00
Contura 400	4Meg/8Meg/16Meg		209/389/719
Contura 4/25, 4/25C, 4/25CX	4Meg	146520-001	189.00
	8Meg	146521-001	329.00
	16Meg	146531-001	699.00
Aero 4/25, 4/33L	4Meg	190532-001	184.00
	8Meg	190697-001	356.00
	16Meg		CALL

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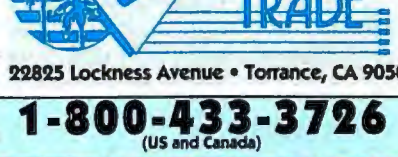

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TOSHIBA LAPTOP MEMORY

MODEL	AMT. UPGRADED	MANU. PART #	PRICE
T2000/T2000SX	2Meg	PC18-PA8317U	89.00
T2000SX/T1000LE	4Meg	PC-PA8314U	189.00
T2000SX/T1000LE	8Meg	PC14-PA8315L	349.00
T2000SX/2200SX/T1800, 1850, C	2Meg	PC-PA2000L	89.00
T2000SX/2200SX/T1800, 1850, C	4Meg	PC-PA2001L	189.00
T2000SX/2200SX/T1800, 1850, C	8Meg	PC-PA2002L	359.00
T4400SX, SXC T6400, T6600	2Meg	PC-PA2004U	189.00
T4400SX, SXC T6400, T6600	4Meg	PC-PA2005U	359.00
T4400SX, SXC T6400, T6600	8Meg	PC-PA2006U	689.00
T4500 C T4600, T4700, T1900, C T1910, T1950 (3.3 v)	2Meg	PC-PA2012U	199.00
T4500 C T4600, T4700, T1900, C T1910, T1950 (3.3 v)	4Meg	PC-PA2013U	389.00
T4500 C T4600, T4700, T1900, C T1910, T1950 (3.3 v)	8Meg	PC-PA2014U	769.00
T3300SL	8Meg	PC-PA2008U	268.00
T3300SL	16Meg	PC-PA2009U	699.00
T3400CT, T2430, T3600	4Meg	PC-PA2019U	194.00
T3400CT, T2430, T3600	8Meg	PC-PA2020U	359.00
T3400CT, T2430, T3600	16Meg	PC-PA2021U	707.00
T3400CT	32Meg		1549.00
T3100e	2Meg	PC9-PA8340U	109.00
T3100SX	2Meg	PC15-PA8308U	109.00
T3100SX	4Meg	PC15-PA8310U	189.00
T3200	2Meg	PC-PA7131U	185.00
T3200SX	2Meg	PC12-PA8307U	119.00
T3200SX	4Meg	PC12-PA8309	199.00
T3200SXC	2Meg	PC19-PA8318U	119.00
T3200SXC	4Meg	PC19-PA8319U	199.00
T5100	2Meg	PC7-PA8301U	95.00
T5200/T8500	2Meg	PC10-PA8304U	114.00
T5200/T8500	8Meg	PC10-PA8313U	419.00

NOTEBOOK, LAPTOP MEMORY

MODEL	AMT. UPGRADED	MANU. PART #	PRICE
AERO 150, 735C, 780	2Meg/4Meg/8Meg		109/219/439
ACER 720	4Meg/8Meg/16Meg		199/439/799
ALR Venture	4Meg	12407980	249.00
Altima Barrage 2	4Meg/8Meg/16Meg		199/319/479
AST Ascentia 900N, 800N	4Meg/8Meg/16Meg		169/349/479
AST Bravo & Explorer	4Meg/8Meg	501255-001, -002	189/479
AST Notebook Prem Exec 386SX/20/25/25L	2Meg	500914-001	109.00
AST Power Exec 3/25C, 425EL, 425SS	4Meg/16Meg	501196-001, -003	199/599
AST Power Exec 4/33SL	4Meg/16Meg	501318-001, 002	194/799
AT&T Safari NSX/20	2Meg	23550-09100	249.00
Bondwell B310 Pad	1Meg	23550-09100	109.00
Bondwell B310V SX	1Meg		109.00
Bondwell B311V SX	1Meg		229.00
Brother HL 630 631, 641, 645	1Meg		CALL
Canon Innova 486	2Meg/4Meg		109/229/449
Canon Innova 4M-10	4Meg		229.00
Canon Notetype 486	4Meg/8 Meg		199/389
Canon Notetype 486	4Meg/16Meg		199/749
Dell Latitude	4Meg/16Meg		199/599
Epson Action Note 700	4Meg/16Meg		199/599
Epson M83		A8M8511	199.00
Everex Tempo LX, JX20, Carrier	2Meg	PCA 00053-0001	109.00
Gateway 2000 Colorbook-s 3.3	4Meg/16Meg		199/599
Gateway 2000 Solo and 425 DXL/SXL	4Meg/16Meg		199/1199
Gateway 2000 486 Handbook	4Meg/16Meg		199/679
Goldstar GSB-386SX/16		S386-4M	249.00
Gricr 1720, 1750	2Meg		59.00
HP Omnibook 300, 480, 425	2Meg		129/269
HP Omnibook 5/25	4Meg/8Meg		229/419
HP Omnibook 4000	4Meg/8Meg/16Meg		199/379/649
Leonnark SX10	4Meg		209.00
Magnavox Notis	4Meg/8Meg	286, 386SX	199/379
Mitch Salem 3180	4Meg/8 Meg		239.449
NEC Prospeed 386	2Meg	PC31-21	119.00
NEC Prospeed 386	4Meg	PC31-22	199.00
NEC Prospeed 386	1Meg	PC31-21, PC31-22	99.00
NEC Prospeed 386, 386SX-16, 386SX-20	1Meg	PC31-21, PC31-22	99.00
NEC Prospeed 286, 386SX-16, 386SX-20	2Meg/4Meg	PC31-22	199.00
NEC Ultralite Versa, LX	4 Meg/8Meg/16Meg/20Meg	0P4104	183/353/729/899
NEC Upgradable Hard Drive	340Meg/2.4Gig		749/899/1149
NEC Versa S	4Meg/8Meg/16Meg		209/399/799
Packard Bell 386SX, 286	1Meg	286, 386SX	109/189
Packard Bell Statesman	2Meg/4Meg		189/369
Panasonic CF-170, CF-270, CF-370	1Meg	CF-BA165	99.00
Panasonic CF-360	2Meg/4Meg/8Meg		119/199/369
Panasonic CF-171F, CF-580	4Meg/16Meg		219/819
Sanyo 17 18 NB	2Meg	MBC-NBAEM2	109.00
Sharp 6781, 6981, 6785, 6700, 6900, 6741	2Meg/4Meg		129/199
Sharp 6781, 6981, 6785, 6700, 7760	4Meg/16Meg		199/679
Sharp 8700 & 8900	4Meg/8Meg/16Meg		199/379/649
Sharp PC-6220		CE-8218	119.00
Silicon, PC Brand, Dataworld	2Meg/8Meg	N8386SX-20	119/349
TI Travelmate 2000	1Meg	2500034-0001	79.00
TI Travelmate 4000	2Meg	2566996-1	149.00
TI 4000, TI 4000E	4Meg/16Meg		199/659
TI 4000M	4Meg/16Meg		219/899
Tandy 1510, 2810, 3810	1Meg		99.00
Tandy 2500, 3820, 3830	2Meg/4Meg/8Meg		119/199/309
Twinhead, Astma, Complumex, 486SX, DX, Tandy 4000	4Meg/8Meg/16Meg		199/379
Twinhead Salmonte 5	4Meg/8Meg/16Meg		199/379/649
Ultra 486 TS/SX	4Meg/8Meg/16Meg		249/459/879
Zeos 386SX Notebook (not the + version)	1Meg		109.00
Zenith Master Sport 386SX	1Meg	ZA-300-1	149.00
Zenith Master SL, SLE, 600, 620, 625NL	1Meg	ZA-314	119.00
Zenith Super Sport 286, 286E	1Meg	ZA-180-66	99.00
286E, SX	2Meg	ZA-180-67	149.00
SX Alpha	1Meg	ZA-180-86	99.00
SX Beta	2Meg	ZA-180-87	149.00
Zenith 4 Note 325L, LC	2Meg/8Meg	ZA2520-4/5	129/419
Zenith 4 Note 425LN, LNC, LNP	4Meg/8Meg		239/469/839
Zenith Z-Star 4/33	2.9Meg		119.00

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(for Palmtop & Subnotebooks)

MODEL	PRICE	MODEL	PRICE
S-RAM Cards 1MEG	159	Visual Media (CD Rom, Tape Dr)	249
S-RAM Cards 2MEG	229	(High speed SCSI II)	199
14.400/14.400 Data/Fax Modems	189	.Wavjammer™ (16 bit stereo sound card)	275
Readwriter Card	149	Type III 105 Mg Hard Drive	319
Lan Ethernet Combo	Call	Type III 130 Mg Hard Drive	399
Lan Ethernet (10 Base T)	169	Type III 170 Mg Hard Drive	439
Lan Ethernet (Coax)	169		

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AMOUNT UPGRADED	OK Bd	256k	1	2	3	3.5	4	5	6	8	16	32
Brother 630, 631, 641	–	–	89	–	–	–	–	–	–	–	–	–
Canon LBP 430	–	–	–	–	–	–	169	–	–	–	–	–
Canon LBP 800	–	–	–	99	–	–	179	–	–	349	869	1249
Canon LBP4, 4Lite, 4plus	–	–	159	219	–	–	–	–	–	–	–	–
Epson 8000, Action Laser	–	–	–	179	–	–	279	–	–	–	–	–
Epson Action Laser 1100, 1600	–	–	99	99	–	–	199	–	–	379	599	–
Epson Action Laser II	–	–	99	–	308	–	–	327	–	–	–	–
Epson 8000	–	–	99	–	308	–	–	327	–	–	–	–
Epson 1000, 1500, 5000, 5200	–	–	–	119*	–	–	239*	–	Call	–	–	–
HP 2 20+	–	–	–	109	–	–	169	–	–	–	–	–
HP 3, 3D, 3P, 2P, 2P+	–	–	–	109	–	–	169	–	–	–	–	–
HP 4, 4M, 4Si, 4SiMX, 4P, 4MP	–	–	–	89	–	–	169	–	–	349	–	–
HP 4L	–	–	59	–	–	–	–	–	–	–	–	–
HP 5Si	–	–	69	–	–	–	189	–	–	349	–	–
HP 4Si	–	–	–	89	–	–	189	–	–	349	–	–
HP Design Jet 600, 650	–	–	–	–	–	–	175	–	–	349	–	–
HP Deskjet 500, 500C, 510, 550,560	55	–	–	–	–	–	–	–	–	–	–	–
HP Deskjet 1200C, 1200C/P	–	–	–	99	–	–	175	–	–	349	–	–
HP Paintjet XL300	109	–	–	–	–	–	289	–	–	469	837	–
IBM Laser 4019, 4019E	–	–	–	–	–	169	–	–	–	–	–	–
IBM Laser 4029 4037	–	–	–	–	–	–	169	–	–	–	–	–
IBM Laser 4039 4079	–	–	–	99	–	–	169	–	–	350	–	–
NEC 90, 970	–	–	59	89	–	–	–	–	–	–	–	–
NEC 95, 97	–	–	69	89	–	–	–	–	–	–	–	–
Oki 400	–	–	–	89	–	–	–	–	–	–	–	–
Oki 400E, 400EX, 410E, 410EX	–	135	–	109	–	–	189	–	–	349	–	–
Oki 830, 840	–	–	–	109	–	–	189	–	–	349	–	–
Packard Bell PB 9500	–	–	–	109	–	–	175	–	–	349	–	–
Packard Bell 9815	–	–	–	109	–	–	–	–	–	–	–	–
Panasonic 4420/4450I	–	–	–	109	–	–	227	–	–	–	–	–
Panasonic 4431/4430	–	–	–	129	–	–	195	–	–	–	–	–
Panasonic 4400	–	–	99	129	–	–	–	–	–	–	–	–
Panasonic 4400/5400	–	–	109	129	–	–	229	–	–	–	–	–
Panasonic 4440, 5410	–	–	109	129	–	–	249	–	–	–	–	–
Sharp 9400, 9460, 9600, 9700E	–	–	84	109	–	–	249	–	–	–	–	–
Sharp 9500	–	–	–	109	–	–	279	–	–	–	–	–
Sharp 9500 E, H, 9700	–	–	109	–	–	–	279	–	–	–	–	–
TI XL/PS/17/PS/19	–	–	55	–	–	–	–	–	–	–	–	–
TI Microlaser Pro E, Powerpro, Pro 600	–	–	Call	Call	–	–	Call	–	–	Call	–	–
TI Microwriter	–	–	79	159	–	–	–	–	–	–	–	–

