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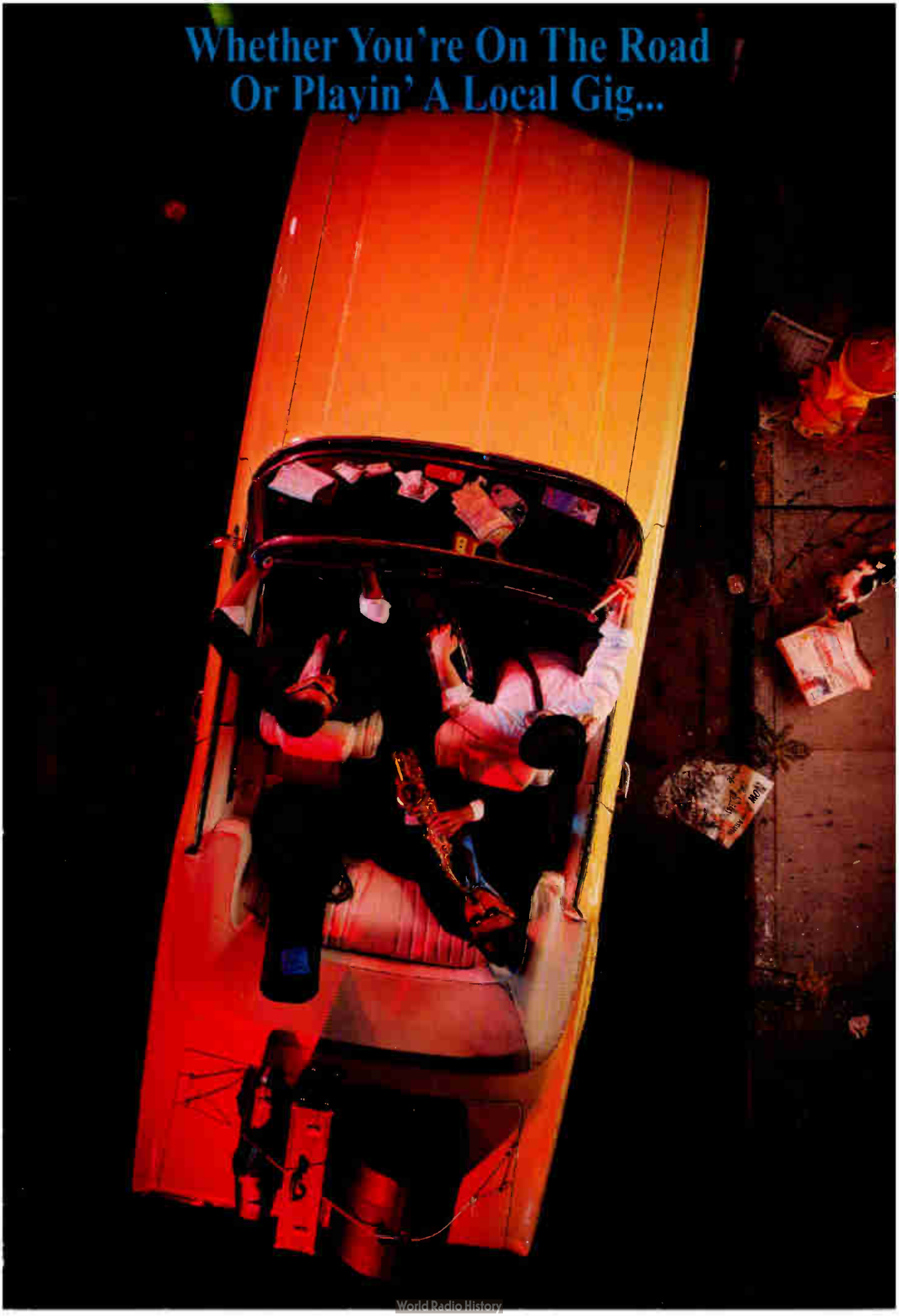

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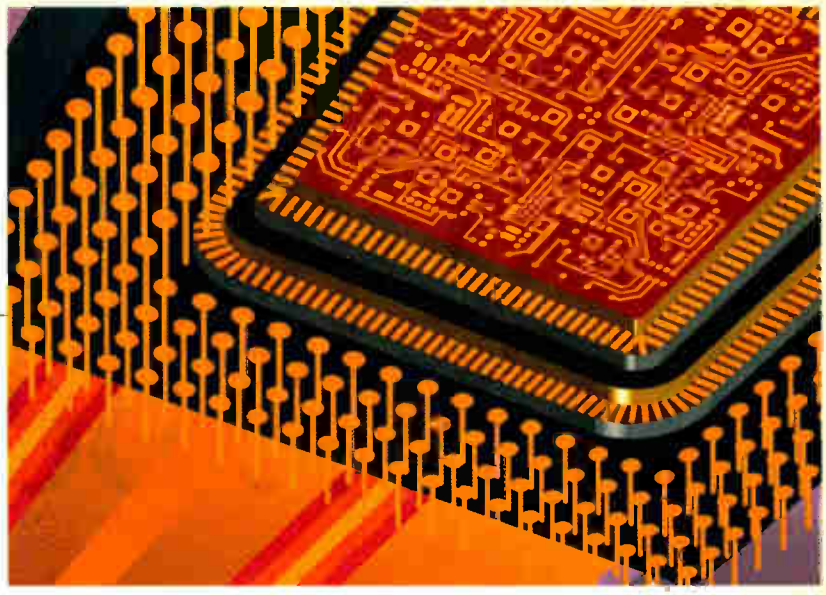

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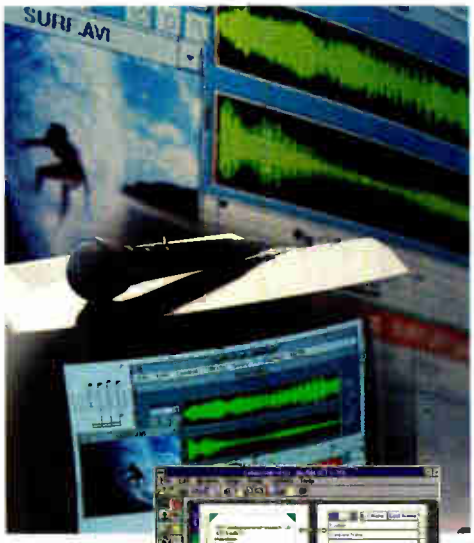

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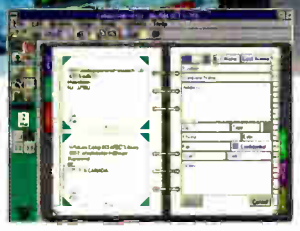

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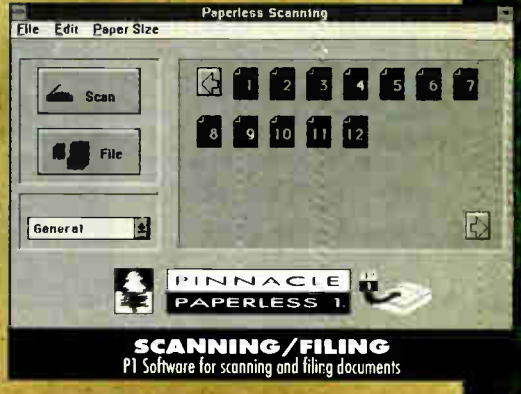

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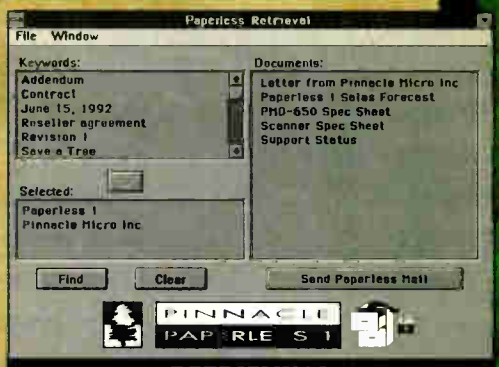

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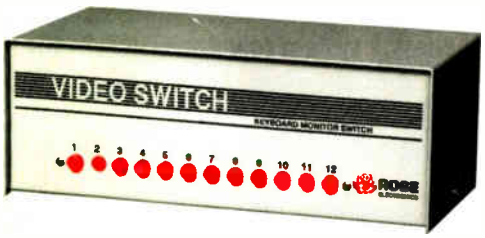

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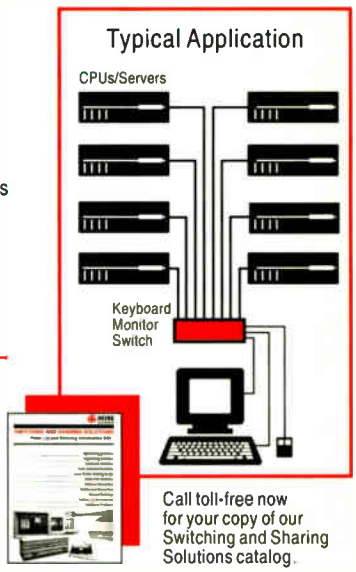

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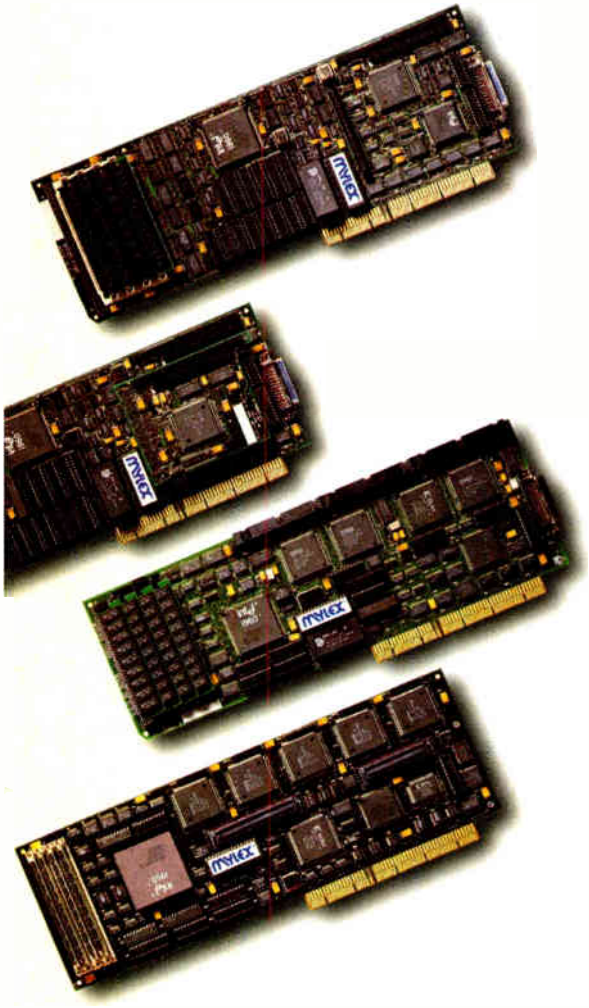

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RAID levels 0, 1, and 5 are supported, with hot swapping, on-the-fly reconstruction, background rebuild, hot standby, multi-threading, and scatter/gather features.

NetWare 3.11, SCO UNIX 3.2.4 and IBM OS/2 2.0 operating environments are supported. All controllers are offered with user-friendly software utilities.

- **DAC960-1/2:** Single fast and wide SCSI-II channel, which can be upgraded to two channels. Each channel has both 8-bit and 16-bit SCSI-II connectors.
- **DAC960-3:** Three fast SCSI-II channels, which can support up to 21 SCSI drives.
- **DAC960-5:** Five fast and wide SCSI-II channels, with the option to drive 8-bit or 16-bit fast SCSI drives.

NetWare, UNIX, OS/2
All Mylex disk array products support Novell NetWare 3.11, with optional support for SCO UNIX 3.2.4 and IBM OS/2 2.0.

Disk Array Subsystem

The disk array subsystem (DAS) features a DAC960 five-channel disk array controller and a flexible enclosure which houses up to five 5.25" or 3.5" SCSI drives. Each drive is powered by its own power supply for improved system reliability. Disk drives are offered as an option. Up to four of these enclosures can be powered by a single DAC960-5 controller, allowing up to 20 drives for each controller.

The DAS can be used in conjunction with any EISA-based computer to build a powerful file server. Up to four controllers can be configured into the system to offer virtually unlimited disk capacity.

Novell Labs Tested & Approved

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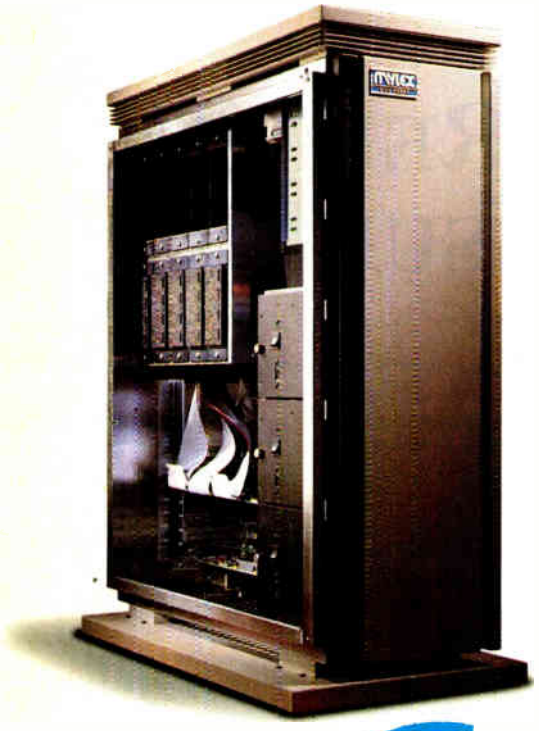
y of Disk Arrays.



Integrated Disk Array Server: IDAS2000

The Mylex IDAS2000 is a high-performance integrated disk array server, utilizing state-of-the-art disk array technology.

▶ **CPU Subsystem:** Intel 486™ DX2-66MHz EISA system with 256-Kbytes of cache, 8-Mbytes of system memory upgradable to 256-Mbytes, six bus master EISA slots, built-in I/O, flash BIOS and future CPU upgrades with the ZIF socket.

▶ **Disk Subsystem:** Features a one-channel disk array controller that is upgradable to two channels for increased performance. The controller utilizes the powerful Intel i960CA RISC processor and includes a standard cache of 4-Mbytes that's upgradable to 64-Mbytes. RAID levels 0, 1, and 5 are supported with fault tolerance, hot replacement, hot sparing and background rebuild capabilities. Both 8- and 16-bit fast and wide SCSI-II drives are supported. Software support for NetWare 3.11 (Novell certified). Optional support for SCO 3.2.4 and IBM OS/2 2.0 operating environments. Extensive user-friendly software utilities included.

▶ **Enclosure:** Includes three redundant power supplies, five cooling fans, 10 drive bays for 3.5" SCSI drives, and four additional drive bays for tape drives, floppy, etc.

The system includes an EISA LAN adapter and super VGA graphics. Disk drives are optional.

We've Benched the Competition

When Mylex conducted benchmark tests to compare our disk array system's performance to our competitors', we outperformed the competition's RAID 3 and 5 systems, as well as duplexed and spanned systems, by a wide margin.

Benchmarks: Disk Array Subsystems

	CIPRICO NetArray RAID 3	CORE IAS RAID 3	MICROPOLIS RAIDion RAID 5	ULTRASTOR U124 RAID 5	MYLEX DAC960 RAID 5
NCOPY all drives enabled	13:19	15:00	13:30	10:06	4:25
NCOPY one drive down	14:05	15:00	15:30	10:36	4:30
NCOPY during rebuild	26:32	–	20:49	18:30	10:17

▶ LAN Technology's performance tests for Ciprico, Core and Micropolis consisted of copying 2400 files—totaling about 80-Mbytes—from one directory to another using NetWare's NCOPY. The Mylex and UltraStor test configuration included a 486 DX2-50MHz CPU-based EISA system using five HP 97556-30 796-Mbyte drives. Times are shown in minutes.

Flexible Purchase Options

Controllers only, a complete system without disk drives, or a complete system with the drives are offered.

For more information on Mylex disk array systems and controllers, call 1-800-77-MYLEX or 1-510-796-6100. Or, fax us at 1-510-745-8016.

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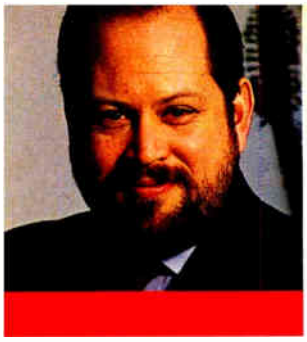

EDITORIAL

DENNIS ALLEN

OUR NEW LAB REPORT: YOUR NEW CONSULTANT

There's something new inside this issue of BYTE, and there has never been anything like it. Check out the Lab Report on printers, starting on page 146—it's the first of our regular monthly hardware reports. This new feature was months in the making, and it represents several worker-years of planning, testing, analysis, and good old-fashioned hard work by the folks at BYTE, the BYTE Lab, and the National Software Testing Labs.

Our report provides focused information you can use when buying or recommending products

For this month's report, we tested virtually every printer on the market—126 of them, to be exact—to provide you with information that you can use when buying or recommending a printer. Let me emphasize the word *information*. After 5600 tests, 28,000 pages of printed output, and thousands of data points, the BYTE and NSTL staffs separated the wheat from the chaff. Rather than turn BYTE into a catalog of product specifications, the two staffs created a report that acts as a highly paid consultant who helps you select the printer that fits your needs.

We've defined the criteria by which a printer should be measured for specific applications. The attributes of a good word processing printer, for example, are not the same as those of a good spreadsheet printer. In fact, we found that printers naturally fall into nine categories of applications, and we analyzed our test data to determine the best printer for each application.

We didn't stop there, though. It's one thing to choose the best overall printer for, say, word processing, but we knew that even in word processing people's needs varied. In these hard economic times, some folks are willing to sacrifice a little print quality or speed for a lower price—provided the printer still meets a certain threshold for word processing. Other folks may have an application in which only the highest quality output will do, regardless of the price. So, we made recommendations for those trade-offs and others—all based on our analysis of hard test data.

Each of our recommendations is built on exhaustive and objective test data. To accomplish the task, we weighted the relevant factors to accurately reflect each of the different application categories. In each case, we tell you up front which printer scored best—just check out the "BYTE Best" on page 147 and the report's easy-to-scan charts. And we tell you which printers came in a close second so that you can make comparisons.

To help us present all this information in the most coherent way, we enlisted the talents of two people. Richard Saul Wurman helped us distill all the data into information. A graphics designer, architect, and cartographer, he is the author of *Information Anxiety* (Doubleday, 1989) and *the* expert on delivering information.

The other person who helped us is Ken Silvia, one of the top magazine designers in North America. Silvia has an ability to present text and graphical information in a consistent style that lets you quickly find what you're looking for. Sounds easy, but it ain't. In fact, creating the design for our lab reports was a challenge greater than that of designing some magazines, and it was a challenge Silvia met with colossal success.

Why Did We Do It?

Like most of you, I've been a BYTE reader for many years, and for the last 10 years, I've been an editor with BYTE Publications. I know you expect BYTE to cover leading-edge products that incorporate new technologies—products like Pentium-based systems, expert systems, and 32-bit operating systems. For that, you want the in-depth technical articles for which BYTE is famous.

You have let me know that you would also like to read about certain staple products, too, such as 486 systems, modems, notebooks, and monitors. Most of these products meet certain standards, and the methods for comparing them are generally straightforward.

We think we've found a way to cover both leading-edge technology and staple products. Nearly all our pages are still devoted to the fine details of new technology developments and products, while 20 pages each month will contain our lab report on the more staple hardware products. We have invested heavily in our multimillion-dollar NSTL facility to bring these lab reports to you, and I hope you will find them useful.

As always, though, you have the final say. Let me know what you think of our new Lab Report series and how you think we could make it better.

—Dennis Allen
Editor in Chief

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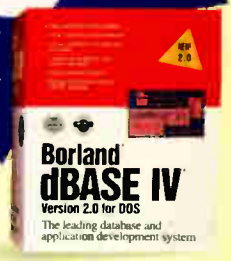

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Announcing the first network printer

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IBM LAN Server	**802.3*
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AppleTalk	**LocalTalk*
	**EtherTalk*
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*SunOS***	**Ethernet*
*Solaris***	**Ethernet*
SCO UNIX†	**Ethernet*

*Standard in the HP LaserJet 4Si MX printer. **For operating HP-UX, SunOS or Solaris, a one-time purchase of $199 in configuration software is required. Adobe and PostScript are trademarks of Adobe Systems Inc. which may be registered in certain jurisdictions. Microsoft is a U.S. registered trademark of Microsoft Corporation. UNIX is a registered trademark of UNIX System Laboratories Inc. in the U.S.A. and other countries. †In Canada call 1-800-387-3867, Ext. 7299.
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Multiple environments are no longer worlds apart. Even if you have Novell Netware on one network, HP-UX on another and EtherTalk on a third, the new HP LaserJet 4Si MX printer easily connects across platforms. Automatically.

The HP LaserJet 4Si MX printer comes out-of-the-box preconfigured for multiple environments. There's nothing more to do than plug-and-play. All interfaces are simultaneously hot, making switching so seamless, end-users won't even notice.

What's more, HP's LaserJet 4Si MX printer is ready to handle whatever needs come down the

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that adapts to multiple environments.

pike. More operating systems? No problem. As your network system continues to evolve, the capabilities of this printer are no longer just impressive. They're indispensable.

The HP LaserJet 4Si MX printer is loaded with features that define state-of-the-art. HP's enhanced PCL5 and genuine PostScript™ Level 2 software from Adobe™ come standard. Printer environments are saved while switching. Setup is a cinch with network software utilities and drivers included in the box. And, if you need any reassurance about trouble-free operation, you have it in our Simple Network Management Protocol (SNMP) support.

At 17 ppm, this is the fastest LaserJet ever, with I/Os and RISC-based formatter capabilities matched to support its speed. It delivers impeccable 600 dpi print quality—thanks to HP's microfine toner and Resolution Enhancement technology. Plus, it comes standard with two 500 sheet input trays.

But what if you don't need the full capabilities of the HP LaserJet 4Si MX printer right away? HP offers another printer that's probably a perfect fit. The HP LaserJet 4Si printer delivers the identical 17 ppm performance and superb 600 dpi print quality. It also has room to grow. The two MIO expansion slots let you add HP JetDirect network interface or third party cards. And you can add on Adobe's genuine PostScript Level 2 software and SIMM memory modules, as you need them.

To find out more about the multiple-network HP LaserJet 4Si MX printer and the upgradable HP LaserJet 4Si printer just call 1-800-LASERJET, Ext. 7299.† Capabilities this advanced make a world of difference—in any environment.

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THE KITCHEN SINK IS

If you're getting the feeling the T4500 series represents a new standard in business notebook computing, you're right.

Our T4500C features an LCD TFT active matrix color screen that can display a kaleidoscope of 256 simultaneous colors from a palette of 185,193. Our T4500 offers a large, bright, easy-to-read 9.5" VGA display with 640 x 480 resolution and 17:1 contrast ratio.

A 150-pin expansion port lets you attach a SCSI adapter to the notebook. Or lets you attach the notebook to our Desk Station IV, providing true desktop capabilities in your office.

System control hotkeys save time by allowing you to quickly change your display setting, power management, security status, etc., without having to call up menus.

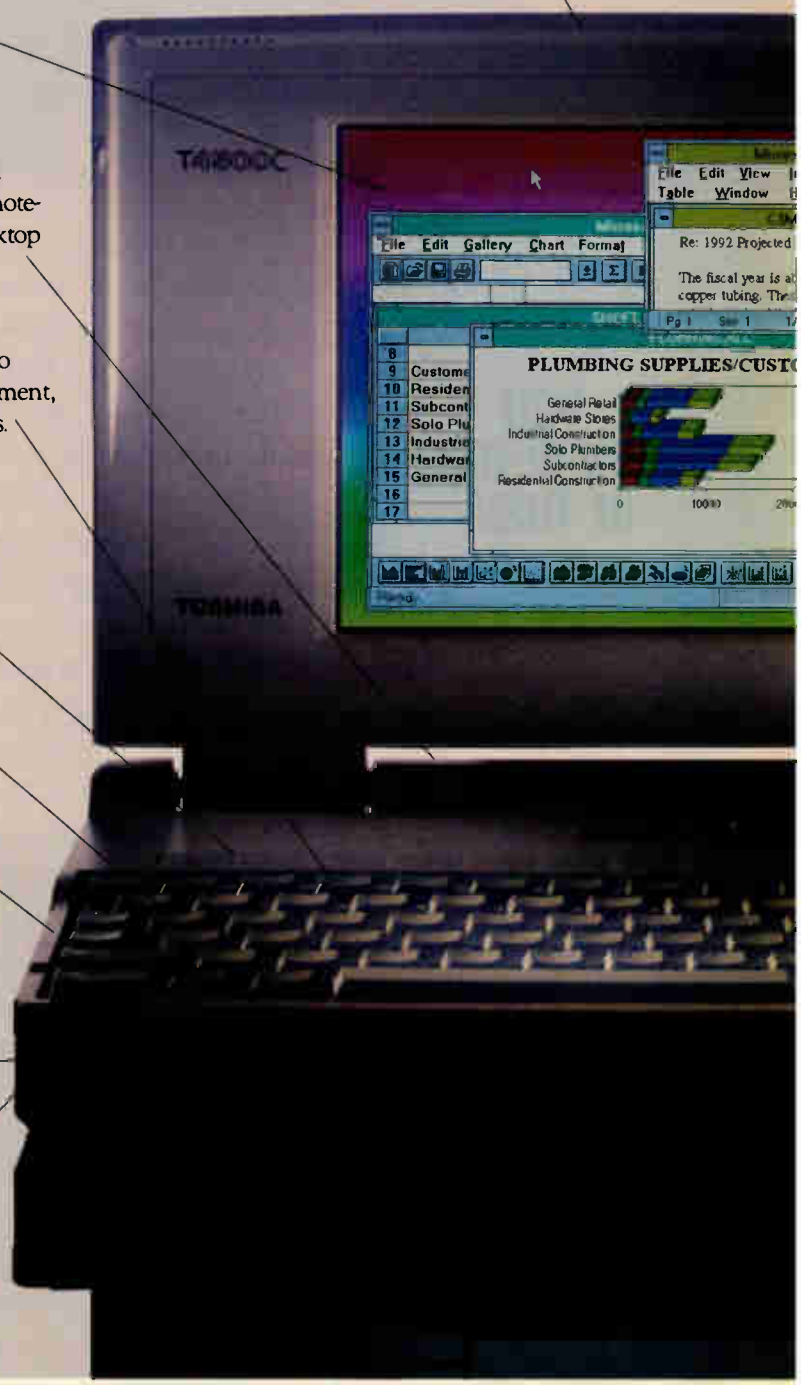
A generous 4MB RAM standard, expandable to 20MB.

Our award-winning keyboard features standard-sized keys and key spacing.

The T4500 series' advanced 20MHz i486™SX processor makes any 386 seem like a tortoise. In fact, tests reveal it's up to two and a half times faster than many 386-based notebooks.

The T4500C comes with a 120MB hard drive and our T4500 comes with a choice of an 80MB or 120MB hard drive.

3.3-volt chip technology decreases power drain by as much as 25%, while adding up to 27% more battery life.



INTRODUCING THE

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OPTIONAL.

The T4500C's dimensions: 11.7"W x 8.3"D x 2.0"H.
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Windows® 3.1 and DOS® 5.0 with Ultrafont™ come pre-installed.

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LETTERS

Gluttons for Punishment

STOP BIT

SOFTWARE GLUTTONY

Andy Nicholson's Stop Bit "Software Gluttony" (February) hits the nail right on the head. The trend toward GUIs and applications written for them has consumed the larger memories and hard drives of new machines at least as fast as the price of memory and storage has come down. The result is a lot of money spent for an upgrade and no more data storage space than before.

Certainly there are legitimate needs for at least some of the features of recent software packages, but rarely does one user need them all. It would help if companies supplied the information needed to do an ad hoc installation.

What would help more would be to require the programmers of some of this stuff to write for a year for the HP 41CX calculator. It has less than 2.5 KB of RAM for programs *and* data, and 4.2 KB of extended memory that can be used like a disk drive. My 41CX has outlived several desktop computers. I have a substantial library of programs for it, and you can bet your bottom dollar that each is optimized to conserve memory. Many programs weigh in at less than 100 bytes. No GUIs, of course, but then who really needs GUIs?

Bernard H. Geyer
Prescott, AZ

I couldn't agree more with Andy Nicholson. I believe the media is partly to blame for software gluttony. Consider GeoWorks. This program is manyfold superior to Windows, but the company's lack of marketing clout and indifference by the media combine to keep it confined to a niche. Unless the designation of good software includes code optimization, software packages will become behemoths that do everything but cartwheels.

Aslam Hassan
Urbana, IL

The New OS/2

Elation erupted as I read that Mark J. Minasi experienced the same condition of "cross-linked extended attributes" using OS/2 2.01 that I did ("A New OS/2," February). I now know that the error did not lie in my particular drive controller. As a simple end user and nonmember of IBM's Developer Assistance Program, I (and my authorized IBM dealer) never reached anyone at IBM who understood the above and other problems.

Thus, I have decided to delete OS/2 from my system. It was a dream to explore but a nightmare to use. OS/2 can return when it operates as promised. Minasi's essay verifies that it does not do so yet.

Michael E. May
Nashville, TN

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Lost in the Translation

The article "Overview: Machine Translation" (January) includes the sentence: "Translating the languages of the world on a desktop computer comes of age." From what I have seen, that age is still aeons away.

I speak five languages fluently and can read another six or seven with varying degrees of comprehension. I have beta-tested Micro-Tac's German and Spanish translators. Frankly, I have difficulty deciding where to put these programs. There's certainly a use for them, but the translations are poor at best. It would be far better to get a human translator to dictate the text to a stenographer or enter the text into a word processing file.

Translation programs miss the subtle points completely and wrongly translate many tenses and cases. The prepositions are mostly wrong, which makes understanding the "translated" text difficult. I do not know that anyone has yet figured out how the human brain translates one language into another, but it's certainly far more complicated than these translating programs' algorithms.

Paul A. Elias
Fountain Hills, AZ

SAS on CD-ROM

We appreciate Jon Udell's mention of SAS Institute in "Start the Presses" (February). However, we are not the developer of SPSS statistical software, as he states. We are the developer of the SAS System, an information-delivery system.

Udell also writes that we use "the Makedisc software from Young Minds and the Philips drive to build custom CD-ROMs for its Unix clientele." While we do distribute the SAS System on CD-ROM for our Unix customers, we use our own software, Kodak software, and a Kodak CD-Recordable drive to automate the process.

Hilary Yeo
SAS Institute
Cary, NC

User's Response

I enjoyed reading Jerry Pournelle's comments on Windows for Workgroups in "The Principle of Pursuit" (January). As a computer programmer and PC networking guru for a large company, I know the type of problems one can run into when setting up LAN software.

Pournelle deleted Windows from his system before installing Windows for Workgroups. That's fine if what you have is a plain-vanilla system, but if you are using high-end hardware like local-bus video, Windows may not start after installation. It's best to upgrade your existing version of Windows to Windows for Workgroups. That way, you preserve all your device drivers and program groups.

William J. Raymond
Gardner, MA

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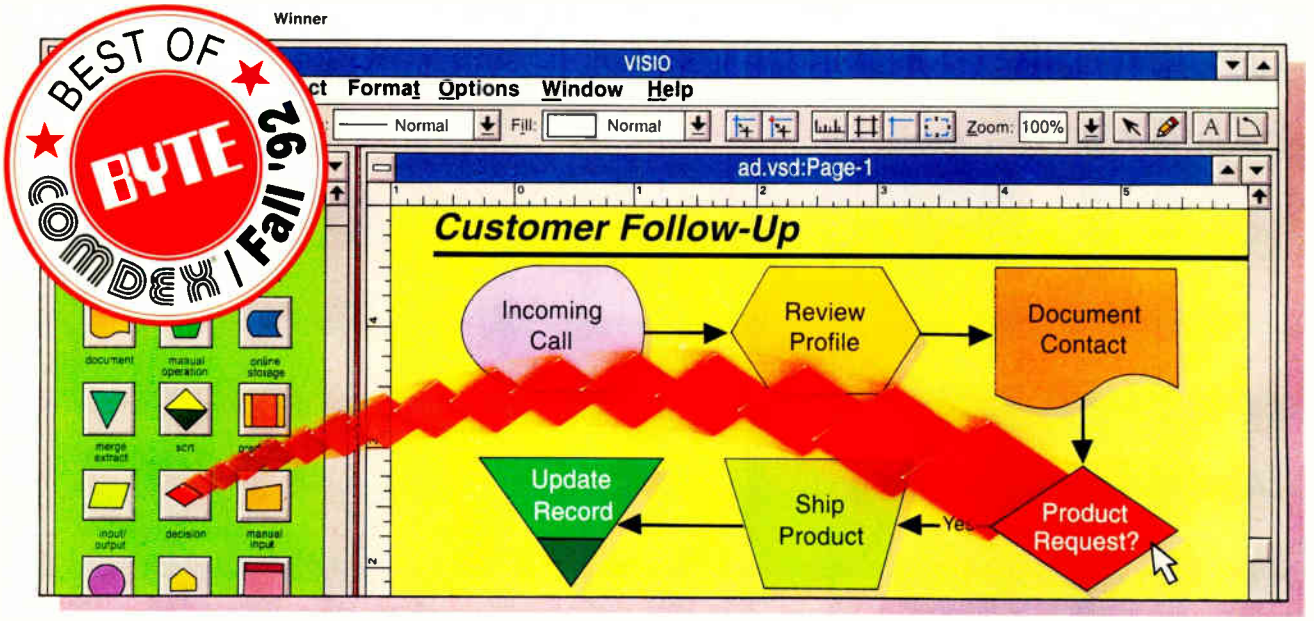

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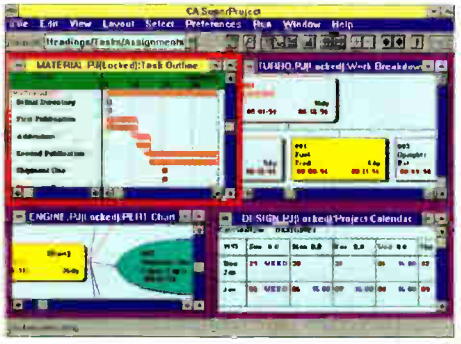

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NEWS

MICROBYTES

Novell Walks the Line Between NetWare and Unix

PROVO, Utah—Novell's acquisition of Unix System Laboratories gives the networking giant a powerful asset in the battle over 32-bit desktop and server operating systems. But bringing Unix into the fold presents Novell with a marketing dilemma: what to tell software developers who ask which platform they should write their applications for.

Microsoft's "Windows everywhere" strategy promises developers a consistent (although by no means identical) API for Windows, which will be available in versions for hand-helds and home appliances up to massive servers. On the other hand, Novell embraces many APIs. On the server side, Novell supports NetWare and Unix, and on the client side, it supports DOS, Windows, Windows NT, Unix, OS/2, and Mac OS. Novell's model presumes a world of heterogeneous computing. However, developers aiming to play in Novell's arena will need to master many more tools and environments.

These divergent visions reflect the underlying philosophies of the two firms. Novell is known for its ready partnering, while Microsoft tends to "roll its own" solutions, using its power and influence to turn proprietary products into de facto standards. With Unix in its quiver, Novell can now stake a claim as a key provider of open-systems solutions. The announcement in mid-March that USL, Hewlett-Packard, IBM, The Santa Cruz Operation, Sun Microsystems, and Univel will deliver in 1994 a common Unix software environment places Unix vendors in stark contrast to Microsoft's single-vendor model.

Since the arrival of NetWare 3.x, Novell has urged developers—with moderate success—to write NLMs (NetWare loadable modules) or applications for the 32-bit operating system. Now the company is changing its tune to accommodate Unix. Says Kanwal Rekhi, executive vice president of the interoperability systems group, "Unix is a very good general-purpose operating system, for an applications server or the desktop. NetWare is the glue that ties together all kinds of desktops and environments with a common set of services. I don't see them fighting for the same space."

Joel Applebaum, president of the Novell/USL Univel joint venture, concedes that each operating system offers different strengths. "Unix doesn't give you [NetWare's] interoperability between all the different clients," he says, but it "adds robustness and richness in options for applications developers."

Rekhi says that the developer's choice between NetWare and Unix will be determined by the needs of the application. "NetWare gives you performance, Unix gives you scalability," he says. "NetWare—access to many shops; Unix—to larger systems. It's a balancing act." Unix, he adds, "is a more traditional environment and people know it better," whereas if you write an NLM, "it's easy to go into a NetWare shop and plop in the application." Rekhi notes that some companies (e.g., Oracle) are hedging their bets by writing for both.

Novell is also working to integrate the environments so that networks of NetWare and Unix servers can easily communicate. In early March, for example, the company introduced the NetWare NFS Gateway, which lets users of NetWare client systems directly access files on a Unix server. Previously, Unix clients could access NetWare services, but NetWare clients had to load Novell's LAN WorkPlace on their systems.

In a clear jab at Windows NT, Novell officials assert that they don't believe a single operating system will solve all market needs. There's a political component as well. Says Drew Major, chief scientist at Novell, "Lots of people are championing us as an alternative; they don't want to have a complete lockout."

—Andy Reinhardt

NANOBYTES

A federal judge has denied Unix System Laboratories' request for a preliminary injunction to keep **Berkeley Software Design, Inc.** (Falls Church, VA), from distributing BSD/386, a Unix-compatible operating system for PCs that BSDI says is free of AT&T code. BSD/386 is based on the Networking 2 software developed at the University of California–Berkeley. □

"Wireless is not here today in the way that we want it to be," says **Marc Porat**, president and CEO of Mountain View, California–based General Magic. Regarding the current state of wireless communications, Porat says, "There's a market failure. It's a failure borne not of technology but borne of institutional and regulatory forces." □

Two top executives of Symantec (Cupertino, CA) have been **indicted** by a California grand jury on felony charges related to the alleged theft of trade secrets from Borland International (Scotts Valley, CA). Gordon Eubanks, Symantec's president and CEO, and Eugene Wang, an executive vice president, were indicted in March, six months after Wang left Borland to head Symantec's languages division. Eubanks's lawyer says the California trade-secrets law covers only technical information, not general business information. Legal experts predict a battle over the admission of Wang's E-mail as evidence, which some consider an invasion of privacy. □

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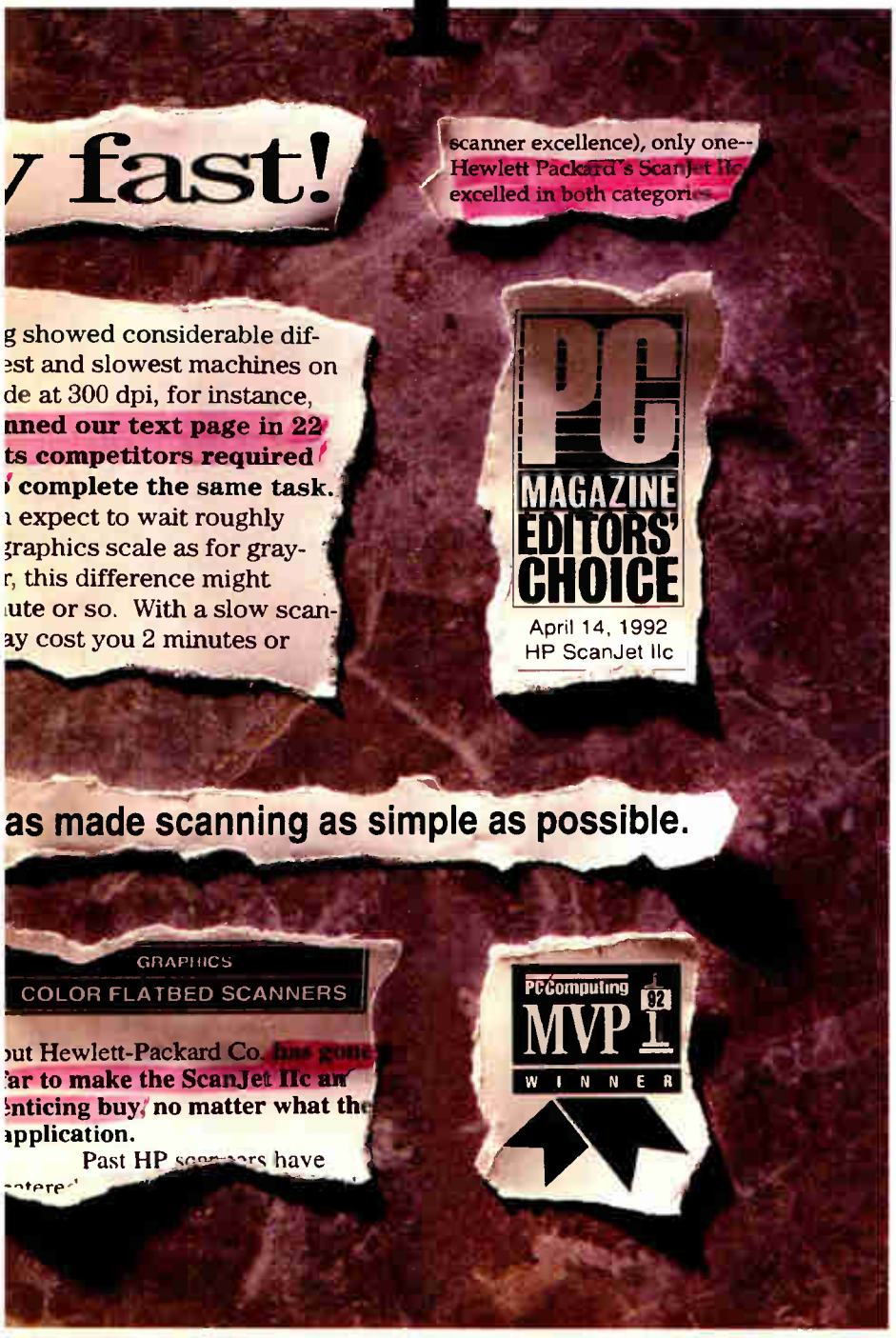

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NEWS

MICROBYTES

Researchers Build General-Purpose Optical Computer

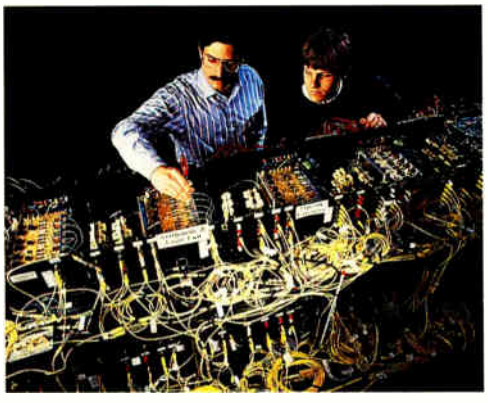
A University of Colorado (Boulder) research team has built what it believes is the first general-purpose optical computer that stores its machine instructions in optical memory. Rather than relying on program control by a second, electronic computer, the new optical computer stores its own instructions and processes data using light.

The proof-of-principle machine is not a marketable product, but according to a CU-Boulder researcher, its unique design could be applied to applications such as optical switching in telecommunications and eventually to optical computers that run hundreds of times faster than conventional computers. The current machine processes information serially (1 bit at a time). Plans call for the next generation of the machine (currently under development) to process data using planar arrays that can communicate their entire contents in one cycle. Such a machine could be applied to high-speed computer graphics.

The optical computer was developed under the direction of CU-Boulder electrical- and computer-engineering professors Harry Jordan and Vincent Heuring. Researchers are designing a palm-size version of the machine that could be used to route data over fiber-optic channels. "I would say that within a three- to five-year time frame, something using [a palm-size version of the machine] could be applied in the telecommunications switching area," Jordan notes.

Jordan says that one of the reasons the research team decided to use a serial design instead of a parallel design was the high cost of the 66 optical switches (about $3000 each) used in the machine. Jordan says, "We took the tack that said we'll give up the parallelism, not because we didn't think it was a good idea but in order to investigate the stored program aspect for optical computing."

—Dave Andrews



CU-Boulder research associate Robert Feuerstein (left) and graduate student John Feehrer adjust the logic unit of a proof-of-principle optical computer. Laser beams encode instructions and data into thousands of light pulses stored in roughly 3 miles of spooled glass fiber.

U.K. Court Protects Innovative U.K. Software

LONDON—A U.K. software house has won a copyright suit that revises the courts handling of look-and-feel issues and gives innovative software developers more confidence to defend their programs. John Richardson Computers, suppliers of software to the pharmaceutical industry, took issue with an ex-JRC programmer who developed a PC package similar to one he had written for the company. JRC did not claim that the programmer had copied source code or a substantial part of the structure and organization of its product. However, the suit did assert that the ex-programmer had used the "general scheme of the company's first... program, including some unusual routines."

To assess the look-and-feel overlap between the products, the presiding judge borrowed methods from U.S. cases, notably the *Computer Associates* v. *Altai* suit that was tried last June. JRC's lawyers cited the CA-Altai case as having "persuasive authority." The High Court of Justice, Chancellery Division, decision decreed that screen elements widespread throughout the industry should be ignored, as should features that represent the obvious or "only real way" of fulfilling a function. Remaining elements were then deemed copyrightable. With the implementation earlier this year of a European Community–wide computer copyright law, the JRC case may be cited in other European courts.

—Louise Cole

NANOBYTES

The Santa Cruz Operation's (Santa Cruz, CA) acquisition of leading GUI management provider **IXI** (Cambridge, U.K.) will give SCO direct access to future IXI technology and help establish IXI's X.desktop software as an industry standard. Apart from SCO's Open Desktop product, IXI's X.desktop comes installed on Unix systems from vendors such as DEC, IBM, and International Computers. Future joint SCO/IXI products will likely focus on areas like group management of networks and multimedia, office automation, and closer links with other computing environments. □

Leading Taiwanese PC supplier **Mitac** has established a manufacturing plant in Telford, U.K., to service increasing demand for its products in Europe. The company plans to complete the first phase of the plant this summer. Mitac says 200 new jobs will be created at the site over the next four years. According to Mitac, nearly half of its $300 million in annual revenues comes from sales of PCs and monitors in Europe, which may explain why the company planned to introduce a range of multimedia PCs and 66-MHz 486DX2-based PCs at the CeBIT computer show in Hannover, Germany. □

Electronic systems that automate the processing of credit-card payments and other merchant transactions are hampered in some regions of the world by inadequate telecommunications. **VeriFone** (Redwood City, CA, (415) 591-6500) has introduced Omnihost for banks in South America and Asian Pacific that want to establish transaction-automation systems. When the normal telecommunications link goes down, Omnihost will stand in temporarily so that service is not interrupted. This is an example of a company having to reengineer its products to sell them in other parts of the world. □

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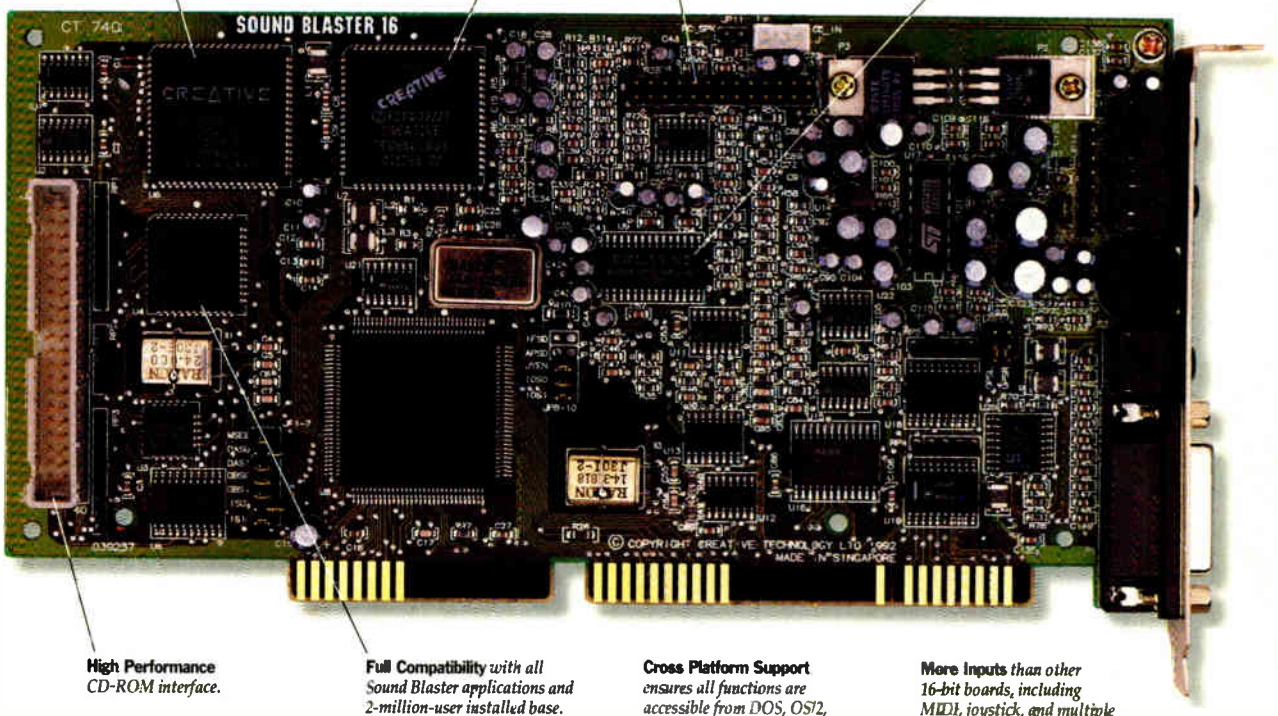

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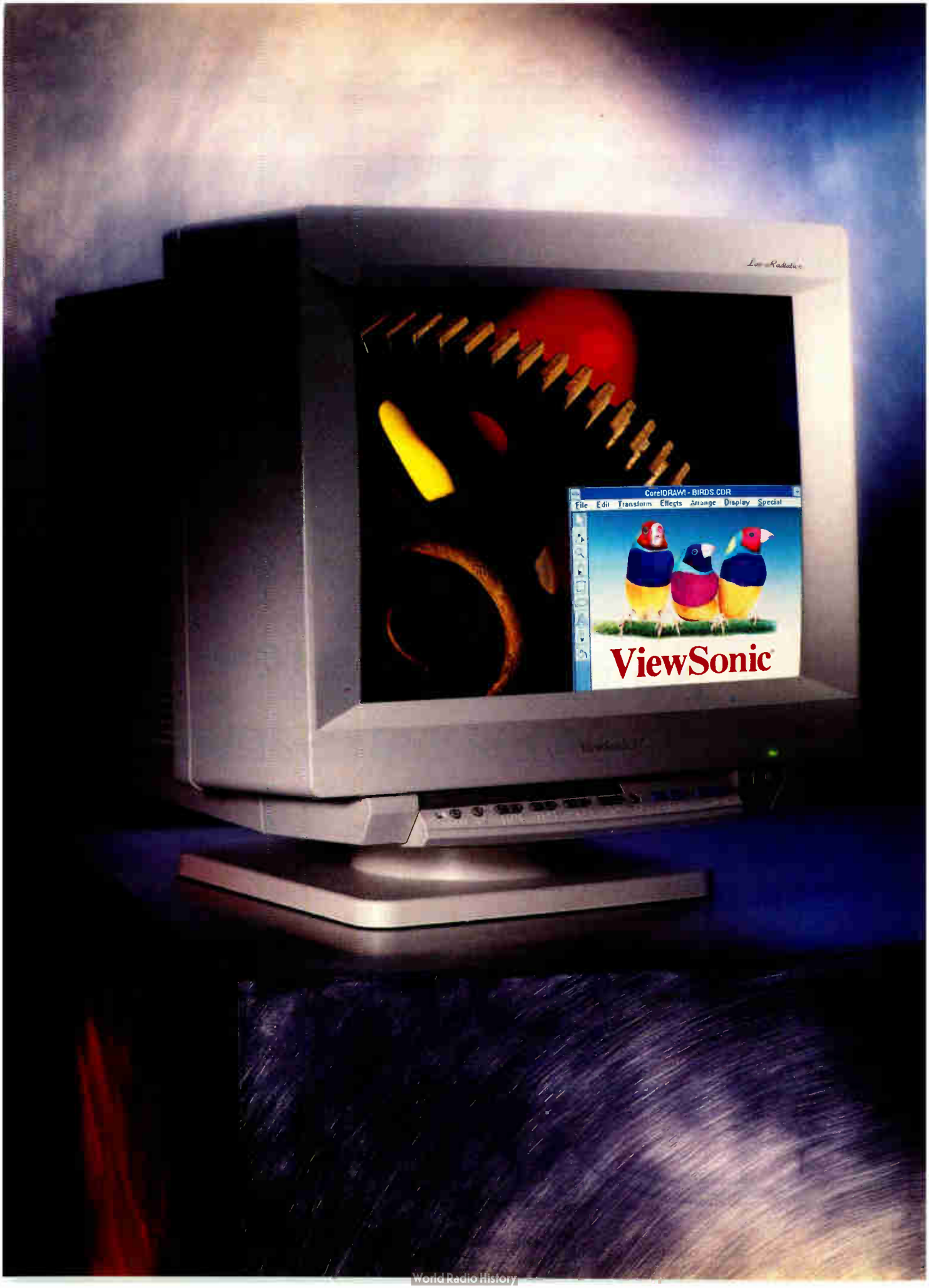

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Call **800-888-8583** for more information on our products, including our new line of 15" through 21" monitors.

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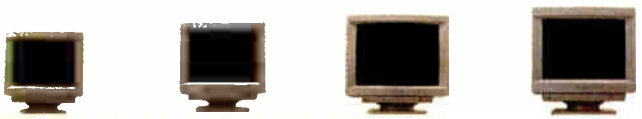

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Circle 147 on Inquiry Card (RESELLERS: 148).

World Radio History

NEWS

MICROBYTES

Mac Compatibles: Better Never than Late?

CUPERTINO, Calif.—After four years of intense engineering effort, NuTek USA is delivering samples of its Mac-compatible chip set, motherboard, and operating system to computer vendors. NuTek also announced the Duet, a multiprocessor system that natively runs Mac and MS-DOS software simultaneously. (For more information on Nutek, see "NuTek: A Mac Emulator in Progress," June 1992 BYTE, page 25, and "NuTek Claims True Mac Clone; No Mac ROMs Required," March 1991 BYTE, page 28.)

If vendors like what they see, Mac compatibles built from NuTek's $899 motherboard and off-the-shelf components could be in stores this summer. NuTek likens the performance of its 33-MHz, 68030-based motherboard to that of Apple's Mac IIvx, and it estimates the street price of a complete system to be about $1600—perhaps $500 to $1000 less than a comparable IIvx. NuTek's four-part chip set requires its own operating system and does not run Apple's System software. Along with a Mac-compatible motherboard, the Duet (about $2995) adds a 33-MHz, 486-based PC clone to a Mac-compatible motherboard.

NuTek claims its machines will run "almost all" of the most important Mac software. But currently, the machines won't run Adobe Photoshop or Microsoft Excel or Works. The Mac landscape has changed dramatically since NuTek first embarked on its ambitious project in 1989. Back then, Apple sold only a handful of Macs, prices were steep, and most of the best Mac software wasn't available for PCs. Today, you can choose from more than a dozen different Macs. Color Macs sell for under $1000. Major programs such as QuarkXPress and Photoshop are already migrating to Windows.

—Tom R. Halfhill

Gigabyte CDs Promise Feature-Length Video

LONDON—A British company surprised the multimedia industry during the Midem-93 show (Cannes, France) by demonstrating an otherwise ordinary-looking CD with over 1 GB of storage capacity. The double-density CD, developed by Nimbus Technology (Monmouth, Wales), can store 135 minutes of full-motion color video with stereo sound. A $150 adapter using a CL450 MPEG-1 decoder from C-Cube converts the digital data to PAL/NTSC signals for direct connection to a TV. Competing formats such as Philips's CD-I (Compact Disc Interactive) offer only 60 minutes of video.

Nimbus achieves the increased density by reducing the pit size, the track pitch, and the tracking speed. Until now, double-density CDs were thought to be impossible using today's infrared laser technology. By a happy accident, Nimbus discovered that the optics of some CD-ROM drives and high-end audio CD players can already discern the smaller pits. However, SCSI controllers for CD-ROM drives will need to be redesigned to handle the higher capacity of the new CD.

Nimbus will license its technology and says two Asian manufacturers will launch commercial audio CD players at the Consumer Electronics Show in Chicago this June. Integrated players without external adapters should hit the streets within a year.

—Osman Kent

Plug and Play for ISA

SEATTLE, Wash.—Microsoft and Intel have unveiled a "plug-and-play" mechanism that could take the hassle out of installing new devices in ISA-based PCs. The mechanism lets users add new devices to your system without worrying about jumpers, switches, and other technical esoterica that can prevent a system from working.

At the Windows Hardware Engineering Conference, Microsoft and Intel demonstrated a set of adapters that a Windows-based setup utility automatically identified and configured. For less than $5, vendors can add the hardware required for such operation to new adapter designs.

The goal of having users automatically configure a PC system is highly desirable but does not represent a breakthrough technology. Micro Channel architecture systems have provided this ability for over five years, and EISA systems have a similar mechanism for newer 32-bit adapters. Unfortunately, neither the EISA setup program nor this new initiative sufficiently addresses the problem that older ISA adapters will not automatically configure themselves. ■

—Matt Trask

NANOBYTES

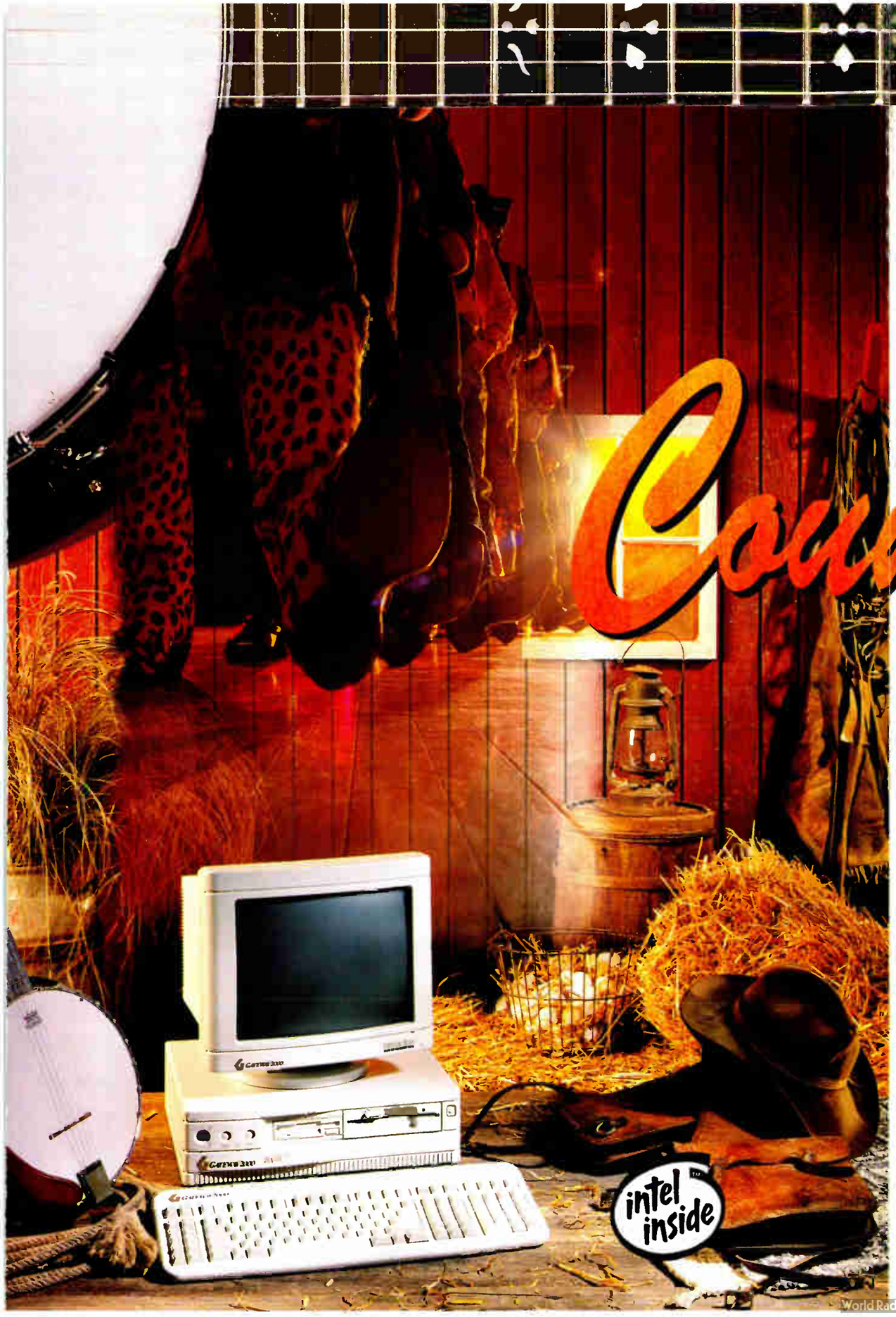
Microsoft is promoting the IEEE P1284 **Extended Capabilities Port** protocol as a way to speed up printing in Windows. This extension to the standard PC printer-port architecture adds support for bidirectional DMA-based operation at up to 2 MBps and permits faster printing and reduces the system CPU's workload during printing operations. At the Windows Hardware Engineering Conference in March, Microsoft said manufacturers that build computers that support ECP will allow multiprocessing operations to achieve greater throughput.

Companies supporting ECP include codeveloper Hewlett-Packard, Adaptec, AMD, Chips & Technologies, Intel, National Semiconductor, OPTi, Standard Microsystems, and Texas Instruments. Microsoft expects the first products supporting ECP to start appearing before the end of the year. □

It's back to the testing grounds for the entrants in the **U.S. HDTV standard** competition. A committee advising the FCC on the U.S. HDTV standard determined that none of the initial entrants was a clear winner. The four competing groups with digital systems asked the FCC for a chance to improve their designs. A new round of testing was scheduled to begin in April, with each new entrant requiring about a month of testing.

The FCC will not likely identify the winner until early 1994. As a result, national-broadcast HDTV service will likely be pushed from 1995 to 1996, according to William Hassinger, system bureau chief of engineering at the FCC's Mass Media bureau. Hassinger says that the four entrants—General Instrument; MIT; a partnership of Zenith Electronics and AT&T; and a consortium of NBC, Thomson Consumer Electronics, North American Philips, and the David Sarnoff Research Center—are discussing a possible merger of the competing systems into one system. ■

World Radio History



Country

If Gateway 2000 was a record, what would we sound like? Music to your ears!

Those Old-Time Country Values –
by The Low Overheads

Our album would kick off with some great Country tunes because, after all, we're the original country PC company with the low-overhead prices. We're located in the heartland of America where our factory is bordered by corn and bean fields. KSUX country radio, the Super Pig, is the number one station in these parts (no fooling). Gateway folks are mostly midwest born and raised, and it shows in our quality workmanship and in the friendly, down-home way we treat our customers. We'll bend over backwards to please you. When you buy from Gateway, you get the best price, quality and service. That's a value nobody can beat.

Gimme the Good Stuff –
by Hammer and the Boys

This song is dedicated to everybody who's tired of new technology becoming affordable only after it's upstaged by something better. At Gateway, we offer the latest, newfangled technology at homespun prices.

Baby, Let Me Baby You –
by The Support Group

Every Gateway 2000 system comes with excellent after-the-sale support. You get a **30-day money-back guarantee**. If you don't like your system, send it back within 30 days for a refund. All systems come with a **one-year limited warranty** and telephone **technical support** for the life of the system from our award-winning tech department. We received *PC World's* World Class Award in 1992 for best service and support in the hardware category. And in a February 1993 survey, *PC Magazine* readers once again gave Gateway an excellent rating for service and reliability. You also get **an automated fax service** to supply you with detailed documentation on over 150 technical subjects, and a **lifetime BBS membership** for additional technical support and online forums.

We offer **on-site service** to most locations in the country (factory service only for notebooks). **Replacement parts** leave our factory as quickly as possible; we pay overnight shipping. Plus we now have **interactive documentation** on 486 desktop systems with pictures and text right on your hard drive (in addition to comprehensive hardware and software manuals).

We make it easy for you to buy a Gateway PC, too, with convenient payment options including major credit cards and C.O.D. terms. Net 30-day terms and leasing options are also available to qualified commercial customers. All this *and* your great-looking Gateway PC comes in our distinctive, country cow-spotted box!

To serve you better, we've hired and trained over 600 new people for customer service, technical support, sales and manufacturing in the past six months, bringing our total number of employees to over 2,000.

◀ *Gateway's 4SX-33 makes a mighty-fine Windows machine!*

World Radio History

Gateway Just Went Platinum. . .

Because We're Playing Your Song!

If Gateway 2000 was a record, we'd be receiving a platinum award – thanks to all of our wonderful customers. Our one-millionth computer system was shipped in April from our factory in North Sioux City, South Dakota. A million is a number that's hard to fathom. At least it is for us.

We send our deepest appreciation to each and every Gateway customer. Thank you for believing in us. We've tried hard to always offer you the best value in the personal computer industry. We've succeeded in meeting this goal, although we're the first to admit that demand for the value we offer has sometimes overwhelmed us. We thank you for the understanding and patience you've shown during our growth spurts.

We also want to thank our remarkable vendors – the companies that supply us with the highest-quality, most technically-advanced components, software and peripherals, and those that provide support services. Gateway 2000 has been a most demanding customer, and they deserve a lot of credit for our success.

Now our goal is to make the next million even better, one computer and one customer at a time!

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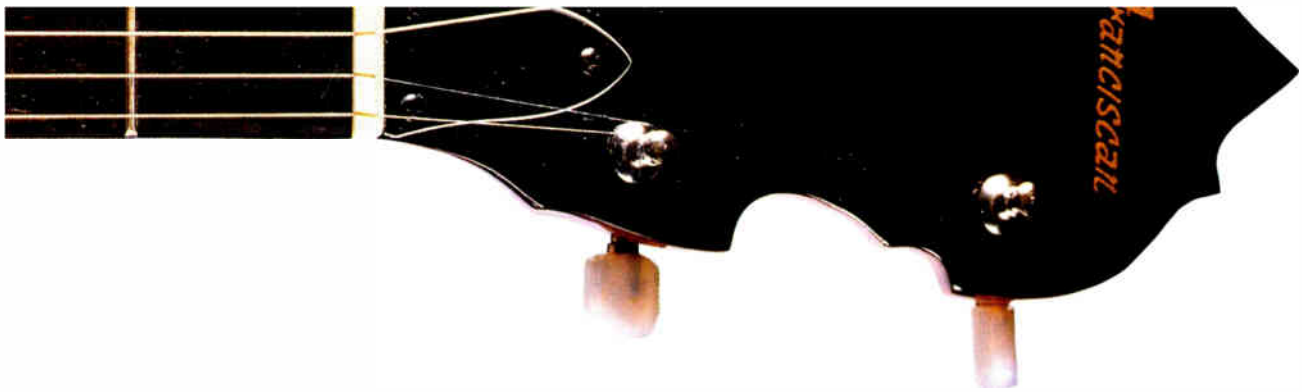

Our award-winning 4DX2-66V system now includes a CD-ROM drive and a 3.5-inch diskette drive as standard features.

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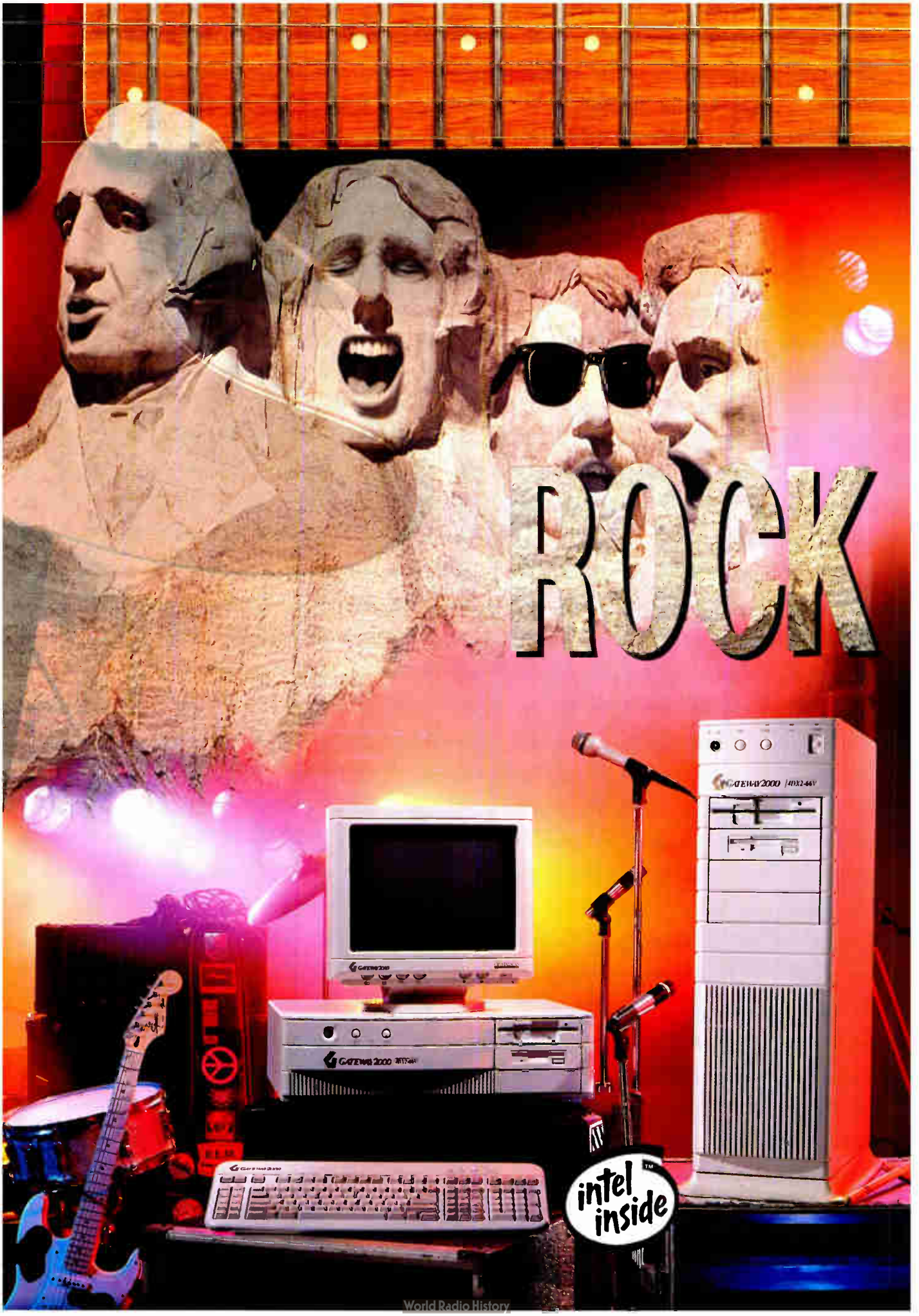

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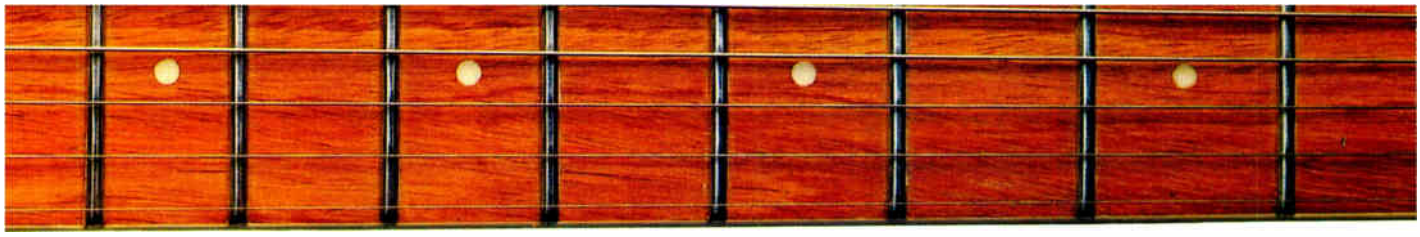

We Got the Goods – *by The Systematics*

Gateway's album would continue with some heart-pounding rock 'n roll cuts because our systems are definitely pure rock. They're cool-looking, hot-performing, high-energy machines – at some sweet prices. There's a model that's perfect for you.

Megahertz So Good – *by Pup and the Cells*

Gateway's mini-desktop systems – 3SX-33, 4SX-33 and 4DX-33 – are petite but plenty powerful, based on an integrated design that incorporates many subsystems on the motherboard for the best price-performance ratio. All mini desktop systems include: 4 to 8MB RAM; a large and fast hard drive, operating on the local bus in 486 models for even faster drive performance; a fast video chipset with 1MB; a brilliant, crisp display from the standard 14-inch CrystalScan non-interlaced color monitor; and more available expansion slots than you find in most small-footprint PCs. The combination of these features makes a cool Windows machine for an unbeatable price.

So You Wanta Fly? – *by The Screamin' Vs*

Power users, pick up the phone and order a Gateway 2000 VESA® local bus 486 machine right now. You'll never regret it. With our 4DX2-50V or 4DX2-66V models, you get screaming PC performance. We put ATI's Graphics Ultra Pro video card with 1MB VRAM on our VESA local bus for results that are simply awesome! Plus these systems have a hefty 8MB RAM with cache, and hard-rockin' hard drives running on the local bus. An extra VESA local bus expansion slot as well. You get a 15-inch flat, square CrystalScan color monitor and more choices of cool application software than you'll find anywhere else. Our award-winning 4DX2-66V now includes a CD-ROM drive, too!

We custom-build each Gateway 2000 computer to your order. We'll gladly provide you with a quote on a special configuration. Call our sales department!

Big Bandwidth Boogie – *by The Gates*

If you're looking for the 32-bit power of an EISA system, we offer three models – 4DX-33E, 4DX2-50E and 4DX2-66E. All models include: 8MB RAM with 256K cache; a very large, very fast SCSI hard drive; 32-bit EISA SCSI controller; and a standard tower case. Please call for details and prices on models not listed on our price page.

Workin' Up Some New Riffs – *by The Harmonics*

This one's our theme song. At Gateway, we're always looking for ways to make your PC easier and more fun to use. For example, we now install a Mach 32 video driver icon in your Windows control panel so you can change your video resolution quickly and easily.

All Gateway systems go through extensive compatibility testing to ensure flawless performance with all products from major software developers and peripherals manufacturers.

◀ *According to PC World, "(Gateway 2000's 4DX2-66V is) by far the fastest machine we've ever tested!"*

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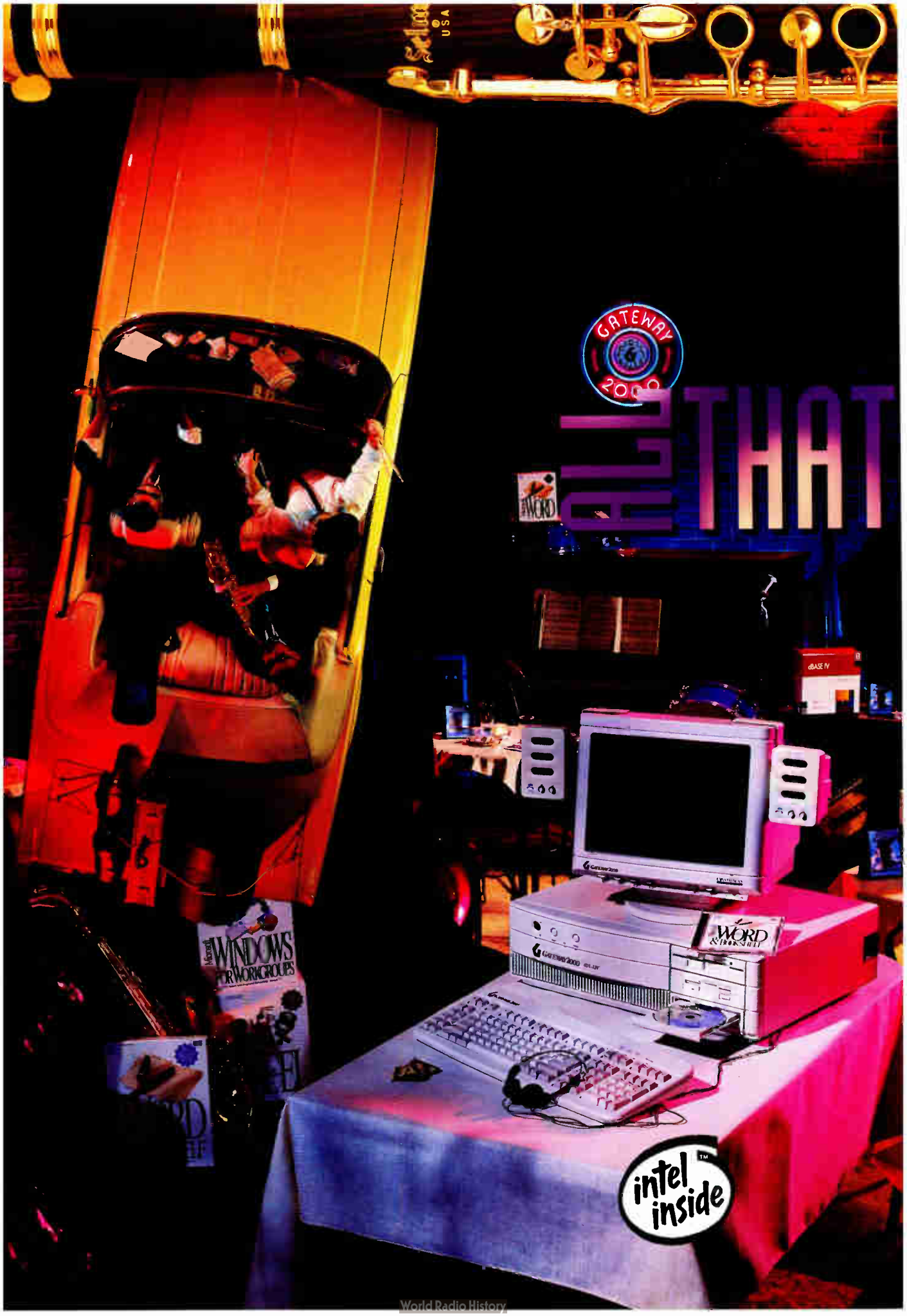

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Windows to the Other Side – *by Tommy Gee*

Gateway's album would also include jazz favorites because we offer a complete line of software and peripherals to make your system extra cool.

Software Improv – *by Good Vibes*

All Gateway systems come with some very hip software, all pre-installed and ready to run the moment your PC arrives. With mini desktop, desktop and tower systems that include "choice of application software," you get to pick one of the following applications, all latest versions:

- Microsoft® Excel for Windows™
- Microsoft Word for Windows™
- Microsoft Word and Bookshelf 92® CD
- Microsoft PowerPoint for Windows™
- Microsoft Project for Windows™
- The MS Entrepreneur Pack (Works,™ Publisher,™ Money,™ and games)
- Borland Paradox® for Windows™
- The Windows Programmer Pack (MS Quick C,™ Visual Basic and more)
- Upgrade to Microsoft Office™ for $175 (CD-ROM Edition also available)

◀ *Gateway's 4DX-33V is shown here with Windows Sound System components, the CD-ROM kit and optional speakers. Call for details on this system.*

New Sensations – *by The Cool Tools*

New this month is the introduction of Microsoft MS-DOS® 6 plus Enhanced Tools, standard on all Gateway systems. Microsoft says it's "the best version of MS-DOS yet." MS-DOS 6 includes features that can increase hard drive capacity, protect your data, free up memory – and much more.

Moovin' Up – *by The Upgrade Express*

For a limited time, Gateway customers can upgrade to MS-DOS 6 for only $48, plus $5 shipping and handling. You get a complete set of disks and a manual for this special price. To order, call our express upgrade number – 800-846-2037 – or fax us your order at 800-846-2038. We need your customer ID, credit card information, and your choice of 3.5-inch or 5.25-inch disks to place your order. Special price offer ends May 31, 1993.

Connectivity – *by The Local Area Group*

TelePath™ Fax/Modem. A 14,400bps modem, V.32bis, with 9,600bps fax capability. Includes WinFax Pro, Crosstalk for Windows, Qmodem. $195

Network Cards. Call for a selection of Ethernet cards and Token Ring adapters, installed and configured.

Microsoft Windows™ for Workgroups. Networking made easy! Price includes an Ethernet adapter and software. Hardware and software factory-installed. $159

WOW – *by Talking Pictures in Motion*

CD-ROM Kit. Includes CD-ROM, interface card and everything you need to add MPC-compliant CD-ROM to your PC. $225

Microsoft Windows Sound System.™ Package includes sound board, microphone, headset and software. $149

Multimedia Accessories. Call for details on other multimedia hardware and software.

The software and peripherals listed here are sold only with the purchase of a system. For details on our complete line of extras for Gateway customers, call direct to our special add-on components division: ***800-846-2080.***

We offer many other system options and upgrades, including 17" and 20" monitors, tape backup units, Texas Instruments laser printers, Panasonic dot-matrix printers, bigger hard drives, other software and more. Call today!

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- 33MHz 386SX Intel® Processor
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- 80MB 17ms IDE Hard Drive
- Windows Accelerated Video w/ 1MB DRAM
- 14" Color CrystalScan™ 1024NI
- Mini Desktop Case
- 5 16-Bit ISA Slots
- 124-Key AnyKey® Keyboard
- MS-DOS® 6, Diags, Windows™ & Mouse
- MS Works for Windows™ 2.0

$1295

4SX-33

- 33MHz 486SX Intel Processor
- 4MB RAM
- 5.25" & 3.5" Diskette Drives
- 170MB 13ms IDE Hard Drive
- Local Bus IDE Interface
- Intel OverDrive Socket
- Windows Accelerated Video w/ 1MB DRAM
- 14" Color CrystalScan 1024NI
- Mini Desktop Case
- 5 16-Bit ISA Slots
- 124-Key AnyKey Keyboard
- MS-DOS 6, Diags, Windows & Mouse
- MS Works for Windows 2.0

$1495

4DX-33

- 33MHz 486DX Intel Processor
- 8MB RAM, 64K Cache
- 5.25" & 3.5" Diskette Drives
- 250MB 13ms IDE Hard Drive
- Local Bus IDE Interface
- Intel OverDrive Socket
- Windows Accelerated Video w/ 1MB DRAM
- 14" Color CrystalScan 1024NI
- Mini Desktop Case
- 5 16-Bit ISA Slots
- 124-Key AnyKey Keyboard
- MS-DOS 6, Diags, Windows & Mouse
- MS Works for Windows 2.0

$1995

4SX-33V

- 33MHz 486SX Intel Processor
- 8MB RAM, 64K Cache
- 5.25" & 3.5" Diskette Drives
- 250MB 13ms IDE Hard Drive
- Local Bus IDE Interface
- Intel OverDrive Socket
- ATI Ultra Pro Video w/ 1MB VRAM on VL-Bus™
- 15" Color CrystalScan 1572FS
- Desktop Case (Tower Upgrade)
- 8 16-Bit ISA Slots, 2 on VL-Bus
- 124-Key AnyKey Keyboard
- MS-DOS 6, Diags, Windows & Mouse
- Choice of Application Software

$2195

4DX2-50V

- 50MHz 486DX2 Intel Processor
- 8MB RAM, 64K Cache
- 5.25" & 3.5" Diskette Drives
- 250MB 13ms IDE Hard Drive
- Local Bus IDE Interface
- Intel OverDrive Socket
- ATI Ultra Pro Video w/ 1MB VRAM on VL-Bus™
- 15" Color CrystalScan 1572FS
- Desktop Case (Tower Upgrade)
- 8 16-Bit ISA Slots, 2 on VL-Bus
- 124-Key AnyKey Keyboard
- MS-DOS 6, Diags, Windows & Mouse
- Choice of Application Software

$2495

4DX2-66V

- 66MHz 486DX2 Intel Processor
- 8MB RAM, 256K Cache
- 3.5" Diskette Drive **AND CD-ROM Drive** ◀
- 340MB 13ms IDE Hard Drive
- Local Bus IDE Interface
- Intel OverDrive Socket
- ATI Ultra Pro Video w/ 1MB VRAM on VL-Bus™
- 15" Color CrystalScan 1572FS
- Desktop Case (Tower Upgrade)
- 8 16-Bit ISA Slots, 2 on VL-Bus
- 124-Key AnyKey Keyboard
- MS-DOS 6, Diags, Windows & Mouse
- Choice of Application Software

$2995

4DX2-66E

- 66MHz 486DX2 Intel Processor
- 8MB RAM, 256K Cache
- 5.25" & 3.5" Diskette Drives
- 500MB 11ms SCSI Hard Drive
- 32-Bit EISA SCSI Controller
- Intel OverDrive Socket
- Windows Accelerated Video w/ 1MB DRAM
- 14" Color CrystalScan 1024NI
- Tower Case
- 8 32-Bit EISA Slots
- 124-Key AnyKey Keyboard
- MS-DOS 6, Diags, Windows & Mouse
- Choice of Application Software

$3495

Software Options

With systems that include "choice of application software," pick one from this selection:

- Microsoft Excel for Windows
- Microsoft Word for Windows
- Microsoft Word and Bookshelf 92 CD
- Microsoft PowerPoint for Windows
- Microsoft Project for Windows
- The MS Entrepreneur Pack (Works, Publisher, Money and games)
- Borland Paradox for Windows
- The Windows Programmer Pack (MS Quick C, Visual Basic and more)

You can also upgrade from MS Works to a choice of software for $100, or upgrade from these choices to MS Office for $175.

Service

Every Gateway 2000 system is backed by:

- 30-Day Money-Back Guarantee
- One-Year Limited Warranty
- Lifetime Toll-Free Technical Support
- On-Site Service Available to Most Locations
- Lifetime BBS Membership
- Automated Fax Service

All hard drive sizes are manufacturer's specified capacities. Microsoft MS-DOS 6 can increase hard drive capacity through software compression.

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intel inside

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World Radio History

AutoCAD Draws on Windows

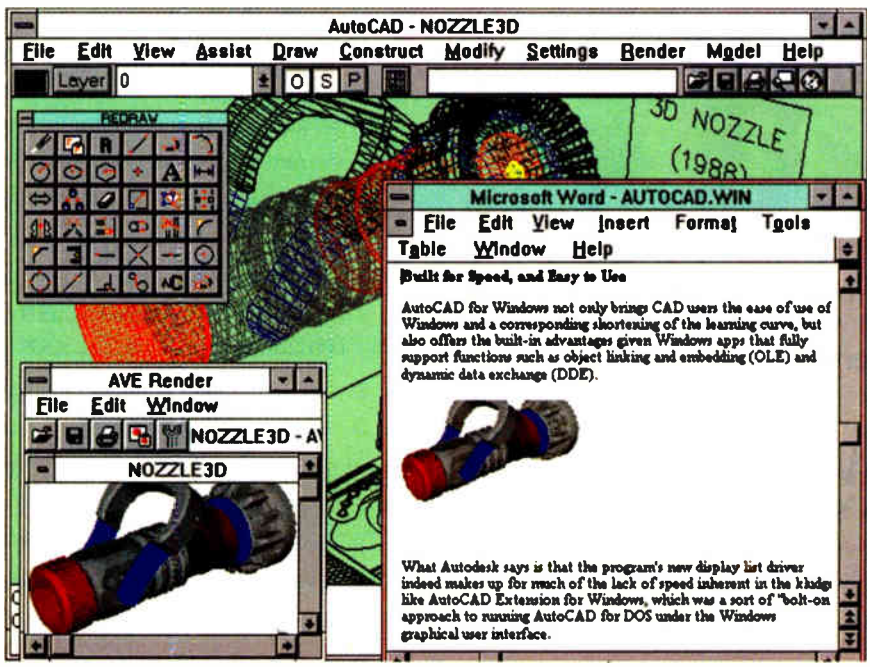
PATRICK WAURZYNIAK

AutoCAD release 12 gets full Windows treatment and adds speed enhancement

AutoCAD release 12 for DOS was the first version of this venerable software to have GUI-like capabilities. When Autodesk released it last year, developers and users alike were excited by its possibilities. Up until that time, engineers and designers first had to master a fairly steep learning curve on the software, although an Autodesk add-on product called AutoCAD Extension for Windows gave users some semblance of ease of use.

An Enhanced Release for Windows

With AutoCAD release 12 for Windows, Autodesk now has a bona fide entry into the world of graphical PC computing. From an inspection of a prerelease version of this product, it's quickly apparent that this is the easiest-to-use AutoCAD ever. In addition, AutoCAD for Windows has taken the improvements made to the DOS-based release 12 a notch higher by bringing the inherent advantages of the Windows GUI (e.g., OLE server support and DDE) to the table.



Because AutoCAD for Windows is an OLE server, AutoCAD users can now easily paste 3-D models of objects created in AutoCAD's integrated AVE Render facility into any other Windows application, such as Microsoft Word for Windows.

But Autodesk did not stop at just adding Windows OLE server and DDE support. In fact, AutoCAD for Windows boasts a list of new features that is too long to mention here. A sampling of these enhancements includes the capability to run multiple AutoCAD sessions (which requires an additional 4.5 MB of RAM beyond the base 8 MB for each multiple session), a rendering window with new MDI (Multiple Document Interface) support, and an Aerial View feature that allows panning and zooming of large CAD drawings in a small window, greatly enhancing the speed of these commonly used CAD operations.

Performance Questions

If you're skeptical of running the notoriously compute-intensive AutoCAD under Microsoft Windows, don't fret. Autodesk says that the program's new display-list driver makes up for much of the speed lacking in AutoCAD Extension for Windows, which was a bolted-on approach to running AutoCAD for DOS under the Windows GUI. Autodesk claims to have sold some 35,000 copies of AutoCAD Extension for Windows. However, because of the software's disappointing performance, it never caught on with users. With AutoCAD for Windows, however, Autodesk claims performance that is comparable to, or in some cases even better than, that of release 12 for DOS.

While I was unable to benchmark the AutoCAD DOS package against the new Windows release, I found the performance of AutoCAD for Windows quite acceptable while running it on what might be termed a base hardware configuration for Windows—a 33-MHz 486DX system with a 256-KB cache, 8 MB of memory, and a 170-MB hard drive. Although Autodesk specifies only a 386 with a math coprocessor and 8 MB of memory as a minimum requirement, you should realistically consider a 33-MHz 486 and between 8 and 16 MB of memory as a good starting point.

