90 FAST 486 SYSTEMS TESTED

BYTE

DECEMBER 1993

What's the best Windows spreadsheet? PAGE 138

DEC's new Alpha PCs

Automating applications with OLE 2.0 PAGE 32

THE WORLDWIDE COMPUTING AUTHORITY

Linking LANs

It won't be fun. Expect culture clashes, bandwidth compromises, protocol headaches, and political turf wars.

STATE OF THE ART

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PLUS

- Put a CD-ROM on your network PAGE 151
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DECEMBER 1993 VOL.18, NO.13

News & Views

Cover Story

Features

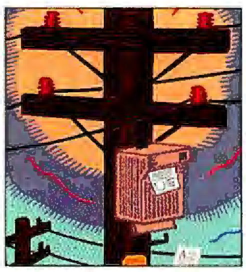
Reviews

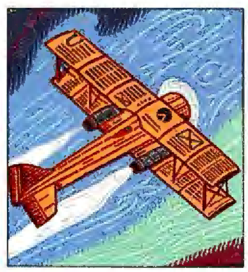
PAGE 153

PAGE 165

PAGE 169

State of the Art





Hands On

Opinions

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BYTE Contents by Platform

Index

Portable Power

The Pinnacle Tahoe™ Portable 3.5" Optical Drive

128 MB REWRITABLE OPTICAL DRIVE

Introducing the world's smallest portable 3.5" optical drive with a rechargeable battery pack option that provides hours of portable computing.
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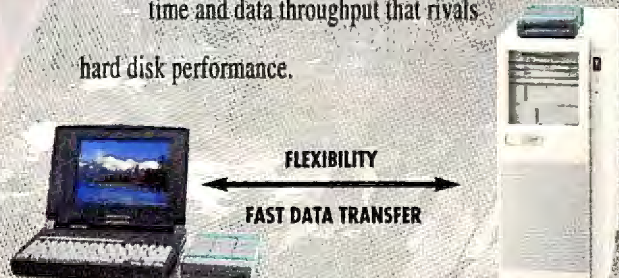
The Pinnacle Tahoe-130 has an ultra fast seek-time and data throughput that rivals hard disk performance.



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Circle 135 on Inquiry Card (RESELLERS: 136).

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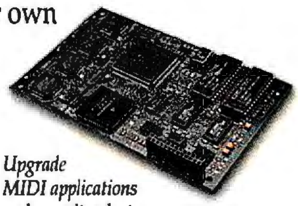

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Advanced Signal Processing Upgradability	Yes	Yes	Yes
Wave Blaster Upgradability	Yes	Yes	Yes
CD-ROM Compatibility	Creative Labs/Panasonic	Sony, Mitsumi, Creative Labs/Panasonic	Any SCSI or SCSI-2
Bundled Hardware		Microphone	Microphone
Bundled Software	Monologue for Windows Creative WaveStudio Creative Soundo'LE Creative Talking Scheduler Creative Mosaic	Software Toolworks Multimedia Encyclopedia HSC InterActive SE PC Animate Plus Monologue for Windows Creative WaveStudio Creative Soundo'LE Creative Talking Scheduler Creative Mosaic Creative VoiceAssist	Software Toolworks Multimedia Encyclopedia HSC InterActive SE PC Animate Plus Monologue for Windows Creative WaveStudio Creative Soundo'LE Creative Talking Scheduler Creative Mosaic Creative VoiceAssist
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W/Advanced Signal Processing	Not applicable	$299.95	$329.95

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Circle 169 on Inquiry Card.

See listing on page 297.

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In fact, they'll do just about

"Computer, read me today's mail."
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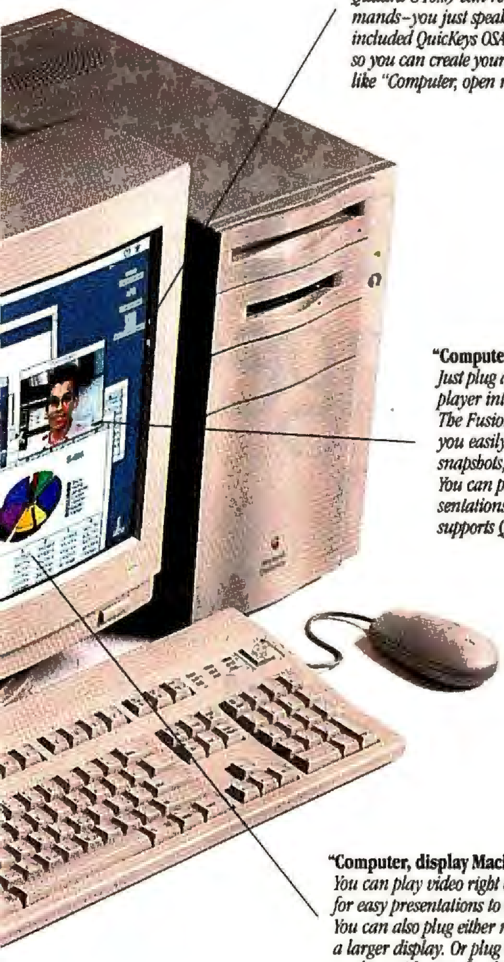
"Computer, call Michelle Dunn."
With Apple GeoPort, you can turn your AV computer (in this case, the Macintosh Centris 660AV) into a telephone and an answering machine. The hands-free phone lets you do work on-screen while you talk. And both computers have ES•F2F software, so all you need is a video camera to hold a video-conference across a local area network.

"Computer, fax letter to Steve Wingate."
Forget the fax machine. The optional Apple GeoPort™ Telecom Adaptor includes fax and modem software–everything you need to send and receive faxes from your desk or use on-line services. And both computers let you try out ExperFax, an application that converts your faxes into text.

anything you tell them to.

"Computer, open my word processor."
Now work the most intuitive way. With Apple PlainTalk™ AV computers (here, the Macintosh Quadra 840AV) can recognize spoken commands–you just speak naturally. We've also included QuicKeys OSA Component software, so you can create your own verbal commands, like "Computer, open my word processor."



"Computer, start video."
Just plug a video camera, VCR or laserdisc player into the back of either AV computer. The FusionRecorder software included lets you easily capture video and single-frame snapshots, or record 16-bit stereo sound. You can paste your videos directly into presentations, documents or any software that supports QuickTime™

"Computer, display Macintosh on TV."
You can play video right on your AV computer monitor for easy presentations to coworkers, clients or a class. You can also plug either machine into a TV, if you need a larger display. Or plug into a VCR, and record your work on videotape for distribution.

"Computer, play CD."
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You've probably read that telephones, computers, television and other technologies will converge soon.

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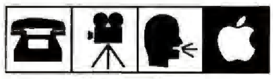


Apple AV Technologies.
Telecommunications, video, speech – all the ways you communicate.

Many of these new functions are sped along by a digital signal processor (this chip flies through data at the rate of 55 MHz in the Macintosh Centris and an even faster 66 MHz in the Macintosh Quadra).

With a 25 MHz 68040 processor and up to 68MB of RAM, the Macintosh Centris has the horsepower required to breeze through huge spreadsheets and documents. And there's room to add a 500MB internal hard disk, a CD-ROM or SyQuest drive and a NuBus expansion card.

The new Macintosh Quadra will make publishing, graphic design and other communications professionals salivate. Its 40 MHz 68040 processor and up to 128MB of RAM make it the most powerful Macintosh ever. And it has room for a gigabyte of hard disk storage, four internal storage devices and three NuBus expansion cards.

Best of all, you can get a Macintosh with Apple AV Technologies starting at $2,489.* Once again, Apple puts the most amazing kind of power within your reach. The power to be your best.®

Apple

Building a Data Highway

Let's face it. The data highway will be built. Who better to guide its development than you?

Making a LAN work is never easy, and the challenges of making multiple LANs work together are paramount. Yet business demands that data flow easily from one end of an organization to the other—even if the organization spans several time zones. There are a lot of ways to create such a wide-area network, and that's the trouble—there are *too many* ways to create a WAN. Or to be more accurate, there are too many *wrong* ways to create a WAN that leave an organization's data bottlenecked.

Some folks say that a national data highway would help solve that problem. The idea is that a massive "highway" of data lines could do for communications and data transfer what the interstate highway system did for travel and commerce in the U.S. To hear Vice President Al Gore's passionate views on the data highway would probably stir you and might even convince you that a data highway *must* be built.

Other folks might say that the data highway is already under construction. For example, look at the recent merger of Bell Atlantic and TCI—a giant phone company and a giant cable TV company. Two multibillion-dollar companies that want to deliver data to millions of people, and who have the wherewithal to do so. Meanwhile, service providers—including other Baby Bell companies—are defining data highways of their own.

Their involvement is not necessarily bad, but what's driving the phone and cable companies is a desire to truck entertainment into homes. In other words, they want a data highway optimized for digital Sylvester Stallone movies, and that kind of data highway may not fit business needs.

To further complicate things, in the midst of all this confusion is the government trying to figure out what role it should play. And whenever the government seeks a role in anything, you can bet that plenty of special interests are trying hard to define it.

Right now, the government is hearing mostly from the telephone and cable TV companies. That's too bad, because what's missing is input from the computer industry and—most important—from you.

What might you have to offer? Plenty. BYTE readers understand technology better than most other groups, and you certainly understand your enterprise computing needs better than anyone else.

Until now, though, you may not have had a reason to give the data highway much thought. However, all the smoke that's rising from the talk in Washington about a data highway is becoming awfully thick, and where there's smoke, there's fire. My point is this: like it or not, the data highway will happen, and you can either have it happen *for* you or *to* you.

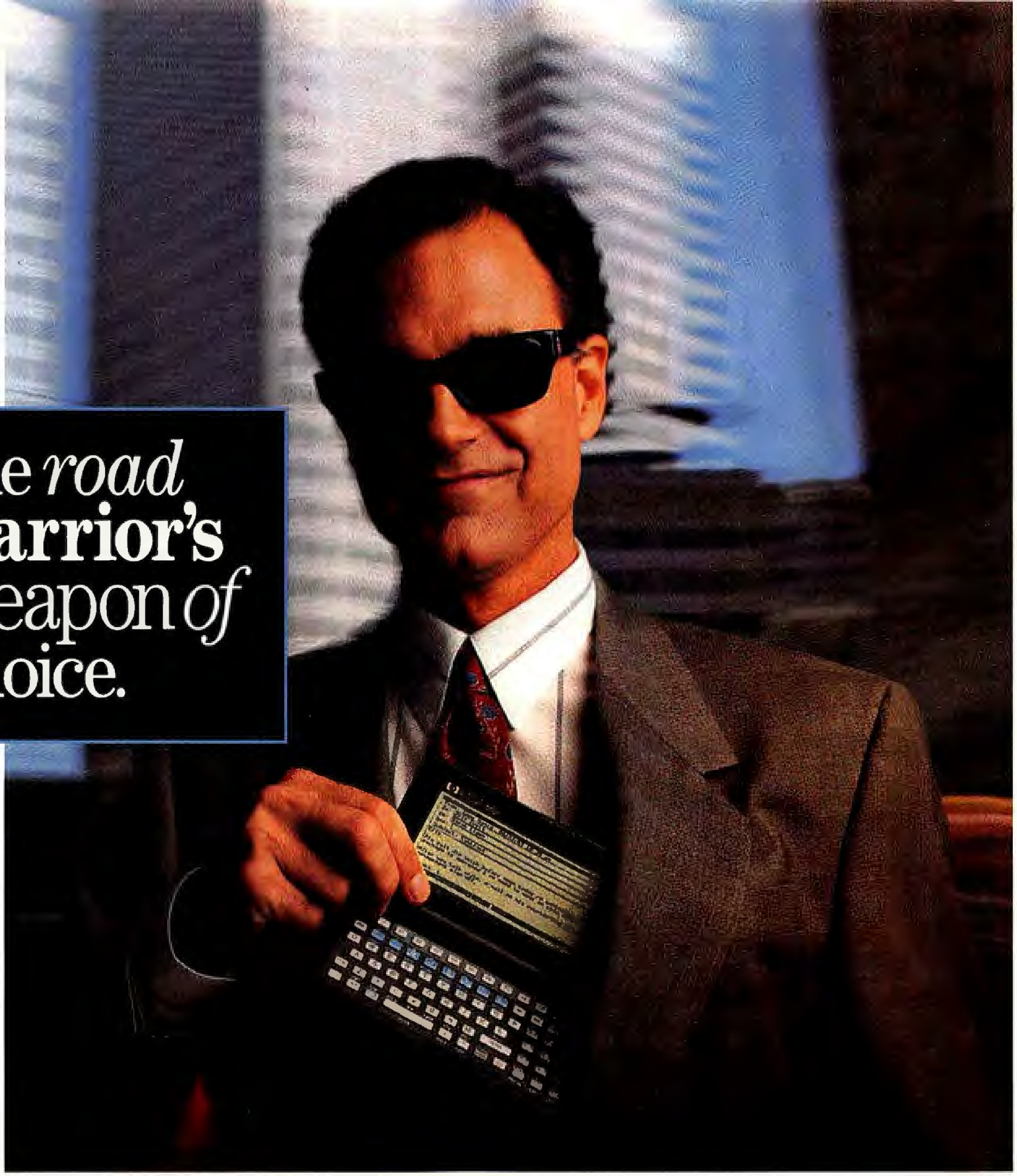
My suggestion is simply this: Offer as much guidance as possible. Write your representative, or work through your professional organization. The Society for Information Management (SIM), for example, is already making its ideas known in Washington.

But please don't think that it doesn't matter how the data highway gets built. At the Anderson School of Management at UCLA this fall I spoke with a group of information managers from a variety of large companies. When I suggested their involvement in shaping the data highway, one gentleman rang out with the age-old axiom (my apologies for mixing metaphors), "Let the plumbers build the pipes, and we will use them."

Sorry, but that's not good enough. That retreating battle cry has only sustained a gigantic bandwidth, protocol, and network management quagmire. It will get worse, too. Think about all the video, audio, and other data that you will soon need to send across a WAN. Data is just data, of course, but think about how much of it you and your company will need to route in the coming years. Add to that the ongoing efforts to push more and more data out to branch offices to empower those staffs. Soon you can imagine the tremendous demands that business—your business—could place on a data highway.

None of us has all the answers, but collectively we can offer some pretty sound advice on what a data highway ought to be. While the editors and writers at BYTE navigate through the maze of information on the subject, I most want to hear from you—especially if your data must cross over continents. Please contact me via mail or E-mail, and let me know your ideas on what the data highway should be.