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ST3491A	420MB	12MS	IDE 3.5"	$234
ST3655A	545MB	12MS	IDE 3.5"	$268
ST3600N	525MB	10MS	SCSI-2	$478
ST31200N	1050MB	10MS	SCSI	$668
ST12550N	2100MB	9MS	SCSI	$1498

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CFA420A	420MB	12MS	IDE	$209
CFA540A	540MB	12MS	IDE	$268
CFA810	810MB	12MS	IDE	$496
CFA1060A/S	1060MB	10MS/IDE/SCSI		$558

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7546A	540MB	12MS	IDE	$288

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	4MB	92F9694	$178
PS/2 30/286,25/286, Adpt Brd 1497259	512K	30F5348	$35
	2MB	30F5360	$88
PS/2 35SX, LS, 40SX,70-E61; 061; 121, Adpt Brd 6450699; 34F3011; 34F3077, 502, 55SX, 65SX, P70, 56LS, 65LS SX Station 120 & 130	1MB	6450603	$39
	2MB	6450604	$84
PS2 50, 50Z, 55SX, 60, 65SX	2-6MB	1497259	$198
	2-16MB	6450609	$368
PS/1 Consultant, Essentials & Expert models x43, x44 & PS/ Valuepoint all models except Cxx series	4MB	95F9290	$174
	16MB	95F9291	$398
PS/2 70-A21; A61; B21; B61; PS/1 Consultant, Essential & Expert models x11, x13 & x14 PS/Valuepoint Cxx series1MB6450503			$39
	2MB	6450608	$89
PS/2 35SX; LS, 40SX, 56SX; LS, 65SX;	4MB	34F2933	$168
PS/2 90 XP, 95 XP, P75 (Palm), 86 57 (all) 76, 77, PS/1 Pro 2123	2MB	6450602	$88
PS2 90, 95 XP, P75 (Palm) 86, 57, (all) PS/1 Consultant, Essential, Expert x11, x13 & x14, PS/1 Pro 2123, RS/6000	4-8MB	6450128	$174
	8MB	6450130	$339
PS/2 35SX; LS, 40SX	8MB	6450129	$336
PS2 70's and 80's	2-8MB	6450605	$297
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	8MB	8188098	$368
	16MB		$647
CL57SX	4MB	07G1420	$208
Thinkpad 700, 700C, 720, 720C, 730D	8MB	07G1421	$376
	16MB	9805109	$696
Thinkpad 710T	4MB	N/A	$188
	8MB	N/A	$318
P/Notia N45SL	2MB	30F6824	$128
P/Notia 760, 760C, SX	2MB	07G1626	$198
	4MB	07G1427	$188
Laptop N33SX, L40SX & P/NOTE 182	8MB	07G1628	$418
	16MB	79F0998	$938
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T1000 SE/LP/DE	2MB	PA8312U	$73
T2000 / T2000SX	2MB	PA8314U	$73
T2000SX/T1000 LE	4MB	PA8314U	$188
	6MB	PA8315U	$358
T1200 XE	2MB	PA8306U	$98
T1600	2MB	PA8303U	$98
T2000, SXE/T2000SX/T1600 T1850, C,	2MB	PA2006U	$78
	4MB	PA2001U	$168
	8MB	PA2002U	$358
T3400	4MB		$198
	8MB		$368
T3100	2MB	PA7136E	$139
T3100 E	2MB	PA8341U	$108
T3100 SX	2MB	PA8306U	$108
	4MB	PA8310U	$188
T3200 SX	2MB	PA8307U	$118
	4MB	PA8308U	$198
	8MB	PA8318U	$108
T3200 SXC	2MB	PA8319U	$182
T3200	2MB	PA7137U	$184
T3200SL	2MB	PA2008U	$118
	4MB	PA2007U	$188
	6MB	PA2008U	$358
	16MB	PA2009U	$698
T3400CT	4MB	PA2012V	$198
	8MB	PA2013V	$398
T4400 SX, SXC, T6400 SXC, DXC	2MB	PA2003U	$125
	4MB	PA2004U	$188
	8MB	PA2005U	$358
	16MB	PA2010U	$698
	32MB		$1548
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	8MB	PA2013U	$368
	16MB	PA2014U	$658
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BRAVO 3/25S	2MB	500697-001	$88
	8MB	500697-002	$348
BRAVO NB/486	4MB		$168
	16MB		$768
ADVANTAGE PRO 486DX/33,SX/25, BRAVO LC 4/25S, 33, 33S, 50T, 4/66	2MB	500697-001	$88
	4MB	500697-002	$184
	16MB	500697-004	$678
PREMIUM 386/25, 33, 33T, 0 386SX/16 20/25	1MB	500780-003	$48
ADVANTAGE 486/25, 25,33P,SX20, BRAVO 4/33, 4/66,25i PREMIUM 4/25, 33T/E, 4/66	2MB	500780-002	$88
ADVANTAGE 486/25,33,33P,SX20,POWER PREMIUM 3/25,4,33,33S, 50,50T, PREMIUM 386/33TE, 486/25,E,33TE, 50, 50TE; PREMIUM II 386/25,33, 486/33, 4/66SX/50	4MB	500780-004	$178
PREMIUM SERVER 33E 4/33	8MB	500780-005	$348

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	4MB	113132-001	$188
Deskpro 386S	4MB Board	113634-001	$254
	4MB Module	112534-001	$188
Deskpro 386-20E, 25E	4MB	113645-001	$238
Deskpro 386/33/33i; 486/25, 33L,50L; Systempro	2MB	115144-001	$108
	8MB	116561-001	$378
	32MB	118568-001	$1458
Systempro, Deskpro , 6 SKT EXP BRD W/2MB		116569-001	$268
Compaq 'M'	2-64MB	121960-001	$189
Deskpro 286N; 386N 386SX/20; 20N; Portable 486c, Deskpro M , Systempro LT Series 129160-001, Pro Signia		118684-001	$48
	2MB	118689-001	$84
	4MB	118690-001	$168
	8MB	128877-001	$348
Prolina 3/25 & 252	2MB	141736-001	$98
	8MB	141742-001	$318
Prolina 4/25si, 4/33, 4/50	2MB Module	141683-001	$94
	4MB Module	141684-001	$178
	8MB Module	141685-001	$338
Compaq Pro Signia	16MB	149320-001	$684
	32MB	149147-001	$1524
DeskPro 5/60, 6/66M	8MB	149911-001	$368
Prosignia PC Server, 486/33/66	8MB	141685-001	$348
	16MB	149320-001	$648
	32MB	149147-001	$1498
Prolignia 5/60	16MB	149949-001	$668
Prolient 100 5/60	32MB	149912-001	$1398
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	4MB	138499-001	$174
	8MB	138499-001	$318
Contura 4/25CX	4MB	146520-001	$178
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	16MB	146532-001	$718
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	4MB	118303-001	$378
SLT/386	2MB	118304-001	$108
	4MB	118305-001	$198
Lte 286	1MB	117061-001	$74
	2MB	117061-002	$99
	4MB	117061-004	$178
Lte 386/20e	1MB	121125-001	$98
	4MB	121125-002	$238
Lte Lite/20, 25, 25C	2MB	129769-001	$138
	4MB	129769-002	$208
	8MB	129769-003	$368
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LTE Lte 486/25C	4MB	142237-002	$178
	8MB	142237-003	$348
	16MB	142237-004	$718
Aero 3.3vdt	4MB	190582-001	$188
	8MB	190582-001	$358

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	4MB Mod	FR-PCIM-BA	$248
	8MB Mod	FR-PCIM-BD	$488
Epson NB-3 Notebook	4MB	AB08511	$195
Epson NB-5LI	2MB Mod	AB08771	$128
EPSON 25C Notebook	4MB Mod	AB08781	$228
Everex Tempo LX, LX20	2MB	00160	$58
Everex Candela	2MB	00253-00	$109
Gateway 2000 Nomad 425 DXL/SXL	4MB		$186
	12MB		$475
Gateway 2000 486	4MB		$186
	16MB		$781
Gold 1500	4MB	52567	$238
Gold 1450SX	2MB	$200203	$145
Goldstar GS350, 386SX16	1MB	N/A	$92
	4MB	N/A	$368
NCR 3120 Notebook	4MB Mod	3120-K104	$252
NCR 3170 Notebook	4MB Mod	3123-K104	$389
Packard Bell, Magnavox, Mitsubi	1MB	N/A	$108
	4MB	N/A	$190
Panasonic CF710/270/370	1MB	CF-BA18S	$64
Samsung Notemaster 386S	2MB	SNV002	$195
	4MB	SNV004	$390
Sanyo 17MB, 18MB & ZEOS	2MB	MBC-NB2MEMZ	$98
Sharp 8230	1MB	CE-621B	$72
Sharp 9540,6781,6881,8781	4MB	N/A	$195
Sharp 4700MZ-200	1MB	CE-471	$198
Sharp 8501 Colorstar	2MB	N/A	$368
TI Travelmate 2000	1MB	2569034-0011	$78
TI Travelmate 3000SX, WFSX	5MB	2569096-0001	$84
TI Travelmate 4000,	4MB		$178
WINDX25 SX16, SX25, DX2/40	4MB	2561205-001	$188
DX2/50	16MB	AVAILABLE	$1296

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MODELS	1MEG	2MEG	3MEG	4MEG	5MEG	6MEG
Canon LBP4, 4 Lite & 4+	$118	$164				
Epson Action Laser II, 8000	$98		$198		$298	
Epson 4 8000 and many more	$128		$198			
Epson Action Laser 1000 & 1500	$98		$198		$298	
HP LJ 4/4M, 4 Plus & 5/5M	$184	$278				
HP Deskjet 500,500C, 510, 550C and 560C						$368 (550C)
HP LJ 2Si	$98		$184			
HP LJ 3, 3D, 3P, 3Si	$98		$198			
HP Laser Jet 4, 4M, 4Si, 4000, 4000T	$84		$168			$318
IBM Laser 4019, 4019E (4 SIMM)	$114		$184			
IBM Laser 4029 ALL MODELS	$95		$185			
NEC 90, 290	$104					
NEC 95	$98					
OKI 400	$66	$98				
Packard Bell PB8500	$125		$208			
Panasonic 4410/4430	$118		$178			
Panasonic 4420/4450	$118		$178			
Panasonic 4450	$95					
Panasonic 4400/6400	$125		$198			
QMS 410	$118	$158		$248		
Toshiba Page Laser 6	$98		$198			
TI XL/P617/P535	$44	$88				

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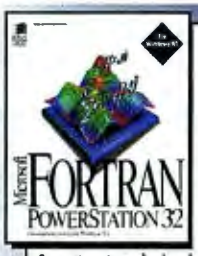

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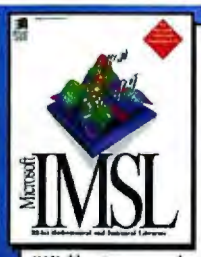

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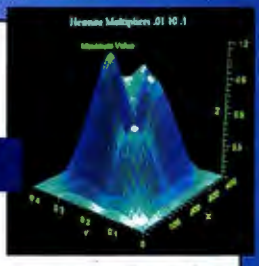

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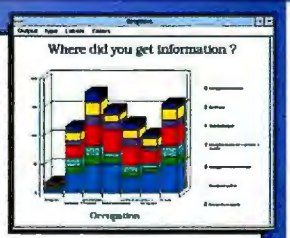

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2MB 64S6604 ... $87

PS/2 70-A21; A61; B21; B61, PS/Valuepoint Cxx models
PS/1 Consultant, Essential, Expert models
2MB 64S6606 ... $95

PS/2 35SX; LS, 40SX, 55SX; LS, 65SX, LS, XStation,
PS/Valuepoint Cxx models
4MB 34F2933 or 87F9977 ... $179