Although some functions, particularly the integrated 3-D modeling and rendering features, do not perform as quickly as under the DOS release, the integration under the Windows GUI more than makes up for any drop-off in raw speed. AutoCAD for Windows brings CAD users the

World Radio History

ease of use of Windows (along with a corresponding shorter learning curve for new users), but it also offers the built-in advantages of Windows applications that fully support functions such as OLE and DDE.

In my tests, I was easily able to render a 3-D version of a wireframe drawing of a nozzle into the AutoCAD AVE Render window, copy the rendered image to the Windows Clipboard, and then use AutoCAD's new OLE server support to paste the image into a Microsoft Word for Windows document (see the screen). You can also print rendered images through Windows and save them in either metafile (i.e., .WMF) or bit-map (i.e., .bmp) formats. Such simplicity isn't possible with previous DOS-based AutoCAD releases.

With all these changes, Autodesk kept AutoCAD's list price at $3750. The company's optional but fully integrated solid modeler, Advanced Modeling Extension release 2.1 for Windows, also carries the same $495 price tag as its DOS predecessor. Autodesk offers upgrades to registered AutoCAD release 12 for DOS users for $75.

Autodesk's Mechanical Move

With the acquisition of Micro Engineering Solutions, Autodesk is realizing its plan to migrate sophisticated mechanical design tools to PCs. Autodesk's DesignExpert and ManufacturingExpert—for solving complex surface modeling and manufacturing problems—are available for Sun Sparcstations, but DOS and Unix versions were expected by late April.

Offered as bundled products that include AutoCAD release 12, DesignExpert retails for $7750, and ManufacturingExpert for $13,750. Each bundle also includes AutoSurf, a CAD/CAM package. ■

Patrick Waurzyniak is a news editor for BYTE in San Mateo, California. You can reach him on BIX as "patrickw."

THE FACTS

AutoCAD release 12 for Windows
$3750; upgrade from DOS, $75

System requirements:
A 386 with a math coprocessor (or a 486) with 8 MB of RAM (additional 4.5 MB for each multiple session), 8 MB of free hard disk space (33 MB for full installation), a permanent swap file four times the size of RAM, DOS 3.3 or higher (DOS 5.0 is strongly recommended), a Windows-supported VGA monitor, and a Windows pointing device.

Autodesk, Inc.
2320 Marinship Way
Sausalito, CA 94965
(415) 332-2344
fax: (415) 331-8093
Circle 1189 on Inquiry Card.

6 Reasons to Buy DOS 6 from The PC Zone

- Money Back Guarantee
  If you're not satisfied, we'll refund your money.
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  Receive a 3.5" disk chock full of information & tips.
- We're DOS 6 Experts
  If you have questions, just call us.
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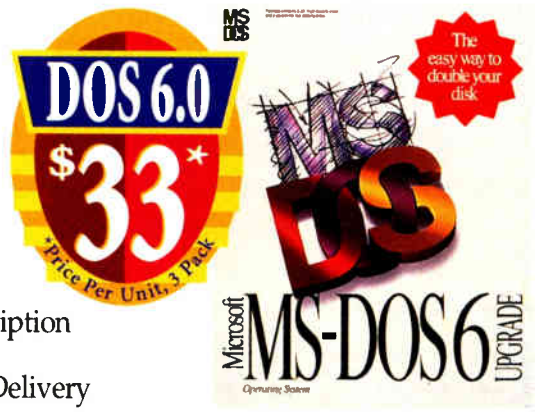

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World Radio History

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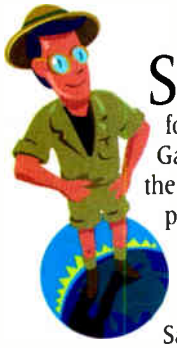

Success. All software developers strive for it. Now, Don Gall was on top of the world. Software protection made all the difference. Especially in Europe and Asia. Sales were four times better than before. He is the founding father of Sentinel — the guru of software success.

Struggling Software Sales

One day, trekking through the coffee fields of Java, Don ran into his old college buddy Simon Seagull. "Don, my sales are well below expectations." Simon explained his plight, "My software should sell like yours, Don!" Yet despite critical acclaim Simon's company, SimonSays Software, teetered on a financial tightrope. "What's your secret, Don?"

They spent hours analyzing potential problems. They looked at everything.

The Key to the Problem

Finally, Don leaned back and asked the assumptive question, "What about protection – are you using Sentinel?"

Nervously, Simon sipped his coffee. His hands shaking as his eyes darted the room. "No. I didn't think I needed to."

Don's chair slid out from under him and he crashed to the floor. Amazed in disbelief, Don cried, "You What?!" Grabbing his tattered scrapbook, Don pulled out photos of his travels. "Ever been to Seoul? Prague? Anywhere? Ten bucks will buy you anything, even bootlegged copies of software."

Don's Road to Success

Thumbing through the scrapbook, Don shared his experiences. "Back in the '80s, I was in your shoes – beaten, battered and bruised." Simon listened. "Then, after a heart breaking trip around the world, I called the Software Publishers Association (SPA)."

"I could hardly believe it. They told me developers lose billions of dollars each year. Why? Illegally copied software. In some countries there are nine pirated copies for each legal copy sold."

Simon was disgusted, "It's just not fair."

"That's why I committed myself to solving the piracy problem," explained Don.

Simon's eyes lit up. "The dongle!" he shouted. Don corrected him, "Not just any dongle — the dongle that paved the road to success for over 10,000 developers worldwide — Sentinel."

Successful Developers Use Sentinel

Don pulled a stack of letters out of his gunny sack. "All of these people tell the same story." Don read about a successful developer from California who swears she wouldn't be in business without Sentinel. Another company says protection costs less than litigation, plus they don't have to spend time and money supporting illegal users.

Others confessed they wouldn't market products internationally without protection.

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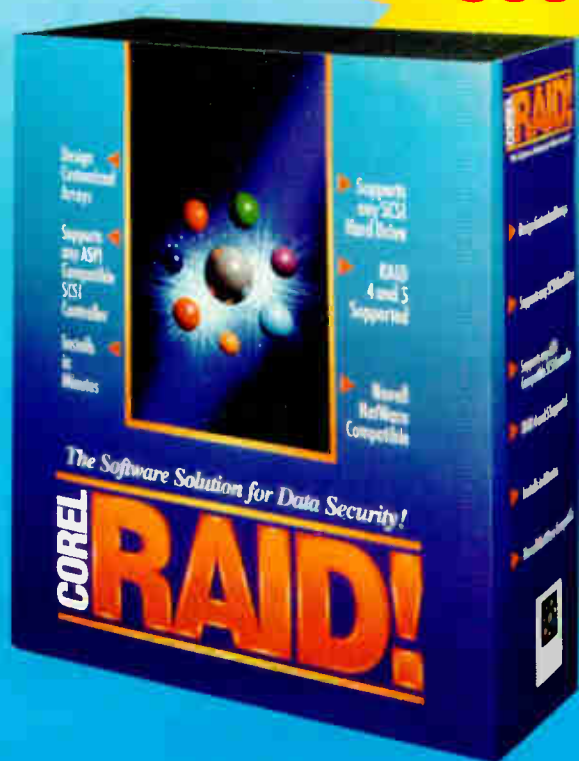

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World Radio History

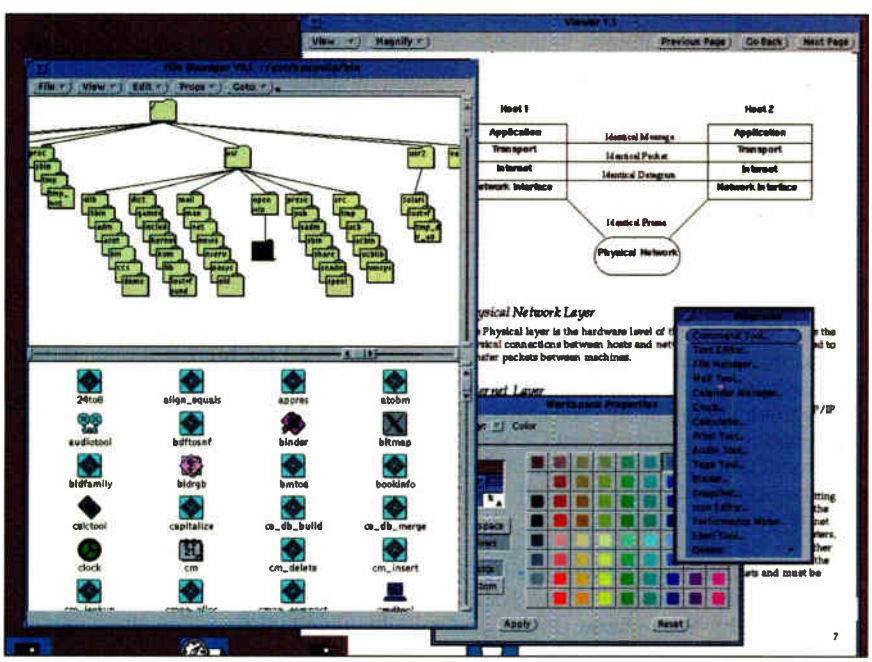
A Heavy-Hitting Unix for PCs

BEN SMITH

SunSoft's Solaris 2.1 for Intel rivals its SPARC-based sibling but exacts a steep price in terms of hardware

Solaris 2.1 for Intel is the most complete and best-looking Unix for PCs. However, the inevitable question remains: Given that you may end up spending as much for a PC to run it (not including your Solaris license or compiler) as you would for a decent Sun workstation, why not just buy a Sun workstation and get everything you need with fewer complications?

Solaris for Intel is not Interactive Unix (SunSoft's operating system based on Unix System V release 3.2) or like any other PC Unix, even those based on System V release 4.0. It is the full-featured SunOS 5 and Solaris 2.1 (see the text box "Solaris 2.1—A More Stable Environment" on page 38). In fact, the only noticeable differences between the SPARC and Intel versions of Solaris 2.1 are in the boot-up procedure, device installation and configuration, and operating-system installation. Because of the PC's greater flexibility, Solaris for Intel's differing procedures are more sophisticated and have more options than the SPARC version.



Is it Solaris 2.1 for Intel or Solaris 2.1 for SPARC? It's tough to tell, as the two versions of SunSoft's new operating system are virtually identical.

Power Consumer

Since Sun does not sell the hardware for Solaris for Intel, you can buy your system from whatever PC vendor you choose. But don't think you're going to cut many costs because you are about to buy a PC instead of a Sun workstation. If you want to take advantage of the differences between Solaris and run-of-the-mill PC Unix systems such as Interactive and SCO, you will need some serious hardware.

The minimum Intel-based system that you should consider putting Solaris on should include a reputable 486/50 with a CPU-to-memory cache that SunSoft has certified works with its kernel. For the basics, 16 MB of RAM may be enough, but for any workstation-oriented application, you will want 32 MB. Unless you plan to run your applications from a server, you should invest in a 500-MB hard drive.

I evaluated a beta version of Solaris for Intel on a Dell PowerLine 450SE/2 (a 486DX running at 50 MHz) with 32 MB of RAM and a 500-MB SCSI drive attached through an Adaptec AHA-1740 controller. The system also had a Graphics Ultra 8514/A card from ATI Technologies. The performance was equivalent to Interactive Unix on the same machine. Even though the display's resolution was only 1024 by 768 pixels with 256 colors (not what you might be used to on Sun workstations), it is very usable, even for graphics.

The prerelease version of Solaris for Intel that I tested supports only a dozen video cards and a handful of the most popular devices. But the list does include Creative Labs' Sound Blaster Pro. There is a major effort at SunSoft to expand the device list to include everything that Interactive Unix supports—hundreds of boards, displays, and devices.

If you have installed devices for standard Unix workstations but have never configured a PC-based Unix system before, you are in for a nasty surprise. If you don't have a Micro Channel architecture–based system, you'll need to keep track of IRQ (interrupt request) numbers, I/O memory addresses, and buffer memory addresses. You will be setting jumpers and running DOS-based configuration programs. There just isn't enough built-in intelligence to the devices and bus. Even an EISA configuration doesn't help if there is

World Radio History

Solaris 2.1—A More Stable Environment

Few people like change, even when the result might be for the better. The process of change implies pain and inconvenience. Certainly, the change from the old BSD Unix SunOS 4.x to the enhanced Solaris 2.x is going to leave more than a few people gasping and grasping. Solaris 2.0 had the added inconvenience of being bug-ridden and unstable (never upgrade to a dot zero release). With Solaris 2.1, the bugs have been exterminated, and the system appears stable. Developers, vendors, and users can get serious about moving to Solaris 2.1.

Not Just a Pretty Face

The base of Solaris 2.1 is the forward-looking Unix System V release 4.0, a complete overhaul of Unix Systems Laboratories Unix that incorporates the best features of BSD Unix and Xenix. It has shared libraries, run-time linkable device drivers, memory-mapped files (i.e., a file can be manipulated with the same functions as memory), file-system-mapped processes, two flavors of networkwide process communications, and file sharing.

Solaris 2.1 is more than Unix SVR4. It adds symmetric multiprocessing with lightweight processes (i.e., multithreaded processes), real-time extensions for deterministic control scheduling, and enhanced security (including Kerberos). There is a new version of Network Information Services (informally known as Yellow Pages), the distributed-name service used to facilitate network-based computing and communications.

At the user level, there is OpenWindows 3.0, the refined and elegant GUI that sits on top of an X Window System 11 release 4 and PostScript-based News graphics server. OpenWindows 3.0 is significantly more versatile than the threadbare Open Look that you will find on more primitive Unix SVR4 systems. OpenWindows 3.0 includes one of the finest graphical file managers as part of its desktop tool set.

Some system-administration features are new, particularly in the area of network-based operating-system installation and maintenance. Many of the old table-driven administration tools now have graphical front ends so that they fit in with Solaris's graphical interface to system administration, AdminTool.

Other bundled features include full-text on-line documentation called AnswerBook and more internationalization/localization. Solaris has also added the XGL 2-D and 3-D geometry-based graphics libraries and API to its development tools (which are now sold separately).

No Pain, No Gain

The future lies in wide-open distributed computing. By bringing BSD Unix, Xenix, and USL System V together in Unix SVR4 and giving applications developers the best of networking and distributed-computing hooks and tools, Solaris 2.1 opens up what was once becoming a restricted space for Sun workstations.

The major problem with Solaris 2.1 has been the reluctance of software developers to port to it, and this they must do, because Solaris 2.1 does not run the older SunOS code. SunOS has more products running on it than any other Unix platform. Right now, the weather looks a little gray, but once the move to Solaris 2.1 for SPARC picks up momentum, which it will, SunSoft will again shine brightly.

a single ISA card on the expansion bus.

SunSoft does help by providing an interactive program (`devconfig`) for setting the driver parameters for any devices. This program will discover all it can about your hardware, but you need to help it by providing device information on your ISA-bus devices.

Unlike SCO and Interactive, you don't rebuild the Solaris kernel on every attempt to add a new device. The drivers are separate, run-time-linked modules. You can even load and unload drivers while the system is running.

An Enigmatic Market

Solaris for Intel is a marketing dilemma for SunSoft. If the product is to create its own market niche—one that doesn't compete with SunSoft's Interactive Unix for PCs and Solaris for SPARC—it also won't be taking any market share away from other adaptations of PC Unix. SunSoft seems to be aiming at an unclear market for Unix running on expensive PCs. While this product is an impressive achievement, the advantage of Solaris for Intel is not clear. ■

Ben Smith is a testing editor for the BYTE Lab. He is also the author of two books: UNIX Step-by-Step *(Sams, 1990) and* UNIX E-Mail and Usenet News *(Sams, forthcoming). You can contact him on BIX as "bensmith" or on the Internet at ben@bytep.byte.com.*

THE FACTS

Solaris 2.1 for Intel
(price not available at press time)

Solaris 2.1 for SPARC
$795; $50 upgrade from version 2.0

SunSoft, Inc.
2550 Garcia Ave.
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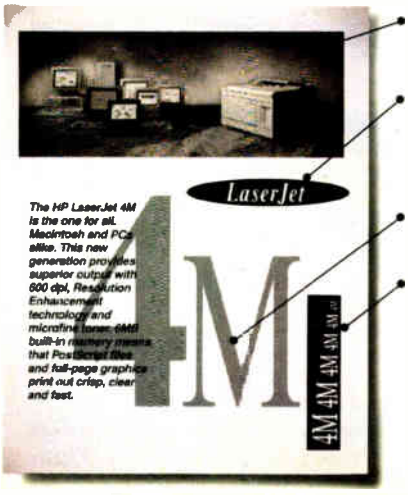

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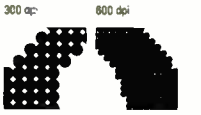

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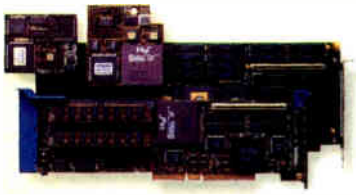

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Landmark Speed 2.0:	13 MHz	33 MHz	22 MHz
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Retail Price:		$245	$1,545
486/Now!	PS/2 Model 70-25MHz	With 486/Now! SX 25	PS/2 Model 90-0[illegible] SX 25
Landmark Speed 2.0:	39 MHz	84 MHz	84 MHz
Recount:	:55 Sec.	:39 Sec.	:38 Sec.
Retail Price:		$495	$3,280
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Landmark Speed 2.0:	16 MHz	84 MHz	84 MHz
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ATMaster	PS/2 Model 40	With ATM SX 25	PS/2 Model 90-0[illegible] SX 25
Landmark Speed 2.0:	21 MHz	84 MHz	84 MHz
Recount:	1:48 Min.	:45 Sec.	:38 Sec.
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All systems tested with 16MB installed except ATMaster, tested with 8MB, and MCMaster, tested with 8MB on-board and 8MB on mother board. All system prices are MSRP at standard configuration as of 2/1/93. Processor upgrade prices are MSRP as of 2/1/93. Recount conducted on 3MB Excel for Windows spreadsheet generated by Kingston Technology.

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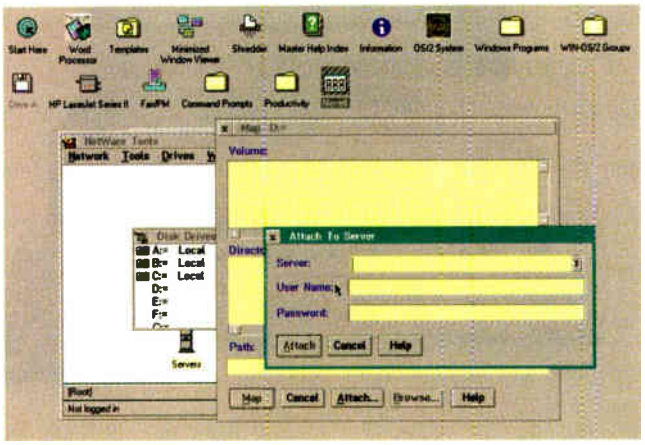
World Radio History

NetWare 4.0 Delivers a New Directory Service

If you're a network administrator, you'll notice a number of significant changes to Novell's NetWare 4.0, such as a new NetWare Directory Service (NDS for short) and support for more connections and servers. However, if you're a network user, you might not even notice that your organization has upgraded to NetWare 4.0. Novell has carefully designed NetWare 4.0 to be compatible with versions 2.2 and 3.11.



I tested a prerelease version of NetWare 4.0, but Novell planned (as I write this) to release the core product in March. Novell says it will release NetWare System Fault Tolerance III—a version of NetWare 4.0 incorporating software techniques that ensure fail-safe operation of the LAN—later this year.

The most significant feature of NetWare 4.0 is Novell's new networkwide NDS, a hierarchically organized database that replaces the old bindery, which operated on a server-by-server basis. With earlier versions of NetWare, you purchased the separate NetWare Naming Services to use global names on your LAN. NDS is a completely redesigned naming service for directories, servers, and log-on accounts. The enhanced directory feature is designed to let network administrators control exactly which network resources a user can access.

Many version 3.11–aware network utilities use the Novell API to access the bindery. By default, NetWare 4.0 turns on bindery emulation, so you don't have to throw those utilities away. Version 4.0's new named-directory service will work with software written to the X.500 directory services specification, according to Novell. This named-directory service is the key that lets people log in to groups of local servers in a single operation. You can also easily access servers located in geographically dispersed LANs (i.e., the enterprise).

NetWare 4.0 supports up to 1000 simultaneous connections (3.11 maxed out at 250), and Novell sells licenses in strata of five, 10, 20, 50, 100, 250, 500, and 1000 users. NetWare 4.0 offers up to 54,000 server connections if you use the new shell (3.11 allowed only eight server connections). You can run version 4.0 in nondedicated mode with the Unix and OS/2 versions, but the core product remains a dedicated server environment. NetWare 4.0 doesn't yet support multiprocessor machines.

In answer to a frequent criticism of version 3.11, NetWare 4.0 distinguishes between ring 0 and ring 3 memory protection. New in this version is a read-ahead cache to help performance, along with two features to help you conserve server disk space: data-block suballocation and data compression. If you're afraid that on-the-fly compression will bog the server down, you can configure data compression to occur during off-hours, when most people have left the office. However, when you access a compressed file, NetWare 4.0 has to do the extra work to restore the file to its uncompressed form.

Version 4.0 has the same limits on number of volumes and total disk space as version 3.11—64 and 32 TB, respectively. NetWare 4.0 offers RSA public/private key cryptography for better security, along with NDS and file-system event logging. You also get remote console session security and remote session modem callback. NetWare 4.0 can use a time server to synchronize clocks among multiple servers (even in different time zones). Future enhancements to version 4.0 will include Image Enabled NetWare, based on Kodak technology, and document management services, based on content document architecture technology.

NetWare 4.0 will ship on CD-ROM. On a Toshiba 3301 drive, I was able to quickly and easily create a NetWare 4.0 server. I had to install only a few more megabytes of RAM in the PC to give version 4.0 a happy home. NetWare 4.0 requires at least 6 MB of RAM and from 12 to 60 MB of disk space (depending on the features you install).

The version 4.0 shell software that enables a DOS client to access a NetWare file server is smaller than version 3.11 (53 KB versus 59 KB for version 3.11), but it otherwise provides the same I/O redirection functions as that shell software. The new client can also attach directly to 3.x servers. Workstations can continue to use the older shell software; you don't have to upgrade all the workstations at once. Novell supplies the NetWare 4.0 DOS client software in modular form as VLMs (Virtual Loadable Modules).

You can log in from within Windows, just as you can from within OS/2's PM (Presentation Manager). People who use the Windows or PM interfaces get new tools for managing their network sessions. NetWare 4.0 has built-in packet-burst support. It provides the ability to back up DOS and OS/2 workstations and offers a smaller RAM footprint for designated remote printers.

NetWare 4.0 is a logical, practical step up from previous versions. If you've outgrown the 250-user or eight-server limits of NetWare 3.11, or if you have some LANs connected in a WAN (wide-area network), you'll find that NetWare 4.0 injects new life into your network.

—Barry Nance

THE FACTS

NetWare 4.0
$1399 for five users (minimum installation)

System requirements:
A 386 server, 6 MB of RAM, and 12 to 60 MB of disk space. Supports PC-DOS, DR DOS, Windows, Unix, Macintosh, and OS/2 clients.

Novell, Inc.
122 East 1700 South
Provo, UT 84606
(800) 459-1253
(801) 429-7000
fax: (801) 429-3944
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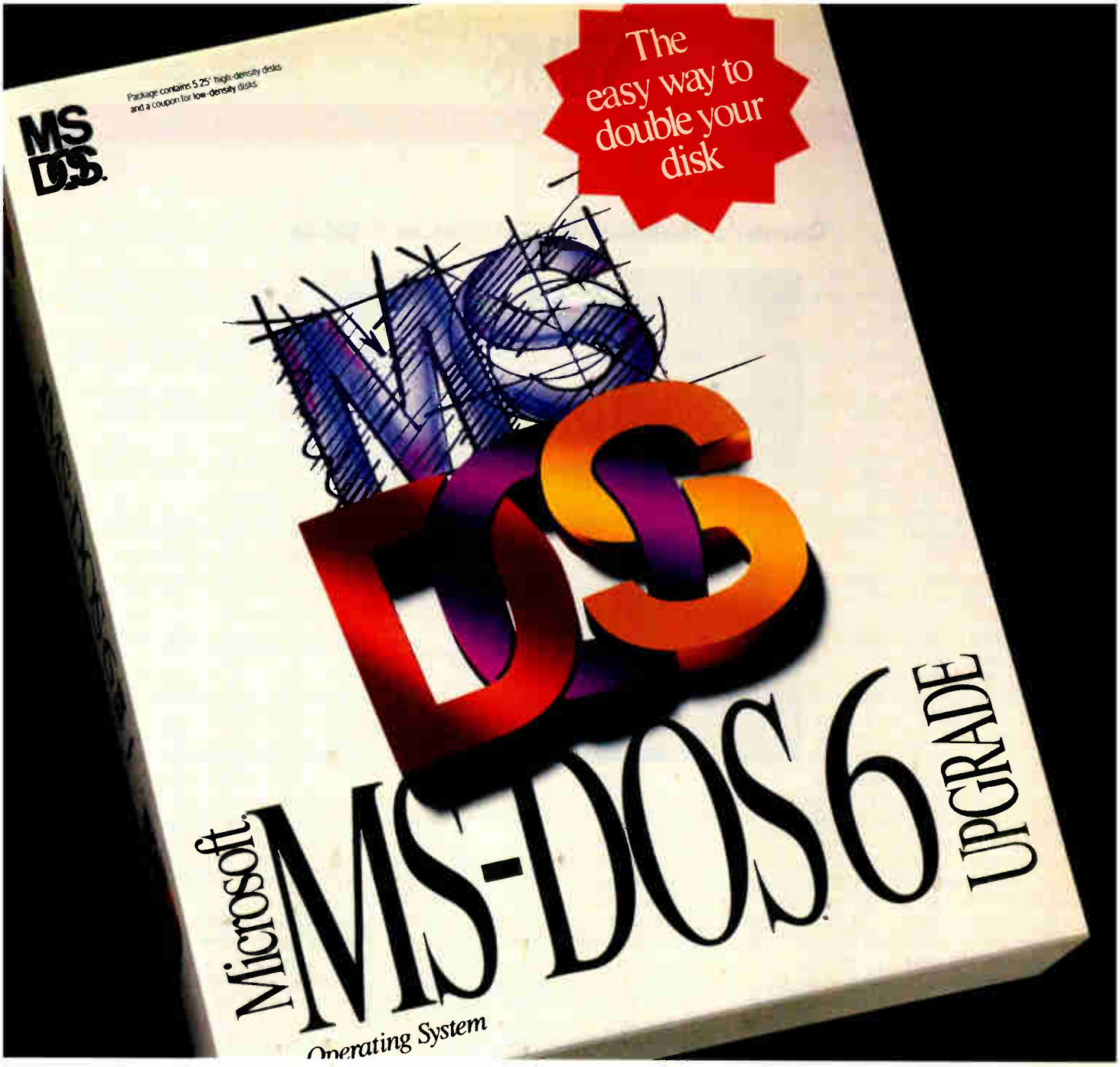

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World Radio History

Canon's NoteJet 486 Packs a Printer

Portability is the trend of the 1990s. As system vendors continue to integrate more computing functionality into smaller, lighter packages, it should be no surprise that notebook PCs are starting to incorporate printers. Canon Computer Systems recently debuted the first of these combinations, the NoteJet 486.

The 7¼-pound NoteJet comprises a 25-MHz TI486SLC processor (Texas Instruments manufactures the nearly identical Cx486SLC CPU for Cyrix), a 9½-inch backlit monochrome VGA LCD, 4 MB of RAM (which is expandable to 12 MB), a 1.44-MB floppy drive, and a 360-dot-per-inch bubblejet printer. The printer most closely resembles a Canon BJ-10ex printer in its design, but at about 25 percent of the size of the original.

Also included in this package are two PCMCIA Level 2 slots (the first two available devices from Canon, both fax modems, will ship concurrently with the NoteJet), a pen-like Canon mouse, a file transfer utility called InterLink, DOS 5.0, and Windows 3.1. Models differ by the hard drive size: I looked at a prerelease version of Model 1 ($2499), which has an 85-MB hard drive. The capacity in the other models goes up to 180 MB.

Canon, which is marketing the notebook as the NoteJet in the U.S. and the BN22 in Europe (the adapter and keyboards will differ with the market), has created some confusion by jointly announcing with IBM a similar notebook/printer that will sell in Japan and nearby markets. That product, called the ThinkPad 550BJ, differs from the NoteJet in its IBM-specification motherboard, 25-MHz 486SLC processor, drives, and other components. The integrated-printer concept is Canon's own.

The inevitable question that potential users will ask is, How much can the NoteJet 486 print before the battery dies? Here is one case where a vendor underrated a product. Canon claims the NoteJet produces eight pages of 1500 characters each before the system loses power, but I was able to print the entire 27-page Windows readme file from the Write applet plus two additional pages of another text file before the nickel-cadmium battery died. The 10-page automatic sheet feeder sucks the paper in beneath the liftable keyboard, and a page guide lets you feed in letter- (or transparencies), legal- (hand-fed only), and A4-size paper.

Canon estimates a print speed of 116 characters per second, or two pages per minute. No underrating here: 10 pages of the same readme file took 11½ minutes to print (using the automatic sheet feeder) once Windows composed the document.

If you keep the separate printer and sheet-feeder switches turned off, the battery provides up to 4 hours of use. Canon provides some handy power management assistance. First, there's an LED indicator, displaying the power level by varying colors, that you can view with the case open or closed. There's a deep-discharge utility that you run before charging the system, and Canon includes a power management utility (for setting various components' shutdown levels) in addition to the power management functions built into the Quadtel BIOS, the Western Digital chip set, and the CPU itself. (Although you cannot recharge the battery when using the system, you shouldn't have to wait long. Canon claims the battery requires only 70 minutes to charge.)

The NoteJet 486's upgrade options, in addition to the two PCMCIA fax modems, are a numeric keypad, connected through the trackball jack, and a palm rest ($45), which screws into the front edge of the notebook beneath the paper-feed slot (the included paper tray fits into the palm rest when you fold up the latter for transport). If you need to install a math coprocessor, you can easily insert Cyrix's Cx83S87 into the system through the same hatch you use to install SIMM banks. Canon itself sells neither SIMMs nor a coprocessor for this system, but the vendor notes you can purchase them through the large retailers and dealerships that carry the NoteJet itself.

A Canon representative discussed the concerns of clients in corporate MIS departments about the NoteJet, which centered on the fact that servicing half of it, say the printer, inevitably takes the whole unit out of commission for the duration of the repair cycle. Had Canon designed the NoteJet to allow you to swap printers, said the representative, the result would have made the notebook bigger and heavier. As it is, the NoteJet may already strain the shoulders of users accustomed to current notebooks.

As for print quality, the NoteJet's output reveals its share of the jaggies, along with some of the stray droplets, called satellites, that are obvious only if you use a magnifying glass to find them. What most greets the naked eye, however, is crisp, easily readable output that does not strain the eyes. The bottom line: You won't find better printing 37,000 feet up.

—Ed Perratore

THE FACTS

NoteJet 486
Model 1 (85-MB hard drive), $2499
Model 2 (130-MB hard drive), $2799
Model 3 (180-MB hard drive), $2999

Canon Computer Systems, Inc.
123 East Paulerino Ave.
Costa Mesa, CA 92628
(714) 438-3000
(714) 438-3099
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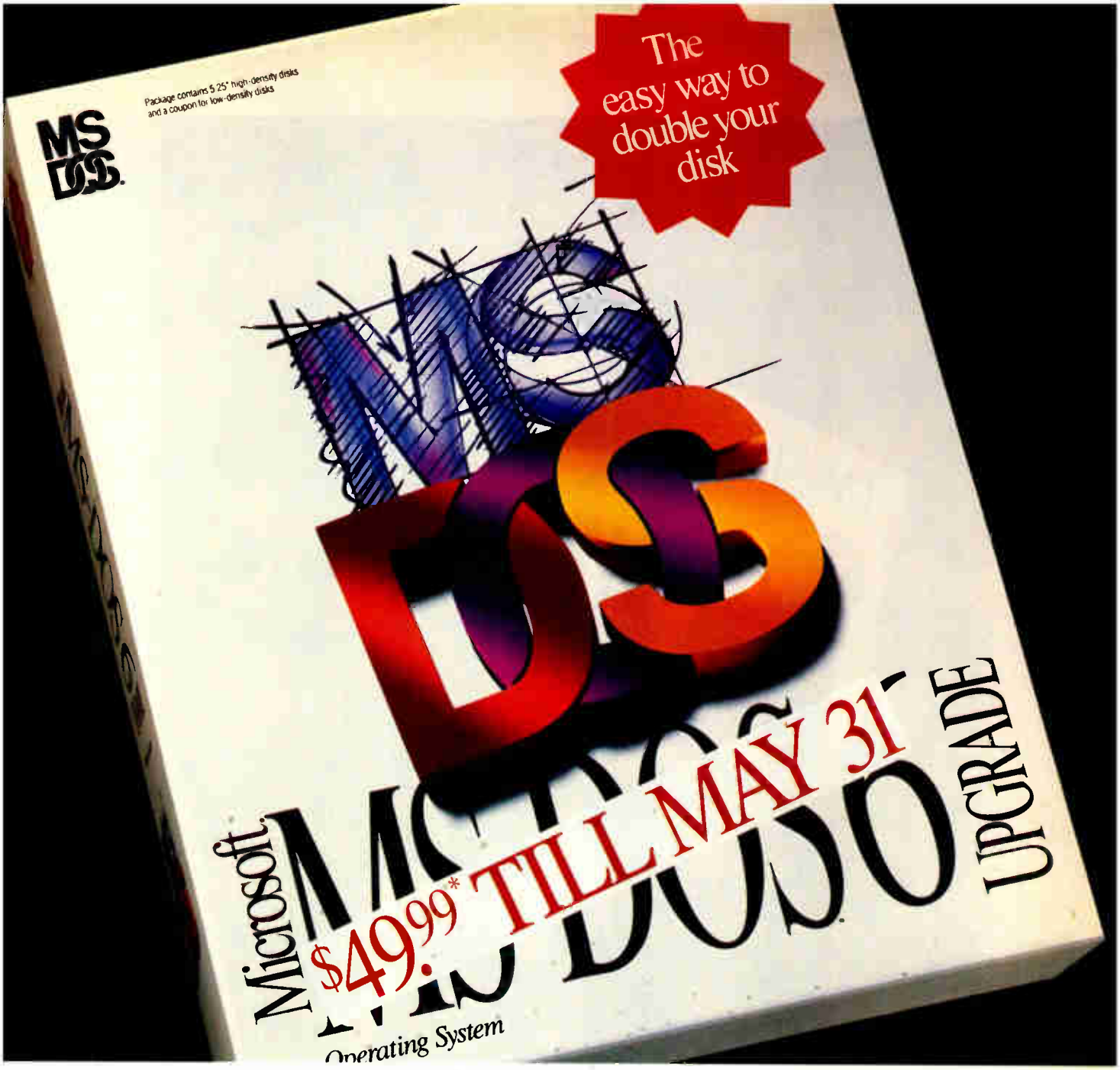

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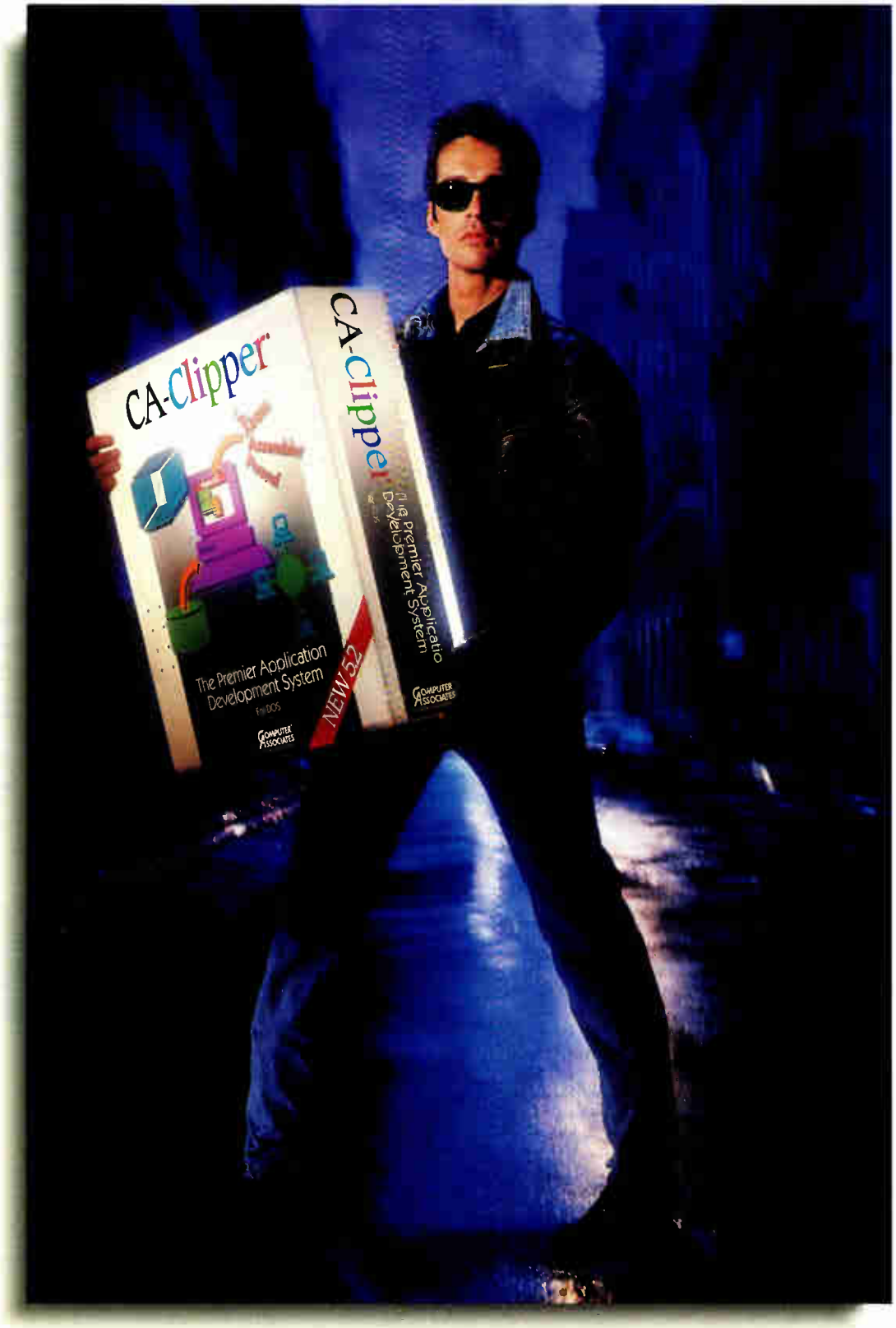

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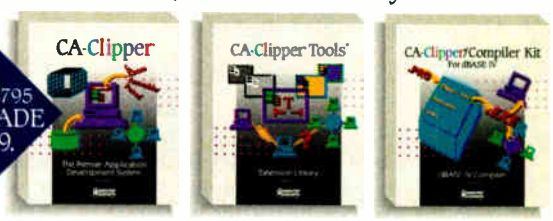

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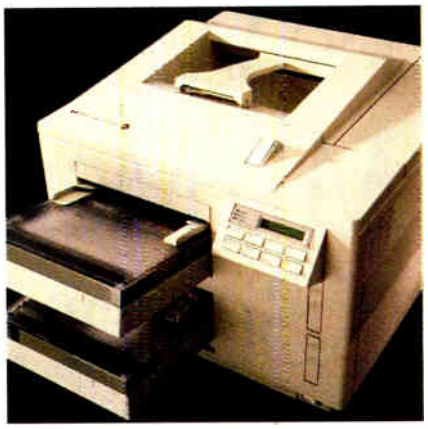
HP Serves Up Two Winning Network Printers

Building on the success of the recently introduced LaserJet 4 series, Hewlett-Packard's newest arrivals, the **HP LaserJet 4Si** and its big sibling, the **HP LaserJet 4Si MX**, set new standards for network printers. Designed to replace the popular HP LaserJet IIISi, the new LaserJets offer many improvements in the areas of output quality, ease of use, and performance.

On the outside, the new printers appear identical to the IIISi; however, appearances can be deceiving. The $5499 LaserJet 4Si MX comes standard with Adobe PostScript Level 2, a LocalTalk port, and HP's JetDirect Ethernet interface, all of which are optional for the LaserJet 4Si (which is priced at $3749). Both printers include 45 scalable typefaces for use with HP's Enhanced PCL (Printer Control Language) 5; the 4Si MX also includes 35 PostScript typefaces. The 4Si comes standard with 2 MB of RAM, and the 4Si MX comes fitted with 10 MB.

Like the LaserJet 4 series, both units offer true 600-dot-per-inch output, thanks to the new Canon P-174 print engine. Thus, the 4Si MX produces four times as many dots as does 300-dpi output in the same area, which is typical of the LaserJet III printers, for much sharper output quality. Of course, the 4Si MX also uses HP's Resolution Enhancement Technology, which smooths the edges of letters and graphics curves. HP's microfine-toner-particle technology results in smaller dots for crisper lines and edges.

The print engine of the 4Si MX is rated at the same comfortable 17 pages per minute as the IIISi. A manufacturer-stated ppm rating doesn't necessarily translate into speed when dealing with text- and graphics-intensive pages. The 4Si MX, however, generated outstanding output at impressive speed, including many clearly discernible gray scales, clean and legible 4-point text, and detailed hairlines. The quality of the 4Si MX's photographic reproductions is comparable to that of a LaserJet 4—overall sharp in detail, but a little splotchy and granular.



The monthly duty cycle has been increased from 50,000 pages per month to 75,000 pages. Although the same 17-ppm engine rating as the IIIsi does not sound like a vast performance improvement, don't forget that the 4Si MX is printing at 600 dpi. From the looks of my tests, HP surpassed its development goal of providing 600-dpi output faster than its former network champion generated 300-dpi output. As expected, the 4Si MX performs more than twice as fast as the 8-ppm LaserJet 4M. (To see how the 4Si MX stacks up in head-to-head competition with the latest offerings from Compaq, QMS, and other printer manufacturers, see "126 Printers" on page 146.)

Performance enhancements include the use of the Intel 80960CF 25-MHz RISC processor for faster page interpretation, a high-speed Bi-Tronics parallel interface that accepts data quicker than do standard parallel ports (introduced with the LaserJet 4), and Enhanced PCL 5 (which HP claims is optimized to provide faster graphics output).

Unlike a typical PostScript printer, HP's successor to the network throne can render one page in memory while another page is still printing. Usually, a PostScript page must complete printing before the next one can start printing. The printer can also accept a steady flow of PCL 5 and PostScript print jobs by instantly switching between the two languages. Similarly, the printer will accept data from any of its interface ports that are simultaneously active.

HP has also introduced its next generation of JetDirect network interfaces. The 4Si MX's JetDirect Ethernet card, which provides twisted-pair and coaxial connections, supports automatic network switching between 10 major network protocols.

The paper-handling capabilities of the 4Si MX are impressive. Two 500-sheet paper trays come standard, and an optional 1500-sheet tray ($649) replaces one of the 500-sheet trays, for a total of 2000 sheets. The printer alternates each print job's placement in the output bin, so you won't have to search for the beginning and end of your printout. An arm senses when the output bin nears its 550-sheet capacity and stops the printer to avoid paper jams.

The 4Si's many attributes should be a welcome addition to most networks. And network managers will be hard-pressed to find anything that HP overlooked in the 4Si MX.

—Richard Fox

THE FACTS

HP LaserJet 4Si
$3749

HP LaserJet 4Si MX
$5499

Hewlett-Packard Co.
P.O. Box 58059,
MS 511L-SJ
Santa Clara, CA 92127
(800) 752-0900
Circle 1193 on Inquiry Card.

Big-League Desktop Publishing

How can a $59.95 Windows desktop publishing package compete with those in the $800 range? After working with a beta copy of Serif's **PagePlus 2.0**, I found that this package includes everything you need for basic desktop publishing, plus a few surprises.

PagePlus 2.0 offers some pretty sophisticated tools, including OLE support, TrueType compatibility, full-color (i.e., 24-bit) images, Pantone palettes, and the ability to generate color-separated output. In addition, with PagePlus 2.0, you get auto-flow text capabilities (both free-flow and frame), the ability to create libraries of styles, and the ability to rotate all objects. PagePlus 2.0 also comes with a table editor, which not all high-end desktop publishing packages include.

The program is fairly simple to install, although the installation procedure lacks

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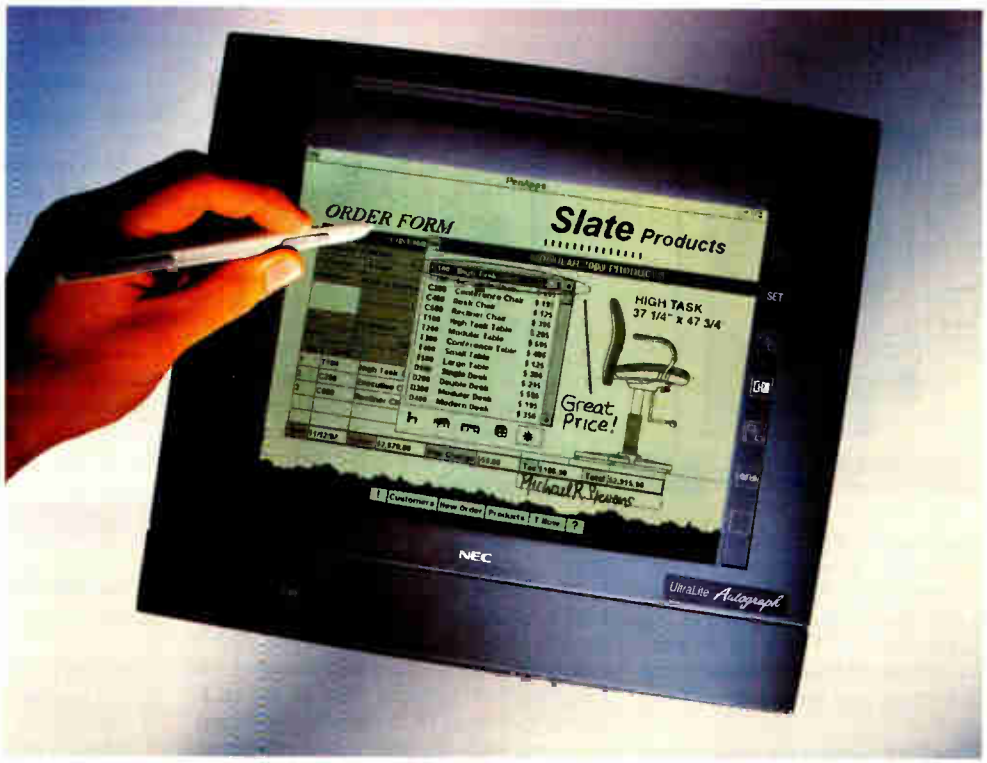
After you see our performance



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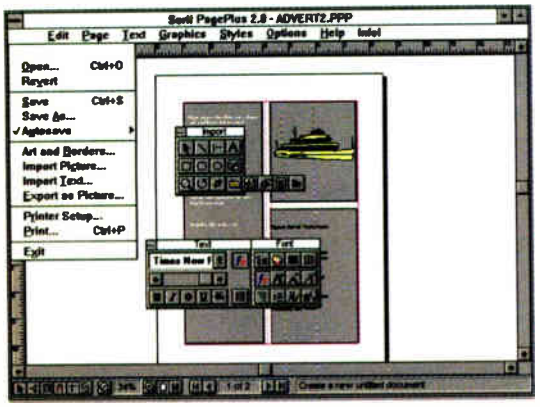

some of the finesse of the high-end packages. Components you can choose to install or not are a table editor, graphics filters, and text filters. Each item shows the amount of space it will take up on your hard drive, and the software also tells you how much space you have left on your drive.

The PagePlus 2.0 screen looks like a typical Windows application with the menu bar. PagePlus 2.0 also makes use of buttons in its ToolBox and ChangeBar windows. I found the placement of buttons, such as those along the Status Bar at the bottom, hard to get used to. But a HintLine tells you what the buttons do, so you're never completely in the dark. The on-screen help is also remarkably complete.

When you start a new file, you can use a template or you can do the layout yourself. If you want to add a graphic to the page, you select a box tool from the ToolBox. Then, using the pointer tool, you can create a graphical object. Although you can similarly create text on the page, PagePlus 2.0 doesn't have any word processing features. Thus, if you're dealing with complex text, it's better to create the text in your word processor and import it.

To import a graphic, you click on the import picture button, and a little "flyout" appears with three indiscernible buttons on it. I had to refer to the HintLine to discover the identity of these buttons. If you click on art and borders, you can access the clip art that comes with PagePlus 2.0. You can click on the OLE button to import OLE objects. To import text, you go to the File pull-down-menu and click on Import Text.

The ChangeBar is an interesting feature. It lets you change the looks of a selected object by changing its properties. To use it, you select the object, such as a headline, and use the scroll bar or the slider bar in the ChangeBar window to change the size of the text. You can see the change automatically take place on the screen. It's pretty nifty, and better than the usual pull-down menu way of changing the point size.

I found myself comparing PagePlus 2.0 to high-end desktop publishing packages, which is a terrific compliment for Serif's low-cost software. I should be comparing it to desktop publishing software in its own price range. However, with features such as OLE capabilities, color separation, text flow, and more, it appears to me that PagePlus 2.0 has put itself in the league with the big-time players—and at a whole lot less cost to us.

—Anne Fischer Lent

THE FACTS

PagePlus 2.0
$59.95

System requirements:
A 286 with 2 MB of RAM, Windows, a mouse, and at least 4 MB of free disk space.

Serif, Inc.
P.O. Box 803
Nashua, NH 03061
(800) 697-3743
(603) 889-8650
fax: (800) 869-8909
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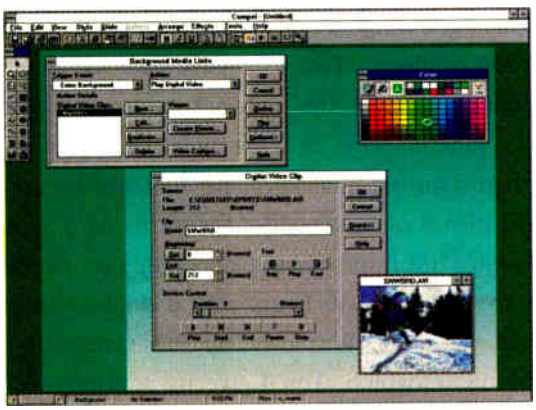
Compelling Presentations

Compel, a $295 presentation package from Asymetrix, can infuse an otherwise dull presentation with colorful slides and a full range of visual elements and sound. Pulling together a simple presentation using this software takes little time and effort.



You start off in Compel by typing text in a default template. The template determines your presentation's color scheme and font selection, while a slide-style selection controls the location of text, bullets, and graphics for an individual slide in the presentation. If you don't like the look of your slides, you can switch templates on-the-fly without redoing your work. You can preview thumbnail views of slide styles to see how well they blend in with the active template. Templates and slide styles together provide a rich selection of designs and make it easy to apply a consistent look to your presentation.

To help you organize your ideas, you can build a bulleted outline of your presentation. Compel automatically generates a full set of slides from the outline, generating a slide from each bulleted topic. You can also use bullets as interactive links so that each bullet calls a unique slide. A full selection of slide transitions includes fade, dissolve, blinds, wipe, and zoom.

The Slide Sorter shows a thumbnail view of all the slides in your presentation. You can easily rearrange slides by dragging them around with the mouse and dropping them in place, or you can perform other quick operations on slides such as copy, paste, and delete. To edit a slide from the Slide Sorter, you simply double-click on it. Compel can automatically generate speaker notes and audience handouts, and your presentation can be formatted for output to the computer screen, an overhead projector, 35mm slides, or a printer.

The most attention-getting aspect of the software is its support for multimedia. Compel does not simply rely on OLE to pull in multimedia clips: Full multimedia support is built into the Compel interface. Any object, including text, can be linked to a multimedia event. You simply select the object and activate the Media Links dialog box. You then designate the

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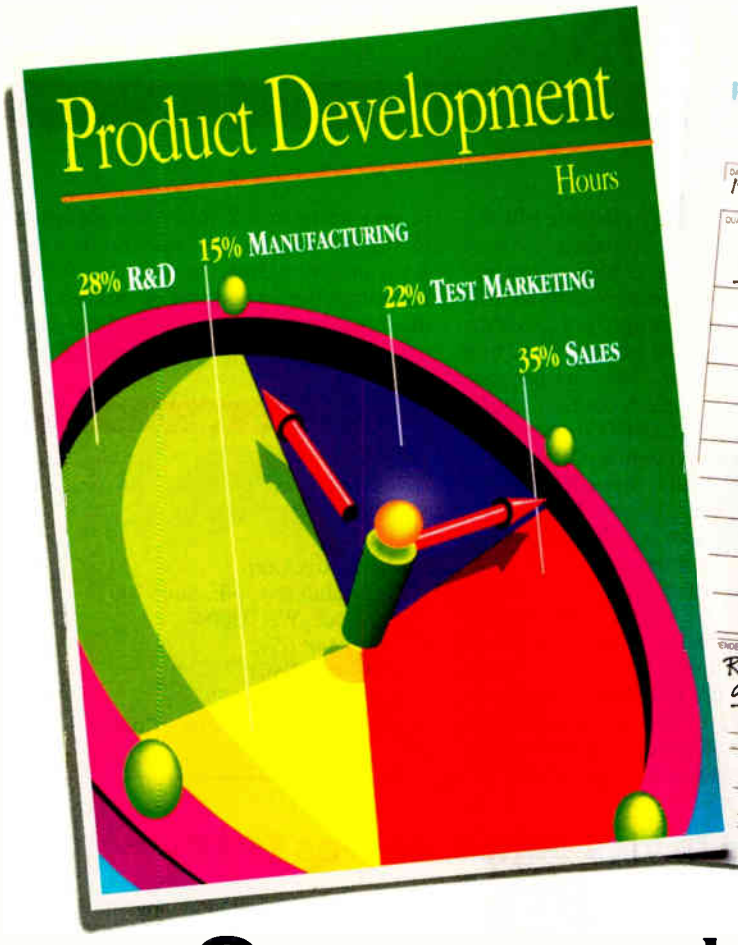

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type of event (e.g., video, sound, or animation) and the action that will trigger the event (e.g., when the object is clicked on). You can even specify a portion of the sound or video to be played by setting beginning and end points, as shown in the screen at the bottom of page 50. This linking mechanism is intuitive and very powerful.

Once you've stored all these divergent elements into a presentation, you can use some helpful tools to deliver it. Asymetrix provides a run-time module that lets you play a slide show without loading the full version of Compel, and the packager utility automatically finds all the files—graphics, sound, video—that are associated with the presentation and bundles them in one place.

The beta software I previewed did have some weak points. The animation tools were rudimentary. While you can come up with some effective charting effects, such as dynamically extending a bar as a bullet points out your company's explosive growth, more complex animation is tricky to pull off or simply not possible. Compel could benefit greatly from true path-based animation. The beta package was also short on clip art, but the final release will include a CD-ROM full of clip art and clip media, Asymetrix says.

The very virtue that makes Compel so appealing—its abundance of features—also makes me a bit wary. When powerful desktop publishing programs such as PageMaker brought desktop publishing to the masses, there was a sudden rash of newsletters and advertising mailings that used six or seven different fonts, superfluous graphics, and unfathomable diagrams. Compel's features should be used sparingly and in good taste. A sudden blaring of trumpets or a needless video clip can be very distracting. Sensory aids are meant to supplement content; they are not the main attraction. But if you keep your creative impulses in check, Compel can add the right touch of pizzazz to seal the deal.

—Stanford Diehl

THE FACTS

Compel
$295

Asymetrix Corp.
110 110th Ave. NE, Suite 700
Bellevue, WA 98004
(800) 448-6543
(206) 462-0501
fax: (206) 454-0672
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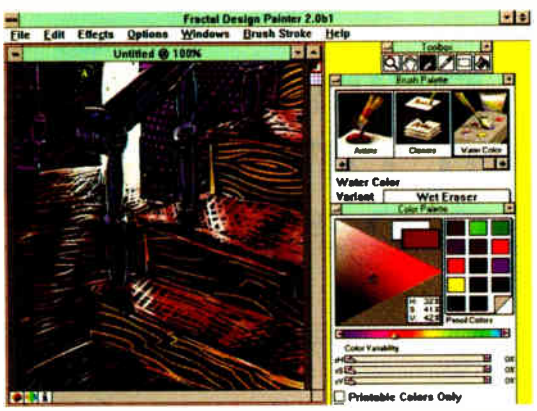
Painter 2.0 for Windows Brings Digital Canvas to Life



Fractal Design's **Painter 2.0** for Windows is a powerful addition to a professional graphic artist's arsenal. And for amateur artists, it's a fun way to develop your skills. (After all, software that comes in a paint can should be fun.) While it was originally created for the Macintosh, Fractal Design now has an updated Windows-based Painter that adds a host of new tools, including one called liquid media.

Painter's strength lies in its "natural media," which give the computer artist an impressive array of canvases and simulated pens, pencils, chalks, charcoal, erasers, and even an airbrush that can approximate the real-world tools. With this latest update of Painter, you gain the ability to liquefy paints with a wet brush, creating more of a diffused look to watercolors on varied textures of papers.

While test-driving a beta version of Painter 2.0, I used a Wacom 6- by 9-inch pressure-sensitive graphics tablet. Using a pressure-sensitive stylus is critical to gaining a true feel for the "canvas," and the Wacom pen worked well. After trying Painter on a Compaq Deskpro 386DX-20 with 6 MB of RAM, I moved it to a 486DX-33 with 8 MB of RAM. The performance improvement was startling.

One of Painter's interesting new features is its capability to play back an entire session that was previously recorded by a professional artist (see the screen). In this update, Fractal Design includes several artist-recorded sessions that can show novice graphic artists like myself the exact, step-by-step process necessary to create an award-winning piece of computer art.

Fractal Design also made the program easier to use. It now has brushes and textures that you can tear off from their palettes and preview windows to see examples of how special filters, such as glass distortion, change an image.

Other enhancements include new brushes, with an Impressionist brush and a Cubist "brush look" added to Painter's familiar van Gogh- and Seurat-style brushes. But perhaps the best feature of Painter 2.0 is its new liquid media, which allow artists to use any of the nine new liquid brushes, such as the spatter airbrush, to add a lifelike liquid look to their digital paintings.

Fractal also has added new image-editing features to Painter, letting you scale, rotate, or flip images, which can be scanned from within Painter 2.0 via TWAIN. The program can export with a Photostyler plug-in module that sends output to film recorders or tape backup systems.

At $399, Painter 2.0, which is available for the Mac at the same price, is a great buy for anyone looking for a sophisticated painting program. But make sure you have the requisite computer horsepower. ■

—Patrick Waurzyniak

THE FACTS

Painter 2.0
$399

System requirements:
A 386SX or higher with Super VGA with 256 colors, 4 MB of RAM (6 MB is recommended), and Windows 3.0 or higher. Wacom, Calcomp, and Kurta pressure-sensitive graphics tablets are recommended. A math coprocessor is supported.

Fractal Design Corp.
335 Spreckels Dr., Suite F
Aptos, CA 95003
(408) 688-5300
fax: (408) 688-8836
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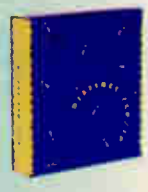
Dolphin C Toolkit	$95	Precursor	$45
Dolphin Encript	$125	Scheme III	$359
Dr. Switch-ASE	$159	Sitback for Windows	$54
ED for Windows	$169	SQA: Replay OS/2	$54
Label Master	$429	SQA: Robot	$389
Logic Gem	$79	Style	$155
mini Ed Tools	CALL	Tempra Pro	$339
MKS Learning UNIX	$99	Tempra Show	$109
MKS Toolkit	$239	Tree 86	$42
MS DOS	CALL	WATCOM FORTRAN 77/386	$719

Distinct TCP/IP for Windows
by Distinct Corp.



INCLUDES WINDOWS SOCKETS. This award winning product is the professional programmer's choice for TCP/IP connectivity in the Windows environment. Windows Sockets, TCP/IP Kernel, RPC/XDR, Telnet, and FTP are the *smallest* and *fastest* DLLs available today. Applications developed with TCP/IP can coexist with LAN Manager, Vines, Pathworks and Novell thanks to Distinct's support for Packets, NDIS or ODI drivers.

SDK List: $495 Ours: $459
Applications List: $395 Ours: $359
FAX*cetera* # 2994-0002

Microsoft Visual C++
by Microsoft Corporation

Microsoft Visual C++ combines the power of reusable, prebuilt code with a seamless, visual environment to shorten the development process. Design user interfaces, build, debug, and browse using a set of tightly integrated tools, while "wizards" assist you with fundamental tasks for maximum productivity. It's the fast, powerful way to program in C++!

Standard Edition
(Comp. Upgrade) List: $99 Ours: $95
Professional Edition
(Comp. Upgrade) List: $199 Ours: $189
FAX*cetera* # 1269-0040

Multimedia Toolbook
by Asymetrix

Complete Multimedia Authoring.
Create your own multimedia applications for MS Windows. Simple interface and set of ready-to-use multimedia objects make it the fastest and easiest way to develop multimedia apps. This award-winning tool provides a complete package versatile enough to develop new applications or put a new face on existing ones, with no runtime fee.

List: $695 Ours: $529
FAX*cetera* # 2776-0005

Q+E Database Library (QELIB)
by Pioneer Software

Q+E Database Library provides complete database connectivity to Windows and OS/2 applications using Dynamic Link Libraries. QELIB can read, insert, update, create or delete database records for the following formats: Oracle, dBASE, SQL Server, Sybase, DB2, Paradox, INGRES, AS/400 (SQL/400), Btrieve, Excel, INFORMIX, NetWare SQL, and many more. Gateways supported include: IBM DDCS/2, Micro Decisionware, Sybase Net-Gateway, and Gupta SQL Network.

List: $399 Ours: $359
FAX*cetera* # 2625-0003

MATLAB® 4.0 for 386 Windows
by Mathworks

A high-performance, interactive numeric computation and visualization envrionment that combines hundreds of advanced math & graphics functions with an easy-to-use and flexible high-level language. The open system architecture enables users to view the pre-packaged functions, customize them as needed, or add new functions. MATLAB toolboxes are available to extend the power by providing leading-edge algorithms and functions developed by renowned experts for specific applications.

List: $1695 Ours: CALL
FAX*cetera* # 1269-0042

MediaDeveloper
by Lenel Systems

Create multimedia-enabled applications with MediaDeveloper and ObjectVision. It is **THE** Multimedia Development Toolkit to integrate sound, images, animation and full-motion video into Windows applications. Includes media and device control for multimedia peripherals including CD-ROMs, VCRs and laserdisc players; support for major animation, video, audio and graphics formats; a multimedia database; OLE server; and many DLLs.

List: $595 Ours: $449
w/MS VB Win. 2.0 List: $794 Ours: $569
w/MS VB Win. Pro 2.0 List: $1090 Ours: $739
FAX*cetera* # 1005-0302

800-445-7899

World Radio History

Software that Sizzles!

800 445-7899

Lahey F77L – Fortran Compiler
by Lahey

Version 5.01 includes Fortran 90 features: ALLOCATABLE Arrays, CASE Constructs, Cycle and Exit, Construct Names, and many other new features. Package includes Editor, Make Utility, Profiler, Debugger, SLR Linker, Opus Make, Video Graphics, and Excellent Diagnostics. 386/486 users have the option of generating 32-bit instructions.

List: $295 **Ours: $259**
FAX*cetera* # 1476-0001

ED–The Programmer's Editor for Windows
by Lifeboat Software

A full-featured Windows-based programmer's editor is here! ED is setting the standard with features like background compilation, automatic code indenting and completion, hypertext function/procedure lookups, "smart" language-specific editing, a fast "C" extension language, Windows Toolbar, unlimited undo and redo, keyboard macros and remapping, and emulation of popular DOS editors.

List: $269 **Ours: $169**
FAX*cetera* # 0233-0011

WindowsMAKER Professional 5.0
by Blue Sky Software

NEW VERSION!

Next generation of most powerful C/C++ Code Generator and Prototyper for Windows 3.1, NT & Win32s. The fastest way to create full-featured Windows apps. This product stands out, does everything, even a toolbar can be created with 1 click. Test run your design/make changes interactively, generate code for multiple platforms - ANSI C, MFC, OWL, etc., widest compiler support in industry. TrueCode technology - user code is 100% preserved. Highly recommended!

List: $995 **Ours: $695**
FAX*cetera* # 2602-0003

PRODUCT OF THE MONTH

Microsoft Visual Control Pack
by Microsoft Corporation

Offers 19 power programming shortcuts for the Windows™ operating system, including quick access to 3D interfaces, charting, and serial communications. You can even add multimedia or Windows for Pen Computing functionality in a fraction of the time it would take you to create your own support. Just add any of the 19 custom controls to your Visual C++ or Visual Basic Toolbox. Use the sample code and documentation with Visual C++ and create your own custom controls.

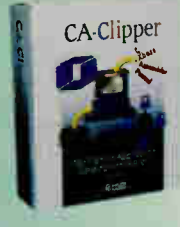
List: $150 **Ours: $99**
FAX*cetera* # 1269-0044

CA-dBFast Windows 2.0
by Computer Associates

The complete standalone dBASE/Xbase development language for MS Windows. Create fast, powerful, easy-to-use graphical applications. Over 200 extensions to the dBASE III PLUS language and includes an interactive editor, compiler, and linker. Challenge your creativity and imagination! Design multiple windows, pull-down menus, check boxes, list boxes, radio buttons, bit-map pictures, and more!

List: $550 **Ours: $359**
FAX*cetera* # 1004-0003

CA–Clipper 5.2 Competitive Upgrade
by Computer Associates



Yes, the newly released CA-Clipper version 5.2 is being offered to Xbase language product owners at the low retail price of $199. This competitive upgrade is available for a short term only! What a great opportunity to get the power of CA-Clipper, at a super price! And now when you buy, get your choice of dBFast, Clipper Tools or dBase Compiler Kit FREE!

List: $199 **Ours: $149**
FAX*cetera* # 5400-0001

dGT Unlimited!
by Blackhawk Data Corp.

PAINLESS PICTURES—The **Database Graphics Toolkit** (dGT Unlimited) turns any database into an image database. In three easy steps: 1) add a field to your database record; 2) add a line to your entry screen; and 3) ***RUN!*** Fast, powerful, reliable, flexible and now *Royalty-Free* up to 1000 copies. ***dGT Unlimited*** works with 40 different languages, runs on any VGA or EGA, supports images up to 1024x768, and can retrieve images from memo fields and BLOBs.

List: $595 **Ours: $449**
FAX*cetera* # 3051-0004

OS/2 2.0
by IBM

OS/2 2.0 increases your operating system choices by providing you with DOS, Windows and OS/2 support. Because OS/2 was created for use with 386SX and above processors, it offers full 32-bit addressability and true concurrent multitasking. OS/2 2.0 also features an object-based user interface, enhanced file system, advanced memory technology and the ability to complete many processes within a task simultaneously.

List: $195 **Ours: $126**
FAX*cetera* # 3142-0009

World Radio History

Programmer's Paradise®

MetaWare High C/C++
by MetaWare, Inc.

MetaWare, Inc. announces its newest product! The 32-bit High C/C++ compiler version 3.0 is a true compiler, not a C to C++ translator. "Incremental Strengths" let you specify the level of C++ compilation, allowing you to migrate from C to C++, one C/C++ block at a time. Included is a C++ tailored source-level debugger and a 32-bit Application Development Kit for Windows. MetaWare offers a full line of multi-language, multi-platform compilers for professional software developers.

List: $795 Ours: $669
FAX*cetera* # 1590-0008

VM Data
by PocketSoft, Inc.

VMData for Windows is a DLL that manages up to 128 MB of dynamic data. Eliminates annoying slowdowns commonly seen in 386 Enhanced Mode when programs use large amounts of dynamic data, and eliminates out-of-memory problems in Standard Mode. Provides superior run-time performance and ensures that your program is a good citizen under the Windows environment.

List: $495 Ours: $359
FAX*cetera* # 1987-0005

WinGEN
by Buzzwords International

Converts ObjectVision .OVD to Source Code!
Make the title bar disappear and run your application at compiled speed. WinGEN produces code for Windows versions of dBASE, C/C++, and Turbo Pascal. Supported engines include: Paradox Engine, Sequiter Codebase, POET, Raima, Faircom c-tree, Sybase, Novell Btrieve, Novell Btrieve with SQL/XQL Manager, OLE & DDE/DDEML, and Q & E. For technical information call 314-334-6317, for orders call 800-445-7899.

List: $149 Ours: $79
FAX*cetera* # 1873-0002

BASIC Network Library
Network C Library
by Automation Software Consultants, Inc.

The most comprehensive libraries available for NetWare software development, supporting all versions of advanced NetWare including 3.11. Over 450 C functions and 300 BASIC functions. Include any features from the NetWare command line utilities and menu utilities in your C or BASIC program. No licensing hassles. C library source code available.

BASIC Library List: $265 Ours: $229
C Library List: $295 Ours: $259
FAX*cetera* # 1004-9201

WATCOM C/386 9.0
by WATCOM

Develop and debug 32-bit applications for extended DOS, Windows, and OS/2 2.0 with the most complete 32-bit C development package available. Includes the royalty-free DOS/4GW DOS extender by Rational Systems, components from MS Windows SDK, compiler, linker, debugger, profiler, plus numerous development tools. Supports other industry standard 32-bit DOS extenders. Create ADS Applications for AutoCAD or embedded systems development.

List: $895 Ours: $599
FAX*cetera* # 1683-0003

Multi-Edit Professional
by American Cybernetics

A richly featured, easy-to-use programmer's text editor. Multi-Edit's flexibility and sheer power combine to provide you with unparalleled productivity. Features include: intuitive user interface, mouse support, syntax highlighting, cross directory multiple file search AND replace, color templates, and much more! Finally, a text editor that thinks like a programmer! Free demo disk available.

List: $199 Ours: $139
FAX*cetera* # 1846-0001

PROTOGEN 3.0
by ProtoView Development

NEW VERSION! The industry standard for code generation and prototyping Windows applications. Develop the user interface of your application using Visual prototyping methods. ProtoGen generates expert level, commented code for ANSI C, Microsoft NT Win32. All generators included! User Code is preserved from one generation to the next. It's easy and fast.

List: $99 Ours: $89
FAX*cetera* # 2553-0002

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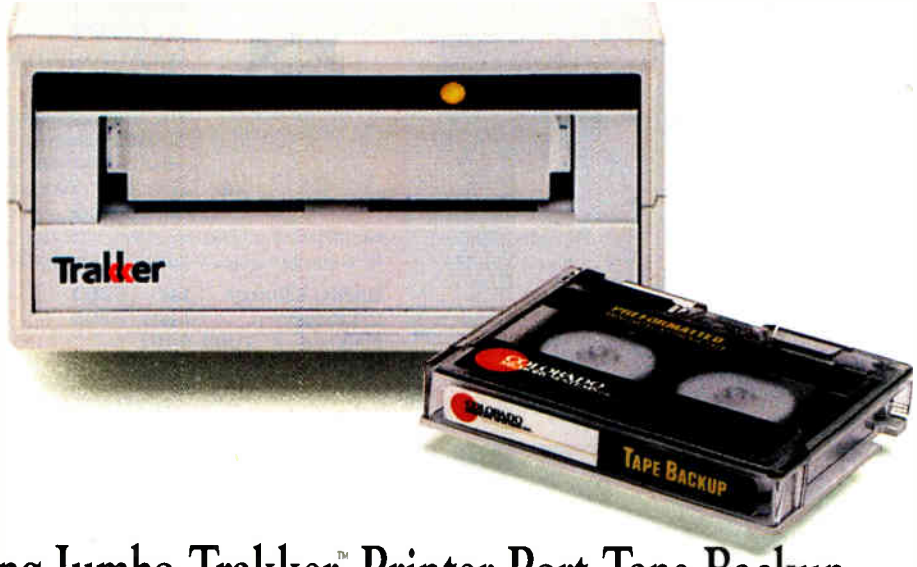

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Now, backing up your computer is easier than ever. Simply unpack Trakker and connect it to your computer's parallel printer port. That's it. No installation, no switches, no floppy disk shuffle. This is tape backup that's ready to go. And it *goes* anywhere. Trakker is light and compact, the ideal solution for backing up notebooks and laptops. And it *goes* fast. Trakker 250 boasts a data transfer rate of up to 8 Megabytes per minute, *easily* the fastest in its class. At $448, Trakker 120 is the price leader as well.

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World Radio History

Three-Way Computing Power

A hand-held computer that is a DOS and Windows notebook or a pen computer using Windows for Pen Computing, the Dauphin DTR-1 (for Desktop Replacement) is also a desktop machine when it is hooked to an external Super VGA monitor and PS/2 keyboard. The 2.2-pound computer, which can be hooked to your network via its internal Ethernet adapter, can send faxes as well as send and receive data via its internal fax modem.

The unit features a 25-MHz 486SLC processor and a Cyrix math coprocessor. With a 20-MB internal Hewlett-Packard Kittyhawk hard drive and data-compression software, the DTR-1 provides more than 30 MB of on-board storage.

The DTR-1's 2 MB of DRAM is expandable to 6 MB. An optional slide-on battery pack extends the life of the internal nickel-cadmium battery for as long as 10 hours.

Price: $2500.

Contact: Dauphin Technology, Inc., Lombard, IL, (800) 782-7922 or (708) 971-3400; fax (708) 971-8443.

Circle 1131 on Inquiry Card.

Single-System EISA and VL-Bus

One of the newest strategies to add power, speed, and flexibility to computers is to combine EISA and VESA (Video Electronics Standards Association) Local Bus (or VL-Bus) on the same system. Two companies that are proponents of this strategy are Tangent Computer and Diamond Technologies.

With the power of a desktop system, the DTR-1 is a hand-held pen computer or a notebook with a mini-keyboard.

The first systems in Tangent Computer's Universal Bus line of 486 workstations are the 433U-SX and the 466U-DX2 combination EISA and VL-Bus systems. Both are designed for upgradability to Pentium processors.

The 433U-SX system, with 4 MB of RAM and 64 KB of cache RAM, features three EISA slots, five ISA slots, and two VL-Bus slots. Other standard equipment includes a 170-MB IDE hard drive, an S3/805 VL-Bus graphics accelerator card, a caching EISA IDE hard drive controller with 512 KB of RAM, a 1.44-MB floppy drive, and a 14-inch VGA color monitor.

The 466U-DX2 has a basic configuration of 8 MB of DRAM and 256 KB of cache RAM. A 200-MB SCSI drive and a Weitek 9000–based VL-Bus graphics accelerator, a SCSI caching controller with 512 KB of RAM, eight EISA slots, one VL-Bus slot, a 1.44-MB floppy drive, and a 14-inch VGA color monitor complete the basic system. The unit is expandable to 256 MB of DRAM and 1 MB of CPU cache memory.

Price: 433U-SX, $1895; 466U-DX2, $3295.

Contact: Tangent Computer, Inc., Burlingame, CA, (800) 800-6060 or (415) 342-9388; fax (415) 342-9380.

Circle 1132 on Inquiry Card.

Diamond Technologies' DT486 ISA/EISA Local Bus tower computer is available as a 486DX machine running at a maximum speed of either 50 or 66 MHz. Each model includes 256 KB of cache memory and a socket for a Weitek 4167 coprocessor. Eight SIMM sockets on the motherboard provide memory options in modules of 256 KB by 9, 1 MB by 9, or 16 MB by 9 DRAM SIMMs, up to a total of 128 MB of memory.

The system has a VL-Bus graphics accelerator card and eight I/O expansion slots, of which three are 32-bit EISA slots, five are 16-bit ISA slots, and two are 32-bit VL-Bus slots. Hard drives range from 40-MB IDE to 2-GB SCSI drives. A 14-inch monochrome monitor is standard with the basic system; optional monitors are available.

Price: $1999.

Contact: Diamond Technologies, Inc., Irvine, CA, (800) 989-7253 or (714) 252-1008.

Circle 1133 on Inquiry Card.

Network from Your Notebook

A lightweight, slim-line, 25-MHz 486SLC–based notebook, the New World 4100 lets you connect optional pocket network adapters to its expansion bus. This provides a seamless connection to other computers, including mainframes, PCs, and PC-based file servers.

The New World 4100 has a data transfer rate of 4 MBps, 1200 percent faster than a network connection via the parallel port, according to New World. The unit supports interfaces for Ethernet, token-ring, 3270, 5250, and X.25 networks.

Other features include 4 MB of RAM (expandable to 8 MB via IC memory cards); an 80- or 120-MB hard drive; a 1.44-MB floppy drive; a 10-inch backlit LCD; an external keyboard port; serial, parallel, and mouse ports; an I/O bus for a docking station; and an auto-switching AC adapter. DOS 5.0 is installed.

Price: $1695; network adapters, $239 and up.

Contact: New World Technologies, Inc., Ashland, MA, (800) 443-8885 or (508) 881-4600.

Circle 1134 on Inquiry Card.

World Radio History

A Busy Companion

Designed to fit under your monitor or attach to your notebook, the Companion peripheral expansion subsystem lets you add peripherals to your computer without having to add more cards. The unit, which plugs into your system's parallel port, has a pass-through port for your printer as well as a pass-through SCSI connector that lets you add more peripherals.

Two front-accessible 5¼-inch bays accept CD-ROM drives, tape-backup drives, and hard drives, including optical and floptical models. Two internal bays are available for half-height 3½-inch drives. The Companion also has a fully integrated surface-mount parallel-port-to-SCSI board, software support for additional SCSI peripherals, and a universal power supply.
Price: Without peripherals, $400; with peripherals installed, price depends on configuration.
Contact: Performance Electronic Packaging Services, Inc., San Marcos, CA, (800) 255-8607 or (619) 471-5383; fax (619) 471-9691.
Circle 1135 on Inquiry Card.

Two of the Companion's uses are as a portable docking station and as a CD-ROM reader.

Scanning in Color

Two color scanners—one for 35mm slides and the other for paper—are now available. Both are priced for the general market.

A color scanner for 35mm film, Coolscan (also known as the LS-10) is available as an internal unit for your PC or as an external unit for Macs and PCs. The scanner is designed for desktop applications and accepts black-and-white negatives and transparencies in addition to color.

Coolscan captures 24 bits per pixel in a single-pass RGB scan with a maximum resolution of 2700 dpi. Nikon's LED-based illumination technology achieves broad-spectrum output, permitting blues to be scanned as effectively as reds and greens. This technology also produces little heat.

The scanner has a footprint of 6 by 13 by 2 inches and is geared for use by medical and industrial publishers and professionals in real estate, education, insurance, and architecture.
Price: Internal model, $2195; external model, $2495.
Contact: Nikon Electronic Imaging, Melville, NY. (800) 526-4566 or (516) 547-4355; fax (516) 547-0305.
Circle 1136 on Inquiry Card.

A desktop sheet-fed scanner for professional-image database and entry-level document management, the Plustek ADF Color 6000 features single-pass scanning in all modes, including color. The RGB scanner can scan a 600-dpi color page in 5 minutes, a 600-dpi 256-gray-scale page in 1½ minutes, and a 300-dpi black-and-white page in 7 seconds. In color mode, the unit provides 256 to 16.8 million colors, depending on the color card you're using. The unit measures about 13½ by 9¾ by 4 inches and has a 50-page document feeder.
Price: $1299.
Contact: Plustek USA, Inc., Santa Clara, CA, (800) 685-8088 or (408) 980-5183; fax (408) 980-5184.
Circle 1137 on Inquiry Card.

Portability with a Handle

The portable PST²-MO128 rewritable MO (magneto-optical) drive connects to the serial, parallel, or SCSI-2 port of your PC. The unit has an average seek time of 45 ms and a data transfer rate of 7 MB in just over a minute. It has a disk capacity of 128 MB and includes the Valitek PST² board with 256 KB of fast cache. A noncontact read/write head with a digital servo system keeps your data safe for more than 10 years.
Price: $2295.
Contact: Valitek, Amherst, MA, (800) 825-4835 or (413) 549-2700; fax (413) 549-2900.
Circle 1138 on Inquiry Card.

The PST²-MO128.

Dot Matrix Goes Quiet

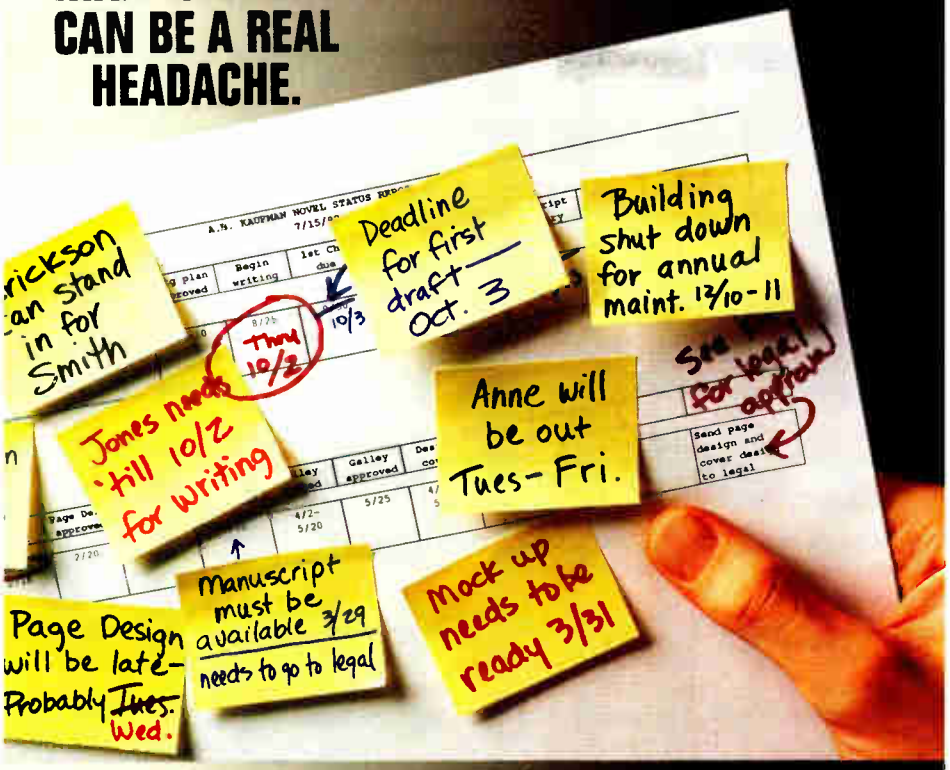
Citizen America's newest entry in its Quiet Color line of dot-matrix printers is the GSX-190. A nine-wire printer, the GSX-190 features the Citizen Acoustic Technology for a claimed sound rating of only 45 dB.

Draft-mode printing speed goes up to 240 cps, and the high-resolution print quality is 240 by 216 pixels. The unit's eight built-in fonts are Roman, Sans Serif, Courier, Prestige, Script, Orator, Draft, and High-Speed Draft.

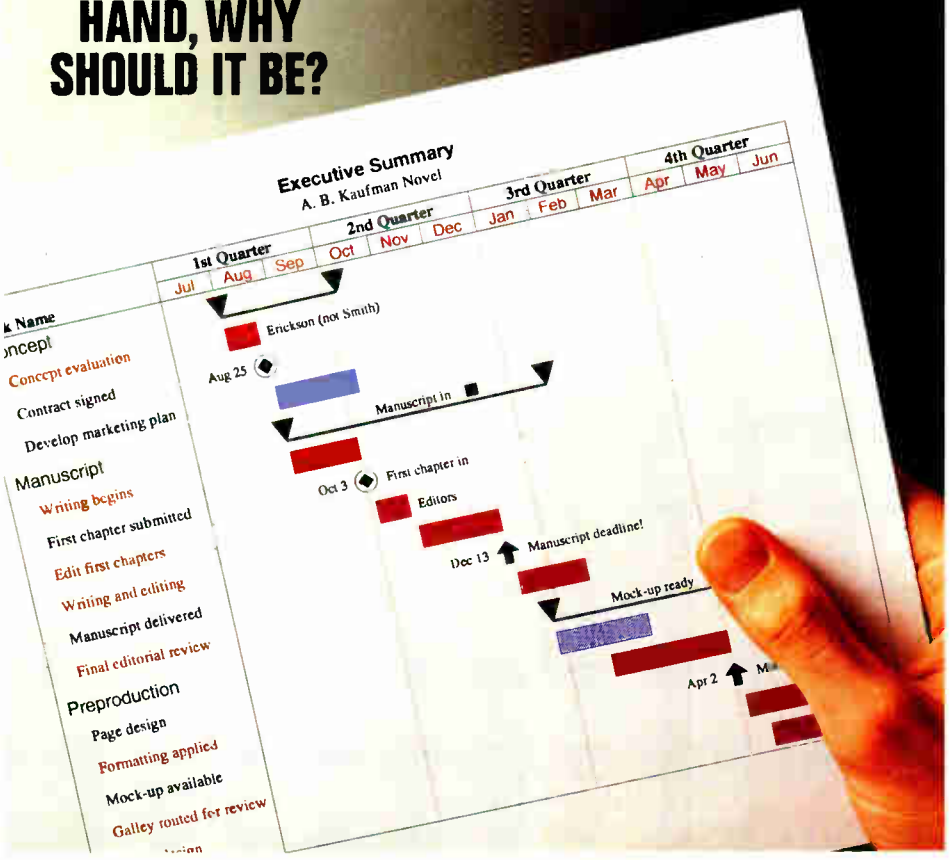
You select your printing options from the plain-English menu choices displayed on the front panel and save the changes with a push of a button. Paper-handling features include a convertible push/pull tractor feed and paperfeed paths on the top, rear, and bottom for switching among forms, letterhead paper, fanfold paper, envelopes, and labels. You can add color printing to the unit by installing the Color On Command kit option ($59), which lets you print up to 256 colors in text and graphics.
Price: $299.
Contact: Citizen America Corp., Santa Monica, CA, (310) 453-0614; fax (310) 453-2814.
Circle 1139 on Inquiry Card.

World Radio History

ON ONE HAND, PROJECT MANAGEMENT CAN BE A REAL HEADACHE.



ON THE OTHER HAND, WHY SHOULD IT BE?



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V.32bis Fax Modem

The SmartLink V32bis FaxModem combines the latest modem chip-set technology with the Motorola 68302 microprocessor and specially written control software held in two flash EPROMs. The company uses the same technology in the Quad and QuadFax versions.

The modems support V.21, V.22, V.23, V.22bis, and Group 3 fax standards, plus MNP levels 2–4 and V.42 error correction. The top-of-the-range models add support for the V.32 and V.32bis data standards. MNP level 5 and V.42bis data compression further boost speed and reduce call charges by up to four times. The built-in data-compression speeds approach basic-rate ISDN, providing potentially more cost-effective data transmission for future applications, such as multimedia.

The packages include a power supply, a telephone cable, a double BT adapter, an RS-232 cable, documentation, and a choice of communications software for IBM PC–compatible or Apple computers.

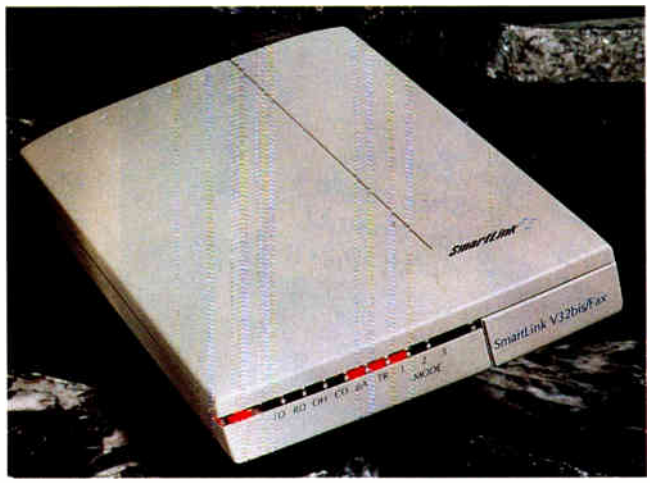
Price: SmartLink V32bis FaxModem, about $1013 (£699); Quad version, about $506 (£349); QuadFax version, about $578 (£399).

Contact: SmartLink Communications, Ltd., Reading, Berkshire, U.K., +44 734 587788; fax +44 734 588057.

Circle 1140 on Inquiry Card.

Workgroup Faxing

A low-cost workgroup faxing device, Faximizer puts the power of PC faxing in every office. Faximizer allows up to eight users to send faxes from their PC or Mac without having to install fax modems and phone lines for each PC and without a LAN. For offices that already have a LAN, Faximizer can be a cost-effective alternative to a dedicated fax server and LAN network software.



For high-security applications, the SmartLink V32bis FaxModem includes data encryption, password access, and dial-back security.

Faximizer is a complete plug-and-go system. You simply plug the supplied cables onto each PC's RS-232 port, load the supplied Quick Link II send/receive fax software, plug in the telephone lines, and start sending faxes.

In addition to faxing, Faximizer also provides modem-to-modem communication while spooling faxes from the other PCs. Then it automatically sends the spooled faxes when the modem is free. Other features include fax scheduling and fax broadcasting from custom directories.

The eight-user Faximizer system comes with 1 MB of SIMM memory (expandable to 4 MB), an internal 9600/2400 V.22bis fax modem (upgradable to a 14,400-bps V.32bis fax modem), Quick Link II faxing software for DOS and Windows, and a cabling kit for nine- and 25-pin PCs.

Price: $895.

Contact: Western Telematic, Inc., Irvine, CA, (800) 854-7226 or (714) 586-9950; fax (714) 583-9514.

Circle 1143 on Inquiry Card.

Remote Boot Technology

A remote boot system, BootWarePlus eliminates the need to change remote boot PROMs each time you upgrade your LAN with a new disk or network operating system. BootWarePlus consists of Lanworks' SmartROM, which enhances a network interface card's ROM socket by allowing read and write access to it, packaged with initialization, configuration, and utility software.

The BootWarePlus utility disks contain software tools such as ROMscan and MapGen. A diagnostic utility, ROMscan finds and reports detailed information on every BIOS option ROM in your workstation. MapGen reads existing DOS image files and writes them to a RAM disk, which emulates a local drive. The utility lets LAN administrators view and modify DOS image files without having to refer back to the original floppy disks from which the image was generated.

Price: $79 per workstation.

Contact: Lanworks Technologies, Inc., Mississauga, Ontario, Canada, (416) 238-5528; fax (416) 238-9407.

Circle 1141 on Inquiry Card.