Dennis Allen, Editor in Chief
(dallen@bix.com)



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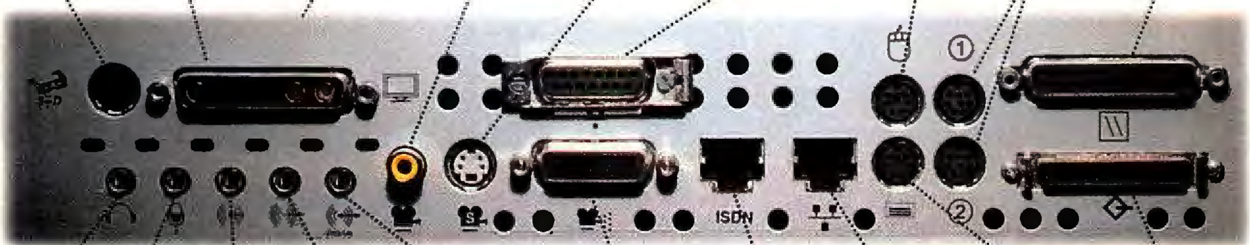

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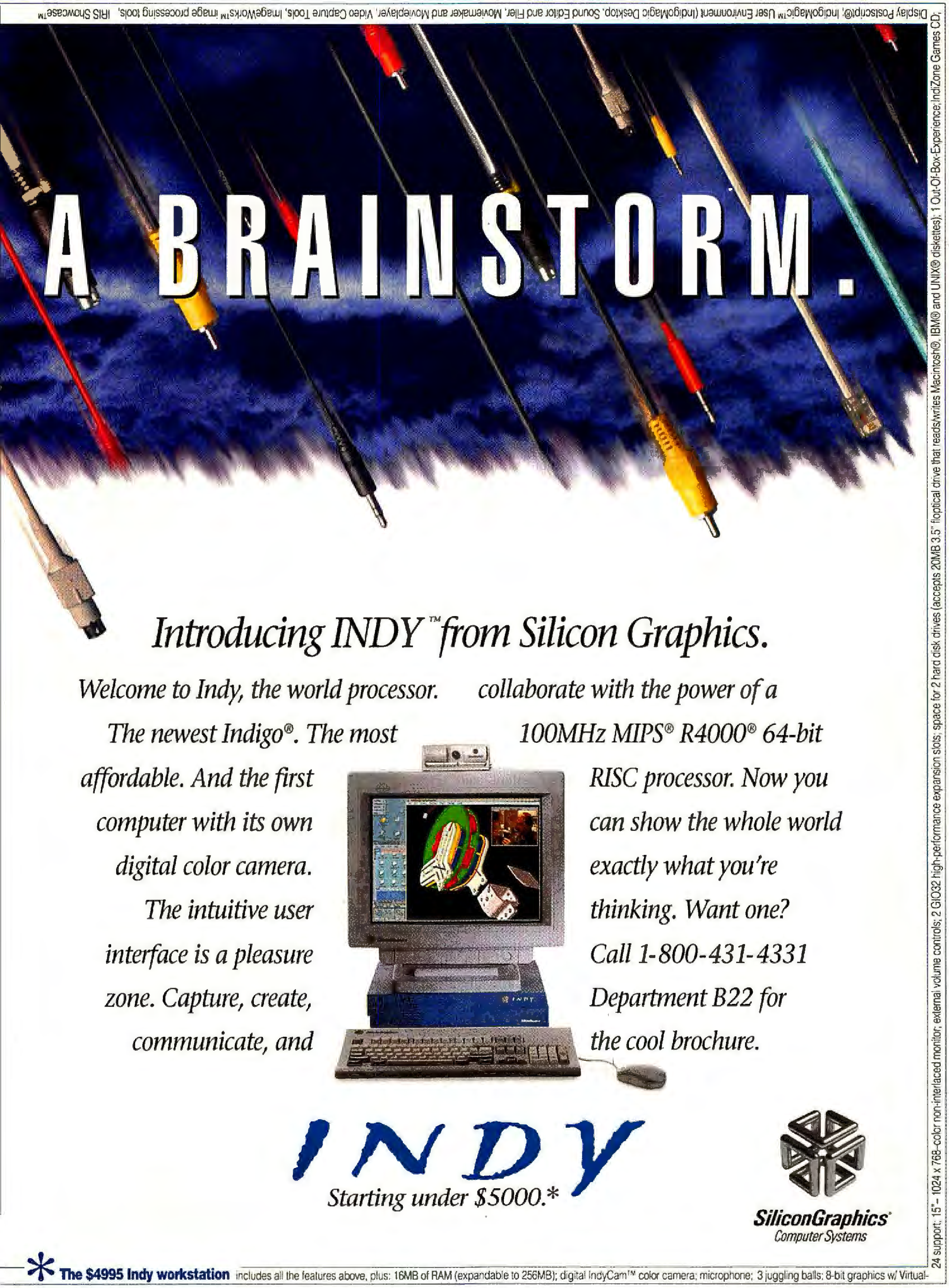
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Video Computing

The "Talk to Me" section of "Apple, SGI Blaze Video Trail" (September) intrigued me. Audiovisual Macs coupled with PlainTalk have enormous potential for disabled computer users. Is Apple or another company planning to take PlainTalk a step further, so spoken words can be entered as text into applications? I know this can be done on PCs with programs like DragonDictate and Voice Type II, but they require expensive proprietary boards and run only on DOS.

Many people with disabilities affecting muscle coordination and control find graphical interfaces much easier to use (I'm included; I have cerebral palsy). If such a system existed, millions of us would be vastly more productive than we are today.

T. Patrick Henebry
Cincinnati, OH

Articulate Systems has several voice-communication and voice-interface solutions. Voice Navigator SW, priced at $399, works on Macs with built-in sound digitizers and requires no external hardware. You can reach Articulate Systems at (617) 935-5656; its fax number is (617) 935-0490. For more information on Apple's PlainTalk technology, call (408) 996-1010.—Eds.

That was an amazing article by Andy Reinhardt ("Video Conquers the Desktop," September). It took clever editing to do a long article on video without mentioning the Amiga. And the following article mentioned the Amiga only in a historical context. One would think that video started with Apple and progressed directly to Sun.

Gary Goldberg
Silver Spring, MD

We should have mentioned the Amiga for its pioneering role in integrating video into desktop computers. But the Amiga's video capabilities weren't intended for real-time conferencing, which was the focus of our story. What makes the Mac AVs and SGI's Indy worthy of cover treatment now is their support for video communications and conferencing software. And these systems are built on technology from dozens of sources—not just Apple.—Eds.

Indian Software

I read and enjoyed Jon Udell's article "India's Software Edge" (September). I wholeheartedly agree that India has much to offer the world in software development, increasingly so as the Indian government reduces red tape.

As a cofounder of Sextant and the designer of Sextant for C, the decision to work with an Indian firm (Softek) was not a light one. While the experiences and lessons learned are enough to fill a book, the overall experience has been quite favorable.

I was pleased to see Sextant and Softek mentioned so prominently, but I was disappointed that the article lacked contact information. You can reach Softek Pvt., Ltd., at M-42 Commercial Complex, Greater Kailash-II, New Delhi 110 048, India, +91 11 644 7308; fax +91 11 648 2680. Sextant is located at 3881 Sparrow Wood, Ann Arbor, MI 48108, (313) 677-0952. Also, although Softek developed Sextant, it is a U.S. product.

Mark J. Steckel
Ann Arbor, MI

SGML and Multimedia

Your recent articles "Unlocking Data's Content" and "Publish It Electronically" (September) miss the mark when describing SGML (Standard Generalized Markup Language). It is not a text-only technology. SGML-based systems effectively handle nontext information, including audio, video, and graphics images. Some of the most exciting hypermedia systems being developed today (e.g., the Interactive Electronic Technical Manual) are based on SGML because of its powerful information-handling capabilities and support for nontext information.

Faye Merrideth
ArborText, Inc.
Ann Arbor, MI

The bottom line is that SGML is a rule book for specifying text-oriented document-encoding rules, called DTDs, not the documents themselves. It is a markup language; binary-encoded video itself does not get marked up. I did say SGML provides for nontext document interchange in two ways: By (1) transferring out of the SGML process, and (2) using the extension of SGML via HyTime to deal with some nontext processing issues (although encoding is not one of them). Saying something is SGML-based is analogous to saying something is Unix-based. It misleads the user into thinking, "Aha! These two SGML-based applications can exchange documents," when in fact they can't if they use different DTDs.—Randall D. Cronk

Installer Hell Revisited

It's rare that I agree completely with an article, but Michael Crichton's Commentary (September) on installers was an exception. Last week I installed fax software for Windows. It failed on lack of disk space, and when it was done, Windows was fried. I finally figured out I had to restore WIN.INI from a backup (fortunately I had one) and reinstall a default printer and all the TrueType fonts. Although this is the worst installation I've experienced, others have done some really weird things.

How about standards for installers? Standards would provide a marketing benefit for those people who followed them: "This product conforms to Installer XYZ-123." It would create a new industry niche, and it would make life a lot easier for those of us who use the products.

Bill Leal
Mobile, AL

"Outstanding" PowerPC Coverage

Your article on the PowerPC in the August BYTE was outstanding, the most well-rounded and informative article I have seen on the subject. It was not overly technical and covered all the major issues. Well done! Now I have some basis for buying decisions. ■

Mike Bailey
Systems Integrator,
Lockheed Missiles and Space Co.
Sunnyvale, CA

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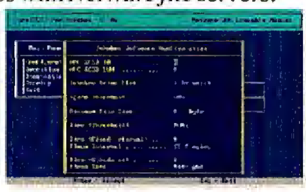

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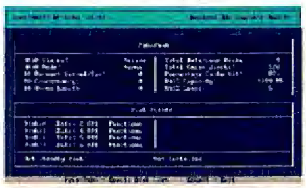

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News & Views

DESKTOP SYSTEMS

Apple Revamps Its Lineup—Again

TOM R. HALFHILL AND TOM THOMPSON

Apple's new Quadra 610 is available with two processors—either an FPU-less 25-MHz 68LC040 or a 68040, which has a built-in FPU.

As the year winds down, Apple is announcing its latest harvest—a batch of new desktop Macs, a pair of PowerBooks, and two workgroup printers. The new products are accompanied by a series of marketing shuffles intended to reduce confusion over the Mac line and increase its visibility in the market.

Although experienced PC shoppers are used to confronting a bewildering array of nearly identical computers, it's been only a few years since Apple's entire catalog consisted of just three or four basic Macs. Now Macs are proliferating so prodigiously that even the experts have trouble remembering the difference between, say, a Performa 400 and a 405, or between a PowerBook 165 and a 170.

Unfortunately, the wider range of choices is confusing some potential Mac buyers. Apple's latest announcements appear even more baffling:

• Centris, Apple's year-old label for midrange Macs, has been dropped. Apple has consolidated its computers into four distinct brands: Performa, LC, Quadra, and PowerBook. Performas are targeted at the home market, LCs are for education, Quadras are for business users, and PowerBooks are for mobile users.

• The former Centris 610 and 650 now have faster processors and are called Quadras. They are joined by a new low-end model, the 605, that's the first Quadra without either a NuBus slot or a NuBus-adaptable PDS (Processor Direct Slot).

• Apple's most successful Macs have been the LC models, which debuted in 1990. In fact, International Data Corp. ranks the LC III as the best-selling personal computer in the world. But instead of capitalizing on the LC's popularity and name recognition, Apple has decided to not let consumers buy them anymore. Under Apple's new marketing strategy, the LC is restricted to educational channels. Consumers will be redirected toward Performas or Quadras.

• Seven new Performas have been introduced, some nearly indistinguishable from one another. For example, the only differences between the 466 and 467 are their bundled software and retail channels.

Still confused? There's a solution: Sort out the different models by their main logic boards. A handful of basic logic boards span the various labels and determine such critical features as performance, expandability, and upgrade paths.

THE SHARPER-IMAGE DUOS

One of the major complaints made about the svelte PowerBook Duo line is the lack of a crisp active-matrix LCD screen. No longer: Apple has introduced two new notebooks, the PowerBook Duo 250 and 270c, that address this problem.

The 4.2-pound Duo 250 has a razor-sharp, 9-inch-diagonal, active-matrix LCD screen with 16 gray levels. For those who need color, the 4.8-pound Duo 270c has an 8.4-inch-diagonal, color, active-matrix LCD screen.

The 270c's screen supports two color-display modes. One provides 256 colors on a 640- by 480-pixel screen. The other provides 32,768 simultaneous colors on a 640- by 400-pixel screen, which lets the 270c reproduce digitized video clips. The active-matrix screens make the new Duos slightly thicker, by about 0.15 inch. They still fit inside existing Duo Docks if you equip the docking station with a new top cover ($70).

These Duos pack other features that are more than skin deep. Both have a 33-MHz 68030 processor, and the Duo 270c also has a 68882 FPU. They also use the new Type II NiMH (nickel-metal-hydride) batteries. Thanks to larger cells and improved chemistry, they deliver 2½ to 6 hours of use with the Duo 250, and 2 to 4 hours with the Duo 270c.

Prices for the Duo 250 start at about $2500 for a unit with 4 MB of RAM and a 200-MB hard drive. A Duo 270c with 4 MB of RAM and a 240-MB hard drive costs about $3000.

68030-Based Macs

The low end of the Macintosh line will be anchored by the

continued on page 26

The new **HP DeskJet 310** *printer.*

Apple Revamps Its Lineup—Again

continued from page 23

new Performa 410. It's really an LC II main logic board in Performa's clothing. The 410's only significant new feature is its floppy drive. All new Macs now sport the same drive found in current PowerBooks. It's functionally identical to the old SuperDrive but no longer grabs the disk and pulls it into the drive during insertion. It still auto-ejects the disk and remains compatible with Mac and PC 3½-inch formats. It also has a dustproof door.

Three new Performas are based on the LC III main logic board: the Performa 460, 466, and 467. The only important difference is the 68030 CPU, now clocked at 33 MHz instead of 25 MHz. Other specs remain the same. Only the hardware configurations, bundles, and retail channels separate these three models. Software bundles also vary slightly. Street prices are expected to range from $1300 to $1400.

Rounding out the 68030-based line is the new Performa 550, a consumer version of the all-in-one LC 520 introduced to educational channels last summer. There are two notable differences: It has a 33-MHz 68030 instead of the LC 520's 25-MHz CPU, plus a 160-MB hard drive.

68040-Based Macs

Four new Macs share a freshly designed 68040-based main logic board that spans the Performa, LC, and Quadra brands (see the table "Mac Board Breakdown"). Derived from the Centris 610 architecture, the new board has an FPU-less 25-MHz 68LC040, a 32-bit data bus, 4 MB of on-board RAM (expandable to 36 MB via 72-pin SIMMs), and 512 KB of VRAM (expandable to 1 MB). It supports 8-bit video on monitors measuring up to 21 inches, and 16-bit video on 16-inch and smaller screens. The processor is mounted on a socket on the main logic board. This lets you remove the processor and install a 68040 if your needs demand it.

Unlike the logic board in the Centris 610, however, the new logic board has a notched PDS connector that accepts either 96-pin LC II or 114-pin LC III cards. A special ASIC (application-specific IC) presents 68030 processor signals to this socket, making it compatible with LC-series cards. However, since it provides no direct access to the 68040 processor bus, there's no way to adapt a NuBus card to this connector or add an accelerator. The main logic board is also smaller than the 610's, sized to fit inside the standard LC "pizza-box" case.

New Macs based on this main logic board include the LC 475, Performa 475 and 476, and Quadra 605. Again, these models are distinguished by their bundles, configurations, and retail outlets. The LC 475, for instance, is available only through educational channels at steep discounts.