PS/2 35SX; LS, 40SX, PS/Valuepoint
4MB 64S0129 ... $356

PS/2 90 XP; 95 XP, P75 (pairs) 56, 57 (all) PS/1 Pro M2123
2MB 64S9303 ... $85

PS/2 90 XP; 95 XP, P75 (pairs) 56, 57 (all models)
PS/1 Consultant, Essential, Expert models, PS/1 Pro M2123
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SystemPro LT and M Series
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Ready 425, 433
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PowerMate 386/33E, 486/25E
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1MB C2024A ... $48

HP Laserjet IIP, III, IIIP, IIID
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HP Laserjet IIISi, 4, 4M, 4Si, 4SiMX, XL300, Deskjet 1200c
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HP Deskjet 500, 500C, 520, 520C, 550C, 560, 560C
256K 22707B ... $40

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IBM/Lexmark Laser 4029 (all models)
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IBM/Lexmark Laser 4039, 4079 (all models)
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Premium Exec
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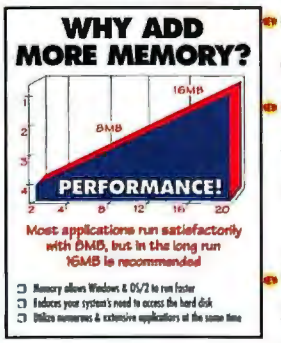

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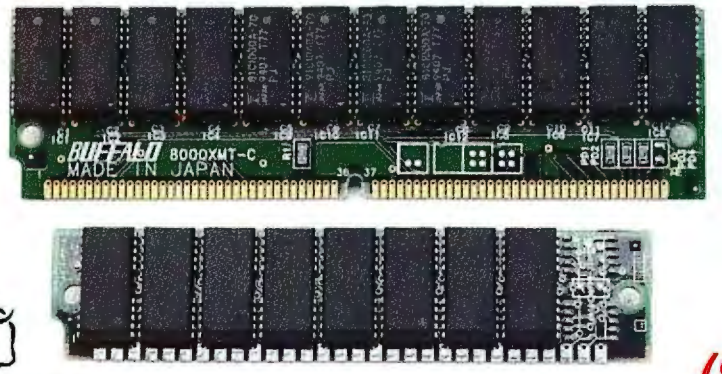

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Trapezoidal Control	YES	NO	NO	YES
Tilt/Rotation Control	YES	YES	YES	NO
Pincushion Control	YES	YES	YES	YES
Color Balance Control	YES	NO	NO	YES
Color Temperature Control	YES	NO	NO	YES
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10BT3-6___	6 ft.	4.25	4.00	3.75
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10BT3-25___	25 ft.	7.25	6.75	6.00

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GY (Gray) GR (Green)	BK (Black) YE (Yellow)	BL (Blue) RD (Red)		
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10BT5-10___	10 ft.	7.75	7.25	6.75
10BT5-15___	15 ft.	8.00	7.81	7.50
10BT5-25___	25 ft.	11.25	11.00	10.25
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KWP-3W	3 Port, White	1.49	1.34	1.22
KWP-4W	4 Port, White	1.49	1.34	1.22
KWP-6W	6 Port, White	1.49	1.34	1.22
KWP-1I	1 Port, Ivory	1.49	1.34	1.22
KWP-2I	2 Port, Ivory	1.49	1.34	1.22
KWP-3I	3 Port, Ivory	1.49	1.34	1.22
KWP-4I	4 Port, Ivory	1.49	1.34	1.22
KWP-6I	6 Port, Ivory	1.49	1.34	1.22

Other Type Inserts

KP-IN	Blank Insert (Ivory)	$0.30	$0.25	$0.20
KP-INW	Blank Insert (White)	0.30	0.25	0.20
KP-BNC	BNC Feed through Insert (Ivory)	3.00	2.73	2.50
KP-BNCW	BNC Feed through Insert (White)	3.00	2.73	2.50
KP-ST	ST Insert	6.50	5.91	5.42

Wall Plate Mounting Boxes

MB-IV	Ivory	$2.50	$2.27	$2.08
MB-WH	White	2.50	2.27	2.08

Power Protection!

SUPER SURGE ALERT Suppressor *features EMI/RFI filtering, suppresses up to 13,000A spikes, UL1449 approved and $10,000 Lifetime Mfg Warranty.*

TERM-6	TRIPPLITE Super Surge Alert (6 Outlet with 6 ft cord)	$32
TERM-6FM	Super Surge Alert w/FaxModem Protection (6 Outlet with 6ft cord)	38

UPS Back-Ups

BC-250	2 Outlet, 250 VA	$99
BC-400	4 Outlet, 400VA	145
BC-500	4 Outlet, 500VA	181
BC-500LAN	4 Outlet, Lan Interface	186

Line Stabilizers

LC-1200	1200 Watt	$139
LC-1800	1800Watt	188
LC-2400	2400 Watt	243

Isobar Suge Suppressors (Lifetime Insurance)

SUPER7	7 Outlets, 7 ft Cord (9.5k Spikes)	$18.95
IB2-0	2 Outlet, Direct Plug-In	23
IB2-6	2 Outlet, 6 ft. Cord	32
IB4	4 Outlet, 6 ft. Cord	42
IB6	6 Outlet, 6 ft. Cord	51
IB8	8 Outlet, 12 ft. Cord	61
MP	Econo Modem Suppressor	$14
SK6-6	6 Outlet, Spike Block, 6' Cord	28
STRIKER	6 Outlet, 4' Cord	12

Government, Institutional and Corporate Purchase Orders Welcome

FAX Modems!

MV.34I	BOCA 28.8Kbps Internal 5 Yr Mfg Warr.	$184
MV.34E	BOCA 28.8Kbps External 5 Yr Mfg Warr.	$225
M1440I	14.4Kbps Internal 5 Yr Mfg Warr.	$89
M1440E	14.4k External 5 Yr Mfg Warr.	$119
MT2834DX	MultiTech V.34 External	$229
VFPV32BIS	14.4K Internal Send/Receive	$89
VFXV32VIS	14.4K External Send/Receive	$119
VFP14.4V	14.4Kbps Internal with Voice Mail	$184
V.34I	ZOOM V.34 Internal	$184

Mitsumi Keyboard

MITSUMI 101/102 Enhanced Keyboard features a small footprint design. Sized at 15 3/4" x 7 7/8" x 1 13/16". Great Value with Mitsumi Reliability!

KBY-20 MITSUMI 101 Enhanced Keyboard $21.50

Replacement Power Supplies

PS-200	MINI 200W Baby Vertical	$39
PS-250	MINI 250W Baby SlimLine	49
PS-300	MINI 300W PS2 SlimLine	69

CD Storage Case

CDB CD "Jewel" Storage Cases Each $0.69 20+ $0.59

Video Boards

BOCA VESA Video "Voyager" Has Video Caching for Peak Performance! 1 MB Accelerator upgradable to 2 Mb. 5 Yr. Mfg. Warranty.

SVCXL1	VESA Accelerator, 1Mb	$119
SVCXL2	VESA Accelerator, 2 Mb	174
SVGAP1	PCI Super Accelerator (1Mb)	115

IFC-46	1024 X 768 SuperVGA with 1Mb of Display Mem.	79
IFC-46L	VESA Performance VBoard (To 2Mb DRAM)	85
IFC-48	BOCA SXVGA Accelerator! 1Mb Memory	129
IFC-33	Color Graphics, Printer Port XT/AT (Mono Avail.)	25
IFC-42	BOCA VGA (800x600)	52
IFC-44	16 Color VGA w/256k Display Mem. (640x480)	45

Disk Controller Boards

LCS-6924G	VESA I/O(2FD,2IDE , 2S,1P,1G)	$30
LCS-6941	VESA LB IDE Caching Cntlr 16Mb (4HD, 2FD)	159
IFC-27-2	Dual AT IDE, Floppy Controller (2HD, 2FD)	19
LCS-6633F	SCSI/IDE Controller (7HD, 2FD) Novell Cert.	99
AHA-1510A	16-Bit ISA to SCSI CD - Adaptec	109
AHA-1542CF	16-Bit ISA Fast SCSI Controller	219
AHA-1542CFK	SCSI Master Kit	299
AHA-2842VL	64-BitVESA SCSI Master Kit	299
AHA-2490KT	PCI SCSI I/O (7 Dev.)	349
DTC-2278EVL	DataTech VESA Super I/O	38
MIO-400KF	DFI All In One (2HD, 2FD, 2S, 1P, 1G)	33
MIO-500	All In One Card (2HD, 2FD, 2S, 1P, 1G)	25

Expansion Boards

I02BY4	BOCA I/O Board. (Supports 2 Par. & 4 Ser. Ports)	$99
IFC-12	Dual Serial Board. 16C550 Upgradeable.	11
IFC-25	2 Serial, 1 Parallel & One 15 pin joystick port.	16
IFC-13	Parallel Board for XT/AT. (LPT2 or LPT3)	9
IFC-20	Game Card (2Ports)	9

Memory!

1MEGX9-70	$46.50	4MEGX9-60	$162	44256-70	$6.64
1MEGX9-60	$47.50	4MEGPS2-60	$189	1MEGX1-70	$6.64
1MEGPS2-70	$55			256KX9-70	$14.50
8MEGPS2-60	$385	16MEGPS2-60	$565		

Hard Drives

ST-3290A	260Mb@16ms	$189	Seagate
ST-3391A	344Mb@15ms	239	IDE Hard Drives
ST-3491A	428Mb @ 15ms	259	
ST-3780A	722Mb @ 12ms	369	
ST31220A	1.08Gb @ 9ms	549	
MXT-7345A	345Mb @ 15ms	$329	MAXTOR Hard Drives
MXT-7420AV	420Mb @ 14ms	229	
MXT-7546A	546Mb @ 12ms	319	

Floppy Disk Drives

DDH-06	5 1/4" DSHD 1.2Mb	$47
DDH-10	3 1/2" 1.44Mb	37
DDH-11	DDH-10 w/no mnt brkt.	34
DDH-12	Combo 3 1/2" & 5 1/4" HD	99
5.25KITFD	Mnts 3 1/2" FD-5 1/4"	6.95
5.25KITHD	Mnts 3 1/2" HD-5 1/4"	6.95

Line Extenders & Auto Switch

Non-Powered Parallel Line Extender

For computer (transmitter) to printer (receiver), you can safely transmit data up to 1600 ft. over 4Pair phone line without data loss. Compact, FCC Approved.

PLE100	DB25 Male to DB25 Male with 30' cable	$49
PLE110	DB25 Male to 36 Pin Cent. Male w/30' cable	49
IC-9V200	9V/200mA Power Adaptor extends to 2000'	6.25

AUTO SWITCH locks onto incoming signal. "First-Come-First-Serve" Basis

AS-251P	2 to 1 Parallel (Compact) Non-Powered	$25
AS-451P	4 to 1 Parallel (Compact) Non-Powered	49

AUTO SWITCH/BUFFER -Powered Auto Switch with a optional Buffer Card. Takes data at full speed, cutting delays and wait time.

AS-411P	4 to 1 Parallel	$79
AS-811P	8 to 1 Parallel	119

Add-on Buffer Memory Boards (AS-411P/811P)

AS-RAM-256K	256k Ram Card	$59
AS-RAM-1M	1 Mb Ram Card	129
AS-RAM-2M	2 Mb RAM Card	215
IC-9V300	9V/300mA Power Adaptor	6

In a Hurry? 2nd Day - $7.00*
* Federal Express or UPS 2nd Day Economy - Up to 20lbs. - $7.00

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MultiMedia!

MITSUMI 4X CDROM Drive *features 600Kbps data transfer, 300Kbps access, 16-bit enhanced IDE/ATAPI interface, front panel headphone jack and volume control, motorized front disc loading/auto eject and MPC2 compliant.*

FX-400	MITSUMI 4X CDROM IDE Drive	$269
FX-001D	MITSUMI 2X CD IDE Drive (32Kb Cache,250ms acces	$149

AZTECH STELLAR MULTIMEDIA UPGRADE Kit *features a Sound Galaxy 16-bit Stereo Sound Card, IDE Double-Speed CD-ROM Drive, Stereo Speakers and 12 CD Titles.*

1. Sound Galaxy Card offers 20 voice stereo FM synthesizer (OPL3), 16-bit Digitized Audio playback at 44.1KHz, recording sampling from 5.5 to 44.1Khz, MIDI interface with full duplex capabilities, Wave-Table upgrade option and Game Port.
2. CD-ROM drive features double-speed, 300Kbps transfer and 350ms access, Quick play button for listening to CD Audio Music, Soft eject motorized loading tray Kodak/MPC2 compliant, programs for DOS and Windows 3.1.
3. CD Titles include Learn to Use Windows, Professor Multimedia, DOOM Ver1.2, AudioStation, AudioCalendar, WINDAT OLE and More...