Messages Network

Now, instead of filling out a paper "While You Were Out" form, you can fill out a similar message form on your PC screen (or any node on the network), and Software Grove Messages Network automatically delivers the message across the network. The software for Windows and Windows for Workgroups also provides instantaneous visual and audible notification of waiting messages.

Software Grove Messages provides automatic filling of message fields (e.g., date, time, and message taker; and company name and telephone number for repeat callers). The package lets you add notes to messages; send messages to individuals or groups; edit, password-protect, and encrypt messages; and search for back-up copies of messages.

Price: Single-user version, $69.95; five-node package, $249; 10-node package, $399; $599 per server.

Contact: Software Grove Corp., Kirkland, WA, (800) 793-0040 or (206) 823-0833; fax (206) 823-1246.

Circle 1142 on Inquiry Card.

World Radio History

Cross platforms easily.

New Timbuktu is the easiest way to network Macintosh and Windows computers, so you can share printers, files and screens.

Call today for a free demonstration video: 1-800-998-7760 ext. 4.

MacUser ★★★★½
PC Week Labs Overall Score 4.2
Macworld ★★★★
LAN Times 5 Nodes

Moving information between Macintosh® and Windows™ computers used to be quite a feat of skill. Let alone nerves.

But now there's Farallon's new Timbuktu® for Macintosh and Windows.

Timbuktu is the easiest way to create a peer-to-peer network. So, whether you're on a PC or Mac, you can share expensive peripherals like printers. And exchange files quickly and easily.

You also get a unique benefit—remote control. Timbuktu can send a real-time, full-color picture of your screen over the network so you can control and view it from another Mac or Windows PC. This lets you use your network for new things like collaboration and user support.

MICROSOFT® WINDOWS™ COMPATIBLE

yes It runs with NetWare

Of course, Timbuktu is easy to use and install. You don't need a dedicated gateway or server. And it works with what you've got. Even other networks on NetWare or TCP/IP.

For a free Timbuktu product demo video, just call. It's that easy. **1-800-998-7760 ext.4.***

Farallon
Power to the network.™

***Call 1-800-678-5075 for upgrades from Timbuktu and PhoneNET PC (previously AppleShare PC and PhoneNET Talk). Upgrades also available for SitkaTOPS and Carbon Copy.**

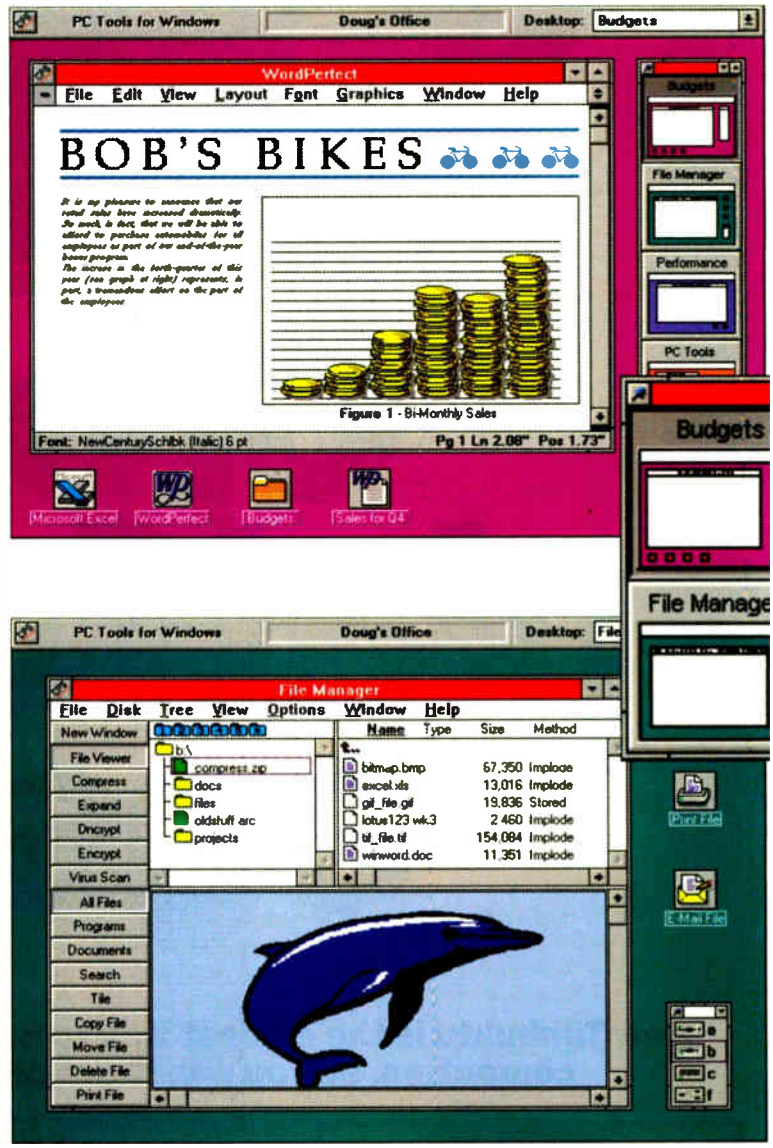
A copy of Timbuktu is required on each machine on the network. Single- and multi-packs are available.

All trademarks are property of their owners. ©1992 All rights reserved. For customer service, call (510) 814-5000. Or contact us on America Online® or AppleLink® ID: Farallon. CompuServe® ID: 75410, 2702. Internet ID: Farallon@farallon.com.

Circle 86 on Inquiry Card.

World Radio History

Introducing PC To
Just think of it

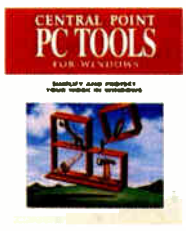


[1]
Organize and simplify your work.

Our unique MultiDesk desktop manager lets you put related applications, folders and files into their own separate desktops. Set up as many desktops as you like, then switch between them instantly. It all adds up to a less cluttered, more productive Windows environment that works like you do.

[2]
Improve the speed and efficiency of common tasks.

Our integrated File Manager has advanced drag-and-drop capabilities that let you quickly locate, view, copy and print files. With over 75 viewers, you can scan files (including compressed PKZIP data) without having to open their applications first. Hate to turn off your PC because you don't want to set everything up again? Our DeskSaver feature solves that problem too.



Windows® is a great product. And someday, it'll be even better. But why wait?

New PC Tools™ for Windows® is here right now. It saves you time, reduces clutter and gives you easy access to all the functions and files you use most often. In fact, PC Tools for Windows is so innovative that after reviewing it, the editors of PC/Computing asked, "Who needs Macs?"

For starters, there's our unique MultiDesk™ desktop. MultiDesk is an intuitive desktop manager that lets you organize your work by creating as many desktops as you need for your projects, tasks, or clients. So, if you spend the day switching between many different projects, you won't lose anything in the clutter.

Ever misplaced a file or couldn't remember its

**Our lawyers said we could run this headline if we make the following absolutely clear: Windows is a trademark of Microsoft Corporation. PC Tools for Windows is the sole product of Central Point Software, Inc. Microsoft and Central Point,® PC Tools;™ MultiDesk;™ WinShield;™ Speed Keys,™ System Consultant™ and DiskFix™ are trademarks of Central Point Software.*

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ols™ for Windows.®
as Windows 4.0.*

[3]

Enhance your system's performance.

System Consultant™ performs over 400 system checks and provides recommendations for improving your PC's performance. Our Disk Optimizer can automatically defragment your hard disk at prescheduled intervals, or on command.

[4]

Automatically protect your data.

We've included new Windows versions of Backup, Undelete, Anti-Virus and DiskFix.® They're all integrated in WinShield,™ an automatic data-protection system that results in worry-free computing. Our Emergency Disk builds a bootable recovery disk to help get a crashed system up and running fast.

name? Our File Manager lets you quickly view files without having to load the program first. Tired of cryptic, abbreviated file names? Now you can attach long file names to your data to keep things clear and simple.

We also created Speed Keys™ so you can take shortcuts through Windows, and System Consultant that gives you specific tips for improving system performance.

PC Tools for Windows is at your nearest dealer.

For more information, a free demo disk, or to upgrade from PC Tools for DOS, call us at **1-800-967-9251.** Your purchase is backed by our 60-day guarantee.

Find out for yourself why the editors are already heralding PC Tools for Windows as "The ultimate desktop." It may just be the best thing since, well...Windows.

Central Point Software, INC.®

Central Point Software did not collaborate on this product, and this ad is not in any way sponsored by Microsoft. PC Tools for Windows does not replace Microsoft Windows or any future version thereof; it simply complements it. Names of other products mentioned herein are used for identification purposes only and may be trademarks of their respective companies.

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NEWS

WHAT'S NEW • PROGRAMMING SOFTWARE

Visual Application Development

Magic 5.0 is a visual, nonprocedural applications development paradigm that lets you design, prototype, test, and modify applications in one step. In Magic, you program applications by description and logic, eliminating the need for writing code. Magic also provides transparent cross-platform portability and interoperability, so you can create applications on one platform and then immediately run them on other platforms, operating systems, and hardware without any modifications.

Magic's client/server architecture lets you access data across LANs and WANs (wide-area networks). Communication between heterogeneous environments is handled through industry-standard communications networks and protocols, such as LAN Manager, Novell NetWare, DECnet, and TCP/IP.

Price: Stand-alone DOS development license, $800; LAN development license, $1500.

Contact: Magic Software Enterprises, Inc., Irvine, CA, (714) 250-1718; fax (714) 250-7404.

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Utilizing 13 nonprocedural operations, Magic 5.0 automates the entire application development life cycle.

Error Detection for SPARC

The latest version of Pure Software's run-time error-detection tool for C and C++ Unix developers, Purify 2 includes an incremental linker for rapid turnaround and a mail mode for remote error reporting. Purify also features object-code insertion technology, which parses the object code and adds commands around every memory function to monitor memory usage at run time and report illegal memory accesses and memory leaks.

The incremental linker lets you interactively debug the software, making single changes and then observing their effects as the application runs. Purify's mail-mode remote error–reporting feature transparently detects bugs in software as other developers run it. The program then sends E-mail with error diagnostics back to a designated developer.

Price: Floating network license, $4000.

Contact: Pure Software, Inc., Sunnyvale, CA, (408) 720-1600; fax (408) 720-9200.

Circle 1274 on Inquiry Card.

Object-Oriented Database for C++

BKS Software has added enhanced capabilities in object locking, transaction support, and event handling to POET 2.0, the latest version of its object-oriented database system for C++ applications development. POET is available as an NLM (NetWare loadable module) for Novell's NetWare 3.x, and its binary database file compatibility also accommodates heterogeneous networks.

POET provides load, store, and query capabilities, as well as eliminating translation when moving data between object-oriented applications and file-oriented database systems based on the relational model. Applications you write in POET remain object-oriented, so code is reusable, maintainable, and extendable.

Price: Development license supporting one to four users, $2700.

Contact: POET Software (formerly BKS Software), Santa Clara, CA, (408) 748-3403; fax (408) 748-9060.

Circle 1273 on Inquiry Card.

Macintosh Programming in C

VIP-C provides a comprehensive environment for programming in ANSI C on the Mac. It lets you write specific algorithms that link automatically generated interface code to specific program functions.

VIP-C contains five levels—a visual C text editor/interpreter/debugger, prototypes of Mac Toolbox calls, precoded VIP-C Functions, integrated VIP-C Resource Editors, and the VIP-C Dispatcher, which facilitates building applications. You can write code in the text editor using standard ANSI C and Mac Toolbox calls or using the higher-level Functions. You use the VIP-C Resource Editors and Dispatcher to automatically set up an application's main event loop and user interface elements. VIP-C provides a library of standard C functions, which it stores in a customizable palette.

Price: $495.

Contact: Mainstay, Agoura Hills, CA, (818) 991-6540; fax (818) 991-4587.

Circle 1275 on Inquiry Card.

Photo CD Access for Sun/Unix

The Kodak Photo CD Access developer toolkit for Sun/Unix helps you build a flexible user interface to images stored on Photo CD discs. The toolkit consists of a library of the basic C-language functions you need to read images from a Photo CD disc into memory in formats that are compatible with Sun/Unix. The toolkit also provides the functions you need to export the images as industry-standard file formats.

You can read the images in standard color and gray-scale formats, including 24-bit RGB color. In addition, the toolkit provides basic image-manipulation capabilities that can expand compressed images and convert them to other formats.

Price: $695.

Contact: Eastman Kodak Co., Rochester, NY, (800) 242-2424 ext. 53 or (716) 724-6404; fax (716) 724-9829.

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Since when is Raima first in Corporate Database Development?

Since April 7, 1992

Raima Database Manager was the database of choice in the First Annual Windows World Open. The competition featured innovative custom applications built with Windows development tools. Three of the seven winners, and two of the finalists, used *Raima Database Manager* to solve their critical application needs.

For professional developers like yourself, Raima products offer:

- *High performance:* unmatched application speed.
- *Portability:* runs on DOS, Windows, OS/2, UNIX, VMS, QNX.
- *Royalty-free distribution:* increase your profits.
- *Source-code availability:* total programming flexibility.
- *Affordable pricing:* starting at just $395.
- *Language support:* ANSI C, C++, and Visual Basic.

Listen to what some of our customers say about our products:

"No other products matched Raima for the price."
James Lisiak, developer, Chevron

"Raima provided us with speed, flexibility, and royalty-free distribution which allowed us to meet and exceed our customers' needs."
Dave Cooper, developer, Atlantic Research Corp.
subcontractor, Naval Electronic Systems Engineering Activity

"Database Manager gave us the edge we needed to handle large amounts of data quickly and efficiently within Microsoft Windows."
Kelly Patrick, developer, PHH Fantus

If you're looking for an award-winning application development tool, give us a call. And discover the Raima advantage.

Raima Database Manager *The high-performance DBMS*
Raima Object Manager *The object storage class library*

1-800-DB-RAIMA Also available for DOS, OS/2, and UNIX

Raima Corporation [illegible]

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Finite Element Modeling

LapCAD 5 for the Mac simplifies the creation of finite element analysis models. Release 5 adds layering, which lets you split the model into as many as 15,000 layers, modify individual layers, and display stresses on selected interior components. LapCAD can also handle an unlimited amount of loading conditions.

The software provides element mesh generation and replication, and standard geometric shapes that you can use as a starting point for the model. LapCAD lets you perform model editing by copying, mirroring, rotating, translating, expanding, contracting, deleting, snapping, and extruding. It writes the model files in MSC (MacNeal-Schwendler Corp.)/pal 2 format (for PCs) and MSC/NASTRAN format (for workstations and mainframes) for subsequent stress and vibration analysis. Once the analysis has been performed, LapCAD reads MSC/pal 2 and MSC/NASTRAN results for display (e.g., deformed shape, stress contour plots, and animation).
Price: $195 to $595, depending on the number of nodes.
Contact: LapCAD Engineering, San Diego, CA, (800) 343-3641, or phone and fax (619) 467-1947.
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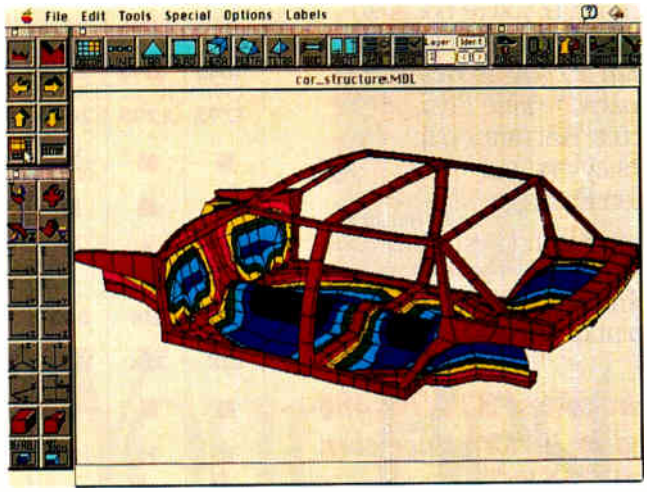

With LapCAD 5 for the Mac, you can zoom in or out and rotate the model as desired (including real-time animation), as well as label elements, grid points, loads, and element and material properties.

2-D Chemical Diagrams

A software tool for 2-D chemical-diagram drawing, ChemDiagram 2.0 for Windows helps you create complex-structure diagrams; move, scale, stack, and rotate them; add labels and text; create illustrations of your research documentation; and produce publication-quality output. The package includes 2-D diagraming tools, illustration tools, a text processor, and page-layout tools.

ChemDiagram's diagram-drawing tools include 12 bond tools, 12 ring tools, three atom tools, and 12 orbital tools. The software also features adjustable "snap to" drawing guides for atom positions, bond lengths, bond angles, and labels, and adjustable parameters such as line weights, fonts, colors, and bond stacking. The ChemGRFX feature lets you import and export vector- and raster-based molecular graphics images via graphics files and the Windows Clipboard. Full support for cut-and-paste operations lets you transfer illustrations into other Windows and DOS-compatible applications.
Price: Single-user industrial license, $349.
Contact: Molecular Arts Corp., Anaheim, CA, (714) 634-8100; fax (714) 634-1999.
Circle 1280 on Inquiry Card.

Civil Engineering Software

Stardust is a Windows 3.1 software package for surveying, digital terrain modeling, and road designing. The package comes in three integrated modules: Survey, Terrain, and Road.

The Survey module provides a host of calculation routines, including least-square adjustment and road geometry. The Terrain module uses free-form lines and polygons as its modeling tools and also provides a full set of options for volumes and contouring. The sectional-based Road module offers a complete set of graphic-design tools and routines for areas and volume measurement, along with specific on-site control for day-to-day measurement and monitoring.

Stardust can talk to other Windows programs via DDE, so you can import and export information to and from other Windows applications.
Price: About $2320 (£1600).
Contact: Softcover International, Ltd., London, U.K., phone and fax +44 71 373 6368.
Circle 1281 on Inquiry Card.

Chart Asteroids

Ceres is an astronomy package that calculates data and plots sky paths for more than 5000 asteroids. The database of asteroids includes number and name, orbital elements, magnitude, residuals, perturbations from major planets, mean motion, and publication data. In addition, you can edit, browse through, add to, import, and export the asteroid data.

Ceres lets you generate ephemerides of asteroid position versus time of high accuracy in several formats. The ephemeris can be geometric, astrometric, apparent, or rectangular, and the point of view can be from the planets or the moon, as well as from Earth. Besides using the built-in database of asteroids, you can get ephemerides of other bodies (e.g., comets) by inputting the orbital elements for any other body, or you can input rectangular coordinates and velocities for the program to solve for the body's motion.

You can get variable size and orientation views of up to seven asteroid orbits on-screen at one time, along with the orbits of Earth and Jupiter for reference. You can change the latitude and longitude reference positions and increase, decrease, or pause the rate of orbital motion.
Price: $159.95.
Contact: Zephyr Services, Pittsburgh, PA, (800) 533-6666 or (412) 422-6600; fax (412) 422-9930.
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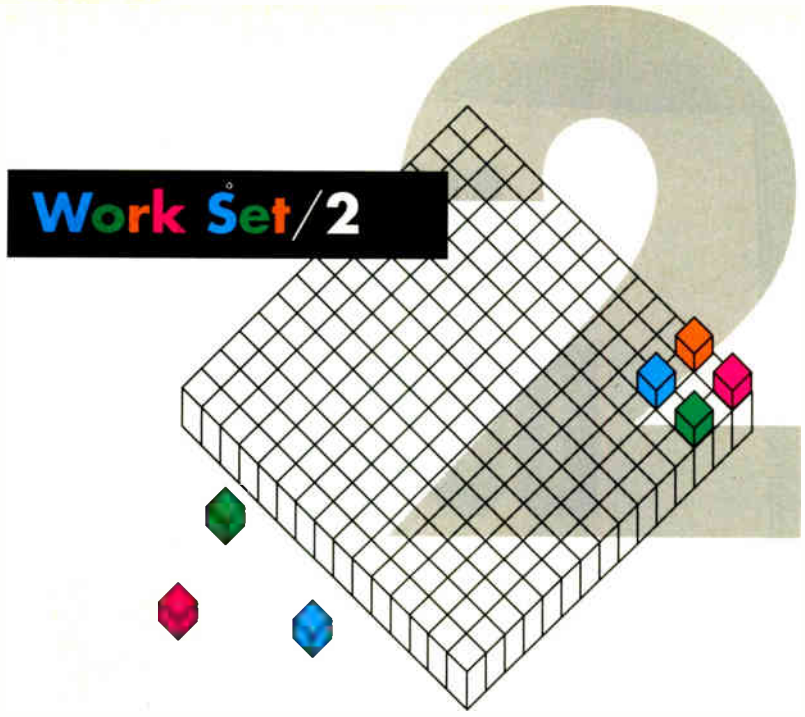

Powerful New Tools for OS/2 Programming

The WorkFrame/2 product ... because the best environment for application development is the one you create yourself.

With WorkFrame/2, you can integrate your choice of development tools – including those for DOS and Windows. It's open, configurable and language independent. And it's easy to customize the WorkFrame/2 interface to create your own development environment.

The concept is simple. WorkFrame/2 organizes files into logical units called projects. By associating each project with your personal choice of compiler/debugger/linker/editor you can get the greatest productivity possible from all your development tools.

The C Set/2 product ... because application development should be fast – and simple!

C Set/2 delivers a one-two punch to help you create some of the fastest-performing OS/2-based applications possible.

First, the 32-bit C compiler enables your applications to exploit the speed and power of 386- and 486-based computers. It's the best high-performance code optimizer in the business. With the C Set/2 compiler, unsafe optimizations simply don't exist.

Second, C Set/2 comes with a fully interactive, full-function, source-level 32-bit Presentation Manager debugger. Just point your mouse and shoot, using the graphical PM user interface – or use the keyboard.

Either way it's easy. And you'll get instant feedback on the screen to verify what you're doing. Debugging has never been so simple!

And there's more. The C Set/2 compiler conforms to industry standards – including ANSI C and ISO/IEC – and offers Microsoft C compatibility. With features like a full suite of run-time libraries and 32-16 bit linkage, you can be sure C Set/2 will provide the function and flexibility you need to make application development fast and simple – the way it should be.

OS/2 2.0 Developer's Toolkit ... because it takes the right set of tools to build powerful applications.

OS/2 2.0 Developer's Toolkit is the perfect companion to use with C Set/2. It contains a variety of language-independent application build and productivity tools. For the C Set/2 compiler, Toolkit provides the system linker and system header files. It also contains the import libraries and the NMAKE utility you need to dramatically increase the capabilities of C Set/2 to build powerful applications.

To order or get more information on how IBM application development tools can work in your OS/2 environment,

in the USA call 1-800-342-6672
in Canada call 1-800-465-7999

Making good things happen in application development ... IBM®

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DOC-IT Manager

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NOW YOU CAN SCAN A GRAPHIC INTO A FAX YOU JUST RECEIVED...

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DOC-IT Manager

DID FOR SOFTWARE, HARDWARE.

It's the first desktop document processor. It's part hardware, part software, and part sheer genius. It's going to multiply the power of your work. It's going to turn document processing from a chore into a breeze. It's going to make you more efficient, more productive, more creative. To receive your own on-screen demo disk, or the name of a dealer near you, call ***1(800)OKIDATA****. And get ready to see your desktop again.*

...EDIT THE GRAPHIC ON-SCREEN AND PRINT IT OUT...

DOC-IT OPENS YOUR WINDOW TO INCREASED PRODUCTIVITY.

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A GUI for AutoCAD

A programmable GUI for AutoCAD 286/386 releases 10 to 12, AutoPix features menu panels that support AutoCAD's menu features, including pause and auto-repeat. AutoPix emulates AutoCAD's prompt area, screen menu, status line, and pull-down menus by displaying them in movable panels. The program lets you have any number of panels active simultaneously, and you can open, close, move, resize, scroll, and shrink them into icons and expand them back to full size.

AutoPix includes a complete AutoCAD menu system with more than 50 AutoPix menu panels and 50 AutoLisp programs and their more than 100 support panels. AutoPix can work with existing AutoCAD menus.
Price: US$175.
Contact: Upper Canada Software, Inc., Stratford, Ontario, Canada, (519) 272-0986.
Circle 1284 on Inquiry Card.

AutoPix displays AutoCAD's prompt area, screen menu, and pull-down menus in movable panels that you can resize and shrink into icons when not in use.

English/Metric Conversion

Metric Calc, an English/metric, metric/English conversion program for DOS and Windows, helps you write and respond to requests for purchases, specifications, and other government correspondence. The program complies with the International System of Units definitions of seven base units, two supplemental units, and 19 derived units.

The package includes both DOS and Windows versions. You can run the DOS version as a normal application or as a TSR program from within other applications. Metric Calc covers units such as linear measure, volume, weight, force, energy, pressure, temperature, and moment of inertia. Context-sensitive help is available from anywhere within the program.
Price: $49.95.
Contact: MBC Enterprises, Huntington Beach, CA, (714) 647-5534.
Circle 1285 on Inquiry Card.

Measure System Performance

Speed Test for Windows gives you accurate measurements of your system's CPU, FPU, and video performance. You can configure the Speed Test to measure the performance of your system using the same types of programs you would normally use. A data capture feature saves all the test results to an internal database.

The database contains results of tests performed by Landmark Research International's lab, for dozens of popular products. You can compare the results for the different applications tested and quickly determine the best system or upgrade for the price.
Price: $49.
Contact: Landmark Research International Corp., Clearwater, FL, (813) 443-1331; fax (813) 443-6603.
Circle 1286 on Inquiry Card.

Compress Images

Iterated Systems has added advanced compression technology and OLE server capabilities to Images Incorporated III, the latest version of its Windows-based program for database, presentation, multimedia authoring, and desktop publishing applications. Version III also includes support for Fractal Transform Template files and an Archive mode, which combine to increase compression performance by from 20 percent to 90 percent.

Images Incorporated functions as an OLE server for fractal compression, decompression, and resolution enhancement. Other new features include background compression and support for Iterated's Fractal Transform compression boards, which, the company says, accelerate compression time by at least 300 percent.
Price: $299.
Contact: Iterated Systems, Inc., Norcross, GA, (404) 840-0310; fax (404) 840-0806.
Circle 1287 on Inquiry Card.

Disk-Mirroring Software

A software-based disk-mirroring and disk-duplexing system, Immunity 2.0 provides real-time data protection for DOS and Windows 3.0. Immunity is a device driver that provides complete fault-tolerant data protection to stand-alone computer systems and LANs by writing all data, with every save, to two separate hard disks contained in the same PC. In the event of a hard disk failure, the PC will read and write to the disk that is live, saving the system from down time and data loss.

Immunity's Windows interface speeds up the process of choosing mirroring options. The package also offers error logging and a fast seek option. When Immunity detects an error, it automatically logs all the pertinent information to a file on the good hard disk. Since identical data is in two places at all times, Immunity can actually speed hard disk access time by reading from the hard disk whose head is closest to the data.
Price: $249.
Contact: Unitrol Data Protection Systems, Inc., Vancouver, B.C., Canada, (800) 665-2212 or (604) 681-3611; fax (604) 681-3615.
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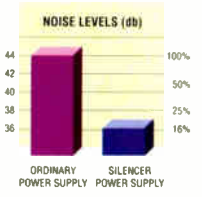
Power Packed Upgrades.

STANDARD UNITS

These UL/CSA approved, fully-tested power supplies are the best basic units available.

STANDARD 200 XT **$69**
STANDARD 205 SLIM **$89**
STANDARD 220 BABY **$89**
STANDARD 220 AT/TOWER **$89**

ULTRA-QUIET UNITS



Unrattle your nerves with a **Silencer** power supply, recognized since 1986 as the industry's quietest. Cooled with efficient, variable-speed fans that are virtually inaudible!

A must for home office or *multimedia* applications.

SILENCER 205 SLIM **$119**
SILENCER 220 AT/TOWER **$129**
SILENCER 270 AT/TOWER **$179**

HIGH-PERFORMANCE UNITS

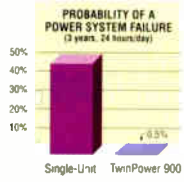
Upgrade your computer with one of our premium **Turbo-Cool** power supplies—the choice of PC professionals. You'll get 50% - 100% more power, built-in line conditioning, a dual-stage EMI filter, super-tight regulation, ultra-clean DC output, our high-capacity **ThermaSense** variable-speed fan (300W models), UL/CSA/TUV approvals, and a no-hassle 2-year warranty! Ideal for high-end workstations and network file servers.

TURBO-COOL 200 XT **$159**
TURBO-COOL 300 SLIM **$169**
TURBO-COOL 300 BABY **$169**
TURBO-COOL 300 AT/TOWER **$189**
TURBO-COOL 450 AT/TOWER **$349**

REDUNDANT POWER SYSTEM

Eliminate the risk of network downtime or data loss due to power supply failure with the **TwinPower 900** redundant power system. It delivers high-capacity, fault-tolerant power to your entire network server. Consists of two **Turbo-Cool 450** power supplies in parallel, utilizing a special power-management interface module. A must for mission critical LANs.

- **Super Server Power.** With 900 watts of peak power, the TwinPower 900 effortlessly runs any array of drives-- without the need for sequencing.
- **100 Times More Reliable.** Why gamble with a single-unit system? TwinPower's load-sharing, redundant design lets you take the power system for granted. It's the peace-of-mind a network manager needs!



- **Hot-Swap Capability.** In the unlikely event that one of its 450s should fail, an alarm sounds, and the other 450 sustains the server while the user simply swaps in a new unit. No downtime!
- **Optional Enclosures.** We offer "monster" cases that hold TwinPower's two power supplies and interface. The Commercial Tower (76 lbs.) holds 13 drives, while the all-steel Industrial Tower (102 lbs.) allows dual systemboards and holds up to 16 drives. Now, that's expandability!

TWIN-POWER 900 ..... **$995**
W/COMMERCIAL CASE **$1695**
W/INDUSTRIAL CASE **$1995**

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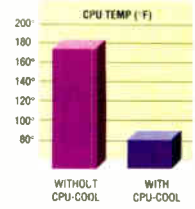
It's a fact. 486 chips run hot, often exceeding 185°F! Now, you can reduce the operating temperature of your 80486 processor to a cool, safe 85° - 95°F with our popular **CPU-Cool**. You'll *prevent random system errors* and add years to the life of your investment. Consists of a quiet mini-fan embedded in a sculptured heat sink that easily mounts on the CPU. Powered by a spare drive connector. Effective, inexpensive insurance!



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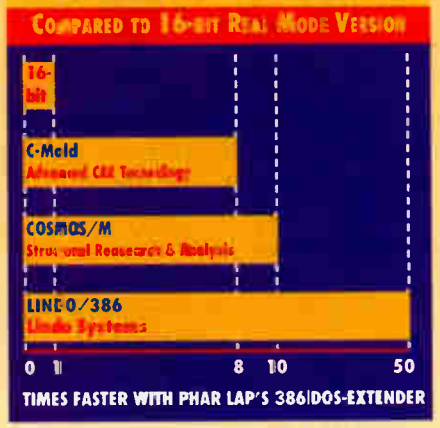

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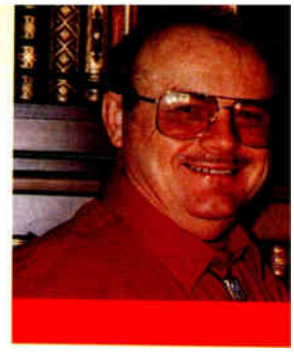

JERRY POURNELLE

ONCE MORE INTO THE BREACH

I have two front-page newspaper articles on my desk. The first, from the *Wall Street Journal*, talks about the computer industry. It concludes that there's a lot of healthy competition, U.S. competitiveness is high and growing, and, while some companies like IBM have been big losers, overall the industry is healthy.

The other article is from the *Los Angeles Times*, entitled "Protectionist Tide Engulfing Trade Issues"; it tells how U.S. industries are pulling Clinton toward a protectionist stance. Steel and telecommunications have already got protectionist rulings, and everything "from automobiles to textiles have lined up behind them to seek protection from overseas competition."

The U.S. steel industry long enjoyed protectionist policies, and as a result fell a long way behind the rest of the world. A protective tariff is like taking dope: once you start, it is very hard to stop. I note that every time the Department of Commerce interferes with the computer industry, prices rise, competition is harmed, and we users are the ones who pay.

I also note that the U.S. recession of 1929 didn't become the Great Depression until the rest of the world's market system collapsed, in large part due to a protective-tariff war. We tried policies of "beggar thy neighbor," and the result was quite horrid. Then I look at those articles again and I shudder.

UPSes

There are two basic kinds of UPSes (uninterruptible power supplies): *on-line* and *switching*. On-line systems continuously charge the batteries while running the system from them; switching systems wait until they detect a power failure and quickly switch your system from on-line filtered power to power supplied from the UPS batteries. Early on, I tried a few switching UPSes, with unsatisfactory results. Then I adopted Clary UPSes, and I've never had any problems, even during the Great Power Spike I reported on in my August 1989 column.

About a year ago, I was asked to try the Network Security Systems' switching UPSes, and since I now have more computers than my wonderful Clary UPSes can handle, I did that. The result is that my network server now runs off an NSS UPS, and we've had no problems. I still have more confidence in on-line UPSes, but if you do use a switching system, I can recommend NSS.

That sounds like grudging praise, but it isn't meant to be. I suspect my preference for on-line systems isn't all that justifiable; meanwhile, while the NSS hardware may be just another switching UPS, it comes with some really nifty network power management software, LANSafe II. You can set up a model of your network, showing which systems are protected by a UPS and which are not. You simulate a power failure and observe what happens: how much of your system comes back up when the power comes on, and what kinds of data losses you may expect. If you have a large and complex network with bridges, you may be surprised at the results.

There's also general network power management software that lets you set times and dates for testing your UPSes, discharging them (UPSes need to be run off the batteries at intervals), and so forth. You can set up an orderly shutdown of NetWare file servers, keep logs of power events, and all the rest. NSS has taken a rather vanilla hardware product and genuinely improved it with their management software.

Jerry wraps up the User's Choice Awards and looks at math and writing programs

I'm not really competent to evaluate the NSS hardware, but people who are tell me it's a high-quality switching system; and certainly mine has worked fine through some heavy thunderstorms with frequent mini power failures. If you're in need of UPSes, and if your time and work are valuable—they are, whether you know it or not—you can trust NSS, and you may decide you like the system because of the software. Having said that, I also have to say that it's storming outside, and the system I'm writing this on is connected to my big Clary UPS.

I've previously given User's Choice Awards to Clary, and they get a renewal. NSS gets a User's Choice Award for their LANSafe II power management software.

Intel OverDrive

I first heard about it from a reader, and then I got an Intel OverDrive chip myself. It really works.

I have two Cheetah systems, a 486/25 and a 486/33. Both of them work splendidly. The 486/33 is my regular

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machine, the one I'm writing this on. When Intel sent me an OverDrive chip, they sent a 33-MHz version, which will change my 486/33 into a 486DX2/66. What that means is that the bus speed remains the same, but the internal speed in the chip is doubled.

Because the Cheetah 486/33 is my main machine, we installed the OverDrive in the 486/25. The chip comes with a small chip puller, but we found that useless: the puller bent before the chip was removed. Then it was back to the screwdriver and being very careful.

Once the 486/25 was removed, we popped in the OverDrive. Alas, because of the configuration of the Cheetah board, we didn't push it down quite hard enough: you could see a little of the pins. When we turned on the machine, it didn't work; the next time we used a bit of Stabilant 22 contact enhancer and lubricant (great stuff) and seated the chip firmly. This time it worked fine and continues to do so.

The 486/25 is now faster than the 486/33. I will now go out and buy an OverDrive 25-MHz chip and put the 33-MHz chip into my 486/33. When I do that, the Cheetah 486/33 will probably be the fastest machine in the house. Its only rival will be the Gateway 2000 4DX2-66V, and my suspicion is that the Cheetah is going to be slightly faster. That Cheetah is one great machine. Alas, the company is out of business.

Note that we made no changes to software or BIOS; we just swapped chips. The results are just wonderful.

The Intel OverDrive chip gets a User's Choice Award. Recommended.

Stealth

Someone once said that Windows is a good way to slow down your computer. That can be true, but it doesn't have to be. While Windows does use up CPU cycles, most machines have those cycles to spare. The problem comes with the video: Windows uses bit maps for everything, including text. Without the proper hardware, you can grow a beard while the screen repaints. The obvious solution to that is to get the proper hardware.

Diamond Computer Systems' Stealth VRAM (video RAM) fast graphics processor is very much the proper hardware. This board is fast, and it produces gorgeous colors; it is simple to install. We're running ours in a Gateway 2000 486/50 at 1024- by 768-pixel resolution, and it works just fine. It comes with fast drivers for Windows and AutoCAD, the WinRix paint program, and a five-year warranty.

I've used a lot of boards this year, and this is the best of the new crop. Diamond Computer Systems' Stealth VRAM gets a User's Choice Award.

Vest-Pocket Hard Drive

Back in the early days of this column, I was sent a Lilith, which was a bit-slice computer designed by Niklaus Wirth to use Modula-2 as its assembly language. It was fast and wonderful, and it had many of the Xerox PARC (Palo Alto Research Center) features that would later appear in the Lisa and Mac. It also featured a Honeywell-Bull 10-MB hard drive.

Hard drives were rare in those days. This particular drive was the size of a washing machine, and it made about as much noise. While the Lilith with Modula-2 made for one of the nicest programming environments I have ever experienced—I think I did more and better programming in the months I had it than I have before or since—that noisy, clumsy, wretched hard drive nearly spoiled it.

Now, I have a 130-MB Flashdrive from

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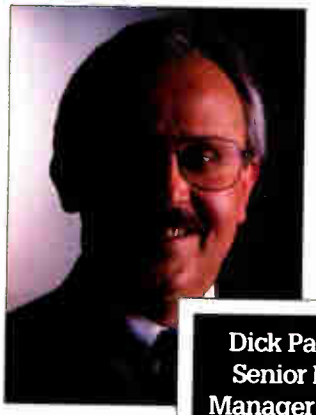

Dick Patefield, Senior Project Manager for Store Systems Support, JCPenney

Recently JCPenney Co., Inc. changed its operations from the old POS systems to the new PC-based technology, relying on PC platforms for point-of-sale and in-store support. And they back each one up with help from MINUTEMAN.

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BSE (they're available from 20 to 210 MB), and it's complete with batteries good enough to keep it running for 2 hours and more. It's smaller than a cigar box and so quiet I have to put my ear to it to be sure it's running. Even better, it plugs into the parallel port of my laptops.

The Flashdrive is ruggedly reliable, portable, and a real convenience. For instance, in the morning I'm catching an airplane to Boston for the annual meeting of the American Association for the Advancement of Science (my favorite convention of the year). Before I go, I'll plug a Flashdrive into the printer port of this machine, peel off a copy of this column and any other work I've been doing, and stuff that into my briefcase.

In fact, if you don't have a network, Flashdrives make great sneaker network systems: they're bigger and faster than floppy disks. If you use them for file transfer, it means you've also made a backup copy.

The Flashdrive installs painlessly and works like a charm. I gave BSE a User's Choice Award last year, and I have no hesitation in handing them another. Highly recommended.

Surprise, Surprise

Back in March, I nominated Trantor for their T348 MiniSCSI Plus, a gizmo that attaches to your printer port and lets you connect SCSI devices, such as a CD-ROM drive for your laptop. I also nominated Knowledge Adventure for their wonderful interactive multimedia science education programs such as Space Adventure and Dinosaur Adventure. I suspect it comes as no surprise that Trantor Systems and Knowledge Adventure get Chaos Manor User's Choice Awards.

Plug-In for Program Manager

I have mixed emotions about shareware. I certainly support the concept, and some of the best programs I've ever had have been shareware. On the other hand, as programs get larger and more complex, it's nearly impossible for one or two people working part-time—a typical shareware production scenario—to compete.

Sometimes, though, shareware really comes through. That's certainly the case with Plug-In for Program Manager. Unlike Norton Desktop for Windows, Plug-In *enhances* rather than *replaces* the Windows Program Manager. It adds features like automatic monitoring of resources, with a warning alarm when resources are getting low. It installs easily. It provides some new and better cursors. It won't let you nest program groups, but it provides neat ways to do group management.

I've been using Plug-In for a couple of months now, and I have nothing but good to say about it. It's invisible, useful, and inexpensive. You can get it from the publisher (Plannet Crafters) or download it from my conference on BIX. Plug-in for Program Manager gets the Chaos Manor User's Choice Award as Shareware of the Year.

Kicking Them When They're Down

I don't know exactly when I concluded that IBM deserved the Onion of the Year, but it was sometime in December. Now we find that IBM has taken the largest corporate loss in the history of U.S. corporations, has lost its chairman, and is downsizing fast.

Longtime readers will recall that I predicted IBM's decline many years ago: I pointed out that as microcomputers became more powerful and more common, one large source of IBM revenue, rental

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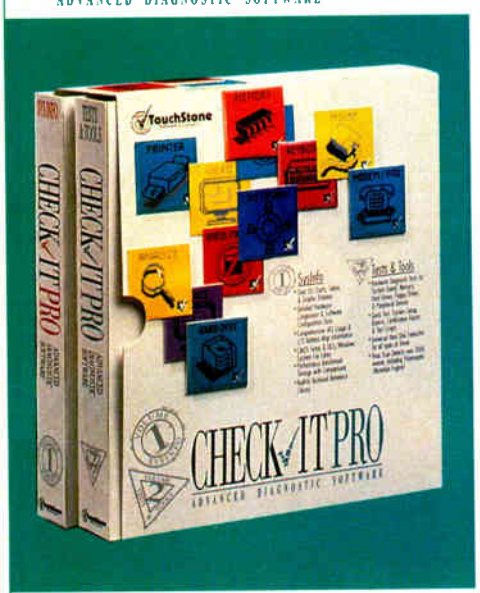

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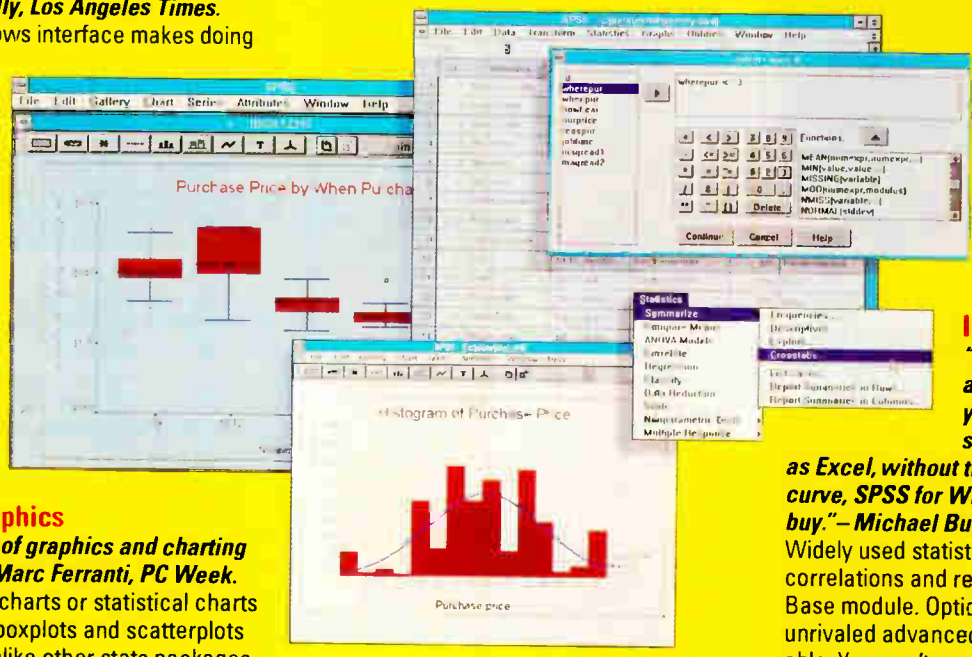

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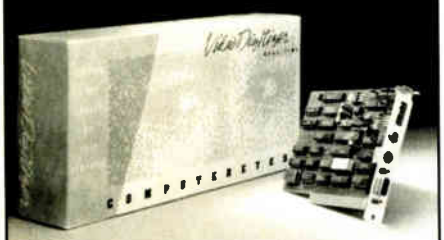

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of big COBOL programs, would dwindle and vanish. After all, why pay tens of thousands of dollars a year in rental and maintenance for a program that does no more than you can do with a big 486 that costs less than your annual program rental? And with modern CASE tools for PCs, reverse-engineering the big COBOL programs that run your business gets simpler every day.

IBM has powerful marketing capabilities, but they're mostly geared to taking care of IBM's largest corporate accounts, not selling products to consumers. Their press relations range from indifferent to abysmal—I'd hate to tell you how many times I've been promised something only to have it lost in the cracks, and how many times my OS/2 contact has changed in the past year.

However, they've recently changed. I'm getting reports that the OS/2 help people are really efficient, and John Patrick seems to have taken command in that division. There are enough signs that IBM is getting their act together that I decided they really don't deserve my Onion of the Year after all.

Onion of the Year

There are several other candidates. The war between IBM and Microsoft, which hurts users more than either company. Microsoft's database marketing tactics. The Department of Commerce, again, for temporarily sending memory prices through the roof. The FCC, which, as always, acts to make life difficult for start-ups to the benefit of large, established companies. A whole raft of lesser offenders.

The good news, though, is that they're all more annoyances than serious concerns, and none is so egregious as to deserve an Onion of the Year. Amazing, isn't it?

The Math Scene

When I first got involved with little computers, I was introduced to Macsyma, the first symbolic algebra program. Really early readers will remember my BYTE reports on it. Macsyma was far too big to run on Ezekial, my wonderful old CompuPro Z80 who now resides in the Smithsonian, but I was connected through what was then called the ARPANET to the Macsyma Consortium, which was a big minicomputer at MIT, where Macsyma was developed. I had a lot of fun playing with Macsyma, and in my role as intellectual honeybee, I was the first to let some important theoretical physicists know there were computer programs that could take a lot of the work out of solving complex equations.

Since then, a number of symbolic math programs have been developed. Probably the best known is Mathematica, which was designed for the Mac but has a PC (with Math Chip) version as well. If you like Mathematica, I won't try to talk you out of it. I found it harder to use than I'd hoped, but you can do some powerful programs with it; but this time I want to talk about some of its rivals.

On the low end there's Derive. I say *low end* because Derive certainly costs the least and takes the least memory and computer resources. It runs nicely on the HP 95LX (there's a PCMCIA version of Derive), so you can take it anywhere you go. It's not the fastest of the math programs, nor does it have as many features as the others; but it's sure good enough for most users. Every high school student ought to have an HP 95LX with Derive on it: it will take the sting out of algebra and geometry homework.

Of course, you'll still have to understand the concepts to make use of it. Knowing how to use real math never hurt *anyone*; indeed, until I started writing for a living, I made as much money out of knowing math as I did out of any other skill I ever acquired. Having a feel for math and statistics gives you an enormous competitive advantage, and spending odd moments playing with Derive on a vest-pocket machine like the HP 95LX will give you that feel.

The next step up is Mathcad from MathSoft. This is a little more intuitive than Derive, and since it incorporates an editor of sorts, it can be very useful for preparing math documents. It's got a bit more power than Derive, and there's a Windows version. The really nifty feature about Mathcad is that you can get it in various handbook and equation packages. You can get Mathcad augmentations ranging from the best of the CRC "rubber handbook" tables of physical and chemical constants; to vectors; to electrical engineering, mechanical engineering, and civil engineering formulas—you name it. This makes it really easy to write math documents, because you can pull in constants and equations without leaving the program.

If I ever write a book on rockets and space travel—and I plan to someday, I hope—I'll likely use Mathcad, since it makes it easy to include lots of examples.

Or I might use Macsyma. It calls itself the most stable, reliable, and powerful of the lot, and I think that's probably true. Macsyma does things its way. It's based on Lisp and uses a "Lispish" kind of interface, but there's an amazingly good help system. It will also do just about everything, and there's a new demonstration capability that's just short of magic.

It is not the easiest thing to install, but

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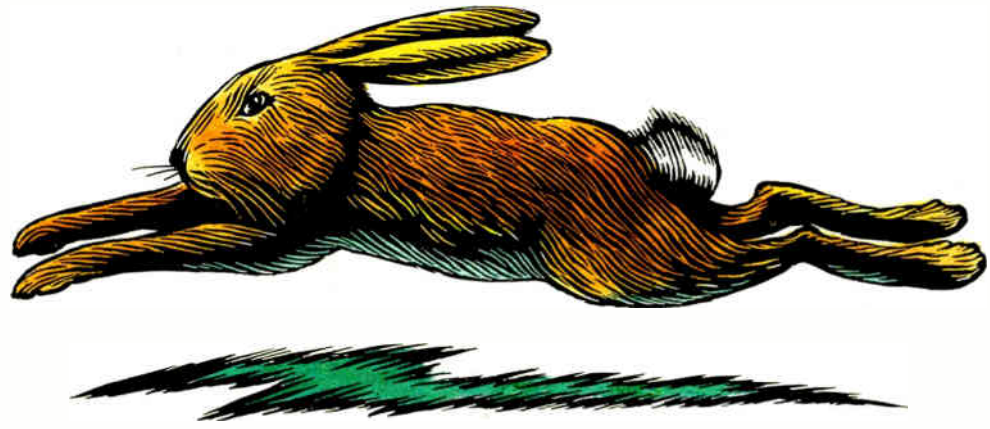

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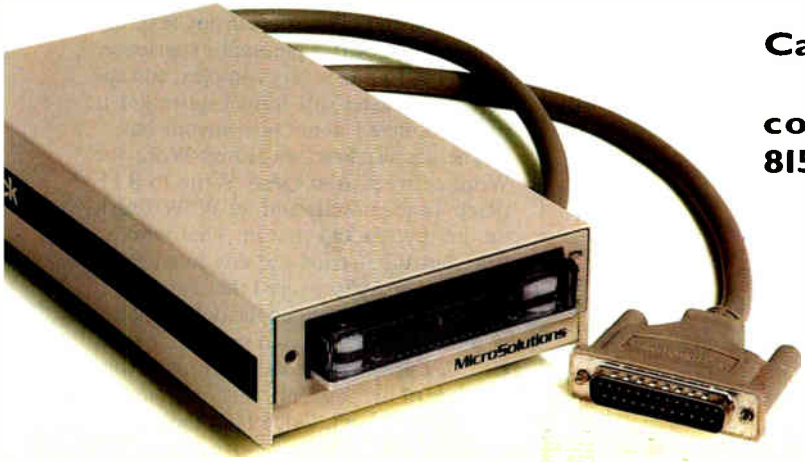

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they've improved that since I first got it. When you install it, it puts a device driver in your SYSTEM.INI file; when you actually run Macsyma, it opens a DOS application called Macsyma Server. After you exit Macsyma, that Macsyma Server is still there, and closing it is not simple. You can't even close it by exiting Windows, because Windows won't let you exit with an open DOS application. You have to go into the Macsyma shell and shut it down from there, ignoring a message saying this is an awful thing to do.

You have to shut it down, because as long as that Macsyma Server is open, Windows (all applications) becomes *intolerably slow*, and this on my Cheetah 486/33; who knows what it would do on a 386SX. Be warned: if you are going to run Macsyma, don't plan on doing much else.

On the other hand, it has some incredible power. You can look at the inside of a torus, or even of a Klein bottle. It has fast and amazing graphics. While I still would not call it user friendly and I am unhappy about the imbecile shutdown procedure, I am much impressed with Macsyma's capability.

No math program will make you an instant mathematician, but any good one will help you learn a lot about the use of math in practical situations. If I were going to do lots of heavy-duty math, I'd probably get Macsyma and invest the time to tame it and learn it; but I confess I'm glad I don't have to do that, because I really don't want to turn my 486 into a dedicated Macsyma machine. They really should work on an easy way to dump Macsyma when you're finished with it.

If you need sheer computational power, get Macsyma. If you're writing papers with lots of mathematical content and need formulas and constants, look into Mathcad. And if you just want to learn more about using math, get Derive. But get one of them. You won't regret it.

Word for Word

Word for Word has a new Windows version that includes some new target formats. Not long ago, Larry Niven, Steve Barnes, and I spent a week down at the beach house working on the sequel to *The Legacy of Heorot*, and we wanted to get a printed copy of what we'd done—about 120 pages—off to our editor. We work in Q&A Write, which is a great text-creation program but not very suitable for printing something that long, so I decided to convert the text from Q&A Write to Microsoft Word for Windows (WfW for short). In the past, I have used Word for Word to convert from Q&A Write to Microsoft Word for DOS and then let WfW pick it up from there. The new version of Word for Word has WfW as a target format, so I tried the direct approach.

Alas, the result was that when I went to change the text header and set up to do page numbers, my machine locked up completely; *nothing* I could do would let me recover, so I had to turn the machine off. Fortunately I didn't lose any text, but I can't say it was a pleasant experience. The WfW format is *very* complex, and apparently MasterSoft hasn't quite got it right; but then I'm not sure anyone has.

The answer here was to let Word for Word convert from Q&A Write to RTF (Rich Text Format) and let WfW finish the job by reading that in. That worked fine, but RTF strips out any headers or footers. I also discovered that the lockup experience had changed the default header setting to 0 inches, and since a LaserJet III can't print closer than 0.5 inch from any side of the page, my first printout had no page numbers. Once I set the header

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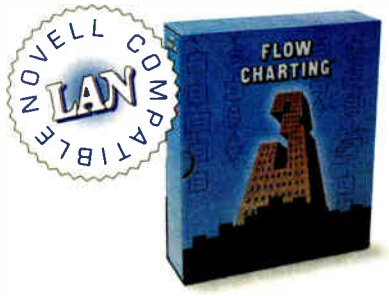

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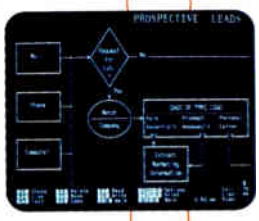

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margin to a half-inch again, all was well.

This isn't a real complaint against MasterSoft, since Word for Word remains the easiest to use of the conversion programs, and it certainly has the widest selection of both source and target formats. However, if your source text has headers and footers, be careful.

Quotes on Line

There are lots of quotation programs. This DOS character-based askSam application program is better than most, with a good selection of quotations you can find by author, subject, or keyword. It's also useful because it's a good illustration of the kind of thing you can build with the character-based askSam information management system. I confess it has caused me to take a much harder and kindlier look at askSam, because the program is very fast, and while there's no mouse support, it's pretty easy to use. I suspect character-based data managers will be around for a while yet. A lot of the things we do are still restricted to words, and as soon as you add graphics capabilities, as with Thinx, you can do more, but it's harder to build applications, and they run more slowly.

The quote database (12,000 quotes) isn't bad. I told it to look for the Boolean *war* AND *peace*, and it found a couple dozen instances, of which three samples follow:

Sydney J. Harris: "There's no point in burying a hatchet if you're going to put up a marker on the site."
Paul Hoffman: "We wage war not to win war, but to win peace."
Thomas Mann: "War is only a cowardly escape from the problems of peace."

All told, not bad, and I didn't find a one of those in the Bartlett's CD-ROM. This is a good collection, fast and easy to use. Quotes on Line is useful in its own right, and it's a good introduction to askSam's capabilities as well. Recommended.

Avagio

There are a zillion desktop publishing systems out there, each with a ton of features, and after a while it becomes impossible to decide which one to use. When Roberta was publishing the LA Opera League's newsletter, she used Aldus PageMaker on a Mac, partly because many of the LA Opera people are Mac users. It got the job done, but there were times when I thought she'd go nuts.

I've done a bit of desktop publishing myself. Also, Jim Baen uses Ventura Publisher to do the actual typesetting for my books—that reminds me, *Prince of Sparta* from Baen Books is out now—and for a job that complex, Ventura Publisher is probably what he needs.

However, if I were going to do ordinary desktop publishing—publicity fliers, memos, small posters—and particularly if I were going to use color, I suspect I'd use Avagio Publishing System from Unison World Software. Of all the desktop publishing systems I've put up and fooled around with, Avagio seems the simplest for just getting something useful done. It has enough fonts, it handles most graphics file formats, it knows how to put in color, and it doesn't require PostScript. It's pretty intuitive, and it can do more special effects than I'm likely to need.

In a word, Avagio is good enough for just about anything you might want to do; it runs on just about any system you may have, from an AT to a 486; it doesn't need Windows; it doesn't need a lot of memory or a huge hard drive; and while it's not

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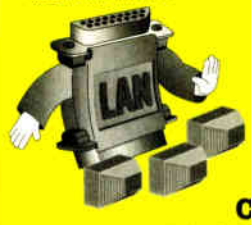

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SpreadBase

The Spreadsheet and Database Wars have begun in earnest. Lotus 1-2-3, Excel, or Quattro Pro? Access, FoxBase, dBase, Paradox? Or scrap the lot of them and try Thinx?

Of course, it's unlikely that any single spreadsheet or database can be all things to all people. Some are designed for customization. Some are best for enormous structured spreadsheets or databases. There are probably more practical business programs written in the dBase language than in any other language, and there are probably more dBase programmers than anything else, which is what made room for FoxBase and Clipper.

Meanwhile, Lotus 1-2-3 was one of the major reasons for the quick penetration of desktop computers into the business world, the killer application that did for PCompatibles what VisiCalc had earlier done for Apple. I can still remember the early days, when businesspeople went to computer stores and said "I want VisiCalc," with no idea what computer it ran on. They just knew they needed that spreadsheet capability.

As the Spreadsheet and Database Wars continue in the PC world, the programs grow with features. You can do a great deal more with them—but they're harder to use. Meanwhile, there's SpreadBase for the Mac world.

SpreadBase doesn't have as powerful a programming language as dBase, nor as powerful a macro capability as Excel. What it does have is a built-in ability to designate different cells as belonging to Categories, which you can then deal with collectively. SpreadBase doesn't do anything you can't do in Excel; indeed, I suspect it has definite limits compared to Excel. But it does do some very complex models with simplicity and ease, and for most people that's likely to be more important anyway.

SpreadBase will import data from most popular spreadsheet and database formats, and it lets you build pretty complex linked spreadsheet models with considerable flexibility. If you do a lot of work with rapidly changing spreadsheets, you'll do well to look into this.

Physics

Given the number of simulation programs around, it's astonishing how little good science education software has been published so far. Here are two good programs, both for the Mac, from a company called

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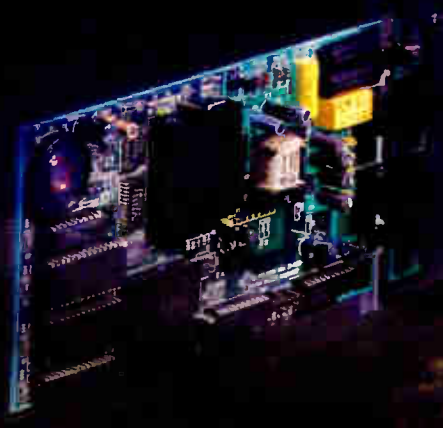

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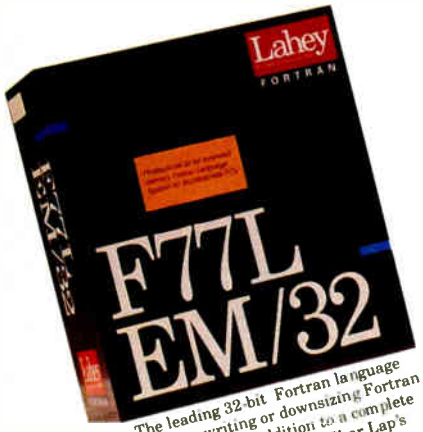

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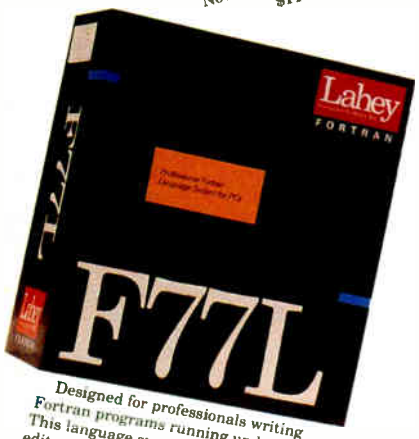

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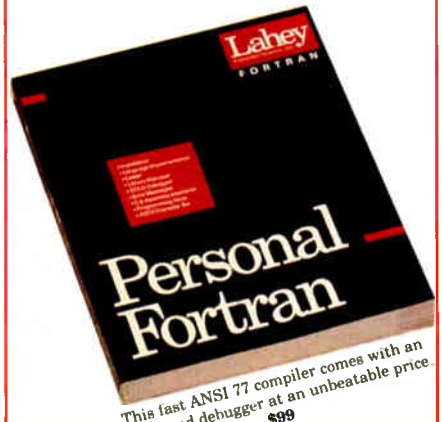

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Knowledge Revolution. Fun Physics is the simple introductory program, and Interactive Physics II is a more serious teaching tool.

Both programs do a good job of teaching mechanics while making it fun to learn. The more advanced program is by far the more interesting, but that's to be expected. I like these, and I hope there will be many more like them.

Presenter Plus

Ever go somewhere with a laptop expecting to find a good color monitor, only to discover there wasn't one for you to use for your presentation? I have, and I was forced to have everyone crowd around the monochrome screen on my Zenith.

Presenter Plus is designed to remedy that situation. It's a lightweight box about 1 by 4 by 5 inches, with connectors for power (one of those little power converters comes with it), VGA input and output, and NTSC video or S-video composite output. Feed your VGA into the box, connect it to a TV, and you get a passable excuse for a monitor. It won't have the resolution of a real monitor, of course, but it will be better than you expected.

Presenter Plus comes with DOS and Windows software, several fonts, instructions, and cables. I wish it came with a carrying case to hold all that stuff. I put mine in an old shaving-kit bag so that the parts wouldn't get separated.

You can feed Presenter Plus's output into a TV, or, if the TV doesn't have a composite input, you'll need an RF converter. You can also feed the output into a VCR and play that tape on a TV.

Presenter Plus chops out some of the horizontal lines, and you'll get some flicker because of the interlaced output. All told, it's sure not VGA; but it beats heck out of having everyone crowd around a monochrome laptop screen.

Up and Coming

A few years ago, I told you to watch for CD-ROM as the up-and-coming technology. It took a little longer than I thought it would—the critical event was getting the price of CD-ROM drives lower—but serious computer systems now need CD-ROM drives.

The first CD-ROM drives were pretty slow, but over the years they got faster. Thus, if what you want out of a CD-ROM is text or still pictures, there's no problem. It's different with motion video, though. Not just speed. Bit-map picture images take up space on the disk, a *lot* of space, enough that a CD-ROM's 600 MB of data isn't enough to hold much full-motion video and a sound track.

What's needed are ways to compress that data, and that, I think, will be one of the real breakthroughs in the next year or so: really efficient on-the-fly compression and decompression of full-motion video with sound. When that happens, multimedia will come into its own.

The other up-and-coming technology is PCMCIA, the credit-card-size solid-state interface that can be nonvolatile memory, a modem connection, an Ethernet connector, or a connection to a video camera. The PCMCIA slot is really a direct route to your system's bus.

I am collecting PCMCIA stuff, including flash-memory cards from Mitsubishi and Epson and various interface connections. One of these days, I'll do a roundup. Meanwhile, this is another technology to be aware of. I'd bet that in a couple of years every new portable system will have PCMCIA, and not long after that, you'll see it become a standard feature on desktops as well.

Winding Down

It has been flooding in Los Angeles, and although we're well above flood level (and below mud-slide level; Roberta did a great job picking this house), it has been pretty hectic the past couple of weeks. In a few minutes, I catch that airplane to Boston and the AAAS meeting, where I get to rub elbows with top scientists and prepare my annual report on the state of the sciences in America. I say all this by way of apology if the column seems a bit choppy and hurried this month.

I'll be carrying my Gateway 2000 HandBook and the NCR laptops. Roberta has a Gateway 2000 Nomad that she likes because it is lightweight and reliable. Also, the screen is bright enough that she can use it to demonstrate her reading program. Incidentally, I heard shouts of joy from downstairs a couple of hours ago: apparently the Mac version is nearly done.

The book of the month is Thomas Sowell's *Inside American Education: The Decline, the Deception, the Dogmas* (Free Press, 1992), a devastating analysis of the flaws of the American education system. Ten years ago, Nobel winner Glenn T. Seaborg, chairman of the National Commission on Excellence, concluded that, "If a foreign government had imposed this system of education on the United States, we would rightly consider it an act of war." Things haven't got much better, and Sowell has some powerful suggestions as to what's wrong and what has to be done. Steve Barnes quite literally couldn't stop reading until he'd finished Sowell's book, which was great praise for the book, but he was supposed to be working with Niven

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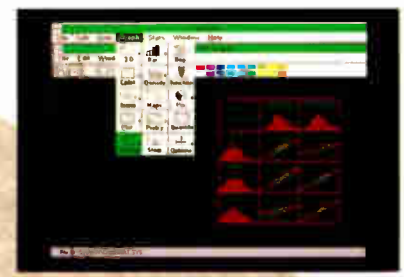

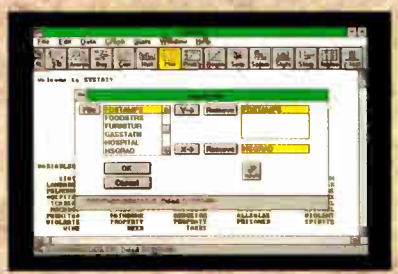

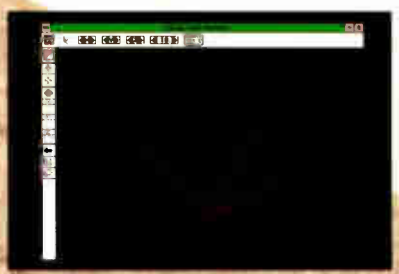

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and me on *our* new novel.

The other book of the month is *High-Tech Ventures: The Guide to Entrepreneurial Success* by Gordon Bell and John McNamara (Addison-Wesley, 1992). I can recommend this to anyone in management at any level.

In looking around the office, I see the "ready line" table is still piled high with good stuff I can't get to this month. That makes me feel better about the protectionist trends I mentioned earlier.

Next month, CD-ROMs, more on networks, and, with luck, some new developments in OS/2. Now I'm off to Boston for good science and better lobster. ■

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future. Jerry welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply. You can also contact him on BIX as "jerryp."

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COVER STORY

FEATURE

Intel Launches Rocket in a Socket

With the Pentium processor, Intel extends the life of the 15-year-old 80x86 architecture, but competing RISC CPUs give users alternative CPU choices

TOM R. HALFHILL

On March 22, Intel unveiled the Pentium—the next generation of the microprocessor architecture that has dominated the PC industry for more than a decade. With this new processor, Intel has begun steering a difficult course between tradition and revolution. On one hand, Intel must prolong the life of the 15-year-old 80x86 architecture, a tried-and-true design that encompasses an installed base of tens of millions of computers and thousands of programs. The corporations and individuals who have spent billions of dollars to buy that hardware and software are as anxious to protect their investment as Intel is.

At the same time, however, Intel must also push the envelope of microprocessor performance to new levels that will satisfy the increasing demands of computing in the 1990s. Multimedia applications with full-motion video and robust new operating systems like Windows NT are pushing the limits of today's fastest desktop computers. To meet these needs, engineers are cramming more and more transistors into their CPU designs. Exotic new architectures that were undreamed of a few years ago are now beginning to appear. To keep pace, Intel must adapt those advances to its 80x86 chips without deviating too radically from the basic architecture that it first committed to silicon in 1978.

The Pentium is not just another new chip but a new 80x86 chip—an event that happens only once every four years (see figure 1). As such, it's a tantalizing combination of inherited limitations and future possibilities. It needs to be judged by two standards: how well it carries on the 80x86 standard and how well it performs.

It's imperative for the chip to be compatible with previous 80x86 chips, and it is. The Pentium is fast, too, though perhaps not as fast as you would like. It's also expensive. With sources estimating an OEM price of about $900 per chip in production quantities (Intel had not released pricing on the Pentium as this went to press), the Pentium is far too costly for today's mass-market, single-user desktop computers. But the same was true of the 486, 386, 286, and 8086 when they hit the market.

Over the course of the next 12 to 24 months, the Pentium will primarily be harnessed to network servers and workstation-class machines priced from $5000 to $10,000, according to system vendors and industry analysts. Systems based on the Pentium will not be announced until May 17. Key vendors expected to make Pentium-related announcements at that time include AST Research, Compaq Computer, Hewlett-Packard, IBM, NCR, Unisys, and Zenith Data Systems. As prices inevitably fall and performance improves, the Pentium could become the dominant

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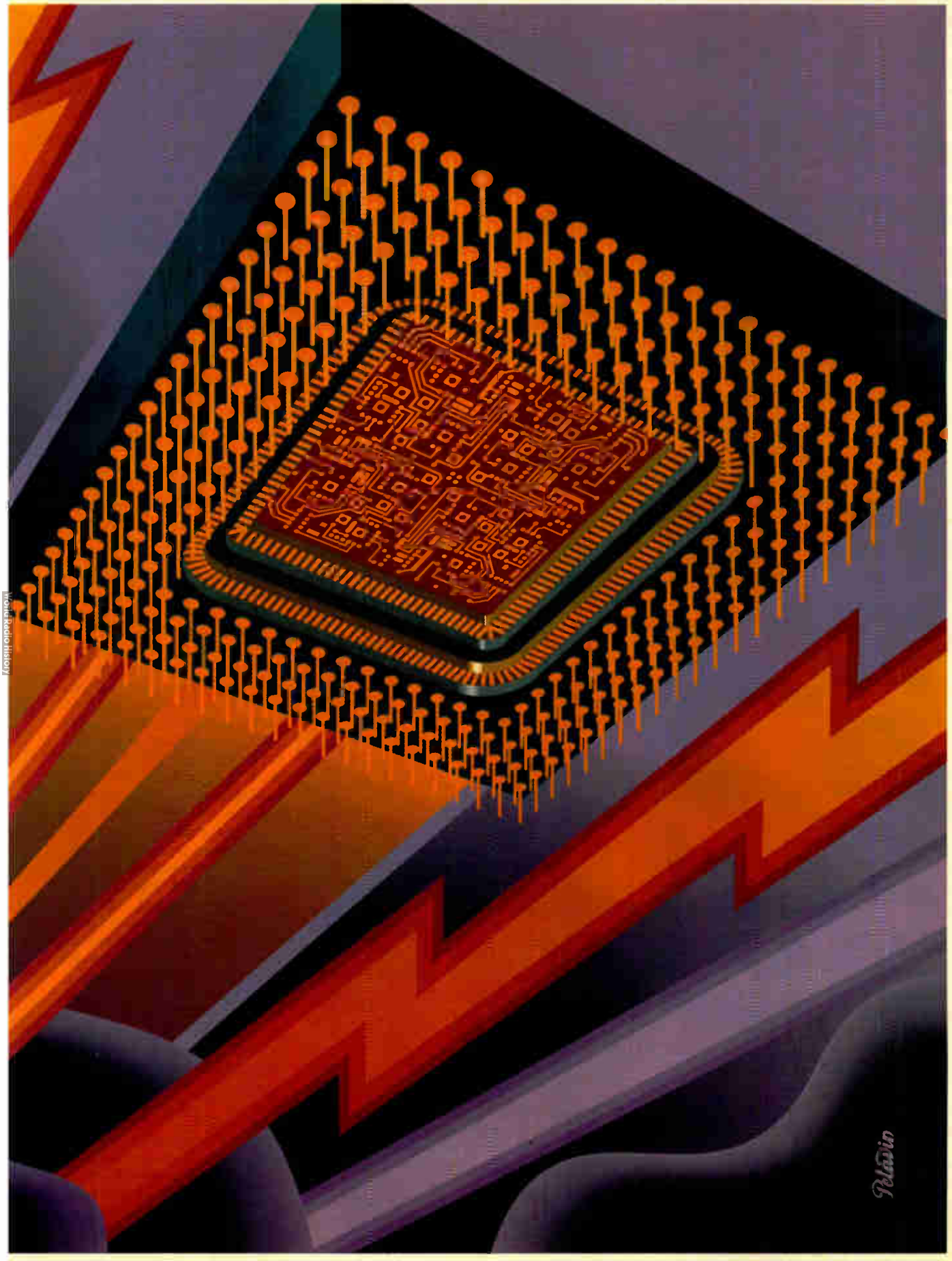

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microprocessor of the mid-1990s.

However, Intel faces a challenge it has never before experienced with a new PC-based CPU: competition right out of the starting block. Microsoft's Windows NT is the anticipated operating system of choice for Pentium systems, but Windows NT–ready workstations based on RISC CPUs will beat the first Pentium systems to market. For the first time ever, you don't have to choose Intel for your next-generation PC system architecture.

Coping with RISC

Intel has announced two versions of the Pentium: one clocked at 66 MHz and the other at 60 MHz. The BYTE benchmarks confirm that the faster Pentium barely exceeds Intel's stated design goal of delivering at least twice the performance of today's fastest 486, the clock-doubled 486DX2-66 (see the text box "Testing the Pentium" on page 96). The 66-MHz Pentium is rated at 112 MIPS according to the Dhrystone 1.1 benchmark, and the 60-MHz Pentium delivers about 100 MIPS. By comparison, a 66-MHz 486DX2-66 yields about 54 MIPS.

A twofold increase in speed is enough to command a premium price in today's performance-hungry PC market, especially in the highly specialized niche of network servers. Because the performance of a server affects all the users on a network, any improvement is easier to justify when weighed against the higher costs. In addition, the Pentium marks the first time an 80x86 chip has broken the magical 100-MIPS barrier, which until now has been the exclusive domain of RISC-based microprocessors.

"I think [the Pentium] sounds real strong," says Roger Rapp, an information technology manager at John Brown, a worldwide engineering and construction firm. Rapp, who is based in Mount Vernon, Indiana, is responsible for all the hardware and software, including 31 AutoCAD licenses, used at John Brown's offices in Indiana, Kentucky, and Missouri. Although Rapp is glad that Intel continues to develop the 80x86 architecture, he has a wait-and-see attitude. "I'm agnostic on the whole shooting match," he says. "I have to do whatever's best for the end user."

Thanks to power-hungry users like Rapp, RISC processors pose the greatest threat to the future of the Pentium. Unbound by any requirements to maintain compatibility with old hardware and software, RISC chips are free to embrace radical new architectures and advanced design theories. As a result, they can deliver impressive levels of raw performance that leave most CISC-based chips in the dust (see the box "Pentium vs. RISC"). But they also tend to be expensive, partly because none has achieved the volume that leads to inexpensive mass production—at least not on the scale of Intel's most popular chips.

All that may change, however, with the dawning of Windows NT. This operating system threatens both the Pentium processor and Intel's long reign over the PC market in two different ways. First, Windows NT offers symmetrical multiprocessing, which means Pentium-based computers will be required to compete on price/performance grounds against systems that include two or more 486 chips working together. Second, Windows NT is strategically designed to be independent of the underlying hardware; it's supposed to run equally well on such non-Intel RISC chips as DEC's Alpha series and the Silicon Graphics/Mips R4000. *continued*

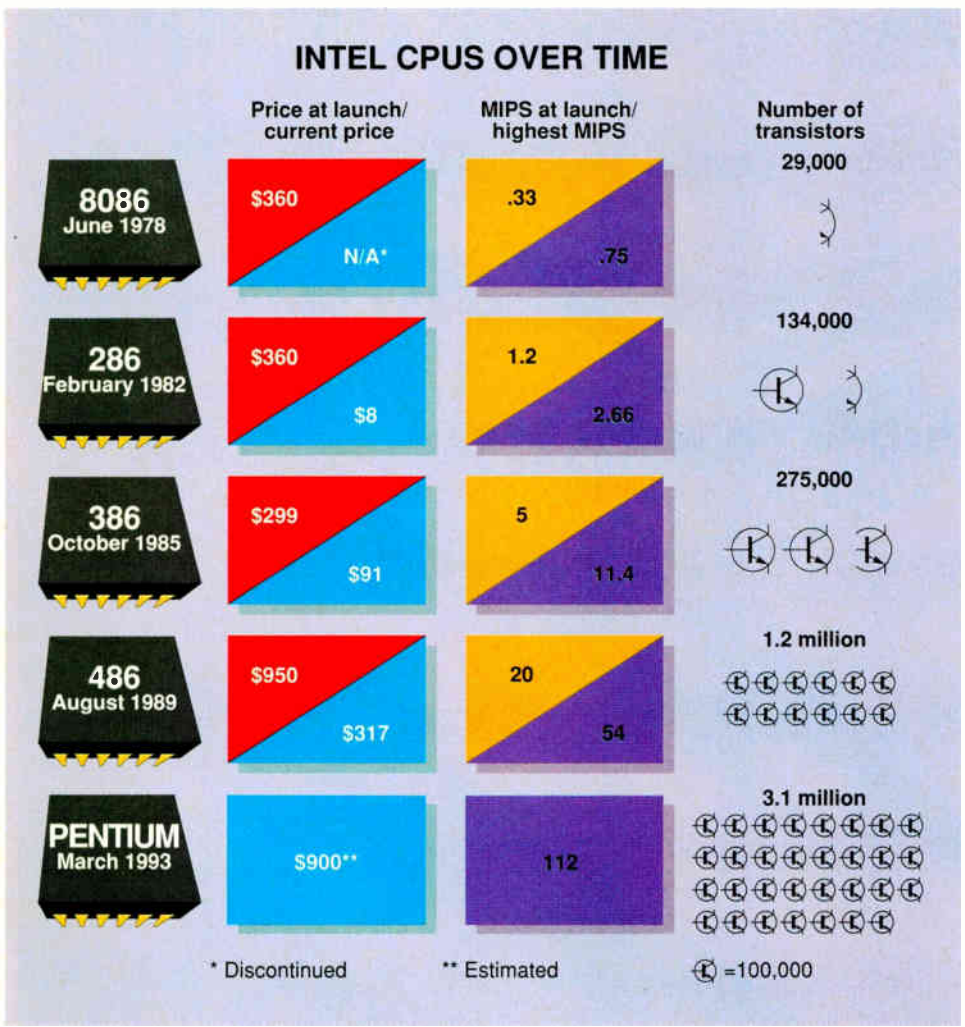

Figure 1: *Intel sticks to a remarkably regular product cycle: Each new generation follows the previous one by about 44 months. The number of transistors on 80x86-series microprocessors has increased exponentially since the debut of the 8086 in 1978. During this period, the minimum feature size has shrunk from 3 microns on the 8086 to 0.8 micron on the Pentium. Future versions of the Pentium will probably use 0.65-micron technology for even higher densities. At 112 MIPS, the 66-MHz Pentium is nearly 150 times faster than the speediest 8086. Note that these MIPS ratings are for the fastest version of each chip; the Pentium is sure to get faster, too, as new versions are introduced.*

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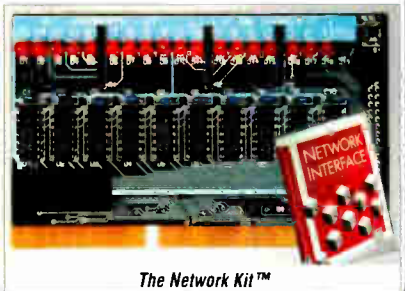

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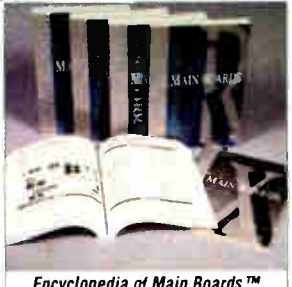

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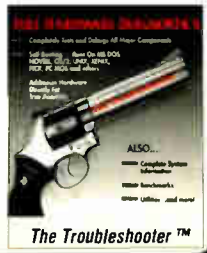

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World Radio History

Testing the Pentium

RICK GREHAN

Because Intel decided to split the announcement of the Pentium processor—the CPU itself on March 22, systems using the Pentium on May 17—only three vendors permitted BYTE to benchmark their Pentium systems, and then only if we agreed not to mention the products or companies by name. We benchmarked four systems. Although all of them are ultimately slated to use 66-MHz versions of the Pentium, the versions we saw were running the 60-MHz version.

We ran our complete suite of low-level and application-level benchmarks (sans the Unix tests) on two of the machines. Since the only common factor in all these machines was the Pentium processor (the hard disk and video systems varied), we concentrated on the portions of our benchmarks that illuminate CPU and FPU performance.

If you average the machines' scores on the low-level benchmarks, the results suggest performance for CPU operations alone to be somewhere in the neighborhood of 1.6 times that of a 66-MHz Compaq Deskpro 66M with a 486DX2 (see figure A). The FPU performance boost is better—around 1.9 times that of the Deskpro 66M. The latter good showing is likely due to Intel's redesign of the FPU core (see the text box "Inside the Pentium" on page 102). Our application-level tests showed results that are slightly below what the low-level benchmarks predicted: a CPU performance boost of around 1.4 and an FPU boost of around 1.6—again, both compared to a Deskpro 66M with a 486DX2-66.

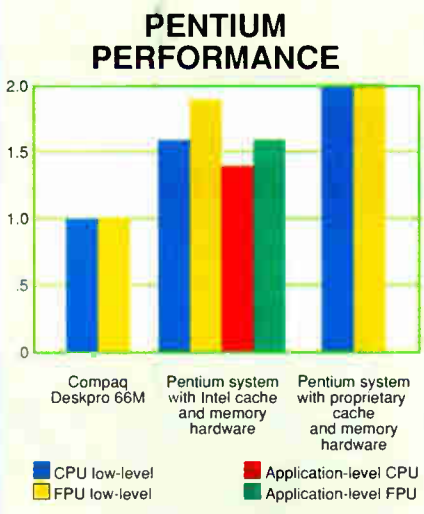

Figure A: *Pentium systems can provide nearly twice the performance of a Compaq Deskpro 66M with a 66-MHz 486DX2. One Pentium system, which had its own CPU support circuitry, did better than the other systems we tested.*

Three of the four machines that we benchmarked used CPU, cache, and memory circuitry designed by Intel. A fourth machine was manufactured by a company that designed its own cache and memory-interface hardware. Although we were able to run only our low-level benchmarks on this system, we saw performance that was significantly better than that of the other three Pentium systems we tested: Both CPU and FPU performance were roughly twice that of the Deskpro 66M. If the correlation between low-level and application-level tests holds true, this translates to application benchmark results in the neighborhood of 1.7 to 1.8 times those of the Compaq.

We believe that these higher numbers are more indicative of the Pentium's true potential. The other three machines are based on existing 486 designs and use the daughtercard-upgrade approach.

There is one caveat here: Our benchmarks use applications that are not optimized for the Pentium. Intel claims that optimization will boost performance by as much as 30 percent.

Rick Grehan is technical director of the BYTE Lab. You can contact him on BIX as "rick_g."

In the Pentium's favor is the fact that DOS and Windows 3.x applications will not run natively on an Alpha- or R4000-based NT system. This is because these RISC chips are not binary compatible with the 80x86 instruction set. To run DOS and Windows applications on these systems, NT will transparently emulate the 80x86, using technology developed by Insignia Solutions, a company best known for its SoftPC emulator. As with all software emulation, there's a performance penalty, so apples-to-apples comparisons between 80x86- and RISC-based systems will be difficult, if not impossible, when running existing applications under Windows NT. But comparisons will be much easier—and tempting—when running new software written for NT.

Until now, the only common ground for comparing the performance of 80x86 and RISC processors was Unix. Although Unix also offers symmetrical multiprocessing and platform independence, the vast majority of PC users have avoided it (see "Is Unix Dead?," September 1992 BYTE). Those users may be more receptive to the more familiar Windows NT, and NT will pit the Pentium directly against its RISC rivals for the first time.

Intel insists it will not shrink from such comparisons. While the RISC-versus-CISC debate has been raging, Intel has been quietly adapting key elements of the RISC philosophy to its decidedly CISC-based 80x86 architecture (see the photo on page 100). A few hints of this were evident in the 486's FPU and cache, but the Pentium goes much further in this respect. The prime example is the Pentium's superscalar pipeline, a common feature of RISC chips. Under certain circumstances the Pentium is capable of executing two machine instructions simultaneously, because it has not one, but two integer pipelines arranged in parallel. It also has intelligent branch prediction and other advanced RISC features (see the text box "Inside the Pentium" on page 102).

Even though the Pentium's FPU pipeline does not execute in parallel, other improvements in the chip significantly boost its floating-point performance. Preliminary benchmarks indicate

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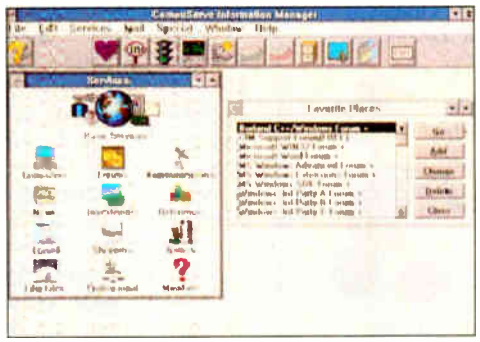

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the Pentium's FPU is about twice as fast as the 486's. This, together with the superscalar ALUs, positions the Pentium closely with competing RISC chips.

"For the average 'schmo,' the average businessperson doing word processing and spreadsheets, [the Pentium] is not going to be a big deal, and I see no reason for a lot of them to go past a 386," says Nancy Thalblum, a New York consultant and member of the NYPC users group. "But for other kinds of people, you have to have the raw horsepower."

For those people, Intel says that the Pentium's hybrid architecture is just a starting point. Faster versions of the Pentium are on the way. The initial Pentiums are based on 0.8-micron, 5-volt BiCMOS technology, with about 3.1 million transistors. Future versions, which may appear by late this year or in early 1994, are expected to use 0.65-micron, 3.3-V technology and will run at 100 MHz or faster, according to industry analysts.

Intel won't comment, but if it keeps with its marketing strategy of spinning off numerous variations of a basic microprocessor, you can anticipate a wide variety of Pentiums for many purposes: servers, desktops, and portables. Meanwhile, if history repeats itself, the Pentium will benefit from the same performance gains and manufacturing efficiencies that have made other 80x86 microprocessors faster, denser, and less expensive. Sales are projected to ramp up quickly: from 400,000 chips this year to 2.1 million next year, according to Ken Lowe, senior industry analyst at Dataquest (San Jose, CA).

Upgrade Paths

One variation of the Pentium is already known. Code-named the P24T, it's an upgrade Pentium for 486-based computers, sort of a Pentium OverDrive. Some 486 machines that are now available, such as AST's new Premmia 4/66d, have a special socket with an extra row of pins for the P24T. When the P24T is introduced early in 1994, it will pop into this 238-pin socket, preempting a machine's existing CPU.

However, some of these computers won't be quite as fast as systems that are designed especially for the Pentium, because the P24T will access its secondary cache memory over a 32-bit bus running at only 33 MHz. True Pentium systems will boast a 64-bit bus that accesses the secondary cache at full CPU speed (see the box "Three Ways to Upgrade").

Another type of upgrade will eliminate the P24T's bus bottleneck by isolating the Pentium on a special daughtercard. Systems with this upgrade will unleash the full power of the Pentium by linking the chip to its secondary cache at CPU speed over a 64-bit bus. The daughtercard will plug into a special connector on the motherboard. AST's Premmia 4/66d offers this option in addition to the P24T socket. More of these kinds of systems will be announced on May 17, and their designers claim they'll match the performance of computers with Pentium-based motherboards.

Some users are wary of upgrades, however. "The vendors have caught on that if they want to make users' check-off lists, they've got to include that upgradability," says Jonathan Braunhut, director of the information center for the New York City controller's office. "In reality, we see that when you want to take the processor up, the video standard has been advanced. Typically, the local hardware storage requirement has advanced. Ultimately, if you've replaced everything but the $50 metal case, what have you accomplished?"

But other users will take all the MIPS they can get. "At this point, I'd pay about $1200 to upgrade a system [to the Pentium]," says William Zeph Ginsberg, a New York City architect. "I use CorelDraw, and I'm getting into Windows applications, and I'm sure tired of watching that hourglass. Life is too short to spend waiting for your hard disk to access. The big CAD drawings and

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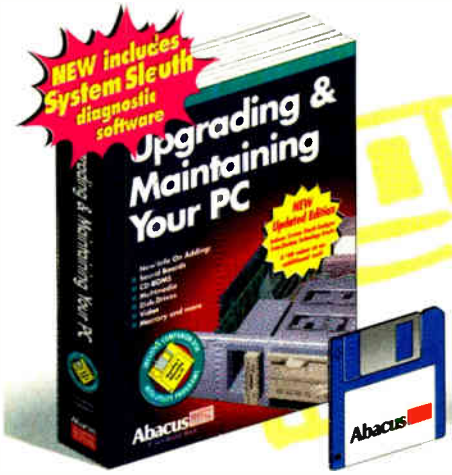

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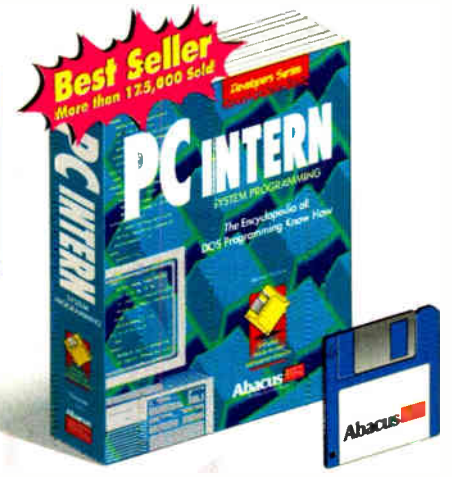

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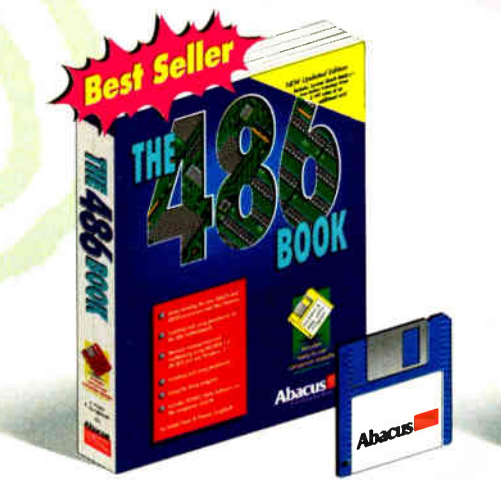

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the complicated Windows files just need more power."

Fine-Tuning the Software

So much attention gets focused on the hardware aspects of microprocessor design that another factor—software engineering—is easy to overlook. For nearly two years, Intel has been working with tool developers to ensure that specially optimized compilers will be available when the Pentium hits the market.

More than any previous Intel microprocessor, the Pentium needs optimized code to reach its full potential. Although it's fully compatible with code written for earlier 80x86 chips (the instruction set is almost identical to the 486's), significant performance gains can be realized by writing code that exploits its superscalar architecture. This is not surprising, because optimized code is also important in maximizing the performance of the RISC chips that inspired crucial elements of the Pentium.