Unlike the Performas, the Quadra 605 isn't bundled with a monitor, keyboard, modem, or software. That means it's the lowest-priced Mac that lets you choose your own components, such as a third-party monitor or an extended keyboard. A basic configuration with 4 MB of RAM and an 80-MB hard drive starts at about $919.

Apple's unified approach to main logic boards obviously benefits the bottom line: One board fits into four computers. Of course, this also means you get nearly identical performance, a fact borne out by the BYTE low-level benchmarks. Preliminary results indicate that despite the different names, the LC 475, Performa 475/476, and Quadra 605 are virtually the same computer.

Next up the ladder are the new Quadra 610 and 650. They're virtually identical to the discontinued Centris 610 and 650 except for slightly faster CPUs. The base-configuration Quadra 610 has a 25-MHz 68LC040 instead of the Centris 610's 20-MHz processor, and the Quadra 650 has a 33-MHz 68040 (with FPU) instead of the Centris 650's 25-MHz 68CL040 (without FPU). Also, Ethernet is now standard, rather than optional. Street prices are expected to start at $1369 for a Quadra 610 with 8 MB of RAM and a 160-MB hard drive. The Quadra 650, with 8 MB of RAM and a 230-MB hard drive, should sell for about $2280. Note that these prices are preliminary, estimated street prices.

Low-level benchmarks indicate that the Quadra 610 is approximately 20 percent faster than the Centris 610, and the Quadra 650 is about 25 percent faster than the Centris 650. The Quadra 610 benchmark results closely match those of the Quadra 605 except for floating-point performance, because the version we tested had a 68040 processor installed.

Although the Quadra 610's specifications and performance appear quite similar to those of the Quadra 605, Performa 475/476, and LC 475, remember that, despite their identical 25-MHz CPUs, they're based on different main logic boards. The 610 has a 68040 PDS that's convertible to a 7-inch NuBus slot; it's expandable to 64 MB of RAM; and it has room for a 5¼-inch internal storage device, such as a CD-ROM drive.

Apple plans to make upgrades available to owners of most LC-series and Performa computers with pizza-box cases by late November. The $599 upgrade includes the new 68LC040-based main logic board and System 7.1. Upgradable systems are the LC II and III and the Performa 400, 405, 410, 430, 450, 460, 466, and 467.

MAC BOARD BREAKDOWN

LC II board 16-MHz 68030 16-bit data path	LC III board 33-MHz 68030 32-bit data path	New 68040 board 25-MHz 68LC040, no FPU, 32-bit data path (derived from Centris 610 architecture, compatible with LC II and LC III cards, but not NuBus or accelerator cards)
Performa 410	Performa 460 Performa 466 Performa 467	LC 475 Performa 475 Performa 476 Quadra 605

PRELIMINARY BENCHMARK RESULTS

As you can see, the performance results of the new Quadra 605, Performa 475, and LC 475 are very close, owing to the common motherboard and processor shared by the three systems. The Quadra 610 was equipped with a 68040 processor, hence its improved performance over the Centris 610. For all tests, a Classic II = 1. Results are indexed; higher numbers indicate better performance.

	MAC CLASSIC II	LC 475	PERFORMA 475	QUADRA 605	CENTRIS 610	QUADRA 610	CENTRIS 650	QUADRA 650	QUADRA 800
CPU index	1.00	4.65	4.66	4.67	3.87	4.71	4.97	5.84	6.35
FPU index	1.00	6.26	6.22	6.25	5.07	35.25	35.35	46.56	46.68
Disk index	1.00	1.97	2.42	3.22	2.38	2.67	3.60	6.30	3.39
Video index	1.00	4.14	4.06	5.23	4.26	5.27	4.04	6.47	6.69

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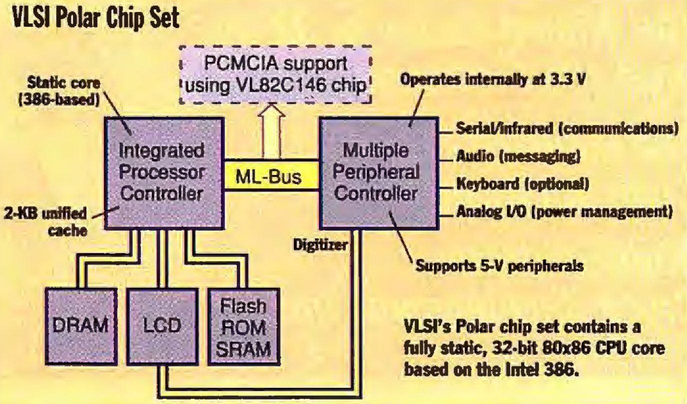
PROCESSORS FOR PDAS

Intel, AT&T, and AMD Continue the Chase



VLSI's Polar chip set contains a fully static, 32-bit 80x86 CPU core based on the Intel 386.

Though little more than curiosities at this point, PDAs (personal digital assistants) are attracting an enormous amount of developmental effort from some of the industry's largest companies, each hoping to establish its platform as an industry standard. VLSI Technology recently brought forth the Polar chip set, which represents the fruits of its joint development effort with Intel. AT&T Microelectronics plans to begin production in the first quarter of 1994 on the second generation of Hobbit processors and support devices. And AMD says it, too, will enter the PDA market in 1994 with an integrated processor that will be able to run a "scaled-down" future version of Windows.

VLSI's Polar chip set, which is slated to enter production in the second quarter of 1994, consists of two devices, the VI86C300 Integrated Processor Controller, or IPC, and the VI86C100 Multiple Peripheral Controller, or MPC. The IPC contains a fully static 32-bit 80x86 CPU core based on the Intel 386 as well as memory and video controllers and a power management system that lets the operating system perform intelligent power management. The MPC provides I/O support to the IPC. The IPC and MPC are connected by a high-speed, 16-bit multiplexed bus, which can also connect to VLSI's VL82C146 PCMCIA controller.

The Polar chip set is the centerpiece of the "mobile companion" platform, which is jointly defined by Intel, VLSI, Microsoft, and Compaq (see the text box below). It will run the Microsoft At Work operating system, which is a DOS-less variant of Microsoft Windows that is designed to support PDA applications. The chip set, which Intel rates at about 6 MIPS, costs $50 in lots of 10,000. A 486 version of Polar is due later next year.

Along with the ARM6-based Newton platform, the major competition for the mobile-computing platform will come from AT&T, which recently introduced three variations of its Hobbit processor, along with highly integrated support chips. AT&T also recently acquired Go Corp. and its PenPoint operating system. Go is now a subsidiary of Eo, which AT&T owns jointly with other companies. AT&T has thus brought all the pieces of its personal communicator platform under its control.

The new Hobbit processors from AT&T Microelectronics are the 92020S (rated at 16 VAX MIPS), the 92020M (rated at 13.5 VAX MIPS), and the 92020MX (rated at 11.5 VAX MIPS). The 92020S is a faster version of the original 92010 Hobbit and integrates with the original Hobbit support chips.

The 92020M uses the same core as the 92020S, but it employs a multiplexed external bus. It is the centerpiece of the M family, which provides CPU, system controls, video, I/O, and support for two PCMCIA slots in three chips. Along with the 92021MX system controller, the 92020MX provides a two-chip solution that includes the CPU, memory and interrupt control, three UARTs, an LCD controller, and a single PCMCIA slot.

AT&T can now provide a range of system solutions. The two-chip MX ($76 in quantities of 1000) is designed for systems where a small form factor is essential, while the 92020S, along with three of the original Hobbit support chips ($152), maximizes system performance and functionality. The three-chip M series ($111) is a midrange solution.

The Polar chip set and the Hobbit family are alike in that they don't run DOS. At least one chip vendor, AMD, is working on a processor that will run an as-yet-unannounced version of Windows that scales down to run on PDAs. AMD says its new highly integrated Elan Am386SC processor, expected to enter volume production in the first quarter of 1994, will comprise a 386 core and AT glue logic. AMD's chip is intended for PDAs and other small computers.

In the PDA market, 1994 will be like 1993, only more so. You will see new players such as Motorola enter the market and established ones such as Apple refine their offerings. Don't look for any semblance of order, however, before 1995.

—Bob Ryan

COMPAQ AND MICROSOFT TEAM UP ON HAND-HELD

Compaq has slated late 1994 for shipments of its Mobile Companion pen-based hand-held computer, which will run Microsoft At Work software. Cellular links will let you access information stored on desktop PCs and networks, according to Jim Hartzog, Compaq's senior vice president and general manager of its portable PC division.

Preliminary plans call for Compaq's mobile system to weigh less than 2 pounds and to be about 6 square inches in the initial 386 version, with a later 486-based machine having a larger motherboard that will probably be "folded" to retain the hand-held format. Up to three PCMCIA slots will be built into the Compaq mobile system.

Compaq says its first Mobile Companion will fall into the category of a "desktop functional equivalent," having enough horsepower and compatibility to run PC applications while you travel. Compaq says its PDA system will liberate the hand-held from its reputation of executive-toy status. Using Microsoft at Work will free the mobile user from restrictive operations, such as connecting via a modem, due to the direct link between mobile and desktop machines. Pricing for the Mobile Companion has not yet been established.

—Dom Pancucci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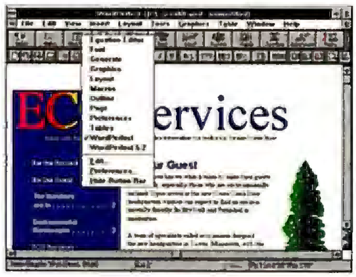

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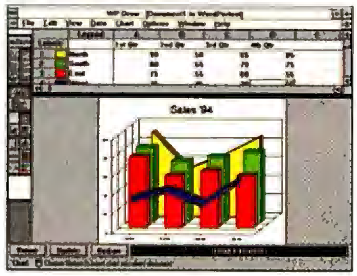

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WINDOWS/OLE 2.0

Moving Toward Windows Building Blocks

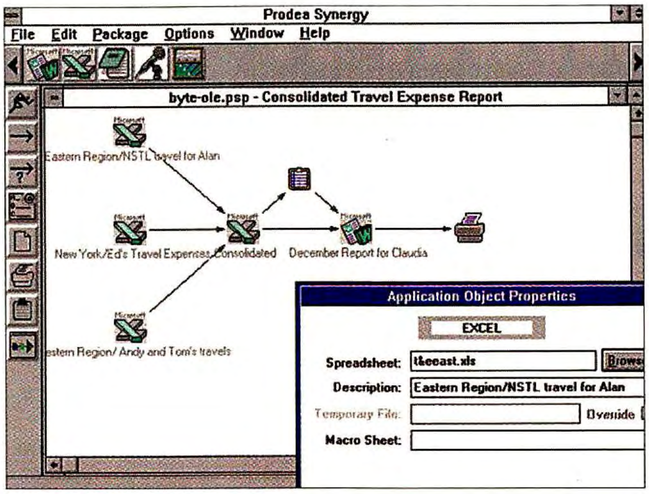
When it comes to making their Windows applications comply with Microsoft's OLE 2.0 specification, many programmers may feel obliged to join in with Ringo Starr as the ex-Beatle laments that "it don't come easy." Nevertheless, Windows programmers in general say Microsoft's specification is a good first step toward implementing a framework for software programs to better communicate with each other.

Although some pieces are still missing to make it easy to tightly integrate these OLE 2.0 applications—namely, a wide variety of applications that currently support OLE 2.0 and universal implementation of program type libraries—developers are for the most part enthusiastic about OLE's potential, through OLE automation, for enabling custom applications in Windows.

Microsoft estimates that over 100 OLE 2.0 applications for Windows will be shipping by summer 1994. Companies such as Corel, Microsoft, and Calera are already shipping OLE 2.0 programs. And OLE 2.0 is not just for Windows anymore: Microsoft is currently testing versions for the Mac and Windows NT.

Windows programs have long been programmable through DDE. But according to Jack Noonan, president and CEO of SPSS, Inc., one of the benefits of OLE 2.0 over DDE is that OLE's API provides a standard way for applications to share, and interact with, objects. Another advantage is that OLE 2.0 is synchronous and asynchronous, unlike DDE, which is asynchronous only.

Under more problematic asynchronous program interaction, a program can pop up a dialog box that tells the end



Prodea's Synergy is one of several visual programming tools that will support OLE 2.0 in 1994.

user that it has requested another program to perform a specific operation. But as Noonan explains, just because one program has told another to perform a specific task (e.g., create a complex graph), that doesn't mean the operation has been completed. In asynchronous operation, an end user of a program might see a graph popping up in a window 30 seconds after he or she actually thought the action had been completed. "Because OLE 2.0 events happen synchronously, this prevents programmers from having to deal with timing tricks and having to estimate how long it would take to create that graph," Noonan explains.

However, OLE 2.0 does not specify a common set of verbs that all compliant applications must support. Unlike the comparable situation on the Mac, in which System 7 programs must support a core suite of Apple Events, the programming verbs supported across OLE 2.0–compliant Windows programs will vary.

Furthermore, OLE 2.0 does not provide for the remote execution of server programs across a network, unlike the Mac situation in which messaging works across networks handily. Under OLE 2.0, you can still link to data files stored on network drives, but you cannot embed objects that will execute applications across the network. For that, you will have to wait for some undetermined amount of time for distributed OLE.

If you find yourself doing the same old operation of pulling data out of one Windows application, reformatting it, and stuffing it into another application, you are a potential beneficiary of OLE 2.0 automation. Using Windows programs and a scripting tool that supports OLE 2.0 automation (see the table "OLE 2.0 Automation Tools"), you can attach your custom macro program to a dialog box that you have visually programmed using a product such as Microsoft's Visual Basic to automate repetitious actions.

But to create such a pushbutton program, you will likely have to sweat out the details of each program's various methods and objects. According to Jim Lawyer, chief technical officer at Summit Software (Jamesville, NY), many users learn how to write a macro program for a specific application by recording an action (e.g., a reformatting operation) with the program's macro recorder and then examining and editing the created macro code. Such a macro recorder in OLE 2.0, which would watch as users perform actions across several applications, would help programmers to more quickly create custom integrating applications, Lawyer says.

Unfortunately, OLE 2.0 doesn't currently support such a systemwide recorder. Nor will most OLE 2.0 applications ship with type libraries in their initial release. Through OLE 2.0's registration database, programs will register their objects with the OLE 2.0 system along with all the methods (i.e., functions) and properties of those objects.

But what most programs will not initially do is support type libraries, which document the specific parameters (or arguments) that various object methods will support. This means that if you pass incorrect parameters to a method, you will likely not catch those until run time, instead of at compile time. This is not necessarily the fault of the independent software vendors, says one developer. "The app builders that build the programs have a lot of other stuff to worry about, like debugging their programs and shipping their product," he says. Others say that once the initial releases of OLE 2.0 applications ship, the type-library situation should improve. Until then, if you are stringing together several

continued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Moving Toward Windows Building Blocks

Windows programs, you may find yourself mucking around in the back of those programs' manuals.