MM1013	AZTECH CD Multimedia Upgrade Kit	$199
1021	AZTECH Voyager+ (IDE CD Drive, 16bit Sound Card & 35 Hot Titles)	$269
SC1017	AZTECH WaveRider 32-Voice Synthesis Board	$159

Motherboards

MB486DX VESA Local Bus Mainboard is a 32-bit 80486DX CPU withAMI BIOS, EMS support and secondary write-back 256k cache. Four 16-bit I/O slots and Three 32-bit VESA LocalBus slots, RAM expandable to 64Mb. Compact size of 250mm x 196mm.

MB486-33	MB486DX running at 33MHz (Intel)	$269.00	SPN1-486	486 CPU Kooler Fan	$9.95
MB486-66	MB486DX running at 66MHz (Intel)	329.00	SPN1-486P	PENTIUM 66MHz CPU Cooler	18.95
MB386-33C	386DX (33MHz,Six 16-bit,Two 8-bit slots,SIMM to 32Mb	124.00	SPN1-486P90	PENTIUM 90MHz CPU Cooler	19.95
MB386SX-40	386SX (40MHz,Six 16-bit,Two 8-bit slots,SIMM to 16Mb	79.00			

GLIDEPOINT *lets you control your computer by simply moving your finger over a ultra precise trackpad, allowing you to move, point, click and highlight with the mere touch of the tip of your finger. Sized at .5"x3.4"x2.7" and weighs 2 ounces. Tracking Speed up to 40inches/second, no contact pressure required. DOS/Windows3.1 Required.*

GPB120 CIRQUE GlidePoint Trackpad (Finger Capacitance $89.00

Switchboxes

Part#	Description	Each	10+
AB25-2E	*2 Way, DB25 Switchbox*	$9.99	$8.99
AB25-4E	*4 Way, DB24 Switchbox*	15.99	14.39
AB15HD-2E	*2 Way, 15Pin High Density Switchbox*	14.89	13.40
AB15HD-4E	*4 Way, 15 Pin High Density Switchbox*	18.89	17.00
ABRJ11-4E	*4 Way, RJ11 Switchbox*	13.99	12.59
ABRJ45-4E	*4 Way, RJ45 Switchbox*	12.99	11.69
ABMKB-2E	*2 Way Keyboard (5, 9 Pin) Switchbox*	14.95	13.45
ABMKB-4E	*4 Way, Keyboard (5, 9 Pin) Switchbox*	29.99	26.99
ABVGKB-4E	*4 Way, VGA Monitor (5, 15 Pin) Switchbox*	24.99	22.49

SIMMSTACK

SIMMSTACK *allows stacking Four 1Mb to 8Mb 30Pin SIMMS on to One 72pin slot converter. Supports IBM compatibles.*

SJ004B	SERMAX SimmStack Converter (Right Load)	$79
SJ004T	SERMAX SimmStack Converter (Left Load)	79

Labtec "Subwoofer" with Speakers

LABTEC Computer "SUBWOOFER" Sound Monster with Speakers features compact design, a long excursion, low resonance 8" dual voice coil driver, Multiport bandpass enclosure for solid bass output, high/low impedance buffer circuits for computer speakers, line/speaker output of sound cards, active circuit electronic crossover to eliminate any midrange from subwoofer. PC/MAC compatible. 20W RMS Output and 40W Peak.

SB-8
LABTEC MultiMedia Subwoofer Unit and Speaker Set
$109.99

Modular

Modular Adapter Kits (Set Screws)

6 = 6 PIN RJ-11 8 = 8 PIN RJ-45
Convert D-Sub to Modular Connectors

Part# MALE	Part# Female	Description	Each	25-99	100+
MA9M-6	MA9F-6	9 pin D-Sub to RJ-11	$3.00	$2.40	$1.90
MA25M-6	MA25F-6	25 pin D-Sub to RJ-11	3.00	2.40	1.90
MA9M-8	MA9F-8	9 pin D-Sub to RJ-45	3.50	2.80	2.40
MA25M-8	MA25F-8	25 pin D-Sub to RJ-45	3.50	2.80	2.40

One-Piece Modular Adapter Kits (Thumb Screws)

MA9M-6TS	MA9F-6TS	9 pin D-Sub to RJ-11	$1.99	$1.59	$1.39
MA25M-6TS	MA25F-6TS	25 pin D-Sub to RJ-11	1.99	1.59	1.39
MA9M-8TS	MA9F-8TS	9 pin D-Sub to RJ-45	1.99	1.59	1.39
MA25M-8TS	MA25F-8TS	25 pin D-Sub to RJ-45	1.99	1.59	1.39
MA25M-10TS		25 pin D-Sub male to 10 conductor	2.95	2.75	2.57

Modular Plugs

Part#	Description	1-99	100-999	1000+
MP-4M	For Handset Plugs 4x4	$.20	$.15	$.11
MP-4	RJ-11 Plugs 4x6	.20	.15	.11
MP-6	RJ-12 Plugs 6x6	.25	.18	.14
MP-8	8 pin RJ-45 Plug 8x8	.30	.22	.17
MP-8S	8 Pin RJ45 Plug (Solid)	.35	.26	.21
MP-10	10 x 10 Pin Modular plug	.58	.46	.40

Modular Wire

Part#	Description	Per Ft.	100 Ft.	1000 Ft.
MW-4	4 conductor	$.08	$.04	$.033
MW-6	6 conductor	.14	.07	.054
MW-8	8 conductor	.17	.08	.067
MW-10	10 conductor	.20	.17	.13
60-3011	Cutter and Stripper for Modular Wire		$6.95	

Modular Surface Mount Jacks

SM-6	Screw Terminal 6 Conductor Jack	$1.83	$1.46	$1.22
SM-8	Screw Terminal 8 Conductor Jack	3.08	2.46	2.05
SM-4IDC	4 Conductor 110 IDC type	3.87	2.90	2.32
SM-6IDC	6 Conductor 110 IDC type	4.30	3.23	2.58
SM-6-2IDC	6 Conductor, 110 DC type, Dual	4.50	3.95	3.46
SM-8IDC	8 Conductor 110 IDC type	4.80	3.60	2.88
SM-8-2IDC	8 Conductor, 110 DC type, Dual	4.95	4.21	3.69

TERMS: For C.O.D. orders add $5 per package. Minimum $25. Cash or Cashiers Check only. For orders under $99 add $3 handling charge. Orders $99 or more no handling fee. All shipping is FOB San Antonio, Texas . Texas residents add 7-3/4% sales tax. All returns require RMA# and must be returned in original condition. A 15% restocking fee will be assessed on merchandise returned in non-resaleable condition. No returns memory, cut cable. Prices subject to change without notice. We are not responsible for typographical errors.

Cable Assemblies

Cable Assemblies		*=6 ft	10 ft	25 ft	50 ft
PPC301-*	*Parallel Printer Cable (DB25 to 36P)*	$2.99	$3.99	$6.99	$16.99
DB-25 Line Cables (Wired Straight Thru, Shielded w/ TS)					
25MM-*	*DB25 Male to Male*	$3.99	$4.99	$8.99	$16.99
25MF-*	*DB25 Male to Female*	3.99	4.99	8.99	16.99
DE-9 Nine Line Cables					
9MM-*	*9P Male to Male*	$2.99	$3.89	$7.99	$14.59
9MF-*	*9P Male to Female*	2.99	3.89	7.99	14.59

Extension Cables		1-9	10+
5MM-6	*D5P Male to Male (6 foot)*	$2.99	$2.54
KEC-6	*Keyboard Extension Cable (6 foot)*	2.99	2.54
PS2-KEC6	*PS2 Keyboard Extension Cable (6 foot)*	3.39	2.99
PS2-KA	*Std AT Keyboard on PS/2 (MD6P to D5S)*	2.89	2.75
MEC-6	*Monitor Extension Cable (6 foot)*	2.99	2.44
PS2-MEC6	*PS2 Monitor Extension Cable (6 foot)*	3.39	2.99
LAPLINK-P	*Lap top Extension (8 foot)*	9.99	9.49

Power Cords			
ACPC-02	*PC Power Cord*	$2.49	$2.23
ACPC-03	*Monitor Power Adpater*	2.29	1.99
ACPC-04	*Monitor Power Extension (6 foot)*	3.69	2.75

15 Pin High Density Cables			
HD15MM-6	*Male to Male (6 foot)*	$4.99	$4.50
15P-5BNC	*15P HD to Five BNC Color Connectors* 6'/$19.99	10'/$23.99	25'/$38.99

Modem Assemblies		1-9	10+
ATM-6	*Modem Cable Assembly (9S to 25P) 6 ft*	$3.29	$2.79
ATM-10	*Modem Cable Assembly (9S to 25P) 10 ft*	3.99	3.49

Drive Cable Assemblies		Each
HD-IDE	*40S-40S Single IDE Hard Drive Cable*	$1.49
DFC-U	*Universal Cable Set (5 Connector)*	2.95
2HDIDE	*Dual IDE Hard Drive Cable*	2.99
YAD-4	*Disc Drive "Y" Adapter 4P*	1.99

SCSI Cables		
SCSI-RC	*Dual SCSI Drive Cable (2 foot)*	$4.95
SCSI-DC	*Daisy Chain (6 foot)*	7.99
SCSI-II	*SCSI-II Adaptor Cable (4 foot)*	29.95
SCSI-II3	*SCSI-II to SCSI-II, (3 foot)*	29.95
SCSI-2HH	*50P HalfPitch to 50Pin HalfPitch*	34.95
SCSI-EC6	*SCSI Extension Cable (6 foot)*	9.99
SCSI-T	*SCSI Terminator*	13.99
SCSI-IIT	*SCSI-II Terminator*	21.00

Gender Changers and Adapters		1-24	25
ATSCA	*9P Female to 25P Male Adapter*	$2.49	$2.04
PCSCA	*9P Male to 25P Female Adapter*	2.49	2.04
TGC-9M	*9P M-M Ultrathin Gender Changer*	2.69	2.45
TGC-9F	*9P F-F Ultrathin Gender Changer*	2.69	2.45
TGC-25M	*25P M-M Ultrathin Gender Changer*	2.99	2.75
TGC-25F	*25P F-F Ultrathin Gender Changer*	2.99	2.75
PS2-MA	*VGA Card - MultiSync Mon. (HD15P to 9S)*	4.29	3.90
PS2-KA	*PS2 Keyboard Adapter (MD6P to D5S)*	2.89	2.75
PC-PS-KA	*PS2 Keyboard Adapter (MD6S to D5P)*	6.95	6.75
BRB-232	*Breakout Box RS-232 (24 Dip Switches)*	27.95	23.00
NMA-25	*DB-25 Null Modem Adapter*	2.99	2.75
NMA-9	*DB-9 Null Modem Adapter*	2.69	2.45

BNC Connectors (Partial Listing Only)

Twist-On Male				
Part #	Description	1-24	25-99	100+
27-9050	*RG 59 & 62*	$1.17	$1.08	$1.00
27-9051	*RG-58*	1.17	1.08	1.00
27-9206	*RG-58 Thin Net*	2.03	1.87	1.74
2 Piece Crimp Male				
27-9000	*RG-59 & 62*	$1.43	$1.32	$1.22
27-9001	*RG-58*	1.43	1.32	1.22
3 Piece Crimp Male				
27-9100	*RG-59 & 62*	$1.28	$1.18	$1.09
27-9101	*RG-58, 141*	1.28	1.18	1.09
27-9205	*RG-58 Teflon*	1.73	1.59	1.48
27-9208	*RG-58 Thin Net*	1.95	1.80	1.67