"As processor architectures become more exotic, with parallelism and so forth, it becomes more important for the software to know what the hardware is trying to do," says Dan Palka, manager of Intel's Compiler Partners Program. "Now there's much more awareness that the software architects and the hardware architects have to work together."

Few applications are carefully hand-coded in assembly language anymore, so optimized high-level compilers are critical to extracting maximum performance from the Pentium. Even small improvements to these compilers have a ripple effect among millions of users, because virtually all of today's commercial applications software (and much of the system software) is written and compiled in C or C++.

According to Intel and the tool developers interviewed by BYTE, programs optimized for the Pentium will run about 30 percent faster than unoptimized programs. In addition, users can expect gains of about 10 percent when these programs are run on the 486 and perhaps 5 percent when they're run on the 386 (see figure 2).

The optimized code won't run at all on earlier chips, but most 286, 8086, and 8088 systems lack the speed and memory to run today's major applications. If a computer can't comfortably run Windows 3.1, it's not current enough to run the software that is likely to be recompiled for the Pentium.

Don't expect to buy these optimized programs anytime soon, though. For one thing, the first optimized compilers weren't scheduled to be available until this spring. Borland introduced a new version of C++ for OS/2 with Pentium optimizations in February, and Microsoft is planning to include the optimizations in an upcoming version of Visual C++ for Windows NT, which is scheduled to ship within weeks of NT's ship date. But even when such compilers are available, the Pentium market is still far too tiny to make it worthwhile for software vendors to recompile their applications for the sake of the Pentium alone. In addition, the performance gains are probably too small to be noticeable on the other chips. Not until the next major upgrade will most vendors even consider optimizing their code.

In fact, some software publishers are just beginning to confront the issue of optimization. "Intel's statements that applications should be recompiled for the Pentium took us somewhat by surprise," says Darin Richins, public relations manager at WordPerfect. "We don't have a good idea yet of what needs to be done to make our applications run well on the Pentium." Microsoft and Borland, the two leading compiler vendors, say that the first of their applications to be optimized will be 32-bit programs for Windows NT. Autodesk, whose AutoCAD package is a natural candidate for the Pentium, won't even comment.

It'll also be a while before optimized compilers include all the possible optimizations. In general, these optimizations affect the ordering of the instructions generated by the compiler. By replacing complex instructions with simple instructions (i.e., those that don't require microcode) and by arranging them in ways that minimize dependencies (so an instruction doesn't depend on the result of the instruction it immediately follows), these compilers generate code that executes in parallel through the Pentium's twin integer pipes. Keeping both of those pipelines primed will greatly increase the chip's throughput, which means your programs will run faster.

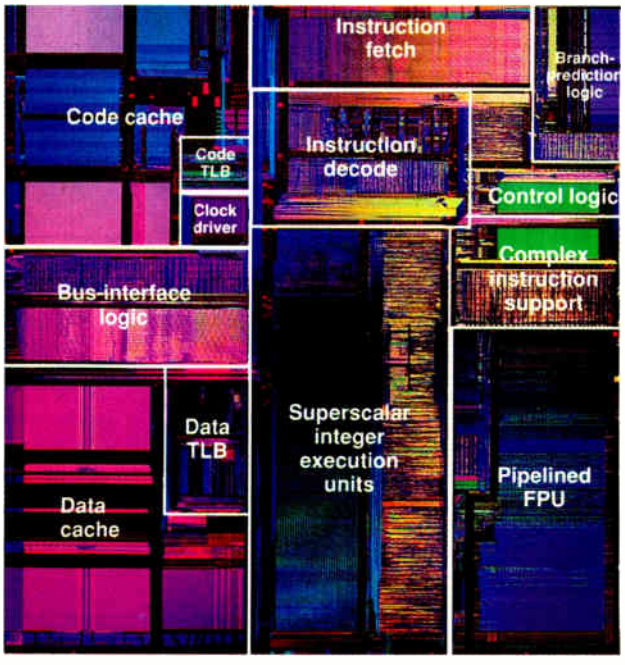
A few optimizations produce code that runs more slowly on the 486 and 386. For that reason, Intel recommends a "blended optimization strategy"—a mix of optimizations that runs very well on the Pentium and either slightly faster or at about the same speed on earlier chips. Future compilers will offer multiple levels of optimization, so programmers can make their own compromises.

System-Design Challenges

Another easily overlooked aspect of Pentium performance is the design of the computer systems that are wrapped around the chip. There's much more to designing a well-rounded Pentium system that just sticking the chip into a socket and adding some memory (see the box "Pentium Design Hurdles"). Indeed, the

Pentium vs. RISC

	Pentium	RISC
Binary-compatible with 80x86 code?	✓	
Upgradable from 486?	✓	
Runs Windows NT?	✓	✓
Existing optimized software base?		✓



The Pentium revealed. *One big change from the 486 is in the FPU: On the Pentium, it has additional circuitry dedicated to math functions.*

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Inside the Pentium

BOB RYAN

To understand how the Pentium takes 80x86 performance to new heights, you have to compare it to Intel's fastest 486 chip, the 486DX2-66 (for the rest of this discussion, read "486" as "486DX2-66"). This comparison is especially enlightening because both chips are clocked internally at the same rate. Any difference in performance must therefore be due to implementation differences.

The Pentium is a big chip, cramming 3.1 million transistors into a 2.16-inch-square, 273-pin PGA (pin-grid array) package. At 66 MHz, the Pentium draws about 13 watts. It is fabricated using a 0.8-micron BiCMOS process and features parity-based internal error detection for both the instruction and data caches, cache tags, and cache TLBs (translation lookaside buffers), as well as for the microcode ROM. It also has circuitry that lets you directly monitor the performance of one Pentium with another.

The Pentium's instruction set is little changed from that of the 486. It features some new instructions that let system programmers implement the MESI (modified, exclusive, shared, invalid) multiprocessing cache-coherency protocol, which the Pentium supports in hardware, as well as an 8-byte compare-and-exchange instruction and a CPU identification instruction. The Pentium has one more control register (CR4) than the 486. It also includes the System Management Mode that Intel first employed on the 386SL.

Using optimizing compilers, Intel gets a 64.5 SPECint92 rating for the Pentium, twice that of the 486. Both processors use the same five-stage integer pipeline design, where instruction execution takes place in discrete stages within the processor. In both the 486 and the Pentium, the stages are Prefetch, Decode, Address Generate, Execute, and Writeback. When an instruction finishes one stage, it moves to the next, making room for the next instruction in the program sequence. The difference between the Pentium and the 486 is that the Pentium has *two* parallel integer pipelines.

The Pentium's integer unit fetches and decodes two integer instructions at a time. It then checks to see if it can execute the instructions in parallel. In general, if the instructions are so-called simple instructions, and if the execution of the second does not rely on the results of the first, then the Pentium will issue the two instructions to separate U- and V-pipes, which contain their own ALUs (see figure A). Thus, as long as two instructions meet the proper conditions, the Pentium can execute them simultaneously.

As defined by Intel, *simple* instructions are those that don't require microcode and, in general, execute in one clock cycle. The exceptions to the latter condition are memory-to-register and register-to-memory instructions, which take two and three cycles, respectively. The Pentium includes sequencing hardware that lets these exceptions operate as simple instructions. When paired with an exception, a one-clock instruction stalls for a cycle or two to keep the two pipes in lockstep.

If an instruction pair doesn't meet the dual-issue conditions, the processor-control unit issues the first instruction to the U-pipe. The second instruction is paired with the next decoded instruction in the program sequence to see if these two can be issued in parallel. If the control unit can't issue these two instructions simultaneously, the one from the original instruction pair is issued; the Pentium does not support out-of-order execution.

The U- and V-pipes are not identical. The U-pipe includes a barrel shifter for bit-level manipulations so that it can execute any 80x86 instruction; this pipe is where the first stages of floating-point execution take place before the scene shifts to the FPU. (Both pipes, however, can fetch FPU operands.) In addition, it is the U-pipe—or rather the instruction in it—that sets any flags resulting from instruction execution.

Adding a second integer ALU in effect doubles the potential processing bandwidth of the integer unit. It also requires that the processor make twice as many instruction and data accesses as it would to support a single-integer pipe. To keep these accesses from interfering with one another, Intel split the unified 8-KB cache found on the 486 into separate two-way set-associative 8-KB instruction and data caches on the Pentium. It also doubled the size of both the internal and external data buses to 64 bits. Thus, each off-chip access that the Pentium issues brings in twice the number of instructions—or twice the amount of data—as the same access does when made by a 486.

One problem Intel encountered in splitting the instruction and data caches was that the split can break self-modifying code. To keep such code functional, the Pentium includes cache coherency between the instruction

Pentium poses so many challenges that some engineers and analysts suggest it will shake out the PC clone industry.

The main design problem is engineering a reliable motherboard that's fast enough to keep up with the chip. This isn't a Pentium-specific problem; it has already been encountered by engineers designing systems around the 50-MHz 486DX. (The clock-doubled 66-MHz 486DX2 has a bus that runs at only 33 MHz, so it presents less difficulty in that regard.) But it's a particular problem with the Pentium because even the slower version is clocked at 60 MHz. At that speed, there's no margin for careless design or sloppy manufacturing tolerances.

This could have a big impact on users. If the Pentium's high clock rate—soon to climb to 100 MHz and beyond—deters the low-end, high-volume system makers, the retail prices of Pentium computers won't drop as fast as they did when 386 and 486 computers were new.

"Fifty MHz was painful, and 66 MHz is turning out to be more painful," says Steve Phillips, the manager of advanced

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486 AND PENTIUM ARCHITECTURES

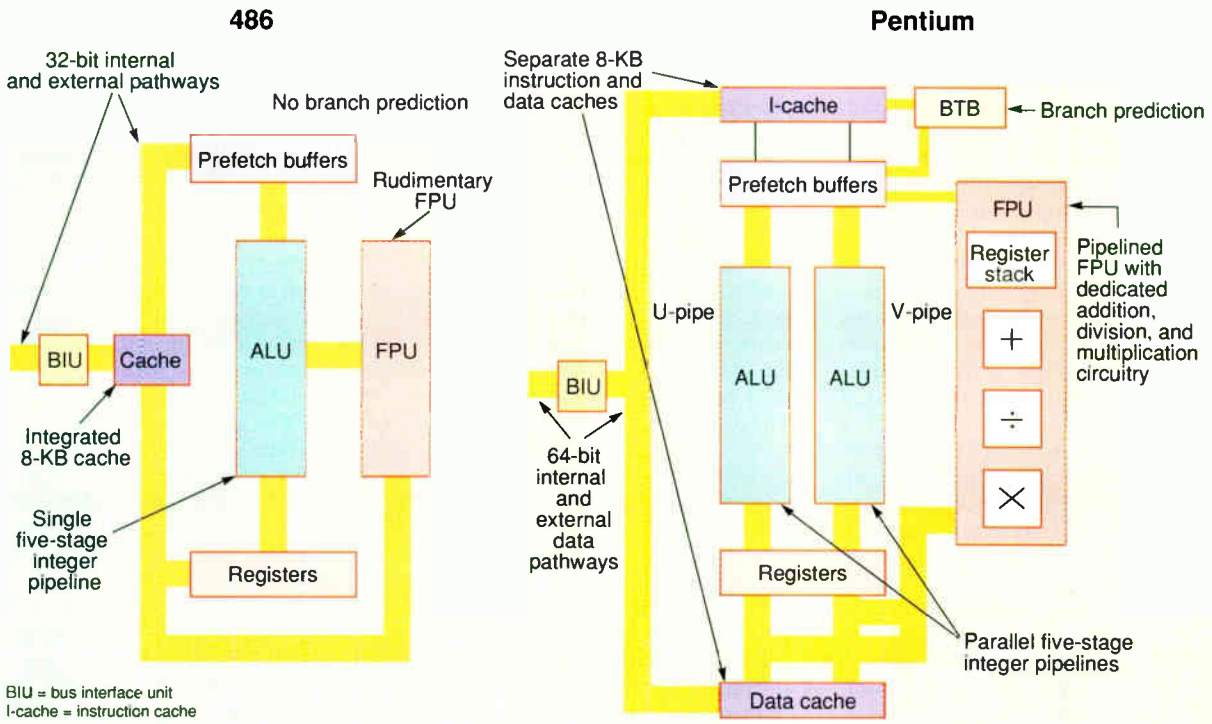

Figure A: *The 486 consists of a single execution pipeline and an integrated cache that serves both the instruction and data pathways. The Pentium adds depth by splitting the data and intruction pathways with separate data and instruction caches. The pathways are also wider to increase bandwidth. Added breadth comes from the two parallel integer pipelines that provide nearly twice the processing bandwidth of the 486. The other major difference between the 486 and the Pentium is the complexity of the FPU. The Pentium has dedicated circuitry for addition, multiplication, and division operations.*

cache and the data cache.

Separate instruction and data caches are not the whole story in keeping the integer pipelines filled, however. On both the instruction and data sides of the processor, Intel has added bandwidth-increasing innovations to the basic 486 architecture.

Most integer instructions require at least one operand, which most of the time will be in the data cache. With two parallel ALUs, you often have two instructions that want to access the data cache at the same time for their operands. To support simultaneous access to the cache, Intel made the TLB and cache tags of the Pentium's data cache *dual-ported* (i.e., readable by both ALUs simultaneously).

Intel did not take the final step and make the entire cache itself dual-ported. Instead, the cache is interleaved on 4-byte boundaries into eight banks. As long as the separate accesses from the ALU don't touch the same bank, the cache can provide data for two simultaneous accesses to the same cache line. In addition, the Pentium data cache is a write-back cache, which increases the cache-hit rate over the 486's write-through cache. (Note: The TLB and cache tags of the data cache are actually *triple-ported*; that is, the third port is to allow them to be read by the multiprocessing cache-coherency circuitry.)

On the instruction side, Intel added

continued

development for the Workstation Products Group at Unisys (Blue Bell, PA). "It's like a barrier. Many of those [clone] manufacturers will be out of business, or else they're going to have to garner experience they haven't demonstrated in the past."

When designing a system to run reliably at high clock speeds, Phillips explains, an engineer has to carefully manage all "boundary conditions": Thermal output, voltage variations, signal losses, RF interference, and TTL signaling all become significant.

Thermal considerations are especially critical. The Pentium is a hot chip in more ways than one. A single fan for the whole computer may not be enough, and the placement of fans and cooling vents isn't a haphazard affair. Even before sample silicon was available, Intel gave systems designers thermal models so they could begin planning how to keep their computers cool.

"This is where our big-system experience really becomes important," says Phillips. "We're used to dealing with issues such as thermal modeling and high-speed electrical design, whereas many PC manufacturers don't have that experience. It's like PCs

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Inside the Pentium *(continued)*

branch prediction to the instruction prefetch process. The Pentium has two 32-byte prefetch buffers. At any time, one prefetch buffer processes instruction addresses sequentially until it fetches a branch instruction. At this point, the BTB (branch target buffer), which contains historical information about branches, predicts whether the prefetched branch instruction will result in a branch.

If the BTB predicts that a branch will not be taken, prefetches continue sequentially. If the BTB predicts that a branch will be taken, the second prefetch buffer begins to prefetch instructions based on this prediction. Thus, if the BTB's prediction is correct, a branch will not stall the execution pipeline, because the proper follow-up instruction will always be in the prefetch buffer. If a branch occurs when the BTB predicts it won't, or if it does not occur when the BTB says it will, or if it is correctly predicted but to the wrong target address, the Pentium flushes the pipelines and fetches the correct instruction, incurring a minimum three-clock-cycle delay.

Floating-Point Performance

Floating-point performance has always been the weak spot in the 80x86's architecture. This "benign neglect" on Intel's part is understandable, given that relatively few PC applications require fast floating-point operation. With the increased emphasis on graphics and multimedia applications, however, the need for good floating-point performance is greater today than when the 486 was introduced. Also, it is important from a competitive standpoint that the Pentium's floating-point performance be at least in the same ballpark as that of popular RISC architectures.

For the most part, floating-point performance is a function of how much silicon you can devote to the job. With the Pentium's 3.1-million-transistor budget, Intel had plenty of silicon to work with, and it used it wisely. The Pentium's 56.9 SPECfp92 rating is 3.5 times that of the 486. The most important advance is that the Pentium FPU contains dedicated addition, multiplication, and division units. The consequences of dedicated circuitry are startling. No matter what the precision, the adder and multiplier units complete their operations in three clock cycles. The divider unit has a much longer latency; it produces 2 bits of quotient per cycle. These cycle times are a great improvement over the performance of the 486's FPU, where an FADD instruction takes 10 cycles and an FMUL instruction can take from 12 to 15 cycles.

Floating-point operations on the Pentium are highly pipelined and are integrated with the integer pipelines. The floating-point pipeline consists of eight individual stages, the first four being the same as the first four stages of the integer pipeline. (You could look at the Pentium as an eight-stage pipeline where integer instructions use only five stages.) A floating-point instruction uses both integer pipelines, allowing it to fetch a 64-bit operand in a single cycle. After the instruction tells the ALU to fetch the operand, floating-point execution takes place in the U-pipe.

One result of FPU pipelining is that, although it has a three-cycle latency, a new addition or multiplication instruction can be issued during each cycle. Thus, if the compiler can keep the pipeline filled, the Pentium can achieve a throughput of one addition or multiplication operation per cycle after the initial two-cycle latency to fill the pipe is completed.

Because floating-point instructions use both pipelines to fetch an operand, it's impossible to perform two floating-point operations in parallel—with one important exception, the FXCH instruction. In the 80x86 floating-point architecture, the FPU register file is organized as a stack. The FXCH instruction swaps the contents of any FPU register with the top of the stack, which is the accumulator in the 80x86 floating-point architecture. On the Pentium, the FXCH instruction can be issued to the V-pipe in parallel with most other floating-point instructions. The net effect is that you can complete a floating-point instruction and have its result appear immediately in the floating-point accumulator, where it is available to the next instruction. This greatly speeds up floating-point operations.

Architecturally, the Pentium is not a leading-edge design. Most RISC designs are already superscalar, with parallel integer and floating-point pipelines, and some even have a parallel load/store unit. Also, the Pentium's double-integer pipeline is not unique, as both the Sun Microsystems SuperSparc and Motorola's 88110 sport this feature. The importance of the Pentium is that it's at the leading edge of the 80x86 design, which, after all, is the most important computer architecture in the known universe.

Bob Ryan is a BYTE technical editor. You can reach him on BIX as "b.ryan."

are finally growing up."

Although the design challenges aren't insurmountable, they will weed out some of the low-end competition, says Dataquest's Lowe. "I don't think these things will permanently bar the no-name companies from participating [in the Pentium market], but it'll take them longer to master the design problems. It's one more barrier that's contributing to a general consolidation of the clone industry," he says.

Engineers must also pay more attention to performance bottlenecks, because a fast CPU often exposes hidden weaknesses in other components. For example, many Windows users have discovered that even a fast 486 gets bogged down without an accelerated video card or local-bus video. Likewise, Pentium-based computers will need to exploit every trick in the book to deliver the performance users expect. Some systems will double the secondary cache to 512 KB, and others will put drive controllers as well as video on the local bus.

Intel claims that today's VL-Bus—a widely adopted local-bus standard created by the Video Electronics Standards Association (San Jose, CA)—is not fast enough for the Pentium. Intel says Pentium systems should use PCI (Peripheral Component Interconnect), the local-bus standard invented by Intel.

It's true that today's VL-Bus is only 32 bits wide. But VESA executive director Tom Ryan says VL-Bus was designed for future expansion to 64 bits and will keep pace with the Pentium, as well as with RISC chips such as the Silicon Graphics/Mips R4000. "Obviously, with the 64-bit extension, that's not a problem," says Ryan. "It's something that's in committee at the moment."

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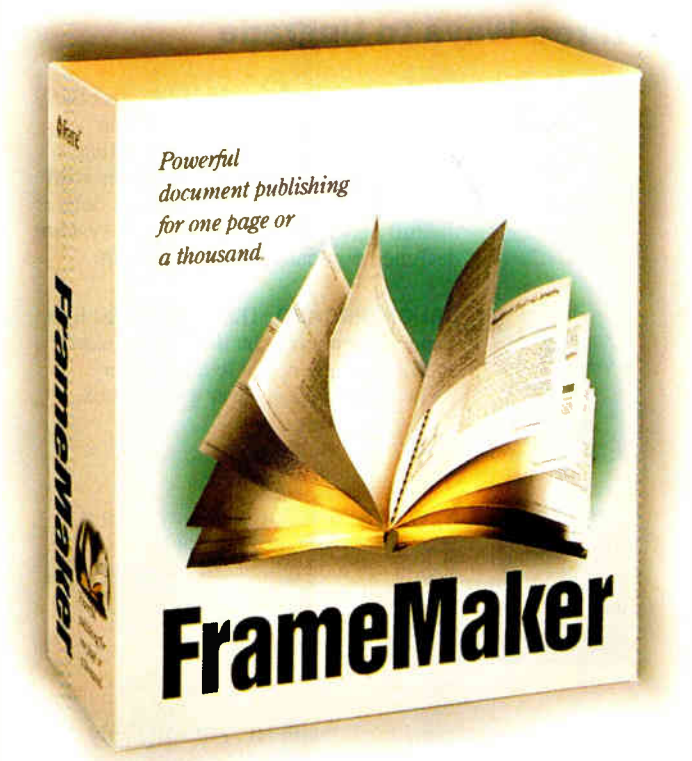

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Because the VL-Bus chip set and connectors are much less expensive than PCI's, it's likely that VL-Bus will be the dominant standard on low-end 386 and 486 clones for the next year or two (see "Fast Transit," October 1992 BYTE). Pentium systems, which by definition will be considered high-end systems for at least the next year, will probably adopt PCI instead.

Keeping Up with the Joneses

The Pentium presents a challenge of a different sort to Intel's competition. These competitors fall into two groups: those that make 80x86-compatible chips, and those that are promoting entirely different architectures, usually RISC-based ones.

So large is the worldwide market for 80x86 processors that the first group can survive by undercutting Intel's prices and providing computer manufacturers with an alternative supply source (see "Make the Right CPU Move," December 1992 BYTE). AMD (Sunnyvale, CA) and Cyrix (Richardson, TX) are the primary players in this group.

Although neither of these two companies has a Pentium-class processor ready to ship, neither admits to being overly concerned about it. "As a company, we focus on the volume markets, and the volume markets right now are the 386 and the 486," says AMD spokesman David Frink. "In fact, we expect the 486 to be the volume product through 1994 and into 1995. When you're talking about a market of 35 million to 40 million PCs that will be sold in the next year, and Intel will sell maybe 100,000 Pentiums in that period, then the Pentium is really insignificant—really nowhere."

If AMD and Cyrix truly aren't worried about the Pentium, they should be, because both companies are having trouble cloning the 486. AMD's 486 project suffered a major setback last December when a federal judge ruled against the company in a long-running court battle with Intel. The judge decided that a 1976 licensing agreement between the two companies did not entitle AMD to use Intel's microcode in future microprocessors, including the 486-compatible chip that AMD had planned to ship in January. As a result, AMD was sent back to the breadboards, forced to rewrite its microcode. The introduction of the Am486 was pushed back to June.

Cyrix introduced three "486" processors during 1992: the Cx486SLC, Cx486DLC, and Cx486S2/50. But despite their names, none is considered a true 486-class chip. Although they're compatible with the 486 instruction set, they lack integrated FPUs and have only 1 or 2 KB of internal cache. Intel's 486SX doesn't have an FPU, either, but it has an 8-KB cache and is otherwise identical to the 486DX. Cyrix won't introduce its 486DX clone, code-named the M7, until sometime during the second half of this year.

Cloning the Pentium will prove an even greater challenge, not just because it's faster, but also because it's architecturally more complex. There are two general approaches to the problem: Either copy the architecture as closely as possible or depart from the Pentium's internal design and use other techniques to make a chip that delivers the same level of performance. Both AMD and Cyrix are taking the second approach.

AMD is working on a new 80x86-compatible core that inherits little from existing designs. It's an ambitious project, because AMD is simultaneously working on a new 0.35-micron process technology and wafer-fabrication facility that will allow engineers to cram as many as 10 million transistors onto a single chip. That's enough density to propel AMD into the Pentium class and beyond. The first chips based on the new submicron process are expected in 1995.

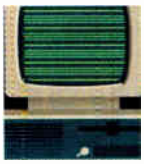
To spread out the burden of these enormous development costs, which Dataquest analyst Charles Bouchet estimates to be $800 million to $1 billion, AMD has formed an alliance with HP. HP will apply the technology to its next generation of PA-RISC processors, as well as to other chips.

Cyrix, too, is diverging from the Pentium's architecture, and spokesman Mike Bruzzone claims the company's first Pentium-class chip will be ready this year. "We'll release a competitor—not an equivalent—to the [Pentium] during 1993," he explains. "It's targeted at 100 to 150 MIPS and will calculate three instructions per cycle. It will be optimized for calculating integer instructions and will not need recompiled software. We don't

Three Ways to Upgrade

CHIP: By early 1994, Intel will offer the P24T, a single-chip upgrade for 486 systems equipped with the appropriate socket. But because the P24T mates with a 486 system's 32-bit bus, it won't deliver the full performance of 64-bit-bus systems designed especially for the Pentium.

DAUGHTERCARD: This board plugs into a special connector on the motherboard and links the Pentium to a secondary cache at CPU speed over a 64-bit bus.



NEW SYSTEM: The only way to go if your current 486 has neither the P24T socket nor a daughtercard connector.

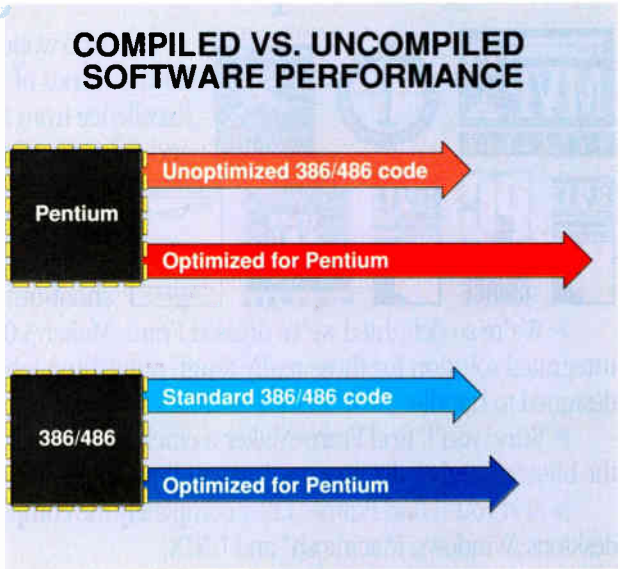


Figure 2: *Based on Intel's estimates, Pentium-optimized applications will run about 30 percent faster than unoptimized programs on Pentium systems and 5 percent to 10 percent faster on 386/486 systems.*

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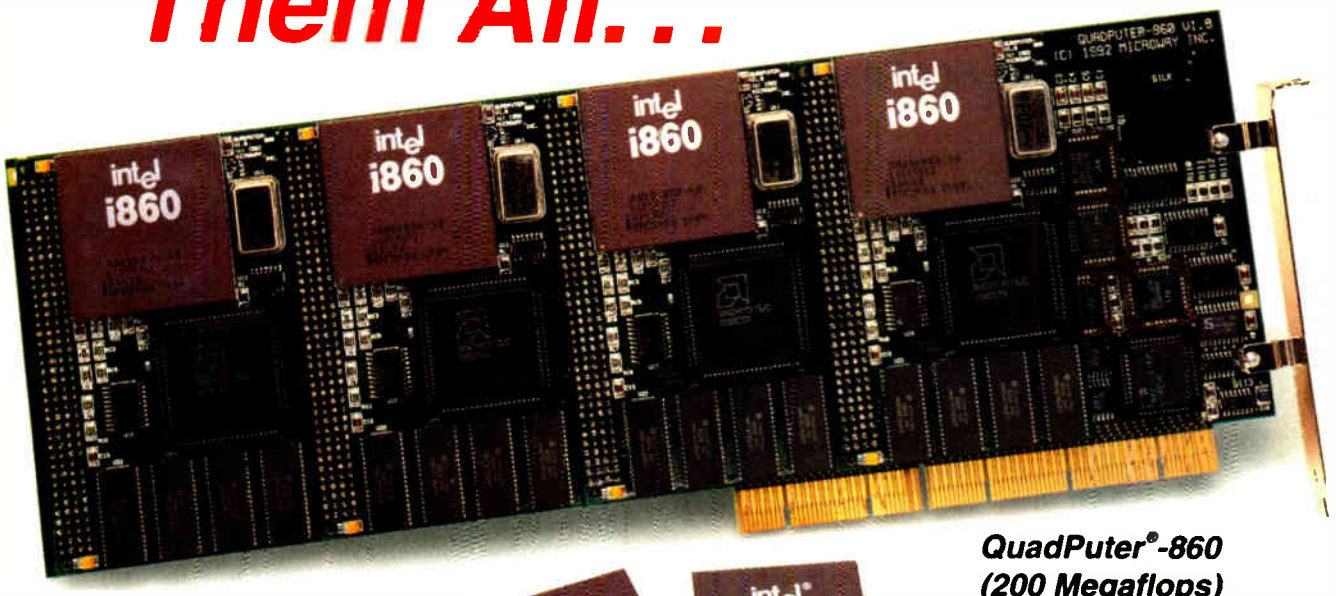

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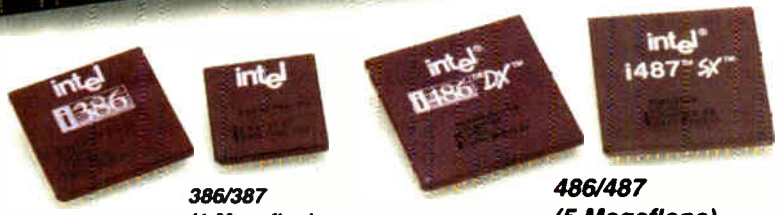

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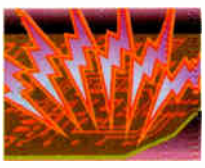
Pentium Design Hurdles

HEAT DISSIPATION: The Pentium runs hot. Intel is providing system vendors with thermal models, but vendors will have to pay close attention to fan and component location.

SPEED: The remainder of the motherboard—memory, video, system bus—must be able to keep up with the speed of the Pentium.

TOLERANCES: With higher speeds, the margin for error diminishes dramatically. Small vendors with little or no experience in building high-speed systems might not be able to master the learning curve.



RF INTERFERENCE: The faster the system, the more RF interference it produces. It will be tougher for vendors to meet the various RF emission standards with the Pentium.

design our chips based on what Intel does; we design our chips based on what 80x86 software requires in a CPU. So we think that one of the big advantages of our superscalar chip, our [Pentium] competitor, is that it'll achieve the most robust performance levels without recompiled code."

However, this design philosophy raises questions about compatibility and performance. If future chips from AMD and Cyrix don't exactly duplicate the Pentium's parallel pipelines and other architectural features, they may cause software written with Pentium-optimized compilers to behave differently. The software may run faster, slower, or at the same speed, but there's also the possibility, however remote, that in certain circumstances it may not run as expected.

For example, the Pentium has special logic to detect and handle self-modifying code, which can play havoc with cache coherency. Programmers aren't supposed to write self-modifying code, but they always have and probably always will. If a Pentium-class chip doesn't implement this logic in precisely the same fashion as the Pentium, the results may be unpredictable.

If enough users start worrying about these questions, it's bad news for AMD and Cyrix. But the two companies downplay these possibilities and point out that their chips undergo rigorous compatibility testing throughout their design cycles. But as the 80x86 architecture becomes more exotic, and as 80x86-compatible processors diverge more radically from the Intel chips they're trying to emulate, chances are that internal differences will translate into external idiosyncrasies.

The Intel architecture won't end with the Pentium, of course. Intel is already working on the Pentium's successor, code-named the P6. Sources say the P6 will debut as soon as 18 months from now, will incorporate 10 million transistors, and will run at 200 MIPS. Aside from promising that an upgrade from the Pentium will be available, Intel isn't releasing any details.

New Competing Architectures

While Intel fends off competition from 80x86-compatible microprocessors, completely different breeds of chips are threatening the Pentium from another quarter. This camp comprises rival architectures, usually RISC-based, from such companies as DEC, HP, IBM, Motorola, Texas Instruments, Silicon Graphics/Mips, and others.

At least in the 80x86 arena, Intel is fighting on familiar turf. But the threat from rival architectures is more serious because of the risk that someone will score a stunning price/performance breakthrough that renders the Pentium hopelessly obsolete. Although Intel staunchly defends the 80x86, it's not easy fighting off challengers with a basic architecture that was laid down when Jimmy Carter was president.

The immediate threats to the Pentium are the DEC Alpha series and the Silicon Graphics/Mips R4400, a pair of hot new RISC chip designs. Because both will run Windows NT, direct comparisons with the Pentium are inevitable. Comparisons must be made thoughtfully, however, because it's not just performance but the price/performance ratio that counts. Historically, the prices of Intel microprocessors usually fall further and faster, but those patterns aren't necessarily carved in silicon.

Motorola's 68000 series, a perennial 80x86 rival since the 1970s, appears to have fallen a whole year behind the Pentium. The next-generation chip in that series is the 68060, which isn't due until early 1994—and Motorola says it will debut at only 50 MHz and 77 MIPS.

A more likely contender is the PowerPC, a new line of RISC chips under development by Motorola and IBM in partnership with Apple. Derived from IBM's RISC System/6000 processor, the PowerPC series is intended to drive the next generation of Apple and IBM computers.

The first entry in the four-chip PowerPC line is the 601. It is designed for moderately priced systems and is expected to debut by early 1994. Its performance is expected to be close to that of the Pentium, though perhaps not quite as fast. Later PowerPC chips will offer higher performance and lower power consumption.

Meanwhile, Microsoft hints that it will port Windows NT to additional processors. Other operating systems are also migrating across platforms: Sun Microsystems' Solaris and Next's NextStep are coming to the 80x86; the PowerPC's PowerOpen is an operating system that's designed to be ported to different chips; Taligent, another IBM-Apple partnership, is developing a portable operating system that's due out in 1995; and IBM's OS/2 remains a dark-horse contender.

PC users suddenly enjoy new alternatives. The relationship that for years has linked these users with the 80x86 architecture, MS-DOS, and Windows is being broken. As the Pentium emerges from the security of that relationship, the 80x86 architecture will face new challenges to its survival in the 1990s. ■

Editor's note: *BYTE news editors Patrick Waurzyniak and Ed Perratore, senior news editor Gene Smarte, West Coast bureau chief Andy Reinhardt, and executive editor Rich Malloy also contributed to this article.*

Tom R. Halfhill is a BYTE senior news editor. You can reach him on BIX as "thalfhill."

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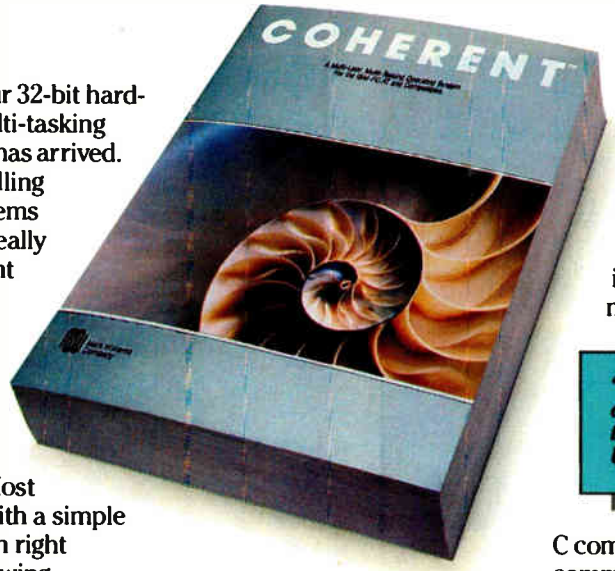

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Oberon: A Glimpse at the Future

A radical object-oriented design by Niklaus Wirth previews many of the features that you'll find in the next generation of operating systems

DICK POUNTAIN

ZURICH, Switzerland—Whether it's Taligent's Pink, Microsoft's Cairo version of Windows, or Apple's NewtOS for the Newton, there is sure to be an object-oriented operating system in your future. But few people know what such an operating system will look like or how it will alter the computer software concepts that affect the way you work.

Niklaus Wirth, a professor at Zurich's ETH (Eidgenossische Technische Hochschule) and the designer of Pascal and Modula-2, has developed the object-oriented Oberon system. It has moved beyond the research labs of ETH and into public domain versions. These include implementations for Apple's Mac IIs, DEC's DECstations, Intel-based PCs, IBM's RISC System/6000s, and Sun's Sparcstations. You can see for yourself what to expect of an object-oriented operating system by contacting ETH directly (see the editor's note at the end of this article).

Work on the Oberon system began in 1985. Wirth and fellow ETH professor Jurg Gutknecht designed the Oberon language and operating system in parallel with their development of the Ceres, a single-board graphical workstation driven by a National Semiconductor NS32GX32 CPU. The Ceres workstation offers a 1024- by 800-pixel color screen, a three-button mouse, 4 to 8 MB of memory, and a simple RS-485-based serial network interface. The Ceres and Oberon became a test-bed for Wirth's philosophy of achieving reliability through simplicity; he's fond of quoting Albert Einstein's epigram "Make it as simple as possible but not simpler."

Wirth believes that much of today's software is overweight and inefficient because it has grown by the mere addition of layers. The solution, demonstrated in the Oberon system, lies in extensibility: the ability for developers to add modules that reuse built-in data structures without having to recompile the entire operating system. For example, it's wasteful to incorporate new text-editing code into every application when all applications could share a centrally provided basic editor and customize it for particular purposes. Oberon also offers you the ability to extend data types so that new data types can inherit features of existing ones.

Under Oberon, the notion of an application program completely disappears; instead, there are groups of small programs called *tools*, which include Edit, Draw, Paint, Write, System, and Compiler. The operating system understands fundamental data types such as structured texts and pictures, and the "applications" are simply customized viewers for these types that add new functions. The result is a system

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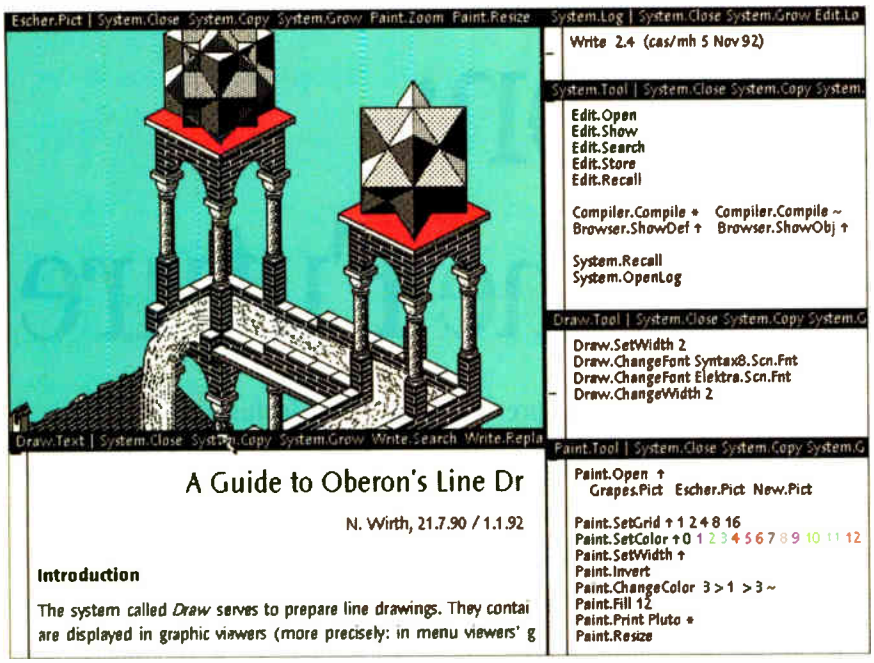

The PC version of Oberon, showing a Paint viewer and a Write viewer on the left and several open tools in the System Track on the right. You can expand any viewer to fill the screen by clicking on its Grow command; clicking on Close shrinks it again. Oberon is designed for a 1024- by 800-pixel screen and would normally display much more text than this 640- by 480-pixel VGA display can.

that provides efficiency and reliability rather than offering inflated size, which dramatically increases the probability of bugs and flaws.

What is most astonishing about Oberon is its smallness. The core operating system—including the Oberon compiler—occupies only 131 KB, which is smaller than most Windows utilities. There are only three assembler modules (Kernel, Display, and Reals); all the other modules are written in the Oberon language, and much of the 12,000 lines of source code for these is supplied with the system.

Working with Oberon

The Oberon system uses a GUI with built-in support for fonts and bit maps, but with tiled rather than overlapping windows. The Oberon screen is split vertically into two tracks, each containing several nonoverlapping panes called *viewers* stacked one on top of another. The wider, leftmost track is the *user track*, where the program output appears; the narrower, rightmost *system track* is used for system messages and commands. You can type text into any viewer after inserting the cursor into it with a mouse-click, and you can expand any viewer to full size with just a couple of mouse-clicks.

Everything in the Oberon system happens in the viewers, so there's no main menu bar at the top of the screen (see the screen). Each viewer has three parts: a main area for text and pictures; a vertical scroll bar; and a reverse-video bar, resembling a horizontal menu, that provides the viewer's title and a list of available commands.

All text that appears on an Oberon screen (e.g., a disk directory, a title-bar command, or a system message) is editable. You can execute any text string that names an Oberon command by pointing at it with the cursor and clicking the middle mouse button. Oberon commands, which are just exported procedure names, are always of the form *module.command* (e.g., `Edit.Copy`). When you compile your own modules, the new procedures immediately become available as commands. The Oberon system has no concept of programs that are comparable to, say, DOS .EXE files.

You work in the Oberon system by setting up small scratch-pad viewers in the system track that hold the commands you are working with. These viewers are, in effect, user-defined menus, and you never have to type any command more than just once.

In fact, you may not even have to type a command at all, because you can load from disk tools that list all the commands exported by a module. The Edit tool provides only the basic editing functions of cutting, copying, and pasting, but the Write tool (which is an extension of Edit) is a full document editor that allows you to select fonts and formats. When you execute a tool's command, the operating system loads the corresponding module into memory—if it's not already there.

Most Oberon commands take their operands from the screen. For example, to copy a block of text, you select it with the mouse and execute the `Edit.Copy` command. To make the whole viewer the input for a command, you place the cursor in the viewer and press the Mark key. You can apply any tool to any viewer or to the output of any previous command. For example, you might list a directory by using the `System.Directory` command, then select a filename from the newly opened directory viewer, and finally use `Write.Open` to edit the file in a new Write viewer.

You can run the compiler on any viewer that contains Oberon source code, compile the object code into memory, and run the new commands. The Oberon system is fast and convenient once you master the daunting mouse-button combinations.

A Model of Interaction

The Oberon system offers a model of user interaction that differs from that of Unix, DOS, or Windows. The system's unit of action is a procedure call, or command, and the unit of compilation is a module that can export several commands. Commands must be parameterless procedures, and they receive their run-time arguments (e.g., screen selections) via a system variable called `Oberon.Par`.

Commands are indivisible actions that you can interrupt only by pressing the Abort key. Because you can't interact with the commands, you must specify a target *before* executing them. Consecutive Oberon commands normally swap data via persistent data structures in main memory, whereas under DOS or Unix the output from one program almost always has to be written to disk before it can be loaded into a second program.

The Oberon system loads modules dynamically on demand, as Windows DLLs do, and they remain in memory unless you manually remove them with a `<module>.Free` command. Machines that possess a hardware MMU (memory management unit), such as the Ceres workstation, use this feature to load modules by raising page faults and to protect modules once they are in memory. The system's kernel contains a garbage collector

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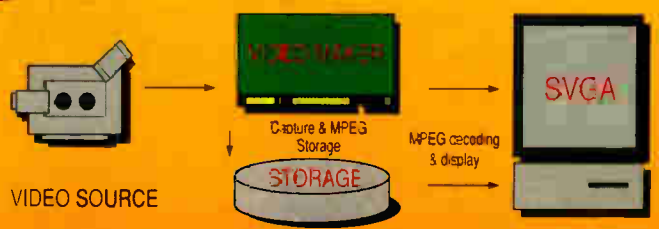

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that operates between procedure calls to free space that's not currently in use; therefore, programmers don't have to deal with explicit memory deallocation.

The Oberon compiler has no separate linking phase; linking occurs when a module is loaded. This conserves system resources in three significant ways. First, the binary images of programs on disk are small, because they don't contain linked copies of all the modules they import. This is in contrast to a DOS system, where you can have several applications on your hard disk that each contain a linked copy of the same massive graphics library. Second, less RAM is consumed, because only one copy of a module is ever loaded at one time no matter how many client modules share it. Finally, when you upgrade a module, all its clients are automatically upgraded as well.

Oberon Benefits

- provides you with a lean system that's less likely to contain bugs or flaws
- extends rather than duplicates system capabilities
- replaces the concept of applications with the concept of small "tools"
- is built around an interface that encourages economy of motion in work procedures
- decouples data from the way it's viewed

The Oberon system can execute only one command at a time, but you can run multiple tasks by simple task switching: You select a viewer as the target for future commands. Whenever it's not executing a command, the system runs a central polling loop that watches for keyboard, mouse, and network events (see figure 1). To prevent such activity from being lost while the CPU is executing a command, the Oberon system queues these events in buffers controlled by hardware interrupts. The interrupts are hidden in their respective device drivers and return control to the point of interruption, so they are invisible to user programs.

A programmer can install new code into this polling loop, either to monitor a new event source, such as a modem port, or to run a lengthy command (which must be packaged into small time slices) in the background. As long as commands are executed quickly (which is normally the case, because the commands are noninteractive), this scheme produces the illusion of multitasking.

The tasks run on a single-threaded system and can't interact in unexpected ways, which eliminates huge chunks of protection code that would otherwise be needed. The Oberon disk file system is equally simple, using a B-tree directory structure for speedy access.

One important design feature of the Oberon system is the decoupling of data from the way it's viewed. Viewers format and display the contents of abstract documents such as texts, graphs, or pictures. Documents are active objects that contain the commands required to change a document's contents. When such a change occurs, the document broadcasts a message to all viewers so they can update their view of it. The generic viewer object, called a *frame*, doesn't need to know the type of document that it contains.

This decoupling enables you to extend the Oberon system by adding new document types and their viewers without having to recompile or duplicate any of the code of their parent document types. It also means that adding new commands to an existing document type will not interfere in any manner with the operations of its viewer.

The Oberon system core is a hierarchical, acyclic structure, with hardware dependency confined to the driver layer. According to Wirth, the system "imports hardware" at the bottom level and "exports commands to the user" at the top level (see figure 2).

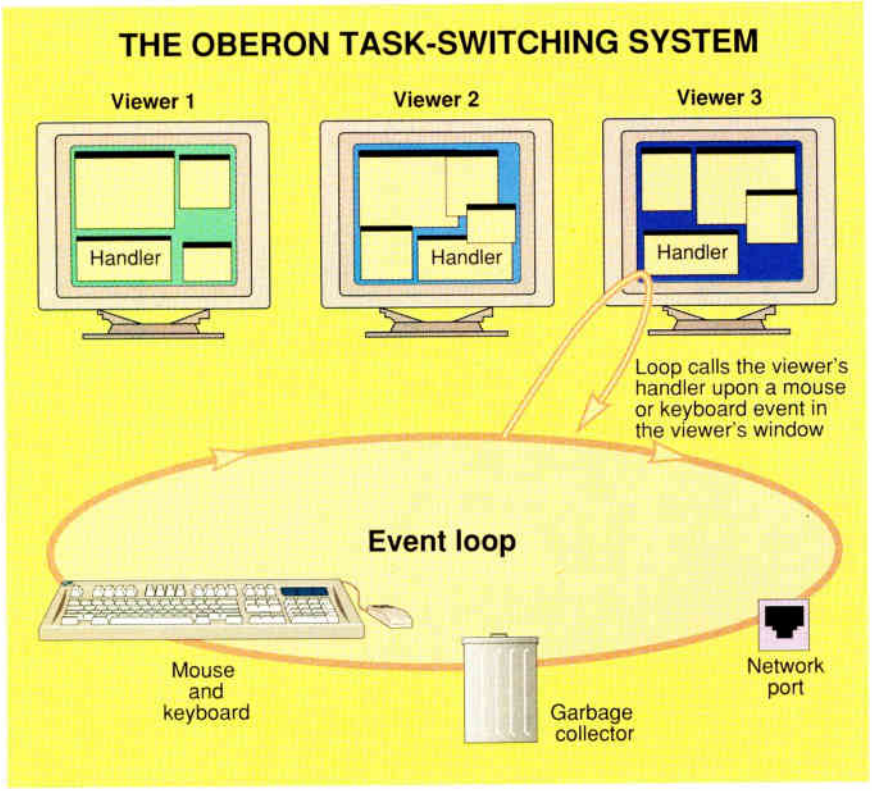

Figure 1: *A simple polling loop is the only process scheduler in the single-threaded Oberon system. Commands get scheduled when their names are selected in a viewer, and they always run to completion unless interrupted by a press of the Abort key. The Handler procedure, the Oberon equivalent of a method table, interprets messages and executes the appropriate code.*

Texts and Write Elements

Text, an abstract data type, has a special importance in the Oberon system. It's defined as a sequence of attributed characters whose attributes are ASCII code, font, color, and vertical offset (the last three are collectively called a *look*). Text is a far more powerful concept than string, the building block of more conventional systems, because it includes the concept of appearance. Texts are divided into *runs*, or sequences of characters that share the same look. Texts are active objects that can edit themselves—through the basic methods of `Delete`, `Insert`, `Append`, and `ChangeLooks`—and store themselves to and load themselves from disk.

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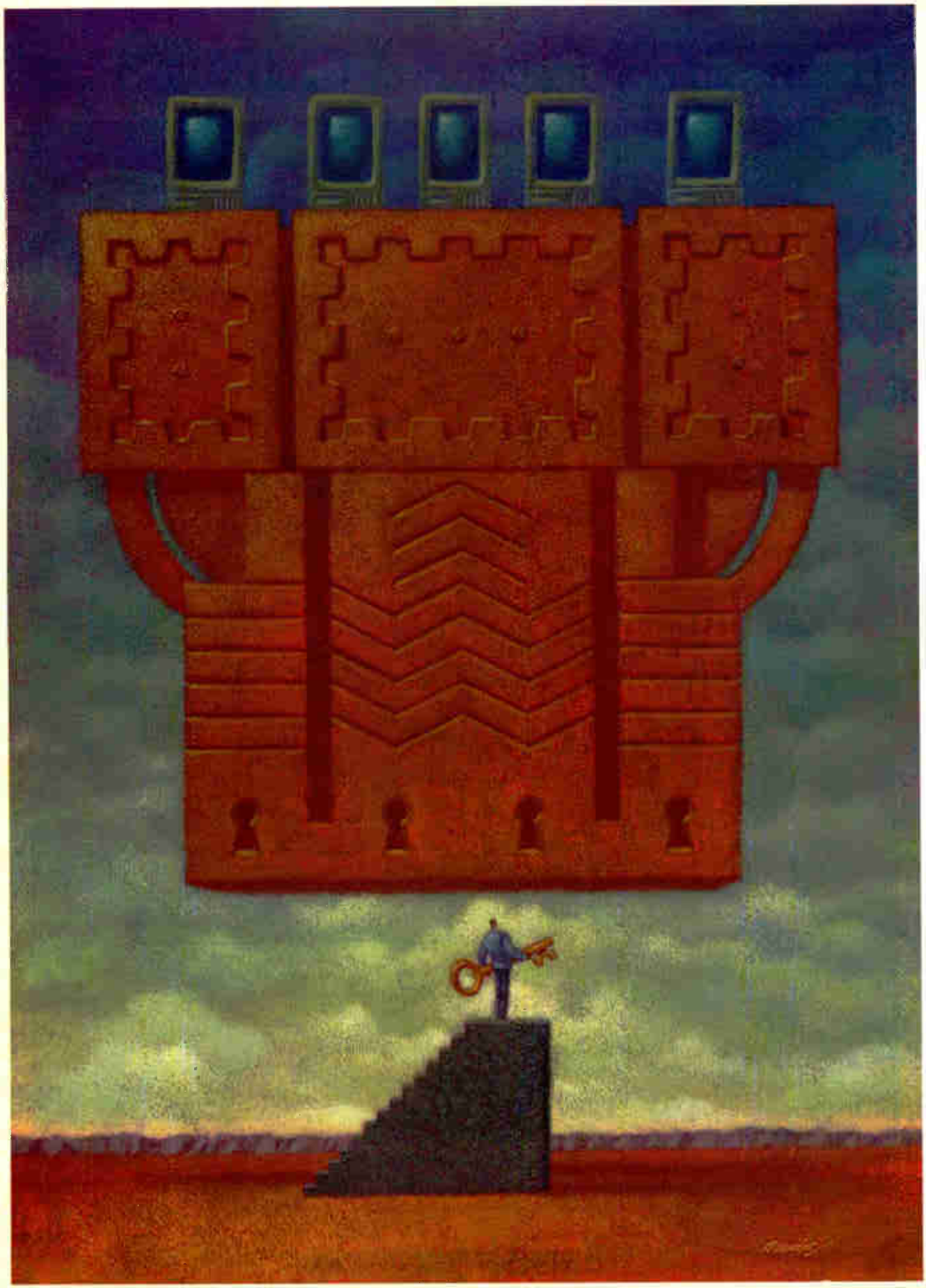

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SEEKING SECURITY

Mainframe techniques define system security. Soon, they'll be adapted to distributed client/server systems.

PAULINA BORSOOK

Jon Ricker, vice president of strategic systems for the overnight delivery giant Federal Express (Nashville, TN), sensed that his colleagues were uneasy about system security. FedEx was downsizing from mainframes to an object-oriented client/server system. Ricker knew that FedEx needed mainframe-type security to safeguard sensitive data, but he also knew that the mainframe security tools he was used to could not be easily adapted to the distributed client/server environment. "Mainframe [security] concepts work," says Ricker. "They just cannot be applied physically to distributed architectures."

But times are changing. What has been learned about security over the years in the world of big iron is about to migrate down to the distributed client/server environment. Unfortunately, not all mainframe security concepts can be applied to distributed computing easily.

Fire and water damage, power glitches, and failure to impose strict backup policies remain the greatest danger to your data. Without massive backups of data, equipment, and network resources, "you're dead," says Robert Watkins of Nova Information Systems (Seattle, WA), a systems integrator.

Yet intentional malice may be the most insidious hazard menacing your data. In order of frequency, the most common human-made threats are programming mistakes, curious interlopers, hostile insiders, and outside attackers, says Tom Patterson, director of information-security programs at Techmatics, a consulting firm in Fairfax, Virginia. Willis Ware, a member of the corporate research staff at the Rand think tank (Santa Monica, CA), considers insider threats to be the most common problem in the business world, as well as the most awkward. With an authorized user, security problems can be difficult to detect, prove, and record, and with any corrective actions, you risk traumatizing the entire organization.

Striking the balance between reasonable security precautions and excessive measures can be your most formidable challenge as you implement a security strategy. "The most secure system is unusable, and the most usable system is insecure," says Don Rife, director of technical services at Towers Perrin (Philadelphia, PA), an international management consultancy.

You Are Whom You Say You Are

Mainframe security systems are built around one of four general methodologies: identification and authentication, discretionary access control, audit control, and object reuse. Many people familiar with mainframe security also add a fifth component to the list—secure communications (see the text box "Security Bulwarks" on page 120). After all, with more and more corporations relying on public-switched data communications networks, "you have to worry about who else is on AT&T," says David Brewer, a systems integrator at Soltech Solutions (Charleston, SC).

Authentication and identification means guaranteeing you are whom you say you are. "All other security problems—viruses, encryption, privilege levels, audits—are meaningless unless you know that people are who they say they are," says Jim Geary, vice president of marketing and international sales for Security Dynamics (Cambridge, MA), a protection-products manufacturer.

The use of passwords is a time-honored authentication technique, but microcomputer operating systems don't insist on password use. Peter Neumann, the principal scientist at the SRI computer lab (Menlo

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Park, CA), believes that microcomputer and network operating-system vendors have been shortsighted, because they have not built security into their standard operating systems.

Technatics' Patterson agrees, saying that five years ago, when Microsoft was approached about adding security to DOS, the company responded by saying that DOS was meant to be open, and if people want security, they'll go with OS/2. But now DOS is everywhere, and everyone is talking about security. Most DOS security is still a result of products running DOS rather than DOS itself. For example, antivirus protection is the sum total of MS-DOS 6 security.

In the enterprise-wide security of the 1990s, the goal is to have users log in once and allow access to all the resources they are entitled to. Passwords should be encrypted by the client, because the pathway between the client and the server can be tapped. "If the passwords are unencrypted on the server," says Soltech's Brewer, "you do not have a chance of maintaining security."

Smart cards coupled with unique identification numbers for each user are one way of authenticating system users. (Photo courtesy of Security Dynamics)

Another authentication technique coming into favor, according to Geoff Goodfellow, chairman of RadioMail (Menlo Park, CA), a wireless E-mail service, is the use of smart cards, long associated with PINs (personal identification numbers) and often keyed to dates and times of day. An example of a PIN is the number that you use with your bank's automatic teller card. Security Dynamics' smart card, SecurID Card, uses PINs in combination with constantly changing sequence codes unique to each user (see the photo above). An access-control module located between the incoming line and the server matches your PIN and sequence number before permitting access to the host computer.

But security smart cards are often difficult to administer, because people forget their card. If a security scheme is difficult to administer, it won't be used. It must be automated and easy to use, says Towers Perrin's Rife. Public-key encryption is still another way of providing authentication (see "Should Encryption Be Regulated?" on page 129).

A Question of Access

Discretionary access control dictates who has access to files, applications, and servers. As you log on to your system, you are given a personalized directory of network resources available to you. PC/DACS and NET/DACS from Mergent International (Rocky Hill, CT), formerly Pyramid Development, provide workstation and Novell NetWare users with this sort of control.

Security Bulwarks

Every day more mission-critical applications and data are bumped from mainframes to distributed client/server networks. But microcomputers evolved without the mainframe world's passion for system security. In response, mainframe protection techniques are being adapted for the distributed computing environment. Here are some techniques soon to be available:

Security Technique	Benefits and Tips
	Identification/Authentication Ensures that you know who your system users are. You can link passwords to data known only to the user; force users to change passwords often; encrypt passwords on both the client machine and the server; make sure that passwords are made up of random characters and numbers; and issue smart cards to govern access.
	Discretionary Access Control Regulates who has access to applications, files, and servers. You can restrict users to directories of network resources available to them; use permission levels to safeguard applications, directories, and files from unauthorized use and modification; deny users the ability to modify permission levels; and use VMMs (virtual machine monitors) to control actions by users and applications.
	Audit Control Keeps you abreast of all network events. You can use programs that report on who has used or tried to use which applications, what data files have been opened, and what files have been written to; monitor all external and internal accesses, including time of access, directories entered, and point of origin; and inspect audit reports daily.
	Object Reuse Clears sensitive data from RAM and hard disks after they have been used and reallocates resources. You can set times-out that automatically disconnect inactive computers, workstations, and other network connections (external and internal).
	Secure Communications Protects your network where it meets the outside world. You can lease private data lines to link remote sites; use modem management programs to defend dial-in access; and encrypt data and files before sending them over a public network or LAN, especially a wireless LAN.

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Windows NT also provides discretionary access control, and future releases will have mandatory access control (i.e., files must have access permission levels attached to them).

You can also gain access to your system through a separate security server, but your server had better be fault-tolerant. "One personal computer as a gateway for a network is too vulnerable if all 3000 users on a network have to log on through it," says Rife.

A technique known as VMM (virtual machine monitor) uses dedicated hardware and software to give you discretionary access control. VMM, a concept borrowed from the U.S. Department of Defense Orange Book specification on computer security, is installed parallel to your platform's native operating system and acts as a security monitor. ACAssure and NetAssure from Cordant (Reston, VA) are two VMM products that are currently available.

The beauty of VMM, according to Rick Carlson, program manager of the government systems group at Novell (Orem, UT), is that DOS has to talk through the VMM, which controls what the user or application is trying to do (see figure 1). The VMM controls file access, drives, and directories and permits access based on the user's security clearance. If implemented properly, your platform will not work if your VMM is not there. VMM solutions update TSR programs that attempted to do the same thing. But as Carlson says, "Any smart 13-year-old can kick a TSR out."

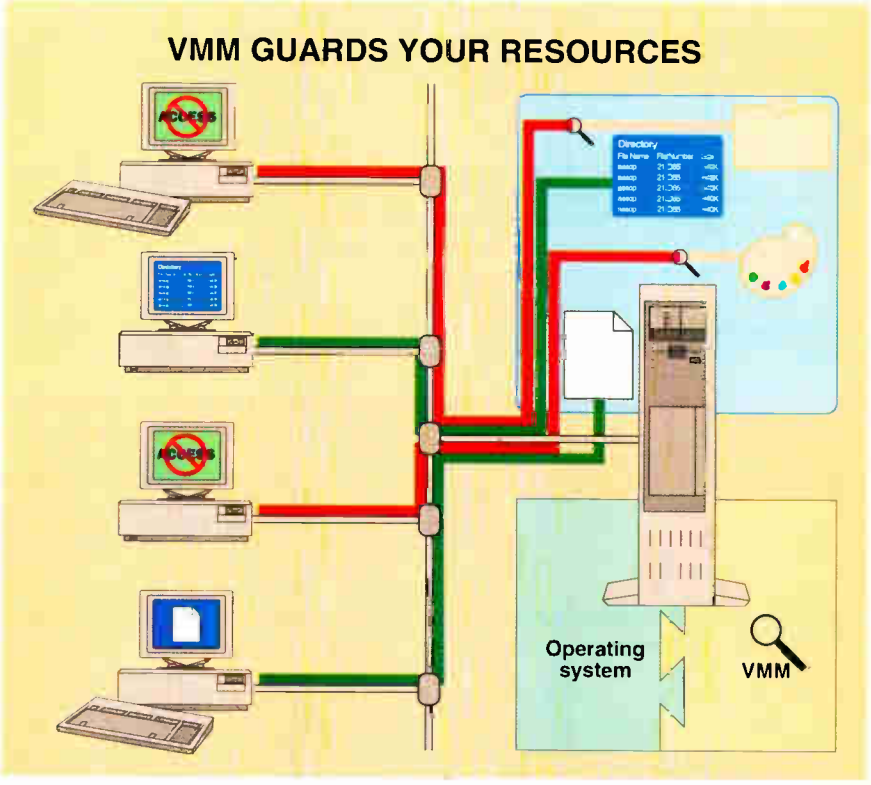

Figure 1: *VMMs let you control who has access to files, applications, drives, directories, and servers. The red line indicates that access has been denied. The green line indicates that access has been approved.*

The Audit Trail

Audit controls track what programs have been used, what files have been opened, how many reads and writes have been executed, and how many times a client or server has been accessed over a day, a week, or a month. Techmatics' Patterson recommends that you always have a part of your audit control running in the background. You can activate this feature with fine granularity when needed.

Audit trails, however, can generate too much information. Although some vendors give you audit-trail capabilities, they generally don't give you analytical tools to go with them, making it difficult to spot suspicious use patterns. Techmatics' Patterson suggests that AI tools could be developed to spot patterns, but as Rand's Ware notes, "these tools are only research vehicles now."

Nonetheless, Ware believes that audit control is a good security practice. "Every working day have somebody look at the audit trail, like a security guard making the rounds of a building," says Ware.

Guarding Networks

- Authenticate all users.
- Define who has access to what files.
- Keep logs of system activity.
- Limit external access.

Object Reuse

Object reuse is a process that clears your RAM or hard disk of sensitive material after you've used it and before anyone else can access it. For this to work, your operating system must know when a user is finished working before it reallocates resources.

A concept related to object reuse is *auto-locking*, a protocol long established in the mainframe world but often lacking in client-server configurations, according to Robert Kane, a partner at Intrusion Detection (New York), a security consulting firm. An *auto-locking* program automatically logs out users who have left their workstations unattended for a few minutes. The program constantly runs in the background.

X Window Systems presents an area of vulnerability, says Kane. A potential intruder searches for a screen that is timed out and then assumes control of the network channel left dangling by the timed-out workstation. The intruder creates a false system log-in screen and waits until you come along to log on to the network.

continued

"There's no such thing as meaningful security. Nothing is at all in any sense secure."

—Peter Neumann, principal scientist, SRI computer lab

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Unknowingly, you try to log on to the bogus sign-in screen. After you enter your password, the intruder mimics the normal system password-error message and passes control back to the network, which prompts you to log in. Thinking that you mistyped your password, you try again and get on-line, and that's the end of it as far as you're concerned. However, what has happened is that the first log-in attempt and your password were captured, encrypted, and sent to the intruder, who now knows how to legitimately access your system.

Securing Your Communications

Secure communications were not a problem when two mainframes were linked over a private line or when you had a private, in-house E-mail system without external connections (see the text box "Securing E-Mail" below). But now you have so many LANs, workstations, and modems connected to public telephone networks that securing your communications can be a nightmare. Towers Perrin's Rife recommends modem management packages, such as TelAssure from Cordant and Total Control from USRobotics (Skokie, IL), to help secure dial-in access.

Kane believes that LANs are the weakest link in security. Network monitors, such as Sniffer from Network General (Mountain View, CA), can monitor all LAN traffic. You can even download network-monitoring shareware from BBSes. But LAN protocols make it difficult to determine if data packets have arrived without having been intercepted. What's more, wireless LANs are even more vulnerable to monitoring by intruders, because anyone with a scanner can pluck the radio signals out of the air without being detected. Most

Securing E-Mail

Downsizing and distributed client/server architectures have placed E-mail into commercial use as never before. As Robert Kane, a security consultant with Intrusion Detection (New York), puts it, "Corporate E-mail [is] becoming an interstate highway." And because E-mail, like Unix, has a history of openness and a lack of privacy, vast efforts are being made to make it trusted enough for workday use.

"Authentication and privacy control are essential if you don't have control of the entire system," says Stephen Crocker, Internet Engineering Task Force area director for security. Before divestiture, the single telephone company was able to exert discipline, and it commanded a high degree of trust. But according to Crocker, that trust has been breaking down since divestiture. "You can either harden the system as a whole—which is not likely—or make end-to-end control more elaborate," says Crocker.

The solution is encryption and authentication of E-mail. One approach is privacy-enhanced E-mail, or PEM as it is called on the Internet. Through cryptography, PEM offers confidentiality, authentication, message integrity, and nonrepudiation of origins between the sender and receiver at or above the user-agent level. This approach imposes no special requirements on message-transfer systems at intermediate relay sites or end points, and it can be incorporated on a site-by-site or user-by-user basis.

PEM is becoming an Internet standard. But it uses RSA encryption-algorithm technology, which was of some concern to Internet users because RSA is patented and controlled by RSA Data Security (Redwood City, CA). Also, as a publicly funded research network, anything used or developed on the Internet is supposed to be in the public domain, and Crocker says that there have been questions about basing Internet standards on material not freely available to everyone. "But Ethernet is a patented technology, too," he says. "You just can't get by with what's in the public domain."

PEM has competition in the form of a semiunderground technology called PGP (Pretty Good Privacy). PGP is "the bottom portion of PEM: encryption for privacy, but without authentication," says Crocker. "It works fine if you feel you can trust the system in a loose way—as in normal communication."

Available in the public domain, PGP is based on published RSA algorithms. As a result, PGP cannot be legally used in the U.S., but its development continues elsewhere, avoiding U.S. patent laws. Further, encryption is considered by the U.S. National Security Agency to be a controlled technology and cannot be exported.

Nevertheless, PGP1, the latest version of PGP, is available through U.S. BBSes. "It's gotten pretty good reviews technically," says Crocker. "But it still violates patent laws, so nobody with anything to lose will use it."

Similar to PGP, Ripem also uses RSA technology but has a more legitimate relationship with RSA Data Security. Ripem, developed in the Internet community, is available in the public domain, but it cannot be used commercially.

To accompany PEM, the Internet will also be offering a certification process that authenticates that E-mail senders are who they say they are. PCAs (policy-certificate authorities), authorized by the Internet Society, grant the equivalent of notary powers to those charged with issuing E-mail authentication certificates to the end users in their organizations. Both RSA Data Security and Trusted Information Systems (Glenwood, MD) have applied to be Internet PCAs.

PEM has its downside, though. Encryption, a controlled U.S. technology, is going into an Internet standard, but the Internet is more global than ever. U.S. regulations allow you to send encrypted messages abroad, but your colleagues in other countries cannot buy the U.S. PEM-compliant encryption software that you're using. They'll have to buy a version that you can only hope will interoperate with the version you're using. Weaker encryption technologies permitted by the U.S. government for export are not part of the Internet PEM specifications.

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analysts recommend encryption if there's a threat of having your data captured electronically.

Securing Unix

Securing a Unix-based system can be a greater challenge than securing a conventional microcomputer system, according to Mike Ressler, technical staff member at Bellcore Laboratories (Morristown, NJ), a research facility funded by the regional Bell companies. Ressler sees three problems with Unix security. First, Unix is customarily used in open or semiopen networked environments with remote, dial-in access capabilities.

Second, there are no Unix standards for access-control lists, applications auditing, or user privilege levels. To help remedy this, the Posix committee is developing audit interfaces that will standardize the way applications fit into audit trails.

Finally, so many people know Unix so well that its weaknesses are easy for the less scrupulous to exploit. Barbara Fraser of the Computer Emergency Response Team at Carnegie Mellon University (Pittsburgh, PA) lists intruders' ability to exploit known weaknesses of Unix among the top five problems CERT handled in 1992.

One way of making your Unix-based network more secure is by instituting mandatory access control enforced by Unix. You classify information so that every file has a security level and every user has a security clearance. System users can't change their security clearances or a file's security level.

Another way of making Unix more secure is by breaking down the power of the Unix root, a technique mapped out in the MSR (minimum security requirement) for multiuser operating systems being developed by the National Institute of Standards and Technology (see the text box "New World Orders" on the right). Unix file systems are organized in an inverted tree format: The root directory is at the top. This directory is under the control of the Unix system administrator. A secure version of Unix would restrict access to the 20 or 30 privileges associated with the root. "Not everyone needs all 30 functions," says Ressler. Partial root privileges would be granted to users according to their needs.

Information labels, a concept originating in the U.S. Defense Intelligence Agency, have also been considered as a means of making multiuser operating systems such as Unix more secure. A label for every file appears at the top of the workstation screen, indicating each file's security status. Such labels are governed directly by Unix and cannot be removed by users.

To improve Unix security now, you can enforce the use of passwords that can't be easily broken and have your system automatically prompt users to change their passwords every few weeks. If you're linked to the Internet, you should adopt such organizational policies as no `ftp` use, particularly no anonymous `ftp` use (*`ftp`* is a network file transfer program used extensively on the Internet; anonymous `ftp` lets you access directories on a remote computer and copy files to your computer anonymously). Going one step further, you

New World Orders

The National Institute of Standards and Technology (Gaithersburg, MD) is developing a new set of computer-security standards to replace the decades-old U.S. Department of Defense Orange Book specifications. Gene Troy, of NIST's computer-security division, oversees the project.

According to Troy, the project came into being because "the world has become too small and interconnected, so people have to be able to trust that interconnectedness and not get killed." With security concerns switching from the political arena to that of industry, business and government recognized a need for a workable commercial computer-security standard. The Orange Book was really only for the military and did not fit the commercial world of nonclassified data. "We need to quit fooling around and set an international standard that can be safely used around the world," says Troy.

The criteria outlined by NIST, says Troy, "takes conscious note of work done elsewhere in the world. The Europeans and Canadians have quite good ideas, and Canada has evolved even beyond the Europeans." In fact, the principal author of the Canadian Trusted Computer Product Evaluation Criteria was a member of NIST's criteria working group.

To give the new standard flexibility, NIST borrowed an idea from the Europeans: The U.S. criteria separate functional requirements (i.e., what a trusted system is supposed to do) from assurance requirements (i.e., how to determine that it does what it is supposed to do). The European security standard F2/E2, the functional equivalent of the Orange Book C2 security specification, already separates features and functions from evaluation. "They took apart our C2," says Troy, "and made it better on both axes, particularly the evaluation part."

The basic U.S. security specification describes how an operating system is supposed to work, how to determine if it can be trusted, and what the rationale is for its use (i.e., what environment a level of security is expected to be used in, what threats it's expected to encounter, and what policies should be enacted with it). These clusters of security characteristics are called *protection profiles*.

Next NIST borrowed the Canadian idea of using security building blocks to specify gradations of security for different technical areas. This provides standards that new computer products can be evaluated with. Similarly, in the area of assurance, the U.S. security criteria specify degrees of testing and documentation complexity.

Embedded in the U.S. criteria is the MSR (minimum security requirement) for multiuser operating systems, such as Unix. MSR is the basis of the only NIST protection profile defined so far: the commercial security protection profile. Mike Ressler, a member of the technical staff at Bellcore Laboratories, says that while MSR has had a strong influence on Posix, an operating system could still meet Posix standards and not be secure.

MSR has been adopted by the Japanese Ministry of International Trade and Industry and by the European Computer Manufacturer's Association. With the federal criteria, Troy says, "We can really have multinational criteria for a trusted system."

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can give your Unix installation only one connection to the outside world.

Philosophical Quandaries

Once you've overcome the pragmatic, mechanical difficulties of securing your distributed client/server system, you will have to resolve a number of cultural, ethical, and philosophical issues. Your biggest problem can be convincing your workstation users that there is a security problem. "People think, 'Why would anyone bother me?'" says Chuck Cole, computer security manager at Lawrence Livermore Laboratory (Livermore, CA). But to an industrial spy, "simply understanding *what* you're doing and *how* you're doing it can be valuable information."

Complicating attempts to convince users of the need for strict security is that nobody really knows how much money is lost because of security breaches each year. All that pundits agree on is that a significant amount of money is lost every year. The National Computer Security Association (Carlisle, PA) estimates annual losses at from $80 million to $150 million, and USA Research (Portland, OR) believes the figure for 1991 topped more than $1 billion. When contacted, the FBI refused to make public any specific dollar amounts, confirming only that it has speculative figures.

Introducing mainframe-type security measures into your Unix-based distributed computing environment can cause a cultural clash. "With Unix culture, it's often the case that security comes second, and getting the job done comes first," says Soltech Solutions' Brewer. "Where with the mainframe mind-set, the job gets done as long as security doesn't get compromised."

Personal computer users can present even more headaches. Dain Gary, manager of Carnegie Mellon's CERT, points out that many of these people are not as well trained in security issues as Unix users. Lawrence Livermore's Cole adds that the prevailing philosophy among computer users favors open communications for nonsensitive data.

To convey the necessity of securing your distributed computing system, you must constantly preach the virtues of due care and due diligence. Remind your users of the potential liabilities of lax security. "People have to think about what their data implies," says Towers Perrin's Rife. For example, what would happen if security were compromised at a hospital and confidential information about a patient with AIDS was made public. Not only might the patient sue over the loss of privacy, but the hospital could lose business because people might be reluctant to use it after such a leak.

You must continually remind your system users of their fiduciary responsibilities, counsels Jon Kaplan, director of security-products development at Fischer International Systems (Naples, FL), a security-products manufacturer. The very essence of your organization is at risk. if data is jeopardized by security lapses, formats are altered, or configurations are changed.

Ethical issues also arise when you establish security policies. You will have to make trade-offs between security and privacy. "Monitoring keyboards is an excellent way of ensuring security," notes Rand's Ware, "but it's also a good way to provoke civil-liberties concerns about privacy."

If you don't want to monitor keyboards, you can install network monitors to inspect traffic down to the character level. Looking at traffic patterns and seeing where things originate, especially beyond their most recent source point, improves security, particularly if you see messages sent from places you've never heard of. Attempting to do this, however, is a judgment call. In the U.S., the legality of such practices has not been established yet.

First Steps Are Critical

Your first steps toward implementing an enterprise-wide security policy are critical. Begin by finding answers to such questions as who can do what on your system? What is the nature of your data? For what purpose is your data used? How much money would your company lose if your data were exposed?

"Look at your data," says Fischer International's Kaplan. "How would it jeopardize your project, organization, or corporation" if that data's confidentiality were breached?

You might find it difficult to classify your information. Further, your company may never have undertaken such an expensive project like this before. "It's hard to rationalize the expense in the corporate world," says Carnegie Mellon's Gary. "The process isn't trivial."

Towers Perrin's Rife says there is a parabola with security. "After a certain point, you can spend 50 percent more money and get 1 percent more security. If you're going to spend that much money to protect [your data], then someone else may find it worthwhile to break in."

Management may not be in favor of security. "It's inconvenient, a hassle to administer, and they think, 'Let's risk it,'" says Rand's Ware.

Oddly enough, with all the concern

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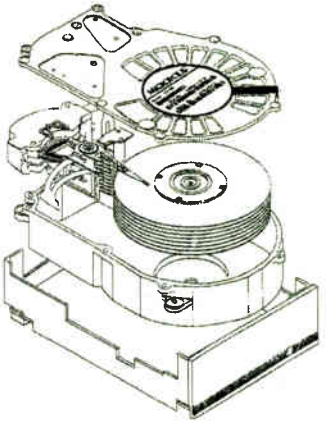

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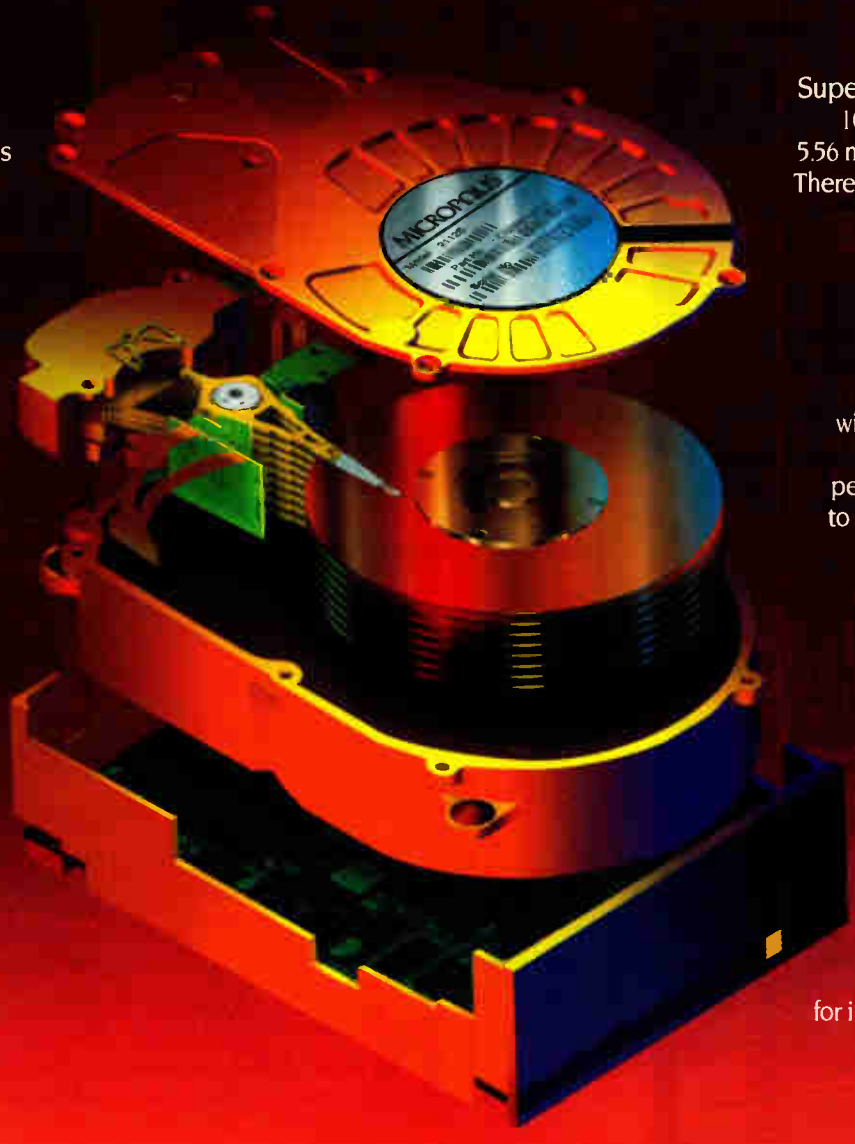

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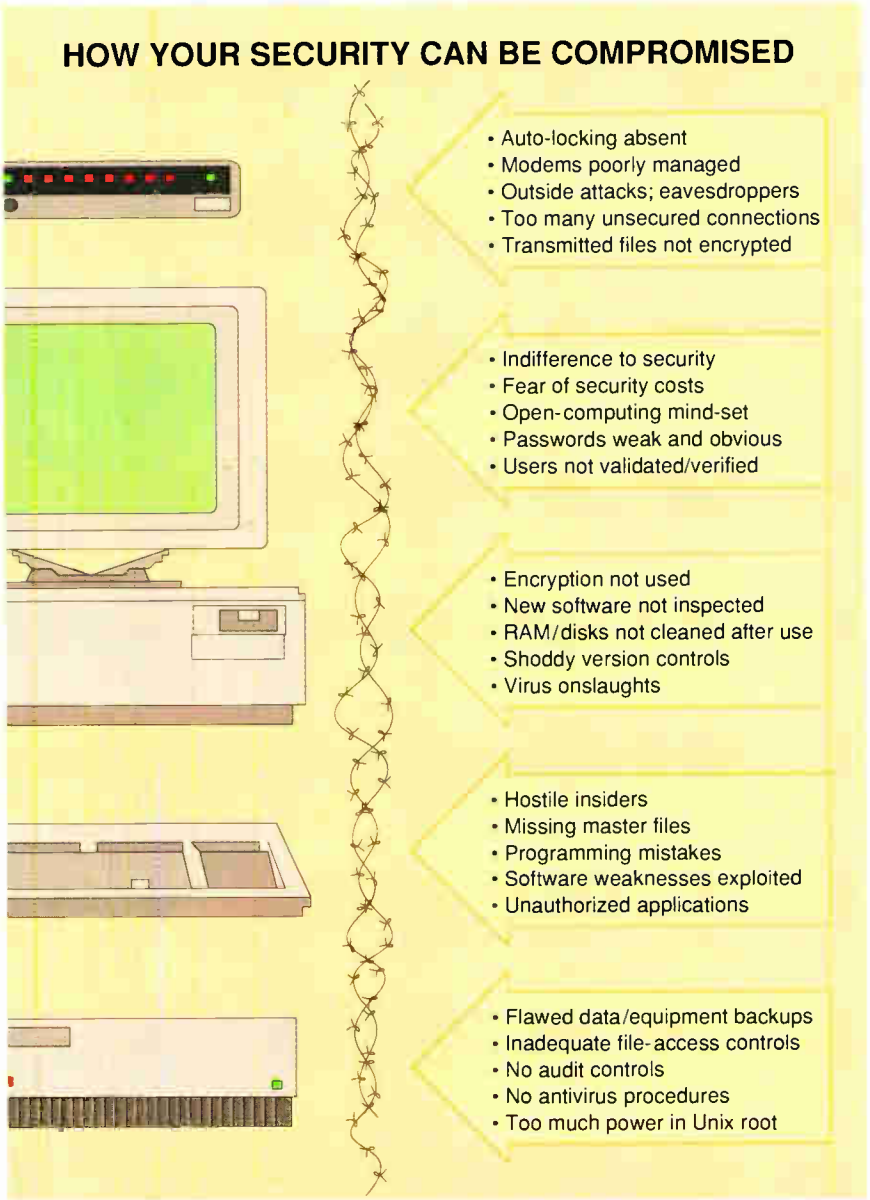

Figure 2: *Security weaknesses include connections to the outside world, lack of a security ethic, poor security management, human folly, and shoddy system control.*

about security, experts cannot agree on where the greatest threats to your data come from. Most agree that the threat from viruses has been given too much media attention, yet pundits still advise you to use virus-protection programs and caution against downloading files from BBSes (see "Stealth Virus Attacks" on page 137).

RadioMail's Goodfellow advocates that you put 90 percent of your security resources into defending your system's perimeter. In other words, protect your system where it meets the outside world—the equivalent of don't leave your keys in the car and always be sure to use your dead-bolt lock (see figure 2).

Ware disagrees, saying that "the temptation is to think there are going to be jazzy, sophisticated attacks" by foreign secret agents. More likely, in Ware's opinion, one of your clerks will make a mistake entering financial data, realize your system didn't catch it, and figure out a way to turn that mistake into personal gain. ■

Paulina Borsook is a freelance writer based in San Francisco, California. She was formerly the West Coast editor for McGraw-Hill's Data Communications *magazine. You can contact her on BIX c/o "editors" or on the Internet at loris@well.sf.ca.us.*

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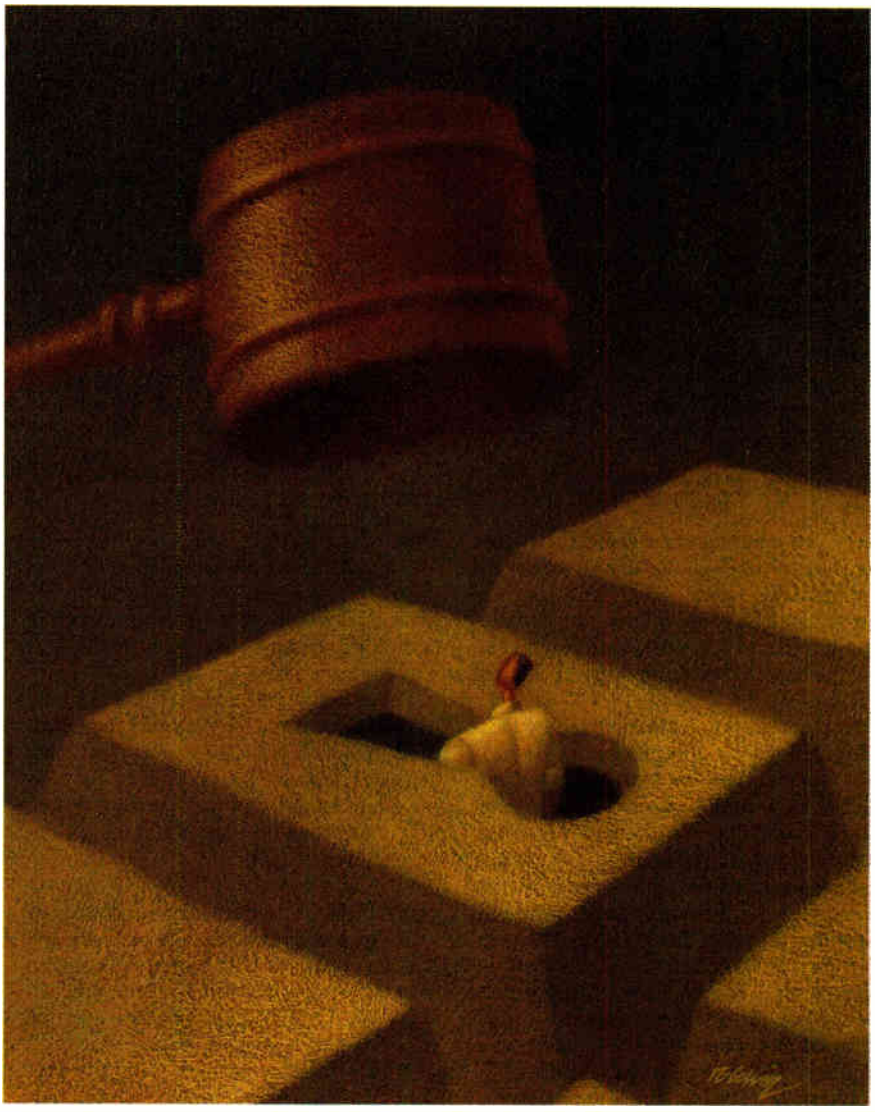
SHOULD ENCRYPTION BE REGULATED?

Politics, not technology, may hamstring the use of data encryption in the U.S.

BY PETER WAYNER

The best of today's computerized encryption systems are virtually impossible to break. This is great news if you're worried about the security of your sensitive files. But U.S. law enforcement agencies want to limit or ban the use of encryption, because they claim it hampers their ability to prevent and prosecute crime. The debate on this issue has gone to extr mes, with proposals ranging from a total b n on cryptographic systems to the unres i d use of encryption.

It's prem tu to say how this controversy will play itself out. But for the first time, po. ical constraints rather than technological rriers may limit the way you use your computer.



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Regulate

Law enforcement agencies argue that criminals can hide their business records or communications om authorities by using encryption. I. the police cannot decrypt a suspect's secret documents, they may not be able to get enough evidence to convict a dangerous criminal.

For example, the police in Sacramento, California, interrogated a person suspected of involvement in child pornography. The suspect maintained a number of large encrypted files that the police believed contained illegal images. The suspect refused to hand over the decryption key, hampering the police's ability to resolve the case. At the time of this writing, the case was still pending.

Congress took a different tack when it considered the Omnibus Crime Act of 1991. Embedded in the legislation was a clause mandating that all communications systems be designed so that system operators could provide a decoded version of any

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Encryption Systems

The best-known and oldest form of encryption are private key systems, which use an encryption key (usually a number) to conceal data with a set of mathematical transformations. The cryptograms in your local newspaper are simple examples of this technique: The keys consist of a pattern for replacing each letter with another.

The most secure private key system is the one-time pad, which consists of an encryption key as long as the message—one key byte is used to encrypt each byte of the file, often using the XOR operation. The system is impossible to break, because any *n*-byte file can be encrypted into another *n*-byte file. The technique can be unwieldy, however, because the large keys must be transmitted securely between the parties.

DES (Data Encryption Standard) is one of the more sophisticated modern private key systems. It encrypts data by mixing in key bits and alternating simple, nonlinear permutations. The U.S. government classified the design details of the nonlinear permutations, and cryptographers speculated that the government had hidden a trapdoor in the system. Recent efforts by Eli Biham and Adi Shamir of Technion, a university in Israel, to prove the existence of a trapdoor were inconclusive. RC-4, a proprietary encryption system produced by RSA Data Security (Redwood City, CA), is similar in design to DES.

One variant of the private key systems is cryptographically secure hash functions—essentially, checksums that cannot be forged. The functions take an arbitrarily long file and reduce it to a number, making it impossible for someone to tamper with the file without changing the number. Hash functions are also able to withstand attempts to recreate a file that might generate the number. The technique effectively guards against viruses and document tampering.

In the late 1970s, public key systems emerged that used two keys. The first key is made public by being published. The second is kept private. Data encrypted using one of the keys can be decrypted only by the other key.