Currently, few shipping programs support OLE 2.0, and the level at which they do so will vary. Some applications will be OLE servers only (i.e., you can embed them in another application, and the server program will provide services to the client application). At press time, the only shipping OLE 2.0 application that was both a client and a server was ShapeWare's Visio 2.0 drawing program, although others, such as Microsoft's Excel 5.0 spreadsheet program, were close to shipping.

Why the delay? For one thing, the original OLE 2.0 SDK (Software Development Kit) released by Microsoft earlier this year shipped with beta automation libraries. In addition, programmers found the performance of OLE 2.0 less than optimal. Microsoft addressed programmers' complaints by shipping OLE 2.01 in September.

And many programmers (though not all) found that the OLE 2.0 specification was very complicated. One developer, who wished to remain anonymous, characterized OLE 2.0 as "a C++ arrangement crammed into a C arrangement. Trying to do it in C is a real nightmare."

Several developers are looking forward to an upcoming release of version 2.5 of Microsoft's Foundation Classes for C++ (which is currently in beta testing). The release reportedly encapsulates much of the complexity of standard OLE functionality and offers Object Wizards and other tools for developers to use to implement visual editing and automation in their programs.

Despite the complexities, developers say that Microsoft has been helpful. David Skok, president of Watermark Software, says Microsoft's developers and porting lab has been "marvelous from the standpoint of looking out for us."

However complicated it may be, a lot of developers believe OLE 2.0 is worthwhile. To be fair, OLE 2.0 is only now starting to approach the type of custom application programming that developers working in the NextStep environment have enjoyed for years now. "OLE 2.0 is a complex system," says Peter Mullen, Visio development manager at ShapeWare. "But all the pieces are required, and you have to ante up to all of them before you reach the Holy Grail."

Watermark's Skok goes even further. He notes that "without OLE, this company couldn't exist." However, by promoting interapplication integration, OLE 2.0 alleviates the need for one Windows product to "do it all" and allows developers to instead concentrate on their applications' core competency.

—Dave Andrews and Selinda Chiquoine

OLE 2.0 Automation Tools

SPSS 6.0 for Windows Developer's Kit
SPSS, Inc., (312) 329-2400

Embedded Basic for Windows
Summit Software, (315) 677-9000

Softbridge Embeddable Basic Language
Softbridge, Inc., (617) 576-2257

Visual Basic 3.0
Microsoft Corp., (206) 882-8080

Synergy
Prodea Software Corp., (612) 942-1000

Capsule for Windows
Metaphor, Inc., (415) 961-3600

OLE bug-hunting technology
Blue Sky Software, (619) 459-6365

WinBatch
Wilson WindowWare, Inc., (206) 938-1743

Not all tools listed here currently support OLE 2.0, although the companies report they are working on OLE 2.0 implementations of their products.

PERIPHERALS

Plug-and-Play to Bring ISA into the 1990s

If you've ever added a peripheral device to a Mac and then tried to do a similar operation with an ISA-based PC, you know the benefits of the Mac's built-in auto-configuration, which eliminates the need for fussing with DIP switches and jumpers to install a network card or modem. Now the first ISA-based PCs to compete in the plug-and-play arena are slated to be available.

In November, Compaq, Microsoft, and Intel were expected to announce that they are putting plug-and-play features onto the motherboard of Deskpro PCs using the ISA bus, according to sources close to the companies. This will reportedly make it easy for users to add peripheral devices and extra components to systems without arduous configuration changes. AST, Acer, Dell, and IBM are also expected to release plug-and-play products throughout 1994.

The move will bring PCs using the ISA bus up to the capabilities of EISA, Micro Channel, and Mac machines, which have been able to do things like automatically reconfiguring systems to accept extra memory. Intel has been heavily involved in this project to bring Windows 3.1 into a tight fit with the hardware. Compaq already has a plug-and-play machine, called Presario, aimed at the home and small-business market. Deskpro PCs equipped with plug-and-play capability will be sold to corporate users.

Plug-and-play for ISA caps a year of activity in the plug-and-play field. In September, 12 companies—including Compaq, IBM, Intel, Microsoft, and Toshiba—agreed on a BIOS specification to allow laptops to get automatic configurations when linking to a LAN through a docking station. A three-phase plan has been set to achieve this goal, with drivers for the docking station at the top of the priority list. The next two phases will see automatic laptop links with network services and automatic loading of specific software once the laptop has docked into the LAN.

While unable to comment at press time on the prospective ISA announcement, Lorie Strong, vice president of Compaq's portable division, predicted that plug-and-play will rapidly become a common feature of the PC industry once Microsoft's Chicago version of Windows appears. Microsoft At Work will be used to make mobile hand-held devices easy to use, while Chicago will apply to notebooks, Strong says.

Microsoft is also working with Toshiba to put plug-and-play capability onto its products. Toshiba will license Microsoft At Work software and will collaborate with Microsoft over future operating-system developments for portables.

—Dom Pancucci


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SOUND CARDS

Sound-Card Standards Heading for MIDI

When you buy an audio CD and play it on your CD player, you're hearing 16-bit sound at a sample rate of 44.1 kHz (44,100 samples per second). But until recently, most computers with sound capabilities offered 8-bit (or less) sound, which is fine for speech playback or for simple "shoot-'em-up" game sounds, but not good enough for many of today's multimedia applications, which may include a range of sound effects and music requiring 16-bit CD-audio sound quality.

Currently there are no clear software-interface standards for 16-bit sound boards. In the Macintosh world, the standard interface is the Macintosh Sound Manager, which now supports 16-bit sound, allowing vendors such as Media Vision to enter the Mac market with their sound boards.

In the DOS/Windows world, the two hottest-selling boards are Creative Labs' Sound Blaster and Media Vision's Pro Audio Spectrum series, both of which use their own sound interfaces. Then there's Microsoft Windows' own sound API, which supports Microsoft's own 16-bit sound interface as well as the General MIDI interface.

These varying standards present a problem for CD-ROM publishers. The sounds that are stored on a CD-ROM disc must support the sound hardware of the host computer or they won't play back. Says Chris Andrews, founder of UniDisc, a Santa Cruz, California–based CD-ROM publisher offering titles such as the Guinness Book of World Records and the Grammy Awards, "the two main companies in the game are Creative Labs and Media Vision, and most [CD-ROM developers] design for those two."

Even competitors of Creative Labs acknowledge that Sound Blaster is currently the dominant sound standard in the DOS/Windows environment. For example, Logitech's SoundMan 16 sound card supports the Sound Blaster interface. Says David Pelton, Logitech's product manager for the SoundMan, "we recognized the fact that Sound Blaster is the de facto compatibility standard."

However, Steve Podradchik's Seattle-based Medio Multimedia CD-ROM publishing company is simply supporting the Windows sound API. "Any sound board that works under Windows," says Podradchik, "will support our titles."

The bottom line is that if you want a multimedia system on a PC, you will need Windows and a sound card that supports Windows.

While Sound Blaster may be the current standard, industry insiders that BYTE talked to all agreed that a more universal standard for sound will take hold in the next few years. Paul Jain, president of Media Vision, points out that "small companies like us and Creative Labs don't spearhead standards." The standard that is likely to emerge is General MIDI, which is already the standard interface in the digital music industry.

Says Joe West, owner of Computers and Music in San Francisco, "General MIDI will become the standard that replaces Sound Blaster files. It will be a lot easier on developers and will allow OEMs to make better stuff." This prediction is echoed by Media Vision's Jain and Logitech's Pelton. "Our belief is that General MIDI will become standard," says Jain. "It allows developers to work with one instruction set."

—Nicholas Baran

Demand for Multimedia Upgrade Kits Growing

If you're going to set up your computer for multimedia applications, you'll need a CD-ROM drive and a sound card. That's why a lot of vendors are selling multimedia upgrade kits.

The demand for both CD-ROMs and upgrade kits is just starting to grow. Paul Jain, president of Media Vision, says that last year the company sold about four times as many individual sound cards as it did multimedia upgrade kits (i.e., sound cards and CD-ROMs sold as a package), which confirms that the game market still dominated the demand for sound cards at that time. Still, "multimedia upgrade kits are becoming a major revenue source for us," says Media Vision's Elizabeth Fairchild.

According to John Eroszonak, director of vendor relations for mail-order house PC Connection, the company has been selling sound boards steadily since last year, but CD-ROM sales are just starting to pick up. "Last year, most customers were buying sound cards for games. But now there are a lot more applications taking advantage of CD-ROM and 16-bit sound, for educational use, for example," he notes. Nevertheless, Eroszonak says that PC Connection sells more CD-ROM drives and sound cards separately than bundled as multimedia upgrade kits, although upgrade-kit sales are also picking up.

In spite of the growth, CD-ROMs "haven't hit their stride yet," says Eroszonak. Chris Andrews, president of CD-ROM publisher UniDisc, says, "a good CD-ROM title ships about 25,000 units; we're like a small book publisher."

But the outlook is promising. First of all, CD-ROMs are not driven only by the multimedia market. Many operating-system vendors are distributing their software on CD-ROM: Sun Microsystems, Next Computer, and Microsoft, to name a few. And software developers like to distribute software on CD-ROM.

Once users have CD-ROM drives, the applications will follow. Says Steve Podradchik of Medio Multimedia, "Acceptance [of CD-ROM] is going up, but there's a lot of confusion. Multimedia always requires CD-ROM, but CD-ROM doesn't always require multimedia." But Podradchik acknowledges that most CD-ROM titles require at least 8-bit sound capability.

Probably the biggest challenge for CD-ROM is gaining acceptance in the business world. According to Cathy Harris, Microsoft's product manager for PowerPoint, a survey of registered PowerPoint users shows that less than 1 percent use sound and video in their business presentations. However, Media Vision's Paul Jain says that a growing number of organizations are purchasing his company's sound boards, including Boeing and the Department of Defense, which is using multimedia systems to teach foreign languages to its intelligence personnel. "Thirty percent of our customers are business users," says Jain.

—N. B.

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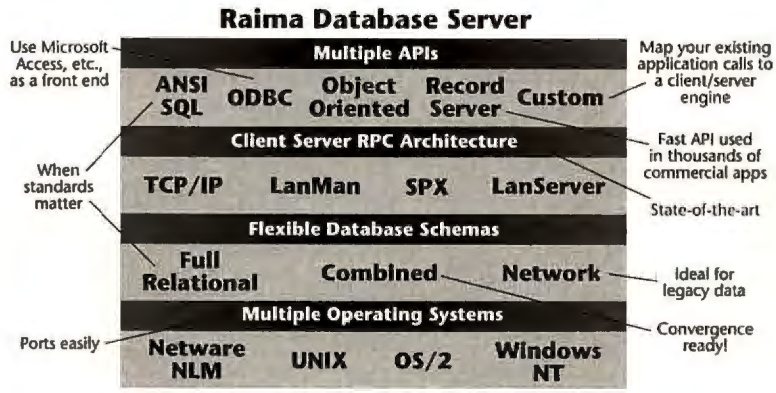

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Windows NT is sparking some hot competition among chip makers who want a piece of the growing market for high-performance desktop PCs and servers. Three new RISC microprocessors from DEC (Hudson, MA), Integrated Device Technology (Santa Clara, CA), and Toshiba America (Irvine, CA) are challenging the early leads claimed by Intel's Pentium and the Mips R4400. All three new chips are sampling now and are scheduled for volume production early next year.

DEC's entry is the AXP 21066, the lowest-cost member of the Alpha AXP family. The 21066 sets a new standard for integration: It's the first microprocessor to include support for PCI (Peripheral Component Interconnect). It also integrates a memory controller and a graphics accelerator.

IDT and Toshiba are introducing separate versions of the new Orion R4600, developed in a joint venture with Quantum Effects Designs (San Jose, CA). The Orion is a Mips R4400–compatible CPU that is claimed to be faster than Mips's own R4400PC. IDT is producing a 5-V version while Toshiba makes a 3.3-V part. IDT says it will introduce a 3.3-V version as well in 1994. All these chips share a common design philosophy: By departing slightly from existing architectures within their respective processor families, they slash costs while delivering Pentium-level or better performance.

DEC's 21066, for example, shares the same superscalar architecture as the faster AXP 21064, but it's clocked at 166 MHz instead of 200 MHz. The data bus was scaled down from 128 bits to 64 bits, and the pin count was reduced from 431 to 287.

Yet despite these modifications, the level of integration was actually increased. The 21066 includes the equivalent of a complete processor-to-PCI chip set, except for a bridge chip to a secondary I/O bus. The bridge chip was omitted so that system designers can couple the 21066 to any secondary I/O bus they want, such as ISA or EISA.

All this integration adds approximately 10 percent more silicon area to the core logic of the 21066. The chip is currently manufactured with the use of a three-layer-metal, 0.68-micron, CMOS process technology, but it will move to a 0.5-micron process next spring, shrinking the die almost 50 percent.

The Orion R4600 similarly diverges from its parent architecture while maintaining compatibility and reducing cost. Although it's pin compatible with the Mips R4400PC, the Orion has a five-stage instead of an eight-stage pipeline, and it substitutes a two-way set-associative cache for the R4400's direct-map primary cache. IDT says these modifications result in fewer stalls during instruction processing.

Another significant departure from the R4400PC is the Orion's fully static core and standby mode. A new wait instruction stops all internal clocks and dramatically cuts power usage. IDT says the 3.3-V Orion consumes only about 2.3 W when running normally, and 40 to 60 milliwatts while on standby.

The Orion's die size, power dissipation, and price are about half that of the R4400PC. Yet it's fully compatible with the R4400PC and has the same 64-bit data paths.

The first Orion will be clocked internally at 100 MHz and externally at 50 MHz (i.e., 100/50). Next year, faster versions are expected to range from 120/40 MHz to 133/66 MHz, topping out at an estimated 84.5 SPECint92.

Of course, other chip makers aren't standing still, either. In 1994, Intel plans to move the Pentium to a 0.65-micron process that should boost its performance while sharply reducing both power consumption and manufacturing costs. IBM and Motorola hope to introduce their PowerPC 603, 604, and 620 chips by late 1994, and speedier versions of the Mips R4x00 series and DEC Alpha are anticipated as well.

—Tom R. Halfhill

TI COURTS 486SX AFTERMARKET

Even as Intel eases off production of its 486SX processor class to embrace its next-generation processors, competitors are jumping in to give new sizzle to old chip designs. Following the example of AMD, which is shipping three versions of 486SX chips, including one that runs at 40 MHz, Texas Instruments [(800) 477-8924 ext. 3726] has announced a family of 486SX-class processors that offer up to 50-MHz clock-doubled performance for energy-aware subnotebook and desktop designs.

Based on microcode that Cyrix wrote for its Cx486SLC and Cx486DLC processors, the two-level "Potomac" family is primarily for users who need portable and desktop performance in the Intel 486DX2-50 range but don't need the FPU and its price premium. The TI486SXLC is pin compatible with Cyrix's 100-pin flat-pack SLC, yet it offers higher speeds: 25 MHz and clock-doubled 20/40 MHz for 3-V designs and 33 and 50/25 MHz for 5-V designs.