Impedence Terminators		1-24	25-99	100+
27-9007	*75 Ohm*	$2.25	$2.08	$1.93
27-9008	*50 Ohm*	2.25	2.08	1.93
27-9093	*93 Ohm*	2.25	2.08	1.93
27-9245	*50 Ohm W/Chain*	4.05	3.74	3.47
27-9246	*75 Ohm W/Chain*	4.05	3.74	3.47
27-9247	*93 Ohm W/Chain*	4.05	3.74	3.47
Chassis Mounts				
27-8460	*Bulkhead Receptacle 3/8"*	$0.90	$0.82	$0.75
27-9248	*RG-58 Crimp*	3.15	2.91	2.70
27-9249	*RG-59, 62 Crimp*	3.15	2.91	2.70
27-8470	*Feed thru - 1/2"*	3.00	2.73	2.50
27-8469	*Economy 8470 (Shorten)*	2.50	2.31	2.14

Chassis Mounts 5/8"		1-24	25-99	100+
Twist-On				
27-8475	*RG-58*	$3.38	$3.12	$2.89
27-8476	*RG-59,62*	3.38	3.12	2.89
BNC Adaptors				
25-7430	*Inline Splice*	1.40	1.27	1.17
27-8110	*Female to RCA Male*	1.88	1.73	1.61
27-8100	*Female to F Male*	1.88	1.73	1.61
27-8140	*"T" 1 Male 2 Female*	2.93	2.70	2.51
27-8141	*"T" 3 Female*	4.73	4.36	4.05
27-8130	*Male to BNC Male*	2.20	2.00	1.83
25-7510	*Male to RCA Female*	1.50	1.38	1.29
25-7500	*Male to "F" Female*	1.73	1.59	1.48

Bulk Wire & Cable

COMMERCIAL COAXIAL TRANSMISSION/COMPUTER CABLE		100-999'	1000+ Ft
9201-BEL	RG-58/U, 20AWG .033 Solid, 78% Shield	$0.14	$0.11
9907-BEL	Thin Ethernet, 20AWG (19x32) Strd, 100% Shield, NEC CL2 CSA	0.19	0.15
9269-BEL	RG-62A/U, 22 AWG (.025), Solid, 95% Shield	0.15	0.11
PLENUM (50 OHM) COAXIAL COMPUTER-INSTRUMENTATION CABLE			
89907-BEL	Thin Ethernet, 20AWG (19x32), 100% Shield, NEC CL2P CSA	$0.34	$0.27

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Bulk Cable 24AWG PVC INSULATED Multi-Conductor (7/32) NEC725, CL2), 24AWG Shielded Cable		1-99'	100-999'	1000'
4304	4 Conductor	$0.13	$0.10	$0.069
4306	6 Conductor	0.17	0.13	0.089
4308	8 Conductor	0.22	0.18	0.117
4310	10 Conductor	0.26	0.21	0.140
4312	12 Conductor	0.30	0.24	0.159
Stranded Twisted Pairs Individually Shielded (NEC725, CL2)		1-99'	100-999'	1000'
3302	Two Pair	$0.11	$0.09	$0.072
3303	Three Pair	0.15	0.13	0.101
3304	Four Pair	0.19	0.16	0.126

Bulk Coaxial Cable		100-999'	1000'
RG-58U	50 Ohm Ethernet	$0.09	$0.065
PRG-58U	50 Ohm Ethernet (Plenum)	0.33	0.233
RG-58THIN	50 Ohm Thin Net	0.16	0.115
RG-62U	93 Ohm Arcnet	0.11	0.073
PRG-62U	93 Ohm Arcnet (Plenum)	0.36	0.243

Voice/Data Cable Level 5				
Part #	Description	1-99'	100-999'	1000'
VDC5-4	Level 5, 4 Pair, Unshielded CL-2 PVC	.12	.10	80
VDC5-4P	Level 5, 4 Pair, Unshielded CL-2P Plenum	.25	.20	180

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116118	80486SLC 66MHz w/CPU	229.95
95222	80486DX 33MHz w/CPU	299.95
95169	80486DX 50MHz w/out CPU	149.95
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42251	511000P-80	1MBx1	5.95
42219	511000P-10	1MBx1	5.75

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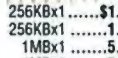

41451	41256A9A-10	256KBx9	$13.95
41700	421000A9A-70	1MBx9	47.95
41718	421000A9A-80	1MBx9	46.95

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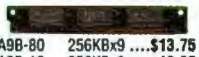

41523	41256A9B-80	256KBx9	$13.75
41486	41256A9B-10	256KBx9	10.95
41689	421000A8B-80	1MBx8	41.95
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113751	CFS210A	210MB	3.5"	179.95
115764	CFS420A	426MB	3.5"	239.95
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19545	200 Watt	79.95
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28708	PPC12	12' - straight cable	7.95
28741	PPR6	6'- right angle cable	5.95

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- P/N 118922: 1.44 MB 3.5", double-sided, high density
- Color (faceplate): beige

118957	1.2 MB 5.25"	$49.95
118922	1.44 MB 35"	49.95

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19908	286/386 Multi I/O w/ floppy cntr.	59.95
19596	8088 Floppy controller	19.95
19617	Floppy Disk Two-drive controller	34.95
19668	Floppy Disk Four-drive controller	44.95
78713	Serial card 16450 UART	29.95
67053	Serial card 16550 UART	39.95
104678	Serial card - 4 serial port UNIX	69.95
117971	I/O Card 4 serial, 3 parallel	89.95
105611	I/O Card	29.95
105072	VESA IDE super I/O card	29.95

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10250	ADP20F	16-bit hard/floppy	24.95
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117786	Tape backup without software	$149.95
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- 0.39 mm dot pitch
- Max. resolution: 1024 x 768

66122:

- Low radiation
- 0.28 mm dot pitch
- Max. resolution: 1024 x 768 (interlaced)

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78676	14" Super VGA	269.95
66122	14" Super VGA (Low radiation)	349.95

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286 12MHz Bare-bones System

VALUE

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118981 486DX 33MHz $499.95

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- Five modes of operation: Period Mode, Frequency Ratio, Time Interval Mode, Totalize Mode, Self-Test Mode
- Frequency range from 5 Hz to 175 MHz
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- Hand-held &easy-to-operate.
- Supports TTL, CMOS, DRAM 41, and DRAM 44 series • Size: 7"L x 3.625"
- One-year warranty

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- Includes adapter card, software and manual
- Size: 7"L x 5.5"W x 1.75"H
- One-year warranty

101400	1 Socket 16K-512KB	$129.95
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78465	4 Socket 16K-2MB Programmer	269.95
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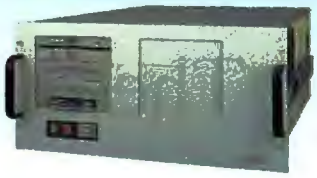

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ST31200N	1.05GB	9MS	SCSI-2	539
ST11900N	1.7GB	9MS	SCSI-2	999
ST12400N	2.1GB	9MS	SCSI-2	969
ST43400N	3.5GB	11MS	SCSI-2	1850
ST15230N	4.2GB	9MS	SCSI-2	1879
ST410800N	9.0GB	11MS	SCSI-2	3299

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ST11950N	1.6GB	8MS	SCSI-2	1109
ST12550N	2.1GB	8MS	SCSI-2	1109
ST32550N	2.1GB	8MS	SCSI-2	1109
ST15150N	4.2GB	8MS	SCSI-2	2199

digital

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CFA850A	850MB	10MS	IDE	359
CNR1275A	1.3GB	10MS	IDE	534
CFP1060S	1.05GB	9MS	SCSI-2	545
CFP2105S	2.1GB	9MS	SCSI-2	1015
CFP2107S	2.1GB	9MS	SCSI-2	1219
CFP4207S	4.2GB	9MS	SCSI-2	1425

Maxtor

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M7420AV	420MB	12MS	IDE	195
M7540AV	540MB	12MS	IDE	232
MXT540A	540MB	8.5MS	SCSI	345
MXT540S	540MB	8.5MS	SCSI	345
DR3410	105MB	MBL MAX	PCMCIA	360

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94G8512	728MB	12MS	SCSI	350
70G8492	1052MB	8.6MS	SCSI	589
70G9493	2040MB	9.2MS	SCSI	1139
90F0780	4250MB	11MS	SCSI	2149
70G3487	270MB	12MS	IDE	177
70G8488	364MB	12MS	IDE	193
70G8486	527MB	12MS	IDE	245
70G8511	728MB	12MS	IDE	325
70G8512	1052MB	8.6MS	IDE	589

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MC4110	1.05GB	9MS	SCSI-2	650
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MC4221	2.05GB	8.5MS	SCSI-2	1095
MC1936	3.0GB	11MS	SCSI-2	1339
MC3243	4.3GB	8MS	SCSI-2	1999
MC1991	9.0GB	11MS	SCSI-2	3199
MC2217AV	1.7GB	10MS	SCSI-AV	962
MC4221AV	2.05GB	8.5MS	SCSI-AV	1179
MC1936AV	3.0GB	11MS	SCSI-AV	1545
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LT540A	541MB	11MS	IDE	222
LT730A	731MB	11MS	IDE	274
LT365S	365MB	11MS	SCSI-2	209
LT540S	541MB	11MS	SCSI-2	243
LT730S	731MB	11MS	SCSI-2	294
IMP1080S	1.08GB	9MS	SCSI-2	525
IMP1440S	1.4GB	9.5MS	SCSI-2	699
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GP2140S	2.1GB	8.6MS	SCSI-2	1269
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ST15150W	4.29GB	8MS	3.5"	2499

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MK2326FC	340MB	15MS	IDE	344
MK2428FC	524MB	15MS	IDE	524
MK2528SE	700MB	15MS	IDE	880

IBM

IBMHDN250	250MB	IDE	$284
IBMHDN340	340MB	IDE	374
IBMHDN520	520MB	IDE	524

Seagate

ST9145AG	128MB	16MS	$275
ST9150AG	128MB	16MS	275
ST9235AG	210MB	16MS	275
ST9385AG	340MB	16MS	395
ST9550AG	455MB	16MS	429
ST9655AG	524MB	16MS	529

Quantum

GLS256AT	256MB	16MS	$295
GLS256S	256MB	16MS	295

FLOPPY DRIVES

TEAC

1.44MB $39
1.2MB 49
DUAL FLOPPY 1.44 & 1.2 99

REMOVABLES/ OPTICALS

SYQUEST

REMOVABLE CARTRIDGE DRIVES

- S0555 44MB INTERNAL/EXTERNAL $235/338
- S03110C 88MB C INTERNAL/EXTERNAL .... 29[illegible]
- 88MB C EXTERNAL W/CART & CABLES .... 42[illegible]
- S03105S 105MB SCSI .... 27[illegible]
- 105MB EXTERNAL W/CART .... 39[illegible]
- 270MB INTERNAL/EXTERNAL FOR PC .... 349/44[illegible]
- 270MB EXT FOR MACINTOSH .... 49[illegible]
- 270MB CART SINGLES/5 PACK .... 80/40[illegible]
- CARTS 44MB/88MB/105MB .... 63/95/6[illegible]
- 5200 200MB INTERNAL .... 39[illegible]
- 5200 200MB EXTERNAL W/CART .... 59[illegible]

IBM

128MB, 3.5" REWRITABLE OPTICAL DRIVES
Internal/External $729/885
1.3GB, 5.25" REWRITABLE OPTICAL DRIVES
Internal/External $2199/2699

MAXOPTIX

1-GB & 1.3GB REWRITABLE OPTICAL DRIVES
- TAHITI IBM 1MB INT/EXT $2,259/2,479
- TAHITI IBM 4MB INT/EXT 2,399/2,599
- 1/1.3GB CARTRIDGE GLASS/POLY 179/199

HEWLETT PACKARD

1-GB & 1.3GB REWRITABLE OPTICAL DRIVES
- C1716T 1.3GB INTERNAL/EXTERNAL $2,199/2,429
- 1.3GB OR 650 MB CARTRIDGE 145

FUJITSU

REWRITABLE EXTERNAL OPTICAL DRIVES
- 230MB 3.5" OPTICAL DRIVE INT .... $79[illegible]
- 230MB 3.5" OPTICAL DRIVE EXTERNAL W/CART .... 99[illegible]
- 230MB CARTRIDGE 1-PACK $69 5-PACK .... 31[illegible]

TAPE BACKUPS

COLORADO MEMORY SYSTEMS

- Jumbo 250 Internal $159
- Jumbo 350 Internal 179
- Jumbo 700 Internal 328
- Trakker 250 parallel port 299
- Trakker 350 parallel port 339
- Trakker 700 parallel port 499
- Powertape 2 4GB SCSI Internal 927
- Powertape 2 4GB SCSI External 1077
- PowerDAT 4GB SCSI Internal 997
- 2120 CARTS SNG/5PK 19/89