A modern address book would include the public keys in machine-readable form for all correspondents. You could send mail to them sealed in an unreadable form. When the mail arrived, the recipients would use their private key to decrypt the mail.

The best-known public key system, and one of the few that remains unbroken after intense public scrutiny, is RSA Data Security's RSA. The system's algorithms are well known and described in many textbooks—such as Bruce Schneier's *Applied Cryptography: Protocols, Algorithms and Source Code in C C++* (John Wiley & Sons, forthcoming). However, they are also patented, and RSA charges licensing fees for their use. RSA does offer a version for noncommercial purposes free of charge.

You can use public key systems to create digital signatures by encrypting a block of text with the private key. Anyone can use the public key to decrypt the message, which might be a cryptographically secure hash function of a large file, but no one can create such a file without knowing the private key.

encrypted material to the police whenever necessary. Although this clause was eventually deleted from the bill, its spirit lives in a recent FBI proposal that all new telecommunications systems be designed so that the bureau can tap any conversation in real time.

Another proposal, championed by Dorothy Denning, a computer science professor at Georgetown University (Washington, DC), would require you to register your decryption key with the government. Encryption wouldn't be illegal; you would just need to tell a government agency how to decode your messages. In her proposal, Denning says that "technology has been drifting in a direction that could shift the balance away from effective law enforcement and intelligence gathering toward absolute individual privacy and corporate security. The consequences of doing so would pose a serious threat to society."

Don't Regulate

The arguments against regulation of cryptography are equally compelling. Information is one of the most vital economic commodities, and encryption is the best way to protect it.

For example, the April 10, 1992, issue of *New York* magazine reported that criminals in New York City scan cordless and cellular telephone traffic looking for people using bank-by-phone services. When you enter your PIN (personal identification number) to authorize a money transfer, the eavesdropping criminals get your account number and authorization code—everything they need to take your money. And last year, the CIA expressed concern over the protection of American industrial secrets. Encryption is a natural solution to prevent both sorts of crime.

A ban on cryptography will only prevent criminals from purchasing commercial encryption programs off the shelf. "If encryption is outlawed, only outlaws will have encryption," says John Gilmore, a founding member of the Electronic Frontier Foundation (Washington, DC), a citizen group campaigning for free-speech rights for electronic communicators.

Meeting in the Middle

Weak encryption is a middle course that may satisfy both end users and law enforcement officials. It involves a mathematical compromise that uses encryption algorithms assumed to be strong enough to resist attack by the average eavesdropper but weak enough to yield to tough police probes (see the text box "Encryption Systems" above).

For example, the proposed cellular telephone encryption system IS-54b reportedly uses a repeating key of 260 bits that scrambles the digital phone system's bit

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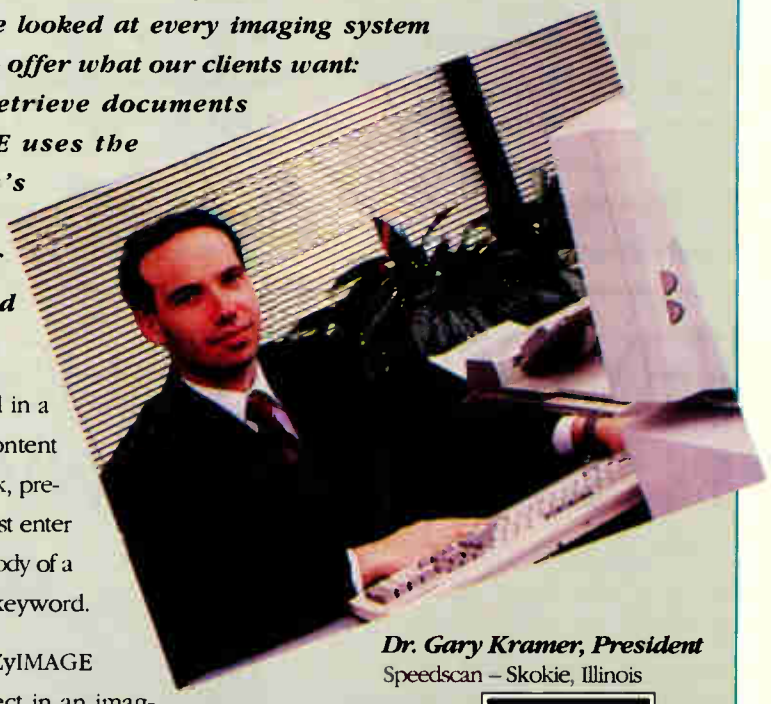

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stream, rendering it meaningless to eavesdroppers. But a voice call encrypted with such an algorithm can be broken by taking adjacent blocks of bits and correlating them with each other. Digitized voice conversations have a strong enough pattern to make attacking them relatively simple, though.

Requiring shorter keys is another technique of weakening encryption software. For instance, RC-4, a proprietary algorithm licensed by RSA Data Security (Redwood City, CA), is regularly exported with keys no longer than 40 bits. The shorter length reduces the number of possible keys to 2^{40}, making it feasible to test all of them with a large multiprocessor machine.

But the problem with these approaches is that they are almost invitations to commit crime. If the cellular phone standard or 40-bit RC-4 becomes widely used and trusted to protect people's credit card numbers or other private matters, it could be a tempting target for disciplined criminals to exploit.

Micali's Solution

Silvio Micali, a professor of computer science at MIT (Cambridge, MA), offers another compromise, calling for the creation of *fair crypto systems*. Such systems allow a user to encrypt messages and a government agency to decrypt them if it has the cooperation of several other governmental branches.

Fair crypto systems use algorithms that require you to break your decryption key into a number of parts and to give each part to a different trustee. The key can be reconstructed only if all trustees agree to assemble their parts of the decryption key. The important technical advance of the system is that it allows each trustee to make sure he or she is not being cheated before reconstructing the key.

Micali's system is based on the Diffie-Hellman key exchange protocol, which was developed by Whitfield Diffie and Martin Hellman in the 1970s. The foundation of this system is the discrete-log trapdoor function, which is easy to compute but difficult to break (see the text box "How the Trapdoor Works" on page 134). The trapdoor function generates the keys for the trustees.

Micali's system provides everyone with secure encryption without shutting out law enforcement officials armed with court orders, but it imposes a lot of record keeping and depends on honest trustees. Although Micali's system is more secure than the weak versions of RC-4, it still offers a plump target for crooks. If everyone uses and trusts this system with monetary transactions, the reward for cracking the discrete-log problem will not be just academic acclaim. Bill Spernow, from Search (Sacramento, CA), a nonprofit company funded by the Department of Justice to help police departments tackle computer crime, is skeptical of the proposal. "The

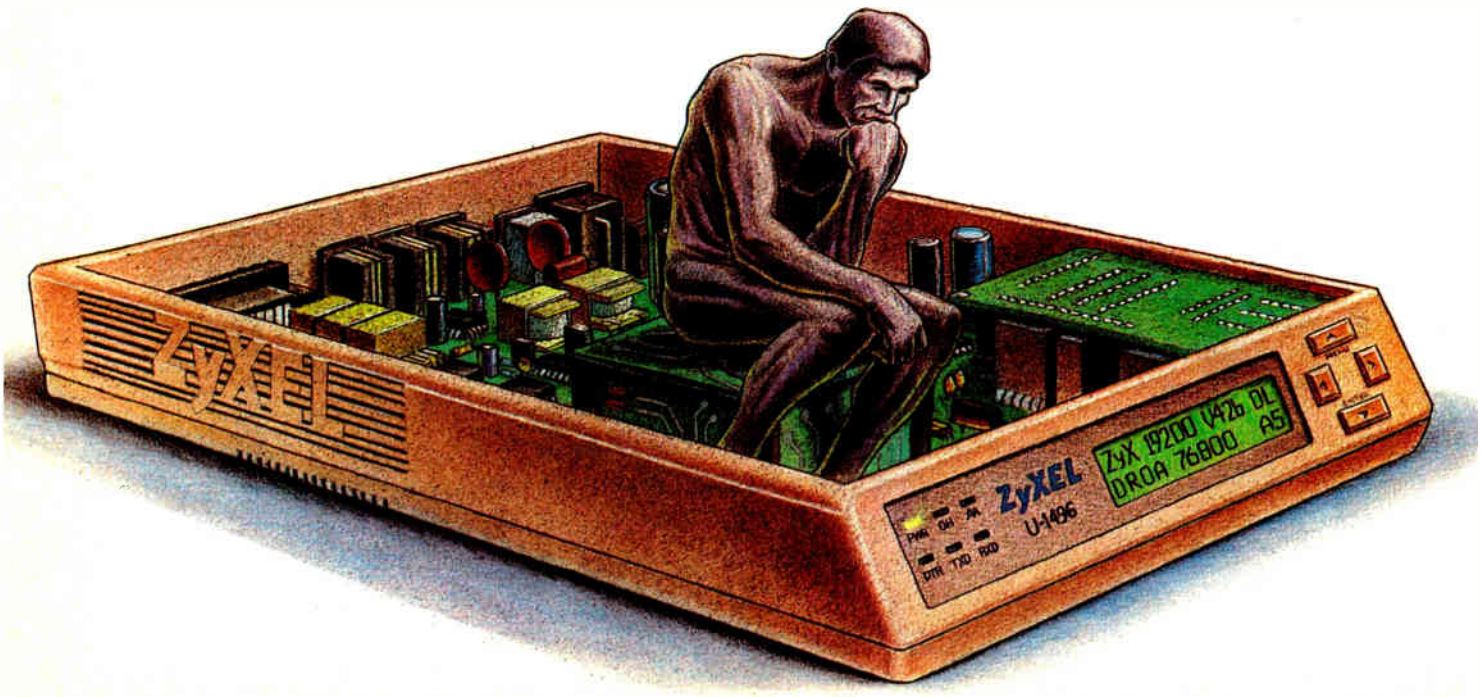
Regulate Encryption

- Criminals use encryption.
- Police are stymied by encryption, and criminals avoid prosecution.

Don't Regulate Encryption

- Vital business data is protected by encryption.
- Criminals are stymied by encryption, and crime is prevented.

WHY OUR INTELLIGENT MODEMS ARE A WISE INVESTMENT.



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government," he says, "has not historically shown the ability to keep secrets of this magnitude."

Masking Microdots

A ban on encryption will not stop secret communication. There are too many ways to hide bits in the billions of terabytes of data flowing throughout the world.

One trick is to hide information in the least-significant bits of a digitized photograph, movie, or audio signal. For example, the Kodak Photo CD format's maximum resolution is 2048 by 3072 pixels, with each pixel containing 24 bits of RGB information. The least-significant bit of each of the 24 bits representing the red, green, and blue intensity of each pixel can be changed easily without greatly affecting the quality of the image. You can hide a 2.3-MB message in a digital snapshot (see figure 1).

But hidden bits in photographs can be lost if the picture is compressed using a lossy technique (e.g., JPEG, the Joint Photographic Experts Group algorithm), which does not reconstruct the image to its original state. Also, hidden information is detectable, to some extent, by measuring the amount of compression attained by a lossless compression scheme, such as run-length encoding. A normal digitized photograph can have many adjacent pixels with the same values, which a run-length compression scheme would reduce to a single value. However, a digitized photograph bearing a secret message has many

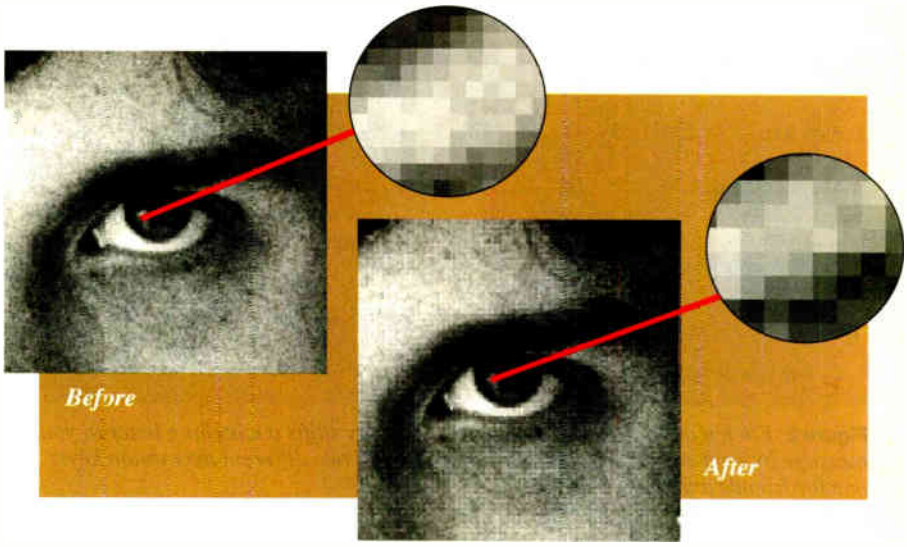

Figure 1: *You can stash a 2.3-MB message in a digitized photo's least-significant bits without greatly affecting the image's quality. The enlargements show the same group of pixels before and after excerpts from the Magna Charta were hidden in the picture.*

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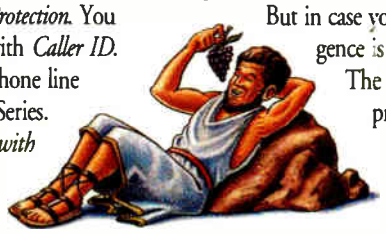

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Encrypted message:	U	N	L	F	R	R	P	F	Y		U	W	T	H	B
Key #1	5	2	17	12	3	4	7	11	12		3	18	19	4	3
Secret message:	P	L	U	T	O	N	I	U	M		R	E	A	D	Y

Encrypted message:	U	N	L	F	R	R	P	F	Y		U	W	T	H	B
Key #2	18	6	23	3	3	6	15	12	20		14	5	15	7	8
Benign message:	C	H	O	C	O	L	A	T	E		G	R	E	A	T

Figure 2: *Each number in a one-time encryption key shifts a matching letter in your message by* n *letters in the alphabet. You can build two different decryption keys: one for friends and one for busybodies.*

variations in the least-significant bits, preventing run-length encoding and dictionary schemes from succeeding. For this reason, you'd rather have a photograph of acne-scarred aliens covered with multitextured slime than a photograph of innocent-looking children with starched white clothes to use for embedding your secret message.

Another solution, called *mimic functions*, works within the domain of words. It uses a precise grammar to describe a type of conversation. The grammar is a rule-based system defining how words, phrases, and sentences are combined. A simple grammar for a sentence might require a noun, verb, and direct object and provide a list of acceptable words for each category. Rules for noun-verb agreement can also be built into the grammar. Adventure games such as Zork require commands to fit into this format so they can be parsed.

Grammars are also popular as poetry generators (e.g., Eliza and Racter). They use a random-number generator to choose between the acceptable uses of nouns and verbs. Secret messages can be hidden by replacing the random-number generator in the poetry generator with the bits of the secret message. Later, the secret information can be recovered by parsing the strings.

A third trick lets you foil any key-registration requirements by using a one-time pad that consists of a key the same length as the message. This technique derives its name from pads of paper: The pages on this pad have random number sequences printed on them. Each page is a key and is used only once.

A simple implementation of this scheme uses each number, n, in the key to shift the matching letter in the message by n letters of the alphabet. *A 3* would convert an *A* to a *D*. Thus, you can create two keys: One key converts the encrypted message into the real message, and the other converts the message into a benign one (see figure 2). Criminals can simply forward the benign key to the authorities and pass the key to the real message to their associates.

Storm's Eye Overhead

The debate has subsided for the time being. No legislation regulating data-encryption technology is pending in Congress, and no high-profile court cases dealing with the issue are in progress. The FBI continues to campaign quietly for telecommunications systems that can be wiretapped by the government. And organizations like the Electronic Frontier Foundation continue to watch for government interference with what they perceive as your right to encrypt data.

The biggest danger is that the government will fail to resolve the tension between computer users and law enforcement officials. The Clinton administration is sympathetic to the problems faced by the computer industry as a result of the export restrictions on encryption software. However, any related legislation, such as the proposed nationwide data superhighway, is a target for antiencryption amendments. The only sure thing is that the outcome will not please everyone. ■

Peter Wayner is a BYTE consulting editor based in Baltimore, Maryland. He consults and writes on encryption and security matters. You can contact him on BIX as "pwayner" or on the Internet at pcw@acess.digex.com.

How the Trapdoor Works

MIT professor Silvio Micali's encryption solution uses a discrete-log trapdoor function to generate a set of encryption keys that are difficult to break. It works like this: If p is a prime number and g is a special element less than p (a generator, in algebraic parlance), the discrete log of a number n is the value a, such that $g^a \bmod p$ is equal to n.

Say that two users, Bob and Ray, agree on a secret key by separately picking secret numbers, S_x and S_y, and exchanging the results of $g^{S_x} \bmod p$ and $g^{S_y} \bmod p$. An eavesdropper cannot determine Bob's and Ray's numbers by overhearing the results of the computations. Bob computes $(g^{S_y} \bmod p)^{S_x} \bmod p$ and Ray finds the result of $(g^{S_x} \bmod p)^{S_y} \bmod p$. These are equal, but anyone listening in cannot find the solution because they don't know the secret numbers. The shared secret number can be used as the encryption key with any normal cipher system to send large blocks of data.

In Micali's fair crypto system, you have five integers, s_1, s_2, s_3, s_4, and s_5, less than p. Your private Diffie-Hellman key is the result of $S_x = s_1+s_2+s_3+s_4+s_5 \bmod p$. You register the five integers with five trustees by sending each trustee one of the five integers. S_x, the secret key that you use in your communications, can be reconstructed only if all the trustees' integers are added up. The trustees then forward the result of $g^{s_i} \bmod p$ to the central key manager but keep to themselves the value of their own integers.

The central key manager computes the product of $g^{s_i} \bmod p$, which is equal to $g^{S_x} \bmod p$, and lists it in an electronic telephone book for people to use when they want to establish a secure link with someone else. You cannot cheat the system and register a fake key, because your listed key is determined solely by the information provided to the five trustees.

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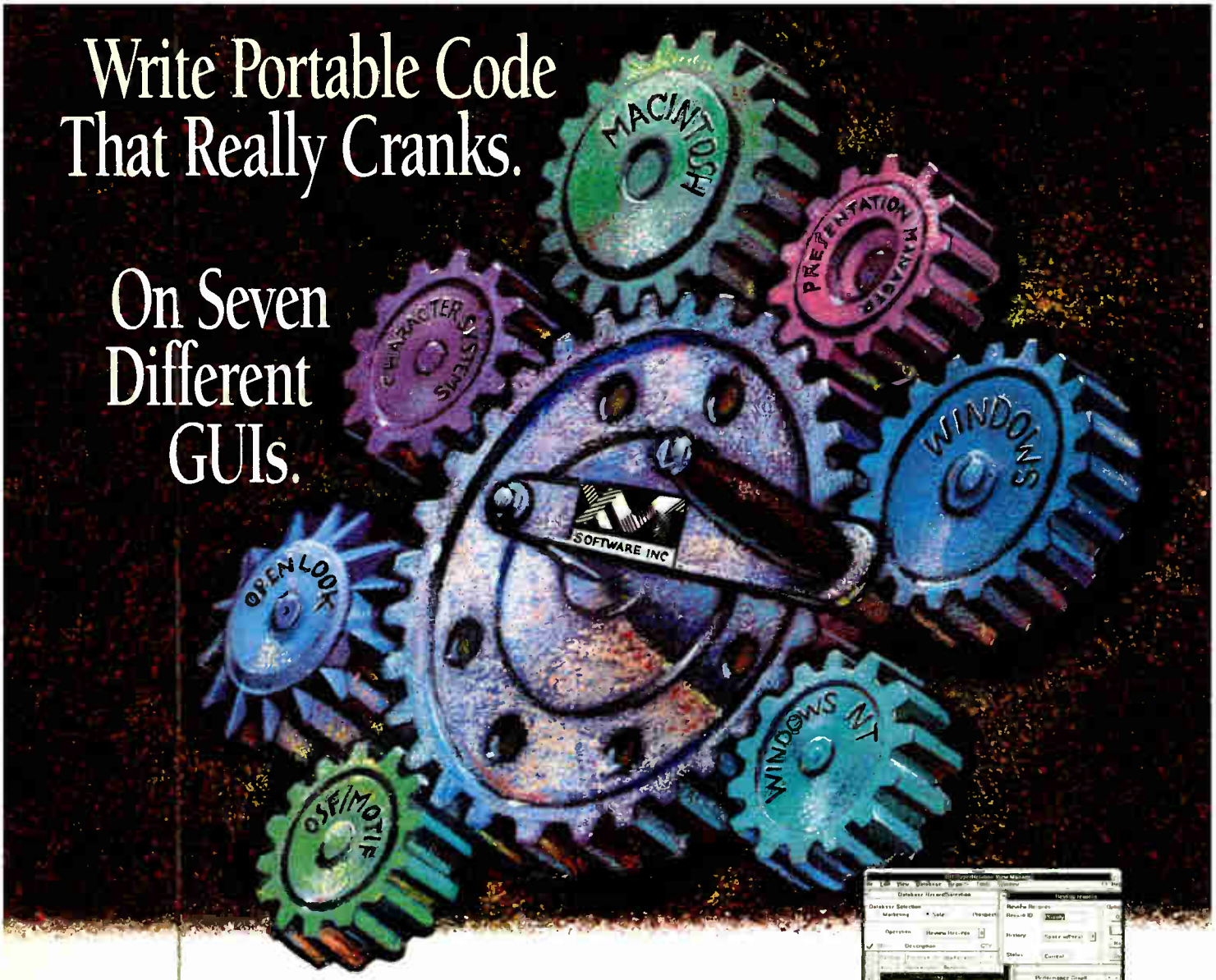

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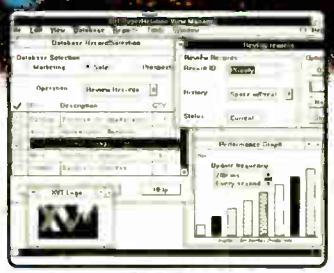
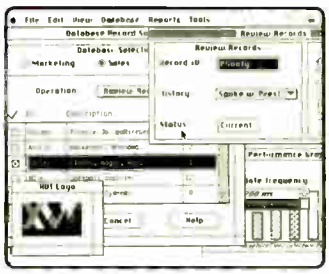
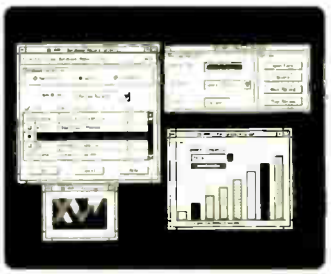


▲ Microsoft Windows & Windows NT



▲ Macintosh



▲ OSF / Motif

Shown above are four of the seven GUIs supported by XVT.

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World Radio History

STEALTH VIRUS ATTACKS

A new breed of computer virus uses stealth to invade your networked computers

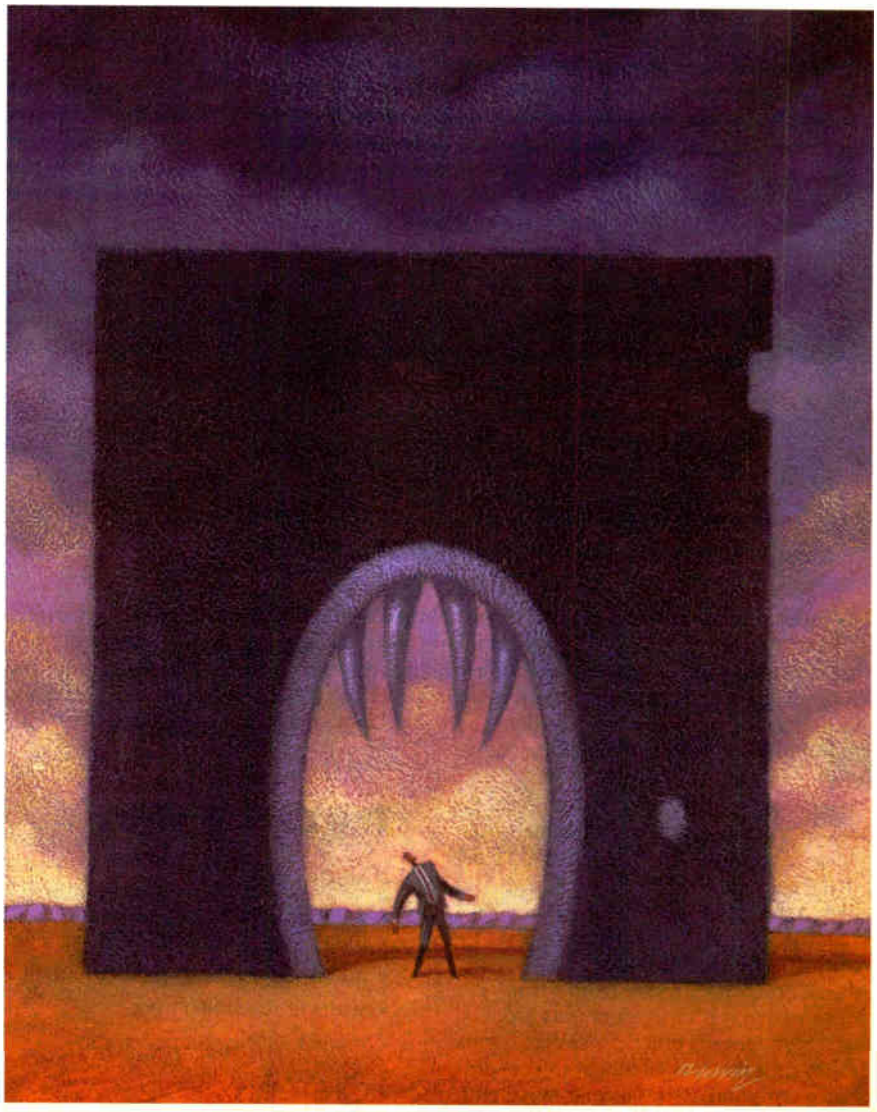
JOHN DEHAVEN

I once helped investigate a software time bomb that had been planted in the accounting system of a large corporation. Months before certain employees left the company (and the country), they planted a bomb programmed to produce a fake invoice that was due and payable. The bill had all the authorizations necessary to satisfy the accounts-payable system, and it was for an amount that didn't require authorization. On the appointed day, the firm's computer automatically transferred the money to a bogus vendor's account in a Swiss bank. The perpetrators withdrew the cash from the bank, left Switzerland, and are still at large. In an international case like this, the legal issues are thorny. When did the crime happen? Where did it happen? In what jurisdiction will you prosecute?

Until now, though, media attention has focused on public domain viruses. These almost never have a specific target, even though some of them carry destructive bombs. But public domain viruses are not the most serious security threat to computer systems and data. Networked computers are threatened by a new type of computer virus: self-replicating, autonomous software that quietly cruises through a network and attacks a targeted computer, often for profit.

The new attack software doesn't have to be introduced directly into an organization's machines. The software packing the payload can be handed out in a public forum, perhaps attached to a utility passed out at a users-group meeting. Spreading quietly through the computing community, it eventually reaches its target. This is sometimes referred to as a *cruise* virus, drawing on the analogy of a cruise missile.

continued



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World Radio History

Commonsense Guide to Security

Like its biological namesake, the computer virus has survived numerous attempts to eradicate and prevent it. More than a thousand viruses and variants have been identified, the majority of which are targeted at PCs. However, no computer is completely safe. Here are a number of minimal precautions that you should keep in mind as you develop the security plans for your networked computers.

	Do this	Reason
	Have a clean write-protected boot disk.	Invaluable for troubleshooting; provides a point of reference for any computer; when trouble-shooting a possible virus attack, you know that no virus is active after you reboot with a clean copy of the operating system.
	Never keep the only copy of indispensable data in a computer.	Multiple copies of important data answer the question, "How fast can you get back up and running after a disaster?"
	Back up data and programs separately.	Data changes frequently, but programs change infrequently (except in development environments); control copies minimize the spread of attack software.
	Make sure only the system administrator installs new software.	The administrator is a trusted employee; promotes version control; eliminates most human variables should something go wrong with the new software.
	Evaluate all software on quarantined machines.	Lets you check for viruses away from everything else; lets you check for proper behavior before installing new software networkwide.

Viruses provide nearly perfect anonymity to an intruder. The origin of almost all viruses is unknown. For example, if Robert Morris had not admitted his complicity in the infamous Internet worm incident, he might not have been prosecuted successfully.

Using attack software, thieves steal financial records and other valuable information. Disgruntled employees broadcast private correspondences for all to see. And others sabotage systems.

Anatomy of an Attack

Attack software differs from virus programs in that it is an autonomous process, not dependent on other processes for its existence. Like every virus, it infects other programs and carries a destructive payload. Attack software comes in various forms. *Trojan horses* are seemingly benign programs that have destructive instructions (e.g., to reformat the hard disk) hidden within them. *Worms* are virus-like programs that can spread throughout a network by exploiting weaknesses in the network software.

Intruders exploit the evolving network environment by targeting its two weakest links—the attached computer and you. In principle, any software can be made to run on a computer attached to a network. To penetrate a system's defenses, an intruder needs only to infect one user's computer (see the text box "Commonsense Guide to Security" above).

Another type of attack software captures user-access passwords or high-level privileges. The intruder substitutes a look-alike log-in screen for the real one, perhaps by emulating the communications software or by gaining control of one of the network's connections. As users log

The Cruise Virus

- attacks for profit
- exploits a network's weakest link—you
- attacks through the public domain
- waits to reach its target
- reports successful penetration
- delivers payload

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Software Compatibility	●	●	◔	●	●	●
Hardware Compatibility	●	●	◔	●	●	●
Reliability	◔	◒	◔	◒	●	◔
Ease of Use	◒	●	◒	●	●	◒
Memory Management Flexibility	◒	●	◒	●	●	◒
Quality of Documentation	◒	◒	◒	●	◒	◒

● GOOD ◒ SATISFACTORY ◔ NEEDS IMPROVEMENT

PC Week carefully compared them all and rated QEMM-386 v6 the best memory manager.

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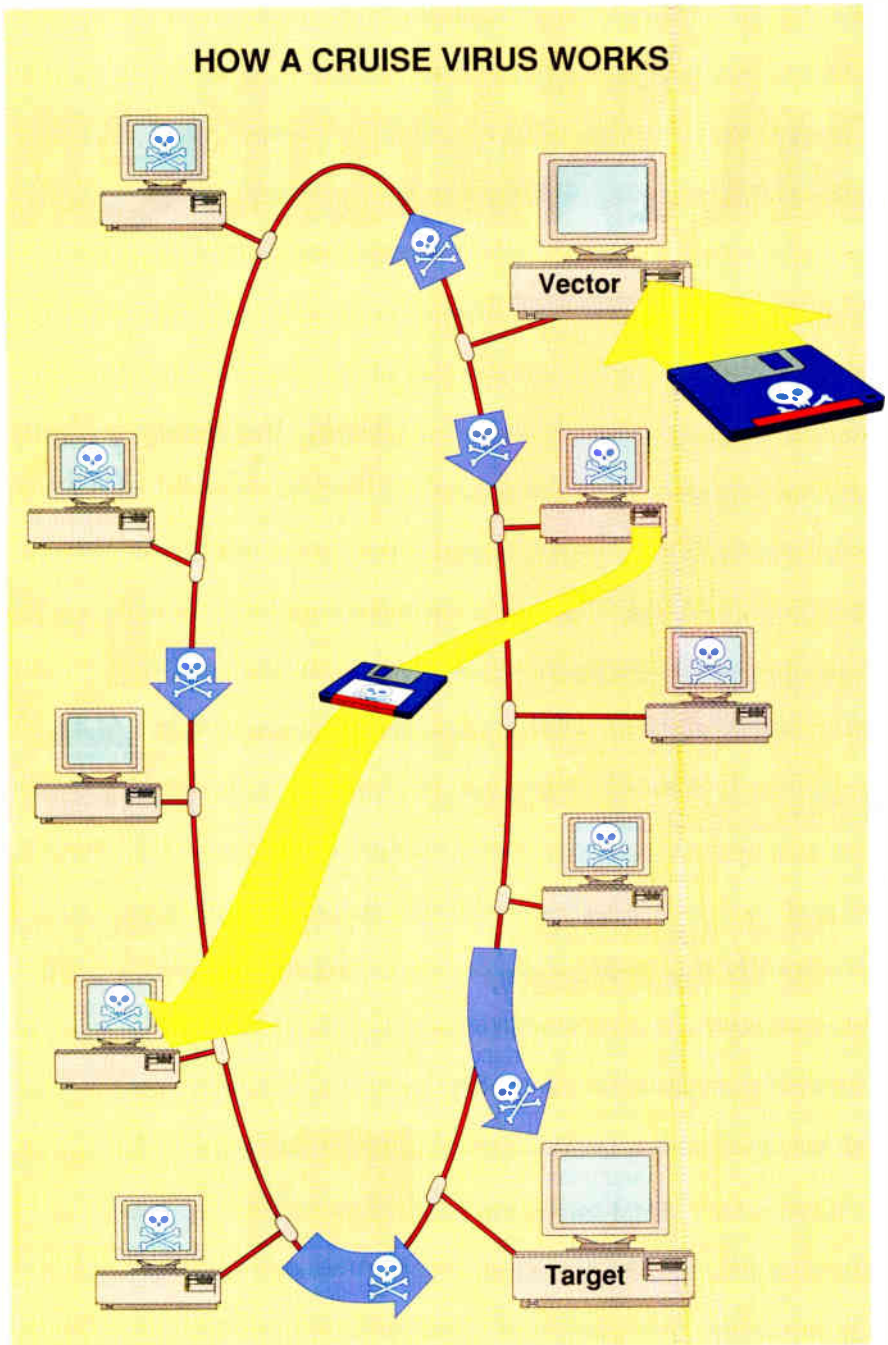

A cruise virus accesses a vector machine through a user who innocently carries the virus and passes it on to others. The virus spreads across the system until the target is found. The payload can then be delivered.

in, the attack software secretly records everyone's name and password. This information is stored or forwarded to the intruder, who can then enter the system as if he or she were an authorized user. In this scenario, the intruder's grand prize is the system administrator's name and password. With that information, everything—encrypted files, communications, and access controls—is vulnerable to the intruder's whims.

A system administrator's account information isn't needed to launch a successful attack on encrypted systems, however. Anyone's access information will do. Once inside a system, the intruder unleashes the virus, which lurks there until an authorized individual decrypts material or enters the access sequence; the virus then attacks the material.

Other attacks use plaintext and traffic-analysis techniques to build lexicons of encrypted traffic from which an intruder can fabricate fraudulent messages and insert them in the communications channel. The messages can have a variety of purposes. For example, an intruder can impersonate a system administrator and fool users into divulging secret file-access information.

Cruise Missile

When most people think of a cruise virus, they envision a virus carrying a sophisticated technological payload heading off on a complex mission. Although this is possible, it requires a lot of work and a high degree of inside knowledge of the targeted system.

Instead, a minimalist attack scenario that maximizes the anonymous nature of the attack is more likely to happen. Such an approach comprises four stages: launch, penetration, report of target acquisition, and delivery.

In the first stage of the attack, an intruder launches a cruise virus into the public domain and waits for it to reach its target (see the figure). The intruder bets that one of the computer users at the target installation will innocently introduce the virus into the system. If that bet fails, nothing is lost.

Penetrations of large systems are almost always a matter of an intruder's impersonating individuals with higher and higher system privileges. In addition, intruders may impersonate trusted computers or message sources to launch an attack.

In many systems, impersonation of a user is just a matter of giving a computer a log-in identification and a password. In a minimalist attack, the virus has only to capture the access sequences for the intruder. Once the intruder has that information, a direct and more complex attack on the mainframe is unnecessary.

Given the access sequences, the intruder enters the system covertly with advanced privileges and proceeds manually with the more sophisticated aspects of the attack, which can be theft, fraud, espionage, sabotage, or discrediting a company or individuals within it.

Report Access

The method a virus uses to report that it has successfully penetrated the target system depends on how much an intruder knows about the system. If it's an inside job, the matter is trivial; the cruise virus can stash the results in any number of places accessible to the intruder. An

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outsider has more difficulty, but it's not an insurmountable task.

For an outside intruder, any covert communications channel can be used to send signals, because even seemingly random signal sequences can contain an embedded message to someone who knows how to read them. For example, if there are rules to prevent signals from being transmitted from the system to the outside world, an intruder can use an alternating pattern of violation/no violation of the rules like Morse code to send messages.

"People would rather spend money on antivirus protection than pay for the cleanup of a virus attack."

Cynthia Carlson, vice president, USA Research (Portland, OR)

An attacker needs only to subvert a network's log-in machinery to erect a reporting mechanism. When built properly, a log-in bomb responds normally to failed log-in attempts but returns whatever activity report is desired when a special log-in name is used. For example, suppose an intruder tries to log in as Joe Bozo. If this fails, the intruder knows that the attack has not yet succeeded. However, if the virus has already reached and infected the target computer, the log-in bomb might respond with a list of legitimate mainframe log-in procedures that it has just captured.

Deliver Payload

Once an intruder has successfully penetrated a computer, the payload is delivered. Unlike the more violent terrorist-type viruses, a minimal attack lays low, disturbing the vector and target systems as little as possible. In a vector machine, which can be any personal computer or a workstation attached to a network, the virus might quietly remove itself after either a prescribed time or a certain number of infections. It would infect no more processes than necessary.

You would be lucky to stumble on this kind of program if one were to invade your system. In fact, because of the target-specific nature of such a program, combined with its low profile, it might never come to your attention.

Professional Viruses

The difference between a cruise virus and other viruses is the difference between amateurs and professionals. The public-domain viruses that arouse so much media attention are probably written to serve the virus author's ego.

Virus-augmented attacks such as the cruise virus are professional. These attacks are bottom-line oriented: Accomplish the mission, and to heck with public recognition. In fact, the less of it, the better. ■

John DeHaven works for Bangkok Security Associates in Thailand. You can contact him on BIX c/o "editors."

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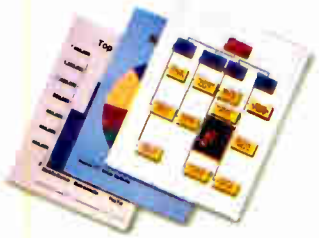

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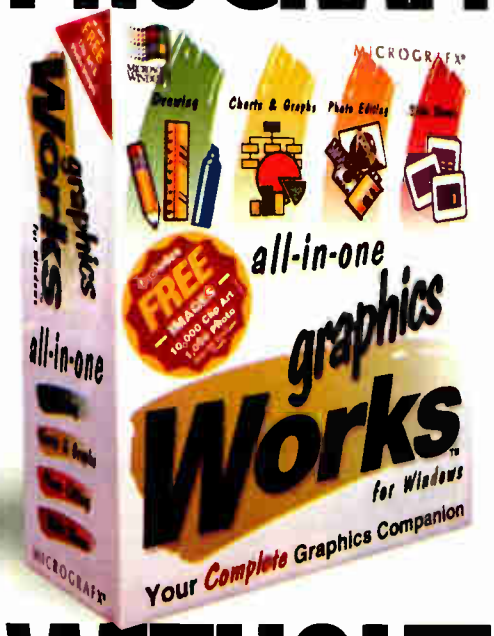

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Virus Protection for Networks

As distributed systems become more prevalent, the need to keep them safe from infection by viruses becomes critical. The following products can help you secure your Novell NetWare, Banyan Vines, Microsoft LAN Manager, AppleShare, Unix, or other LAN.

ASET
Network support: NFS (Solaris)
SunSoft, Inc.
(415) 960-3200
fax: (415) 390-9578
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CENTRAL POINT ANTI-VIRUS FOR NETWARE
Network support: NetWare
Central Point Software, Inc.
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(503) 690-8090
fax: (503) 690-8083
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DRIVE-IN ANTIVIRUS
Network support: IBM Token Ring, LAN Manager, LANtastic, NetWare, TCP/IP, 3Com, Vines
SafetyNet, Inc.
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(908) 851-0188
fax: (201) 467-1611
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EMPOWER I, EMPOWER II, EMPOWER REMOTE
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Magna
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fax: (408) 275-9147
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FORTRESS
Network support: TCP/IP (Unix)
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fax: (415) 949-4825
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F-PROT PROFESSIONAL
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(407) 575-3200
fax: (407) 575-3026
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FS SCANMASTER
Network support: Vines
NetPro Computing, Inc.
(800) 998-5090
(602) 998-5008
fax: (602) 998-5076
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LAA AGENT TOOLKIT
Network support: LAN Manager, MS-Net, NetWare, Vines
Saber Software Corp.
(800) 338-8754
(214) 361-8086
fax: (214) 361-1882
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LANPROTECT
Network support: NetWare
Intel Corp.
(800) 874-6835
(503) 696-8080
fax: (503) 696-4633
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NETSCAN
Network support: AppleShare, AT&T StarLAN, DEC Pathworks, LAN Manager, NetWare, TCP/IP, Vines
McAfee Associates
(408) 988-3832
fax: (408) 970-9727
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NETSHIELD
Network support: NetWare
McAfee Associates
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NETSTREAM
Network support: AppleShare, TOPS
Personal Computer Peripherals Corp.
(800) 622-2888
(704) 656-2076 (same for fax)
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NORTON ANTIVIRUS
Network support: IBM Token Ring, LAN Manager, NetWare, OS/2, 3Com
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NOVI
Network support: LAN Manager, NetWare, Vines
Symantec Corp.
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fax: (408) 446-9750
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PC/DACS
Network support: NetWare
Mergent International
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fax: (203) 257-4245
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PC SCANMASTER
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QUARANTINE
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New England Research and Design Software
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SITELOCK
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STOPLIGHT
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UNTOUCHABLE NETWORK NLM
Network support: NetWare
Fifth Generation Systems, Inc.
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VIRUS BUSTER
Network support: DEC Pathworks, LAN Manager, LANtastic, NetWare, Vines
Leprechaun Software International, Ltd.
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fax: (404) 971-8828
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VIRUSNET
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VIRUS PREVENTION PLUS
Network support: LAN Manager, NetWare, Vines
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fax: (415) 459-1162
Circle 1168 on Inquiry Card.

VI-SPY PROFESSIONAL EDITION
Network support: LAN Manager, NetWare, Vines
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HANDS-ON TESTING

126 PRINTERS

Dot-matrix, laser, ink-jet, and portable printers: Lab tests show which printer best matches your application

RICHARD FOX, ALAN JOCH, CHANDRIKA KRISHNAMURTHY, STEPHEN PLATT, AND LEONARD PRESBERG

One hundred twenty-six printers. 5600 tests. 28,000 pages of output. We knew our goal of testing every printer we could get our hands on was ambitious, but the magnitude of the project seemed to grow day by day. However, what we learned in the end was priceless. We now know how all the leading printers on the market compare with one another in performance, print quality, price, features, and ease of use.

But don't look for us to tell you which is the single best printer. We're not keeping secrets; we just don't believe a single recommendation is useful. Instead, this Lab Report will help you choose the best printer for you depending on the kind of printing you do. Just look to the far right, and you'll see the best printers for word processing, listings and forms, presentations, desktop publishing, spreadsheets, graphic arts, workgroups, CAD, and portable use.

Throughout the next 19 pages, we'll give details about these printers, as well as about printers that were outstanding for specialized needs within the nine application categories. Our recommendations are based on our performance and quality test results and assessments that came from our hands-on work with each printer. We determined our winners without bias for or against any technology, so you'll see laser printers ranked along with dot-matrix and ink-jet printers. The exception was a category that included only dot-matrix printers because of their ability to print multipart forms. See "How We Tested" on page 152 for details on our test suite.

How to use this guide

To find the best printers for you, just follow the main headings until you come to the categories for the applications you use the most. In each category, we name one printer "Best Overall." This is the printer we recommend if you need one to perform a variety of jobs important to that application. If you have special needs, look to the other selections within each application group.

For example, if your budget is limited, consider printers included under "Low Cost." Similarly, we'll tell you which printer to buy if you produce newsletters and want superior print quality or if you print spreadsheets and want the fastest printer available. In addition to the leading printer in each category, we list several runners-up—printers that ranked near the top in our evaluations.

The Key to Our Summary Charts

List price for as-tested configurations.

A composite measurement of engine or print-head speed and processor time. Test scores are weighted to emphasize those most important for each application category.

A composite score from a suite of print-quality tests; 5 represents highest quality.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS
BEST	Epson Stylus 800	■ PC	$499	1.10 / 1.14 / —	2.5	120 cps

Vendor's rating for engine or print-head speed. Does not include printer processor time.

Dashes indicate tests that could not be run because of a printer's design. For example, the Stylus doesn't support the Mac.

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EPSON STYLUS: PAUL AVIS © 1993

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Essential Components

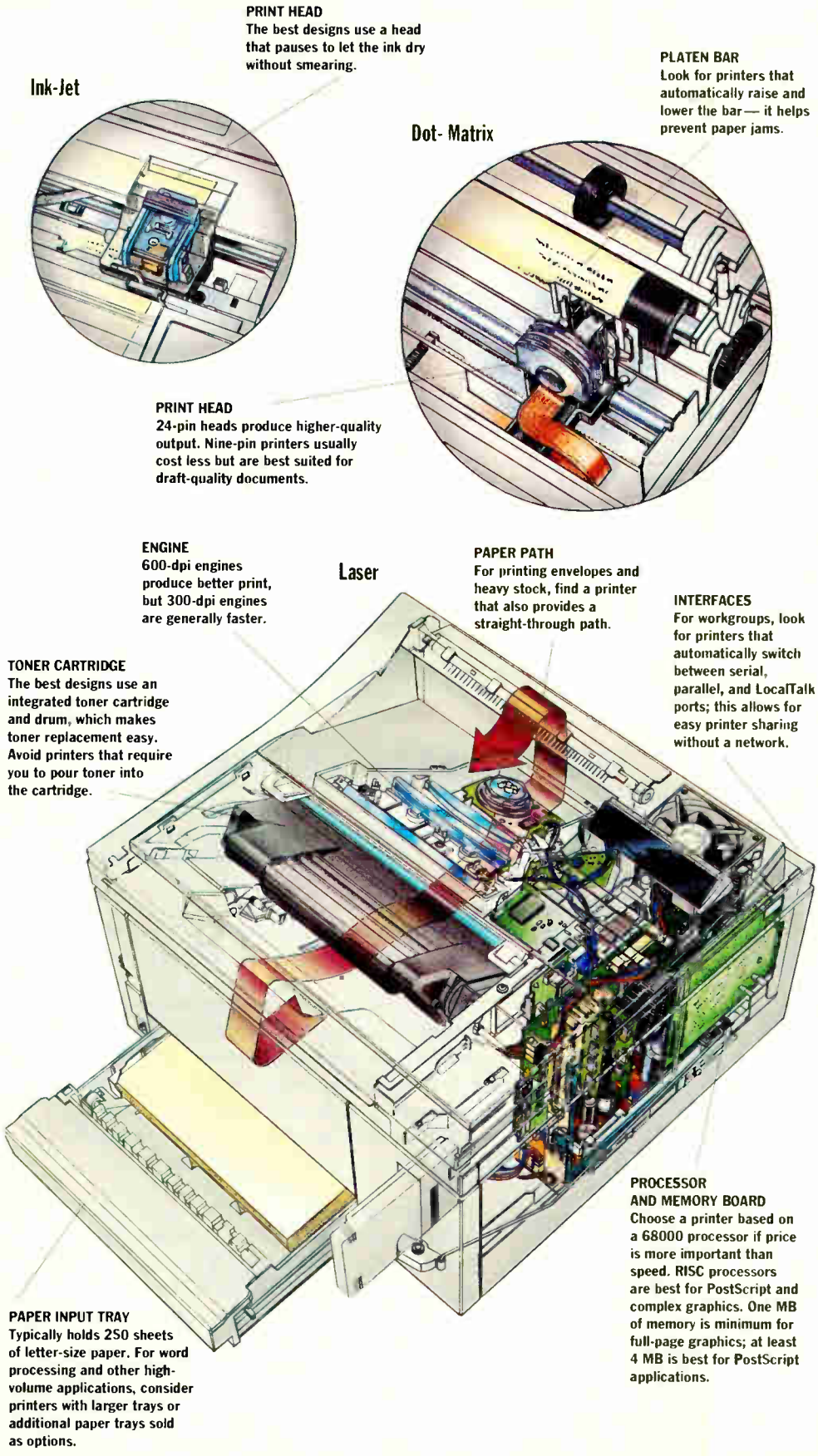

ILLUSTRATION BRUCE SANDERS 1993

BYTE BEST

WORD PROCESSING
HP LaserJet 4M
Print quality and flexibility make this a stand-out for text. **PAGE 148**

LISTINGS AND FORMS
Mannesmann Tally MT 360
A dot-matrix printer whose speed far outpaces that of others in this category. **PAGE 154**

PRESENTATIONS
QMS 860
Consistently a print-quality and performance leader. **PAGE 156**

DESKTOP PUBLISHING
QMS 860
Support for 11- by 17-inch paper rounds out this laser's desktop publishing capabilities. **PAGE 160**

SPREADSHEETS
Epson ActionLaser 1000
Posted the highest spreadsheet-test speed and the lowest price tag in this class. **PAGE 162**

GRAPHIC ARTS
LaserMaster Unity 1200XL
Produced the best output of the fully evaluated printers. **PAGE 164**

WORKGROUPS
HP LaserJet 4Si MX
A new entry that raises speed and quality standards for network printing. **PAGE 166**

CAD
QMS 860
Excels at printing complex drawings. **PAGE 168**

PORTABLES
Lexmark IBM 4070 IJ
Compact, light, and fast, with good print quality. **PAGE 172**

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PRINTERS FOR

WORD PROCESSING

Letters to customers, memos to your staff, reports to potential investors: These documents remain the lifeblood of communication in today's business world. Depending on your needs, the printer you choose for word processing may only produce simple memos, or it may serve a variety of purposes. You might print a five-page letter in the morning and in the afternoon generate a report using text that elegantly wraps around a series of pie charts. And since this report will be sent to customers, you want the print quality to be as sharp as possible.

To fulfill their missions, printers for word processing should produce text and simple graphics quickly and efficiently. Print quality is equally important. The printer should offer fonts, in a range of sizes, embedded in the printer or in removable font cards. Additionally, since printers for word processing are worked hard, they require large paper trays or efficient paperfeed mechanisms that can easily be restocked. The printer should allow you to easily change ribbons, ink cartridges, or toner, depending on the printing technology. Finally, it should have a standard or alternative paper path that handles envelopes without mangling them.

Besides identifying the best printers for word processing, our testing revealed some important trends. For example, people who need high-quality print output but don't want to pay a premium price can now choose from a new generation of 600-dot-per-inch laser printers, characterized by the Xante Accel-a-Writer 8000 and the Hewlett-Packard LaserJet 4M. Most business correspondence today is printed on 300-dpi-resolution laser printers. The 600-dpi printers can produce four times as many dots in the same space, so edges of letters are sharper, boldface type is blacker, and pie-chart curves are more precise.

But at $2300 and up, these high-resolution lasers aren't the cheapest printers. Some 300-dpi laser printers, such as the Epson ActionLaser 1000, the Sharp JX-9600, and the DECLaser 1152, now offer fine print quality for less than $1300—among the lowest prices ever for laser printers.

Because there are now two resolutions available for lasers being sold as general-purpose printers, comparing speed and print quality can become confusing. For example, our high-quality speed tests used PostScript files, while our draft-quality tests ran PCL (Printer Control Language) documents. Even though the growing number of 600-dpi laser printers can also be run in 300-dpi mode, we decided to evaluate these printers at their highest resolutions. This became an issue when it

Are Built-In Fonts Better?

Unless the fonts you use are built into your printer, the printer will take considerable time to produce your documents.

A built-in font resides in a printer's memory, so the printer can quickly find the font description and can print the text almost as fast as the print mechanism can move. On most dot-matrix and ink-jet printers, these fonts are stored as bit maps—graphical representations of letters.

In Windows, built-in fonts are indicated by a small icon of a printer next to the font name in the font dialog box. But a surprising number of the printers we tested did not support built-in printer fonts with their Windows drivers. If printing speed is important, make sure your printer's Windows driver supports built-in fonts.

LASER, DOT-MATRIX, OR INK-JET?

With prices for lasers falling below $1000 in some cases, it's easy to assume that you should buy a laser over a dot-matrix or ink-jet printer because lasers typically offer higher quality. However, the kind of printing you do should ultimately determine your choice.

Dot-Matrix	Inexpensive dot-matrix printers are your only option if you print multipart forms. They're also worth considering if you mostly print draft-quality text.
Ink-Jet	Ink-jets can be a compromise between dot-matrix and lasers in price, but claims of laser-quality output were generally not borne out in our quality tests. Some ink-jets (e.g., the Apple Color Printer, Canon BJC-800, and HP PaintJet XL3000) recorded print-quality scores higher than some laser printers', but ink-jet quality ratings in general fell between those of laser and dot-matrix printers. Ink-jets were slower than lasers, but slower or faster than dot-matrix, depending on individual models.
Laser	Low-end lasers have always been faster than dot-matrix and ink-jets while offering superior print quality, and now their prices are lower than ever. We tested models with list prices from $800 to $3000 and street prices as low as $700 in a basic configuration. If that's within your budget, pick one of these for their performance and quality gains over competing technologies. Two caveats: Dot-matrix and ink-jet printers offer the only economical choices for color printing, and both are low-cost alternatives for printing on 11- by 17-inch and larger paper.

World Radio History

came time to compare the speeds of these printers with those of 300-dpi lasers, which still make up the bulk of the market. Because 300-dpi printers produce only a fraction of the number of dots, they have a speed advantage over higher-resolution models.

After a lengthy debate, we decided to compare printers running at their highest resolutions; we reasoned that someone paying a premium for 600-dpi capability will most likely use the printer at that resolution. Thus, in our summary box for the Best Overall word processing printer, we compare the Fujitsu PrintPartner 10W, a 300-dpi-resolution printer, with three 600-dpi printers. This accounts for the PrintPartner's fine performance—it ran the high-quality tests faster than any other printer in this group and was comparable in draft-quality speed to the Accel-a-Writer 8000.

But our resolution debate didn't stop there. The next discussion centered on the importance of 600-dpi resolution. If you're mainly interested in printing text for correspondence and reports, do you really need resolution of more than 300 dpi?

There's no hard and fast answer to this. Certainly the benefits of 600 dpi for text quality are subtle, and many people will be perfectly happy with the output of a printer like the PrintPartner 10W, which we chose as a Runner-Up in the category of Best Overall word processing printer. But when we forced ourselves to choose between the 600- and 300-dpi printers on the basis of what we would buy for ourselves, we opted for the 600-dpi models. The higher-resolution printers, such as the LaserJet 4M and the QMS 860, give you superior print quality when you need it, and the price they command for this is only marginally above that of their 300-dpi competitors.

KEY

▲ Laser ■ Ink-jet

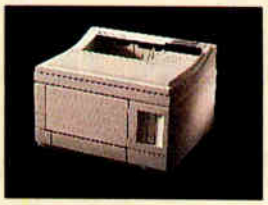
● Dot-matrix

BYTE BEST WORD PROCESSING

Do you want speed and quality?

BEST OVERALL — Hewlett-Packard LaserJet 4M

This 600-dpi laser's print quality was among the best offered by the tested printers. The 4M also stood out for its flexibility: Standard are PostScript plus PC and Mac interfaces (the LaserJet 4, without PostScript or LocalTalk, costs $1759). And you don't need to manually set the printer for PostScript or PCL jobs: The 4M switches automatically. Its speed, while acceptable, fell in the midrange of this printer group. (To boost performance, the LaserJet can drop down to 300 dpi for print jobs that don't require the higher resolution.)



			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	POSTSCRIPT AVAILABLE?
BEST	HP LaserJet 4M	▲ PC MAC	$2999	1.87 / 2.80 / 1.69	4.6	8 ppm	Yes
RUNNER-UP	QMS 860	▲ PC MAC	$4595	2.18 / —[1] / 1.20	4.7	8 ppm	Yes
RUNNER-UP	Fujitsu PrintPartner 10W	▲ PC MAC	$2768	2.48 / 3.73 / 2.43	3.2	10 ppm	Yes
RUNNER-UP	Xante Accel-A-Writer 8000	▲ PC MAC	$2295	1.63 / 3.78 / 1.68	4.3	8 ppm	Yes

On a limited budget?

LOW COST — Epson Stylus 800

For $499, this ink-jet printer won't outperform a laser printer. But for most documents, the Stylus's speed and print quality will fulfill your word processing needs. Its print output was clearly legible even down to 4-point text. Thanks to Epson's enhanced printer language, ESC/P2, DOS users have access to nine built-in fonts, two of which can be scaled from 8 to 32 points. But Windows users should note that none of the built-in fonts are available when you're using Windows applications, which can mean performance delays for certain fonts. The paper input tray holds 100 sheets of either letter-size or A4 paper. A manual feeder accepts envelopes.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	POSTSCRIPT AVAILABLE?
BEST	Epson Stylus 800	■ PC	$499	1.10 / 1.14 / —	2.5	120 cps	No
RUNNER-UP	Canon BJ-200	■ PC	$449	0.97 / 1.69 / —	2.1	124 cps	No
RUNNER-UP	HP DeskJet 500	■ PC	$599	1.27 / 1.81 / —	1.8	120 cps	No
RUNNER-UP	DEC LA95 DECWriter	● PC	$319	0.83 / 1.19 / —	2.2	240 cps	No
RUNNER-UP	Apple StyleWriter II	■ MAC	$359	— / — / 0.64	2.2	0.5 ppm	No

Sharpest text most important?

PRINT QUALITY — QMS 860

Only a 1200-dpi printer costing twice as much beat this laser printer on the BYTE quality index. The 860 also ranked second in its class for PostScript print speed, so PC and Mac users won't have to sacrifice speed for quality. The trade-off: QMS commands a premium price; compare the 860's $4595 price tag to the prices for other laser printers in this group (most noticeably Lexmark's LaserPrinter 4029-10P, which posted slow speeds but delivered comparable quality for $2000 less).

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	POSTSCRIPT AVAILABLE?
BEST	QMS 860	▲ PC MAC	$4595	2.18 / —[1] / 1.20	4.7	8 ppm	Yes
RUNNER-UP	Lexmark LaserPrinter 4029-10P	▲ PC	$2499	0.79 / 5.87 / —	4.5	10 ppm	Yes
RUNNER-UP	HP LaserJet 4M	▲ PC MAC	$2999	1.87 / 2.80 / 1.69	4.6	8 ppm	Yes
RUNNER-UP	Apple LaserWriter Pro 630	▲ PC MAC	$2529	1.84 / 1.61 / 2.19	4.7	8 ppm	Yes
RUNNER-UP	Xante Accel-A-Writer 8000	▲ PC MAC	$2295	1.63 / 3.78 / 1.68	4.3	8 ppm	Yes

[1] Failed to complete our draft-quality tests. BYTE/NSTL and QMS couldn't resolve the problem during the test cycle.

World Radio History

COMPAQ PRINTERS NOT PEOPLE PRINT, THEY CHAN

When we first introduced our network printers, the experts were at a loss for words. Not because they had little to say. The problem was finding words for printers that thoroughly outperformed all others.

When you add together the performance, paper-handling and unique network capabilities of the COMPAQ PAGEMARQ Network Laser Printers, it's no wonder they have received such overwhelmingly favorable praise from the industry's leading analysts and experts.

Network Printers Steal HP Thunder

Compaq's new low-cost, high-speed PageMarq laser printers should give the Hewlett-Packard LaserJet IIIsi a run for its money. The PageMarqs fix the major deficiencies of many earlier network

—PC Week, September 7, 1992

Powerful print engines along with our own RISC-based controllers, for example, produce output faster than any other printers in their class.

And so that printing quickly doesn't translate into quickly running out of paper, the COMPAQ PAGEMARQ 20 holds up to 1500 sheets of paper—more than any other desktop printer.

What's more, both the COMPAQ PAGEMARQ 15 and 20 can accommodate practically every size of paper, up to 11" x 17".

In complex network environments, even the biggest problems are no problem for COMPAQ Printers. Our intelligent emulation sensing feature, for example, automatically adjusts from

Compaq's Pagemarq Series offers users just about anything they could want in a reasonably priced line of network printers.

—PC Magazine, December 22, 1992

nt and best of all, a fax-modem board
d that turns the printer into a plain-paper fax that can receive faxes even as it handles incoming print jobs.
is included that
DOS P

—Macworld, January 1993

World Radio History

ONLY CHANGE THE WAY GE THE WAY PEOPLE WRITE.

PCL* to PostScript and back again without your having to do a thing. So whether people on your network are using PCs, Macs, or both, COMPAQ Printers can easily and effortlessly take care of what everybody needs.

> On a desktop-publishing document that contained mixed text and graphics, the PageMarq 20 was almost 100 percent faster than the LaserJet IIISi, while the PageMarq 15 ran about 50 percent faster than the HP printer.
>
> —*PC Week, September 7, 1992*

We've also included five separate interfaces to allow for a variety of network connections. You can simultaneously run Token Ring or Ethernet, AppleTalk on LocalTalk, a serial and parallel port, and even an optional Internal FAX Modem that allows you to send and receive presentation-quality faxes directly from the printer.

In addition to all that, our printers are covered by CompaqCare, the most extensive service and support program in the industry.

> Compaq is bringing a printer to the network printer market after listening to its most important resource: its customers. The PAGEMARQ series is a direct result of users' wants and needs.
>
> —*BIS Special Report, August 1992*

> **printer sho**
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> —*Computerworld, September 21, 1992*

You get a free one-year warranty with on-site service, as well as unlimited technical support via our hotline for as long as you own the printer.

For more details on the COMPAQ PAGEMARQ Printers, call. In the U.S., we're at 1-800-345-1518. Or in Canada, you can call us at 1-800-263-5868.

And find out more about the network laser printers that everybody's talking about.

And writing about.

According to PC Week, the COMPAQ PAGEMARQ Printers "speedily handle even complex documents."

The envelope please . . . In the few months since their introduction, our printers have already won eight prestigious industry awards.

COMPAQ

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World Radio History

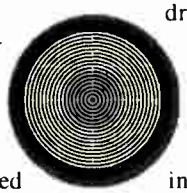
How We Tested

Our printer test suite consisted of nine tests for speed and print quality. We ran each of these tests multiple times in each printer's highest-quality and draft-quality modes, and on both PC and Mac platforms, if supported.

Each test was designed for a specific purpose, allowing us to exercise printer attributes appropriate for each application category and subcategory for which we made recommendations. For example, some of our tests helped us differentiate between the printers' ability to draw lines and arcs, which is important to someone producing CAD drawings; others focused on raw text speed, which is more relevant for printing listings.

PERFORMANCE

Our speed tests measured the ability of a printer to print five document elements: dense text, sparse text (for paper-handling evaluations), bit maps, graphics, and fonts. The dense-text test consisted of large and small documents with dense ASCII text; this gave us scores for raw text speed. Our paper-handling test was a page with a small amount of text to simulate printing invoices and forms. This test showed how fast the dot-matrix and ink-jet printers advanced paper.



The bit-map test generated scores applicable to graphics applications. It also showed the speed of the communication link between printer and computer.

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We determined the performance index of each printer by weighing and combining the scores of individual tests. For example, to judge a printer's abilities for CAD, we weighed the graphic arts test most heavily, the bit-map test minimally, and other tests in-between. The performance results in each of the Best charts show scores weighted for the individual application. The scores listed in the Roll Call on pages 174–175 are composite scores that weigh each performance test equally.

PRINT QUALITY

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Testing team (clockwise from left): Presberg, Platt, Krishnamurthy, and Fox.

OUR TEST CONFIGURATION

The BYTE Printer Benchmarks run under Windows 3.1 and System 7.1. We turned off print servers, spoolers, and buffers. Our time measurements began when the first byte of information was sent to the printer and ended when the last page dropped into the output tray.

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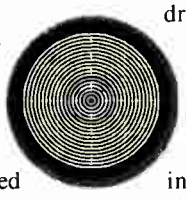

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SUPERIOR DISPLAYS ARE PART OF OUR HERITAGE.

PC MAGAZINE EDITORS' CHOICE
June 30, 1992
FlexScan F550i

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FlexScan F550i

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BYTE BEST

LISTINGS AND FORMS

If you print multipart inventory reports, invoices, or shipping labels, your printer must fulfill some specific needs. First and foremost, you'll need a dot-matrix printer to imprint multiple copies. And because of the high-volume nature of most listings and forms jobs, your printer must be fast. Quality is not a concern as long as the printout is readable, and font support and graphics quality are usually irrelevant.

In addition to speed, look for an efficient paperfeed mechanism that will avoid paper jams. Your printer will also need a long duty cycle and low-cost consumables.

Be aware that many printers in this category aren't intended to use cut-sheet forms, a point more important for general-purpose dot-matrix printing than for listings and forms. (We didn't test more specialized impact line printers, which can cost more than $5000, or laser printers that support continuous forms.)

Inventory reports and other types of long lists often require printers that can handle oversize paper. In addition to having the best mixes of raw speed and acceptable print quality, the Mannesmann Tally MT 360, Alps America DMX800, and Okidata ML395 and PM 3410 in our Best Overall class had wide-carriage versions.

When we began our analysis, we planned on making recommendations for a third subcategory: the fastest printer. Once the performance numbers were in, however, it became clear that the models we identified for Best Overall covered speed as well. For example, not only did the Mannesmann Tally MT 360's 9-page-per-minute rating outpace that of other dot-matrix printers in our listings tests, but its composite speed score also placed it among the five fastest printers in the entire 126-printer test sample.

Don't expect these printers to be priced like those aimed at the general market just because they are dot-matrix. For example, our Best Overall printer for listings, the Mannesmann Tally MT 360, sold for $2695, more than many general-purpose lasers. Three of the runners-up had list prices of $1500 or higher.

Although you'll have to dig deep to afford the best dot-matrix printer in this class, we found seven low-cost (less than $800) alternatives that perform well for listings but run roughly a third slower than the expensive models. Happily, speed was about the only trade-off we found when comparing low- and high-cost dot-matrix printers. For example, the $699 Okidata ML590 posted a quality score comparable to the MT 360's.

We named the Gcc WriteImpact a runner-up for those who need a dot-matrix printer with Mac support, but this is a qualified recommendation. Mac support is rare for dot-matrix printers, so the choices are few. The WriteImpact was the fastest, but it failed to complete our quality tests. But judging by the output from our speed tests, it fulfills the typically draft-quality needs of listings and forms printing.

KEY

▲ Laser ■ Ink-jet

● Dot-matrix

Is high speed a must?

BEST OVERALL — Mannesmann Tally MT 360

This 24-pin dot-matrix printer was the fastest by far in our listings speed tests. The MT 360 is loud and large, but it balances these drawbacks with an easy-to-use control panel and an LCD that clearly presents status messages. Another nice touch: The MT 360 automatically switches between parallel and serial ports. It can print bar codes, and it can ship with a color option.

			PRICE	BYTE SPEED RATING (PPM) DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	WIDE CARRIAGE?
BEST	Mannesmann Tally MT 360	● PC	$2695	9.11 / —	1.8	720 cps	Yes
RUNNER-UP	Alps America DMX800	● PC	$2195	8.60 / —	1.4	800 cps	Yes
RUNNER-UP	Okidata PM 3410	● PC	$1999	7.79 / —	1.3	550 cps	Yes
RUNNER-UP	Okidata ML395	● PC	$1499	6.48 / —	1.9	486 cps	Yes
RUNNER-UP	Gcc WriteImpact	● MAC	$599	— / 0.87	—[1]	192 cps	No

Is price more important?

LOW COST — Okidata ML590

This $699 printer ran our listings tests almost as fast as competitors costing twice as much. Unlike other printers in its class, the ML590 doesn't have an LCD, but its simple control panel makes it a pleasure to use. The printer is solidly built, and it comes with an easy-to-use tractor-feed mechanism.

			PRICE	BYTE SPEED RATING (PPM) DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	WIDE CARRIAGE?
BEST	Okidata ML590	● PC	$699	5.42 / —	1.7	360 cps	No
RUNNER-UP	Decision Data 6520-41	● PC	$460	5.00 / —	1.5	320 cps	No
RUNNER-UP	Epson FX-1170	● PC	$499	5.30 / —	1.2	380 cps	Yes
RUNNER-UP	DEC LA310 MultiPrinter	● PC	$599	5.08 / —	1.3	300 cps	Yes
RUNNER-UP	Okidata ML521	● PC	$799	5.38 / —	1.2	430 cps	Yes
RUNNER-UP	DEC LA95 DECWriter	● PC	$319	3.15 / —	2.1	300 cps	No
RUNNER-UP	Gcc WriteImpact	● MAC	$599	— / 0.87	—[1]	192 cps	No

[1] Failed to complete our quality tests. BYTE/NSTL and vendor could not resolve the problem during the test cycle.

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PRINTERS FOR PRESENTATIONS

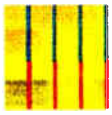
Print quality outweighs speed when you're judging printers for presentations. Speed is important, however, especially for those of us who always seem to be printing our speech materials when we should be leaving for the airport. Our tests identified a number of printers, both black-and-white and color, that successfully balanced these two considerations. In few application categories were the relative strengths and weaknesses of the various printing technologies as stratified as in this one. Lasers excelled when a combination of speed and quality was important. When low cost and high-quality color were considered, ink-jets rose to the top. And low-cost color output proved the domain of dot-matrix printers.

For black-and-white high-quality output, you can select HP's LaserJet 4M, the QMS 860, or Xante's Accel-a-Writer 4000. All these lasers received similar scores in our quality test. The new 600-dpi laser printers (including the LaserJet and the 860) produce a wide range of grays, sharp text, and dark solid fills. Prices begin at about $3000 for PostScript models. The lower-cost 300-dpi printers also provided fine print quality. Among the better 300-dpi performers in our quality and speed tests were HP's LaserJet IIIP, Mannesmann Tally's MT908, and Texas Instruments' MicroLaser XL.

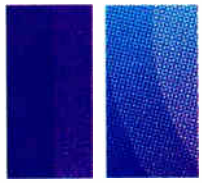
If you only need color to separate bars in charts or to highlight important text, look to high-end ink-jet printers such as the Canon BJC-800, HP's PaintJet XL300, or Lexmark's IBM Color JetPrinter PS 4079, all of which can print to paper or transparencies. We found color dot-matrix printers to be acceptable for draft-quality work, but their print quality was too inferior to ink-jets' for us to recommend them for formal presentations. The solid-ink printers like the Dataproducts Jolt PS and the Tektronix Phaser III PXi provide outstanding color quality, but they cost $6695 and $9995, respectively.

The Problem of Color

While testing color printers, we discovered an assortment of problems that adversely affected color-output quality. Most common were color smearing and incorrect colors.



Smearing (see figure at left) occurs in dot-matrix printers when the printer shifts the color ribbon while the ribbon is still in contact with the paper. This frequently happens when printing adjacent filled bars in charts. Careful adjustment of the print-head gap can alleviate (but not always eliminate) smearing.



Ink-jets have their own problems. The color you see on the screen may not match the printed color. The figure on the right shows samples from two printers that printed the color "blue." One sample is a rich royal blue, the other a strong purple. If you must match a screen sample to the printed document, inaccurate representations like these mean you'll spend a great deal of time adjusting on-screen colors to obtain the desired effect.

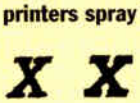
TRUST YOUR EYE

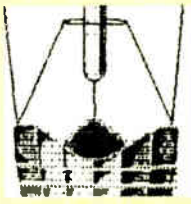
Our quality testing proved once again that only actual output tells the whole truth about quality. A vendor's claimed resolution for its printer is not always an accurate measurement of print quality. Here's why.

Printers use a theoretical grid, measured in dots per inch, to determine where to place each dot on the page. The tighter the grid, the higher the output quality, because dots placed closer together result in sharper images. Thus, a 360-dpi dot-matrix or ink-jet printer should produce higher-quality output than a 300-dpi laser printer. But other factors make this impossible.

DOT SIZE. Although many printers work within a 360-dpi grid, they cannot produce a dot small enough to fit the grid. For example, the dots pictured here were produced by two 360-dpi printers. On the left is a dot from an ink-jet printer, and on the right is a dot produced by a dot-matrix printer. The dot-matrix's larger dot will fall outside the grid structure and result in lines and edges that look jagged compared to the smaller ink-jet-printed dot.

STRAY DOTS. Some printers produce undesired dots during the printing process. Ink-jet printers spray ink, shotgun fashion, at the page. On the left is an ink-jet printout that shows many stray dots along the edges of a letter, resulting in fuzzy text. The laser printout on the right shows fewer stray dots, but still enough to reduce overall quality.





ERRORS. Not all printers can precisely place a dot on the page, and some may produce irregular dot shapes. This blowup (right) shows an error-ridden vertical line with changing dot shapes and poor placement.

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Our evaluations of printers for presentations focused on models that ranked high in output quality but also demonstrated solid performance.

In terms of speed, some of the ink-jet printers fared well even when compared to laser printers. The Epson Stylus 800, for example, ran our speed tests faster than several lasers we tested. In fact, its graphics test score was only an insignificant tenth of a percent behind HP's LaserJet 4M. As a result, if you often find yourself churning out speech handouts and overheads and you're not especially concerned about fine quality, the trade-off you make for a low-cost printer will be small.

If quality is of greater concern, however, ink-jets probably aren't viable options. In the same Stylus-to-LaserJet comparison, we found great differences in print quality. In our graphics test, the LaserJet (at 600 dpi) earned a score that was nearly double the Stylus's.

Our choice for Best Color printer, the Canon BJC-800, recorded a color-quality score below that of Dataproducts' Jolt PS, which earned the highest quality score of any ink-jet printer in our roundup. We rank the Jolt as a runner-up for color, but we think its $6695 price tag makes it a candidate only for those who must have the best in color and can justify the cost.

Don't expect low-cost color dot-matrix printers to provide anything but draft-quality output. Even our recommended DEC LA95 DECWriter produced color output of a quality below that of all the ink-jet printers. Note that none of the color printers we tested supported the Mac *and* sold for under $1000.

Mac users with a small budget will find that, while models like the Apple Color Printer and the Lexmark JetPrinter PS 4079 aren't especially low cost, their print quality is competitive with the even pricier Jolt.

KEY

▲ Laser ■ Ink-jet

● Dot-matrix

BYTE BEST PRESENTATIONS

Are speed and quality essential?

BEST OVERALL — QMS 860

As it did in the other categories, the 860 delivered impressive quality and speed ratings in our presentations tests. Its standard 12 MB of memory was among the most generous we saw. The 860 also fares well in workgroups: It accepts simultaneous jobs through its parallel, serial, and LocalTalk interfaces.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	QMS 860	▲ PC MAC	$4595	1.01 / — / 1.44	4.6	8 ppm	600
RUNNER-UP	Xante Accel-A-Writer 8000	▲ PC MAC	$2295	0.77 / 2.26 / 1.07	4.0	8 ppm	600
RUNNER-UP	Fujitsu PrintPartner 10W	▲ PC MAC	$2768	1.04 / 2.13 / 1.32	3.1	10 ppm	300
RUNNER-UP	HP LaserJet 4M	▲ PC MAC	$2999	0.84 / 1.26 / 1.37	4.4	8 ppm	600

Looking for a real deal?

LOW COST — Epson Stylus 800

With a resolution of 360 dpi, this ink-jet produced gray-scale quality that you'd expect from a printer four times its price. Its speed outpaced a number of laser printers in our high-quality presentation graphics test.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	Epson Stylus 800	■ PC	$499	0.81 / —	2.4	120 cps	360
RUNNER-UP	Canon BJ-200	■ PC	$449	0.74 / —	2.0	124 cps	360
RUNNER-UP	HP DeskJet 500	■ PC	$599	0.86 / —	1.7	120 cps	300
RUNNER-UP	Apple StyleWriter II	■ MAC	$359	— / 0.45	2.1	0.5 ppm	360

Need the best color?

COLOR — Canon BJC-800

The Canon BJC-800 ranked near the top in print quality even though its list price was the second lowest in this subcategory. Its speed was below average, but its support for ledger-size paper and its intuitive interface counterbalanced this deficiency.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	Canon BJC-800	■ PC	$1999	0.17 / —	3.3	170 cps	360
RUNNER-UP	Dataproducts Jolt PS	■ PC MAC	$6695	0.32 / 0.52	3.6	2 ppm	300
RUNNER-UP	Apple Color Printer	■ MAC	$2349	— / 0.58	3.2	3.5 mpp	360
RUNNER-UP	Lexmark JetPrinter PS 4079	■ PC MAC	$3495	0.26 / 0.24	3.5	167 cps	360

Want color at black-and-white prices?

LOW-COST COLOR — DEC LA95 DECWriter

This $319 printer ranked near the top in its class for speed, and its print quality was the highest among the dot-matrix printers. There were faster printers overall, and ink-jets produced better quality, but the LA95 is the clear choice for color if you can't squeeze $2000 out of your budget.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	DEC LA95 DECWriter	● PC	$319	0.48 / —	2.3	240 cps	360
RUNNER-UP	Citizen GSX-240	● PC	$599	0.21 / —	2.3	99 cps	360
RUNNER-UP	Citizen GSX-230	● PC	$399	0.16 / —	2.2	90 cps	360
RUNNER-UP	Panasonic KX-P2124	● PC	$599.95	0.21 / —	2.0	106 cps	360

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Windows Printer Drivers

When you've shopped for a printer, you may not have given much thought to drivers, but if you use a variety of fonts or print in color, the availability of drivers may ultimately determine how satisfied you are with your purchase. Printer drivers, such as those for Windows, send the printer control codes that tell the printer when, for example, to switch fonts or how to print graphics. Our printer tests relied heavily on Windows, and our testing experiences revealed a number of driver problems. Here's a summary of driver questions for you to ask before you make your purchase.

1. IS THERE A WINDOWS DRIVER?

Not all the printers we tested came packaged with a Windows driver. If a printer runs its own unique control sequences (without emulation), as do many ink-jets, a Windows driver is necessary to print from Windows applications. Some printers (e.g., any made by Epson) can be used with a printer driver packaged with Windows. However, when we used a standard Windows driver to run our text and graphics tests, we often couldn't take advantage of all of the printer's built-in fonts or color capabilities.

2. WHERE'S THE LATEST VERSION?

Often, we received a printer with no driver, or an outdated driver, so we couldn't get the printer's best output quality or performance. Many drivers were available on MSL (Microsoft's Software Library). To get these drivers, however, you need a modem and access to MSL through CompuServe or a similar service.

Other drivers were available only from the vendor's BBS. On the surface, this distribution scheme seems like it would be the most effective way to update a driver, but it wasn't foolproof. For example, the Lexmark PPS 2380 had drivers available on both Microsoft's and Lexmark's BBSes, but the drivers were different and only one of them worked correctly. For some printer models, we needed to make repeated calls to technical support to get the proper drivers.

3. IS THE DRIVER ANY GOOD?

We found problems with a variety of drivers. Many of them did not support built-in printer fonts. Many didn't correctly switch from draft- to high-quality modes when printing text. And many didn't support all of a printer's features. One driver from Citizen allowed us to select Burst-mode printing, which was supposed to speed up the printing of graphics files without slowing down other printing operations. But the price we paid for a performance gain from choosing the Burst mode was the inability to use any TrueType fonts.

4. WHICH ONE DO I USE?

If manuals mentioned printer drivers at all, it was often just in a short list of supported drivers. Even armed with such a list, it is often difficult to know which driver to use. For instance, the Epson LQ 870 driver comes in two different flavors, the ESC/P2 version and the scalable fonts version, both of which have a bearing on printer performance.

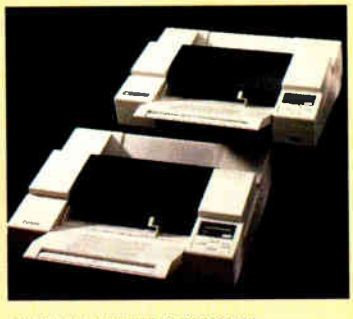
Many drivers don't support color printing even though the printer is capable of color. The only way for you to know which printer driver you should choose is to try them all. In most cases, you are probably better off just sticking to the first driver that you get to work, even though the downside to this is that you may be sacrificing some performance or quality. Otherwise, you could find yourself making a career of test-driving printer drivers.

SEPARATED AT BIRTH?

So you think that your printer is unique and was designed by the company on the nameplate. Think again. We saw numerous examples of ink-jet, laser, and dot-matrix printers that shared the same overall design, so that, on the outside, at least, it was hard to tell one printer from another. However, once we opened printers up and took a look under the hood, we sometimes saw processors and other internal components that differentiated similar-looking models. But the pairs listed here differed physically only in their nameplates. Nevertheless, even these printer pairs performed differently, thanks to unique drivers supplied by their respective vendors.

DEC LA95 DECWRITER AND CITIZEN GSX-240

These two were so similar, the LA95 even arrived with a Citizen user's manual. However, our testing showed that DEC's driver got the jump on Citizen's: The LA95's overall speed rating was a full two points higher than its twin's.



CANON BJC-800 AND APPLE COLOR PRINTER

These two printers earned identical scores in our print-quality tests. Their difference: The BJC-800 supports only PCs, while the Apple printer supports only the Mac.

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BYTE BEST

DESKTOP PUBLISHING

Desktop publishing programs have become essential for businesses that create newsletters, marketing brochures, and other corporate literature. Print quality is of prime importance for desktop publishing, whether the output will be distributed as is or will serve as camera-ready output. Along with high print quality, the printer should be able to generate large and complex documents with reasonable speed.

We considered only PostScript printers because of that language's abilities for scaling fonts and producing high-quality text. This factor, combined with our considerable emphasis on print quality, resulted in top honors going only to laser printers. Of these, only the Fujitsu PrintPartner 10W did not support the growing trend of high-resolution printing at 600 dpi or greater. In general, we found that the 600-dpi printers produced clearer curves and a greater range of gray levels than the 300-dpi competitors.

The Best Overall printer, the QMS 860, was one of the few printers that could handle 11- by 17-inch paper (the printer prints this size at 4 ppm). Both it and LaserMaster's Unity 1200XL (the winner for Best Print Quality) have unconventional feed mechanisms that allow you to feed in paper that is up to 11 inches wide.

Ink-jet and dot-matrix printers showed their stripes in the low-cost category, where trade-offs in quality and features were evident.

KEY

▲ Laser ■ Ink-jet

● Dot-matrix

Looking for both print quality and speed?

BEST OVERALL — QMS 860

This laser printer's print quality was second only to that of the more expensive 1200-dpi printers. In performance, the QMS 860 ranked among the best. It posted the third-fastest time when running our PC PostScript tests, and it came in second in our Macintosh desktop publishing tests. The QMS was one of the few laser printers that accepted 11- by 17-inch paper, and it supports both the PC and the Mac in its standard configuration.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	QMS 860	▲ PC MAC	$4595	1.53 / 1.65	4.6	8 ppm	600
RUNNER-UP	LaserMaster Unity 1200XL	▲ PC MAC	$9995	2.08 / 1.14	5.0	8 ppm	1200
RUNNER-UP	Fujitsu PrintPartner 10W	▲ PC MAC	$2768	1.68 / 1.79	3.2	10 ppm	300
RUNNER-UP	HP LaserJet 4M	▲ PC MAC	$2999	1.28 / 1.36	4.5	8 ppm	600
RUNNER-UP	Xante Accel-A-Writer 8000	▲ PC MAC	$2295	1.16 / 1.30	4.0	8 ppm	600

Is cost most important to you?

LOW COST — Epson Stylus 800

The Epson Stylus 800 excelled in speed and print quality. This $499 ink-jet printer's text performance was surprisingly quick even though its Windows driver did not support built-in fonts. Still, the Stylus completed our font-rendering test (which consisted of TrueType fonts in 30 different font sizes) more quickly than any other ink-jet. What's more, the quality of its text and graphics was the best of any in this group.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	Epson Stylus 800	■ PC	$499	0.94 / —	2.4	120 cps	360
RUNNER-UP	Canon BJ-200	■ PC	$449	0.84 / —	1.9	124 cps	360
RUNNER-UP	HP DeskJet 500	■ PC	$599	1.04 / —	1.6	120 cps	300
RUNNER-UP	DEC LA95 DECWriter	■ PC	$319	0.61 / —	2.1	240 cps	360
RUNNER-UP	Okidata ML590	● PC	$699	0.96 / —	1.5	120 cps	360
RUNNER-UP	Apple StyleWriter II	■ MAC	$359	— / 0.54	2.0	0.5 ppm	360

Want typeset-quality output?

PRINT QUALITY — LaserMaster Unity 1200XL

At 1200 dpi, this laser printer scored highest among the fully evaluated printers in our quality tests. With a list price of nearly $10,000, it's clearly a printer for typesetting or for producing camera-ready materials. It comes standard with a number of important features for this class, including a 20-MB hard drive, 135 resident fonts, and 21 MB of memory. For your networking needs, the LaserMaster Unity 1200XL also supports Ethernet networks running NetWare, TCP/IP, and AppleTalk.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	LaserMaster Unity 1200XL	▲ PC MAC	$9995	2.08 / 1.14	5.0	8 ppm	1200
RUNNER-UP	QMS 860	▲ PC MAC	$4595	1.53 / 1.65	4.6	8 ppm	600
RUNNER-UP	Apple LaserWriter Pro 630	▲ PC MAC	$2529	1.05 / 1.75	4.6	8 ppm	600
RUNNER-UP	HP LaserJet 4M	▲ PC MAC	$2999	1.28 / 1.36	4.5	8 ppm	600
RUNNER-UP	Lexmark LaserPrinter 4029-10P	▲ PC	$2499	0.53 / —	4.3	10 ppm	600

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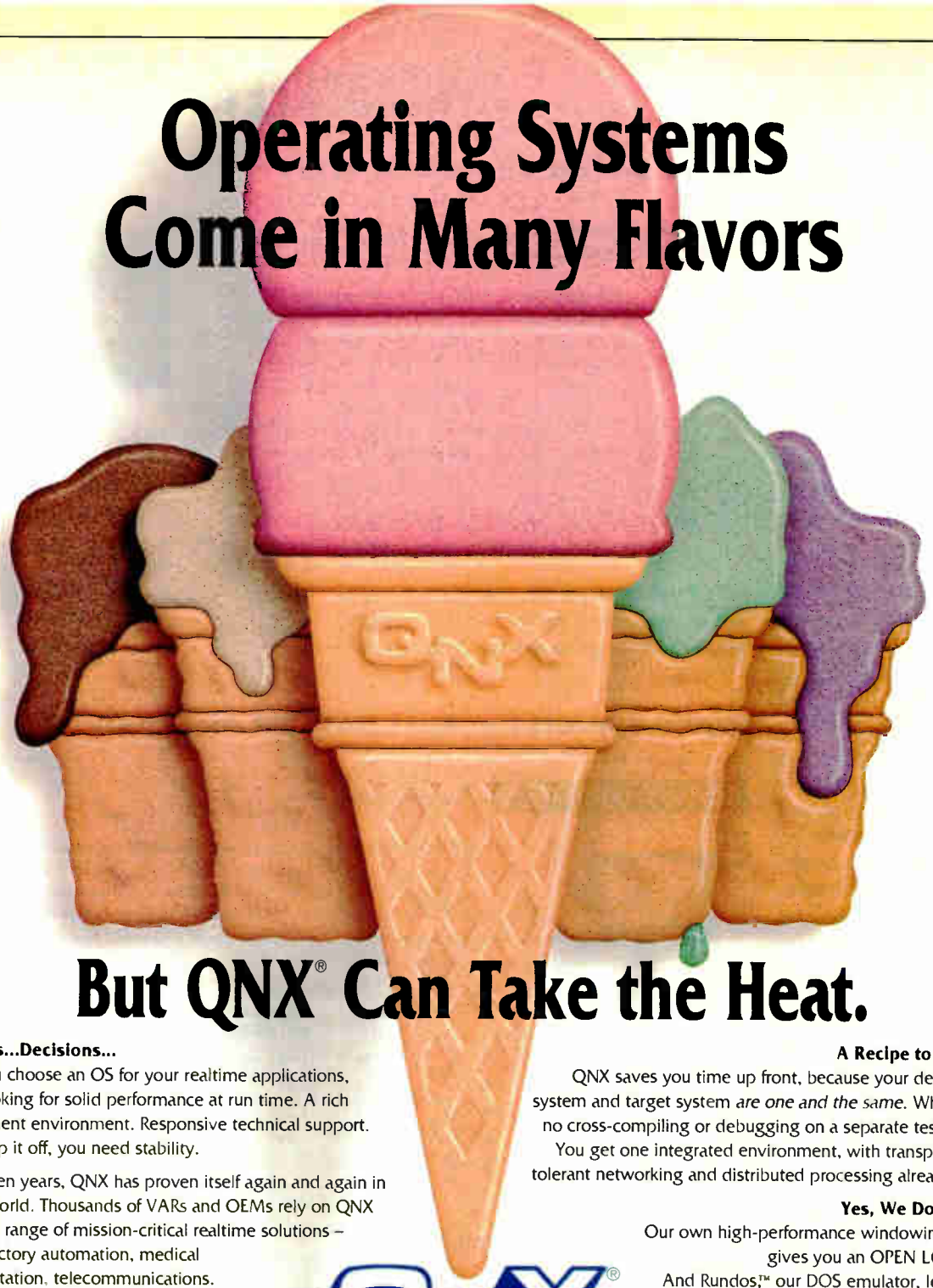
Operating Systems Come in Many Flavors



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BYTE BEST

SPREADSHEETS

From corporate expenses to cash-flow estimates, spreadsheets are the bread and butter of today's financial analysis. Many people simply print budgets or tables consisting solely of columns of numbers. Here, speed and perhaps the ability to handle oversize paper are important criteria. Other times, you may create bar charts and pie charts that detail expenditures or comparative sales figures, accompanied by some descriptive text. The printer for this type of output must produce flattering hard copy that accurately reproduces these figures. Finally, a printer for spreadsheets shouldn't throw your finances into the red.

Through our testing, we became enamored with laser printers for spreadsheets because of their high-quality output and speed. The Epson ActionLaser 1000 ranked as both best overall and fastest printer for spreadsheets and carried an impressive $1125 list price for our test configuration. This price is almost one-third the average price of the lasers we tested.

Several ink-jet and dot-matrix printers made strong showings in the low-cost category, including Canon's $449 BJ-200, an ink-jet that took top low-cost honors.

To judge speed, we considered only draft-quality text tests when we made our evaluations for the leading spreadsheet printers. Laser printers made a strong showing because of their combination of high-quality output and speed.

KEY

▲ Laser ■ Ink-jet

● Dot-matrix

Need speed and simplicity?