—Ed Perratore

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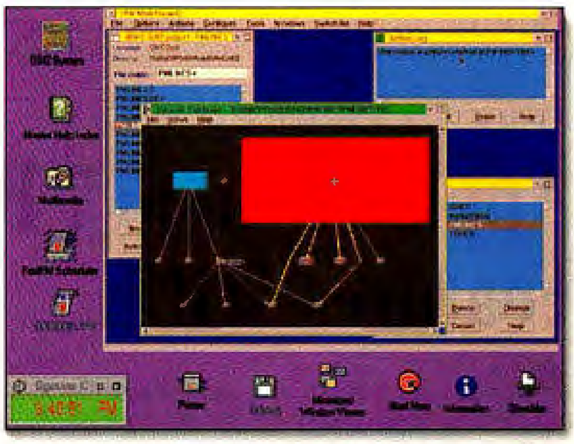
C Set++



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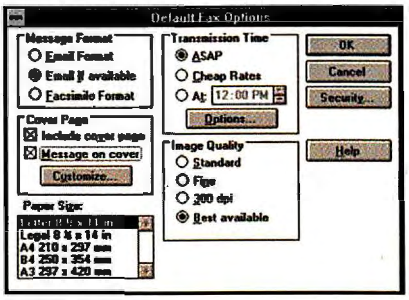
WORKGROUP COMPUTING

Microsoft Tunes WFW

Microsoft tried to have us believe that Windows for Workgroups 3.1 was *the* product that would propel the PC industry into the twenty-first century, but it wasn't quite the force that many had expected. Version 3.1 falls down when it meets complex network architectures, failing to deliver the necessary security, and it offers no support for ODI, LANtastic, and other popular networks. WFW 3.1 further fails to take adequate care of DOS users and is woefully slow.

WFW 3.11, now in beta testing, came out of the starting gate as no minor upgrade. Had Microsoft released 3.11 before releasing 3.1, the product just might have topped the peer-networking charts. Important additions to version 3.11 include increased support for NetWare with host peer services over IPX and ODI drivers, and a 32-bit protected-mode version of the IPX protocol. The product's speed is also improved because it incorporates some of the 32-bit technology that will be in Chicago. And its function as a DOS-peer client is enhanced, in addition to its new ability to function as a DOS server that doesn't require Windows.



WFW now includes fax capabilities.

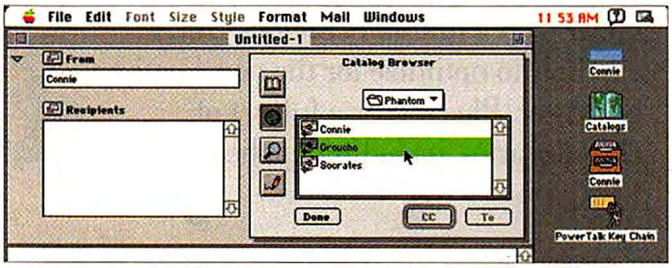
Microsoft also added Microsoft At Work Fax capability, remote access to Windows NT servers, and, finally, a central configuration utility that adds access control and security for system administrators.

The new features of WFW 3.11 make it not only a leading contender for a peer-networking solution, but a viable update to Windows for those who have no need for a network. MIS managers may keep it at arm's length, because it is a peer environment that gives users the potential of wielding too much power for the needs of an MIS department.

—Anne Fischer Lent

PEER NETWORKS

Apple's System 7 Pro Features AOCE



System 7 Pro now provides systemwide messaging.

Apple has announced System 7 Pro, the latest version of the Mac OS that provides significant capabilities for office workgroups. System 7 Pro is technically System 7.1, but it has new communications features based on AOCE. Known as PowerTalk, these services provide systemwide electronic messaging, consolidate communications services, and offer security.

PowerTalk is based on Apple's IAC, a high-level protocol that Mac applications use to pass messages requesting services among themselves. IAC, first available when System 7 was introduced, operates across networks and so provides a solid transport foundation for PowerTalk's services.

However, IAC is an immediate messaging protocol: The target Mac on the network must be active to receive application messages. AOCE makes effective workgroup software possible by providing a store-and-forward mechanism that's required when the target Mac is switched off. For a typical Mac with System 7 Pro, the message is queued until the target Mac appears on the network.

But ultimately the target Mac must be on while the sending Mac is active for the deferred messages to proceed. A server version—called PowerShare Collaboration Server—implements true store-and-forwarding by queuing the sender's message until the target Mac becomes available. This way, the sending Mac can be off and the target will still get the messages directed to it.

PowerTalk manages communications in two ways. First, it provides a basic mail service API where—from any application—a user can attach a "mailing label" to a document. Second, PowerTalk consolidates all communications into a universal mailbox. This mailbox appears as an icon on the Mac Desktop, and documents can be dragged and dropped to and from the mailbox.

Bundled with System 7 Pro are AppleScript and QuickTime 1.6.1. AppleScript allows you to automate forms processing.

PowerTalk provides security features with its DigiSign software. It's based on RSA's digital signature technology. A PowerTalk user can "sign" a document and forward it to a manager, who uses DigiSign to confirm that the signature is valid and that the document hasn't been tampered with.

PowerShare servers can function as signature repositories and can also establish peer-to-peer sessions between Macs with encrypted data streams. These security features allow offices to eliminate most paper documents and thus expedite forms processing.

The single-user System 7 Pro Personal Upgrade Kit costs $149. A 10-user version is available for $999. Volume licensing is available. PowerShare Collaboration Server software will be available in early 1994 for $999. A Mac with 5 MB of RAM is required to run System 7 Pro, and 8 MB is required to run PowerShare Collaboration Server.

—Tom Thompson

This VX•REXX will really get you GUI-ing.

Developers: on your marks, get set—GUI! With VX•REXX,™ WATCOM™'s visual development environment for OS/2® REXX, you're on the fast track to creating applications that exploit the graphical user interface capabilities of OS/2 and the Workplace Shell.™

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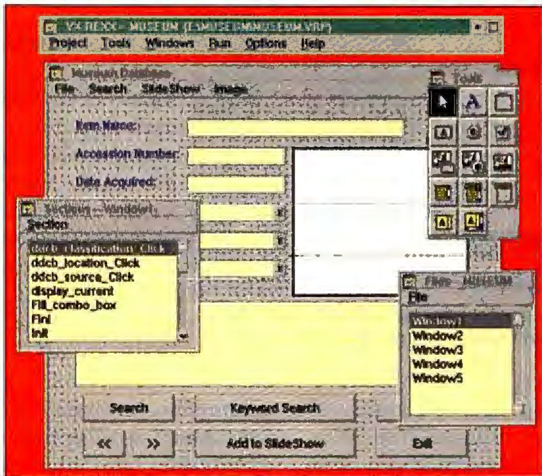

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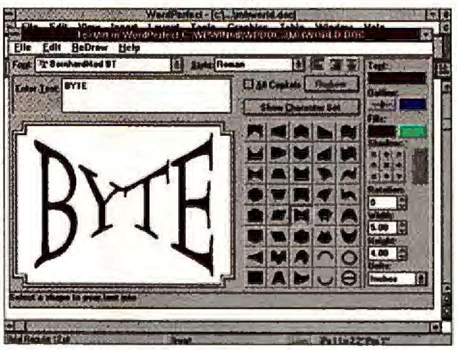
WINDOWS WORD PROCESSING

WordPerfect 6.0 for Windows: Bigger and Meaner

A full installation of WordPerfect 6.0 for Windows uses 33 MB of hard disk space, about 21 MB more than version 5.2. Figuring 312 days between versions, that comes to a growth rate of about 69 KB of code per day, or roughly 49 bytes per minute. Yes, Windows word processors do grow. But so have the reasons to consider WordPerfect Corp.'s latest rollout.



TextArt, a bundled utility that WordPerfect licensed from Bitstream, lets you create special text effects.

For the same $495 price, the new version sports a cleaner, more graphical, and customizable interface—the result, says the company, of a complete rewriting of the product. New icons for the button bar and the addition of a smaller "power bar" speed the most-used functions you select from among a total of 81. The top line of your screen, formerly reserved for the WordPerfect title plus your current filename, now changes by default to a help prompt that describes each button you point to with your mouse.

You can alter information on the bottom of your screen's status line to show what you find pertinent or, as with the other menus and bars, hide the line if you want. And if you want to use another program from within WordPerfect, such as a personal dictionary, you can drag a file or program icon from the Windows File Manager onto the button bar.

Enhancements are rampant. QuickMenus of commonly used functions, for example, showed up in version 5.2 only when you clicked your right mouse button on a graphic box, OLE objects, or the button bar. Now, the limits are off; click on text, graphics, bars, or anywhere else, and you'll get a QuickMenu. Another function, called tables, now allows data fills, named ranges, and the use of 98 cell formulas—a far cry from version 5.2's simple arithmetic.

Much of the program's additional girth is due to not merely enhancements, but functions you never saw here before. For one, WordPerfect 6.0 is bundled with ExpressDocs, more than 45 customizable document templates that previously cost an extra $19.95. If a staffer needs some handholding, for instance, the new Coach feature provides a step-by-step walk-through of a variety of tasks.

TextArt, an impressive bundled utility licensed by Bitstream (which also created the 25 included TrueType fonts), lets you create special type effects in various shapes, colors, fills, and shadows.

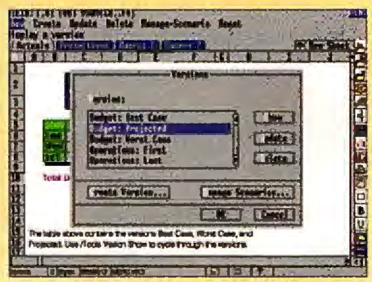
Perhaps the biggest new addition to 6.0, however, is that much of the functionality of WordPerfect Presentations has been included here, too: Bézier curves, text contour around a curve, vector drawing tools, and seven chart types that you can create from a table or from imported spreadsheet data.

—Ed Perratore

NEW WORDPERFECT 6.0 FEATURES AT A GLANCE

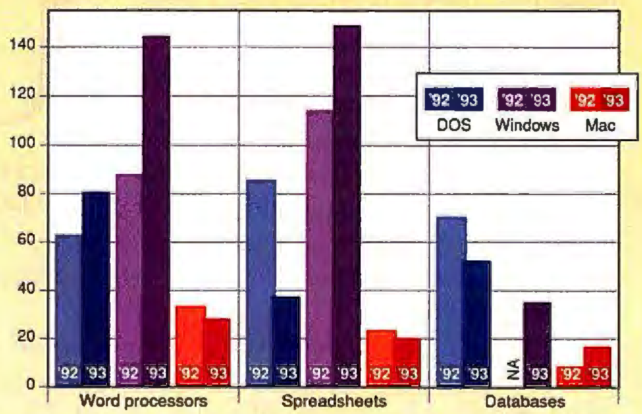
- Increased customization of the user interface.
- Comes bundled with ExpressDocs templates.
- Import and export of all common word processing, spreadsheet, and database formats.
- Improved tables, with 98 formulas, numerical cell formatting, automatic calculation, and other spreadsheet features.
- Incorporation of WordPerfect Presentations' drawing tools.
- Charting functions for graphs based on table or spreadsheet data.
- Sound-clip embedding in documents; also, support for OLE server multimedia applications.
- Document Information feature counts words, lines, paragraphs, pages, and more.

LOTUS, BORLAND UPDATE DOS SPREADSHEETS



The latest Software Publishers Association report estimates that North American sales for DOS-based spreadsheets declined by 56.2 percent in the second quarter of 1993 compared to the same period in 1992. Still, the SPA shows that total sales for DOS spreadsheets in the second quarter of 1993 accounted for $37.6 million in North America (and an estimated $125 million in 1993), a market that Borland and Lotus continue to cater to.

This fall, Borland released Quattro Pro 5.0 for DOS. Now Lotus is poised to strike back with 1-2-3 release 4 for DOS (shown above), which will require at least a 286 processor (Lotus says it will continue to sell and enhance 1-2-3 release 2.4, which runs on Intel 8088-based processors). Release 4 will likely include faster recalculation, improved printing and charting, and version management similar to that of release 4 for Windows. Lotus says it will release the upgrade in the first quarter of 1994.



Although sales of DOS spreadsheets were down in the second quarter of 1993 compared to the same quarter of 1992, sales of DOS word processors increased, thanks to new versions of DOS-based Microsoft Word and WordPerfect. (NA indicates sales of less than $1 million. All figures are in millions of dollars.)

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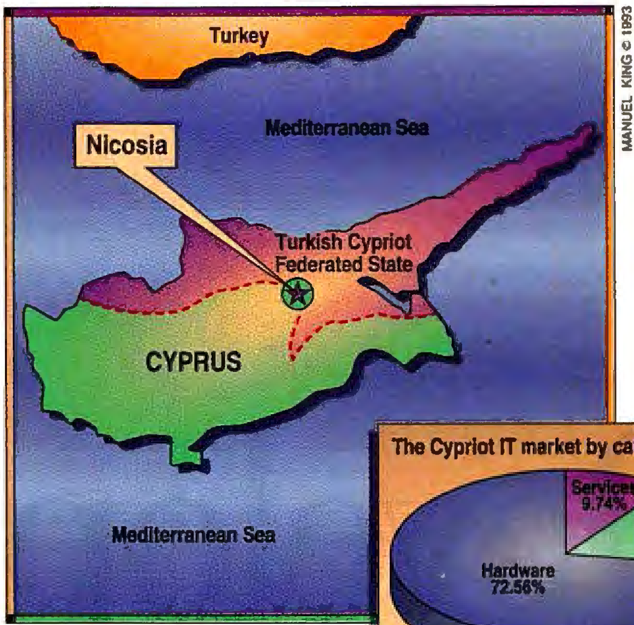
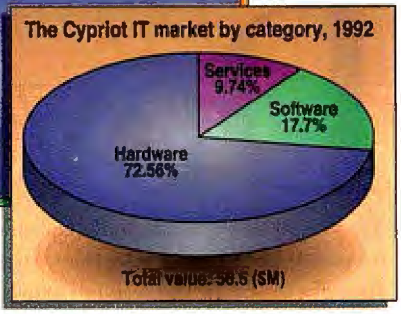
DAVID C. KITTOS

A Market in Transition





With reduced profits hitting an oversaturated computer dealers' marketplace and a new copyright law taking effect on January 1, software and IT consulting should become much more important commodities in 1994

Nicosia is the last divided capital city in Europe, an obstacle that hinders both the growth of IT (information technology) and the sharing of knowledge and ideas between its Greek and Turkish communities. IT in Cyprus is changing from a hardware-oriented market to a solutions-oriented market. The high profit margins on hardware, traditionally about 30 percent, have led to 110 dealers for a population of 650,000. The Cyprus PC market is clearly becoming saturated.

Most vendors can no longer expect large profits from PCs—margins now average about 10 percent. Some may retrieve a portion of their investment through maintenance agreements. While some vendors are "one-man-and-his-dog" businesses, many offer a wide range of professional, high-quality solutions. These include PCs from well-known makers (e.g., IBM, Compaq, Hewlett-Packard, Zenith, NCR, Dell, and Samsung) including cross-operating-system communication. Novell solutions are popular for office-automation projects, while Unix dominates the client/server arena.