CONNER

- TapeStor 250MB Internal $151
- TapeStor 250MB Ext. Par A250ep 339
- TapeStor 420MB Internal 187
- TapeStor 420MB Parallel Port 337
- TapeStor 850MB Internal 288
- TapeStor 820MB Parallel Port 429
- C2150S 250MB DC6000, 6MB/MIN, BARE INT/EXT 339/439
- C2525S 525MB DC6000, 14MB/MIN, BARE INT/EXT 469/569
- C4320 2GB DAT, 11MB/MIN, BARE INT/EXT 799/899
- C4340 4-8GB TURBO DAT, 88MB/MIN, BARE INT/EXT 999/1,099

WangDAT

- 3100 2.0GB TAPE TAPE INT/EXT 849/349
- 3200 4-8GB TAPE TAPE INT/EXT 899/399
- 3400DX 4-8GB TAPE TAPE INT/EXT 959/1,099

EXABYTE

- FS1G 1.5GB TAPE INT/EXT .... $795/$949
- 4200 2GB TAPE INT/EXT 849/959
- 4200C 4GB TAPE INT/EXT 829/899
- 8205 2.5GB TAPE INT/EXT 1,325/1,549
- 8200 2.5GB TAPE INT/EXT 1,379/1,579
- 8505 5GB TAPE INT/EXT 2,025/2,399
- 8500 10GB TAPE INT/EXT 2,269/2,399
- AUTOCHANGER 48GB TAPE EXT 5,595
- 5 PACK TAPES FOR FS1G 199
- 5 PACK TAPES FOR FS10G 89

MicroSolutions

BACKPACKS
- SPEED PARALLEL PORT CD ROM DRIVE $339
- 250 TAPE DRIVE 329
- DSKTTE DRV 1.2, 5.25 155
- DSKTTE DRV 1.4, 3.5 145
- HARD DRIVE 420 469

Mountain

- TD-250 250MB IDE Internal $158
- FS8500 305MB IDE Internal 313
- SideCar II 305MB Parallel 313
- 1200-4 4GB SCSI External 2045

IOMEGA

- Iomega Tape250 Internal Basic $184
- Bernoulli 5.25" 90MB cart gold 99
- Bernoulli 90 DR w/cart 345
- Bernoulli 150MB Internal SCSI 413
- Bernoulli 150MB Internal IDE 389
- Bernoulli 230MB Insider SCSI 454
- Bernoulli 230MB Transportable 454
- 150MB Cartridge 92
- 230MB Cartridge 99

HEWLETT PACKARD

- 35470A 2.0GB TAPE INT/EXT $739/899
- 35480A 4-8GB TAPE INT/EXT 849/999
- C1533A 4-16GB TAPE INT/EXT 999/1,199
- 4MM 90MM DAT CART (1/5 PK) 18/86
- 3.5"-5.25" CONVERSION KIT 39

SIMMS

- LIFETIME WARRANTY/ MONEY BACK GUARANTEE
- BUY WITH CONFIDENCE FROM THE MEMORY UPGRADE EXPERTS
- PERSONAL COMPUTERS · WORK STATIONS · NOTEBOOKS · LASER PRINTERS
- GREAT SERVICE · FAST DELIVERY · SUPER SELECTION · BIG SAVINGS
- GET IT EXPRESS FROM THE MEMORY SUPER SOURCE

4MB X 9-80NS SIMM	$139	256K X 9-80NS SIMM	14	256K X 9-70NS SIPP	20
4MB X 9-70NS SIMM	139	256K X 9-70NS SIMM	15	256X36-1MB-70NS	55
4MB X 9-60NS SIMM	145	256K X 9-60NS SIMM	18	512X36-2MB-70NS	95
1MB X 9-100NS 9 CHIP SIMM	38	1MB X 8-80NS SIMM	40	1X36- 4MB-70NS/60NS	165/175
1MB X 9-80NS 3 CHIP SIMM	40	1MB X 8-70NS SIMM	42	2X36-8MB-70NS/60NS	338/348
1MB X 9-80NS 9 CHIP SIMM	44	4MB X 8-80NS SIMM	135	4X36-16MB-70NS/60NS	535/545
1MB X 9-70NS 3 CHIP SIMM	40	4MB X 8-70NS SIMM	140	8X36-32MB-70NS/60NS	1125/1175
1MB X 9-70NS 9 CHIP SIMM	45	1MB X 9-100NS SIPP	43	16X36-64MB-70NS/60NS	2395/2435
1MB X 9-60NS 3 CHIP SIMM	42	1MB X 9-80NS SIPP	49	1X32-4MB-70NS/60NS	150/160
1MB X 9-60NS 9 CHIP SIMM	46	1MB X 9-70NS SIPP	50	2X32-8MB-70NS/60NS	299/319
16MB X 9-70NS SIMM	595	1MB X 9-60NS SIPP	51	4X32-16MB-70NS/60NS	499/520
16MB X 9-60NS SIMM	635	256K X 9-100NS SIPP	18	8X32-32MB-70NS/60NS	1095/1135
256K X 9-100NS SIMM	13	256K X 9-80NS SIPP	19	16X32-64MB-70NS/60NS	2295/2335

DYNAMIC RAMS

1MB X 1-100NS	$8.00	256K X 1-80NS	3.75
1MB X 1-80NS	8.25	256K X 1-70NS	3.75
1MB X 1-70NS	8.50	256K X 1-60NS	3.75
1MB X 1-60NS	8.75	256K X 4-100NS	6.00
256K X 1-150NS	3.00	256K X 4-80NS	6.25
256K X 1-120NS	3.25	256K X 4-70NS	6.50
256K X 1-100NS	3.50	256K X 4-60NS	6.75

CACHE MEMORY

8 X 8-15	$5.00	32 X 8-20	8.00
8 X 8-20	4.50	32 X 8-25	7.00
8 X 8-25	4.00	64 X 1-15	15.00
16 X 4-15	8.00	64 X 4-20	10.00
16 X 4-20	5.50	64 X 4-25	8.00
16 X 4-25	5.00	128 X 8-20	33.00
32 X 8-15	10.00	128 X 8-25	30.00

CPU'S

INTEL							
386DX-33	$33	486DX2-50	148	PENTIUM 60	528	486DX2-80	225
486SX-25	69	486DX-50	352	PENTIUM 90	760	486DX4-100	425
486 SX-33	113	486DX2-66	208	AMD		CYRIX	
486DX-25	109	486DX4-75	573	386DX-40	$45	486 DX-33	$100
486DX-33	153	486DX4-100	473	486DX2-50	109	486 DX2-40	109
		PENTIUM 66	508	486DX2-66	189	486 DX-50	86

MATH CO-PROCESSORS

INTEL						CYRIX									
8087 5MHZ	$40	80287-10 10MHZ	75	80387DX-16 16MHZ	75	83D87DX-16 16MHZ	58	83S87SX16 16MHZ	58	2C87-10 10MHZ	54	3C87-33 33MHZ	58		
8087-2 8MHZ	130	80287XL 10MHZ	75	80387DX-20 20MHZ	75	83D87DX-20 20MHZ	58	83S87SX20 20MHZ	58	2C87-12 12MHZ	60	3C87-40 40MHZ	60		
8087-1 10MHZ	80	80287XLT 12MHZ	75	80387DX-25 25MHZ	75	83D87DX-25 25MHZ	58	83S87SX25 25MHZ	58	2C87-20 20MHZ	54	3S87SX-16 16MHZ	58		
80287-6 6MHZ	40	80387SX-16 16MHZ	75	80387DX-33 33MHZ	75	83D87DX-25 25MHZ	58	82S87XL	58	3C87-16 16MHZ	58	3S87SX-20 20MHZ	58		
80287-8 8MHZ	50	80387SX-20 20MHZ	75	80487SX-25	345	3D87DX-33 33MHZ	58	IIT		3C87-20 20MHZ	58	3S87SX-25 25MHZ	58		
		80387SX-25 25MHZ	75			83D87DX-40 40MHZ	58	2C87-8 8MHZ	54	3C87-25 25MHZ	58	3S87SX-33 33MHZ	58		

SCSI-IDE CONTROLLERS

FUTURE DOMAIN

- TMC850 8-Bit w/Bio $59
- TMC1670 SVP 16-Bit SCSI Value Pack 139
- TMC1680 SVP 16-Bit Value Pack 7HD/4FD 139
- SCSI 2 GO PCMCIA Fast SCSI-2 Type2 279
- TMC3260 32 Bit PCI Kit 149
- TMC3260 SVP Value Pack 149
- TMC7000EX 32 Bit EISA SVP Kit Floppy 369

adaptec

- 1505 CD ROM 16-Bit SCSI Card Kit $75
- 1515 16 Bit ISA-SCSI 2 KIT 99
- 1522 16 Bit 7HD/2FD Kit 139
- 1530PK 16 Bit ISA to FAST SCSI-II Kit 189
- 1542 Bus MasterCard Only 210
- 1542CF Bus Master Complete Kit 249
- 1542C+ Bus Mstr Compl. Kit w/Corel SCSI 314
- 1640 MicroChannel for PS/2, 7HD 299
- 1570 ISA-SCSI AUDIO KIT 299
- 2940 PCI-FAST SCSI KIT 294
- 2742 EISA KIT, 14HDs 369
- 2742W FAST WIDE SCSI CARD 399
- 2825VL Enhanced SCSI/IDE Kit 179
- 2842A VLFast SCSI-II VESA 259
- APA-460 Slim SCSI PCMCIA SCCSI Card 289
- APA-2940W PCI Fast-Wide SCSI Kit 389
- AMM-1570 FullSCSI w/Advanced Audio 319

PROMISE TECHNOLOGY, INC.

IDE CACHING CONTROLLERS
- DC200 2FD/4HD ISA (exp. to 16MB) $89
- DC200M 2FD/4HD ISA (exp to 8.5MB) 2.88 Support 99
- DC420VL VESA 2FD/2HD 512K (EXP TO 16MB) 99
- DC4030VL-II 2FD/2HD 4MB/Sec Iso Rate 2.88 Support 109
- DC2300+ Enhanced IDE VLB w/16550 i/o 69
- DC5030 EIDE PCI Caching controller .... $call

SUPER CONTROLLERS

IDE CONTROLLERS
- 200 2HD/2FD Controller Cables $22
- 211 2HD/2FD w/2 serial/1 Par/1 Game 29
- 243 2HD/2FD VLB EIDE w/o 2s/1p/1g 49
- 400 16550 2HD/2FD 2-16550 2s/1p/1g ISA 65
- 500 16550 2HD/2FD 2-16550 2s/1p/1g VLB 69
- 1050 16550 I/O Controller 2s/1p/1g 55

TRANTOR

- T130 8-Bit SCSI $85
- T348 Parallel Port to SCSI Plus 149
- T358 Parallel Port to SCSI Plus Enhnc. 199

Q logic

- FastSCSI EISA $179
- FastSCSI EISA FL floppy contr 199
- FastSCSI ISA 143
- FastSCSI ISA FL floppy contr 169
- FastSCSI VESA Local Bus 199
- FastSCSI PCMCIA 199
- FastSCSI PCI 299

DTC

- 2278VL IDE/FDD/1P/1S/1G $25
- 2277VL VL-Bus Caching IDE (Up to 16 MB) 139
- 2130PC PCI/IDE 29
- 2280 IDE/FD/1 P/2S/1 G 29
- 2290 EISA IDE 32-Bit 137
- 3270VL SCSI-2 VL-BUS FDD/HDD 119
- 3280AS SCSI-2/4-FDD 119
- 3290AS EISA SCSI-2/4-FDD 339
- CD-ROM Kit SCSI-28 Bit 47

Acculogic

- s-IDE-1/16 8BIT XT Cont. w/Bios $49
- s-IDE-2 PCI 2HD/Enhanced IDE 39
- s-IDE-3 2 Floppy 2HD IDE Card 39
- s-IDE-3+ 2HD/2FD w/ Bios 2.88 Support 59
- s-IDE4/HP 2HD/2FD 16550 IO 2.88 Support 189
- s-IDE4+ 2HD/2FD 59
- s-IDE4/VL 2HD/2FD 16550 2.88 Support VLB Enhanced 99
- ISApport 16bit SCSI Kit Model 20 129
- VESApport 32bit VLB kit w/Corel SCSI M/20 249
- PCIpport Model 20 w/wide SCSI-3 Support 249
- PCIpport Model 40 w/wide SCSI-3 w/Corel SCSI 299

BUSLOGIC

- BT445S VESA Local Bus Kit $199
- BT545KT BusMaster Fast Scsi 229
- BT8747AK EISA Fast SCSI Kit 379
- BT757S SEISA/WIDE SCSI (SINGLE S) 375
- BT946C Bus Master Fast SCSI for PCI 269

IDE CACHE CONTROLLERS
- KT510A ISA/IDE Cache Controller 99
- KT410A VESA/IDE Cache Controller 139
- KT910A PCI/IDE Cache Controller 189

VIDEO BOARDS

DIAMOND Computer Systems, Inc.