BEST OVERALL **Epson ActionLaser 1000**

The ActionLaser scored lowest in this group for print quality, but its fast draft-quality speed more than made up for it. This is also a simple printer to use. Its control panel is accessible and easy to read, and you load paper conveniently in the front of the printer. The ActionLaser supports PCL 5; HPGL is an option ($299). It can automatically switch emulations. Our as-tested configuration included PostScript and additional memory, but the base price without these options is $799, the lowest laser list price we saw.

			PRICE	BYTE SPEED RATING (PPM) DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	ACCEPTS 11×17 PAPER?
BEST	Epson ActionLaser 1000	▲ PC	$1125	2.80 / —	2.5	6 ppm	No
RUNNER-UP	Apple LaserWriter IIg	▲ MAC	$2309	— / 2.11	2.7	8 ppm	No
RUNNER-UP	Xante Accel-A-Writer 8000	▲ PC MAC	$2295	2.79 / 1.07	3.9	8 ppm	No

Want something fast but not expensive?

LOW COST **Canon BJ-200**

This $449 ink-jet will keep most spreadsheet users satisfied. It performed admirably in our speed tests, posting the fastest score of any ink-jet in this category. Its print quality was the second best, only slightly below that of the leader, the Epson Stylus 800. Unlike some other low-cost contenders, the BJ-200 can print spreadsheets in landscape format. The printer supports Epson LQ-510 and IBM Proprinter emulations. It comes with 49 KB of RAM, which is not expandable.

			PRICE	BYTE SPEED RATING (PPM) DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	ACCEPTS 11×17 PAPER?
BEST	Canon BJ-200	■ PC	$449	1.42 / —	2.2	248 cps	No
RUNNER-UP	Epson Stylus 800	■ PC	$499	0.96 / —	2.6	225 cps	No
RUNNER-UP	HP DeskJet 500	■ PC	$599	1.30 / —	1.9	360 cps	No
RUNNER-UP	Okidata ML590	● PC	$699	1.74 / —	1.7	120 cps	No
RUNNER-UP	Apple StyleWriter II	■ MAC	$359	— / 0.47	2.2	1 ppm	No

Want the fastest?

SPEED **Epson ActionLaser 1000**

In addition to all the attributes that made this the best printer overall for spreadsheets, the ActionLaser also was the fastest in this category. And its price was half that of the comparably performing dot-matrix Mannesmann Tally MT 360.

			PRICE	BYTE SPEED RATING (PPM) DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	ACCEPTS 11×17 PAPER?
BEST	Epson ActionLaser 1000	▲ PC	$1125	2.80 / —	2.5	6 ppm	No
RUNNER-UP	Mannesmann Tally MT 360	● PC	$2695	2.33 / —	1.8	720 cps	Yes
RUNNER-UP	Apple LaserWriter IIg	▲ MAC	$2309	— / 2.11	2.7	8 ppm	No
RUNNER-UP	Okidata OL 810	▲ PC	$3536	2.74 / —	2.4	8 ppm	No

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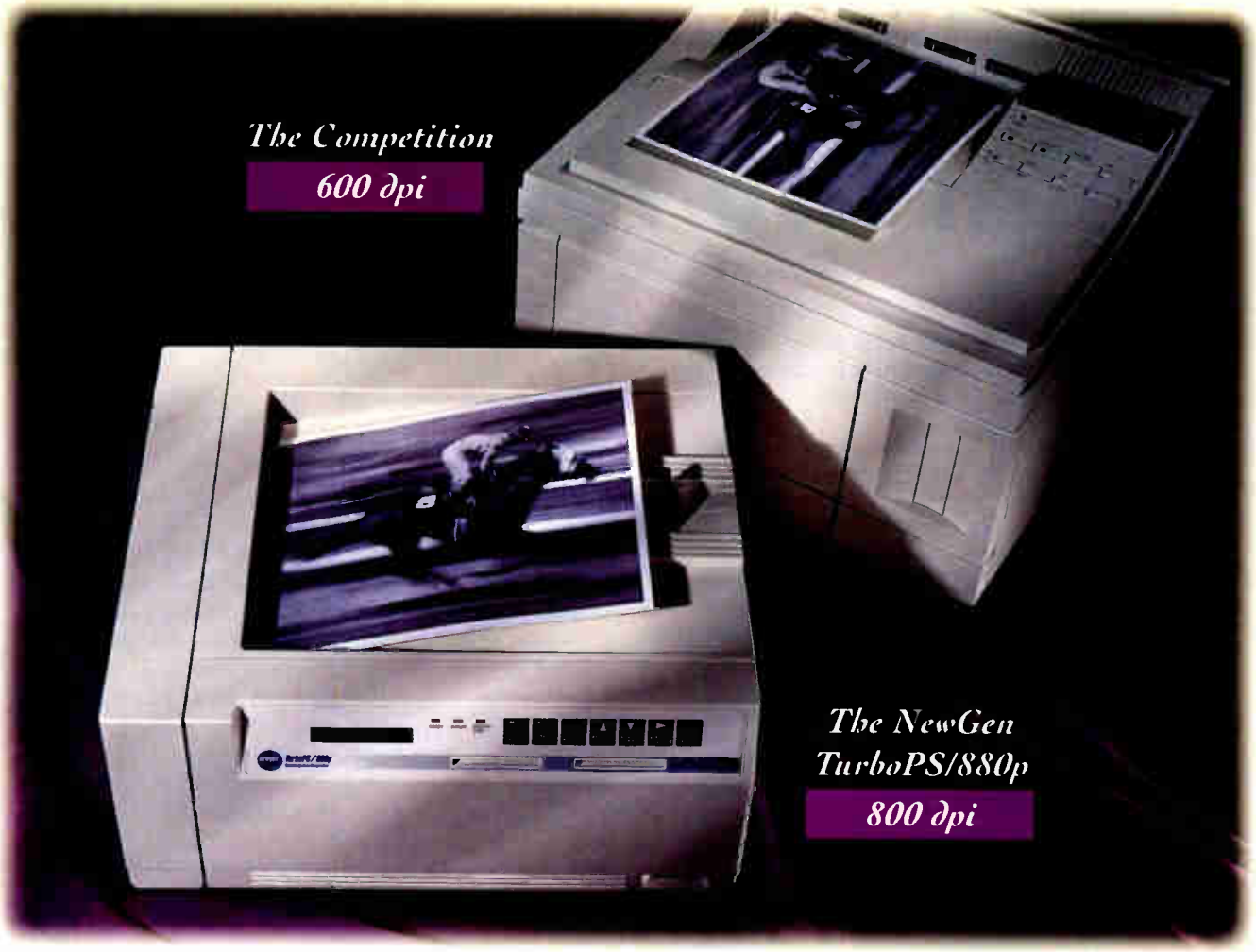

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PRINTERS FOR

GRAPHIC ARTS

A printer can make or break graphic arts jobs. If you use service bureaus for final output, your printer will be producing drafts of illustrations and graphics elements. Sometimes you'll need to generate full-color finished artwork and prepress proofs in-house.

Because of this specialization, the printers we considered for this category were among the most sophisticated and expensive in our sample. LaserMaster's Unity 1200XL carried a list price of $9995, but it came with a number of features that would hardly be considered standard for a printer. Also noteworthy was the winner for Best Color, the Dataproducts Jolt PS, a $6695 solid-ink printer. Unlike the liquid inks used by traditional ink-jet printers, the solid Jolt inks are similar to a crayon. During printing, the inks are heated and shot to the page, where they instantly solidify. The resulting colors are vibrant, with impressive dithering and little color bleeding and smearing.

For those whose color needs are less demanding, we found DEC's LA95 DECWriter to be a good low-cost choice. Even though its $319 price was at the opposite end of the price spectrum compared to the Jolt, no other low-cost color printer had better color-output quality than the LA95. Note that none of our low-cost test printers supported both color and the Mac.

Depending on your needs, the printer you choose will need to balance resolution, color capability, and cost. Here are some guidelines:

Rule 1: Ideally, graphic arts printers should include PostScript. Most graphic arts software and outside printer and service houses support PostScript, and having this capability on your printer ensures that any draft accurately represents the final look of a page or illustration.

Rule 2: You should buy the highest-resolution printer you can afford. Some people can trade quality for speed if the printer is only used to generate drafts, but most users find that a high-resolution printer can support both production art and internal activities. With the emergence of 600- and 1200-dpi printers at affordable prices, users can also generate acceptable presentations and illustrations in-house, saving time and money.

Rule 3: A company that generates large amounts of pages or illustrations that use color can save time and avoid mistakes with a color printer. At the high end, color printers also allow the company to

New From XLI: High Res, Low Price

At press time, XLI released the Image Xpert 5000, a laser printer designed for graphic arts and desktop publishing applications. The 8-ppm Xpert prints text and line art at 1200 dpi; gray-scale images print at resolutions equivalent to 2400 dpi. The printer handles 11- by 17-inch paper at a rated engine speed of 4.6 ppm.

The printer didn't arrive in time to consider it in our formal evaluations, but we did run our quality tests. See the Roll Call on pages 174–175 to see how the Xpert compares with other high-end lasers.

At $6995, the Xpert costs less than the $9995 LaserMaster Unity 1200XL, the other 1200-dpi printer we tested. But the Xpert required at least a 33-MHz 486 PC, because it relies heavily on its host for performance. You must install a controller board in your computer and connect the printer via a video interface.

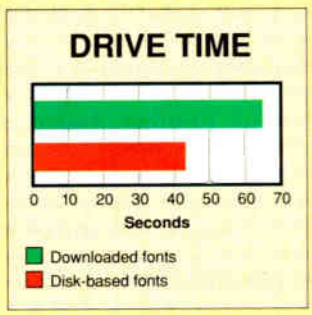
DOES YOUR PRINTER NEED A HARD DISK?

The alternative to storing fonts on your computer's hard disk is to store them on a hard disk in your printer. The advantage is that the font is already in the printer, so no time is wasted downloading the font.

How much time does this save? Using a LaserMaster Unity 1200XL, a $9995 printer that comes standard with a 20-MB hard disk and 135 fonts, we printed a one-page file using 10 fonts. The page printed in 42.9 seconds when using disk-based fonts, and in 64.6 seconds when using downloaded fonts. This 22-second difference is a one-time gain: Fonts need to be downloaded only once; repeated reference to these 10 fonts in a longer document would not cause an additional performance penalty.

Printer hard disks are often designed to meet the space limitations of their hosts, and prices reflect the custom designs. For example, Compaq's 60-MB drive for the Pagemarq lists for $549. Some printers have a port that can accept an external SCSI disk.

If you make extensive use of a large font library, consider a hard disk. If you do not use nonstandard fonts, or if you use them infrequently, we do not recommend adding a hard disk to your laser printer.



World Radio History

generate prepress proofs, avoiding the cost of using outside services. Most users, however, use color output to improve the effectiveness of presentations. Ink-jet color printers provide a relatively low-cost solution for this, but they fail to provide the color accuracy needed for prepress proofs.

Rule 4: Look at the entire cost of operating a printer. Short toner-cartridge life, expensive cartridges, and special paper drive operating costs up. These costs may appear minimal, but they can alter the financial incentives that justify moving a graphic arts application in-house in the first place.

Our Best Overall printer for graphic arts was also one of the most unusual we tested. LaserMaster's Unity 1200XL provides 1200- by 1200-dpi resolution, as well as resolution enhancement, which, like similar technologies offered by HP and others, smoothes edges of text and lines. (In practice, the printer performed up to expectations: It received a quality rating of 4.9 on a scale of 5.0.) The Unity was also the fastest printer in our graphics speed tests.

Along with its graphics and speed capabilities, the Unity comes standard with LocalTalk, parallel, and serial interfaces. Ethernet is an option. The printer can handle simultaneous input from each of the four ports.

As you might expect, there was one more area in which the Unity stood out from all the other printers that we tested. Its $9995 price tag was nearly $3000 higher than the most expensive color printer we reviewed.

For those of us whose printing needs are much more modest than the camera-ready quality offered by the Unity, seeing this printer perform was a treat. It demonstrated to us what laser technology is capable of, if you are willing to pay the price.

KEY

▲ Laser ■ Ink-jet ● Dot-matrix

BYTE BEST — GRAPHIC ARTS

Do you want spectacular prints?

BEST OVERALL — LaserMaster Unity 1200XL

Photographic images produced by the Unity were spectacular. The 33-MHz RISC processor provided more than adequate processing power for a combination of high quality and good performance. Although expensive, the Unity was the finest high-quality graphics printer we tested.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	LaserMaster Unity 1200XL	▲ PC MAC	$9995	1.14 / 0.75	4.9	8 ppm	1200
RUNNER-UP	QMS 860	▲ PC MAC	$4595	0.70 / 1.35	4.3	8 ppm	600
RUNNER-UP	Xante Accel-A-Writer 8000	▲ PC MAC	$2295	0.48 / 0.71	3.6	8 ppm	600
RUNNER-UP	Apple LaserWriter IIg	▲ MAC	$2309	— / 1.60	3.1	8 ppm	300

Cost-conscious?

LOW COST — Epson Stylus 800

The Stylus 800 had the best quality-to-price ratio in this class. It scored especially well on our line and circle quality tests. This printer will not replace the printers in the Best Overall category, but it produces output that's competitive with that of more expensive models.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	Epson Stylus 800	■ PC	$499	0.75 / —	2.3	150 cps	360
RUNNER-UP	DEC LA95 DECWriter	● PC	$319	0.40 / —	2.1	240 cps	360
RUNNER-UP	Canon BJ-200	■ PC	$449	0.68 / —	1.7	124 cps	360
RUNNER-UP	Apple StyleWriter II	■ MAC	$359	— / 0.33	2.2	0.5 ppm	360

Need stunning color?

COLOR — Dataproducts Jolt PS

This solid-ink printer produced vibrant colors that few liquid-ink printers can match. Solid ink produces good color blends while reducing bleeding and smearing. However, we found that the ink easily rubbed off of acetate transparencies. And don't expect your output in a hurry: The Jolt took 2 to 5 minutes to print a complex one-page document.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	Dataproducts Jolt PS	■ PC MAC	$6695	0.21 / 0.45	3.8	2 ppm	300
RUNNER-UP	Lexmark JetPrinter PS 4079	■ PC MAC	$3495	0.19 / 0.27	3.5	167 cps	360
RUNNER-UP	Canon BJC-800	■ PC	$1999	0.12 / —	3.2	170 cps	360
RUNNER-UP	Apple Color Printer	■ MAC	$2349	— / 0.45	3.1	3.5 ppm	360

Need cost-cutting color?

LOW-COST COLOR — Digital LA95 DECWriter

This dot-matrix printer's color graphics performance was second to the Okidata ML590's, while its quality scores were the highest of any dot-matrix printer. At $319, this printer is hard to pass up if you need color for graphic arts jobs.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	RESOLUTION (DPI)
BEST	DEC LA95 DECWriter	● PC	$319	0.38 / —	2.3	240 cps	360
RUNNER-UP	Okidata ML590	● PC	$699	0.45 / —	1.6	120 cps	360
RUNNER-UP	Citizen GSX-230	● PC	$399	0.12 / —	2.3	90 cps	360
RUNNER-UP	Citizen GSX-240	● PC	$599	0.15 / —	2.2	99 cps	360
RUNNER-UP	Panasonic KX-P2124	● PC	$599.95	0.18 / —	1.9	106 cps	360

World Radio History

BYTE BEST

WORKGROUPS

Network printers make up one of the hottest segments of the laser printer market, thanks to introductions from vendors like Compaq, HP, and QMS. (Any printer can be a "network" printer. For our purposes, we considered laser printers with engine speeds faster than 10 ppm and monthly duty cycles of at least 25,000 pages. In most cases, Ethernet and Token Ring cards were available.)

One consideration when you're shopping for a network printer is how easily it can switch emulations—a must for mixed workstation environments. There are three methods of switching modes: Switch the printer setting manually; send the printer special codes before each print job to specify an emulation; or use a printer that's capable of automatic emulation sensing.

Do you need emulation-sensing technology? If you work in a small group with standard setups, probably not. If you work in a mixed-platform group with both PCs and Macs, it can be indispensable—if you can trust it. If it fails, you can end up with reams of printed PostScript instructions instead of your monthly report.

Printers vary in how they identify print jobs. Some base their guess on the first couple of hundred characters in a job. If these look like a PostScript header, the printer chooses PostScript; if not, it chooses PCL. But if a printer runs out of paper in the middle of a job, it may try to retrain from the middle of the document and get confused. Other printers analyze continually.

Network-printer costs are high; our Low Cost choice listed for $3395. But the cost is shared among a group of users, and a 12- to 17-ppm printer can't be beat when a deadline is tight and you need printed output fast. On the other hand, if the printer breaks down, the frustration ripples throughout an entire department or company.

One more point: Many people find that the most annoying part of using a shared printer is having to get up and walk to their output. For smaller workgroups that don't need the speed or paper-handling features of a shared laser, two cheaper lasers may be better than one network model.

KEY

▲ Laser ■ Ink-jet

● Dot-matrix

Looking for the leader?

BEST OVERALL **HP LaserJet 4Si MX**

This new printer was the hands-down winner for workgroups. The 4Si MX ranked above the QMS 1725 and Compaq Pagemarq 15 in overall print quality. It provides automatic emulation switching. The printer offers parallel, LocalTalk, and Ethernet interfaces and supports IPX, TCP/IP, EtherTalk, and NetBIOS protocols. Its paper trays hold 1000 sheets, and a sensor signals when the output bin reaches its 550-sheet capacity.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	EMULATION SWITCHING?
BEST	HP LaserJet 4Si MX	▲ PC MAC	$5499	2.32 / 4.48 / 4.12	3.6	17 ppm	Yes
RUNNER-UP	QMS 1725 Print System	▲ PC MAC	$5995	2.17 / 3.10 / 2.67	3.4	17 ppm	Yes
RUNNER-UP	Compaq Pagemarq 15	▲ PC MAC	$5196	1.67 / 1.95 / 2.45	3.4	15 ppm	Yes
RUNNER-UP	TI MicroLaser XL Turbo	▲ PC MAC	$4442	1.46 / 2.35 / 2.26	2.4	16 ppm	Yes

Want economical sharing?

LOW COST **Dataproducts LZR 1560**

For less than $4000, this laser printer offers RS-232, RS-422, parallel, and LocalTalk interfaces standard. The printer also ships standard with PostScript and PCL 4 emulations. It can't automatically sense emulations, but you can dedicate interfaces to specific emulations; for example, the parallel interface can deal with PCL 4 jobs while the LocalTalk port handles PostScript.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	EMULATION SWITCHING?
BEST	Dataproducts LZR 1560	▲ PC MAC	$3395	1.22 / 2.43 / 1.38	3.1	15 ppm	Yes
RUNNER-UP	TI MicroLaser Turbo XL	▲ PC MAC	$4442	1.46 / 2.35 / 2.26	2.4	16 ppm	Yes

How to Connect Your Network Printer

To connect a laser printer to a NetWare network (a popular combination), you have at least five options: Attach the printer to the file server; to a dedicated PC print server; to a nondedicated PC that acts as a workstation and a print server; to a stand-alone box that connects to the printer and to the network wire; or directly to the network.

More and more printers come with standard or optional Ethernet or Token Ring connections. But just hooking a printer directly to your LAN doesn't guarantee smooth network operation. Once you've established the physical connection, you're faced with higher-level protocol matching, configuring your printer to work with IPX (NetWare), TCP/IP (Unix), EtherTalk (Apple), and NetBIOS (LAN Manager).

Printers may soon handle more of the duties currently shared between the printer and the network operating system. The Network Printing Alliance, which includes IBM, TI, and Canon, is drafting a standard for users to obtain detailed information from the printer, including printer status and configuration. HP has defined its own protocol, called Printer Job Language, which debuted with the LaserJet 4.

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BYTE BEST

CAD

CAD applications require a wide range of output devices. At the high end, the applications require large plotters to output complex blueprints and renderings. Others need color just to code the drawings. Simpler constructions, illustrations, and drafts require less resolution but more speed.

Each CAD application sets its own requirements. Circuit board design requires output with high accuracy. Architectural designs generally spread across large sheets of paper. Both require plotters and high-end printers with abilities beyond those of most office printers. Still, the 126 tested printers can support many CAD applications.

Paper size can be critical. Many printers support images less than 8½ inches wide. Some page printers, like the QMS 860, support 11- by 17-inch images; wide-carriage dot-matrix printers can print unlimited lengths of 11-inch-wide paper using fanfold paper. Some software automatically splits images across several sheets of paper, but this creates multiple pages that must be taped together. If your application requires images that exceed printer limits, go with a plotter.

For applications that require color printers, ink-jets provide acceptable color output for most renderings. Applications requiring subtle coloring or dithering effects need higher quality, while applications that just code diagrams in color can use color-capable dot-matrix printers.

KEY

▲ Laser ■ Ink-jet

● Dot-matrix

Is quality most important?

BEST OVERALL — QMS 860

The 860 scored highest in our CAD print-quality test and ran significantly ahead of the Xante Accel-a-Writer and Lexmark LaserPrinter, which came in second and third in quality. The 860 uses an Intel 25-MHz 960 RISC processor. The printer can hold a maximum of 32 MB of memory (12 MB are standard), and QMS supplies utilities that allow you to configure memory as buffers for each input port or for font caching. The printer can hold up to two SCSI hard drives, and you can program the controller to use the drives for print spooling. Adding its ability to print 11- by 17-inch paper (at a 4-ppm engine speed), the 860 stood out as a multipurpose CAD printer.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	ACCEPTS 11×17 PAPER?
BEST	QMS 860	▲ PC MAC	$4595	0.63 / — / 1.55	4.5	8 ppm	Yes
RUNNER-UP	Xante Accel-A-Writer 8000	▲ PC MAC	$2295	0.41 / 1.78 / 0.64	4.0	8 ppm	No
RUNNER-UP	Apple LaserWriter IIg	▲ MAC	$2309	— / — / 1.64	2.7	8 ppm	No
RUNNER-UP	Lexmark IBM LaserPrinter 4029-10P	▲ PC	$2499	0.18 / 1.54 / —	4.0	10 ppm	No

Money matters?

LOW COST — Epson Stylus 800

The Stylus 800 received the highest ink-jet CAD performance score, in part by completing our graphics test one-third faster than most ink-jet printers. Output quality was slightly above average overall, but its line/circle and text quality output rivaled that of ink-jets costing several thousand dollars. The print quality may be the result of Epson's new print head, which is designed to create more uniform dots and fewer stray dots.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	ACCEPTS 11×17 PAPER?
BEST	Epson Stylus 800	■ PC	$499	0.76 / 0.77 / —	2.5	120 cps	Yes
RUNNER-UP	Canon BJ-200	■ PC	$449	0.70 / 1.11 / —	2.2	124 cps	No
RUNNER-UP	DEC LA95 DECWriter	● PC	$319	0.40 / 0.68 / —	2.1	240 cps	No
RUNNER-UP	Apple StyleWriter II	■ MAC	$359	— / — / 0.30	2.2	0.5 ppm	No

Require color?

COLOR — Okidata ML590

If your CAD jobs primarily use color to clearly label diagrams, the ML590 is a fine overall performer. This mid-priced dot-matrix printer was the fastest in this category in our color tests. Its print quality was inferior to that of the Apple Color Printer and the Canon BJC-800, but these printers cost three to four times more than the ML590. Standard emulations are Epson LQ and IBM Proprinter.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/DRAFT QUALITY/MAC	BYTE QUALITY INDEX	CLASS	ACCEPTS 11×17 PAPER?
BEST	Okidata ML590	● PC	$699	0.5 / 0.93 / —	1.7	120 cps	No
RUNNER-UP	DEC LA95 DECWriter	● PC	$319	0.40 / 0.65 / —	2.2	240 cps	No
RUNNER-UP	Canon BJC-800	■ PC	$1999	0.11 / 0.59 / —	3.2	170 cps	Yes
RUNNER-UP	Star Micronics XB-2425	● PC	$949	0.28 / 0.69 / —	2.2	125 cps	No
RUNNER-UP	Apple Color Printer	■ MAC	$2349	— / — / 0.68	3.1	3.5 mpp	Yes

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BYTE BEST

PORTABLE PRINTERS

Portable printers fill a special need for those who often travel with a notebook computer. The printers may create on-the-fly custom documents, such as personalized insurance tables, revised contracts, proposals, and price schedules. If a deal is at stake, the ability to produce a hard copy for a client puts you ahead of your competitors.

But you will not want to carry a printer if it is cumbersome. The 7- to 8-pound models were too heavy for anything but checked luggage. Since time is money, a portable should produce its output quickly and efficiently, at roughly 1 to 2 minutes per page. And output quality must be impressive enough to help the deal go through.

The final factor to consider is printing method. Dot-matrix printers consistently scored near the bottom of our quality tests and were among the noisiest, largest, and heaviest we tested. The two less well known printing techniques, thermal fusion and thermal transfer, use heat to pass ink to the paper from an ink foil or cartridge. The two thermal-fusion printers (Citizen PN48 Professional and Lexmark IBM Portable) provided slightly improved output quality over dot-matrix but were dead last in speed. The thermal-transfer printer, Mannesmann Tally's MobileWriter, consistently placed in the top three in our speed tests and produced acceptable print quality. Ink-jets outpaced the other technologies in most of our tests.

KEY

▲ Laser ■ Ink-jet

● Dot-matrix

Is print quality important?

BEST OVERALL — Lexmark IBM 4070 IJ

The $499 4070 IJ repeatedly placed among the best in our performance tests. Its quality was second only to the Canon BJ-20. Its design is similar to those of the Canon BJ-20, the Brother HJ-100 i, and the Star Micronics StarJet SJ-48. All were a little larger than a sheet of letter-size paper and roughly 2 inches thick (the 50-sheet feeder adds another 2 inches to the 4070 IJ's thickness). At 4 pounds, it was also among the lightest portables we tested. The 4070 IJ supports Epson LQ 510, IBM Proprinter X24E, IBM Graphics, and Canon BJ-130e emulations. It comes standard with a Centronics parallel port or you can purchase Ethernet and token-ring ports for $695 and $895, respectively.

				PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	SIZE & WEIGHT (INCHES; LBS.) (WITHOUT BATTERY)
BEST	Lexmark IBM 4070 IJ	■	PC	$499	0.71 / —	3.0	83 cps	2.1×12.4×8.7; 4
RUNNER-UP	HP DeskJet Portable	■	PC	$599	1.23 / —	2.3	167 cps	2.5×12×5.7; 4.4
RUNNER-UP	Brother HJ-100 i	■	PC	$499	0.62 / —	2.8	83 cps	8.5×12.25×1.9; 4
RUNNER-UP	Canon BJ-20	■	PC	$349	0.69 / —	3.3	83 cps	8.5×12.2×2; 4.4

On a limited budget?

LOW COST — Eastman Kodak Diconix 701 P

With a $479 list price, the Eastman Kodak Diconix 701 P was the cheapest portable we saw. Performance and quality were only average, but the Diconix 701 P had other features that made it a standout. Its built-in 30-page sheet feeder and svelte 6-pound weight are strong selling points for portability. A straightforward control panel eliminates confusing DIP switches. The printer ships with Courier, Gothic, and Helvetica fonts (it doesn't include a slot for font cartridges), and it accepts legal and A4 size paper, in addition to standard letter-size sheets. For an additional $79, Mac users can purchase an interface kit that lets the Diconix attach to their machines.

				PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	SIZE & WEIGHT (INCHES; LBS.) (WITHOUT BATTERY)
BEST	Eastman Kodak Diconix 701 P	●	PC	$479	0.53 / —	2.0	120 cps	2.4×7.68×1.7; 5.6
RUNNER-UP	Brother HJ-100 i	■	PC	$499	0.62 / —	2.8	83 cps	8.5×12.25×1.9; 4
RUNNER-UP	Lexmark IBM 4070 IJ	■	PC	$499	0.71 / —	3.0	83 cps	2.1×12.4×8.7; 4
RUNNER-UP	HP DeskJet Portable	■	PC	$599	1.23 / —	2.3	167 cps	2.5×12×5.7; 4.4

Do you just want the smallest?

MOST PORTABLE — Citizen PN48 Professional and Lexmark IBM Portable

If size is your main concern, choose the Citizen PN48 or the Lexmark IBM Portable (they're identical in design and operation). They're 2½-pound thermal-fusion printers that stand only 2 inches high and are a mere 3½ inches deep. Thermal-fusion printers pass ink from a cartridge to paper by applying heat. Both of these printers showed slightly better print quality than dot-matrix printers in this group. However, performance was lackluster—a page of text took 1½ minutes to print, and a one-page bit map took 6 to 7 minutes.

			PRICE	BYTE SPEED RATING (PPM) HIGH QUALITY/MAC	BYTE QUALITY INDEX	CLASS	SIZE & WEIGHT (INCHES; LBS.) (WITHOUT BATTERY)
BEST	Citizen PN48 Professional	PC	$549	0.22 / —	1.6	53 cps	2×11.7×3.5; 2
	Lexmark IBM Portable	PC	$549	0.22 / —	1.6	53 cps	2×11.7×3.5; 2

World Radio History

SPLIT DECISION

THE CASE FOR THE ULTIMATE IN TECHNOLOGY:
M X 1 5 F

- 15-INCH MICROPROCESSOR-BASED COLOR MONITOR.
- FLAT SQUARE TECHNOLOGY PICTURE TUBE WITH INVAR SHADOW MASK.
- 0.28MM DOT PITCH.
- 1280 x 1024 NON-INTERLACED RESOLUTION.
- INTELLIGENT MODE SWITCHING.
- DIGITAL CONTROLS.
- LED INDICATORS FOR MODE AND STATUS INFORMATION.
- VERTICAL REFRESH RATE UP TO 76 Hz AT 1024 x 768.

THE CASE FOR THE ULTIMATE IN VALUE:
L X 1 5 6 4

- 15-INCH FLAT SQUARE TECHNOLOGY COLOR PICTURE TUBE WITH INVAR SHADOW MASK.
- 1280 x 1024 RESOLUTION.
- ERGONOMIC ANALOG CONTROLS.
- AUTOMATIC SYNCHRONIZATION AND SIZING.
- VERTICAL REFRESH RATE UP TO 76 Hz AT 1024 x 768.

When it comes to advanced technology there's no debate. The MX15F has it all. From its super-sharp image to an on-board processor, ultrahigh resolution, optimal synchronization and sizing, LED status read outs and more...much more.

Ideally suited for high-level engineering, scientific, graphic and business applications, the MX15F is the computer monitor of choice for serious power users.

It's no wonder the MX15F has won so many awards. These include *PC Magazine* Editors' Choice-1993 and *PC World's* Best Buy in both 1991 and 1992.

Clearly, this is the monitor for those who refuse to compromise. It delivers the very highest performance, quality and technology.

PC MAGAZINE EDITORS' CHOICE 1993

PC WORLD BEST BUY 1991

PC WORLD BEST BUY 1992

MAG INNOVISION, INC.
4392 CORPORATE CENTER DRIVE
LOS ALAMITOS, CA 90720
714/827-3998 FAX: 714/827-5522

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For high performance at an affordable, competitive price, the new LX1564 is the popular choice.

Using the advanced 15-inch flat square picture tube in combination with an economical design, it offers a true melding of high-performance and economy.

And, with features like edge-to-edge overscan and 80 MHz video bandwidth, the LX1564 compares well against competitor's higher priced models.

THE CHOICE IS YOURS

Two great monitors. Two sets of features. Designed to fit the way you work. Designed to fit your budget. The choice is yours – Ultimate Technology or Ultimate Value.

Can't decide? Give us a call at 1-800-827-3998, extension 4304. We'll be glad to help.

MAG INNOVISION

Circle 162 on Inquiry Card (RESELLERS: 163).

World Radio History

DOT-MATRIX •

ROLL CALL OF PRINTERS TESTED

MANUFACTURER	PRINTER MODEL	SPEED (PC/MAC)[1]	QUALITY[2]	PRICE[3]	PHONE	TOLL-FREE NO.	INQUIRY NO.
Advanced Matrix Technology, Inc.	AMT Accel-214	1.15 / —	1.4	$529	(805) 388-5799	(800) 992-2264	1293
Advanced Matrix Technology, In .	AMT Accel-242	.85 / —	1.8	$529	(805) 388-5799	(800) 992-2264	1294
Advanced Matrix Technology, Inc.	AMT Accel-535	0.57 / —	1.6	$1485	(805) 388-5799	(800) 992-2264	1295
Alps America	DMX8	1.23 / —	1.3	$2195	(408) 432-6000	(800) 825-2577	1296
Brother International Corp.	M-1324	0.76 / —	1.6	$399	(908) 356-8880	N/A	1297
Brother International Corp.	M-1824L	0.55 / —	.1	$749	(908) 356-8880	N/A	1298
C-Tech Electronics, Inc.	ProWriter C-610II	0.64 / —	1.3	$799	(714) 833-1165	(800) 347-4017	1299
C-Tech Electronics, Inc.	ProWriter C-310P	0.62 / —	.1	$739	(714) 833-1165	(800) 347-4017	1300
Citizen America Corp.	GSX-230	0.76 / —	1.9	$399	(310) 453-0614	(800) 477-4683	1301
Citizen America Corp.	GSX-240	0.91 / —	2.1	$599	(310) 453-0614	(800) 477-4683	1302
Dataproducts Corp.	9044	0.43 / —	1.6	$1132	(818) 887-8000	(800) 334-3174	1303
DataSouth Computer	XL300DD	.92 / —	1.1	$1795	(704) 523-8500	(800) 476-2120	130
Decision Data	6520-41	1.40 / —	1.4	$460	(215) 956-6700	(800) 933-9897	1305
Digital Equipment Corp.	LA95 DECWriter	.95 / —	.1	$319	(508) 493-5111	(800) 344-4825	1306
Digital Equipment Corp.	LA75 Plus	0.47 / —	1.4	$549	(508) 493-5111	(800) 344-4825	1307
Digital Equipment Corp.	LA310 MultiP nter	1.09 /	1.	$599	(508) 493-5111	(800) 344-4825	1308
Digital Equipment Corp.	LA424 MultiPrinter	0.56/ —	1.4	$1349	(508) 493-5111	(800) 344-4825	1309
Epson America, Inc.	Action Printer 3250	0.34 /	.9	$269	(310) 782-0770	(800) 922-8911	1310
Epson America, Inc.	FX-1170	0.78 / —	1.3	$499	(310) 782-0770	(800) 922-8911	1311
Epson America Inc.	LQ 870	0.79 / —	1.9	$629	(310) 782-0770	(800) 922-8911	1312
Fujitsu Computer Products of America, Inc.	DL1200	0.61 / —	1.5	$649	(408) 432-6333	(800) 626-4686	1313
Fujitsu Computer Products of America, Inc.	DL5800	1.68 / —	1.6	$1995	(408) 432-6333	(800) 626-4686	1314
Gcc Technologies, Inc.	WriteImpact	— / 0.38	0.0	$599	(617) 275-5800	(800) 422-7777	1315
Lexmark International, Inc.	IBM PPS II 2380	1.04 / —	1.3	$499	(606) 232-2000	N/A	131
Lexmark International, Inc.	IBM PPS II 2390	0.44 / —	1.9	$499	(606) 232-2000	N/A	1317
Lexmark International, Inc.	IBM 4226	.98 / —	1.4	$2295	(606) 232-2000	N/A	1318
Mannesmann Tally Corp.	MT 150/9C	0.92 / —	1.1	$799	(206) 251-5524	(800) 843-1347	1319
Mannesmann Tally Corp.[4]	MT 150/24/C	— / —	—	$999	(206) 251-5524	(800) 843-1347	132
★ Mannesmann Tally Corp.	MT 360	2.35 / —	1.6	$2695	(206) 251-5524	(800) 843-1347	1321
NEC Technologies, Inc.	Pinwriter P6200	.74 /	2.1	$499	(508) 264-800	N/A	1322
Okidata	ML380	0.44 / —	1.3	$349	(609) 235-2600	(800) 654-3282	1323
Okidata	ML395/C	0.88 / —	1.8	$1599	(609) 235-2600	(800) 654-3282	1326
Okidata	ML521	0.84 / —	1.1	$799	(609) 235-2600	(800) 654-3282	1325
Okidata	ML590	1.65 / —	1.6	$699	(609) 235-2600	(800) 654-3282	1324
Okidata	PM 3410	1.89 / —	1.2	$1999	(609) 235-2600	(800) 654-3282	1327
Panasonic Communications & Systems Co.	KX-P212	.62 / —	1.9	$419.95	(201) 348-700	(800) 742-8086	132
Panasonic Communications & Systems Co.	KX-P2124	0.74 / —	1.9	$599.95	(201) 348-7000	(800) 742-8086	1330
Panasonic Communications & Systems Co.	KX-P218	0.62 / —	1.1	$299.95	(201) 348-7000	(800) 742-8086	1328
Panasonic Communications & Systems Co.	KX-P2624	0.95 / —	1.6	$649.95	(201) 348-7000	(800) 742-8086	1331
Seikosha America, Inc.	SL-90 Plus	0.94 / —	1.4	$499	(201) 327-7227	(800) 338-2609	1333
Seikosha America, Inc.	SL-270	1.09 / —	0.9	$999	(201) 327-7227	(800) 338-2609	1334
Seikosha America, Inc.	SP2400	.57 / —	1.3	$329	(201) 327-7227	(800) 338-2609	133
Star Micronics America, Inc.	NX-2430 Multi-Font	0.72 / —	1.3	$399	(212) 986-6770	(800) 447-4700	1335
Star Micronics America, Inc.	XB-2425 Multi-Font	1.00 / —	2.1	$949	(212) 986-6770	(800) 447-4700	1336
Tandy Corp.	DMP 204	0.58 / —	1.4	$349.95	(817) 390-3011	N/A	1337
Tandy Corp.	DMP 302	0.59 / —	1.6	$499.95	(817) 390-3011	N/A	1338

INK-JET ■

Apple Computer, Inc.	StyleWriter II	— / 0.57	2.0	$359	(408) 974-2042	N/A	1339
Apple Computer, Inc.	Color Printer	— / 0.69	2.8	$2349	(408) 974-2042	N/A	1340
Canon Computer Systems, Inc.	BJ-200	.34 / —	.	$449	(714) 438-3000	(800) 848-4123	1341
Canon Computer Systems, Inc.	BJC-800	0.54 / —	2.8	$1999	(714) 438-3000	(800) 848-4123	1342
Dataproducts Corp.	Jolt PS	0.51 / 0.69	3.3	$6695	(818) 887-8000	(800) 334-3174	1343
Digital Equipment Corp.	DECMultiJet 2000	1.05 / —	1.4	$499	(508) 493-5111	(800) 344-4825	1344
Epson America, Inc.	Stylus 800	1.13 /	2.3	$499	(310) 782-0770	(800) 922-8911	1345
Gcc Technologies, Inc.	WideWriter 360	— / 1.07	2.4	$1699	(617) 275-5800	(800) 422-7777	1346
Hewlett-Packard Co.	DeskJet 500	1.30 / —	1.6	$599	(619) 592-4676	(800) 752-0900	1347
Hewlett-Packard Co.	DeskJet 550C	0.88 / —	1.8	$1099	(619) 592-4676	(800) 752-0900	1348
Hewlett-Packard Co.	PaintJet XL300	0.27 / 0.17	2.7	$3495	(619) 592-4676	(800) 752-0900	134
Lexmark International, Inc.	IBM ExecJet 4072	1.40 / —	2.1	$1099	(606) 232-2000	N/A	1350
Lexmark International, Inc.	IBM JetPrinter	.41 / 0.29	3.	$3495	(606) 232-2000	N/A	1351
Pacific Data Products	ProTracer	0.66 / 0.50	2.3	$1499	(619) 552-0880	N/A	1352
Royal Consumer Business Products	CJP 450	0.87 / —	1.2	$499	(908) 526-8200	(800) 527-2960	1353
Smith Corona Corp.	Coronajet 200j	0.93 / —	1.4	$499	(203) 472-1471	N/A	1354
Tektronix, Inc.	Phaser III PXi	0.26 / 0.40	3.2	$9995	(503) 682-7377	(800) 835-6100	1356

★ BYTE BEST [1] Average of high- and draft-quality speeds (ppm) with no application weighting. [2] B&W score. [3] As tested. [4] Drivers not available in time for testing.

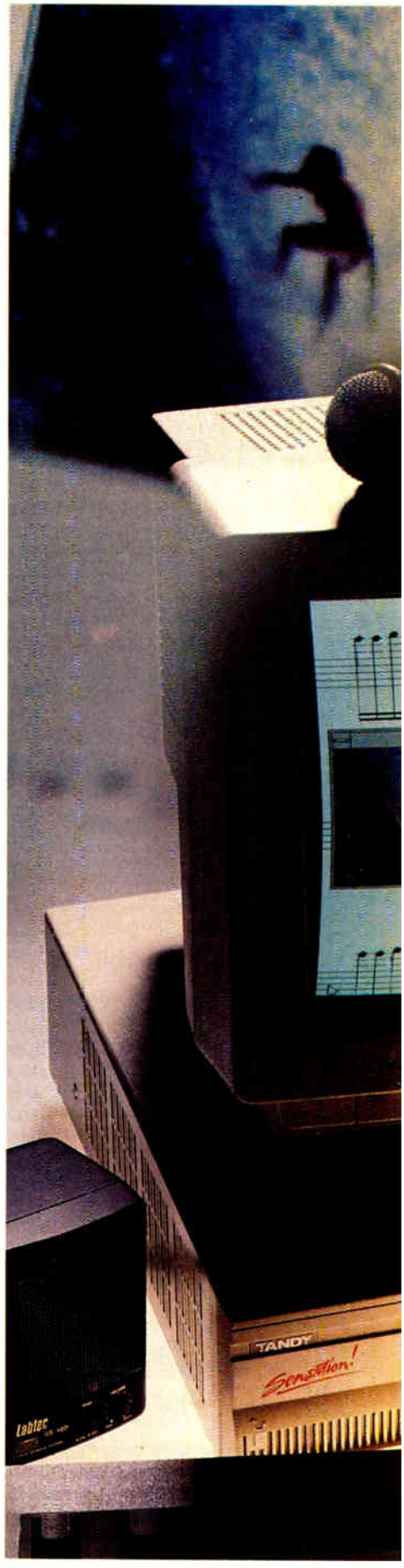
World Radio History

MANUFACTURER	PRINTER MODEL	SPEED (PC/MAC)[1]	QUALITY[2]	PRICE[3]	PHONE	TOLL-FREE NO.	INQUIRY NO.
Apple Computer, Inc.	LaserWriter NT[5]	— / 0.59	3.0	$1649	(408) 974-2042	N/A	1357
Apple Computer, Inc.	LaserWriter NTR	— / 1.17	3.1	$1649	(408) 974-2042	N/A	1358
Apple Computer, Inc.	LaserWriter IIf	— / 2.03	2.8	$1869	(408) 974-2042	N/A	1359
Apple Computer, Inc.	LaserWriter II	— / 2.23	3.0	$2309	(408) 974-2042	N/A	360
Apple Computer, Inc.	LaserWriter Pro 630	1.19 / 2.01	4.4	$2529	(408) 974-2042	N/A	1361
Brother International Corp.	HL-10 PS	1.65 / —	2.9	$2714	(908) 356-8880	N/A	362
C-Tech Electronics, Inc.	ProWriter CI-8	1.66 / —	3.5	$3453	(714) 833-1165	(800) 347-4017	1364
C-Tech Electronics, Inc.	ProWriter CI-8E	2.60 / —	2.8	$2170	(714) 833-1165	(800) 347-4017	1363
Canon Computer Systems, Inc.	LBP-4SX	1.91 / —	2.1	$2094	(714) 438-3000	(800) 848-4123	1365
Canon Computer Systems, Inc.	LBP-8SX	1.64 / —	2.0	$2774	(714) 438-3000	800) 848-4123	1366
Compaq Computer Corp.	Pagemarq 15	1.74 / 2.29	4.0	$5196	(713) 370-0670	(800) 345-1518	1367
Dataproducts Corp.	LZR 965	1.33 / 2.15	2.6	$2995	(818) 887-8000	800) 334-3174	1368
Dataproducts Corp.	LZR 1560	1.74 / 1.27	3.8	$3395	(818) 887-8000	(800) 334-3174	1369
Decision Data	6010 SI	1.46 / —	2.3	$3995	(215) 956-6700	(800) 933-9897	1370
Digital Equipment Corp.	DECLaser 1152	0.50 / 0.84	3.0	$1258	(508) 493-5111	(800) 344-4825	1371
Digital Equipment Corp.	DECLaser 2200 Plus	0.40 / —	2.9	$4027	(508) 493-5111	(800) 344-4825	1372
★ Epson America, Inc.	ActionLaser 1000	3.21 / —	2.8	$1125	(310) 782-0770	(800) 922-8911	1375
Epson America, Inc.	EPL-8000	2.15 / —	2.5	$1976	(310) 782-077	(800) 922-8911	1376
Fujitsu Computer Products of America, Inc.	PrintPartner 10W	2.35 / 1.80	3.0	$2768	(408) 432-6333	(800) 626-4686	1377
Genicom Corp.	Model 7170	1.34 / —	3.	$5960	(703) 802-9200	(800) 443-6426	1378
Hewlett-Packard Co.	LaserJet IIIP	1.06 / 0.72	3.4	$2814	(619) 592-4676	(800) 752-0900	1379
★ Hewlett-Packard Co.	LaserJet 4M	1.64 / 1.59	4.1	$2999	(619) 592-4676	(800) 752-0900	1380
★ Hewlett-Packard Co.	LaserJet 4Si MX	3.31 / 3.89	4.3	$5499	(619) 592-4676	(800) 752-0900	1381
Kyocera Electronics, Inc.	FS-1500A	2.01 / —	2.6	$3402	(908) 560-3400	(800) 621-6777	1382
★ LaserMaster Corp.	Unity 1200XL	2.01 / 1.26	4.9	$9995	(612) 944-9330	(800) 950-6868	1383
Lexmark International, Inc.	IBM LaserPrinter 4029-6P	1.22 —	3.	$2188	(606) 232-2000	N/A	1384
Lexmark International, Inc.	IBM LaserPrinter 4029-10P	1.74 / —	3.9	$2499	(606) 232-2000	N/A	1385
Mannesmann Tally Corp.	MT908	1.68 / —	3.3	$3074	(206) 251-5524	(800) 843-1347	138
NEC Technologies, Inc.	Silentwriter Model 95	1.20 / 0.84	3.6	$1949	(508) 264-8000	N/A	1387
NewGen System Corp.	Turbo PS/440ND	.45 / —	3.	$6495	714) 641-8600	(800) 756-0556	138
Okidata	OL 810	3.58 / —	2.6	$3536	(609) 235-2600	(800) 654-3282	1389
Panasonic Communications & Systems Co.	KX-P4430	.41 / —	2.6	$1770	(201) 348-7000	(800) 742-8086	1390
Panasonic Communications & Systems Co.	KX-P4455	0.78 / 0.77	2.9	$3270	(201) 348-7000	(800) 742-8086	1391
QMS, Inc.	QMS-PS 410	0.97 / 0.94	2.9	$2490	205) 633-4300	(800) 631-2692	139
QMS, Inc.	QMS-PS 815MR	1.77 / 1.4	3.6	$3995	(205) 633-4300	(800) 631-2692	1393
★ QMS, Inc.	QMS 860 Print System	1.45 / 1.80	4	$4595	(205) 633-4300	(800) 631-2692	1394
QMS, Inc.	QMS 1725 Print System	2.58 / 2.58	4.0	$5995	(205) 633-4300	(800) 631-2692	1395
Samsung Electronics America, Inc.	Finale 8000	.94 / 1.51	2.1	$2260	201) 229-4000	(800) 446-0262	396
Sharp Electronics Corp.	JX-9600	— / —	2.5	$1395	(201) 529-9593	(800) 237-4277	1373
Sharp Electronics Corp.	JX-9600PS	.59 / 1.00	2.5	$197	(201) 529-9593	(800) 237-4277	1374
Star Micronics America, Inc.	LS-5TT	1.37 / 0.61	3.0	$1804	(212) 986-6770	(800) 447-4700	1397
Tandy Corp.	LP800	1.66 / —	3.1	$2499	(817) 390-3011	N/A	1398
Texas Instruments, Inc.	MicroLaser PS35	1.08 / 0.83	2.9	$1766	(817) 774-6001	(800) 527-3500	1399
Texas Instruments, Inc.	MicroLaser PS35 Turbo	1.71 / 2.12	3.0	$2148	(817) 774-6001	(800) 527-3500	1400
Texas Instruments, Inc.	MicroLaser XL	1.26 / 0.83	2.8	$4086	(817) 774-6001	(800) 527-3500	1401
Texas Instruments, Inc.	MicroLaser XL Turbo	1.85 / 2.12	3.0	$444	817) 774-6001	(800) 527-3500	140
Toshiba America Information Systems	PageLaser GX200	1.52 / —	3.9	$3096	(714) 583-3000	(800) 468-6744	1403
Toshiba America Information Systems	PageLaser GX400	1.75 / —	3.1	596	(714) 583-3000	(800) 468-6744	1404
Xante Corp.	Accel-a-Writer 4000	1.50 / 1.09	4.3	$1795	(205) 476-8189	(800) 926-8839	1405
Xante Corp.	Accel-a-Writer 8000	2.17 / 1.39	4.0	$2295	(205) 476-8189	(800) 926-8839	1406
Xerox Corp.	4213	1.07 / —	2.8	$4795	(310) 333-2202	N/A	1407
XLI[4]	Image Xpert 5000	— / —	5.0[5]	$6995	(617) 932-9199	(800) 433-8040	1408
Axonix Corp.	Milwrite L	0.82 / —	0.8	$139	(801) 466-9797	(800) 866-9797	1409
Brother International Corp.	HJ-100 i	0.65 / —	2.8	$499	(908) 356-8880	N/A	1410
Canon Computer Systems, I	BJ-20[5]	0.79 / —	3.1	$349	714) 438-3000	(800) 848-4123	1411
Citizen America Corp.	PN48 Professional	0.33 / —	1.7	$549	(310) 453-0614	(800) 477-4683	1412
Eastman Kodak	Kodak Diconix 701 P	0.71 / —	2.1	$479	(716) 253-0740	(800) 344-0006	141
Hewlett-Packard Co.	DeskJet Portable	1.32 / —	2.3	$599	(619) 592-4676	(800) 752-0900	1414
★ Lexmark International, Inc.	IBM 4070 IJ	0.77 / —	3.0	$499	(606) 232-2000	N/A	415
Lexmark International, Inc.	IBM Portable	0.34 / —	1.6	$549	(606) 232-2000	N/A	1416
Mannesmann Tally Corp.	MobileWriter	1.08 / —	2.7	$875	(206) 251-5524	(800) 843-1347	1417
Seikosha America, Inc.	LT20	0.47 / —	1.4	$499	(201) 327-7227	(800) 338-2609	1418
Star Micronics America, Inc.	StarJet SJ-48	0.55 / —	2.8	$499	(212) 986-6770	(800) 447-4700	1419

[5] Discontinued. [6] Preliminary results. N/A=Not available.

World Radio History

MAKING THE MPC UPGRADE



PHOTOGRAPHY: PAUL AVIS © 1993

10 top kits and complete systems for bringing multimedia to the PC

GREG LOVERIA

When it comes to delivering information, the PC is no longer saddled to a static blend of text and graphics. Sound, dazzling animation, and CD-ROM delivery are becoming essential elements in educational and entertainment software, and these elements are also quickly blending into traditional business applications. Companies realize that an entertaining presentation and powerful visual cues cannot only persuade and influence but can also enhance the retention of information. And, with the introduction of Microsoft's Video for Windows, motion video promises to further ornament the once-drab face of PC information delivery. The promise of exciting mixed-media applications relies on some basic hardware and software components, packaged together as an MPC system.

The MPC Marketing Council's definition of an MPC system includes five basic components: a PC, a CD-ROM drive, an audio adapter, Microsoft Windows with Multimedia Extensions, and a set of speakers or headphones for audio output. In addition, video capture and playback technologies, along with codec advances, are being incorporated into MPC systems as standard fare. A good MPC system blends all these technologies into an interactive educational and business tool. If you're still plugging along with an outdated, non-MPC system, it's time to consider either renovating your current system with an MPC upgrade kit or investing in a totally new MPC system. This month, BYTE examines some of the best MPC options available.

The MPC Component Mix

Several factors determine how well an MPC system's hardware components are suited for any particular MPC task. Perhaps the most critical element of an MPC system is the CD-ROM drive speed. The MPC Marketing Council's current specifications for CD-ROM drives require an average sustained data transfer rate of 150 KBps. A CD-ROM drive must also have a stereo headphone or output jack for playback of stereo CD audio (Redbook Audio) at a sampling rate of 44.1 kHz and at 16-bit resolution. These specifications may not be crucial for some MPC applications, such as simple text search-and-retrieval software, but there are mixed-

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BYTE ACTION SUMMARY

- **WHAT MPC SYSTEMS AND UPGRADE KITS ARE**
  Hardware and software components—including a sound board and a CD-ROM drive—that bring multimedia capabilities to the PC platform.
- **LIKES**
  MPC can add dazzle and depth to almost any educational or business application.
- **DISLIKES**
  The MPC specification doesn't include provisions for video playback, and the base MPC systems need larger hard drives or data compression to use massive audio and video files.
- **RECOMMENDATIONS**
  Tandy's Sensation is a strong offering with a good overall mix of features and included titles. For video-based training and educational applications, you should go with the NCR 3331 MLS. Creative Labs' Multimedia Upgrade Kit, with the new Sound Blaster 16 ASP audio card option, is the top upgrade choice.

media applications that can bog down slower drives.

For objective testing of each CD-ROM drive, Greg Smith of Profit Press (2956 North Campbell Ave., Tuscon, AZ 85719, (602) 577-9696) provided a custom benchmark, CD Bench 2, which tests CD-ROM read and seek times. You can find the stock CD Bench utility on the company's Mega-Demo CD. All stroke, read, and seek times bypass any CD-ROM caching and are unaffected by system processor speeds. System performance affects the overall index, which rates performance of the drives in each system configuration tested. These tests were not designed to be compared against manufacturer ratings but are offered as a direct drive-against-drive comparison. A key feature for CD-ROM drives is compatibility with Kodak's Photo CD format.

The MPC upgrade kits and systems were gauged subjectively by price-versus-performance comparisons, audio quality, the number and quality of MPC software titles shipped with each unit, ease of installation, and how well each ran a mix of multimedia and CD-ROM-based applications. The complete systems were also evaluated on overall system performance. For an overview of the features available with each bundle, refer to tables 1 and 2.

continued

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Table 1: *These multimedia systems cover a wide range of configurations, options, and prices. (N/A = not applicable.)*

	CompuAdd 433DX	Dell 433s/L	IBM Ultimedia M77
Price as tested (with monitor and accessories)	$4060	$3019	$9720
Base price (without monitor and accessories)	$2165	Sold only as a bundle	$5295
Options	TV/Video adapter, $525 MPC upgrade kit, $575 AM/FM tuner with remote, $200 Test monitor, $150	N/A	ActionMedia II playback, $1695 ActionMedia II capture, $750 DVI developer's toolkit, $510 Test monitor, $1470
System features			
CPU	486DX/33	486SX/33	486DX2/66
RAM as tested/maximum (MB)	8/64	8/64	8/32
BIOS manufacturer	Phoenix/CompuAdd	Phoenix	IBM
Cache memory (external/on-chip)	64 KB/8 KB	128 KB/8 KB	0 KB/8 KB
Number of slots/bus architecture	8/ISA	3/ISA	5/MCA
Power-supply capacity (W)	200	150	118
Maximum half-height drive bays (ext./int.)	3/3	2/1	3/1; 4 ext. via SCSI
Floppy drive(s) size	3½-inch, 5¼-inch	3½-inch, 5¼-inch	3½-inch
Internal fax modem	No	Yes	No
Analog-to-digital tuner	Yes (uses $525 PC/TV option)	No	Yes (uses DVI w/external tuner)
Hard drive			
Capacity as tested (MB)	170	230	212
Manufacturer and model	WD Caviar 2170A	Quantum 240 AT	Not published
Vendor speed rating (ms)	15	16	12
Type (IDE/SCSI)	IDE	IDE	SCSI
Monitor			
Vertical inches/model	14/Hi-Resolution 51118	15/UltraScan 15FS	17/Model 9517-001
Maximum resolution	1024x768	1024x768	1024x768
Dot-pitch ratio (mm)	0.28	0.28	0.26
Vertical-scanning frequency	50–90 Hz	50–90 Hz	Not published
Horizontal-scanning frequency	30–58 kHz	30–60 kHz	39.5–58 kHz
Maximum bandwidth frequency	75 MHz	80 MHz	75 MHz (VGA), 72 MHz (XGA)
Range of modes	MCGA through Super VGA	CGA through Super VGA	MCGA, Super VGA, XGA
Display adapter			
Manufacturer	Western Digital	Dell	IBM
Maximum resolution (color support)	1024x768 noninterlaced (8-bit)	1280x1024 interlaced (4-bit)	1024x768 noninterlaced (8-bit)
Maximum color support (resolution)	16-bit (640x480)	8-bit (1024x768)	16-bit (640x480)
Accelerator chip	WD 90C31	S3 86C805 (on motherboard)	XGA coprocessor
On-board memory	1-MB VRAM	1-MB VRAM	1-MB VRAM
Maximum memory	1-MB VRAM	1-MB VRAM	1-MB VRAM
VBE-/VXE-compliant	Yes	Yes (uses TSR)	VXE 1.0–compliant (uses TSR)
VGA chip set	Paradise	S3/Dell	XGA
Normal modes	CGA through Super VGA	CGA through Super VGA	CGA, Super VGA, XGA
CD-ROM			
Manufacturer/model	Philips LMS CM-205	Panasonic 521C	Toshiba 3301
Interface card/type	SCSI/audio card	SCSI/audio card	SCSI on motherboard
Requires CD caddy	No	Yes	Yes
Kodak Photo CD/XA–compatible	No	No	Yes
Vendor throughput rating	153.6 KBps	150 KBps	150 KBps
Audio board			
Model	Pro Audio Spectrum 16	Sound Blaster Pro 16	M-ACPA
Maximum playback/record resolution	44.1 kHz/16-bit	44.1 kHz/16-bit	88.2 kHz/32-bit
Stereo	Yes	Yes	Yes
On-board synthesizer	Yes	Yes	Yes
Synthesizer chip	Yamaha YMF262 (OPL3)	Yamaha YMF262 (OPL3)	Texas Instruments MS-320C25
Synthesis technology	16-bit FM DAC	16-bit FM DAC	DSP-digital subtractive
Number of voices (in stereo)	20	20	8
MIDI port/cable	Optional	Optional	No external MIDI port
On-board SCSI	Yes	Yes	No
Direct CD–to–hard disk record	Yes	Yes	No
Microphone included	No (add $45 w/speakers)	Yes	Yes
Headphones included	No	No	No
External speakers included	No (add $45 w/microphone)	Yes	Altec (add $300; $400 w/subwoofer)
Internal speaker size	PC speaker	PC speaker	4-inch
External system volume controls	No	No	Yes (front panel)

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NCR 3331 MLS	Packard Bell PB-402	Tandy Sensation
$4394	$2500	$2498
$3805	$2200 (includes speakers)	$1999
Test monitor, $589	PB-TV3, $399	Test monitor, $499
DVI capture board, $639		PC/TV card, $400
DVI playback board (standard)		1-MB VRAM upgrade, $39.95
486DX/33	486SX/25	486SX/25
8/32	8/20	4/32
NCR	Phoenix/Packard Bell	Phoenix/Tandy
256 KB/0 KB	256 KB/8 KB	0 KB/8 KB
4/ISA	4/ISA	3/ISA
175	150	100
3/1	2/1	2/1
3½-inch	3½-inch, 5¼-inch	3½-inch
No	Yes	Yes
Yes (uses DVI w/external tuner)	Yes (uses $399 PC/TV option)	Yes (uses $400 PC/TV option)
240	170	107
Conner LPS-240	Conner CP30-174E	Seagate ST-3120A
17	17	15
IDE	IDE	IDE
15/Model 0271	14/Model PB8548	14/VGM-441
1024×768	1024×768	1024×768
0.28	0.28	0.28
55–110 Hz	50–90 Hz	43.3–70 Hz
30–57 kHz	31.5–48 kHz	31.5–41.5 kHz
75 MHz	65 MHz	44.9 MHz
EGA, VGA, Super VGA, XGA	CGA through Super VGA	CGA through Super VGA
NCR	Oak Technology	Western Digital
1024×768 noninterlaced (8-bit)	1024×768 (8-bit)	1024×768 (8-bit)
8-bit (1024×768)	16-bit (1024×768)	24-bit (640×480)
NCR 77C22E (on motherboard)	Oak chip set (on motherboard)	WD 90C31 (on motherboard)
1-MB VRAM	1-MB VRAM	0.5-MB VRAM
1-MB VRAM	1-MB VRAM	1-MB VRAM option ($39.95)
Yes	Yes (uses TSR)	Yes (uses TSR)
NCR	Oak Technology	Tandy/Western Digital
VGA through Super VGA	CGA through Super VGA	CGA through Super VGA
Toshiba XM-3301	Panasonic CR-521B	Philips LMS CM-205
SCSI/audio card	SCSI/audio card	LMS chip set on daughterboard
Yes	Yes	No
No	No	No
150 KBps	150 KBps	150 KBps
Pro Audio Spectrum 16	Sound Blaster Pro 16	Tandy Enhanced Audio adapter
44.1 kHz/16-bit	44.1 kHz/16-bit	44.1 kHz/16-bit
Yes	Yes	Yes
Yes	Yes	Yes
Yamaha YMF262 (OPL3)	Yamaha YMF262 (OPL3)	Yamaha YMF262 (OPL3)
16-bit FM DAC	16-bit FM DAC	12-bit FM DAC
20	20	20
Optional	Optional	Optional
Yes	Yes	No
Yes	Yes	Yes
No	No	No
Yes (NCR)	No	No
No	Yes (Roland)	No
3-inch	Uses external Roland CS-10 unit	4-inch
Yes (front panel)	Yes (Roland)	Yes (front panel)

MPC Upgrade Kits

Sound Blaster Multimedia Upgrade Kit

Creative Labs, one of the pioneers of PC audio (the MPC sound standard was developed using Sound Blaster specifications), offers a number of MPC upgrade kits. The Sound Blaster Multimedia Upgrade Kit tested comes in two flavors: the external ($899) and the internal ($799) CD-ROM versions. As with most of the system and upgrade kits listed in tables 1 and 2, street prices are considerably lower.

The upgrade kit consisted of a 16-bit Sound Blaster Pro audio card, an external Creative Labs/Panasonic 531 CD-ROM drive, an 8-bit proprietary SCSI card, and Creative Labs' Sequencer Plus Pro (which includes MIDI cabling and Voyetra sequencer software for controlling external keyboard synthesizers and other MIDI instruments). The Sound Blaster bundle includes a rich set of CD-ROM titles and software, as shown in table 3.

The Sound Blaster CD-ROM proved to be one of the swiftest in the group, although it is slower than Media Vision's CD-ROM offering (see the figure). The kit tested does not ship with external speakers, so I used Sony's SRS-58 minispeakers to test digitized audio, CD audio, and FM synthesizer playback quality of the board—all of which sounded good. Creative Labs' $249 WaveBlaster, an add-on synthesizer module, uses sampled Emu sounds, which are excellent.

Late in the review process, Creative Labs shipped me the new $349 Sound Blaster 16 ASP audio board for examination with the test Multimedia Upgrade Kit. (I merely swapped audio boards and installed the new Sound Blaster 16 ASP drivers.) The Sound Blaster 16 ASP audio adapter uses two new Creative Labs proprietary processors, a DSP (digital signal processor) chip and an ASP (advanced signal processor) chip, to reduce CPU overhead when playing or recording digitized audio. The DSP, acting as a sound-command-processor "traffic cop," controls audio interpretation, processing, and dispatch commands, while the ASP is responsible for processing all digital-audio data. The two chips speed compression and decompression of audio files.

The dynamic range of the Sound Blaster 16 ASP is 90 decibels (96 dB is out of the range of human hearing), and its signal-to-noise ratio is a quiet 85 dB, allowing the board to produce quieter, cleaner, and crisper audio, approaching DAT (digital audiotape) or CD quality. *continued*

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MPC UPGRADE KITS

Table 2: *The basic components of an MPC upgrade kit include an audio board and a CD-ROM drive. For a listing of bundled software and CD-ROM titles, see table 3.*

	Creative Labs Sound Blaster Multimedia Upgrade Kit	Media Vision Pro 16 Multimedia System	Procom Technology PxCDS	Sony Desktop Library
Price	$799 (int.); $899 (ext.)	$1195	$465 (int.); $515 (ext.)	$849.95 (int.); $1069.95 (ext.)
Audio board	Sound Blaster Pro 16	Pro Audio Spectrum 16	Pro Audio Spectrum 16	Pro Audio Spectrum 16
CD-ROM drive	Panasonic 531	NEC-84J	Sony CDU-7305	Sony CDU-7305
External speakers	No	No	Yes	Yes
MIDI	Yes	Yes	Yes	Yes
Kodak Photo CD	No	Yes	Yes	Yes

The Sound Blaster 16 ASP audio board is a truly unique advancement in digital-audio boards. Creative Labs plans to bundle the Sound Blaster 16 ASP board with its other multimedia upgrade kits at prices close to that of the current kit. The Creative Labs' Multimedia Upgrade Kit I tested is a very good value; the pending release of a new MPC kit, coupled with the $349 Sound Blaster 16 ASP option, gets my nod as the overall best MPC upgrade currently available.

Pro 16 Multimedia System

Media Vision, one of the leading manufacturers of MPC audio boards, offers a number of MPC upgrade kits. The Pro 16 Multimedia System upgrade kit ($1195) ships with an internal NEC-84J CD-ROM drive (Media Vision does not offer an external CD-ROM Pro 16 Multimedia System MPC upgrade), Media Vision's Pro Audio Spectrum 16 sound card, and a large array of DOS and Windows audio applications.

All Media Vision's Pro Audio Spectrum 16 and Spectrum 16 sound cards use an on-board Yamaha YMF262 chip for FM music synthesis generation and playback of MIDI files. Midisoft's Recording Session for Windows, featuring MIDI sequencing and real-time music notation and transcription, also ships with the kit.

Hardware and audio-software driver installation takes about 30 minutes, mainly due to internal CD-ROM-drive bay preparation and cabling. The Pro 16 Multimedia System does not ship with external speakers. You will need to attach headphones or an amplified set of mini-speakers to the audio board's rear ⅛-inch stereo mini-plug before hardware configuration and software-driver installation can begin.

Using Media Vision's Pocket Mixer, Pocket Recorder, and Pocket CD Windows applications, you can play audio CDs or record audio .WAV files. The digital-audio quality of Media Vision's audio products has always been good but not perfect. Even if you record at the highest sampling rate and bit depth, you can still hear some background noise during quiet passages of music.

The NEC-84J CD-ROM drive is Kodak Photo CD–compatible. It consistently outperformed all the other drives. FM MIDI synthesizer operations and the audio playback functions of the Pro 16 Multimedia System performed admirably as well.

Alternative Media Vision MPC upgrade kits include the $1495 CDPC XL system, which contains a dual-speed SCSI CD-ROM drive, a Pro Audio Spectrum 16 sound board, and a 100-watt amplifier/speaker bass-subsystem combination. For the budget-conscious, the company's $699 Fusion CD 16 MPC upgrade kit includes an internal or external CD-ROM drive, a Pro Audio Spectrum 16 board, and external Labtec self-amplified mini-speakers.

Photo 1: *All the MPC upgrade kits include a sound board, a CD-ROM drive, and software drivers. Most of the kits, such as Creative Labs' Sound Blaster Multimedia Upgrade Kit (left), also bundle a set of CD-ROM titles; other packages, such as Procom Technology's PxCDS (right), include external speakers.*

PxCDS Multimedia CD Station

Procom Technology manufactures a variety of MPC-compatible upgrade kits using Sony CD-ROM drives. The PxCDS Multimedia CD Station I tested retails for $515. It incorporates Procom's external PxCDS caddyless CD-ROM drive, a Media Vision Pro Audio Spectrum 16 audio adapter, and two 7-W Labtec SS-100 self-amplified 3-inch stereo speakers (see photo 1). Procom's PiCDS Multimedia CD Station ($465) contains the above components and an internal CD-ROM drive. CD-ROM drive specifications for both kits are rated at 490-millisecond access speeds and are Kodak Photo CD–compatible. Other than the Pro Audio Spectrum 16 sound card's utilities, the only additional software that ships with the kit is an audio CD music sampler.

Installation of the PxCDS external unit I tested was straightforward but unique. The sound card occupies a single 16-bit slot, while a 34-pin ribbon cable connects the audio card to a Sony proprietary 37-pin output connector located on an expansion plate. As with an internally mounted floppy or CD-ROM drive, the PxCDS external CD-ROM drive uses internal power connections. The extra three pins on the output connector pass current to the CD-ROM drive using a supplied splitter cable, sharing parallel current with an existing floppy drive.

Although the benchmark tests of the PxCDS showed its performance speed to be medium to

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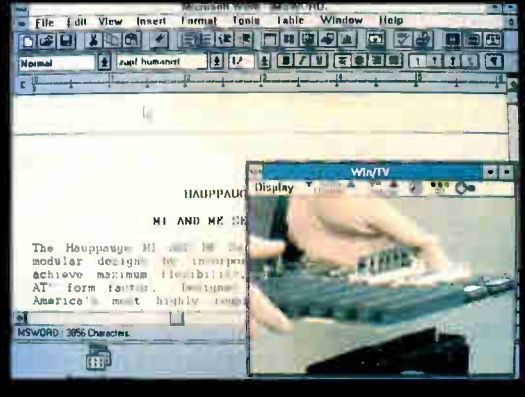

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slow, the drive worked flawlessly. I successfully imported and manipulated large graphics images directly from Kodak Photo CDs.

Procom also offers Multimedia CD Station II upgrade kits, sporting CD-ROM speed ratings of 200 ms. The price for the kit with an external CD-ROM drive is $755; it costs $685 with an internal drive. Judging from the PxCDS Multimedia CD Station's fine documentation and its price/performance levels, I'd rate Procom's products a very good value.

Desktop Library

Sony's Desktop Library ships with a Media Vision Pro Audio Spectrum 16 sound board, Sony's wonderful little SRS-58 self-amplified mini-speakers, a caddyless Sony CDU-7305 CD-ROM drive, and a seven-title CD-ROM software set. Sony's library comes in two internal or external CD-ROM drive flavors, which cost $850 and $1070, respectively. While Sony's CD-ROM/audio-board combination is 100 percent MPC Windows–compatible (it comes with all Media Vision's Windows audio applets), the CD-ROM software titles Sony bundles with the package revolve around DOS or the GeoWorks GUI.

Hardware installation is relatively easy. It takes about 10 minutes to plug the Pro Audio Spectrum 16 adapter into an empty 16-bit slot and connect internal audio input pass-through and proprietary SCSI cables from the sound card to an external drive adapter that mounts in a case-expansion-plate opening.

You'll spend about 20 minutes installing the audio-board configuration software and the complete GeoWorks GUI, and you'll need 12 MB of free hard disk space. If you choose not to install GeoWorks, you can run the Desktop Library's CD-ROM software from DOS or in Windows in a DOS shell. In Windows, the CD-ROM MPC applications worked well. Sony's CDU-7305 CD-ROM drive is Kodak Photo CD/XA–compatible, and I experienced no problems loading Kodak Photo CD images within Windows or with the supplied Tempra Access software from within GeoWorks.

Benchmark tests showed the Sony CD-ROM drive to be relatively slow compared to the other drives tested. Although rated at only 5 W, Sony's miniature SRS-58 speakers had superb clarity with some surprisingly great bass response. Judging by the performance observed and the unique titles bundled with the system, I would rate Sony's Desktop Library MPC upgrade kit a good buy.

MPC Systems

CompuAdd 433DX

CompuAdd's approach to MPC is to mix and match MPC components as requested by the end user and then assemble them into custom MPC systems. As a base system, CompuAdd's 33-MHz 433DX retails for $2165. It costs an additional $575 to get an MPC-compliant system with an internal caddyless Philips LMS CM-205 CD-ROM drive, a Media Vision Pro Audio Spectrum 16 sound card, and bundled audio software. Other basic components included in the test system were a $200 170-MB hard drive, a $200 8-MB memory upgrade, a $150 14-inch Hi-Resolution 51118 Super VGA monitor, and CompuAdd's $25 two-button serial mouse. This brought CompuAdd's total basic MPC system cost to $3315.

Also installed was CompuAdd's TV/Video adapter. This $525 option converts analog TV signals to a digital video-display window. You can directly connect cable TV or an external antenna to the board's video inputs and use its on-board tuner to select channels via pop-up windows. Since the video is digital, you can shrink and stretch the motion window to any shape or aspect ratio. Later in the test process, I received CompuAdd's $200 AM/FM tuner board, complete with a hand-held infrared remote control.

With these two accessories installed, I used CompuAdd's Rack, a Windows-based utility, to control all MPC functions (see the screen). The total system cost, with the tuner and the TV/Video adapter, is $4060. These extra items came in handy. While writing this review, I was able to watch CNN via the video board (with the TV audio muted) and simultaneously listen to a nice classical station tuned in on the FM receiver. When a particular headline story appeared on-screen, I just used the mouse or the remote control to instantly switch from FM audio to TV audio. I also found that by attaching a remote TV camera to the TV/Video adapter, you could, for example, monitor a sales floor while updating a database, or a broker could keep up with the stock quotes while working on a spreadsheet.

The test unit did not ship with external speakers—CompuAdd sells a $45 microphone/stereo-speaker combination—but with the Sony SRS-58 mini-speakers attached to the Pro Audio Spectrum 16 sound card, the audio quality was quite good with CD audio, MPC applications, and digitized .WAV files.

During my tests, all MPC applications ran smoothly without any glitches at 1024- by 768-pixel resolution and 640- by 480-pixel resolution, although the test monitor was not sharp. The CD-ROM benchmarks placed the 433DX with the Philips LMS CM-205 drive at the bottom of the heap, but on many CD-ROM-based applications, the system displayed excellent performance and perfect synchronization of full-frame animation and audio. I attributed the fast display speeds under Windows to CompuAdd's Paradise accelerated display adapter.

Although CompuAdd does not bundle any CD-ROM titles with its MPC units, the MPC configuration—along with the extra accessories—made working with the system enjoyable. But, with all the bells and whistles, you could invest a sizable chunk of change in a CompuAdd MPC unit. My recommendation? Pick up CompuAdd's catalog and put together the best system to fit your application's needs and budget requirements.

The CompuAdd Rack controls all MPC functions, with the optional TV/Video adapter and AM/FM tuner. (File-to-slide conversion courtesy of Image Center, Roanoke, Virginia.)

Dell 433s/L

Dell Computer's 433s/L, a 33-MHz 486SX system, is priced at $3019 and is sold only as a complete bundle. A 486DX system costs an extra $250. The test system included 8 MB of RAM, a 230-MB Quantum hard drive, an accelerated 1-MB

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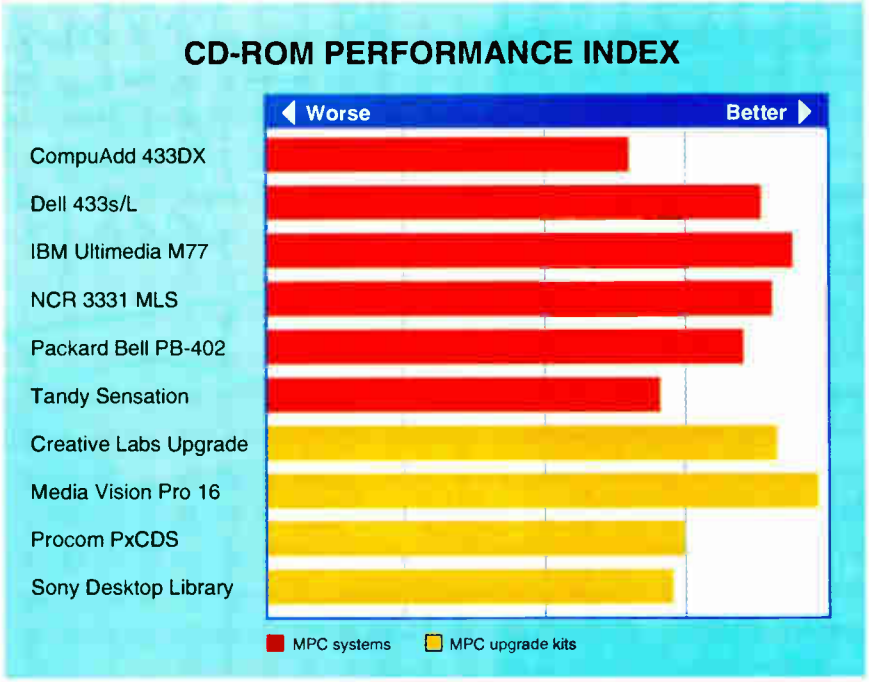
SOFTWARE AND CD-ROM TITLES

Table 3: *MPC systems and upgrade kits are bundled with a wide range of software programs and CD-ROM titles. (N/A = not applicable; ● = yes; ○ = no.)*

	MPC SYSTEMS					
	CompuAdd 433DX	Dell 433s/L	IBM Ultimedia M77	NCR 3331 MLS	Packard Bell PB-402	Tandy Sensation
CD-ROM titles						
Action 2.0	○	●	○	○	●	○
Authorware Star	○	●	○	○	●	○
Compton's MultiMedia Encyclopedia	○	●	○	○	○	○
Creative Sounds Library	○	●	○	○	●	○
Grolier's Multimedia Encyclopedia	○	○	○	○	○	○
Lotus 1-2-3 for Windows	○	○	○	○	○	○
Microsoft Bookshelf	○	●	●	○	●	●
Microsoft Money 2.0	○	○	○	○	○	●
Microsoft MPC Works for Windows	○	●	○	○	●	●
Nautilus Intro Magazine	○	○	●	○	○	○
Prosonus Sound Library	○	●	○	○	●	○
SB Mixer, Wave Studio, Mosaic, Scheduler, and JukeBox	○	●	○	○	●	○
Sherlock Holmes Consulting Detective	○	●	○	○	●	○
Tempra Access for Photo CD	○	○	○	○	○	○
Tempra (full version)	○	●	○	○	●	○
Other	N/A	N/A	Illuminated Books; Ultimedia applications	N/A	N/A	America On-line; WinMate (4 CD applications)
Disk-based software						
Mixer, Pro Mixer, Pocket Mixer/Recorder utilities	●	●	○	●	●	○
Prodigy Trial Subscription Pak	○	○	○	○	●	●
Quicken	○	●	○	○	○	○
Video for Windows	○	○	○	●	○	○
Other	MPC Rack	Micrografx Draw	N/A	NCR/DVI; System Tutorial	hDC Windows Express; WinFax Lite	N/A



CD-ROM drive speeds are a key factor in the overall performance of an MPC system. Media Vision's Pro 16 Multimedia System MPC upgrade kit consistently proved to have the fastest overall CD-ROM drive with the NEC-84J. All MPC upgrade kit tests were performed using an MIS 486/66 system. Performance ratings between MPC systems and upgrade kits should not be compared head-to-head.

VRAM (video RAM) display controller capable of 8-bit color at 1024- by 768-pixel resolution, a 15-inch UltraScan monitor, Creative Labs' Sound Blaster Pro audio card with external Labtec CS-550 self-powered speakers and microphone, and a Panasonic 521C internal CD-ROM drive.

If you double-click on the front-panel reset button, a diagnostic routine embedded in flash memory checks the entire system down to component-level errors. Anyone who has ever experienced a memory parity error knows that isolating the bad RAM chip is time consuming. The Dell system automatically detects and reports these types of errors.

Although Creative Labs' Sound Blaster Pro audio board is capable of quality audio output, Dell's choice of Labtec's external speaker system makes the final sound textures raspy. And, even with higher-quality speakers attached, I could not get a good audio sample from the inexpensive Labtec electret microphone.

With 8-bit color at 1024- by 768-pixel resolution and 640- by 480-pixel resolution, the bundled monitor was sharp and steady, and the S3/Dell LBV Super VGA display chip set was a real barn burner. All the applications I tested simply blazed.

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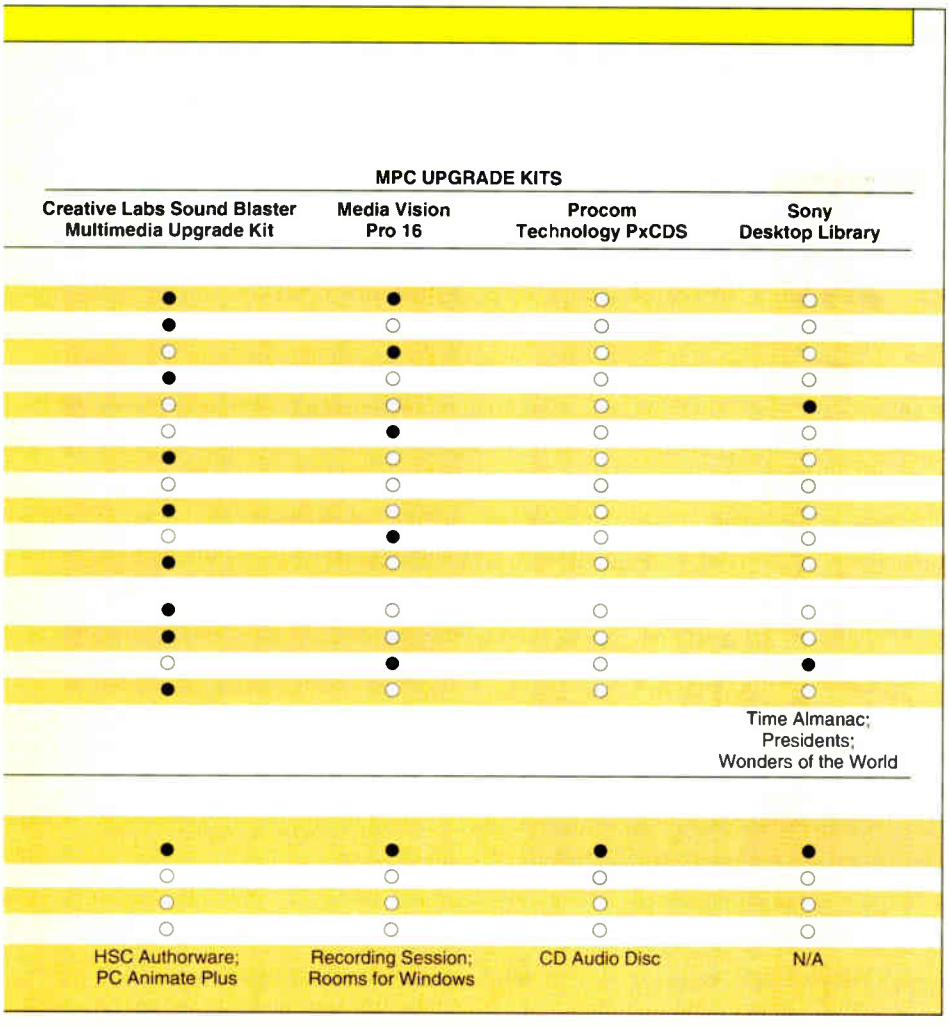

MPC UPGRADE KITS

Creative Labs Sound Blaster Multimedia Upgrade Kit	Media Vision Pro 16	Procom Technology PxCDS	Sony Desktop Library
●	●	○	○
●	○	○	○
○	●	○	○
●	○	○	○
○	○	○	●
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even at the higher resolutions.

With a host of bundled software, an excellent display, and outstanding video performance, the Dell 433s/L is an attractive MPC offering. And since the motherboard is socketed to accept future processors as they become available, you can upgrade to a faster system easily. The poor external audio and microphone quality aside, Dell's 433s/L bundle is a system that deserves consideration.

Ultimedia M77

IBM's array of PS/2 Ultimedia systems have a wide range of pricing considerations and options: the M57 SLC ($3355), a 386SLC 20-MHz system with a 160-MB SCSI hard drive; the M57 486SLC2 ($4225), a 50-/25-MHz unit; the DV M57 486SLC2 ($5675), with an ActionMedia II/A DVI playback adapter; the M77 486 ($4695), equipped with a 486SX/33 processor; and the Ultimedia M77 486DX2 ($5295) (the review unit I tested), with a 33-/66-MHz 486DX2 processor.

All Ultimedia systems come standard with 8 MB of on-board RAM, and all (except the M57 SLC) ship with 212-MB SCSI hard drives. IBM's Ultimedia systems use IBM's Micro Channel architecture bus and ship with internal Kodak Photo CD/XA–compatible CD-ROM drives. Depending on the model, the systems ship with either an XGA (Extended Graphics Architecture) or an XGA-2 display adapter, supporting an 8- or 16-bit color display at resolutions of 640 by 480 pixels or an 8-bit color display at resolutions of 1024 by 768 pixels. IBM's display technology, based around the XGA-coprocessor chip, uses point-to-point vector-graphics fill functions rather than manipulating display memory as one large rasterized bit-map graphic.

IBM's Ultimedia M77 486DX2 test unit arrived preconfigured with DOS 5.0, OS/2 2.01, and Windows 3.1. The audio is surprisingly good coming from the unit's internal 4-inch speaker. IBM's M-ACPA (Multimedia-Audio Capture and Playback Adapter) uses the Texas Instruments MS-320C25 DSP chip for playback, recording, and mixing of audio. All MPC applications functioned perfectly; the sound was exceptionally clean. According to IBM's engineers, the M-ACPA uses digital subtractive technology to record and play back digital audio at sampling rates as high as 88.2 kHz at 32 bits, which is twice the sampling rates of current CD audio. This technique, called *over-sampling* or *over-scanning*, is commonly used in other digital applications like scanning digital photos or rendering 24-bit images at the highest number of dots per inch or resolutions possible.

IBM also markets an Altec Lansing MPC audio subsystem for $400 with subwoofer, but the test unit shipped without an external speaker system. I connected my external stereo system to the audio board's output jack and was pleased with the clean CD and digitally sampled audio.

During the installation of IBM's ActionMedia II DVI playback and capture boards ($1695 and $750, respectively), IRQ (interrupt request) conflict problems arose. After over 60 calls to IBM, during which I'd been put on hold for long periods of time or bounced from department to department, I wasn't hopeful about getting answers.

But I placed a service call late one Friday night, and on Saturday morning, a representative showed up at my door. With the assistance of an IBM Ultimedia specialist in Boca Raton, Florida, we had the ActionMedia II adapters up and running and capturing RTV (real-time video) in no time flat.

One of IBM's main strengths in multimedia and MPC is its reliance on DVI technology. In my opinion, DVI still stands well above Video for Windows' AVI (Audio Video Interleave) in quality of output. DVI's i750 chip set and codec routines operate at NTSC's 30-frame-per-second rate and at 640- by 480-pixel resolution; DVI/RTV captures produce good-looking 4-inch by 5-inch motion-video windows on a 17-inch monitor. For critical multimedia applications, developers should consider DVI PLV (Production-Level Video). While still relatively expensive to produce (motion-video sequences are compressed using mainframe equipment), PLV looks excellent on playback in interactive CD-ROM applications.

IBM's Ultimedia systems are targeted toward business, educational applications, and courseware developers. If you're a serious developer, corporate end user, or educator, IBM's line of Ultimedia systems deserve your consideration.

NCR 3331 MLS

NCR's modestly priced MPC systems are targeted for corporate training and educational applications. With AT&T's communications muscle behind it, NCR's vision of multimedia includes remote location and tele-distribution of interactive motion-video courseware for institutions with heavy-duty training demands. The NCR 3331 MLS (Multimedia Learning Station), a 33-MHz DX system, retails

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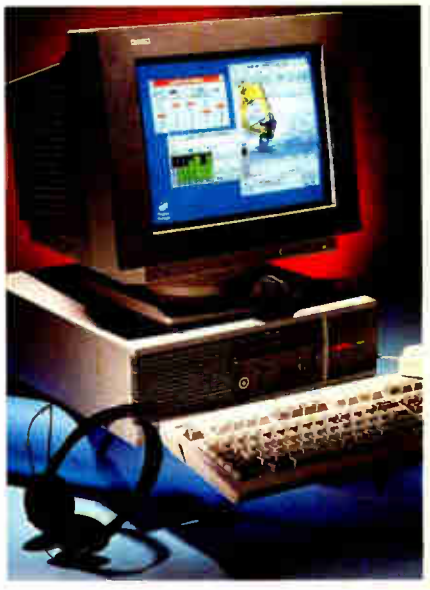

Photo 2: *An excellent platform for video-based training applications, the NCR 3331 MLS comes standard with Intel's DVI playback board installed. The bundle also includes headphones and a microphone.*

for $3805 (see photo 2). A 50-MHz DX2 model costs an additional $136. NCR's test unit shipped with a 240-MB hard drive, a Toshiba XM-3301 internal CD-ROM (Kodak Photo CD/XA–compatible), Media Vision's Pro Audio Spectrum 16 sound card, and 8 MB of RAM. NCR's 25-MHz 486SX system retails for $1995 and ships with a 120-MB hard drive, 4 MB of RAM, and Intel's DVI playback adapter.

As mentioned above, the 3331 MLS is geared toward delivering video- and audio-training information to users at a relatively inexpensive price. To enable this type of application, the 3331 MLS ships preconfigured with Intel's DVI playback adapter installed. All video pass-through cabling between NCR's VGA/Super VGA display chip set and the DVI adapter is preconfigured internally.

The unit ships with both a Sony electret microphone and NCR headphones. NCR's system doesn't ship with external speakers, but the 3-inch internal front-mounted speaker sounds very good. NCR offers two display monitors for its system: a 15-inch model for $589 and a 14-inch model for $428. Both monitors can display 256 colors at 1024- by 768-pixel resolution in noninterlaced mode. The 15-inch monitor used for testing was clear, sharp, and stable.