Marios Loucaides, manager of Demstar, a large PC and peripherals dealer in Nicosia, observes that many dealers have trouble distinguishing between products and services. "They spread themselves thin, over too many activities, without trying to find out how profitable each one is," he says. His firm is divided into several profit centers. "Activity-centered accounting helps us maintain a clear picture of how business is going," Loucaides adds.

Nick Stephanides, operations manager for IBM in Cyprus, believes that vendors who lack professionalism have little future. IBM conducts seminars for its dealers, giving them access to extensive resources. Level of service and technical know-how are very important. "We do not expect vendors who make little or no investment in training to be in business for long," Stephanides says. According to International Data, expenditures for IT on Cyprus in 1992 totaled $56 million, with 72 percent for hardware, 18 percent for software, and 10 percent for services. Forecasts for this year projected the market at $70 million.

These figures show that the market does not yet appreciate the value of software, which is often ignored by dealers or seen as an insignificant sideline. Recently, I overheard a graphic designer brag that he had purchased a used Mac with some CY£10,000 (approximately $20,000) worth of "free" software on its hard disk.

The absence of a software copyright law on Cyprus obviously hurts software sales, but new laws will be effective as of January 1. Also, the relative importance of services and software may rise as a new generation of business users and scientists—people who appreciate the value of services—takes over.

Cypriot computer users also show a lack of appreciation, even hostility, toward management consultants. This may be part of a wider trend to devalue intangible commodities. Many believe that advice can and should be free. Part of the problem stems from abuse of the word *consultant* by anyone who wants to make a quick buck. In Cyprus, almost everyone claims to be a consultant.

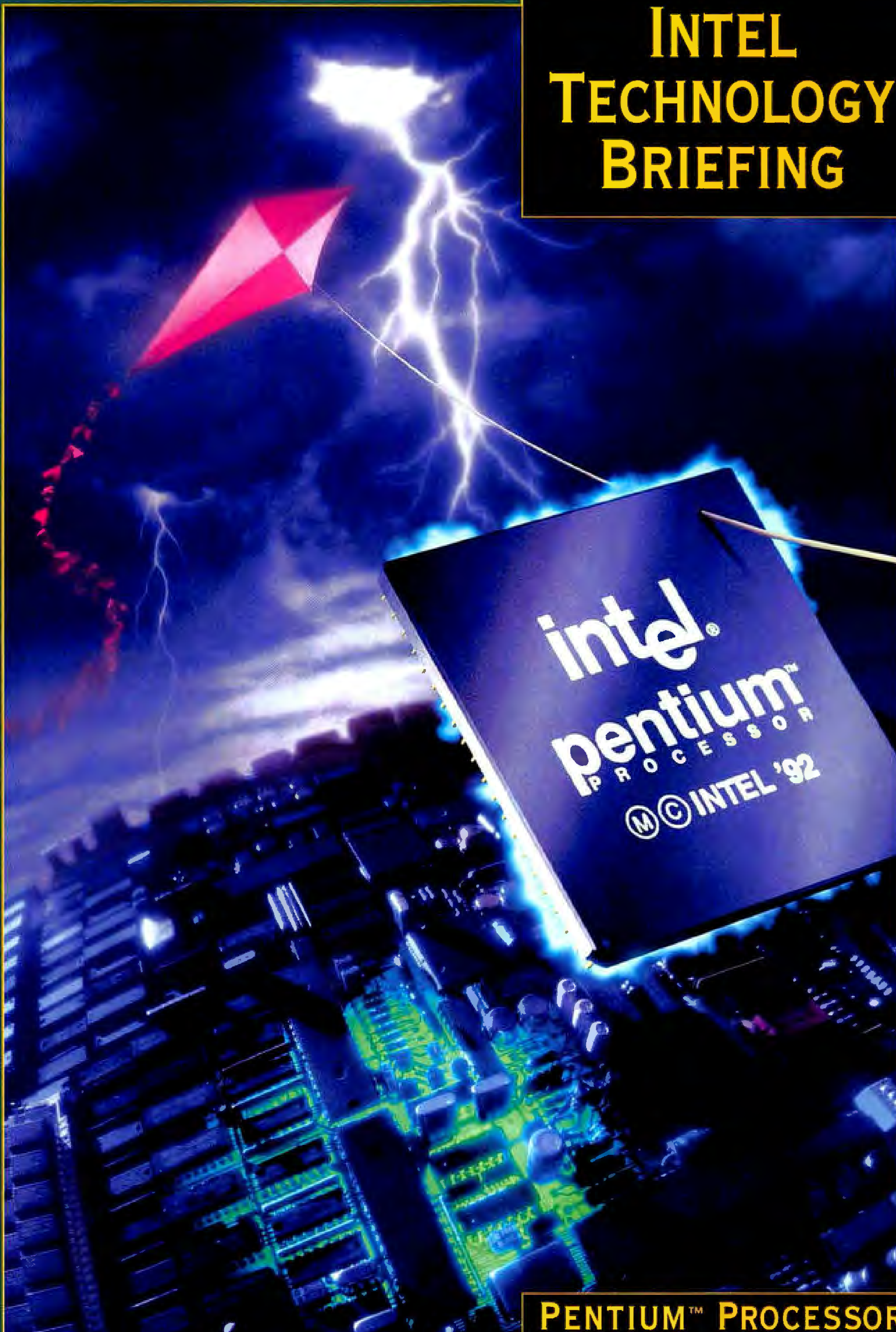
However, this is changing. A new Management Consultants Association aims to control entry to the profession on the basis of qualifications and experience. Through its Institute of Technology, the government has compiled a list of registered consultants. No subsidy will be paid on a project unless a registered consultant is used.

Kostas Kataras, the managing director of International Data's Greece and Cyprus office, believes that the local IT industry is changing: "We expect the market will soon follow its own direction, and this may be painful for inefficient and unprofessional PC sellers." Kataras adds that "aggressive marketing, value for money, a solution-oriented approach, customer support, and efficient distribution channels are... the name of the game. It happened in Greece, and now Cyprus follows. Transitions are painful, but that is the way markets work." ■

Editor's note: *The views expressed in this article are those of the author and persons interviewed by him and do not reflect the views of his employer.*

David C. Kittos is an IT consultant for KPMG Metaxas Loizides & Syrimis in Nicosia, Cyprus. He holds an M.Sc. in analysis, design, and management of information systems from the London School of Economics. He can be reached on BIX c/o "editors."

INTEL TECHNOLOGY BRIEFING



PENTIUM™ PROCESSOR
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HOW WE'RE GIVING PCs ELECTRIFYING POWER.

There is a new source of computing power. It's capable of executing two instructions at once. It's produced processing speeds over 100 MIPS. It's the next generation of compatible power. It's called the Pentium™ processor. And this brief will tell you how its technology is making PCs run faster today.

THREE WAYS TO MAKE FASTER PCs.

Faster PCs start with faster microprocessors. And there are three ways to make faster processors:

1. Increase the number of transistors. Today, the use of sub-micron components lets designers fit more than 3 million transistors on a single chip. So we can integrate components such as math coprocessors and caches right onto the CPU—dramatically cutting access time.

2. Increase the clock speed. Twelve years ago the clock speed ticked along at a measly 4.7 MHz. Today we can run at an astonishing 66 MHz—and we're still pushing for more.

3. Increase the number of executions per clock cycle. Using new superscalar technology, our processors are now capable of executing two instructions per clock cycle.

THE NEW PENTIUM PROCESSOR IS FULLY SOFTWARE-COMPATIBLE WITH OUR INTEL ARCHITECTURE FAMILY.

WORKS IN PRINCIPLE AND IN PRACTICE.

Employing the techniques above, we've created the new Pentium processor. A processor that is over 300 times faster than the first PC microprocessor.

THE PENTIUM PROCESSOR. A MODEL OF EFFICIENCY.

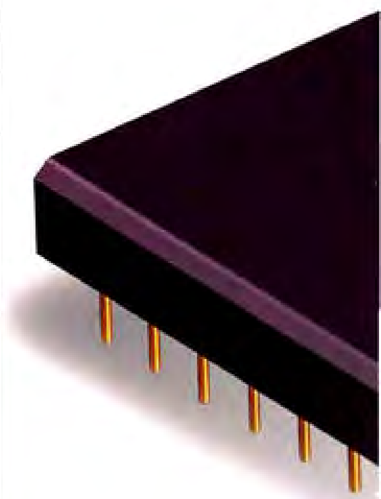
The Pentium processor can be described as a super-efficient factory. Its main assembly line is its superscalar technology—which enables information to be processed simultaneously through dual pipelines. To accomplish this, the pipelines divide up an instruction, then send it through five stages. As it passes from one stage to the next, the pipeline is free to begin another instruction. Speeding up operations substantially.

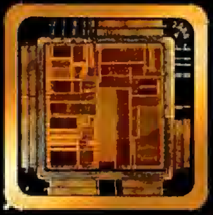
PUMPING DATA THROUGH.

The rest of the features on the processor are designed to keep that main assembly line working at peak capacity *(see diagrams).* These features, along with the superscalar technology, help the Pentium processor to crunch more than 100 MIPS at a clock speed of 60 MHz.

HOW FAST DID YOU SAY?

Twice the performance of our own Intel486™ DX2 66 MHz processor. Plus, the redesigned floating-point unit on the Pentium processor offers up to five times the performance of the Intel486 DX2-66 CPU for math-intensive applications.





The line width of each transistor is 1/100th the thickness of a human hair. Or 0.8 microns to be exact. So we can pack 3.1 million transistors into an area this size.

PENTIUM PROCESSORS

A photographic memory right on board.

Now there are separate 8K code and data write-back caches that reduce cache conflicts and increase system performance. With an on-chip cache, we keep essential information within an arm's reach of the main assembly line. So that instructions and data can be fetched without wasting any time. And a full 95% of the time, the information is right at hand.

Think of it as a 64-lane freeway inside your CPU.

To get data really moving, we doubled the size of the bus on the first Pentium processor. This allows twice as much information to be fetched at once. There is even a burst mode for high-speed information transfer—so more information gets to where it's going quicker. Plus, automatic data integrity checking to be sure the right data is being moved.

We programmed the chip to be clairvoyant.

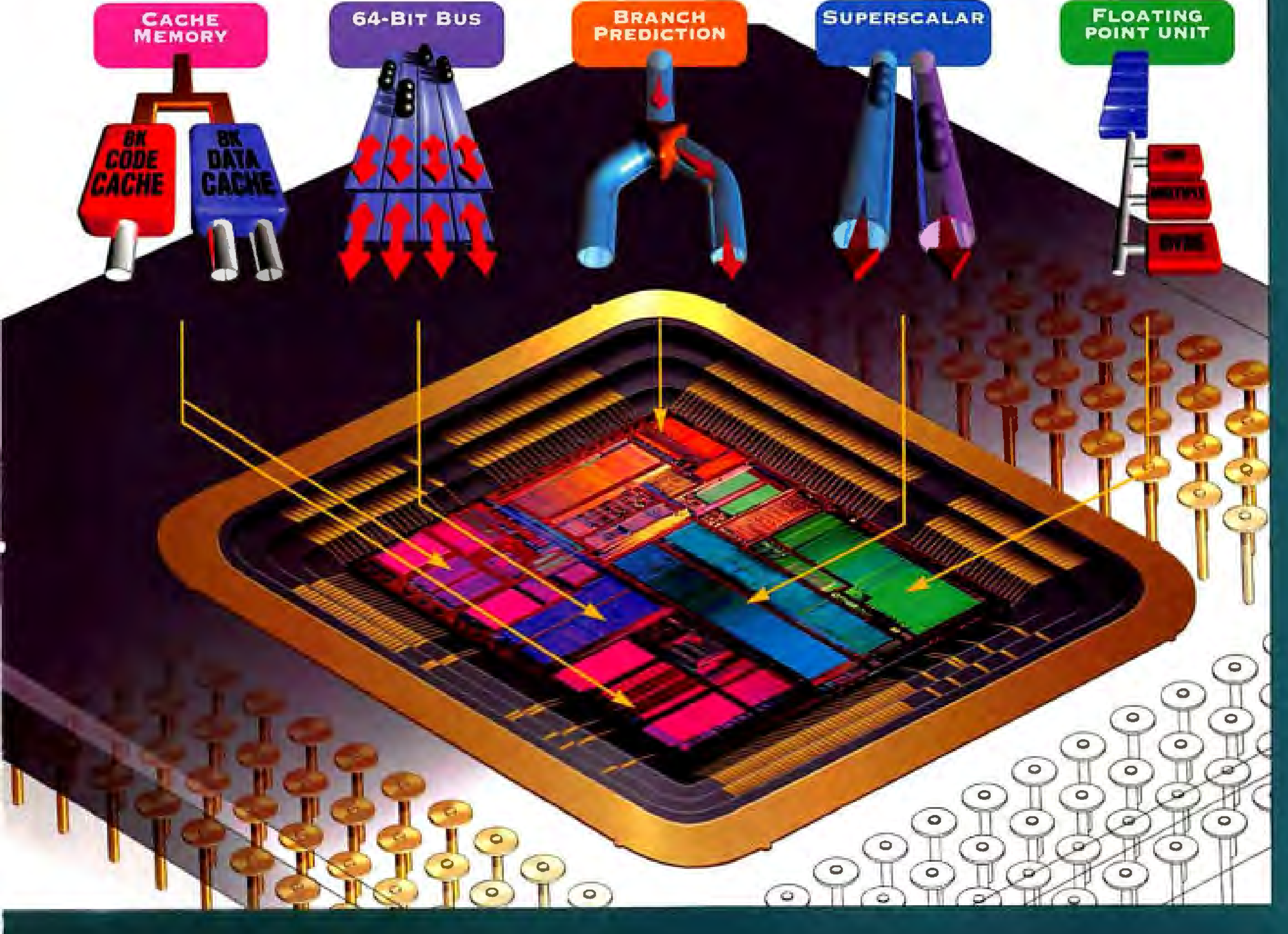
We've given the Pentium processor an intelligence of its own—a small cache known as the Branch Target Buffer, which predicts which way an execution will branch. When the prediction is correct (and it is over 90% of the time), the branch is executed without delay—enhancing performance.

Who said you can't do two things at once?

The first Pentium processor has two side-by-side pipelines for integer instructions. This enables the processor to execute two instructions at once. After grabbing and partially decoding an instruction, the Pentium processor determines if the instruction can be executed in parallel with the next instruction in line. If it doesn't detect any dependencies, the two instructions are sent along the parallel pipes for execution.

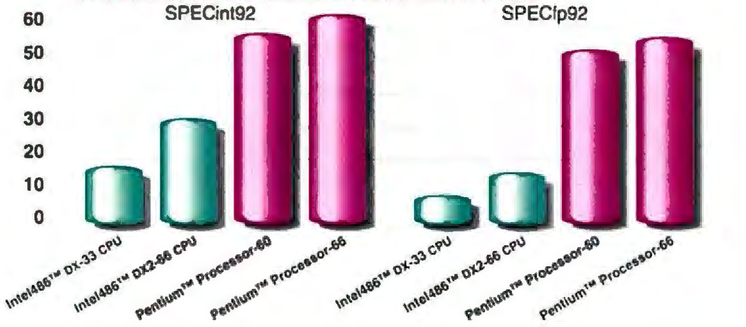
A big point of difference in math-intensive functions.