- Speedstar Pro 1MB ISA $105
- Speedstar Pro 1MB VLB 105
- Speedstar 64 1MB ISA 149
- Speedstar 64 2MB ISA 195
- Stealth 64 DRAM 1MB VLB 149
- Stealth 64 DRAM 1MB PCI 143
- Stealth 64 DRAM 2MB VLB 199
- Stealth 64 VRAM 2MB PCI/VLB 329
- Stealth 64 VRAM 4MB PCI/VLB 459
- Viper SE 2MB VLB 319
- Viper SE 2MB PCI 319
- Viper SE 4MB VLB 469
- Viper SE 4MB PCI 469

ORCHID

- Kelvin 64 1MB ISA/PCI/VLB $149
- Kelvin 64 2MB ISA/PCI/VLB 199
- Kelvin EZ 1MB ISA/PCI/VLB 119
- Fahrenheit 64 1MB VLB/PCI 149
- Fahrenheit 64 2MB VLB/PCI 196
- Fahrenheit PRO 64 2MB VLB/PCI 299
- Fahrenheit PRO 64 4MB VLB/PCI 459

ATi

- Graphics Wonder VLB 1MB $154
- Graphics Xpression 2MB ISA 235
- Graphics Xpression 2MB VLB 235
- Graphics Xpression 2MB PCI 235
- Graphics Ultra Pro 2MB ISA 279
- Graphics Ultra Pro 2MB VLB 279
- Graphics Pro Turbo 2MB ISA 379
- Graphics Pro Turbo 2MB VLB 379
- Graphics Pro Turbo 2MB PCI 379
- Graphics Pro Turbo 4MB ISA 598
- Graphics Pro Turbo 4MB VLB 598
- Graphics Pro Turbo 4MB PCI 599

Matrox

- ULT2AH ULTIMA VLB 2MB 1600 X 1200 Capability $499
- IMP3AH Impres. AT 3MB 1600 X 1200 Capability 699
- IMP3V Impres. AT 3MB 1280 X 1024 Capability 739
- IMP3VH Impres. AT 3MB 1600 X 1024 Capability 799
- PCI/2 2MB 1280 X 1024 IMPRESSION 399
- PCI/2 IMP Plus 2MB 1600 X 1200 (upgradable) 429
- MGA VLB PLUS 2MB 1600 X 1200 459
- MATROX 2MB Upgrade Kit 209

Hercules

- Stingray VL 1MB VLB $109
- Stingray PCI 1MB PCI 109
- Graphite ISA 1MB HG210 195
- Dynamite Pro 2MB ISA 195
- Dynamite Pro 2MB VLB 195
- Dynamite Power 2MB VLB/PCI 209
- Graphite Power ISA 1MB PG310 229
- Graphite Power VLB 1MB PG510 229
- Graphite Power ISA 2MB PG420 335
- Graphite Power VLB 2MB PG720 335
- Graphite Power PCI 1MB/2MB 229/339

TRIDENT

- SVGA 1024 X 768 1MB ISA VGA card $39
- SVGA 1024 X 768 1MB VLB VGA card 39

BOCA

- Voyager 1MB VL-Bus 125
- Voyager 2MB VL Bus 195
- SVGAP1 PCI SuperX VGA 1MB 125

SVGA

- SVGA 256K $38
- SVGA 512K 1024 X 768 50
- SVGA 1024K 1024 X 768 70
- SVGA VESA local bus 80

#9GXE Number Nine Computer Corporation

128-Bit Level Graphics Engine #9GX28
- 9GXe LVL 10 1MB ISA/VLB $239/249
- 9GXe LVL 11 2MB ISA/VLB 349/349
- 9GXe LVL 12 3MB ISA/VLB 429/429
- 9GXe LVL 14 4MB ISA/VLB 679/679
- 9GXe 64 PCI 1MB/2MB 175/249
- 9GXe 64 VLB 1MB/2MB 175/249
- 9GXe 64 Pro PCI 355

128B Level Graphics Based on TI TMS 34020
- 9GXi Lite Level 20 1MB VRAM 539
- 9GXi Lite Level 21 ISA or VESA 2MB VRAM 699
- 9GXi Lite Level 23 ISA/MCA 1M VRAM/1MB DRAM 999
- 9GXi Lite Level 25 ISA/MCA 2M VRAM 1MB DRAM 1269
- 9GXi Lite Level 29 4MB VRAM 1MB DRAM 1389
- 15-Pin to 5BNC Monitor cable 39

GENOA

- 8500-16 Million Color VGA ISA $94
- 8500 Veloce VL-Bus Graphics I/O 139
- 8500-28 VL-Bus (1MB Expandable to 2MB) 97
- 8900VL Phantom 321 2MB 175
- 8900PCI Phantom 321 2MB 199

SCSI-IDE CABLES

HARD DRIVE EXTERNAL CABLES
- CENTRONICS 50 TO SCSI-II $50
- CENTRONICS 50 TO MAC 25-PIN 18
- CENTRONICS 50 TO CENTRONICS 23
- CENTRONICS 50 TO CENTRONICS 50 6FT 23
- CENTRONICS 50 TO CENTRONICS 50 3FT 20
- CENTRONICS TO DB-50 50
- DB-50 TO SCSI-II 50
- DB-50 TO DB-50 50
- SCSI-II TO SCSI-II 50
- FAST WIDE SCSI-II TO CENTRONICS 100

HARD DRIVE INTERNAL CABLES
- SCSI 50-PIN RIBBON 3 CONNS 2 DEVICE 11
- SCSI 50-PIN RIBBON 4 CONNS 3 DEVICE 15
- SCSI 50-PIN RIBBON 5 CONNS 4 DEVICE 18
- SCSI 50-PIN RIBBON 8 CONNS 7 DEVICE 28
- IDE 40-PIN RIBBON 3 CONNS 9
- FLOPPY & IDE CABLES SET 11

PROCESSOR UPGRADES

intel INTEL OVERDRIVE UPGRADES

- Intel OverDrive SX2/50 .... $179
- Intel OverDrive DX2/50 179
- Intel OverDrive DX2/66 244
- Intel OverDrive DX2/75 459
- Intel OverDrive DX24/100 549

Cyrix

- 386SX-16/20 systems, ... $239
- 386SX-25MHz 239
- 386DX-16 systems, use Cx486DRx2-33 249
- 386DX-20 systems, use Cx486Rx2-40 249
- 386DX-25 systems, use Cx486Rx2-50 269
- 386DX-33 systems, use Cx486Rx2-66 269

MULTIMEDIA

Creative Labs

- Omni CD $179
- Omni CD 3X SCSI 339
- Discovery CD 16 179
- Game Blaster CD 16 379
- Advanced Signal Proc Upgrade Kit 55
- Wave Blaster 175
- Voice Assist 55
- Sound Blaster Value $59
- Sound Blaster Pro Value 79
- Sound Blaster 16 Value 99
- Sound Blaster 16 MCD 139
- Sound Blaster MCD w/ASP 179
- Sound Blaster SCSI 179
- Sound Blaster SCSI w/ASP 199
- Sound Blaster AWE 32 279
- Sound Blaster Discovery CD16 239
- Sound Blaster Entertainment 298
- Digital School House CD 2X kit int 435
- Edutainment CD 16 kit int/ext 379/549
- Multimedia Office CD 2X kit int 546
- Omni CD 3X kit int 289

Media Vision

- Pro Movie Studio $179
- MV 0400 289
- MV 2000 319
- MV 3000 389
- MV 4000 499
- MV 5000 899

TURTLE BEACH SYSTEMS

- MAUI WAVE Table System Synthesizer $149
- TURTLE BEACH Crescendo 369
- MONTE CARLO 16 Bit Game Sound Card 99
- MONTEREY Multimedia Sound Card 369
- RIO Midi Synthesizer Module NEW 129
- CRESENDO Music Upgrade kit NEW 269
- TAHITI Digital Audio Recording Card 249
- WAVE for Windows Sound Editing Software 79
- TURTLE TOOLS for Multimedia 39

CD ROMS

NEC

- NEC 2Vi $179
- NEC 2V Deluxe 298
- NEC 3XP Plus/PlusKit 399/469
- NEC 4XI Plus/Plus Kit 399/469
- NEC 4XE Plus/Plus Kit 499/559
- NEC 4XE Pro 679

PLEXTOR

- 4 Plext 1MB Internal/External 405/515

PIONEER

- DRM604X 4 X 6 disc $959
- DRM1804X 4 X 18 disc 1879

TOSHIBA

- 3501 SCSI 4X Internal/External $295/395

CHINON

- CDS535 DS SCSI II Internal Drive Only $199
- CDS535 Double Speed SCSI II Internal 279
- CDX535 Double Speed SCSI II External 349

SONY

- CDU-55E 2X Internal $149
- CDU-55S SCSI 2X Internal 199

TEAC

- CD-55A Quad Speed Int/Ext $249/349
- CD-55S Quad Speed Int/Ext 279/379

DIAMOND Computer Systems, Inc.

- 4000 Quad CD kit internal $429
- 5000 Quad CD kit internal 514

MITSUMI

- CRMC-FX400 Quad Speed IDE $223

MODEMS

US Robotics

- Sportster 28.8/28.8 V.34 Int $239
- Sportster 28.8/28.8 V.34 Ext 259
- Sportster 28.8/28.8 V.Fast Ext 209
- Sportster 28.8/28.8 V.Fast Int 189
- Sportster 14.4/14.4 Ext 119
- Sportster 14.4/14.4 Int 99
- Worldport 14.4/14.4 Pocket 195
- Courier V.34 28.8/28.8 Ext 429
- Courier V.34 28.8/28.8 Int 399

Hayes

- Accura 14.4 int w/fax $95
- Accura 14.4 ext w/fax 111
- Accura 28.8 V.34 int w/fax 188
- Accura 28.8 V.34 ext w/fax 228
- Optima 14.4 ext w/fax 374
- Optima 14.4 pocket w/fax 296
- Optima 28.8 V.34 int w/fax 365
- Optima 28.8 V.34 ext w/fax 421

MOTOROLA

- Fastalk II 14.4/14.4 Int/Ext Faxmodem $119/139
- Cellect 14.4 Cellular Pocket Modem 299

Supra

- MBSUP141 14.4/14.4 Int $109
- MBSUP14LCE 14.4/14.4 Ext 129
- MBSUP5014 14.4/14.4 PCMCIA 235
- MBSUP734E 28.8 V.34 Int 209
- MBSUP734 28.8 V.34 Ext 239

PRACTICAL PERIPHERALS

- 14.4/14.4 Int. Proclass $139
- 14.4/14.4 Ext. Proclass 229
- 28.8/14.4 Int. Proclass 259
- 28.8/14.4 Ext. Proclass 349
- 14.4/14.4 Int. Series II 105
- 14.4/14.4 Ext. Series II 119
- 28.8/14.4 Int. Series II 219
- 28.8/14.4 Ext. Series II 245

Megahertz

- PCMCIA 2.0 Modem with XJACK™ retractable phone connector 14.4/14.4 bps Gold Series $239
- 9600/9600 bps 169

intel

- SatisFAXtion 200 Int $209
- SatisFAXtion 400 Sup Fx Pk 298
- SatisFAXtion 400 Ext 308

BOCA

- Online Express 14.4 Int/Ext $66/79
- V.34 28.8 Int/Ext w/fax 184/224

NETWORKING

Xircom

- PE3108C pkt Ethrnt coax 310
- PE3108Z pkt Ethrnt coax 267
- PE3108T pkt Ethrnt 10BT 268
- PT316CTP pkt Tkn Ring III 455
- PPX03 Parll port mltiplex 78