NCR's RTV DVI capture board retails for $639, and Intel's DVI Development software and AimTech's Present, a run-time playback module, ship preinstalled

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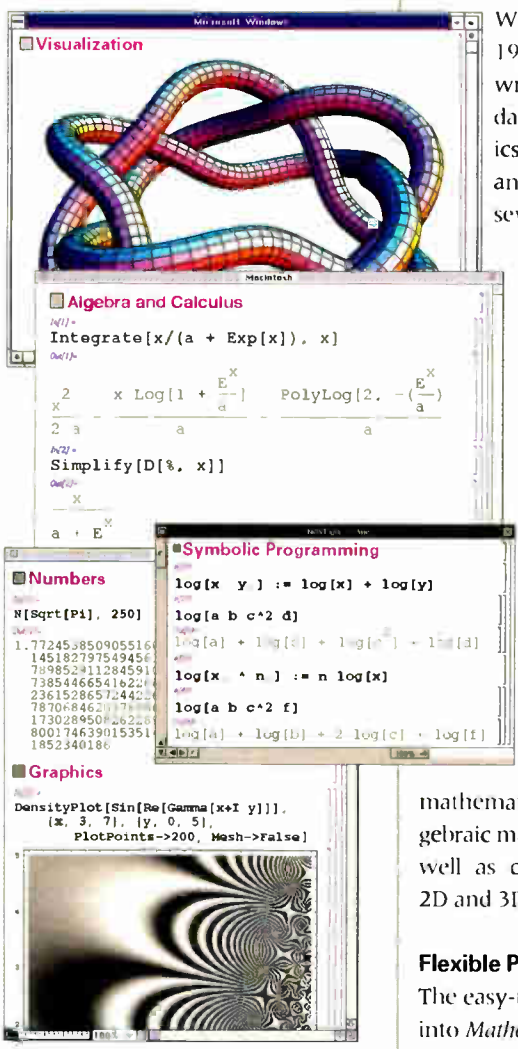

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on the system as well. The DVI capture board mounts easily on the DVI playback adapter as a daughtercard, and a six-lead pigtail cable connects to the S-Video port of the playback adapter to input NTSC composite video or RGB component video and stereo audio.

The NCR 3331 MLS should appeal to corporate buyers, but it's also a solid choice as a personal MPC system. For either application, I rate NCR's MPC system very high.

Packard Bell PB-402

Packard Bell's MPC PB-402 base system, a 25-MHz 486SX, retails for $2200 without a monitor. The review system shipped with a $300 14-inch Packard Bell 8548 monitor capable of 8-bit color at 1024- by 768-pixel resolution in noninterlaced mode. With a 0.28-millimeter dot-pitch ratio, the display looked clean, sharp, and stable in 8-bit color at 1024- by 768-pixel resolution and 640- by 480-pixel resolution. The PB-402 includes a 170-MB Conner hard drive, 8 MB of RAM, a caddyless Panasonic CR-521B CD-ROM drive, and Creative Labs' Sound Blaster Pro audio card. The unit also ships with a 2400-/9600-bps fax modem and Roland's powerful little CS-10, an external stereo-speaker and amplifier combination.

Booting the system automatically takes you to hDC Windows Express, where you can either launch applications or, if you're a first-time computer user, take a guided tour of the system and step through Packard Bell's own MPC Windows tutorial. Late one Saturday evening, I had questions concerning the CD-ROM and hard drive. By hypersearching through the above tutorials, I found an 800 number for service and support. Surprisingly, a technician was quick to respond and answered all my questions. Packard Bell's technical-support line is staffed 24 hours a day, 365 days a year; all its products carry a one-year, on-site parts-and-labor warranty.

The review system also came with Packard Bell's $399 PB-TV3 adapter, which converts analog video to a digital-video window. Because of the PB-TV3's unique on-screen remote and TV-tuner utilities, I preferred Packard Bell's unit over CompuAdd's. The Roland CS-10 audio subsystem, though only rated at 5-W output, really cranked out some clear, crisp audio. The unit combines two front-mounted 3-inch mid-to-high-range speakers and a face-down 5-inch subwoofer for added bass response. The CS-10 also has four rear-mounted RCA audio-in jacks to allow automatic mixing of both CD audio from the CD-ROM drive and digitized sound and synthesized MIDI sound from the Sound Blaster Pro 16 adapter.

The system's benchmark tests were disappointing. With a 256-color display at 640- by 480-pixel resolution, the system's display speed is passably fast for all applications, but with a 256-color display at 1024- by 768-pixel resolution, the system slows to a snail's pace (e.g., when you open a window, you can actually see it slowly scrolling from top to bottom down the screen). If you're looking for fast MPC video speeds, you should install an accelerated Super VGA adapter, such as Diamond's Stealth. But first you must disable the PB-402's on-board Oak Technology Super VGA chip set by moving a jumper.

Packard Bell's PB-402 MPC system is a winner when it comes to overall price versus performance. It's an outstanding MPC configuration jam-packed with applications. If you plan to run MPC applications only at resolutions of 640 by 480

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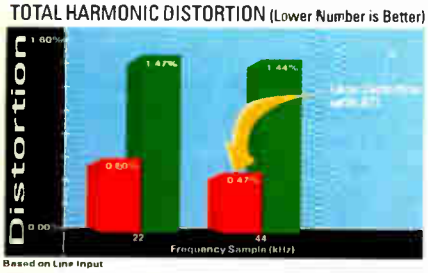

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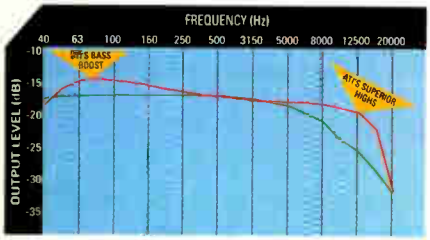

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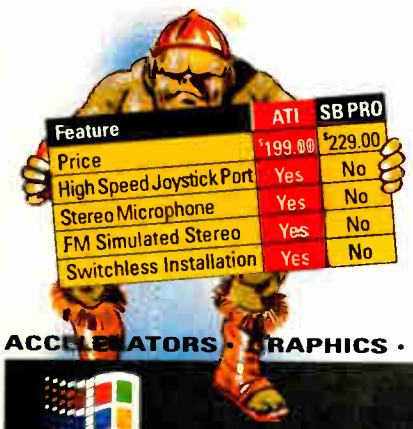

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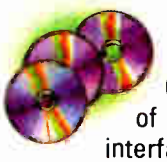

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Photo 3: *The Tandy Sensation ships with an audio adapter, an enhanced internal speaker, a CD-ROM drive, an internal fax modem, and a rich bundle of MPC software and CD-ROM titles. A PC/TV board is optional.*

pixels in 256 colors, or if you can afford to install an accelerated Super VGA board at resolutions of 1024 by 768 pixels, then I highly recommend this unit.

Sensation

Tandy's Sensation MPC system ($2495 with a monitor included; $1999 without one) is aptly named. The basics of the system include a 25-MHz 486SX, a 107-MB hard drive, a caddyless internal Philips LMS CM-205 CD-ROM drive, Tandy's own MPC-compatible Enhanced Audio adapter (which uses a Yamaha YMF262 synthesis chip), an internal 2400-/4800-bps fax modem, and 4 MB of on-board RAM (see photo 3). Tandy uses Western Digital's 90C31 video display accelerator chip set mounted directly on the motherboard for VGA/Super VGA output of up to 256 colors at 1024- by 768-pixel resolution and 16.7 million colors (24-bit) at 640- by 480-pixel resolution. For audio output, you can either hook the system to your stereo or use the internal 3-inch speaker system.

You can use Sensation as a "smart" answering machine to route callers to multiple voice mailboxes. An incoming caller's message is stored digitally in .WAV format on the hard disk, and you can retrieve it remotely using Touch-Tone passwords. A highly understandable text-to-speech voice synthesizer can also convert any typed text message to synthesized speech for output to voice mail.

Tandy's WinMate software automatically boots as a prelude shell to the Windows Program Manager (you have to run Program Manager from within WinMate). WinMate is, in essence, a Windows desktop manager. WinMate categorizes different functions of Sensation into easily understood groupings: In Touch links you into Sensation's communications area mentioned above; In the Know taps into Microsoft Bookshelf's encyclopedia and dictionaries; In Charge keeps track of "to-do" lists, names, addresses, phone lists, and appointment schedules with voice reminders using the speech synthesizer; and so on.

Options include a $400 PC/TV card, which functions much like CompuAdd's board, and a $39 1-MB video-memory upgrade kit to support an 8-bit Super VGA display at 1024- by 768-pixel resolution. Tandy also offers a $799 MPC upgrade kit.

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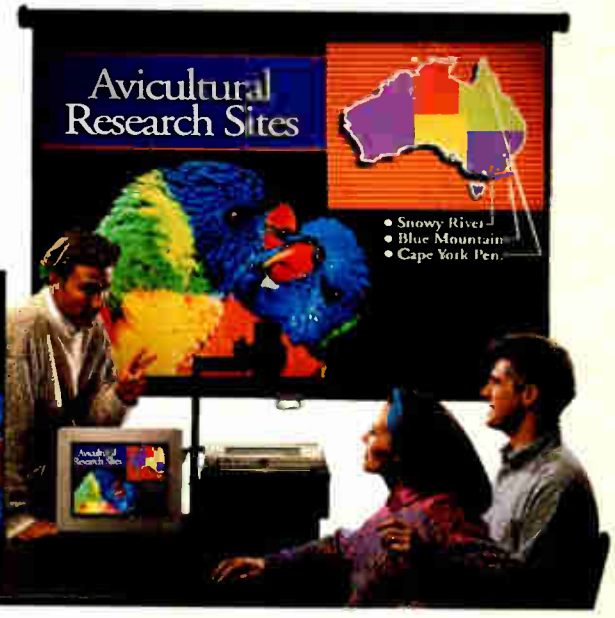

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adapter are relatively slow compared to the other units tested. Still, I urge anyone who is looking for a good all-around MPC system to test-drive the Sensation.

Multimedia at Its Best

All the MPC upgrade kits performed admirably. The Creative Labs Multimedia Upgrade Kit, with the Sound Blaster 16 ASP option, gets the overall nod for best MPC sound quality and price-versus-performance ratio. Media Vision's Pro 16 Multimedia System MPC upgrade kit gets a close second, not for sound quality but for the speeds displayed by the bundled NEC-84J CD-ROM drive with its Kodak Photo CD compatibility.

NCR's 3331 MLS is the clear choice for high-end, low-cost educational and business MPC development and delivery systems. Overall kudos go to Tandy's Sensation; it's a well thought-out execution of what every MPC system manufacturer should strive to emulate. ■

Greg Loveria is a computer graphics, desktop publishing, and MPC consultant; an animator; and a writer based in Binghamton, New York. He can be reached on BIX as "loveria."

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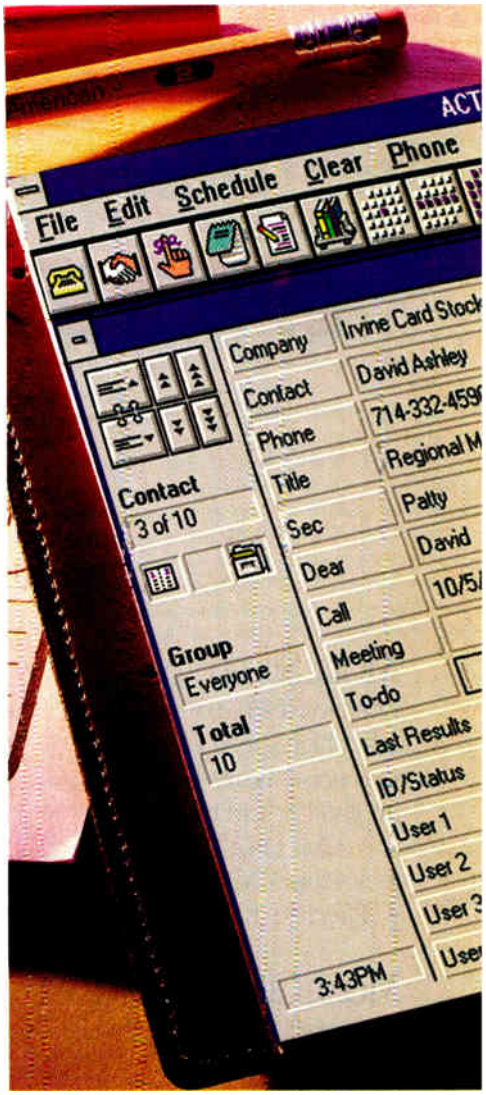
World Radio History

SOFTWARE

Personable PIMs

NICHOLAS BARAN



As personal computers have grown more mobile, PIMs (personal information managers) have emerged as a major category of software. Dozens of companies have developed various types of PIMs; in this article, I'll look at 10 of the most popular products for Windows, DOS, and Macintosh operating environments.

A PIM does exactly as its name suggests: It manages your personal information. Most PIMs include an appointment scheduler and calendar, an address book with telephone-dialing capability, a note taker, and a few other information management functions. The basic idea is to replace your paper Day-Timer or address book with an electronic one, although the products reviewed here range from simple time schedulers to comprehensive project management programs.

A Good PIM

So what makes a good PIM? For those of us not directly involved in sales or project management, oft-cited PIM features like the ability to track hundreds of contacts or manage complex projects may not be very important. If the objective of a PIM is to replace the paper notepad and address book, it should be as easy to use as its paper equivalent and at least as fast. Few users will make the switch to a PIM that requires hours of laborious tutorials and poring over the user's manual. Fast performance is important. If it takes 30 seconds for the PIM to find a name in its address book and it only takes one flip of the page in the Day-Timer, I wouldn't make the switch.

PIMs should also be able to operate in the background. Let's say you're working on a document in your word processor, the phone rings, and someone wants to make a date for lunch next Thursday. You want to be able to access your PIM immediately. You don't want to have to exit your word processor and launch the PIM while the person is waiting on the phone.

A PIM's ability to exchange data with other sources should be considered. You may want to import data from an existing database or spreadsheet, or perhaps you'll need to exchange information with someone who uses a different PIM or database. To summarize, some of the features that I looked for in reviewing these PIMs include the following:

- Ease of use
- Fast and responsive performance
- Background operation
- Data transfer capabilities

Of course, there are many other features to consider depending on what you plan to do with the PIM. You'll find a summary of basic features and pricing in the table on page 196. Some PIMs are strictly for time management. Others have extensive database capabilities.

The products described below are grouped according to operating environment (Windows, DOS, and Macintosh) and are discussed in alphabetical order. I tested the Windows and DOS products on a Dell 320N (a 20-MHz 386SX) and the Macintosh products on a Mac SE.

DOS/Windows

ACT for Windows 1.0

ACT is designed for the business person who has hundreds of contacts. It bills itself as the "best-selling contact manager"; if you're in the contact business, this may be the product for you. As I'm not in sales, I found it a bit overwhelming, particularly at $495. ACT includes a full-featured word processor, mail-merge functions, a calendar and appointment scheduler with autodialer and alarm clock, a phone manager utility for tracking call histories, and macro utilities, to name just a few features.

The program uses the dBase data format (DBF files) and provides myriad data fields for tracking your contacts. The database is linked to the other functions of the program, so, for example, if you click on the meeting button in the database form, a window for scheduling a meeting opens.

ACT performed well, moving quickly from record to record and module to module, although I wouldn't call it easy to use. It uses icons liberally (see screen 1), but the functions of most of them are not readily obvious. On the other hand, ACT has extensive documentation, which starts off with a tutorial. With patience, you should be able to learn the product thoroughly.

One major disappointment was the difficulty of importing data. I struggled for close to an hour trying to figure out how to import a comma-delimited text file, and when I finally got the file imported, the fields didn't match up. The procedure is poorly explained in the documentation,

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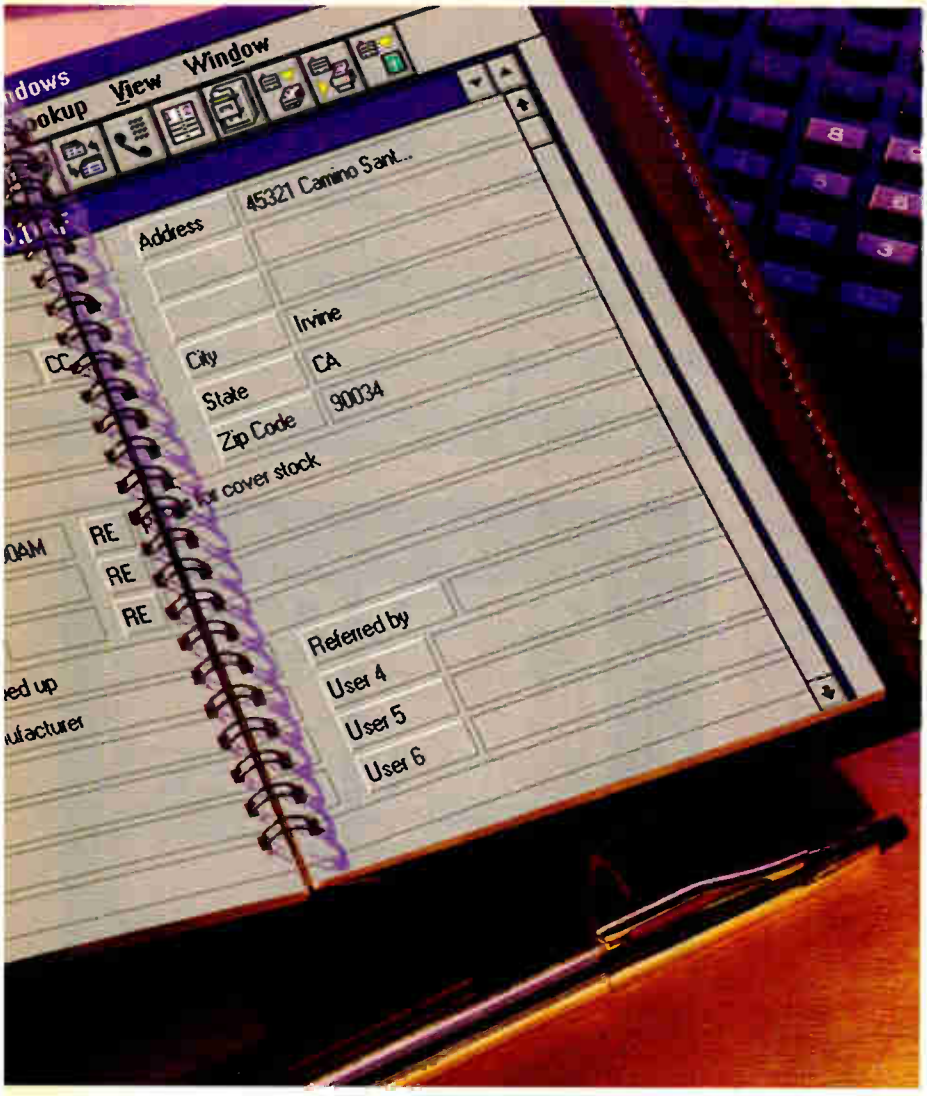

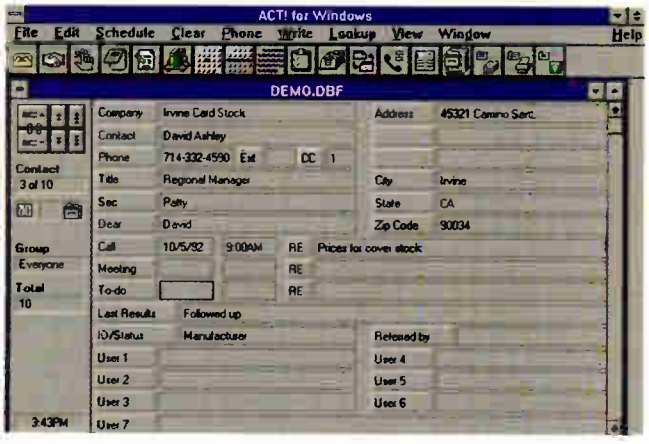

Screen 1: *ACT for Windows is a fast, full-featured package with an emphasis on contact management.*

and the program is very unforgiving if you make a mistake in the import process. On the positive side, the import process is pretty straightforward if the data is already in DBF format.

ACT is a big program designed for a big job. It is certainly a great pick if your work involves a lot of contacts. If you have more modest information management requirements, some of the less expensive products reviewed here will probably better fit the bill. One feature that may be of interest is that ACT is also available in versions for MS-DOS, the Macintosh, and the HP 95LX.

BYTE ACTION SUMMARY

- **WHAT PIMS ARE**
  They're software packages for managing information; most include appointment scheduling, contact management, and project management.
- **LIKES**
  Fast, intuitive, simple interfaces.
- **DISLIKES**
  Some are slow, and some throw too many features into the mix.
- **RECOMMENDATIONS**
  Lotus Organizer and Prisma Software's YourWay are both simple, useful packages that will suit most users. Those who have special requirements (e.g., maintaining very large contact lists) should check out ACT or Commence.

Ascend 4.0

Ascend is another full-featured information manager for Windows, although its macro and programming capabilities aren't as sophisticated as ACT's. It has a good interface and an icon bar that I found quite intelligible. It has an appointment scheduler, a calendar, and an address book; a contact management function for tracking phone histories; a note taker; and even a "values and goals" and "favorite quotes" repository so that you can remind yourself of ambitions and pull up inspiring quotes when the going gets tough.

In addition, Ascend provides two separate utilities: a journal and Red Tabs. The journal lets you maintain a free-form text journal. Red Tabs is similar to the journal, but it's intended for storing miscellaneous bits of information; you can file and organize Red Tabs information into categories. You can import text into either the journal or Red Tabs using the Windows Clipboard.

Ascend is really designed for the person who wants to keep track of everything, from his or her business associates and appointments to thoughts and ideas. But I

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PERSONAL INFORMATION MANAGERS FEATURES

Basic PIM features. More expensive, high-end packages like ACT and Commence have more sophisticated project and contact management features. (● = yes; ○ = no.)

	PIMS for DOS and Windows					
	ACT for Windows 1.0	Ascend 4.0	Commence 1.0	GoldMine 2.5	Lotus Organizer 1.0	OnTime for Windows 1.2
Price	$495	$199	$395	$295	$149	$129.95
Platforms	Windows, DOS, Mac, HP 95LX	Windows, Mac	Windows	DOS	Windows	Windows, DOS
LAN version	○	○	○	●	○	●
Macros	●	●	●	●	○	○
Word processing features	●	Notes	●	●	Notes	Notes
Database features	●	●	●	●	●	○

found the program more accessible than either ACT or Commence, although not as easy to use as Lotus Organizer. However, Ascend was another product that made it difficult to import data into the database.

Priced at $199, Ascend is definitely worth looking at if you want to keep track of more than just your contacts and appointments.

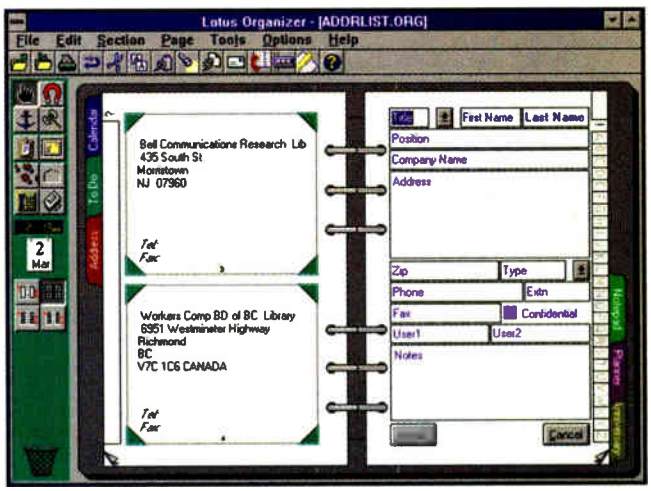
Commence 1.0

Commence is an information manager on the same scale as ACT, but it's optimized more for project management than for tracking business contacts. Commence is based on a predecessor called IBM Current, which was marketed by IBM for Windows 2.0. Unlike IBM Current, Commence is optimized for Windows 3.1 and includes a programming facility called Agents, which allows you to program Commence to perform tasks automatically. Using *triggers* and *conditions*, you can program Commence to remind you of due dates for specified tasks or to modify data based on certain conditions or time intervals.

The product includes a comprehensive appointment and task scheduler, an address book, a to-do list, a letter writer, and a phone tracking function. Through DDE, you can use external word processors such as Word, Ami Pro, or WordPerfect to create documents within Commence.

Although you could use Commence simply as an appointment scheduler and address book, the program is optimized for more complex project management tasks. It offers a Gantt chart function for tracking tasks on a time line. With the extensive programming capability, you can generate custom reports and charts to track the progress of various tasks.

Like ACT, this product has a substantial learning curve along with substantial capabilities. Once again, importing data is not a trivial operation, although with some study of the import procedure you can import virtually any data in ASCII, DBF, or DIF. Commence is a powerful and capable program that takes a focus on project management. But with a price of $395, it's not for everyone.



Screen 2: *Lotus Organizer's SmartIcons aren't always obvious, but overall the package is very easy to use.*

GoldMine 2.5

GoldMine is strictly an MS-DOS product with a broad range of information management capabilities. GoldMine is in the class of ACT and Commence in that it tries to cover all bases, providing tools for everything from contact management and appointment scheduling to word processing and data analysis. The product also includes a scripting language and a facility for creating call guides for telephone operators to follow when they're conducting sales calls.

But in spite of all its power, GoldMine is limited as a DOS-only product. That means that you can't run it in the background. It gets around this limitation by allowing you to run external programs from within while it swaps itself out to expanded memory. And GoldMine has the old-fashioned DOS text-field interface, making it seem a bit primitive compared to some of the Windows products.

If you are firmly committed to MS-DOS and need very powerful information and task management capabilities, this product may be for you. It's not cheap ($295), but it has a lot of capabilities.

Lotus Organizer 1.0

Lotus Organizer for Windows is a product that Lotus acquired from a small software firm called Threadz, which began showing the product about two years ago.

Organizer now has features that integrate it with other Lotus products, such as Lotus 1-2-3 and Ami Pro. In particular, Organizer uses the SmartIcons interface that has become standard in Lotus products for the Windows environment. The trick with SmartIcons is remembering what all the various icons stand for (almost as challenging as memorizing commands back in the good old days of DOS). Organizer

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		PIMS for Macintosh	
PackRat 4.1	YourWay 3.0	Danny Goodman's Connections 2.1	Now Up-To-Date 2.0
$395	$99	$199	$99
Windows	Windows	Mac	Mac
●	○	●	●
●	●	○	○
●	Notes	Notes	Notes
●	●	●	○

works with 1-2-3 spreadsheets or Ami Pro documents and provides mail-merge capabilities. You can also send and receive E-mail if you have cc:Mail or Lotus Notes installed on your machine.

Organizer provides the essentials of a good PIM: an address book, an appointment calendar, a to-do list, and a notepad. It uses a notebook metaphor as its interface (see screen 2) so that you can click on the tabs along the side of the notebook to open various modules of the program. I found the performance to be more than adequate on both the Dell desktop and my 386SX laptop.

You can set alarms for scheduled appointments. The alarm beeps and displays the appointment information at the specified time, regardless of whether you're working in Organizer or in another Windows application. (Organizer must at least be running in the background for the alarm to work.) The product includes an auto-dialer function so that you can automatically dial numbers as you look them up in the address book.

Of the products reviewed, Organizer was one of the easiest to use. I found myself making appointments having barely opened the manual. In addition, Organizer provides a good data import and export facility. The product did have a few minor bugs: For example, the alphabetical notebook tabs for searching the address book didn't work with my imported data file, although I could still search names using the Search command in the Edit menu. But overall, Organizer is a slick product with a reasonable price of $149. It has a concise and easy-to-use user's manual and the strong technical support of Lotus behind it.

OnTime for Windows 1.2

OnTime for Windows 1.2 is a basic time scheduler. It doesn't have an address book. You use it to schedule appointments and to maintain to-do lists. You can attach notes to appointments and perform keyword searches. You can set up alarms and reminders for recurring tasks or appointments (e.g., setting an alarm for a monthly staff meeting). You can also print out oversize calendars to mount on the wall and work with daily, weekly, monthly, or annual time intervals.

I found OnTime easy to use and very intuitive. The manual is a concise 50 pages. Priced at $129.95, it's affordable and immediately useful. However, I would have liked it better with an integrated address book.

PackRat 4.1

PackRat is an extremely ambitious information management package, with tools for managing appointments, addresses, project tasks—even the files on your hard disk. It is replete with alert and tickler functions and includes an index-card tool for storing notes and memos, a scratchpad for copying information from other PackRat utilities, a resource utility for managing things like conference rooms and equipment, a Gantt chart function, and an auto-dialer, among other features.

PackRat uses an elaborate icon interface that you can customize with additional icons. It also includes an Integration Library for developing macros for working with other Windows products. But I found this product to be one of the more difficult to learn. You cannot just plunge in. The best introduction is in the tutorial booklet. I found data import to be virtually impossible in PackRat.

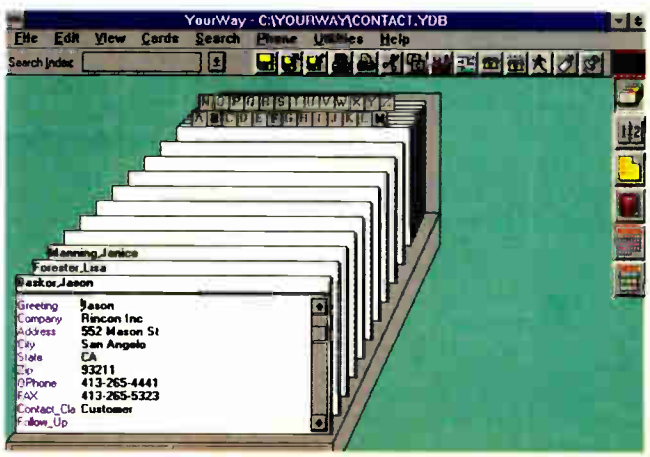
Polaris plans for its next release of PackRat, version 5.0, to be available by the time you read this. The company says that version 5.0 will be an even more comprehensive package that will manage the entire Windows applications environment, integrating with Windows applications.

Priced at $395, PackRat 4.1 is in the expensive league of information managers, and it has a lot of functionality. In my opinion, this product tries to do a little too much and ends up being too difficult to use. Nevertheless, if you're looking at the PIM heavyweights like ACT and Commence, PackRat deserves your consideration.

YourWay 3.0

YourWay is a direct competitor of Lotus Organizer. Considering its capabilities, it's a bargain at $99. YourWay uses a card-file metaphor for storing address-book entries (see screen 3). One nice feature is that you can create your own card files and use your own field names, providing a high degree of customization. This feature makes data import easier, because you can set up a card file with the same number of fields as the data to be imported.

YourWay has the usual address book, appointment scheduler, calendar, phone tracking function, and note taker, plus a Gantt chart feature. YourWay doesn't have a separate notepad or word processing function, although you can attach notes to



Screen 3: *Prisma Software's YourWay uses a card-file metaphor that makes it one of the more accessible PIMs.*

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particular address or appointment records. YourWay supports macros through DDE, although you'll need to be an experienced DDE user to take advantage of this feature.

I found YourWay easy to learn and very accessible, although its icons were in the unintelligible category. At such a low price, YourWay is definitely worth a serious look.

Macintosh

Danny Goodman's Connections 2.1

Danny Goodman's Connections is a HyperCard-based PIM with appointment scheduling and calendar functions, a to-do list, an auto-dialer, a note taker, and a telephone directory. Since it's based on HyperCard, you can also integrate data from other HyperCard stacks, and an import/export facility is included. It has a group calendar feature for use on a network.

The program has the basic ingredients of a complete information manager. But Connections has one major problem: It's terribly slow on a Mac SE. When you search for a record or make a link between an appointment and a name in Connections' telephone directory, you may as well go for coffee while it completes (that's only a slight exaggeration). To be blunt, the performance is unacceptable on a Mac SE or Mac Plus. On a Mac IIfx the performance is more adequate, but if you're working with a 68020 Mac, you'll find the performance frustrating.

Connections has one major problem: It's terribly slow on a Mac SE.

Now Up-To-Date 2.0

Now Up-To-Date is a simple calendar and scheduling program similar to OnTime for Windows. It doesn't have an address book, but it does have a to-do-list function. Its specialty is working with appointments, schedules, and calendars. Now Up-To-Date includes a Control Panel that can remind you of appointments while you're working in other applications.

Now Up-To-Date is easy to use, and the performance is good. One nice feature is the ability to print oversize wall calendars to post in an office or meeting room. Priced at $99, Now Up-To-Date is a good choice for a basic time scheduler.

Best PIMs

Personal information managers are, of course, personal. And each of these PIMs focuses on different requirements; depending on what you want to do, your preferences may be quite different from mine. If you're looking for an address book or Day-Timer replacement, Lotus Organizer and YourWay are both good choices. Organizer has the advantage of being tightly integrated with other Lotus products. YourWay has more flexible data management functions and costs $50 less.

If you're in the sales business, ACT is a good choice. If you need major project management capabilities, Jensen-Jones's Commence fits the bill. And if you're the more philosophical type and like to keep journals and keep track of ideas, take a look at Ascend. Finally, if you want a basic no-frills time manager, OnTime for Windows or Now Up-To-Date for the Mac would both be good selections. ■

Nicholas Baran is a BYTE consulting editor and coeditor of Pen-Based Computing, *an industry newsletter based in Sandpoint, Idaho. He is also author of* Windows from the Keyboard *(John Wiley & Sons, 1993). He can be reached on BIX as "nickbaran."*

COMPANY INFORMATION

Campbell Services, Inc.
(OnTime for Windows 1.2)
21700 Northwestern Hwy., Suite 1070
Southfield, MI 48075
(800) 345-6747
(313) 559-5955
fax: (313) 559-1034
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Contact Software International, Inc.
(ACT for Windows 1.0)
1840 Hutton Dr., Suite 200
Carrollton, TX 75006
(800) 365-0607
(214) 919-9500
fax: (214) 919-9750
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Elan Software Corp.
(GoldMine 2.5)
4917 Gerald Ave.
Encino, CA 91436
(818) 999-9872
fax: (818) 999-9903
Circle 1233 on Inquiry Card.

Franklin Quest Co.
(Ascend 4.0)
2550 South Decker Lake Blvd.
Salt Lake City, UT 84119
(800) 877-1814
(801) 975-9992
fax: (801) 975-9995
Circle 1234 on Inquiry Card.

Heizer Software
(Danny Goodman's Connections 2.1)
P.O. Box 232019
Pleasant Hill, CA 94523
(510) 943-7667
fax: (510) 943-6882
Circle 1235 on Inquiry Card.

Jensen-Jones, Inc.
(Commence 1.0)
Pkwy. 109 Office Center
328 Newman Springs Rd.
Red Bank, NJ 07701
(800) 289-1548
(908) 530-4666
fax: (908) 530-9827
Circle 1236 on Inquiry Card.

Lotus Development Corp.
(Lotus Organizer 1.0)
55 Cambridge Pkwy.
Cambridge, MA 02142
(800) 343-5414
(617) 577-8500
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Now Software, Inc.
(Now Up-To-Date 2.0)
319 Southwest Washington St., 11th Floor
Portland, OR 97204
(503) 274-2800
fax: (503) 274-0670
Circle 1238 on Inquiry Card.

Polaris Software, Inc.
(PackRat 4.1)
17150 Via Del Campo, Suite 307
San Diego, CA 92127
(619) 674-6500
fax: (619) 674-7315
Circle 1239 on Inquiry Card.

Prisma Software Corp.
(YourWay 3.0)
2301 Clay St., Suite 100
Cedar Falls, IA 50613
(800) 437-2685
(319) 266-7141
fax: (319) 266-2522
Circle 1240 on Inquiry Card.

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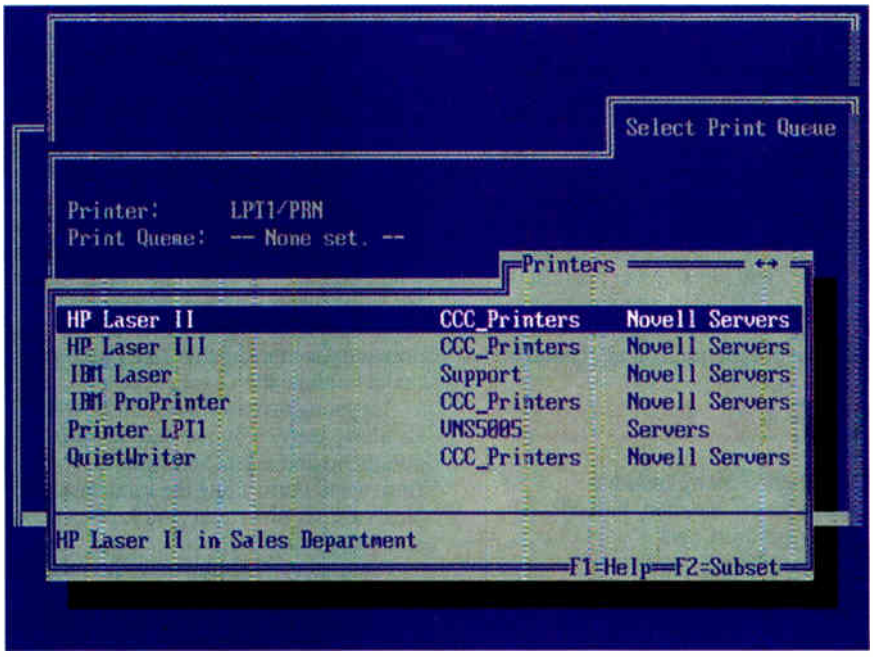
SOFTWARE

Banyan's "StreetTalk for NetWare"

JOHN RYDBERG

NetWare does a lot of things well, but coordinating access to network resources across multiple servers isn't one of them. Banyan Systems' ENS for NetWare addresses this limitation through StreetTalk, Banyan's global naming service. ENS, which stands for Enterprise Network Services, hardens NetWare's weakest link by applying Banyan's traditional strength: It brings to NetWare a server-independent directory structure that Novell's dominant LAN operating system has always lacked.

ENS for NetWare is a family of products that provides resource and user management networkwide. ENS networks are global and service-based, which means that users can easily access resources such as file volumes, print queues, and mail services by searching the StreetTalk database. Unlike users of plain NetWare (at least until NetWare 4.0), users under ENS for NetWare never need to know exactly on which server a service resides.



ENS for NetWare simplifies administration and use of multiserver NetWare networks. From this screen, users can reach printers throughout the network rather than find queues server by server.

StreetTalk Meets NetWare

StreetTalk, a distributed database that contains information about the users and resources on a network, has been the foundation of the Banyan Vines operating system for over nine years. Each StreetTalk object has a three-part name that indicates the item, group, and organization to which an object belongs. For example, the StreetTalk object `Laser Printer@Sales@Connect` indicates a laser printer that is a member of the group Sales in the organization Connect. When a user requests access to a resource, StreetTalk decides how to connect the user and the resource. Since users see all resources as part of a single virtual system, they are not required to know about the server to which a resource is attached. Each user needs only a valid service name and sufficient access rights to use a resource.

Novell had not provided global naming services until its recently announced NetWare 4.0 (see page 42). Administrators of multiple NetWare servers are well aware of the administration problems in dealing with network resource management. Each server must have a log-in name for every user that requires access. User-access and security changes must be made manually to each network server that counts the user among its clients. When there are many users and many servers, this can become a difficult task.

This is where Banyan's ENS can be of help. A single ENS server complements a network of up to eight NetWare servers (this is a limitation inherent in NetWare) by combining all users and resources under a common StreetTalk database. Administrators can then link ENS servers to support additional NetWare servers.

Adding ENS

The ENS system has three primary components: ENS server software, the StreetTalk agent, and client software. The ENS server—where StreetTalk runs—is a dedicated PC that runs the ENS server software. It installs like any Banyan server. You boot the machine and just keep feeding disks as prompted until the system indicates installation is complete. There are a few prompts to answer, but installation is generally straightforward.

The second component, the StreetTalk agent, is used to bring in NetWare servers. It's a collection of NLMs (NetWare loadable modules) or VAPs (value-added processes) that run under NetWare 3.11 or 2.2. You install the agent using the INSTALL program supplied for the NetWare servers. INSTALL copies the required NLMs or VAPs along with new management utilities and client software to each NetWare server.

The third component is a program called BANV, the client software that runs on DOS or Windows workstations. BANV lets users access resources across the network and allows administrators to perform central management of those resources.

The administration utilities of ENS for NetWare are similar to the normal Vines utilities. The MANAGE utility acts as the front end, presenting a menu offering network resources for management and configuration. These resources include services, users, lists, nicknames, groups, and organizations.

Using ENS

Under ENS, the process of creating or deleting network resources is really the registration or deletion of the resources in the StreetTalk database. The StreetTalk agent reads and writes the NetWare bindery during this process, but only to create or delete the object. It's important to point

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out that the Vines utilities offer only limited control over the NetWare resources. The configuration and creation of printer and disk resources on a NetWare server still require the use of NetWare utilities.

To create a file service on a NetWare server, you use the MSERVICE utility. This registers an existing NetWare volume with StreetTalk, using the name you supply. When you delete the file service, only the StreetTalk information is deleted, not the data. Another utility called STI (StreetTalk Integration) allows the administrator to map or unmap users and groups found in the NetWare bindery files to StreetTalk names. Note that once ENS is set up, you must be very careful if you run any of the NetWare management utilities like SYSCON. Banyan recommends that you not use them at all, because NetWare won't communicate any bindery changes to StreetTalk.

Once resources and users are mapped to StreetTalk, network clients can begin reaching network services with a common set of commands. This is where ENS simplifies some common procedures in NetWare. For example, to assign print queues to printer ports, you run the ENS SETPRINT command and press the F2 key; you are shown a list of printers available across the ENS system (see the screen on the previous page). You then select the printer you wish to use, and ENS automatically makes the connection. The equivalent function using NetWare requires searching through individual servers for print queues using the PCONSOLE command, attaching to a different server if necessary, and using the CAPTURE command to make the connection.

Assigning drive volumes under ENS is similarly easy. You run the SETDRIVE command and select an available volume from a list. Performing the same task with NetWare requires that you know server and volume names.

These examples illustrate the primary advantage of ENS. Clients can draw upon the StreetTalk database to see all network resources. If StreetTalk Directory Assistance is loaded, you can even call up the database with a hot key.

ENS for NetWare runs on a variety of platforms: A 386 machine with 8 MB of RAM and an 80-MB hard drive is the minimum requirement. Server software also supports dual-processor platforms. I used a 486 clone with 8 MB of RAM and a 120-MB IDE hard drive for my test of the software.

Banyan offers several options with the ENS product line. I recommend two options in particular: MNET and Vines Assistant. These are Vines applications that report on performance, including communication statistics, service information, and disk requests. This type of feedback is useful when troubleshooting network performance problems. Currently, the MNET and Vines Assistant options provide information only on ENS and other Vines servers. While this is limiting, it is still useful information.

Other Banyan software options support server-to-server WAN (wide-area network) and LAN communications transparently over X.25 or SNA (Systems Network Architecture) networks. Options are also available for SNMP, SMTP gateways, Macintosh connectivity, TCP/IP routing, and Token Ring bridging, just to name a few. Further, an Intelligent Messaging option allows the exchange of mail through SMTP mail gateways or many third-party mail gateways, as well as providing a functional mail service.

The Big Picture

ENS for NetWare is not without drawbacks. First, a single ENS server can connect with only eight NetWare servers, which could be a difficult constraint. Second, the StreetTalk naming service has only three levels in its naming structure, which may not be enough for large organizations. Third, the BANV client program takes 30 KB of base memory, which could push clients with multiple network drivers over the edge. Also note that while ENS vastly simplifies some common network procedures, users and administrators will need training to use the system effectively.

Banyan's software licensing for ENS is a little complicated. In addition to the ENS server software, you have to purchase an authorization code for each NetWare server according to the number of users for which the NetWare server is licensed. This determines the base price; options are extra, ranging in price from $699 to $4495. Standard pricing is $3995 for the ENS server software ($2995 to add to an existing Vines server). The NetWare NLM/VAP software pricing ranges from $295 for a five-user NetWare license to $3495 for a 250-user NetWare license.

ENS plugs a large gap in NetWare. But with NetWare 4.0 and NDS (NetWare Directory Services), Novell will introduce its own solution. NDS works like Banyan's ENS when used with 2.x and 3.x servers. It offers a bindery emulation mode that allows the 4.0 servers to function like 3.x servers. And it adds the ability to register resources on servers running earlier versions of NetWare in the Directory Services database. It also allows an unlimited number of levels in resource names.

So where does ENS for NetWare fit? It has a few advantages over NDS. StreetTalk has over nine years of development behind it, with a proven track record. And ENS is far more than a directory services program: ENS software options greatly expand the WAN capabilities of a NetWare environment. But most critically, a single ENS server brings many benefits of NetWare 4.0 to as many as eight existing NetWare servers—without an expensive upgrade for each. ■

John Rydberg is a senior network engineer with Connect Computer in Eden Prairie, Minnesota. He's had over seven years' experience in network technology and specializes in network design, installation, and troubleshooting. You can reach him on BIX c/o "editors."

BYTE ACTION SUMMARY

- **WHAT ENS FOR NETWARE IS**
  A distributed directory that allows NetWare users and administrators to work with resources networkwide rather than on a server-by-server basis.
- **LIKES**
  Very simple one-point access to all network resources. Options for wide-area connectivity.
- **DISLIKES**
  Only eight NetWare servers per ENS server. StreetTalk's fixed, three-tiered naming scheme.
- **RECOMMENDATIONS**
  Even in light of NetWare 4.0's Directory Services, ENS for NetWare offers a good solution for enterprise networks running NetWare 3.11 or 2.2. It's ideal for mixed Vines-NetWare LANs.
- **PRICE**
  ENS for NetWare 1.0, $3995 (varies by configuration and number of users for which NetWare server is licensed)
- **FOR MORE INFORMATION**
  Banyan Systems, Inc.
  120 Flanders Rd.
  Westborough, MA 01581
  (800) 828-2404
  (508) 898-1000
  fax: (508) 898-1755
  Circle 1222 on Inquiry Card.

World Radio History

HARDWARE

Windows Video Recorders

TOM YAGER

Video is a vital component of many professional multimedia projects. Microsoft Video for Windows (VFW) adds digital-video playback capabilities to Windows, but that video has to come from somewhere. Almost all digital video starts out as analog video from a videotape, laserdisc, or TV tuner. VFW can turn these analog samples into digital video for you, but you need a video-capture board.

In this review, I'll take a look at five of the first VFW-compatible video-capture boards to hit the market: Creative Labs' VideoSpigot for Windows ($499) and VideoBlaster ($499), AITech's VideoSurge ($995), New Media Graphics' Super VideoWindows ($995), and Matrox Marvel ($995 without integrated VGA, $1495 with 15-bit-color VGA). All but the VideoSpigot are actually video-in-a-window devices. They're built to take video from an external source and display it on your computer's monitor, picture-in-picture style.

Hardware for pulling video into Windows (from left to right): the Matrox Marvel, VideoBlaster and VideoSpigot from Creative Labs, AITech's VideoSurge, and New Media Graphics' Super VideoWindows.

The Right Tool

Using a video-in-a-window board for VFW usually means making allowances. First, you must have a vacant block of memory under the 16-MB mark. In general, your system cannot have more than 15 MB of memory. Of the boards tested, the VideoSpigot is the only one that did not have that requirement.

Also, for live real-time video, you have to plug your monitor into a connector on the overlay board and hook the board to a separate VGA adapter through a ribbon cable. The Marvel's on-board Tseng ET-4000 VGA controller simplifies things considerably, since the video-in-a-window part of the board is tuned to the Tseng chip and works with most of its VFW-useful video modes. When you're forced to use a separate VGA, there is no such synergy between the VGA and the overlay board. In fact, for my tests, the only Super VGA (Actix GraphicsEngine) mode that worked reliably with all three non-VGA-equipped video-in-a-window cards was Windows' 640- by 480-pixel, 16-color generic VGA setting.

If you only plan to use the board for video capture, you can limit your exposure to VGA mode-mismatch troubles by simply not hooking up the feature connector cable. VFW does not require that your board be able to run in video-in-a-window mode, so you can just plug your monitor directly into your display adapter.

Dropping a Few Frames

To test the capture boards, I installed each into an ALR Flyer 32LCT system with 8 MB of memory and a 66-MHz 486DX2 processor. For boards that required a separate VGA card, I used the Actix GraphicsEngine, an S3-based accelerated VGA adapter. The video came from a Sony CVD-1000 computer-controllable Hi-8 VCR. I used video supplied by Firstlight Productions.

The performance tests were simple: I captured 60 seconds of video at three different resolution/color-depth combinations (see the table on page 202). VFW drops frames when it can't maintain the capture rate that's requested (measured in frames per second). The performance statistics reflect the maximum capture rate that resulted in no dropped frames. For all tests, I set audio recording at 8-bit, 11-kHz mono (the VFW default).

Built around the same set of Philips digital-video chips, the Super VideoWindows and the VideoBlaster share a nearly identical set of features and performance attributes. The Super VideoWindows has been a mainstay in the video-in-a-window market, and capture-driver support for the board is included with VFW. The Super VideoWindows handles, by default, three composite video and three stereo audio channels. As with the other multichannel devices, you can connect multiple video sources and select any one of them in software. The audio connectors are for pass-through audio only; the Super VideoWindows has no audio-digitizing capabilities.

The VideoBlaster differs mostly in its handling of audio. While the Super VideoWindows has separate RCA jacks for all its audio channels, the VideoBlaster has only one set of RCA stereo line-input jacks on its fan-out cable. Two other line-level audio inputs are on the board itself in the form of pin connectors for a CD player and another arbitrary audio source. There's also a microphone jack at the board's rear.

Not Ready for Plug-and-Play

I ran into some trouble while installing the Super VideoWindows card. The software makes changing the board's settings easy, but you have to power off and on to apply the changes. For my setup, I had to go through five such cycles before I found a workable combination. Once it started working, Super VideoWindows turned in a respectable 14 fps at the standard 160- by 120-pixel, 8-bit capture setting.

The VideoBlaster wasn't quite so cooperative. The board eventually worked, but not before causing several diverse problems: It made the display go black when I started a capture, it refused to let Windows shut down or reboot, and it made my system's Pro Audio Spectrum sound card stop working with Windows. This

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VIDEO CAPTURE FOR WINDOWS

Video for Windows drops frames when it can't maintain a requested capture rate. The performance statistics reflect the maximum capture rate (in frames per second) that resulted in no dropped frames. The VideoSpigot aced all the performance tests, beating all the other cards for capture rates while turning in exceptional quality. (● = yes; ○ = no.)

Capture board	Price	Inputs	S-video	Daughtercard connectors	Video-in-a-Window	Capture performance (frames per second) 160×120/ 8-bit	160×120/ 16-bit	320×240/ 8-bit
AITech VideoSurge	$995	Two	○	●	●	11	8	2
Creative Labs VideoSpigot for Windows	$499	Two (no audio)	●	○	○	18	10 (24-bit YUV)	4
Creative Labs VideoBlaster	$499	Three	○	○	●	14	9	4
Matrox Marvel	$995[1] $1495[2]	Two	●	●	●	11 (dithered)	2	3
New Media Graphics Super VideoWindows	$995	Three	○	●	●	14	9	3

[1] Without VGA [2] With 15-bit-color VGA

was also the only card that refused to work with the GraphicsEngine's 15-bit-color mode (with no feature connector attachment). These difficulties appeared even though I painstakingly set all I/O well out of the way of other system components. These same settings worked fine with the other overlay boards. When it worked, the VideoBlaster's performance and video quality matched those of the Super VideoWindows.

AITech's VideoSurge roughly matches the capabilities of the preceding two overlay boards. It handles two incoming composite video channels and three channels of pass-through stereo audio (through ⅛-inch stereo jacks). There is an S-video connector on the board that was not enabled in the review unit. The documentation is poor and all the connectors are unlabeled, and the card was as difficult to install as the VideoBlaster. I had to cycle power several times to fix blank screens, bad colors, and other unpredictable behavior. The capture drivers and the standard Windows software are good, and the VideoSurge includes a simple program (ProImage) that performs image capture, paint, and graphics format conversions. VideoSurge's AVI (Audio Video Interleave) capture performance is acceptable at 11 fps for 160- by 120-pixel, 8-bit video.

Rising to the Top

Two boards in this review rose to the top of the group for decidedly different reasons. In the video-in-a-window class, the Matrox Marvel brings more to the party than any board I've ever seen. Since this article is primarily about VFW capture, I'll open with the most disappointing aspect of the Marvel: It turned in the worst overall capture performance of all tested boards. But in an application where both digital and analog video are used, the Marvel carries the analog side of its double duty better than the other boards.

Either of the Marvel's two video inputs can be turned into an S-video channel by a simple Y cable, and a connector at the rear of the card accommodates a fan-out cable set that puts *six feet* of cable behind each clearly labeled connector. The quality of the real-time video is astoundingly good, thanks to Matrox ASICs (application-specific ICs). The Marvel filters incoming video to reduce streaks and distortion in the overlay video that are caused when an object in the scene moves quickly or when the camera is panned rapidly. These motion artifacts have long been the most serious drawback of using video-in-a-window devices.

Another unique advantage of the Marvel is its effects processing. Overlay video can be manipulated through the Keyframe Editor to apply effects such as invert, posterize, strobe, mosaic, resize, and position. The effects are fast, smooth, and clean. Wipes, tumbles, fades, tints, and other effects can be combined in a precisely timed animated effects script that you can load and invoke from within any MCI-capable (media control interface) application (including Visual Basic and ToolBook).

When it comes to choosing the overall best VFW capture board, there's no contest: The VideoSpigot for Windows wins easily. This was the first chance I had to see the complete bundle, and I came away extremely impressed. The VideoSpigot includes VFW, Asymetrix Multimedia ToolBook, and a pair of ToolBook-based presentation programs. This is, in one box, everything you need not only to capture great-looking video but to build that video into presentations and programs as well.

The technology behind the VideoSpigot's video quality has one aspect in

BYTE ACTION SUMMARY

- **WHAT VIDEO FOR WINDOWS CAPTURE BOARDS ARE**
  PC boards that can digitize several frames of external video per second, which VFW stores to your disk as a digital-video file to be played back later.
- **LIKES**
  Very easy to use once they're installed; video-in-a-window boards support both analog and digital video and multiple video/audio sources.
- **DISLIKES**
  Video-in-a-window boards limit system memory to 15 MB; there are incompatibilities with nonstandard VGA modes; some boards exhibit unpredictable behavior.
- **RECOMMENDATIONS**
  For straight VFW capture, Creative Labs' VideoSpigot for Windows is the best choice; for quality and versatility, the Matrox Marvel wins over other video-in-a-window cards.

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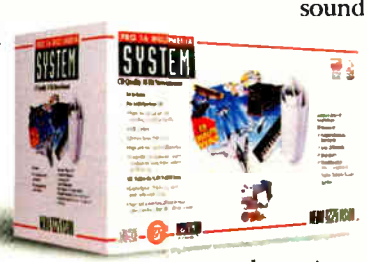

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COMPANY INFORMATION

AITech International
(VideoSurge)
830 Hillview Court, Suite 145
Milpitas, CA 95035
(408) 946-3291
fax: (408) 946-3597
Circle 1227 on Inquiry Card.

Creative Labs, Inc.
(VideoBlaster, VideoSpigot)
1901 McCarthy Blvd.
Milpitas, CA 95035
(408) 428-6600
fax: (408) 428-6611
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Matrox Electronics Systems, Ltd.
(Matrox Marvel)
1055 St. Regis Blvd.
Dorval, Quebec,
Canada H9P 2T4
(514) 685-2630
fax: (514) 685-2853
Circle 1229 on Inquiry Card.

New Media Graphics
(Super VideoWindows)
780 Boston Rd.
Billerica, MA 01821
(508) 663-0666
fax: (508) 663-6678
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common with the Marvel: A special digital encoding scheme captures and stores twice as much color information as typical overlay boards. This translates into truer colors and better representation of subtle shading variations. The VideoSpigot is not an overlay board, so it can't display incoming video in real time. It also has no provision for pass-through audio. What it does have is great capture performance, both composite and S-video connectors, and the most complete capture-driver software of any VFW board on the market.

The VideoSpigot's capture driver supports some uncommon codec formats, including VFW's only software compressed-on-the-fly format (Spigot Compression). The VideoSpigot aced all the performance tests, beating all the other cards for capture rates while turning in exceptional quality.

Windows Video at Its Best

The overall best choice for Video for Windows capture hardware is Creative Labs' VideoSpigot. The standard software bundle, advanced codecs, effortless installation, and S-video input place it head and shoulders above the rest of the pack for VFW capture alone.

In my work, I tend to create applications that call for both analog and digital video. For that combination, I'm strongly inclined toward the Matrox Marvel. Its video quality is unmatched by any overlay board I've seen, the optional on-board VGA makes combining high-color Windows and video-in-a-window a snap, and Marvel's keyframe effects, tastefully applied, can give a multimedia application a little extra polish. ■

Tom Yager is a multimedia consultant, analyst, and producer. You can reach him on BIX as "tyager" and on the Internet at tyager@bytepb.byte.com.

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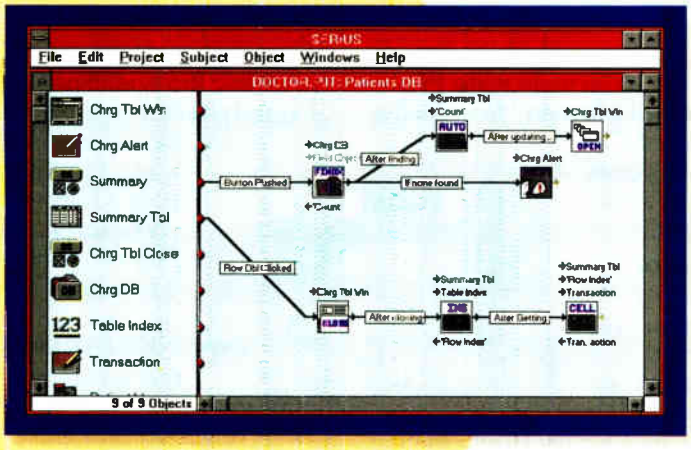

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HARDWARE

Tape Backup on the Go

HOWARD EGLOWSTEIN

We've all made excuses about tape backup: "I have no free drive bays for a tape drive" or "It's too expensive to buy a tape drive for one machine" are common rationalizations around the office. And on the road, there's simply no way to connect a SCSI- or floppy drive–interface tape drive to your laptop.

Parallel-port tape drives solve these problems. They plug into your PC's printer port and allow you to connect your printer through a pass-through port. In the office, you can carry the drive from machine to machine and share the cost of the drive among several users. A small parallel-port tape drive will tuck nicely into your laptop computer bag and save you from data disasters on the road.

This review covers four 250-MB, parallel-port tape drives: the Jumbo Trakker 250 from Colorado Memory Systems, the Tape250 from Iomega, the Backpack tape drive from Micro Solutions, and the Model 250P from Storage Devices, Inc. (SDI). A fifth drive, the Archive SuperHornet, did not ship in time for this evaluation. All these units are QIC (quarter-inch cartridge) 80 format and store 80 MB on a standard DC2000 cartridge, or 120 MB on an extended-length DC2000XL or DC2120 cartridge.

In addition, the software that comes with each drive provides data-compression routines that promise to compress your data at a ratio of about 2 to 1, for a potential tape capacity of 250 MB. In most cases, the compression will fall short of the 2-to-1 ratio because a lot of data on your machine may already be compressed. Many bit-mapped image formats include some compression, and files made with ARC or PKZip probably won't compress at all. Expect to get between 180 and 200 MB of data on one of these drives.

To test these tape drives, I connected each one to a 33-MHz 486 EISA machine with a fast SCSI hard drive and an EISA SCSI controller (see the figure for test results). I used a fast machine to ensure that the machine's performance wasn't a significant factor in the transfer rates. The 486's 300-MB drive had 200 MB of mixed data, including a complete Windows installation with a variety of applications, several DOS applications, and lots of text and image files. The mix is typical of what you'd find on desktops.

Portable tape drives connect to your PC through a standard printer port and provide tape backup-and-restore functions. Pass-through connections let you keep your printer connected at the same time. From left to right: Colorado Memory Systems' Jumbo Trakker 250, SDI's Model 250P (top), Iomega's Tape250, and Micro Solutions' Backpack tape drive. All except the Iomega Tape250 use an external power brick (the Trakker's is a bit large for portable use).

I timed a complete backup/verify cycle of the 200-MB mix and deleted a 10-MB directory from the hard drive. The second test was a timed restore of that 10-MB directory. By comparing the time taken and space used on the tape, I determined the tape drive's transfer rate and the tape software's compression ratio. Our battery test fixture, Thumper 2, kept the timing fair (and automated). I put a custom activity detector between the computer and the tape drive; any transition of the data lines looked like a transition on Thumper's screen sensor inputs. A second computer used the status messages from Thumper to accurately time transfers.

Colorado Memory Systems' Jumbo Trakker 250

The Jumbo Trakker 250 is the parallel-port version of Colorado's internal QIC 80 tape drive. The $548 package I reviewed came with the drive, two preformatted DC2120 tapes, and version 2.58 of Colorado's backup software. This version is being replaced with a much flashier version, 3.04, and I had a chance to look at a prerelease version 3.04 as well.

The Trakker 250's backup software managed the best compression ratio in the group: 1.8 to 1. The other units achieved rates between 1.5 to 1 and 1.7 to 1. On a fast machine like the 33-MHz 486, speed improves with compression; on slower machines, turning compression off will make backups faster but use more tape. Trakker's TAPE.EXE includes both menus and a command-line interface. You can do anything from the command line that you can do from the menus.

Trakker 250 tapes are fully compatible with the standard Jumbo drives. If your office machine has one of these internal drives, you can share data directly with your laptop.

Only two things prevent the Trakker from being the perfect portable tape drive: The power brick is very large and heavy (with the brick, the Trakker weighs 4.2 pounds), and the software has to be installed on a hard drive before it will run. When recovering from a hard disk crash, I'd appreciate being able to run the restore software from a floppy disk.

Iomega's Tape250

Iomega has a reputation for solid equipment. The $548 Tape250 is easily the beefiest drive in the group, and it looks built to last. To enhance reliability and portability, the Tape250 has no special connection cables or power bricks. You power the drive with a standard AC cord

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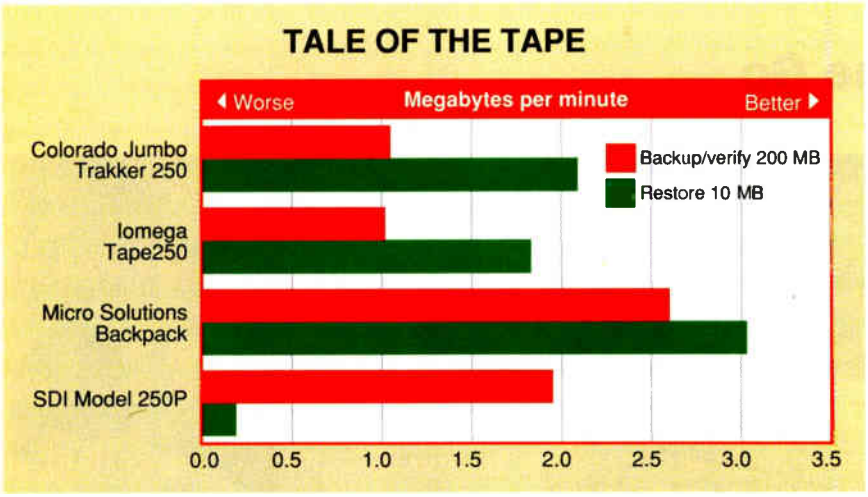

The graph indicates the kind of performance you can expect when backing up and restoring a typical mix of data. The Micro Solutions Backpack was the fastest drive. The SDI Model 250P may have posted better restore times, but its software insisted on scanning an entire tape even after recovering the requested files.

BYTE ACTION SUMMARY

- **WHAT PARALLEL-PORT TAPE DRIVES ARE**
  These tape drives hold up to 250 MB of data and connect directly to your PC's parallel port. A pass-through connection lets a printer share the port.
- **LIKES**
  They're portable, convenient, and easy to set up and use; an excellent solution for notebook computers.
- **DISLIKES**
  The power bricks and cables are a hassle to carry around, and the one unit without a power brick, the Iomega Tape250, makes too much noise.
- **RECOMMENDATIONS**
  For backing up notebook computers, the Backpack is the smallest and fastest unit around. In an office environment, the Jumbo Trakker is sturdy and reliable.
- **PRICE**
  Backpack, $539
  Jumbo Trakker 250, $548
  Model 250P, $549
  Tape250, $548

and hook it up through a standard 36-pin printer cord (one is provided with the drive). A 25-pin connector on the drive accepts your existing printer cable, enabling you to print in pass-through mode. When you're traveling, you could conceivably take just the drive and trust that someone at your destination will have a power cord and printer cable. You don't need to lug around an extra cable and power brick. Still, the drive is no lightweight; it tips the scales at 4.1 pounds.

Unfortunately, the internal AC supply on the Tape250 requires an internal fan. The fan on this drive was louder than the power-supply fan on the full-size 486 to which it was connected. You'll definitely want to turn the drive off between uses to keep from annoying everyone around you; but with the drive turned off, you can't use connect-through printing.

The backup software is Central Point's CPBACKUP, a large, unwieldy backup package with an obscure user interface. It consumes over 2 MB of disk space and requires a hard drive installation before use. It also turned in the slowest performance in the backup/verify test.

Micro Solutions' Backpack Tape Drive

For portable use, it's hard to beat the $539 Backpack tape drive. It's small and lightweight (just 3.2 pounds complete), and it comes with a fairly small power brick. It's also fast, completing both the backup/verify test and the restore test in significantly less time than the rest.

BPBACKUP, the Backpack's utility software, formats tape and handles backup and restore operations. It's DOS-based and slightly outdated, but it works reliably and is simple enough to use. For a transportable drive, a simple backup application can be a big win. For example, one of the hard drives in your office might go crazy and damage its directory. The first thing you'll want to do is back up any readable data files. The software included with the other drives requires that you install it onto the hard drive first. Do that, and you'll risk damaging the directory and FAT (file allocation table) structures even further. BPBACKUP will run comfortably off a floppy drive and requires no configuration.

BPBACKUP's major drawback is its lack of a command-line interface. Unlike with the Trakker 250's software, you can't control BPBACKUP from a batch file. Instead, you have BPBACKUP create a keyboard macro that records your tape commands and writes out a separate DOS executable file. Later you run the new executable program, which loads BPBACKUP for you and automates backup. It works, but I'd still prefer a command-line interface.

SDI's Model 250P

I was impressed by the small size and weight (2.6 pounds) of the Model 250P drive ($549) and SDI's choice of Gazelle Systems' Back-It 4 as a backup utility. I've used previous versions of Back-It before, and they were quite usable.

SDI provides a custom Back-It tape driver and a standard copy of Back-It 4. After you install Back-It, you specify that all your backups should go to tape and use the SDI driver. My 486/33 had a compatibility problem with Back-It's "compatibility" mode. SDI's technical support was quickly able to diagnose the situation. Everything went fine after I changed a default setting.

Well, sort of. Back-It 4 doesn't appear to keep track of the original DOS directory structure in one place on the tape. As a consequence, when you restore data, Back-It has to search the entire backup to find what you asked for. For the 10-MB restore test, the directory I wanted off tape was early in the backup mix; Back-It found and restored the data in less than 4 minutes. However, it didn't know it had finished and kept reading for the better part of an hour. If I had specified data at the end of the backup, Back-It wouldn't have been smart enough to skip over the first part of the tape.

Back-It also uses a proprietary tape format that makes it impossible to read Back-It tapes on any other drive. The other drives all support standard QIC 40/80 formats and can interchange tapes to some degree.

continued

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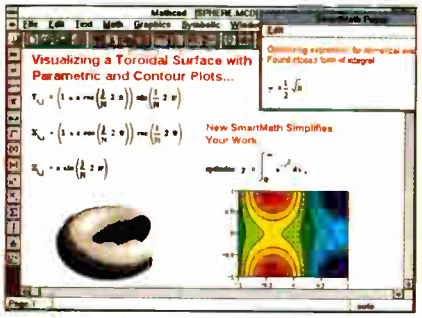

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TAPE BACKUP ON THE GO

Have You Backed Up Lately?

With notebook computers regularly shipping with 200-MB drives, it's difficult to imagine anyone using a new notebook without some sort of backup. These portable tape drives are perfect for drives up to 200 MB—for transient use in the office as well as for portables. But which one? For me, that would depend on the specific application.

For extended traveling, I'd want a tape drive along with my notebook, and that would probably be Micro Solutions' Backpack. It's small and fast, and the software runs easily without being installed onto the hard drive. That can be a lifesaver in the event of a disk crash.

Around the office, weight isn't as much of an issue. Colorado Memory Systems' Jumbo Trakker 250 is a solid drive that should stand up to lots of use. The Trakker software's full command-line interface greatly simplifies automated backups. ■

Howard Eglowstein is a BYTE Lab testing editor who holds an S.B. from MIT. Contact him on BIX as "heglowstein."

COMPANY INFORMATION

Colorado Memory Systems, Inc.
(Jumbo Trakker 250)
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SOFTWARE

Lotus 1-2-3 Release 3.4 for DOS

NICHOLAS JOHN DELONAS

Lotus 1-2-3 release 3.4 for DOS is a continuation of the "high-end" series of 1-2-3 for DOS. The new release ships with some swell bells and whistles, but the real news is that it runs quite a bit faster than its predecessor, release 3.1+. Is it full-featured enough and, what is more important, fast enough to justify an upgrade from either release 2.4 or release 3.1+?

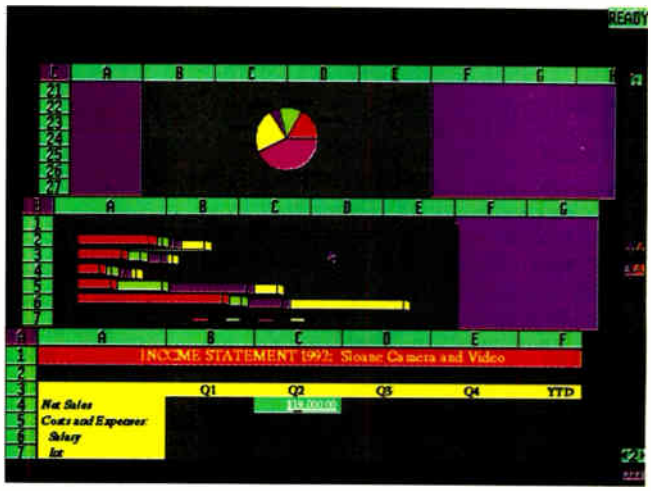
As you might expect, that depends on what you need. All 3.1+ users and most 2.4 users should be happy with the new product. The one user who will be less enthusiastic is the macro developer now working with 2.4. Despite significant optimization of 3.4, the old-style, "low-end" 2.4 still runs macros much faster than any other major spreadsheet program. Release 2.4 users may also be unhappy with higher RAM requirements (1 MB versus 384 KB) and the lack of a true character mode (3.4 is always in graphical mode, WYSIWYG or not).

Lotus has made some big claims about performance improvements, and benchmarks tend to support its boasting. Release 3.4 is indeed faster than 3.1+ in every way. In every worksheet I tested, 3.4 recalculated at least 12 percent faster than 3.1+, and sometimes as much as 29 percent faster. In my tests, 3.4 consistently recalculated worksheets faster than 2.4 and, more often than not, outperformed 1-2-3/W 1.1.

But 3.4 fell far short of 2.4 in terms of loading and macro processing. Release 2.4 loads much faster, coming up from the command line more than twice as fast as 3.4. And macros ran over 30 percent faster in 2.4 than in 3.4. However, 3.4 easily runs 1-2-3 macros faster than 1-2-3/W, Excel, and both versions of Quattro Pro (although Excel and Quattro Pro generally *recalculate* worksheets faster than any version of 1-2-3).

More Than Fast

Aside from performance, Lotus worked on improving 3.1+ in other ways. For example, release 3.4 provides updated DataLens drivers, to make better use of external dBase, Paradox, and SQL Server files. Backsolver technology is a bit better, now supporting simultaneous changes to multiple variables. You can now load a worksheet directly from the command line.



Lotus 1-2-3 release 3.4 for DOS introduces SmartIcons that let you perform common tasks with a click of the mouse.

The most noticeable difference in 3.4 is the column of SmartIcons on the right edge of the display (see the screen). This puts the 3.x line on a par with 2.4, and the two products share many of the same icons. If you like to use the mouse and haven't made the jump to Windows or OS/2, you'll appreciate the convenience of these SmartIcons.

For macro developers, an important bonus in 3.4 is the inclusion of the 2.4-style macro-trace facility. This lets you step through macro code and view each command before it executes.

Release 3.4 is definitely an improvement over 3.1+. It's worth the $150 upgrade price if you need faster recalculations. Macro developers now working with 3.1+ will appreciate the long-overdue macro-trace feature. Power users fond of 2.4 may be less impressed with the new release. Unless you need 3-D or the external data-access features of DataLens, stick with 2.4. ■

Nicholas John Delonas is a consultant based in Boston, Massachusetts. He is also coeditor of The Spreadsheet Consultant, *a newsletter for spreadsheet power users. You can contact him on BIX as "ndelonas."*

BYTE ACTION SUMMARY

- **WHAT LOTUS 1-2-3 RELEASE 3.4 IS**
  Lotus's latest high-end DOS spreadsheet—the successor to 1-2-3 release 3.1+.
- **LIKES**
  Performance is much improved over 1-2-3 release 3.1+. Release 3.4's DataLens is better than Excel's Q+E and Quattro Pro for Windows' Database Desktop.
- **DISLIKES**
  No character mode. Macro processing is slow when compared with release 2.4.
- **RECOMMENDATIONS**
  Worth the upgrade from release 3.1+ for recalculation speed. Stick with release 2.4 unless you need 3-D spreadsheets or database access.
- **PRICE**
  Standard edition, $595
  Upgrade or competitive upgrade from Quattro Pro for DOS, $150
- **FOR MORE INFORMATION**
  Lotus Development Corp.
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  Cambridge, MA 02142
  (617) 577-8500
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BOOK
AND CD-ROM REVIEWS

HUGH KENNER

FROM THE MIND OF MIT

Up the Infinite Corridor: MIT and the Technical Imagination
Fred Hapgood
Addison-Wesley, $22.95,
ISBN 0-201-08293-4

Fractal Vision: Put Fractals to Work for You
Dick Oliver
Sams, $39.95,
ISBN 0-672-30248-9

Probably "the tightest and most elegant piece of cash register code in the entire country" sits in a restaurant in Santa Fe. It materialized after an engineer was told that there was no way to make him a copy of his receipt. He and a friend demanded a look at the program that drove the cash register. Ugh! Spaghetti! "Booby traps cocked and waiting!" They didn't leave till, after several hours, they had recast it from the ground up.

Brighten, you see, the corner where you are; notably, any corner of solution space that comes your way. Fred Hapgood, who says he was present at that Santa Fe dinner, writes comfortably at a level of abstraction from which he can zoom in to anecdotes and out to the aesthetics of disturbing the universe. His *Up the Infinite Corridor: MIT and the Technical Imagination* disjoins the engineer from the blacksmith (an alter ego for much of two centuries) while managing not to beach the engineer amid the nerds.

"The products of engineering are tools, and the test of a well-made tool, of one that is a credit to its designer, is the speed with which it vanishes into the consciousness of its user. (This is what distinguishes tool-making from sculpture.) When we fly to some city we say that 'we' flew there, not that the jet did." That's lucid, low-pressure prose. The first half of the book—mainly a history of engineering in the U.S. and at MIT—is continuously illuminating. (Why was hydraulic power for so long an American specialty? Hapgood can tell you the answer.)

Though the second half seems much less sure what it's up to, by the last page we've still understood a lot. "What we do is find out what silicon wants to do and get out of its way," an MIT professor is saying three pages from the end, and somehow you're prepared to accept that silicon can, yes, nudge mind toward a tighter marriage with nature. Anyone who can make that feel obvious in a mere 50,000-odd words is a gifted writer indeed.

The same week brought me the following book, Dick Oliver's *Fractal Vision: Put Fractals to Work for You*. I can't be the only user of his Fractal Grafics software—reviewed here in May 1991—to have admired it, doodled a little, and set it aside. Not that it's hard to use; no, you just don't glimpse its range. All along, it's needed a book to give it context. Fortunately, Oliver's English is as deft as his C, and what he's now provided is the best introduction to fractal geometry I know of. It comes with a DOS disk—the full current retail version of Fractal Grafics, plus addenda. So every few pages the writer can break off to coach you through a hands-on demonstration.

Thus, a section called "How Long is the Coast of Maine?" is spiced by a session with the Koch Coastline (16 numbered step-by-step instructions). And when we come to the nonintuitive fractal dimension, rumors of which can send browsers rushing off screaming, we're calmly led through a routine that computes it for a curve we've just drawn.

From "A History of Fractals and Chaos" we're led to "Fractals in the Real World," "The Philosophy of Fractals," "The Art of Fractal Modeling," and "The Math Behind the Magic." There are *lots* of illustrations, including a color insert. There's a first-rate bibliography. And what nudges the mind all through this big book isn't silicon, it's the uncanny fit between fractal math and the real-world shapes of clouds and trees and chickens. ■

Hugh Kenner is Franklin and Callaway Professor of English at the University of Georgia. His recent books include Mazes *and* Historical Fictions. *You can contact him on BIX as "hkenner."*

THE SCOOP ON NT

Inside Windows NT, *Helen Custer*, Microsoft Press, $24.95, ISBN 1-55615-481-X

Helen Custer's *Inside Windows NT* is neither technical reference nor design philosophy, although it includes elements of each of these. Custer's book is like Peter Norton's classic work *Inside the IBM PC* in terms of depth and scope, providing users and developers alike with a thorough tour of Microsoft's highly publicized next-generation operating system.

This is a great overview. Custer proceeds from a top-level description of NT and its design goals to deep inside the NT kernel, always keeping NT's object orientation in the forefront. Along the way, she covers the structure of NT's Win32 subsystem and virtual memory manager, with a stop for a detailed discussion of NT's multilayered I/O architecture. Objects pervade NT, and Custer skillfully uses the relationships of NT's objects as a unifying thread through each of these diverse subjects.

Inside Windows NT isn't an easy read. There's plenty of meat here, and sometimes I had to slog through the details before I could glimpse the overall picture. If you're an NT developer, slogging through is well worth the effort. *Inside Windows NT* gives you most of the information that you would have found at a developer's conference, API details aside. But this book isn't just for developers; it's also for curious and technically adept users who want to peek behind the curtain. Like *Inside the IBM PC*, Custer's book provides you with more details than you can comfortably swallow—but once those details are digested, you'll know NT inside and out.

—*Steve Apiki*

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MULTIMEDIA QUARTET

Multimedia Toolkit, *Russell Lipton,* Random House Electronic Publishing, $45, ISBN 0-679-74084-8
Instant Multimedia for Windows 3.1, *Kris Jamsa,* John Wiley & Sons, $29.95, ISBN 0-471-58972-1
Multimedia Creations, *Philip Shaddock,* Waite Group Press, $44.95, ISBN 1-878739-26-3
Multimedia: Making It Work, *Tay Vaughan,* Osborne McGraw-Hill, $27.95, ISBN 0-07-881869-9

No subject is filling bookshelves and magazine pages faster than multimedia, and four new books give this subject varied treatments. In *Multimedia Toolkit,* Russell Lipton is clearly influenced by hypertext, as both the focus of his book and its layout. Unfortunately, the "paper-hypertext" layout only clouds the book's content, which is more a collection of the author's opinions than a hands-on guide. Lipton includes the Bell Atlantic DocuSource hypertext document builder on disk.

Kris Jamsa's *Instant Multimedia for Windows 3.1* is an introduction to the field. It includes a Windows PC speaker driver, sound files, animations, and a screen saver on disk. The text contains plenty of references to real products, and the book's approach is grounded in off-the-shelf applications and the enclosed sample programs.

If you prefer DOS, pick up Philip Shaddock's *Multimedia Creations,* which includes a version of Paul Mace Software's Grasp graphical authoring system on disk. Shaddock uses Grasp to describe techniques for building procedural multimedia programs. This version of Grasp has only primitive facilities for using nongraphical media (you can order Grasp Multimedia for $249), but this is a good introduction to procedural multimedia authoring.

Tay Vaughan's *Multimedia: Making It Work* promises to cover "everything you need to know" about multimedia. If you limit your scope to the PC and Mac, I agree: This book is the most useful of the lot and easily the best multimedia book I've seen. It's filled with useful examples, some built around the included Tempra GIF and Show programs (for DOS). The publisher offers a reasonably priced ($32.95) companion CD-ROM that's piled high with multimedia demonstrations and tools for DOS, Mac, and Windows.

—Tom Yager

Tom Yager is a multimedia consultant, analyst, and developer based in Amherst, New Hampshire. He is the author of The Multimedia Production Handbook for the PC, Macintosh and Amiga *(Academic Press, forthcoming). He can be contacted on BIX as "tyager."*

COMPTON'S COMES UP SHORT

Compton's Interactive Encyclopedia for Windows 3.1, $395; **Compton's Multimedia Encyclopedia for Macintosh,** $795, Compton's NewMedia, Inc., 2320 Camino Vida Roble, Carlsbad, CA 92009, (619) 929-2500

These two largely identical encyclopedias contain all 9 million words of a printed encyclopedia (32,000 articles, 13,000 visuals), plus 50 minutes of sound, music, and speech. They also include the whole Merriam-Webster OnLine Dictionary ("70,000 definitions of 60,000 words"). They've been put together in unconcealed breathlessness; although the copyright date is 1992, the Moscow article still stages May Day and October parades in Red Square.

Like the Grolier package reviewed here two months ago, Compton's claims a pretty fancy search engine. That's certainly been the weak spot of Gutenberg technology: only one ordering (alphabetic by article title), abetted by an occasional "See also."

Alas, Compton's demonstrates how, even technologized, search strategy can remain a weak spot. The Guided Tour in the Windows version can walk us to a sample topic; let's choose Space Travel. We can get from there to Astronauts, thence to Articles, whereupon a cross-reference to Language offers something tied to Astronauts: "People who work together—astronauts, doctors, gangsters—often share special work words, a sort of shop talk." Yes, yes, the chaining is ingenious, but did anything useful get done? All the search engine has turned up is the nigh-random presence of the word *astronauts* in a piece about something else.

And the implementation itself seems not quite bug-free. Icons in the left margin of an article promise Video for Windows enhancements (the Mac version has animations only); but the first time I clicked on a Videos icon from Astronauts, a "Precondition violated" error message about "BorlandC\allinc" kicked me right out of Compton's. (Later tries did fare better.)

Or, out of interest in moviedom, let's try Animation. An Idea Search yields a list of seven articles: Cartoons, France, Motion Pictures, Directing, Jules Feiffer, Compact Disk, and Horse. France and Horse are there because both topics teem with animated critters, Frenchfolk and Steeds, respectively. Feiffer is there because he did animation during a hitch in the Signal Corps. But what's *not* present? The encyclopedia has a fairly long article on Walt Disney that the Idea Search failed to list, and it's surely evident that Disney here deserved precedence over Feiffer, let alone Horse. One way Idea Search spends its time is "computing scores," presumably to select the finalists for display in a box with only seven lines. I'd say the scoring algorithm needs work.

And speaking of Animation, I find little enlightenment in 1-second snippets like "Birds—How They Fly," even aided by the frame-by-frame option. Multimedia, yes, hence jazzy. But seldom informative. The bird is hand-drawn, side view, and flaps through eight frames, of which 7 and 8 repeat 1 and 2 in different locations. True, his red beak is nice.

In short, this is a dreary attempt to move a routine 26-volume printed work into the twenty-first century. It corrects the most egregious misjudgments of the same publisher's Multimedia Encyclopedia for Windows, now withdrawn, without beginning to approach the Grolier publisher's intelligence. If you crave interaction, get Grolier; if less breathy, get some books.

—Hugh Kenner

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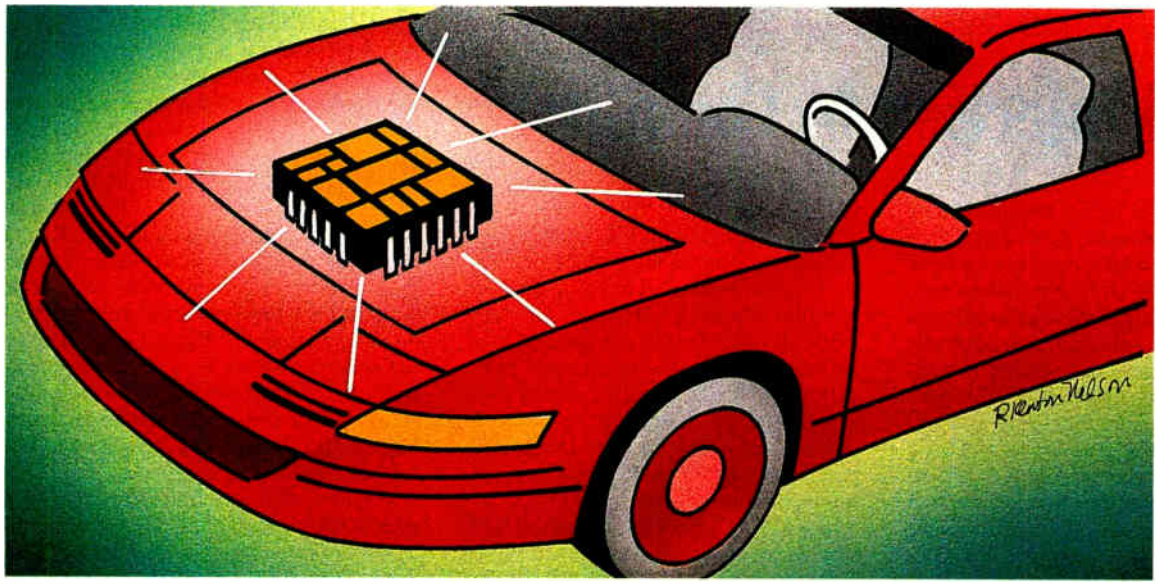
DICK POUNTAIN

COMPUTING ON WHEELS



LANs, parallel processing, and RISC technology are driving a new generation of passenger cars

If you've purchased a new car in the past five years, chances are that the engine systems are computer controlled. Today's automotive computer systems already control fuel injection and ignition; your next car may incorporate RISC- or CISC-based control systems that communicate over tiny LANs, monitoring everything from your power brakes and suspension system to the on-board navigation system. In fact, these features are already included in some race cars.

Why the push toward automotive computerization? One reason is government regulations. With the successive waves of ever-tougher emissions legislation that are being introduced, it's practically impossible for any engine to meet U.S. government emission standards without the aid of computer control. Many other computer advances are driven by the plummeting costs of microprocessor power and the need of manufacturers to gain an edge in the highly competitive passenger car market. This month's column goes under the hood—literally—to examine how computer systems are changing automobile designs.

Where Computers Work

To understand how computers are revolutionizing automobile designs, you first must understand how an engine works. Most internal combustion engines are based on a piston design. Each piston moves back and forth in its cylinder, driven by the combustion of a hydrocarbon fuel and air mixture, and transmits the power it generates to a rotating crankshaft.

Engine designs vary, but all share four crucial control variables: the quantity of the mixture of fuel and air that's admitted to the cylinder, the ratio of fuel to air in that mixture, the timing of the mixture's admission relative to the piston position, and the timing of the mixture's ignition. These four variables must all be held within very narrow ranges for the engine to work, and some of them must be varied within equally precise limits to alter the engine's power output to meet different loads.

Unfortunately, there is no neat mathematical function that relates these key variables to engine load. Even with the aid of sophisticated computer simulation, designing a new engine remains a strongly empirical task that involves running prototypes on a dynamometer under different load conditions.

Much of the knowledge acquired on a test rig gets "frozen" into the physical structure of the engine (e.g., its bore-to-stroke ratio and crank throw) and into various peripheral devices that control the variables in production versions of the engine. For example, some of this information resides in the cams that raise and lower the valves in a four-cycle engine and determine the inlet and exhaust timing. The cam profiles are complex curves that "compute" an empirically determined function that

ILLUSTRATION: R. KENTON NELSON © 1993

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relates valve lift to crank angle.

This simple analog "computer" is reprogrammable, as any racing enthusiast who has installed a "hot" camshaft can testify. Similarly, an old-style carburetor contains information about the correct composition and quantity of the fuel-and-air mixture for different engine loads. The information is encoded as the diameters of various fuel jets and air passageways, which a garage mechanic can partially "reprogram" by, for example, turning an idle adjustment screw or changing the jets on a race car. The introduction of microprocessors for engine control has not done away with these stores of empirically acquired knowledge, but they now exist as tables of digital data (called *maps*) stored in ROM rather than as physical attributes of mechanical devices.

When fuel injectors began to displace carburetors in the 1980s (see the text box "Fuel Injection by Computer" at the left), the door was opened to fully computerized engine management: Integrated electronic control of all the variables became possible. These electronic EMUs (engine management units) have brought with them the benefits of lower fuel consumption, lower exhaust emissions, better cold-starting, smoother power delivery, better cruise control, steadier idling, and faster pickup.

Fuel Injection by Computer

Computers began taking control of automobile functions when fuel-injection systems became popular. Unlike a carburetor, which passively draws fuel from a jet by way of a passing airflow, a fuel injector is a pump that squirts a measured quantity of liquid fuel into an automobile's inlet manifold. The key advantage of such a system from a computing perspective is that, unlike carburetors, fuel injectors are actuated electrically by a solenoid, allowing computer control.

It's impractical to measure directly the volume of fuel that is passing through an injector nozzle, so instead the fuel is delivered at a constant pressure and the duration of the injector's squirt is used as a measure of volume. To vary the amount of fuel injected into the engine, the computer alters the pulse width of the train of electrical impulses that start and stop the injectors (see figure A).

Less expensive fuel-injection systems use a *central* injection scheme, in which a single fuel injector sprays fuel into a forking inlet manifold that feeds all the cylinders. *Sequential* injection systems use one injector per cylinder, spraying directly onto the inlet valves just prior to the valve's opening. Sequential injection gives the most precise engine control but consumes more computing power.

Between these two extremes lie *banked* injection schemes, which provide an injector for each cylinder. With this method, all injectors fire simultaneously; the system uses the frequency and duration of injection to control the fuel supply.

Sequential injection already rules in the racing world for performance reasons. It is now being used more frequently in passenger cars to meet emission standards.

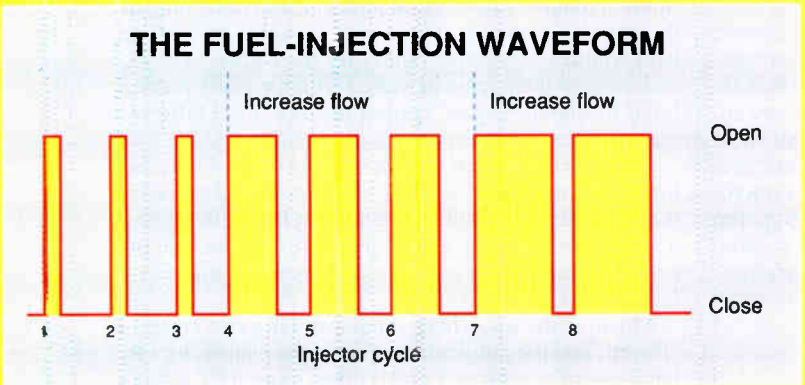

Figure A: *Fuel injectors work by pulse-width modulation of fuel flow. Computers such as Ford's EEC-IV can easily generate such waveforms to control the fuel-injection process.*

EMUs: A Closer Look

A basic EMU for a gasoline engine has just two inputs: one for the throttle opening and one for the crankshaft position. Such a system would compute just three outputs: injector-pulse start time, pulse width, and spark timing. In the real world, however, things are not so simple. While throttle opening is a reasonable predictor of load for racing engines, which operate flat-out most of the time, passenger cars must cope with a wide variety of partial throttle loads. As a result, many EMUs in passenger cars use either a mass air-flow sensor or a manifold air-pressure sensor to measure the volume of air entering the engine, and they use the throttle opening primarily to detect sudden load changes.