We've added specialized pieces of hardware to speed up the three most common floating-point instructions—a multiplier, a divider and an adder. With these features, most floating-point instructions can be executed in a single clock cycle. Giving you up to five times the floating-point performance of Intel486 DX2-66 CPU-based computers.

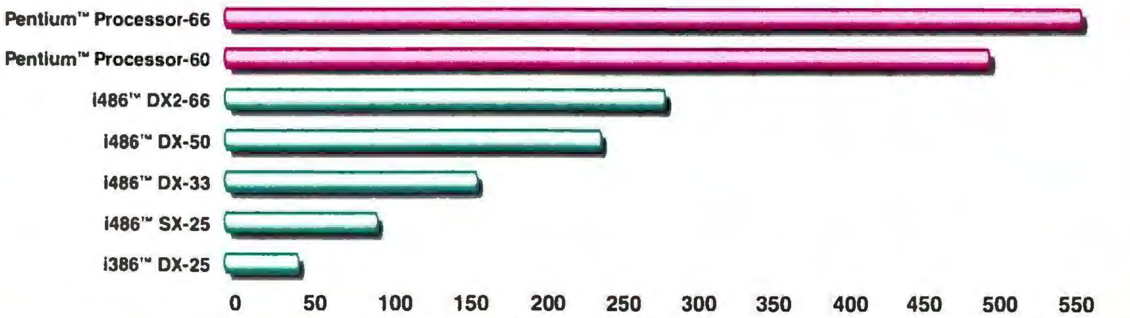


The Pentium Processor Provides Workstation Class Performance

Based on SPEC 92, the industry standard workstation benchmark, the Pentium processor is in the same performance class as the best workstation. But the Pentium processor is running at only half the clock frequency, and systems based on the Pentium processor cost only one-half as much.



The Intel iCOMP™ Rating Index*



*The iCOMP index is an Intel microprocessor "horsepower" rating. It is a composite of selected performance measurements from SPEC 92, ZD Bench, and Power Meter. Source: iCOMP™: A Simplified Measure of Relative Intel Microprocessor Performance, Intel Corp., 1992.

What Does This Technology Really Mean?

It means Pentium processor-based PCs are now as fast as workstations. It means faster Intel486 microprocessors, because our experience with Pentium processor technology allows us to improve them. It means new software horizons being brought to more and more users—such as 3-D design, multimedia, handwriting and voice recognition, virtual reality and more.

Obtaining the Power.

Almost all leading PC vendors have introduced high-performance Pentium processor systems at affordable prices. As we increase the production of Pentium processors from hundreds of thousands in 1993 to millions in 1994, there will soon be scores of Pentium processor systems to choose from. These systems will be available in a wide variety of configurations, from high-performance desktops more powerful than existing engineering workstations to servers containing multiple Pentium processors and capable of replacing mainframes.

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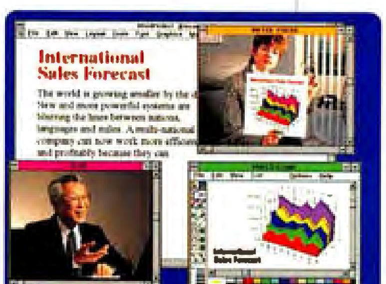

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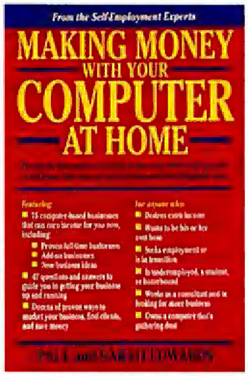
Entrepreneurial Enterprise

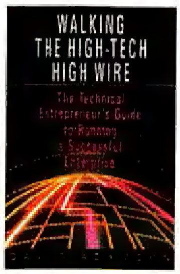


RAYMOND GA CÔTÉ

Layoffs. Company cutbacks. Restructuring. In today's economic climate, more professionals are finding less job security. Starting and running your own company is a perennial dream of many. Just because you work for yourself, however, does not mean that many (indeed any) problems disappear. Now, instead of just dealing with your manager's schedules, you need to plan your own schedules, make payroll, find (and please) customers, and run a company in addition to completing the technical work. This month, I've looked at three books that promise to help make you a successful entrepreneur. Their quality ranges from the superfluous to the superb.

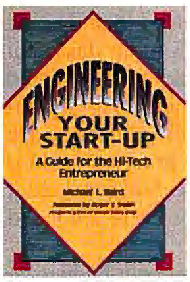
When I was a teenager, I would frequently read the classified ads in the back of magazines and dream of the riches to be made raising earthworms, breeding rabbits, or addressing envelopes at home. Even today, I find it difficult to walk by books with titles like *1001 Guaranteed Profit-Making Ideas*. It's not that I'm seeking a career change, mind you; I just believe that somewhere in all that paper might be an interesting idea.

Making Money with Your Computer at Home by Paul and Sarah Edwards belongs in the "1001 ideas" category. It's filled with 75 truly uninteresting job opportunities (e.g., diet-planning services or disk copying). What would make this book interesting is if it took a realistic approach to what was required to run each of the companies, or even profiles of people actually running such one- or two-person shops. Even a realistic approach to the income potential would help. Hey, if you get 300 people to each pay $100 for your newsletter, you could make an extra $30,000 a year! OK, how about deducting that new laser printer, page-layout software, advertising, postal fees and permits, and mailing-list databases. Suddenly that $30,000 "extra income" turns into a $5000 loss.



How well do you deal with stress? Do you feel you need to actually sleep nights? In his aptly named book, *Walking the High-Tech High Wire: The Technical Entrepreneur's Guide to Running a Successful Enterprise*, David Adamson describes the highs and lows of his experiences as founder of a high-tech electronics company. Perhaps "walking" is a little too bland. "Juggling" on the high wire is more appropriate. Adamson provides a series of personal memoirs, each with its own business moral. He covers the difficulties of starting a business, problems of undercapitalization, competition for venture capital, bill-collection trauma, and dealing with the government as a customer. You'll even get a glimpse of some interesting international mail fraud.

Each of Adamson's stories is entertaining, but factual details are lacking. I frequently wanted to call him and ask, "Yes, but what were your criteria for laying people off? How did you manage to convince your investors to back off for a month? When you determined sales were down, how did you motivate your sales force?"



Many entrepreneurs, at least the ones I've met, are a lot like teenagers: They feel invincible. It's only as maturity sets in that they realize, "Hey, I've actually got a company I need to run. We need to plan." If you fall into this category, you must read *Engineering Your Start-Up: A Guide for the High-Tech Entrepreneur* by Michael L. Baird.

THE OED ON CD-ROM

OXFORD ENGLISH DICTIONARY (SECOND EDITION) ON CD-ROM
Oxford University Press, Walton St., Oxford, U.K. OX2 6DP, +44 865 267979; fax +44 865 56646, $895

The *Oxford English Dictionary*, or *OED*, was first printed as 125 separate volumes, from 1884 to 1928. Revisions and supplements were issued over the years, culminating in a new 20-volume second edition in 1989 containing 616,500 words. The word definitions and 2.4 million quotations make up a work of 59 million words.

On paper, the *OED* spans 21,728 pages, weighs around 145 pounds, and costs $2750. In contrast, the CD-ROM version weighs less than an ounce.

On a Mac Quadra 840AV, I tried to locate a few sample words from my Merriam-Webster unabridged dictionary, such as *aardvark*, *poikilothermal*, *quark*, and *zymurgy*. It found all these words without a hitch.

If you need a pithy quote, searching the quotations section can be rewarding, although the search mechanism takes some getting used to. Asking for all the quotes by Chaucer yields 11,902 quotes. You can do a subsequent search on this list, narrowing your search by providing a date, title, or portion of the quote.

When you find a quote or definition, you can print it. I had problems printing results to an original LaserWriter: It crashed and reset before it would print out the page, and then with some garbled fonts. I had no problems printing to a LaserWriter Pro 630 with PostScript Level 2 and lots more memory.

Does this mean I don't like the OED on CD-ROM? Not at all, although I do hold it to exacting standards, based on its reputation. The OED on CD-ROM will be of great use in libraries and offices that normally couldn't spare space for the printed version. The software's ability to search and cross-reference through all those millions of words makes it a valuable research tool. The vast resources of this dictionary, especially when they're available with a few keystrokes, demands exploration of the material. From my page-leafing days with the unabridged dictionary, this happens to produce better results as well.

—Tom Thompson

His book contains some very sobering insights. The preface starts, "I first thought of writing this book ... just one week after the president and I decided that our ... start-up must file for Chapter 11 bankruptcy." Although it does not appear to be the author's overt intention to scare you out of being an entrepreneur, you will finish the book more sober than when you started it.

Baird has created a handbook for building a company—from identifying opportunities, to raising capital, to working with investors and banks, to writing a business plan, to marketing your ideas. Although the book is targeted specifically at software start-up companies, you'll find little discussion of technology. After all, technology is what you already know how to do. Running a business is what you need to learn. And learn you will—how to price products, exploit market niches, and position your product for particular markets.

You'll also find lots of hard facts on issues such as determining your risk of bankruptcy, financing your start-up while protecting your personal assets, building the right management team, and considering your obligations to your current employer. Remember, you may want your old job back.

If you're dreaming of a future business, consider following the exploits of Adamson. But if you've already made the plunge, *Engineering Your Start-Up* is an essential guide through the pitfalls and hazards of the business world. Baird cannot guarantee a successful start-up, but his book will help improve your odds. ■

Raymond GA Côté is a BYTE contributing editor who, among other things, runs his own business. You can reach him on BIX as "rgacote."

ENGINEERING YOUR START-UP: A GUIDE FOR THE HIGH-TECH ENTREPRENEUR
Michael L. Baird, Professional Publications, ISBN 0-912045-48-5, $19.95

MAKING MONEY WITH YOUR COMPUTER AT HOME
Paul and Sarah Edwards, Putnam, ISBN 0-87477-736-4, $10.95

WALKING THE HIGH-TECH HIGH WIRE: THE TECHNICAL ENTREPRENEUR'S GUIDE TO RUNNING A SUCCESSFUL ENTERPRISE
David Adamson, McGraw-Hill, ISBN 0-07-000468-4, $24.95

PUTTING COMPUTERS TO REAL USE

WATCH WHAT I DO edited by Allen Cypher MIT Press, ISBN 0-262-03213-9, $45

Today's computers are much more powerful than they were 10 years ago. Yet, we're still doing the same old things with these faster machines: writing, running spreadsheets, and connecting to on-line services. Shouldn't today's generation of computers do more for us? Such is the subject matter of *Watch What I Do*, a series of articles about Programming by Demonstration. This is where a computer observes what we're doing and, for repetitive tasks, learns them and ultimately does them for us. Importantly, PBD will empower typical users to do this—not just programmers. *Watch What I Do* covers such topics as macro recorders, learning by example, and inferencing, with implementation examples. This book is not for the faint of heart: Code examples, screen shots, block diagrams, and grammars adorn the pages. The text isn't in a dry academic style, however, and it actually makes for interesting reading. If you're interested in the *real* future of computing, check this book out.

—*Tom Thompson*

Books & CD-ROMs

A MATH TOOLCHEST

C/MATH TOOLCHEST FOR ENGINEERING AND SCIENTIFIC APPLICATIONS by Charles Bernardin Prentice-Hall, ISBN 0-13-605866-3, $65

C/Math Toolchest for Engineering and Scientific Applications by Charles Bernardin is not casual reading. Neither is it a reference work, a tutorial, or a general review of computational algorithms. It is a fine and coherent collection of C functions that Bernardin has gathered over several years for use in his work as a professional signal-processing engineer. This book, and the accompanying disks, are not simply a collection of routines picked up in the public domain and repackaged. Rather, this is a professional set of tools that includes proper error-handling and signaling routines.

Although the book's accompanying software is distributed on PC disks, the code is written in standard ANSI C and is portable to any platform. Over 170 functions span the range from common complex number manipulations to less common matrix and vector manipulations. The functions are grouped into major areas: complex arithmetic, matrix and vector manipulations (for both real and complex values), probability, statistics, numerical analysis, and signal processing. Bernardin's own interests are evident in the large section on signal-processing and filtering routines.

Another example of the professional quality of these routines is that all the matrix and vector functions use a dynamic, run-time memory-allocation scheme that allows array sizes to be determined as the data is generated. A charting package from Mix Software is also provided that lets you view the results from some of the sample programs. These are not necessarily award-winning graphs, but they're quite sufficient for viewing experimental data. Professional engineers, programmers, and students will find a wealth of useful routines to address their numerical problem-solving requirements.

—Raymond GA Côté

WORLDWIDE COMPUTING

THE MULTILINGUAL PC DIRECTORY by Ian Tresman Knowledge Computing, ISBN 1-873091-02-8, £35 (about $53)

Today, with communications needs that span the globe, I find myself constantly limited by a plain English-only computer. Although my primary machine of choice, a Mac, lets me add such touches as a proper greeting in Russian, a salutation in Japanese, or even the proper spelling of my last name, the ubiquitous PC is a bit hard-pressed to provide the proper characters, particularly under DOS.