Novell

Netware V3.12
- 5 User 3.5" $616
- 10 User 3.5" 1397
- 25 User 3.5" 2064
- 50 User 3.5" 2786
- 100 User 3.5" 35

Personal Netware V1.0
- 1 User $60
- 5 User 259

Netware V4.02
- 5 User CD $794
- 10 User CD 1805
- 25 User CD 2646
- 50 User CD 3544
- 100 User CD 4938

IBM

- IBM Token Ring 16/4 ISA $309
- IBM Token Ring 16/4 MCA 489
- IBM Token Ring MAU 409

ASP

- Multiptcl print server 10BT HP MIO $247
- Multiptcl print server 10BT HP plt 287
- Multiptcl 2 printer server cmbo 309
- Multiptcl 4 printer server cmbo 499
- SNAP stz ld-2 compats 1 printer 119
- SNAP add-on transmitter 49
- Fax Acm Solo ntwk fax server 499

MONITORS

ViewSonic

14"	14EX	$289
15"	15G	389
15"	V15	389
15"	15EX	399
17"	17E	399
17"	17G	759
17"	V17	839
20"	20G	1399
20"	V20	1499
21"	V21	1679

SONY

15"	CPD-15SF1	$459
17"	GDM-17SF	899
17"	GDM-17SE1	999
20"	GDM-20SE1	1949

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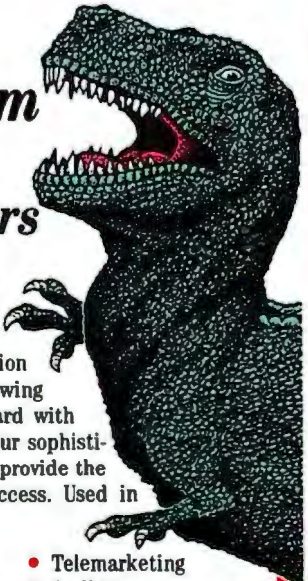

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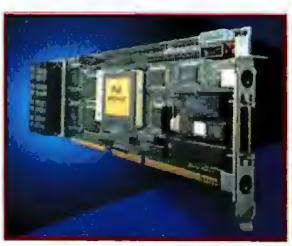

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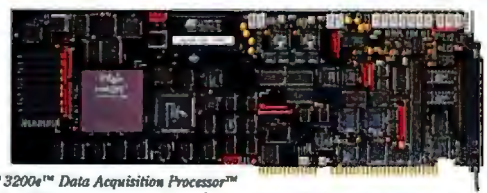

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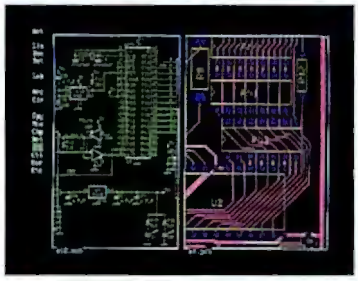

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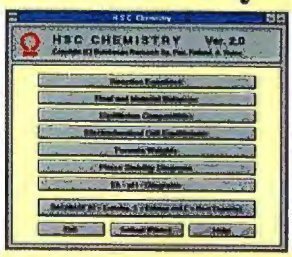

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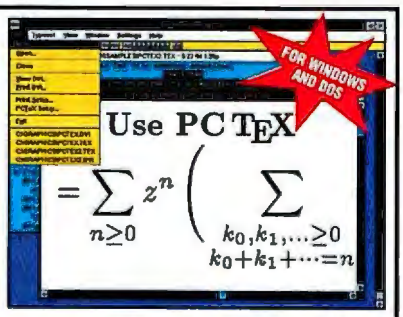

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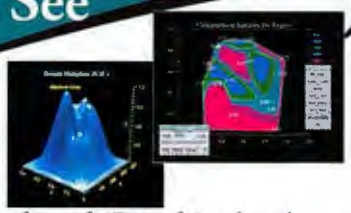

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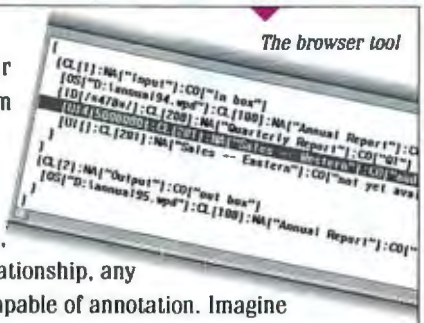
Windows



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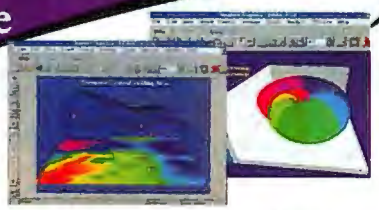

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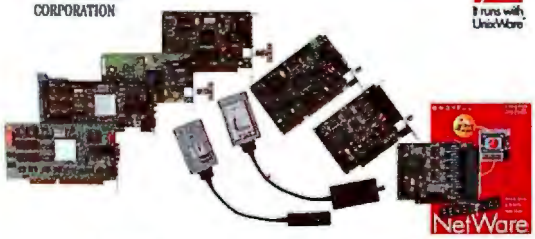

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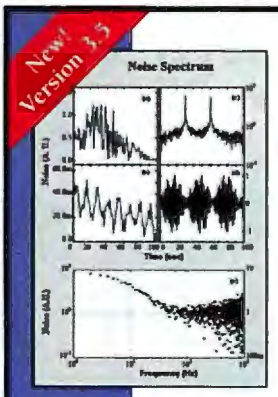

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Circle 286 on Inquiry Card.

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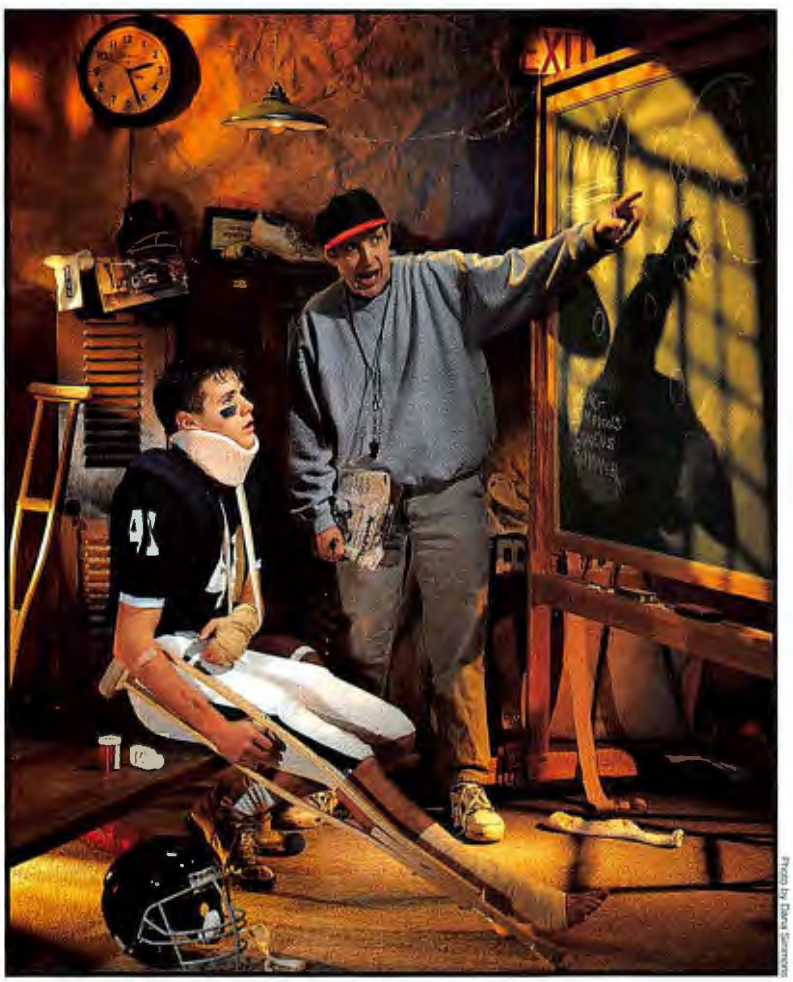

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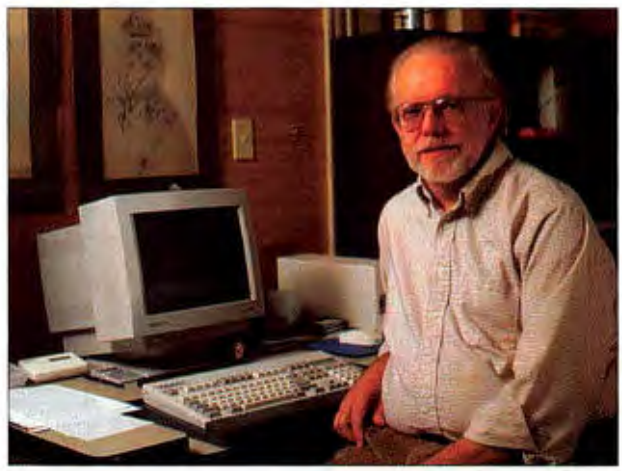

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Once upon a time, some of us slogging through the mud of the information cow path believed computer-based communications would build cohesive, coherent communities. We saw conferencing systems as the vehicle to bring people together in great democratic forums. In our fantasies, we saw the realization of what the early Greek philosophers had described and dreamed.

We saw democracy. It was a world where it didn't matter what sex or color or age you were, or if you could see or speak or walk or use your hands, or if you were short or tall or skinny or fat. It didn't matter where you were born or where you lived. We saw a world where all that mattered was what you could contribute to your society. People would be judged on what they made of themselves, not what they were born to or what was inflicted on them.

Boy, were we wrong!

Instead of leading people to a golden age, the Internet and other conferencing systems are simply reflecting the world at large. Instead of becoming a great gathering place for the democratic exchange of ideas, the Internet in particular is becoming a fragmented world riddled with enclaves of xenophobic, crabby egotists.

As far as I know, no one has actually been killed on the Internet yet. Most likely, however, this is because no one has been able to figure out how to send a zillion volts from point A to point B and fry somebody who posted an offending message.

A story made the rounds a few months ago concerning some political correctness at a university in California. A department assistant was told to set up message areas for students on a university computer. The students—of both sexes—requested private, gender-specific discussion areas in addition to a mixed area. Later, some of the students filed a complaint that discussions in one of the closed areas were offensive. The assistant who was running the system is now in deep trouble for doing exactly what his constituents demanded.

Old-line netnicks react to newcomers with aol.com at the end of their electronic addresses, with the Internet equivalent of Bosnia's ethnic cleansing. Say the wrong thing in a group—something as "provocative" as "I kind of like my Newton" in a DOS area—and you'll likely find yourself splattered with vitriol for days. Somali have extended their country's clan warfare from the East African deserts to the soc.culture.somalia newsgroup.

The thought police on campuses try to impose sanctions on Internet use that doesn't conform with their beliefs about the way things ought to be. They patrol the byways of the Internet looking for violations of their standards. One university administration shut down several newsgroups because they carried sexually explicit material that the administrators thought—but apparently never got a lawyer's opinion—would violate state obscenity statutes. Students screamed. The faculty senate screamed. The ACLU told the university it was wrong. The administrators backed off.

Lawyers Laurence Canter and Martha Siegel, who spammed (i.e., cross-posted the same message) the Internet with ads seeking aliens who wanted help getting green cards, learned the hard way about the fanatic antibusiness bias of many Internet dwellers. Spamming is thoughtless, but the Constitution doesn't say freedom of speech can't be practiced as widely as possible. Unfortunately, other users, even in generally polite environments, such as CompuServe, tend to respond to spammed messages by flaming. And the flames are seldom restrained. Of course, flames are just another expression of free speech. Churlish, but free, speech.

Of course, on-line systems have yielded some wonderful benefits—shut-ins gaining access to the world, citizens using BBSes in political campaigns, and college dropouts completing their degrees electronically. But these, just as the bad things, simply reflect the world at large.

So what's to be done? Can the data highway be a democracy, a welcoming community where people help each other?

Sure. So can the world.

How?

I don't know, but let's keep working on it. ■

George Bond publishes a newsletter for people who manage telecommuters. He's been messing about with computers since the 1950s. He was a cofounder and the executive editor of BIX. You can kvetch at him at his Internet address, gbond@mv.com.

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