Figure 1 shows a block diagram of a typical EMU, containing a single-chip microprocessor, some working RAM, program code and engine maps stored in ROM, multiple digital and analog input channels, and multiple digital outputs. There's also a small amount of rewritable EEPROM, which is used to store maps computed dynamically at run time.

The three main engine maps store the ideal injector pulse start, pulse width, and ignition timings, respectively, for a range of different engine speeds and loads. The load might be represented by throttle valve angle, intake air flow, or air pressure. The manufacturer compiles these tables empirically on the dynamometer bench.

You can think of these engine maps as describing 3-D surfaces in an abstract engine-parameter space. The CPU reads the ideal values from the maps for the current engine speed and load (interpolating between data points if necessary) and then applies corrections calculated from the other inputs. For example, the intake air pressure and intake air temperature inputs can be applied to compensate for the density of the actual mixture entering the engine, which is why a modern EMU-controlled car doesn't pop and sputter when you drive it over a 10,000-foot mountain pass.

The EMU uses the engine-coolant temperature input to detect different running conditions (e.g., cold starting, warming

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up, or cruising), which require adjustments to the optimum fuel-to-air ratio. From the throttle input, for example, the EMU can detect sudden hard acceleration, a situation when it must temporarily richen the fuel mixture for smooth pickup. To improve fuel economy and reduce emissions, the EMU shuts off the fuel supply when the vehicle is decelerating. The EMU can detect deceleration by monitoring the vehicle-speed input from an electronic speedometer.

The fuel pressure supplied to the injectors is not an absolute constant, but rather a constant amount above the air pressure in the intake (which varies with the throttle opening), so an EMU can use the intake-pressure input to control fuel pump pressure. Mass-produced fuel injectors can't be made accurate enough to guarantee the perfect mixture that minimizes unburned hydrocarbon emissions—referred to by combustion chemists as the *stoichiometric* mixture. The injectors' delivered volume varies between samples, and it also changes slowly due to wear and tear during the service life of the engine.

It's not economical to hand-calibrate the injectors in every vehicle, so the EMU uses a UEGO (universal exhaust gas oxygen) sensor to detect any increase in exhaust emissions. The CPU uses this information in a closed feedback loop to compute a table of correction factors, which it stores in EEPROM (or less expensive battery-backed RAM). Exhaust and evaporative emission regulations also dictate the necessity of extra outputs to control exhaust gas recycling, as well as "canister purge" for the subsystem to trap fuel evaporating from the gas tank.

Even controlling the idle speed of an engine is a complex process on a typical American sedan; the pumps and motors that drive the power steering and air-conditioning can cause a variable load on the engine even when the vehicle isn't moving, and the computer needs to compensate for this to maintain a constant idle speed. I've omitted these inputs from figure 1 (along with others, such as battery voltage and ignition switch position) for clarity.

Engine maps are rarely changed after an automobile leaves the factory, but an aftermarket in "hot" ROMs has developed among performance enthusiasts. These chips, which contain more radical but less environmentally friendly maps, are the digital equivalents of the hot-rodder's racing carburetor. In the near future, most EMUs will contain some rewritable map storage so that service engineers armed with diagnostic computers can fine-tune an engine to make it stay within the new, tougher exhaust-emission laws.

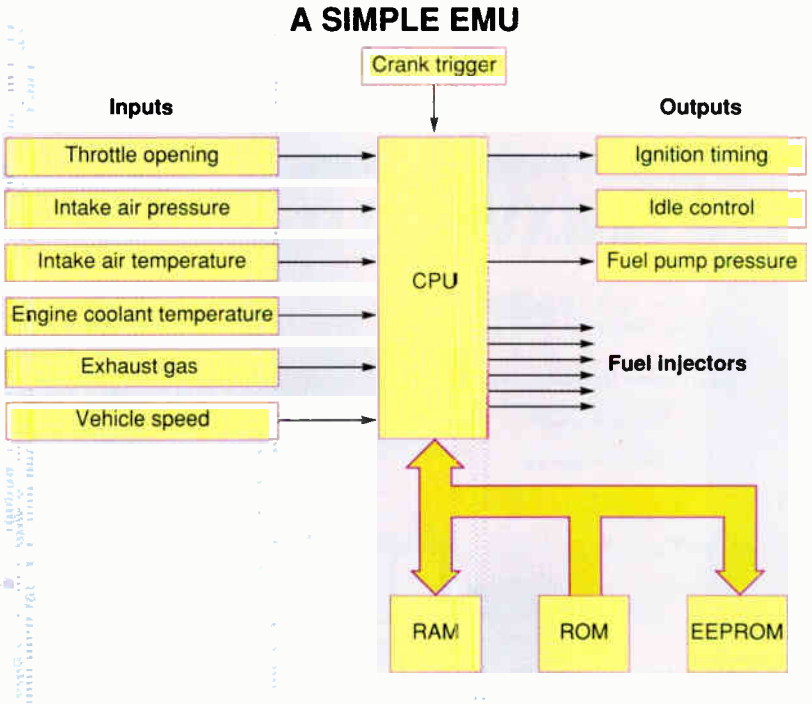

Figure 1: *A typical EMU processes multiple inputs using engine "maps" in RAM, ROM, or EEPROM to control engine fuel injectors and ignition and idle controls. The turning crankshaft serves as the CPU clock.*

Computing for Performance

The most taxing aspect of engine management is not computational power; it's I/O. For the most part, computations consist of table lookups, followed by rather simple integer arithmetic to apply correction factors. The real problem comes in sampling all the inputs in the limited amount of time available.

In this respect, an EMU resembles other embedded real-time control systems, although it's not a true real-time system: It actually operates in *crankshaft time*. Important engine events, such as fuel injection and spark ignition, take place relative to the position of the valves and pistons, and hence the angle of rotation of the crankshaft, so the primary input to the EMU is a master timing interrupt from a sensor (referred to as the *crank trigger* in figure 1). In practice, the camshaft in a four-cycle engine generates a similar event so the EMU can distinguish intake cycles from exhaust cycles.

In multicylinder engines, the piston strokes are always staggered. In a V-6, for example, a different spark plug might fire after every 60 degrees of crankshaft rotation, and the trigger interrupt would then be generated six times per crank revolution, typically by a magnetic Hall-effect switch. Engine speed can vary between about 1000 rpm at idle to perhaps 9000 rpm (or up to more than 15,000 rpm for a racing engine).

All the inputs must be sampled, and all the necessary computations must be performed, in the interval between successive ignitions. That interval is on the order of 20 milliseconds at idle and 2 to 3 ms at top speed. (For a V-12 Grand Prix racing engine, the interval can be as short as 600 microseconds.) The shortest interval determines the peak computing power needed; at idle the CPU will have spare cycles that might be used to process less time-critical background tasks.

The raw CPU performance required for a passenger car's EMU is at present still within the abilities of 16-bit CISC processors. A low chip count is desirable for both road and race applications because PCB (printed-circuit-board) space is at a premium and cost is a critical factor. This rules out general-purpose PC processors like the Intel 80x86 or Motorola 680x0 families, which would require many peripheral chips to achieve sufficient I/O bandwidth.

Instead, EMU manufacturers like Delco, Nippondenso, Lucas, and Bosch favor embedded microcontrollers (e.g., the Intel 8096 family). Ford has designed its own custom CPU. All these processors tend to feature many on-chip I/O lines, timers,

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and A/D converters, as well as ROM and RAM, all of which can reduce chip count enormously.

Most EMU manufacturers are evaluating 32-bit RISC processors, but it's likely that faster I/O will prove more attractive than raw CPU speed for next-generation EMUs. Many manufacturers are moving to dedicated timing-control circuits that service timer tasks such as event capture and comparison and pulse accumulation without interrupting the CPU. This frees the CPU for other duties and increases the timing resolution—microcode is faster than software. The TPU (time processing unit) module of Motorola's 68300 family exemplifies this approach, while Ford's 8016 and Siemens's 80166 have similar functions built into the CPU.

Ford's EEC-IV

Ford refers to its EMUs as EECs (Electronic Engine Controls). Introduced in 1979, the first EEC, called the EEC-I, was a simple ignition-spark controller. In the early 1980s, the EEC-II and EEC-III added fuel-injection control and were based on a curious 11-bit chip from Motorola. Then in 1983, Ford teamed up with Intel to develop the 8061, a special CPU for engine control that powers the EEC-IV that's currently used in Ford's passenger cars and in Ford-Benetton racing engines (see photo 1). The 8061 chip itself is proprietary to Ford, but Intel used the experience it gained during the CPU's development to design the 8096 microcontroller family.

The 8061 is a 16-bit microprocessor with 120 registers and extensive on-chip I/O and timing control, including 13 analog inputs (with 10-bit A/D converters) and eight digital inputs. It was designed with low chip and pin counts as primary goals. Clocked at 12 to 18 MHz, the 8061 delivers a modest 1.6 MIPS, but its high-speed custom I/O renders this sufficient to control even a V-12 racing engine using sequential fuel injection at 14,000 rpm.

Events that enter the 8061 are time-tagged and placed into a FIFO (first-in/first-out) buffer so that the CPU can deal with them in its own time. Similarly, output events are placed into a circular FIFO buffer called a *carousel*, leaving the CPU free to proceed. This results in much more efficient CPU throughput than would be achieved in a purely interrupt-driven system. The 8061 contains a proprietary 8-bit multiplexed bus interface (called the M-bus) for which Ford has developed several peripheral chips: the RAM, EPROM, EEPROM, and the communications controller that make up the EEC-IV.

The CART (custom asynchronous receiver/transmitter) chip in the 8061 controls a 19.2-kilobaud serial network running over simple twisted-pair cabling that can be run through a car's normal wiring loom. This network uses phase modulation and collision detection to provide a very high degree of fault tolerance and noise resistance.

The EEC-IV uses this CART network to communicate with the instrument cluster; over the next few years Ford plans to extend communications to the other electronic systems available in today's automobiles, such as speed-sensitive power steering, antilock brakes, and electronic suspension control. Ford also plans to replace the CART network with its faster 83-kilobaud SCP (Standard Corporate Protocol) technology in the 1994 model year.

In Ford's racing engines, the EEC-IV periodically broadcasts key parameters such as engine rpm and throttle opening to all systems, and any system can request direct node-to-node conversations. This capability will appear in passenger cars within the next two years.

A recent addition to EEC-IV is an on-board diagnostics system that enables service engineers to check the state of the ignition, fuel injectors, and exhaust emissions by plugging in a hand-held terminal. Such systems will be required by U.S. law beginning in 1994.

The EEC-IV exemplifies the original Henry Ford philosophy that revolutionized mass production: Use relatively low-tech, low-cost components with long product life cycles; use well-defined proprietary interfaces that allow for future expansion; and achieve economies of scale by using the same units across all models. Ford uses the racing EEC-IV units as test-beds and will take their performance in racing cars into account when it refines EECs for passenger cars.

High-Tech Performance

At the opposite end of the spectrum from the EEC-IV lies the no-compromise racing EMUs made by companies such as Tag Electronics (Woking, U.K.). These EMUs can cost up to $35,900 (£25,000) each—more than the purchase price of many cars. The Tag/McLaren Group owns, among other things, the famous Tag-Heuer Swiss watch brand and the phenomenally successful McLaren formula-1 racing team.

The latest Tagtronic 2.12F control unit is a multiprocessor system that contains seven microcontrollers and three DSP (digital signal processor) chips that put out a staggering combined computational power of 106 MIPS (see photo 2). The microcontrollers (which are hidden on the back side of the data acquisition board) are devoted to I/O processing, table lookup, and

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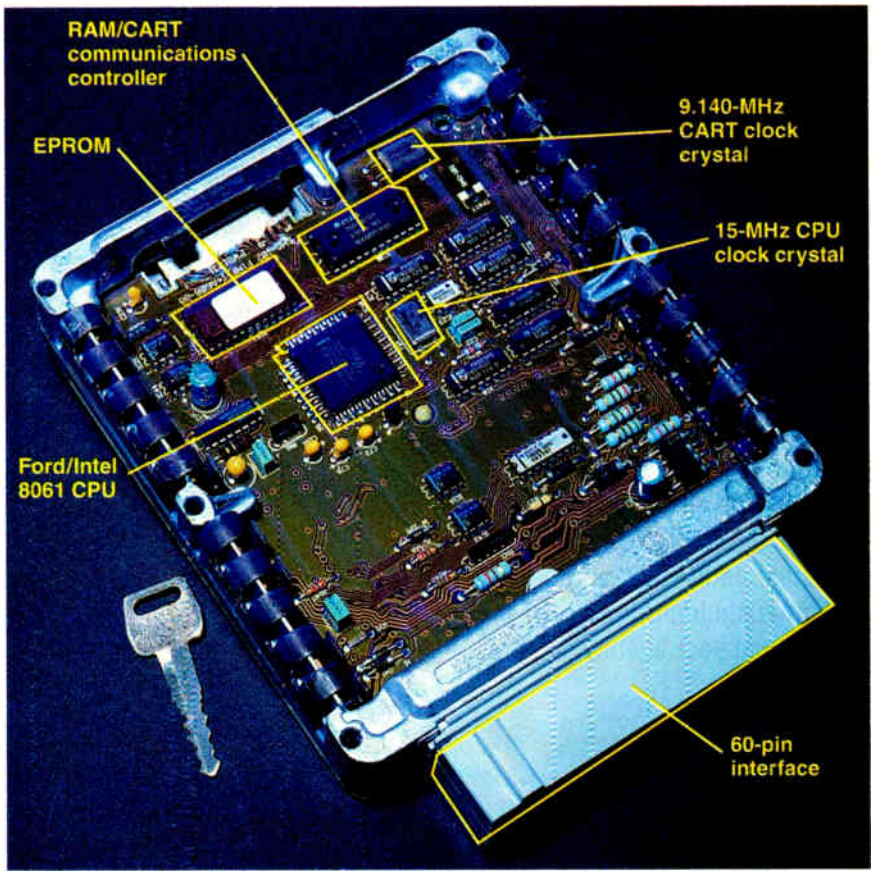

Photo 1: *Ford's EEC-IV uses a proprietary Ford/Intel 16-bit 1.6-MIPS CPU to handle 13 analog and eight digital inputs. The chip communicates with RAM, EPROM, and a CART communications controller chip. The latter controls a 19.2-kilobaud serial network running over twisted-pair wiring in the car's wiring loom. In the future it will communicate with systems such as the power steering, antilock brakes, and electronic suspension-control systems. The entire circuit board is sealed with a clear epoxy layer to protect it from vibration and dust.*

calculations; the DSPs also perform the calculations and handle serial communications. The 2.12F monitors over 40 inputs (the EEC-IV handles only 10), and many of these inputs are duplicated with redundant sensors.

On the output side, the 2.12F can control up to 24 sequential injectors (a V-12 engine with two injectors per cylinder for more precise mixture control) and 12 spark plugs. The 2.12F's impressive computing power brings only a relatively small engine performance increase. A 60-fold increase in computing power (compared to the EEC-IV) buys an increase in total power output of only a few percentage points, but those points might decide a world racing championship.

The Tagtronic 2.12F is more than just an EMU. It's also a test-bench and telemetry system that performs sophisticated engine analyses and stores the resulting diagnostic data in 4 MB of internal RAM. A built-in UHF radio receiver allows pit crew engineers to modify the engine maps on the move while a 5-Mbps telemetry system dumps the diagnostic RAM contents to the engineer's workstations each time the car passes the pits.

The Tagtronic 2.12F has inputs for four exhaust gas/oxygen sensors. These are wideband devices that can keep *lambda* (a measure of mixture strength) at 0.8 to maximize power output, whereas EMUs in road cars are designed to anchor lambda to 1.0, the point of minimum exhaust emissions. Thanks to the 2.12F's on-board DSPs, an engineer can program sophisticated combustion-analysis algorithms (often involving fast Fourier transforms) into the 2.12F that control spark advance via a closed-feedback loop and optimize the engine for various exotic racing fuels. Combustion-knock-sensor inputs allow the 2.12F to avoid engine-destroying detonation. While a passenger car's EMU

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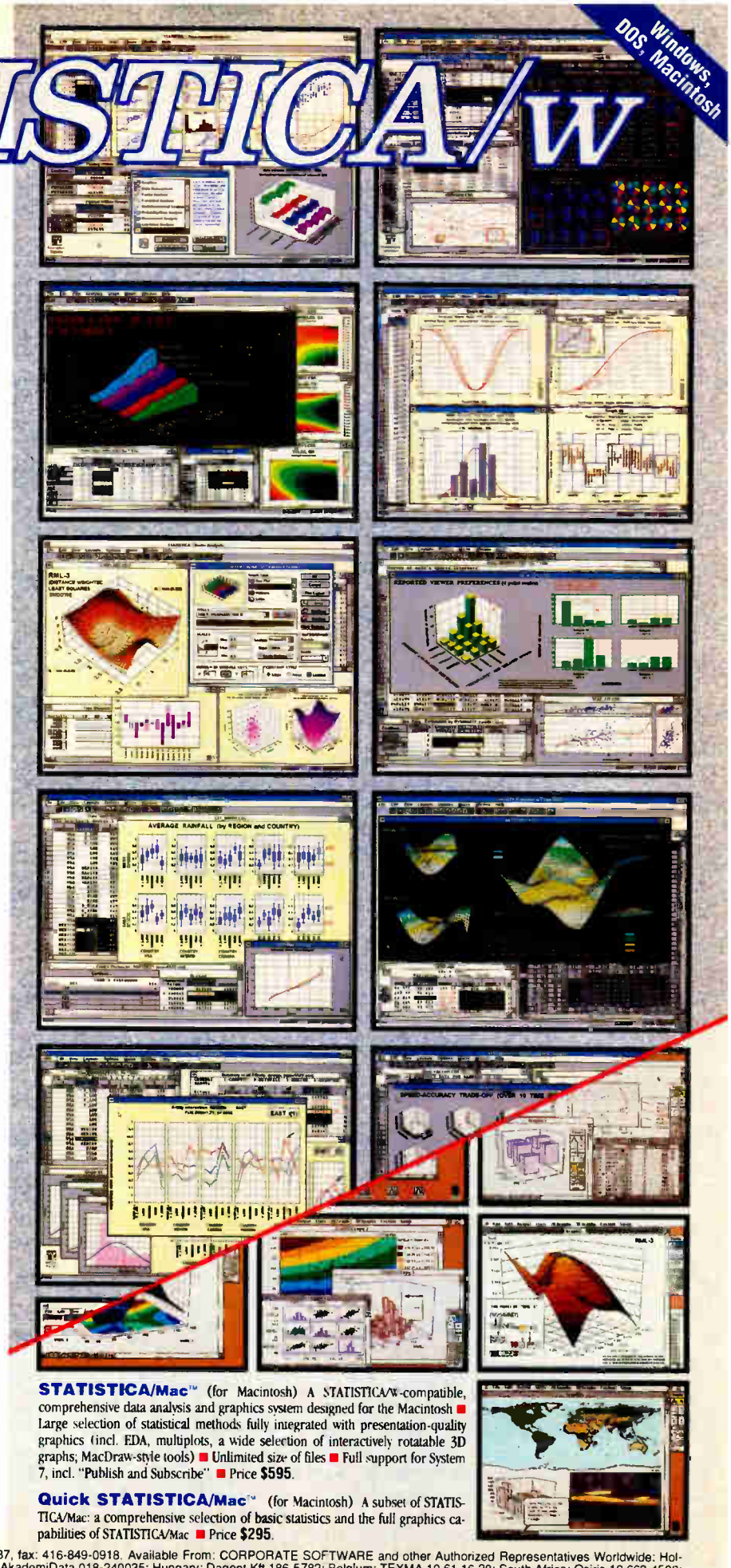

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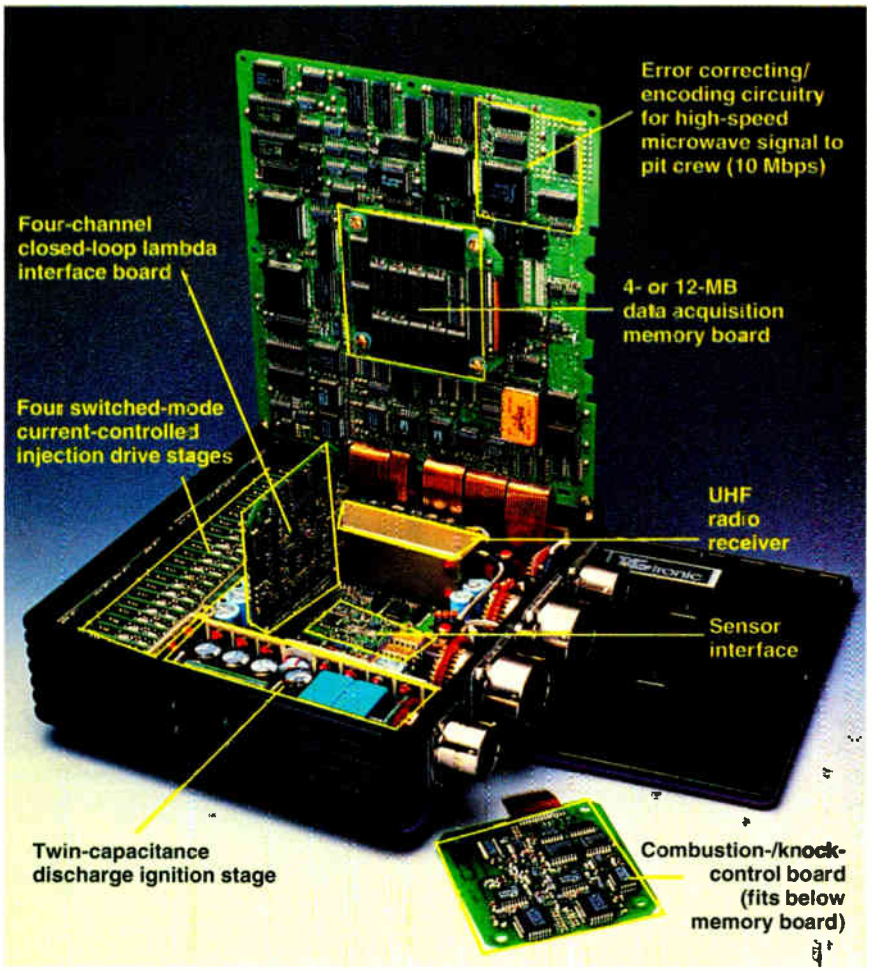

Photo 2: *The Tagtronic 2.12F multiprocessor racing control system includes seven Siemens 80C166 CPUs and three Analog Devices 2101-2111 DSPs (hidden from view) that crank out 106 MIPS. Most processing cycles are spent handling I/O from over 40 inputs. A data acquisition board performs real-time diagnostics that are transmitted to pit crew engineers via a microwave link. The engineers then transmit modified engine data maps to the unit's UHF receiver on the fly.*

optimizes the engine for fuel economy, drivability, and cleanliness, the 2.12F enables an engine to run continuously at the very edge of its performance envelope, just this side of self-destruction.

The seven microcontrollers used in the 2.12F are Siemens 80C166s, 16-bit devices with 1 KB of RAM and an eight-channel peripheral event controller that can transfer bytes or words in a single CPU cycle. Also on-chip are two USART (universal synchronous/asynchronous receiver/transmitter) serial interfaces, 10 multiplexed analog inputs with 10-bit A/D conversion, five 16-bit counter/timers, and a CAPCOM (capture/compare) unit that generates timing sequences and waveforms for 16 channels at 400-nanosecond resolution per channel.

That's a great deal of control hardware, but the 2.12F still needs seven of these devices to get the necessary I/O bandwidth. The three DSP chips are Analog Devices 2101-2111s. Together these 10 processors form a shared-memory parallel computer system that is programmed entirely in assembly language and needs no operating system.

Tag uses equally drastic PCB technology to cram the electronics into a 2-kilogram magnesium box that's roughly 20 by 17 by 6 centimeters in size. The 32-layer PCBs use blind *vias* (connections between buried layers) and are completely encrusted on both sides with surface-mount chips. They may well be the most densely packed PCBs made anywhere—the military and the aerospace industry included—and they can tolerate peak vibrations of up to 60 g's.

Next Year's Model

Computers are going beyond the automobile engine and are beginning to control many other automobile systems. You can see a glimpse of the future in today's racing designs. Top formula-1 race cars began using computer-controlled ride height (called *active suspension*) only a few years ago, but this feature is already beginning to appear in passenger cars. Most new cars now offer computer-controlled ABS braking, and some already offer speed-sensitive power steering.

Other technologies ready for prime time include computerized driver aids like fuel-usage computers, navigational and route-finding systems, and radar sensors for automatic collision avoidance. Luxury cars even have "smart" seats that remember your seating preference.

As they become more common, these control systems will need to communicate with one another. For example, an active ride system must know when engine power increases or when the brakes are applied so it can make necessary changes to the suspension system.

Loading all these functions onto a single central computer might seem to be an attractive option. Doing so would minimize the cost of the silicon, but it would almost certainly require adoption of a proper real-time operating system (such as OS-9 or Chorus) in place of the ad hoc hand-crafted software approach that's currently being used.

Instead, new designs are integrating spatially and computationally related systems. For example, engine management goes hand-in-hand with gear-box control and traction control, as do braking and suspension control. In the interim, manufacturers will place in each car a small number of powerful control computers that communicate over highly reliable networks of the type that Ford and Bosch have pioneered. Intel, Bosch, and Philips are promoting their CAN (Controller Area Network) bus system as an industry standard. However, as in the personal computer industry, the emergence of universal standards does not happen easily in such a highly competitive market. ■

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Dick Pountain is a BYTE consulting editor based in London. You can reach him on BIX as "dickp."

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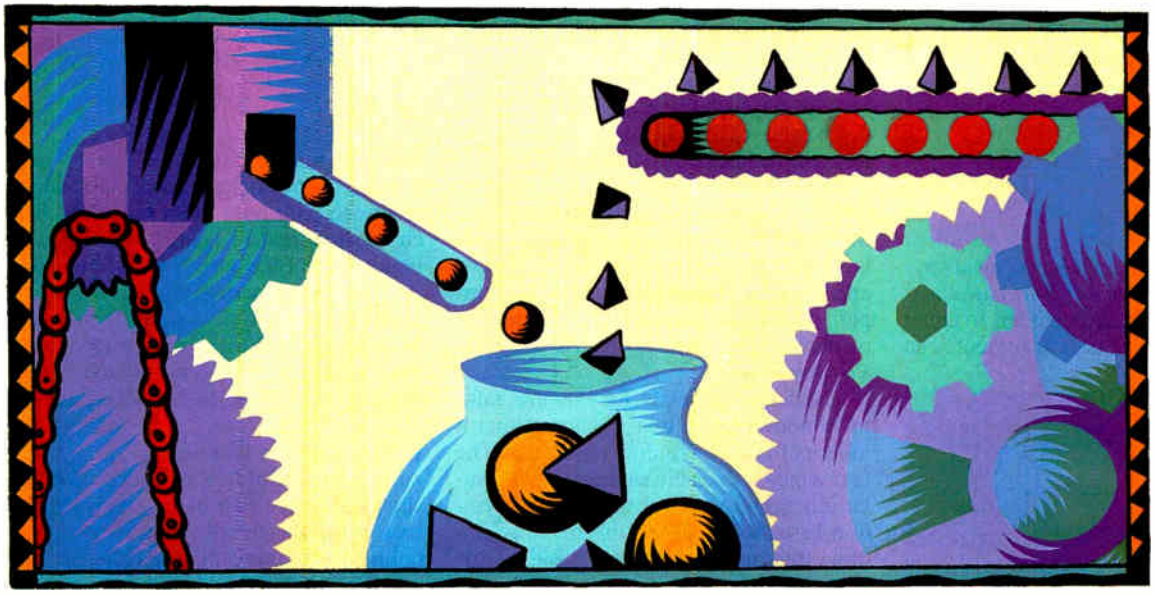
ALLEN HOLUB

THE POWER OF INHERITANCE



Here's how to tap the power of multiple inheritance in your C++ class hierarchy designs

Multiple inheritance means that a class can derive from more than one base class. It's one of the most powerful, controversial, and poorly understood features of C++. In this column, I'll discuss what's right and wrong with multiple inheritance in C++ and give you some tips on how to design a C++ class hierarchy.

Derivatives of a base class satisfy the "is-a" test. An Employee class, for example, might include information such as name and salary. A Manager class, derived from Employee, might add a list of managed employees. Similarly, a Peon class, also derived from Employee, might add other fields appropriate to peons. Both a Manager and a Peon are Employees, so the "is-a" test holds. Because a Manager *is an* Employee, all functions that can manipulate employees can also manipulate a Manager (or, more accurately, can manipulate the Employee component of the Manager object). In other words, this class design abstracts the fields common to Manager and Peon—name and salary—into a shared base class.

What happens, however, when you want to store Employee objects in a linked list? A typical list implementation uses two class definitions: The member functions of a *List* class insert, delete, or find objects of the class *List_node*. To use another kind of object in the list, you derive a class from List_node. Since an object of that derived class is a List_node, you can pass it to any function that expects a List_node (i.e., object, pointer, or reference) argument—in particular, to the List member functions. To list employees, then, you derive the Employee class from List_node, so all Employee objects and their descendants can be part of a list (see figure 1 and listing 1).

Mix-in Classes

Unfortunately, this solution wastes storage. A List_node contains pointers needed for list manipulation. Since Employee derives from List_node, all Employees have to carry around these pointers, whether or not they're actually being used. Suppose you need to make lists of Peons but never of Managers. Every Manager will unnecessarily include space for a List_node.

Enter the notion of a "mix-in" class (the term comes from Grady Booch's *Object-Oriented Design with Applications*, Benjamin-Cummings, 1991). In this model, an Employee is not a List_node in the same way that a Manager is an Employee. Rather, one aspect of an Employee is *listability*. With multiple inheritance, you can mix listability into Peons without having to make Managers listable, too (see figure 2 and listing 2).

Problems with Multiple Inheritance

One source of difficulty is when you merge class libraries. Say you have two, both organized in a Smalltalk way by deriving everything from a root object. I'll call the two root classes ObjClassA and ObjClassB. One of the

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hierarchies supports a set-of-ObjClassA's class, and the other supports basic data structures like a tree-of-ObjClassB's class. Thus, an object of any class that derives from ObjClassA can be added to a set, and an object of any class that derives from ObjClassB can be added to a tree. How do you create an object that can be in either a set or a tree? You can derive a new class from both base classes:

```
class myCombinedClass
 : public ObjClassA
 , public ObjClassB {...};
set s;
tree t;
myCombinedClass *p
  = new myCombinedclass;
s.add(p);
t.add(p);
```

Since a derived-class object can always be converted to any of its public base classes, all functions that take pointers to either ObjClassA or ObjClassB arguments can take a pointer to a MyCombinedClass object. For example, the MyCombinedClass object derives from ObjClassA, so it can be put into a set by passing a pointer to the `set::add()` function, which expects an ObjClassA pointer argument. Since MyCombinedClass also derives from ObjClassB, a MyCombinedClass object can also be put into a tree.

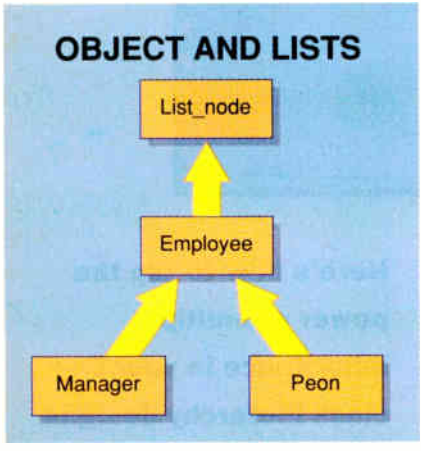

Figure 1: *In this example, all Employee objects and their descendants are stored in one linked list.*

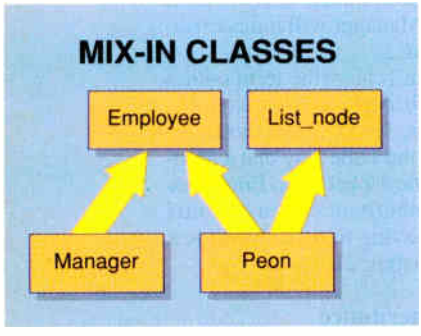

Figure 2: *Here, Employee is not a List_node, but Peon becomes "listable" by way of List_node.*

There are problems, though. For one thing, there's likely to be overlap between the set and the tree operations. That means you'll have to call in two versions of some functions, one from each library. Moreover, each of the root classes is likely to contain fields that the set or tree classes don't need, so the MyCombinedClass object will be larger than it needs to be.

Other combined-library problems are even trickier. Imagine trying to merge two Microsoft Windows class libraries. One has a very nice editable-text-window class, and the other has good dialog-box support, but each uses the Smalltalk technique of deriving all classes from a common Window class.

The dialog-box class, for example, talks to Windows by calling a function that it inherits from its Window base class. The text window does the same, using a similar function from its own, different, Window base class. Odds are that the two Windows interfaces aren't compatible, so this organization makes it impossible to pick and choose from the two class hierarchies.

You can't pluck a class definition from the middle of one hierarchy and plug it into the other. Unless the two interfaces can coexist (unlikely), you'll be able to use only one library. Even if they can, you'll have to put both libraries into your program, swelling it to huge proportions.

Curiouser and Curiouser

There's a further complication. Except for constructors and `operator=()` overloads, the derived class inherits all public functions of both base classes. All messages handled by objects of either base class can be handled by the derived-class object as well. Things can get tricky, though, when the developers of ObjClassA and ObjClassB use identical names for member functions. For example, both base classes could have a member function called `print()`. When you send a `print()` message to the MyCombinedClass object:

```
myCombinedClass confused;
confused.print();
```

the compiler won't know whether to call `ObjClassA::print()` or `ObjClassB::print()` and will print a hard-error message.

You can solve this problem, to some extent, by introducing an unambiguous `print()` member function into the derived class:

```
class myCombinedClass
 : public ObjClassA
 , public ObjClassB
{
public:
 void print(void)
 {
   ObjClassA::print();
   ObjClassB::print();
 }
};
```

A call to `confused.print()` now gets the one from the derived class, which chains to both base-class functions. The class names and `::` operator take the ambiguity out of the base-class references.

A "disambiguating" function isn't an ideal solution. A class definition should be a black box. You should be able to derive a class without having to worry about the function names the base class uses.

Pure Interface Classes

Another multiple-inheritance problem shows up when two base classes share a base class. This usually happens when you define a class that defines an interface but nothing else. Suppose you want to create a common interface to several different data structures. You can start with a Node class that defines an interface to objects of the class Data_structure. The Node class might contain virtual functions that handle messages like "print yourself" and "insert yourself into the data structure." These functions must be virtual because there's no way to know how to perform the operation at the Node level.

Together, the Node and Data_structure classes simply define an interface. Implementation requires that you derive, for example, Tree_node and Tree classes that flesh out the interface with necessary data fields and methods.

The alleged advantages of using classes that do nothing but define an interface are twofold. First, because data structures share a common interface, maintenance is easier; once you learn how to manipulate a tree, you'll also know how to manipulate linked lists, hash tables, or other derivatives of Data_structure. Second, you can write functions that can manipulate data structures without having to know about those data structures. A function, for example, can take a pointer to a Data_structure and add an item to it just by calling its `add_item()` method.

The disadvantages of having a base class

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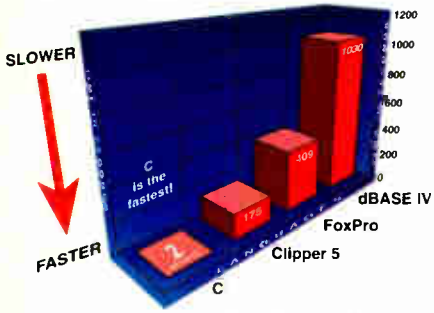

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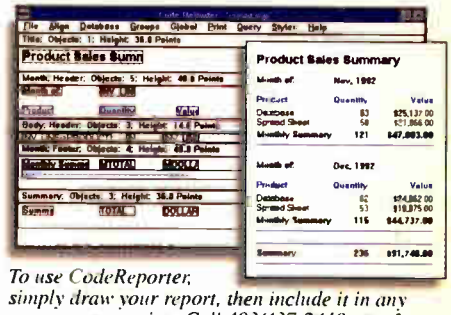

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Listing 1: *Standard multiple inheritance.*

```
class list_node // an element of a list
{
  list_node *next, *previous;
};
class list
{
public:
  insert( list_node *p );
};
class employee : public list_node
{
  char *name;
};
class manager : public employee
{
    list peons;  // managed people
};
// A peon is an employee.
class peon : public employee
{
  // Peon information goes here.
};
list      the_list;
list_node *p;
// A peon "is-an" employee and list_node.
p = new peon;
the_list.insert( p );
// Managers work the same way.
p = new manager;
the_list.insert( p );
```

Listing 2: *Using a mix-in class.*

```
class employee
{
    string name;
};
// A manager is an employee.
class manager : public employee
{
    list peons;  // managed people
};
// A peon is an employee and listable.
class peon : public employee
           , public list_node
{
 // Peon information goes here.
};
list      the_list;
list_node *p;
p = new peon;

 // A peon "is-a" list_node.
the_list.insert( p );
p = new manager;
// But managers are not list_nodes.
the_list.insert( p );
```

that just defines an interface show up when multiple inheritance comes into the picture. Say you created a Linked_list that derives from Data_structure (and a List_node that derives from Node). You then want to create an Employee class, objects of which can be put into either trees or linked lists (or both). You can try to do this with multiple inheritance by adding the following classes:

```
class linked_list
 : public data_structure {};
class list_node
 : public node {};
class tree
 : public data_structure {};
class tree_node
 : public node {};
class employee
 : public tree_node
 , public list_node
{
 // Information about an
 // employee goes here.
};
```

Ambiguous Inheritance

The resulting diamond-shaped class hierarchy (see figure 3) has a classic problem: There is more than one path from a derived class (Employee) to one of its base classes (Node). But the actual layout of an Employee object in memory (see figure 4) shows that there are two Node components of an Employee, which is correct if you want an employee to be in a linked list and a tree simultaneously.

There are several difficulties here. First, both List_node and Tree_node inherit public functions from Node. If you try to call one of these functions through an Employee object, the compiler will complain—it won't know which inherited version to call. (More properly, it won't know which Node component of the Employee to send the message to—there are two possible `this` pointers.) You can solve this problem by introducing a disambiguating function to the Employee class that calls one (or both) of the inherited functions:

```
employee::f()
{
 list_node::f();
 tree_node::f();
}
```

but that's a maintenance headache.

What if the Employee will be in either a tree or a list, but never in both at once? In this case, the duplicate Node component of the Employee object wastes memory; one Node will do. What if the common Node class caused an external side effect (e.g., creating a window) as it was constructed? A single Employee object would incorrectly create two windows when its two Node components were initialized. A partial solution to this is to redefine the class hierarchy to use virtual base classes:

```
class list_node
 : virtual public node {};
class tree_node
 : virtual public node {};
class employee
 : public tree_node
 , public list_node
{
};
```

Now that you've made a base class virtual, only one object of that class will be in the derived-class composite object, even if several of the derived class's base classes themselves derive from the same virtual base class. If there are both virtual and normal instances of the base class in the hierarchy, one object will be created for all the virtual instances, and additional objects will be added for each nonvirtual instance. There will be only one Node, because all Nodes are virtual base classes.

Again, there are difficulties. You must decide to make the Node virtual when you

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create the Tree_node and List_node classes. Having done so, you can't put an object in a tree and a list simultaneously, and the only way to know that's true is to examine the entire class hierarchy, looking for virtual base classes. The only solution is to derive two classes for each data structure, one with the Node base class declared virtual and one with the virtual omitted—but this, too, presents a maintenance problem.

Avoiding Problems

In general, C++ classes should do something real. They should have state data (i.e., fields) manipulated by the member functions. Don't impose a Smalltalk hierarchy onto C++; they're different languages.

You can argue that if two classes share any functionality, then that functionality should move into a common base class. The reasoning is that a single body of code is simpler to maintain. But remember that inheritance is a form of coupling, so merging functionality into a base class can cause as many problems as it solves. Adding base classes also increases the depth of the class hierarchy and adds complexity to it. In practice, a little duplication of code doesn't hurt anything, provided that the programmer uses identical interfaces to the duplicate functions.

C++ is closer to C than it is to Smalltalk, which posits that the language should force the programmer to use a particular interface. For C++, the C philosophy of a gentleman's agreement is a better approach. For example, there's nothing in the language that forces you to put the destination first when a function takes source and destination arguments; you do it, however, to keep yourself sane. By the same token, there's nothing stopping you from accessing the elements of a `FILE` structure directly, but you don't do it, because those elements might change with the next compiler release.

Similarly, nothing keeps you from using a common interface to all data-structure-element classes. Your good sense should encourage you to do so. Thus, you can just dispense with the abstract Node base class and define Tree_ node and List_node classes that have the same member functions but don't derive from anything. Since all the Node functions are virtual, you can do this by just removing `:public node` from the existing definitions. In fact, one way to ensure that the interfaces are the same is to use the Node base class initially and then comment it out once the class compiles. Eliminating the Node class eliminates all the multiple-inheritance-related problems that come with it.

What you lose when you eliminate

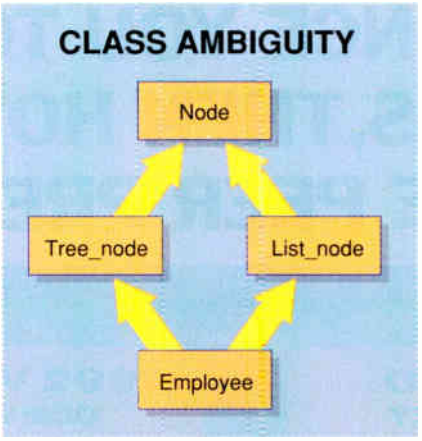

Figure 3: *The path from Employee to Node class only appears ambiguous (see figure 4).*

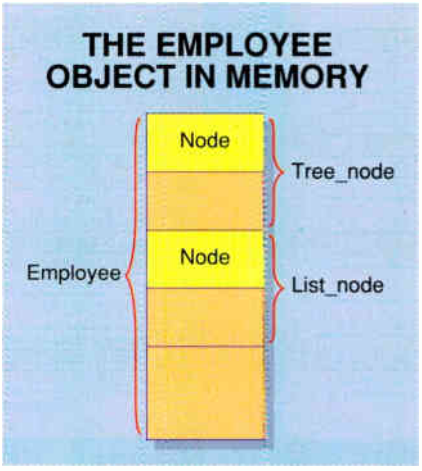

Figure 4: *The memory layout of the Employee object in figure 3 shows that there are actually two Node components.*

Node is the ability to manipulate generic Data_structure and Node objects blindly. But in practice it's almost never the case that you can write a function in complete isolation. A function that traverses all the Node objects in some data structure, for example, is going to have to do something with those nodes, and so will have to know what kind of Node it expects.

It's handy to be able to write a function that manipulates a generic data structure:

```
some_function( data_structure
    *p );
```

but you can use a `typedef` to get the same effect:

```
typedef tree
    the_data_structure;
some_function( the_data_
    structure *p );
```

Rules for Multiple Inheritance

There are a few rules you should follow to use multiple inheritance safely. Use multiple inheritance only for mix-in classes that add capabilities to a class. Avoid classes that do nothing more than define an interface. (Typically, these classes have no member data, and all or most of the member functions are pure virtual functions.) Use similar interfaces for mix-in classes that do similar things.

Problems with multiple inheritance often arise because inheritance itself is used inappropriately. Since it is a form of coupling, avoid it unless you're really extending the definition of a base class—customizing it for a particular application. You can check yourself by ensuring that the derived class satisfies the "is-a" test, although this can be tricky. You could argue, for example, that a "pop-up window" is a "window" and derive a Popup class from Window. Similarly, you could argue that a "blue window" is a "window" and derive a Bluewindow class from Window. If you now try to create a blue pop-up window by deriving simultaneously from both Popup and Bluewindow, you'll have the dreaded diamond-shaped inheritance graph discussed earlier.

A better approach treats "color" and "display methodology" as components of a window. That is, a window has (not *is*) a color, and it has (not *is*) a display methodology. The window class provides `set_color()` and `set_display_method()` functions that you can use to customize it. You can create your blue pop-up window with single inheritance, deriving directly from the Window class. If you can choose between "has-a" and "is-a" in an implementation, try to go with the former.

Multiple inheritance is a powerful and flexible way to mix capabilities into classes. Used properly, it brings few problems and has many benefits. To use it properly, design your class libraries from the ground up to support multiple inheritance. ■

Editor's note: *The complete listings for this article are available in electronic format. See page 5 for details.*

Allen Holub teaches C++ and compiler design for the University of California at Berkeley Extension. His recent books include C+C++: Programming with Objects in C and C++ *(McGraw-Hill, 1991) and* Compiler Design in C *(Prentice-Hall, 1990). You can reach him on BIX c/o "editors" or on the Internet at holub@violet.berkeley.edu.*

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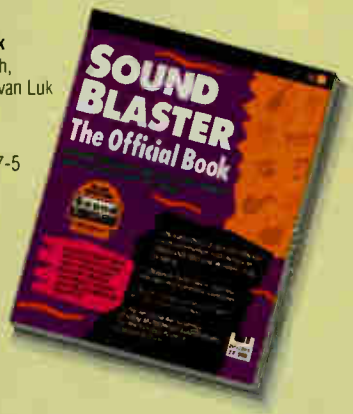

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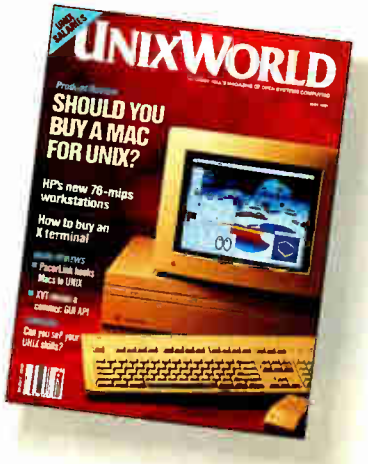

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GETTING A HANDLE ON NT

Businesses cannot afford software systems that make informal or implicit assumptions about the conditions in which they execute. By formally including such assumptions, you let the software behave robustly. The operating systems, languages, and tools simply afford varying degrees of convenience for expressing the subtleties of the design.

Windows NT's proposed C-language extensions and structured exception-handling model provide excellent design tools for meeting this goal. Win32 under NT introduces concisely expressed solutions to design problems that have impeded the development of vigorous software programs and plagued Windows 3.x with reliability problems. When used with a good design, these tools produce a software system of unparalleled reliability.

The Object Model

A good exception-handling model does nothing without a good software design. An object-oriented model provides the foundation for your software design because it lets you build reliability and robustness into a set of reusable software components. Because software consists of micro objects (e.g., a single integer variable) within macro objects (e.g., a DLL) within system objects (e.g., applications that interact on the desktop), the object model must apply design considerations that affect system reliability in general. Any component not properly designed should be prevented from having an adverse effect on other parts of the system.

An object is merely a packet of data around which you wrap the set of methods used to manipulate the state of the object's data. Any implementation that fails to observe the exclusivity of access to data via an object's methods circumvents the design assumptions and places the reliability of the software in question. For any object in a software system, it can be said that the private data can assume a finite number of states that fall into two categories: valid states and invalid states. An object's methods provide a reliable means of transforming the private data from one valid state to another, ensuring behavior consistent with the design.

A general definition of an exception in an object-oriented system might say that the private data of an arbitrary object has reached a state for which the assumptions of the designer do not hold. My experience suggests that bug reports are merely observations of a software program attempting to apply object methods to private data that has reached some invalid state. The behavior that the designer promised applies only to objects in valid states, and the effect of applying methods to invalid data is unpredictable, undesirable, and usually downright embarrassing.

Windows NT makes exception handling easier for applications developers

ILLUSTRATION: DAVID CHEN © 1993

In his book *Object-Oriented Software Construction* (Prentice-Hall, 1988), Bertrand Meyer provides a compelling argument for explicitly including design assumptions in software. He offers a conceptual model of system health in the form of exception detection and the prevention of object transitions into invalid states. Because an object's methods exclusively control the state transitions of its data, the methods form an appropriate place to implement design assumptions.

A method invoked on an object can therefore result in one of two outcomes: successful or unsuccessful. The criteria for determining success come from the preconditions and postconditions of the method, assertions that must hold for an operation to be considered successful. If any precondition or postcondition does not hold, an exception has been detected.

The liberal use of preconditions precludes the need for postconditions and provides an effective debugging tool. A complete set of preconditions ensures that an object will never go into an invalid state and thus fail to carry the operation to completion. I use preprocessor macros to define a `PRECONDITION ( expression, returnValue )` to simplify the declaration of these explicit assumptions. I base my precondition macro on the standard `assert()` macro declared in the ANSI C `assert.h`.

However, there is a difference between a true precondition, which alters program flow in both debug and production builds, and the assertion macro, which takes a benign role in production code. Murphy's Law explains that any assertion that failed to appear during debugging is certain to occur once the product is released.

Given a robust model, the problem of reliability can be reduced to these four problems: exception detection, typing, cleanup, and handling. You can detect most program exceptions by a complete

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set of preconditions in the program code. In the absence of an intrinsic mechanism, exception conditions can be typed via return values and error codes. Here, the caller acts on the exception, most often by propagating an indication of the operation's failure back to the boundary of the system that received the event. Usually, an operation foiled by early detection is not a problem. The longer an invalid object state goes undetected and unreported, the greater the chance of data corruption.

Beyond the Model

In the absence of a general conceptual model (e.g., the one proposed by Meyer) and elegant operating-system services (e.g., the ones provided by Windows NT), exceptions are considered infrequent situations for which you use special function calls to save and restore a minimum execution state. Standard C libraries provide `setjmp` and `longjmp`, and Windows 3.x includes `Catch` and `Throw`. The execution state that these functions save does not include the state of objects that might be acted on by the miscreant code. Therefore, you must limit the use of these functions to prevent the exception handler's negative side effects from occurring undetected later in the program.

Floating-point libraries often provide facilities for hooking the exception handler. Under 16-bit Windows, you can handle memory-protection and divide-by-zero violations by using the ToolHelper DLL, a component designed to help programmers develop debugging tools. ToolHelper merely provides a means for identifying the exception after the fact. You must rely on `Catch` and `Throw` to give logical structure to the flow of execution.

This limitation is loosely enforced by the need for `setjmp` and `longjmp` to reference a common symbol representing the buffer where the execution state is stored. These services provide handling for exception conditions that can be readily anticipated and identified.

The absence of a robust operating-system design places a burden on applications software developers. Many choose to ignore this, designing software without explicitly expressing underlying assumptions. It would be a mistake for these developers not to apply the Win32 exception-handling services. NT's exception-handling services provide a consistent, reliable model for reporting and handling exceptions detected by the hardware, operating-system software, third-party DLLs, subsystems, and programming libraries in use by your software, and those subsystems your own code defines and detects.

Windows NT's structured exception-handling model provides a clean, reliable method of unwinding nested program execution at the advent of an unhandled exception. It supports an elegant method for implementing selective handlers and provides a guaranteed means for releasing system resources allocated during the course of execution that lead up to an exception condition. The NT model conveniently proposes a few simple extensions to the C-language syntax, along with some intrinsic functions that will require standardization to maintain source code portability to other operating systems.

Guarding Your Code

Under Win32 and the Microsoft C implementation of the syntax extensions, you can guard code segments against exception conditions with the `try-except` statement. The `try` keyword sets forth a compound statement block that is protected against exception conditions. This protection extends to nested functions called within the protected block of code. Immediately following the closing brace of the guarded code, the `except()` statement receives an argument capable of selectively filtering exceptions for the handler, the compound statement block occurring immediately after the `except()` statement.

The absence of a robust operating-system design places a burden on software developers.

After identifying an exception condition, the operating system searches backward through the frames of execution history, searching for a handler that's capable of dealing with the exception. Exceptions are typed by a single 32-bit word obtained from a special function, `GetExceptionCode()`, whose meaning is of value only inside the exception filter. An arbitrary amount of exception-specific information is also available by way of a call to `GetExceptionInformation()`.

This system allows for the development of rich, capable user-defined exceptions (invoked by the `RaiseException()` function) and complex filtering functions. Yet it maintains a concise declaration for simpler, more common scenarios. Given that exception handlers adeptly handle nested execution by implying that the execution be unwound back to the first capable handler, any critical, shared system resources allocated during the inward course leading up to an exception must be freed as the execution frames are unwound.

Again, this provision is expressed by a new language construct, called the `try-finally` statement. As with `try-except`, the `try` keyword precedes a block of code to be guarded against exceptions. The `finally` keyword sets forth a block of code that the operating system/compiler implementer has guaranteed will execute, regardless of whether an exception occurred or the whereabouts of the handler.

Applied Knowledge

There's no excuse for not including robust architecture by design. Relying on the types of exceptions that the operating system and processor hardware identify is hardly a starting point for healthy software. By the time an uninitialized pointer gets to the point of generating a memory-protection violation, it has probably already trashed several of your software's most crucial data structures. Even if the execution is unwound to the satisfaction of a programmer concerned with keeping the software alive, users are likely to go on and destroy their chances for data recovery.

Meyer's model gives a practical means for interrogating object instances to force early exception detection. The arrival of Windows NT makes handling common exceptions more convenient. But the real question is how well you can apply forward-thinking, object-oriented techniques to early detection of exceptions, using the consistency of `RaiseException()` to unify exception-handling procedures. Such an approach is likely to produce robust code at the expense of concise declaration and execution speed.

The art of identifying circumstances and judicious application of the different approaches is a matter of good design. It's a good feeling knowing that the best design is relatively easy to implement. The only time I get that feeling is when I'm developing software for Windows NT. ■

Gen Kiyooka is the founder of Electron Image and the inventor of Blue Sky Software's RoboHelp and BugMan programming tools. You can reach him on BIX c/o "editors" or on CompuServe at 76376,43.

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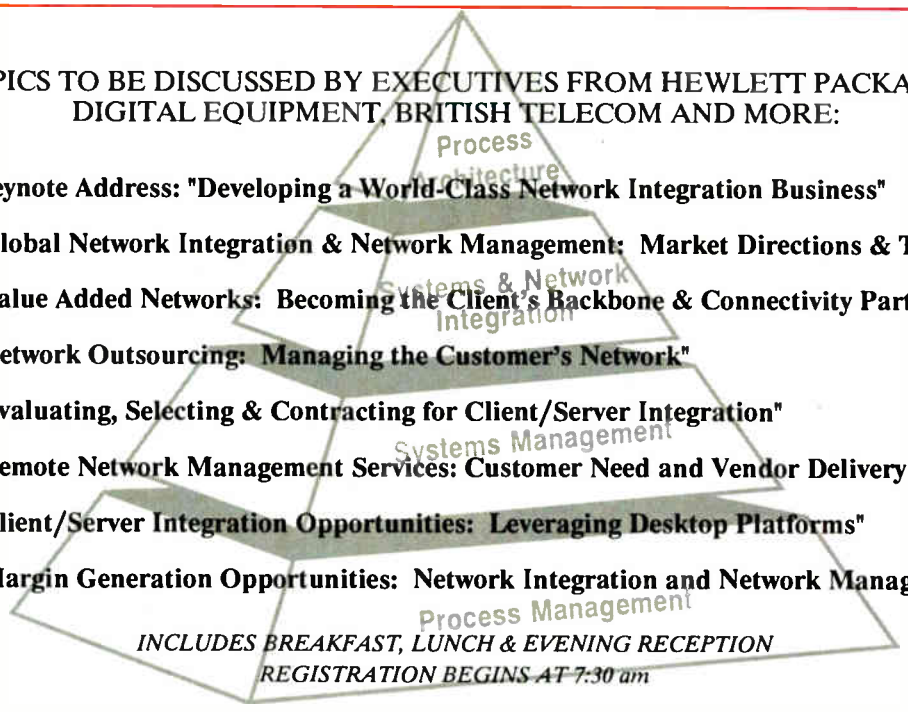

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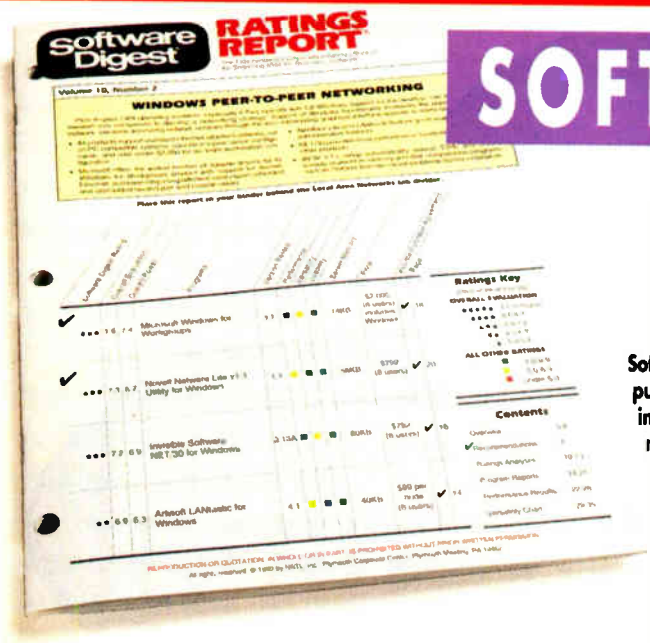

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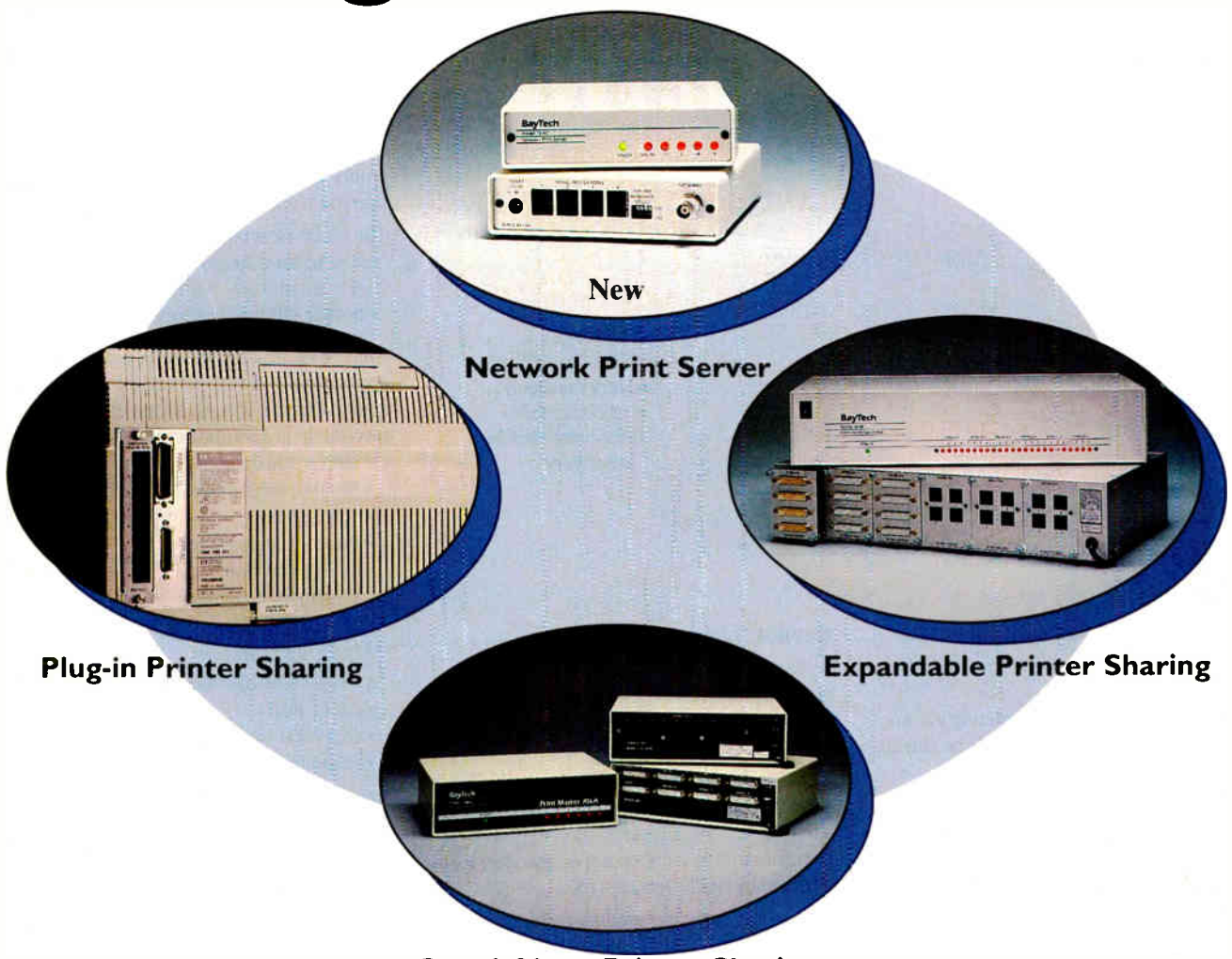

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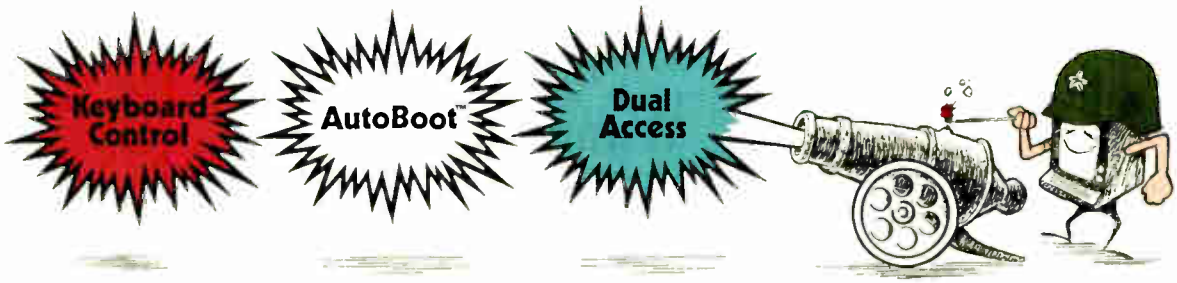

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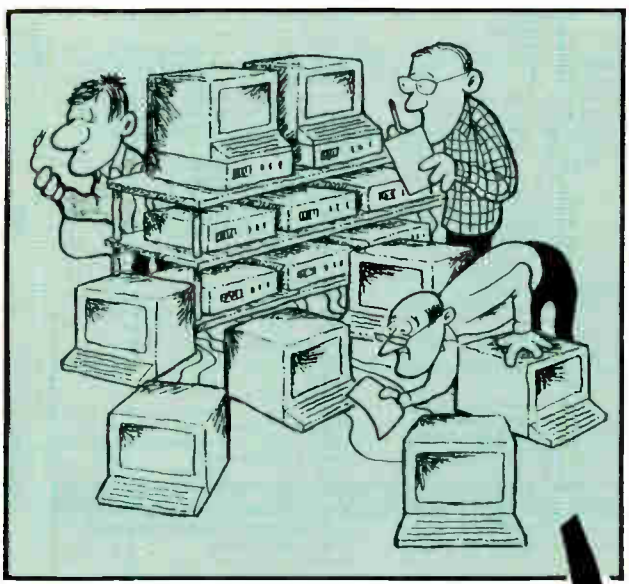

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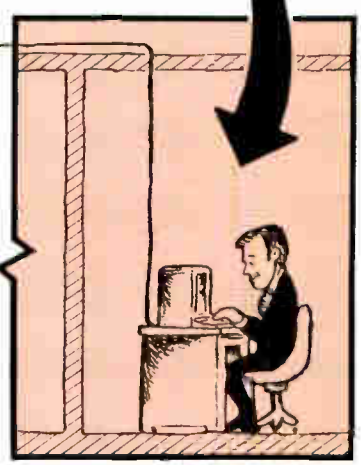

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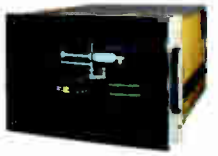

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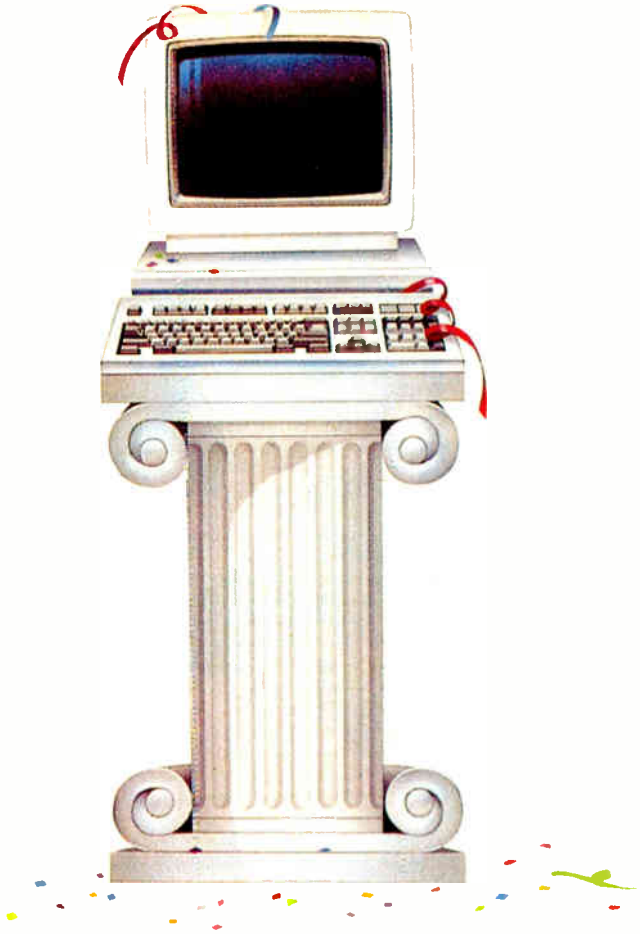

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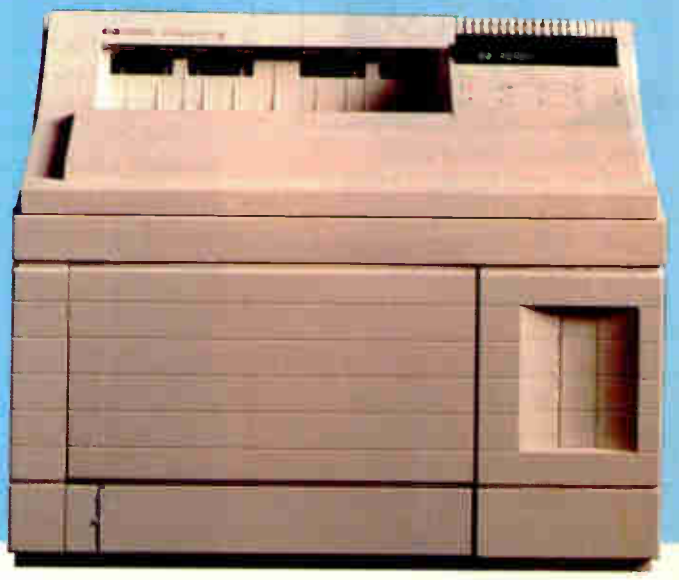

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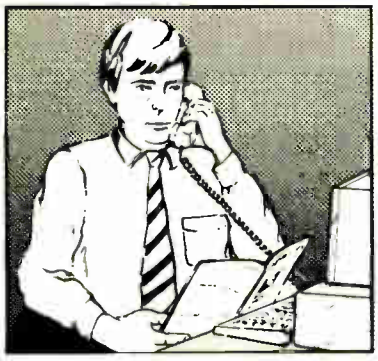

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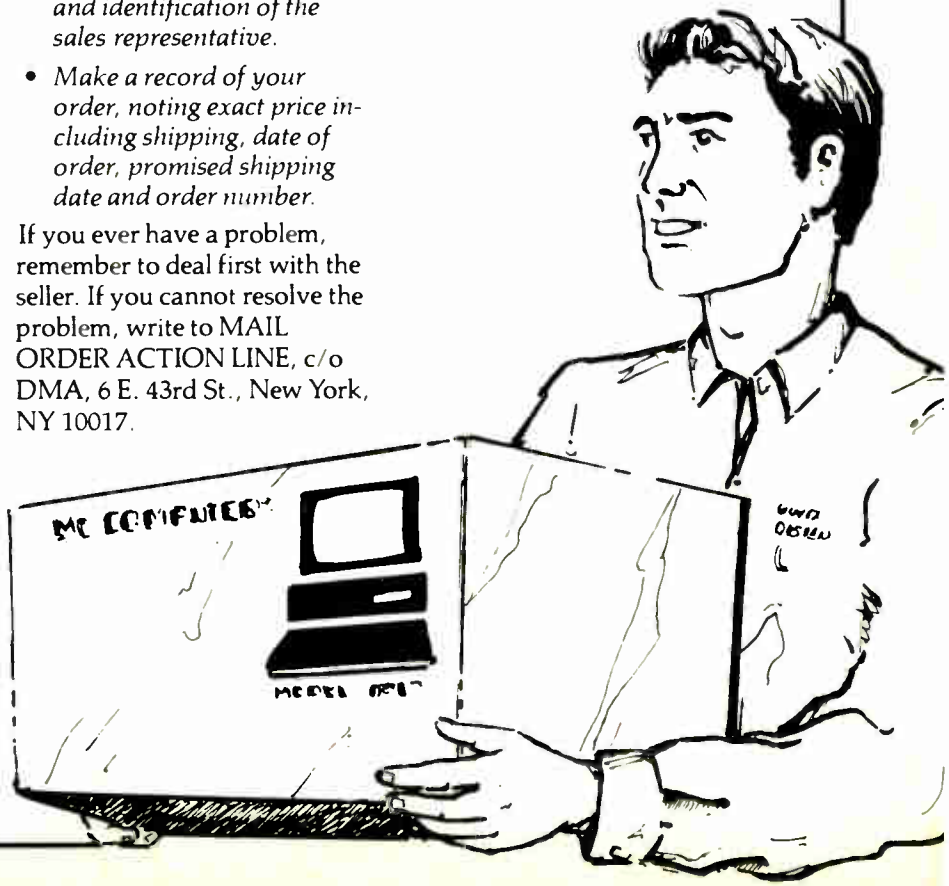

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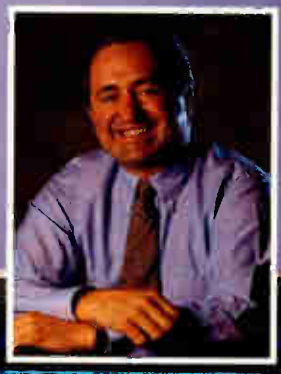

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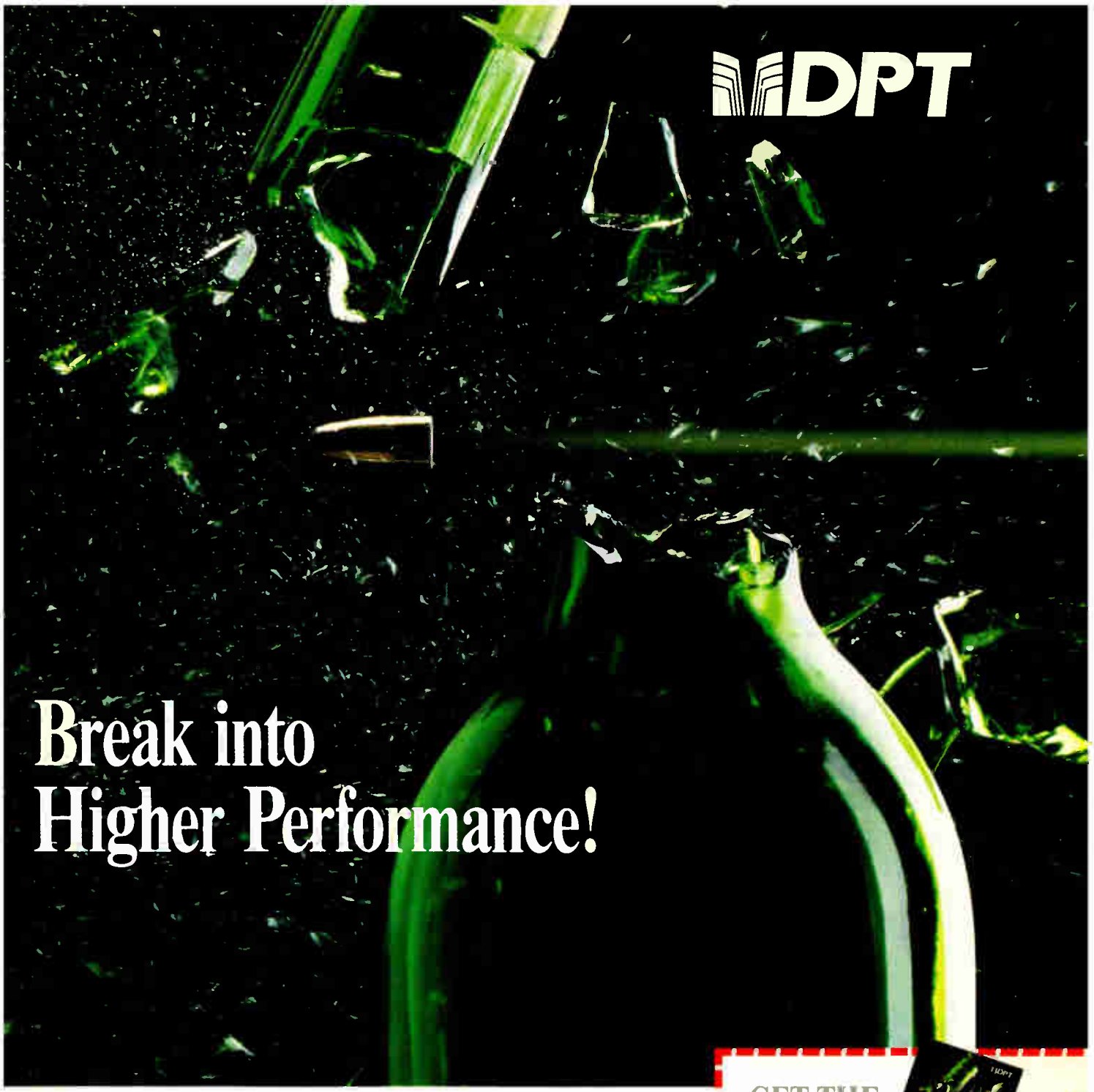

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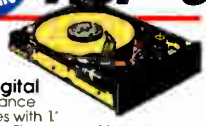

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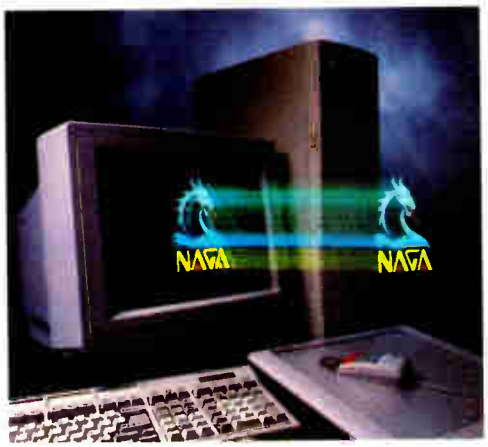

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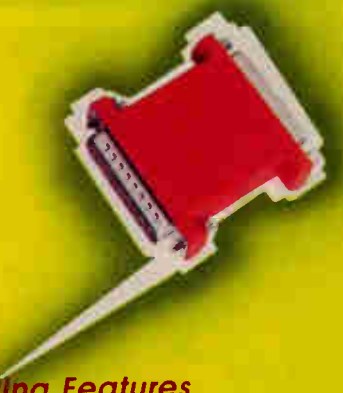

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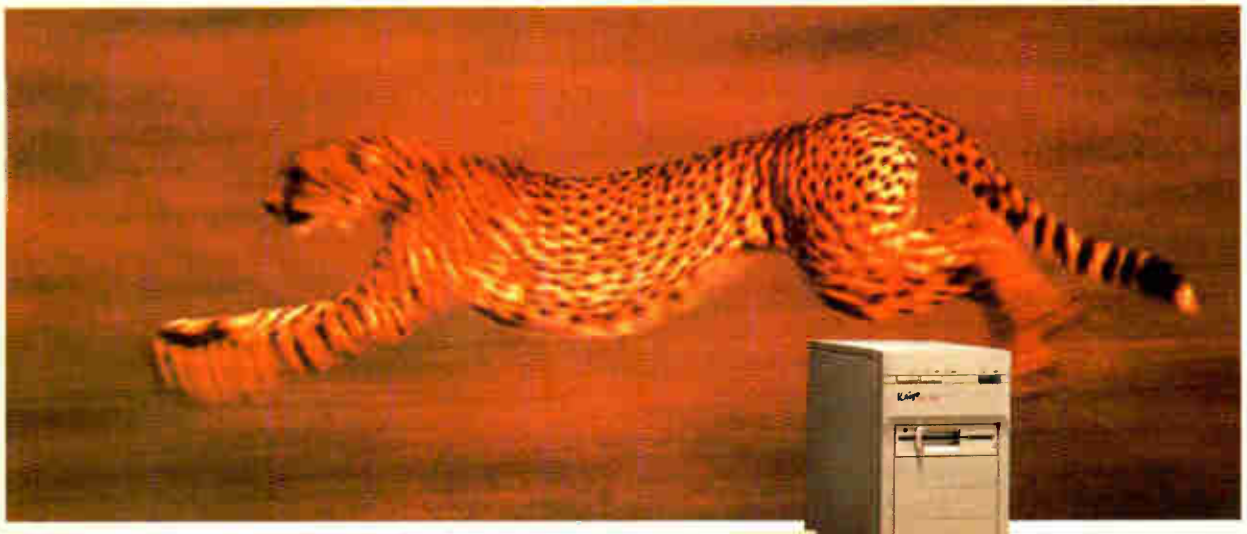

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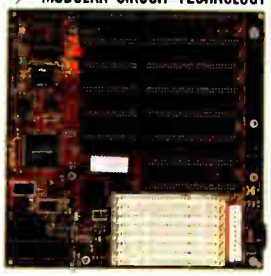

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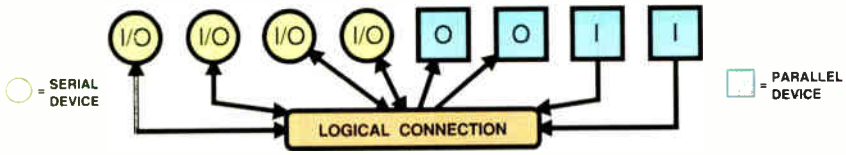

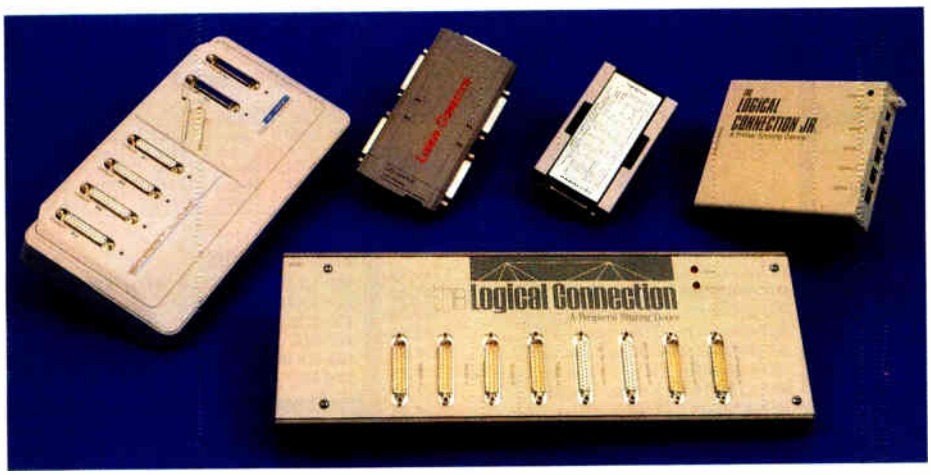

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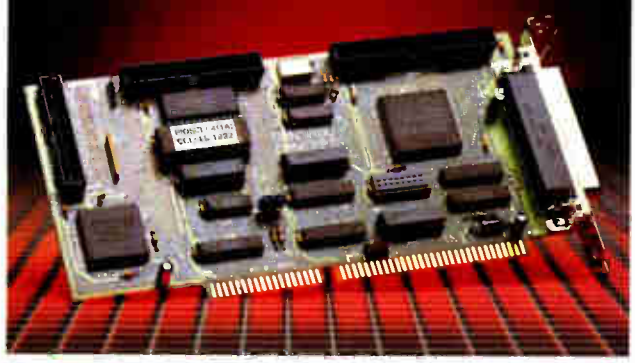

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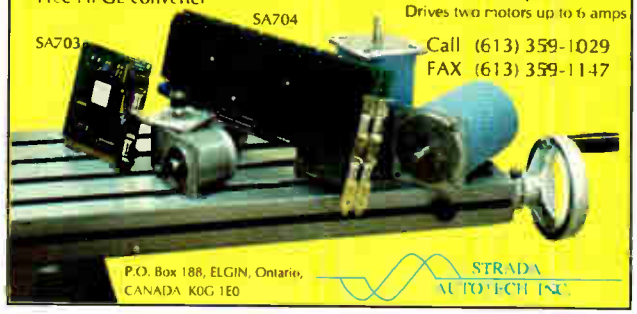

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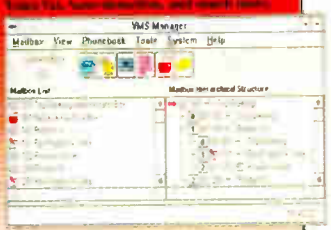

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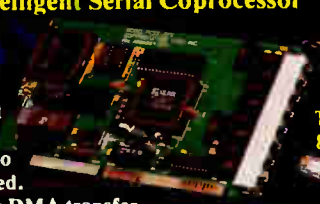

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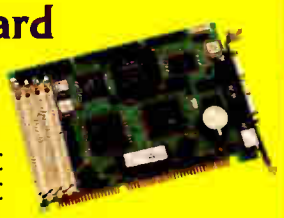

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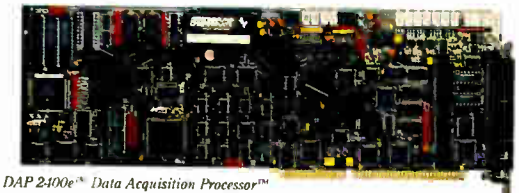

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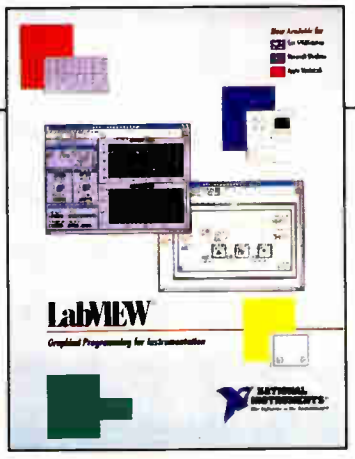

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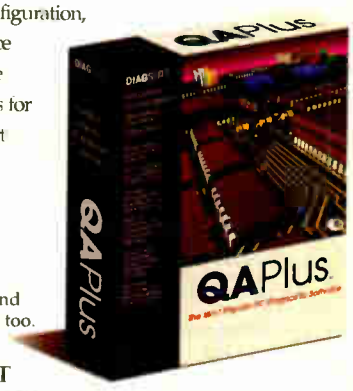

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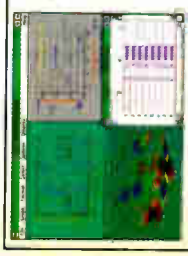

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England
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McGraw-Hill Publishing Co.
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England
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Zena Coupé, Amanda Blaskett
A-Z International Sales Ltd.
70 Chalk Farm Road
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England
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FAX: +44 71 2843174

ISRAEL
Dan Ehrlich
Ehrlich Communication Int'l.
P.O. Box 99
Herzliya 46101, Israel
Tel: +972 52 586245
Tel: +972 52 586246
FAX: +972 52 585685

AUSTRALIA
Rod Tremain
Rod Tremain Media
Suite 4, 1st Floor,
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Crows Nest, NSW
Australia 2065
Tel: +61 2 955 3545
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JAPAN
Masaki Mori
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STOP BIT

HANS BERLINER

LOSING THE HUMAN EDGE

Computers are making significant inroads into our understanding of games. Two important games, Qubic (i.e., 3-D tic-tac-toe) and Connect-Four, have already been solved with the aid of computers. (The computer always wins if it moves first or if its opponent errs.) In most other games, computers are near the forefront or have already surpassed the best humans. In Reversi, for example, the best computers know somewhat less about the game than the best humans, but they are able to calculate more accurately. Human players, sensing the potential for defeat, are refusing all computer challenges. In checkers, a computer is clearly the second best player in the world—it narrowly lost a challenge match for the world title last year. A rematch is expected.

Computers that think like humans may beat us at our own games

One way computers are advancing on their human opponents is by compiling databases. When few pieces are left on the game board, the computer can calculate the game's outcome, assuming that both players execute their best possible moves. In checkers, a computer can determine the conclusion when there are just eight pieces left. Once three-quarters of the pieces are played in Reversi, the computer can determine the outcome.

Computer programs that learn are also having an effect. One program has learned how to play world-class backgammon by playing hundreds of thousands of games against itself and remembering important details.

When a database can't provide the best move, searching is necessary. In chess, you may have 40 moves from which to choose in any given turn. Of these, a world-class human considers three, at most. A computer examines all moves except those it can logically eliminate using the alpha-beta (A-B) algorithm. This algorithm operates on the principle that, when a move is played for one side, the other side has to refute it only once. Once it finds a refutation, the computer doesn't have to look at the remaining moves.

Programs that use the A-B algorithm perform better because they do not overlook anything, but they can search to only a certain depth before running out of time. Suppose, for example, that your opponent has captured your queen and your only reasonable action is to recapture it. A human takes 1 second to decide; the computer requires 30 to 180 seconds, depending on the program's sophistication.

To counteract this, programmers have devised methods, called *search extensions*, that let the search proceed deeper in branches that have moves involving captures, checks, and certain other attributes, such as whether a move is clearly better than any of its siblings. All these methods reallocate the effort to branches that are likely to contain important data for deciding the best move. These algorithms produce search trees that are far different from those of humans, however. Human players examine, at most, 200 positions in determining what move to make; these algorithms examine millions.

My new B* search algorithm is more humanlike. For every move examined, it computes an optimistic value, which measures threat potential, and a realistic value, which measures the likely short-term outcome. It assumes that the real value of a move lies between these limits and explores the alternatives accordingly. The same is true for the opponent's moves, which it must also consider.

For about a year, I have used this algorithm to drive Carnegie Mellon University's custom Hitech chess machine, which processes 160,000 moves per second and was the best in the world when constructed in 1984. (The current champion is Deep Thought at the IBM Thomas J. Watson Research Center.) The new algorithm is playing on a par with the A-B algorithm and is improving all the time. The B* algorithm usually examines 90 percent of its search nodes only once, indicating that these failed to prove "interesting" for further pursuit. B* usually expands from 100 to 300 nodes in its search tree, but it can stop searching and make its play when it determines that no meaningful alternatives exist.

If you quintuple the time available to decide a move, the A-B algorithm will use it to go one move deeper almost everywhere in the tree. But the B* algorithm will use this additional time to go even deeper at "interesting" points—three levels or more, on average. The working algorithm should be in competition at the AEGON tournament in Holland this month. Eventually, a new Hitech chess machine that's 20 times faster should provide enough power to play at the world-class level. That should be easy to do on certain parallel machines available today. This machine will learn to play using a human decision style and may expand its chess knowledge to the point where it can compete with the world champion. ■

Hans Berliner is principal research scientist at Carnegie Mellon University's School of Computer Science. He is a former world champion of correspondence chess and has been researching computer chess since the 1960s.

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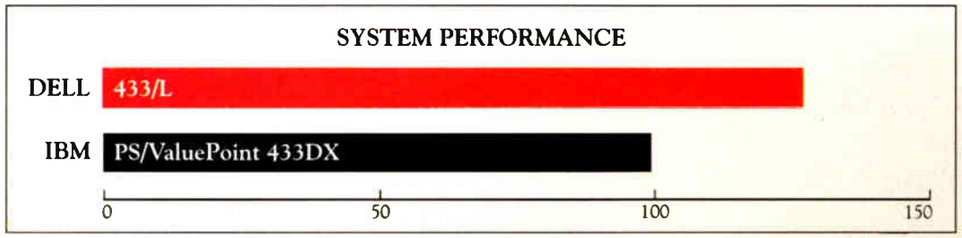
NOT SO FAST, IBM.



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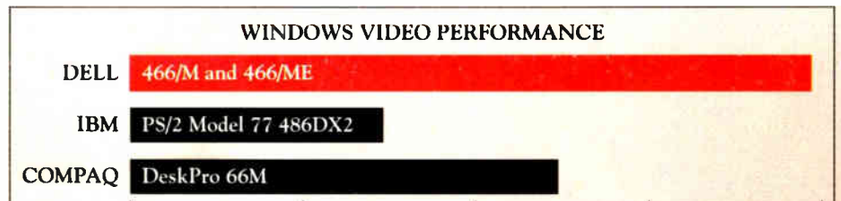

Performance measured by running WINBENCH version 3.1 at 640 x 480, 256 colors. Results measured in millions of WINMARKS. Results for IBM and Compaq as published by PC Magazine in issue dated January 26, 1993. Results for Dell 466/M and 466/ME provided by Dell Performance Measurement Lab, January 1993. DeskPro 66M configured with 8MB RAM, 210MB IDE HD, QVision 1024/E controller with 1MB VRAM. PS/2 model 77 486DX2 configured with 8MB RAM, 400MB SCSI HD, XGA-2 with 1MB VRAM and 256KB cache. 466/M and 466/ME both configured with 8MB RAM, 170MB IDE HD, local bus video with 1MB VRAM, and 128KB cache.

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