Make no mistake, though, such products do exist, from Egyptian hieroglyphic word processors to Russian databases and Zuni font packs. *The Multilingual PC Directory* is a growing collection of multilingual and foreign-language products for IBM PCs and compatibles. Whatever your desire, to chatter in Chinese, expound in Ethiopian, or declaim in Danish, you'll find a product to fill your needs. This is an invaluable resource for anyone who ever needs to write in more than one language. ■

—Raymond GA Côté

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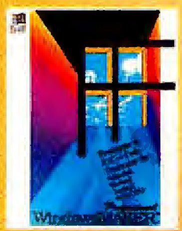

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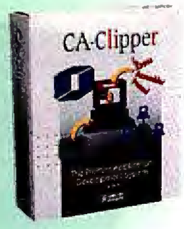

Yes, the newly released CA-Clipper version 5.2 is being offered to Xbase language product owners at the low retail price of $199. This competitive upgrade is available for a short time only! What a great opportunity to get the power of CA-Clipper, at a super price! And now when you buy, get your choice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

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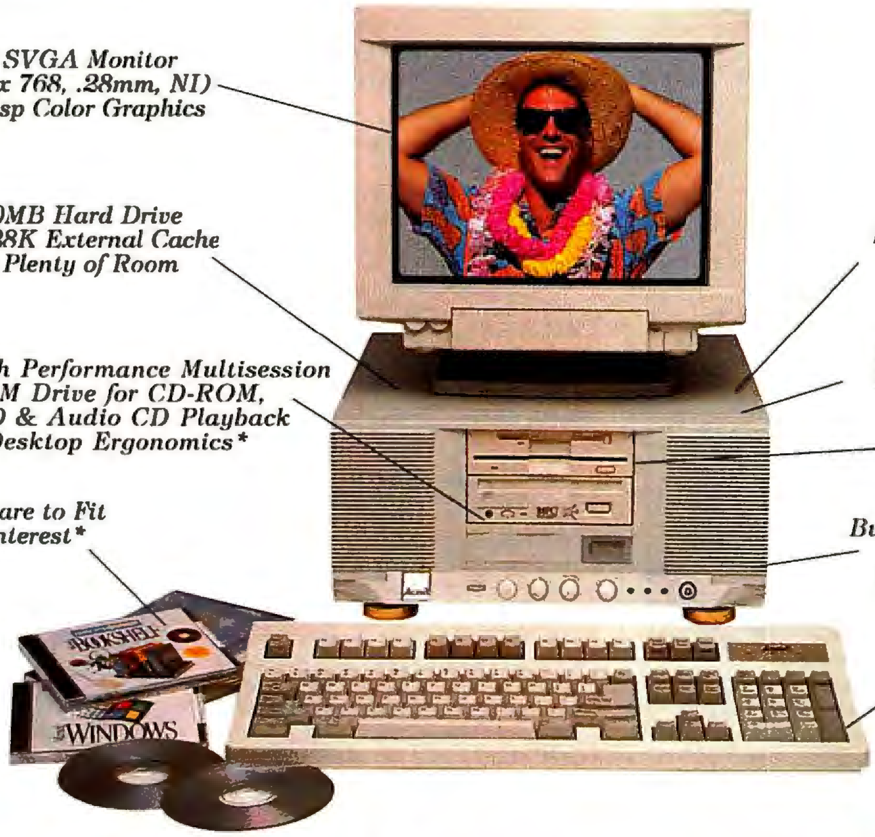

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Track People with Active Badges

DAVE JONASON © 1993

DICK POUNTAIN

You're in a meeting with a colleague, far from your desk, and you need to consult some figures from your PC. You approach your colleague's workstation, and as if by magic your own customized desktop appears. This is just one way that an electronic location system could enhance a computer network; you might also have phone messages or E-mail routed to the workstation nearest to you, or check a workstation display to find the whereabouts of another colleague. Electronic location, or Active Badge, systems like this are finally emerging as a commercial reality.

Current location methods have their inconveniences. Broadcast techniques, like ringing around all extensions or hailing via a public-address system, cause disruption and annoyance to everyone. Beeper-based paging systems work well only if the sought person chooses to answer, as anyone who has worked on a hospital switchboard knows. An electronic location system, whether used by a human receptionist or connected to a call-forwarding PBX, can overcome all these problems.

Electronic location technology tracks your location within a network site and allows your system resources to follow you

Olivetti Research Ltd. of Cambridge, U.K., a research organization jointly funded by Olivetti—Europe's largest PC manufacturer—and DEC, is at the forefront of location research. ORL's Active Badge hardware is used by several other research groups, including those at Xerox PARC (Palo Alto Research Center) and MIT's Media Lab, and went on sale commercially at CeBIT in Hannover this year. Currently, only Olivetti sells Active Badge, through its Network Services division; pricing depends on the size and complexity of the installation.

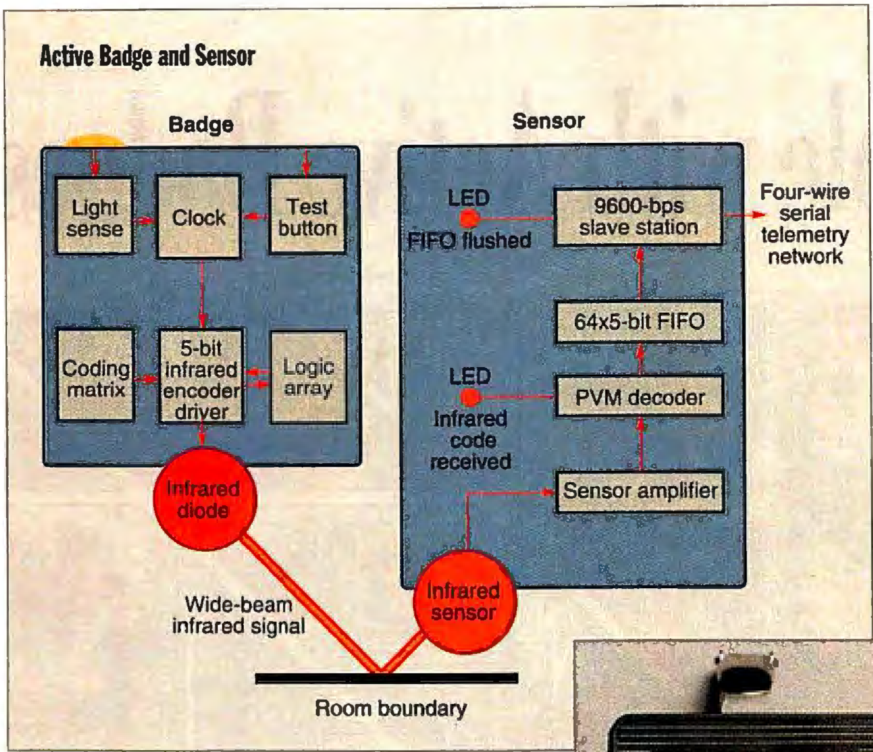
The Active Badge system depends on a small transmitting device that you pin to your clothing. Sensors distributed throughout the workplace pick up the signals from these badges and relay them, via a low-cost network, to location servers. The servers translate the signals into position information that you can access through the regular office LAN.

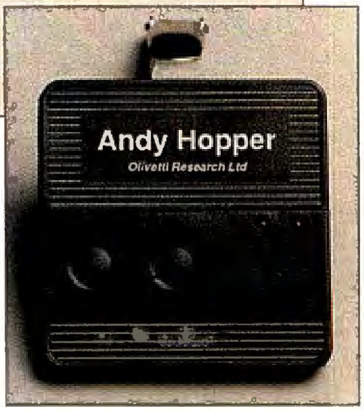
Such location systems raise ethical concerns, as they have the potential to be abused by overzealous management to create almost Orwellian surveillance regimes. But this could be said of other network and telephone monitoring devices that are beneficial when used properly.

Currently, most Active Badges are used in research labs, which typically enjoy good labor relations, and users report that the improved communication and diminished interruption more than compensate for any loss of privacy. Since 1989, ORL's staff has worn Active Badges by choice, and locating people is perhaps the major consumer of computing cycles on the network. Interestingly, discovering when someone is *not* available appears to be the most useful function, saving countless wasted journeys and phone calls, and telephone traffic has reduced overall.

Active Badge Hardware

For an active badge to be acceptable to its wearers, it must be unobtrusive (which implies a combination of smallness, lightness, Feature





The Active Badge *(above left and photo) is based around a 5-bit infrared driver chip originally designed for remote controllers. A PLA (programmable logic array) takes the unique code word stored in ROM and creates a 10-bit identifying signal using two successive cycles of the driver chip. The clock causes the signals to occur every 15 seconds, unless preempted by pressing the button or delayed by the light-sensitive resistor. Sensors (above right) pick up these signals and relay the data to the network.*

and easy maintenance) and have a very simple user interface. ORL's Active Badge is a plastic box some 2 inches square by ¼ inch deep (55 by 55 by 7 mm) weighing 1.4 ounces (40 gm). Its only external control is a test button.

The badge acts as a beacon by periodically emitting a unique infrared signal. ORL chose infrared rather than radio technology for communication between the Active Badge and its sensors for several reasons: Infrared circuits are cheap because of their widespread use in TV and VCR remote-control handsets; infrared signals reflect from walls and partitions, so they are not directional when used in a small room; and, unlike radio waves, infrared signals will not penetrate walls and so are well localized.

The battery-powered Active Badge employs an MV601 5-bit infrared encoder/driver chip, designed for remote-control handsets, that generates a unique pulse-width encoded signal of around 0.1-second duration; a small ROM stores an encoding matrix. To ensure that a high proportion of badges are always operative, it's crucial that battery changes be infrequent. The Active Badge runs for about a year on a tiny lithium battery, thanks to stringent power-saving design decisions, the most important of which was to make the badge's signaling period just once every 15 seconds. Consequently, you can't know a wearer's location with any finer granularity than 15 seconds, but this is really not a problem unless your office is staffed by Olympic sprinters.

If several badge wearers are in the same room and their badges all signal simultaneously, the room's sensor can detect only one of them, and this unsatisfactory state would persist if the badges' periods were all exactly in sync. However, the low signaling rate means that the chances of any two badges firing simultaneously are only 2 in 150, so for small groups, all should be detected within a reasonable time. The badges are deliberately built from low (10 percent) tolerance components so that the chances of them having exactly the same frequency and thus staying in step for more than one 15-second period are very low.

To further reduce power consumption, the Active Badge incorporates a light-sensitive resistor that decreases the signaling rate (i.e., increases the period beyond 15 seconds) as the light level falls. When you take off your badge and place it in a dark pocket or desk drawer, signaling nearly ceases—and with it the power consumption, so that battery life is extended fourfold. Signals are still emitted occasionally so the "resting" badge can be found.

ORL's designers rejected the option of an on/off switch, because many users would likely forget to turn on a manual switch and there wasn't enough space to incorporate an automatic tilt or accelerometer switch. In fully lighted rooms, the resistor has a small but random effect on the badge's signaling period, so moving between different lighting levels is a further protection against badges' accidentally falling into sync. Pressing the test button on the Active Badge forces it to transmit immediately, and system software may use this to implement a very primitive command interface.

The Telemetry Network

To track Active Badges as they move through a building, infrared sensors need to be placed in every room and corridor (preferably high on a wall or ceiling) and connected by a telemetry network. In an ideal world, your regular LAN would serve as this network; in practice, however, this doesn't work well. For one thing, LANs seldom span a whole building, usually missing corridors, entrances, cafeterias, and so on. You may also want to follow Active Badges into buildings that have no LAN at all. More important still, adding the interface chips to, say, an Ethernet LAN would vastly inflate the price of the infrared sensor units. ORL's solution was to design a low-cost RS-232-based telemetry network that runs over ordinary telephone twisted-pair cabling, allowing any spare telephone wiring to be pressed into service.

To cover a whole site, you can create several separate badge networks, each connected to the RS-232 port of a LAN workstation that acts as its controller. Each of these badge networks can support up to 128 infrared sensors. The badge network transport is a simple four-wire affair: Two wires carry power for the infrared sensors, one carries serial addressing information to select an individual sensor, and the fourth carries returned data. The network control software may simply poll all the sensors in turn and collect their badge sightings—not a highly time-critical task, since each sensor contains a FIFO (first-in/first-out) buffer that can hold up to 20 badge sightings. A sensible optimization is to have the controller software inspect sensors with

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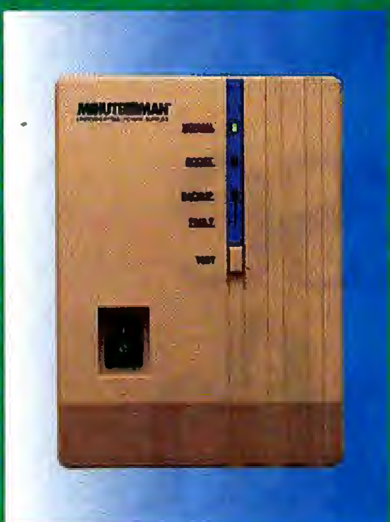

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Site Wiring Fault Indicator	YES	YES	NO
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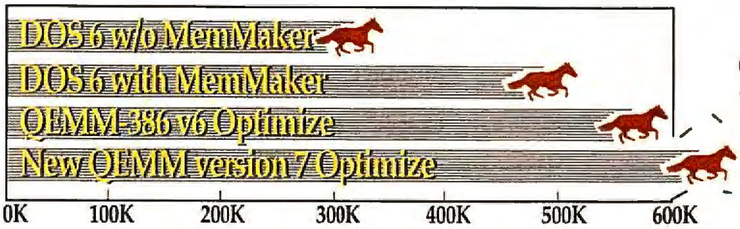

We tested DOS 6 with and without MemMaker and with QEMM 6 and our new QEMM 7 runs away from all of them. See details of test conditions listed below.

DOS 6 Giveth; DOS 6 Taketh Away

The best feature of new DOS 6 is the stable of utilities it includes. Trouble is, they all eat up memory. DoubleSpace file compression needs 43K, Vsafe anti-virus needs 7-45K, Smartdrv disk cache needs 28K and even Undelete takes 10-14K as a resident program. Using Microsoft's free memory utility, MemMaker, you could easily end up with a net loss of available 'conventional' memory in DOS 6.

New QEMM 7 takes the best of the new DOS 6 features into account, finding ways to give you more free memory for your program while taking full advantage of DOS 6. One new QEMM 7 feature, DOS-Up, moves the DOS 6 kernel, its data and resources to memory above 640K (this feature also works with DOS 3-5), freeing 7-70K. Another new QEMM 7 feature, Stealth DoubleSpace, frees 40K of the memory addresses used by DoubleSpace and makes them available for other drivers and TSRs. Both features ensure that the all-important memory below 640K is free for your programs. And QEMM 7's seemingly small feature of supporting multiple configurations gives you the flexibility and ease of setup that you expect. (MemMaker doesn't work well with this important DOS 6 feature.) That's why it makes more sense than ever to put your money on the best memory manager.

Prior versions of QEMM won just about every competition in sight, as well as remaining the #1 best-selling memory manager 5 years straight.

Page Frame: the Key to Your Future

There's been a lot of talk about our patent-pending Stealth technology. Jealous talk, mostly. Because nobody else can touch its performance. Our Stealth ROM feature, pioneered in QEMM 6, frees 48-115K of ROM addresses for use by TSRs and drivers. Our Stealth DoubleSpace feature, described above, frees another 40K. And as you might imagine, there's more to come.

The key to Stealth is its use of a 64K reserved area above 640K called the page frame. Besides being used by Stealth, the page frame is used by Lotus 1-2-3 r2.x for larger spreadsheets and WordPerfect 5.x for larger documents, DESQview for multitasking, Novell Netware, IBM LAN Server and DECnet for reducing the network driver memory footprint, plus games like Wing Commander, Car and Driver, Ultima Underworld II, Wolfenstein and others for fast action. You sacrifice all this when you turn off the page frame (which other memory managers do to maximize available memory above 640K). It's this use of the page frame by Stealth that lets you set up your PC with a mouse, CD ROM, sound board, a network such as Novell NetWare, reserve 8-24K of extra memory for optimal MS Windows performance, use all of DOS 6's memory-hungry utilities and still have more than 630K available for your programs. (Compared to DOS 6's 527K available in the same configuration, after using MemMaker).

There's lots more to QEMM 7:

- Tuned for MS Windows
- New ability to use Vidram inside MS Windows
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  - Detects adapter RAM and ROM and bus-mastering hard drive controllers
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Easier to use for Novices, More Power for Experts; More Memory for All

Our seventh-generation thoroughbred QEMM has improved ease-of-use, with Express Install and Help features. And for power users, Advanced Install and editable parameters and troubleshooting hints.

And QEMM 7 comes with Manifest, the award-winning memory analyzer—enhanced for more flexibility with Pentium testing, laptop battery reporting, network analysis and editable configuration files.

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QEMM Users: upgrades are available from dealers.

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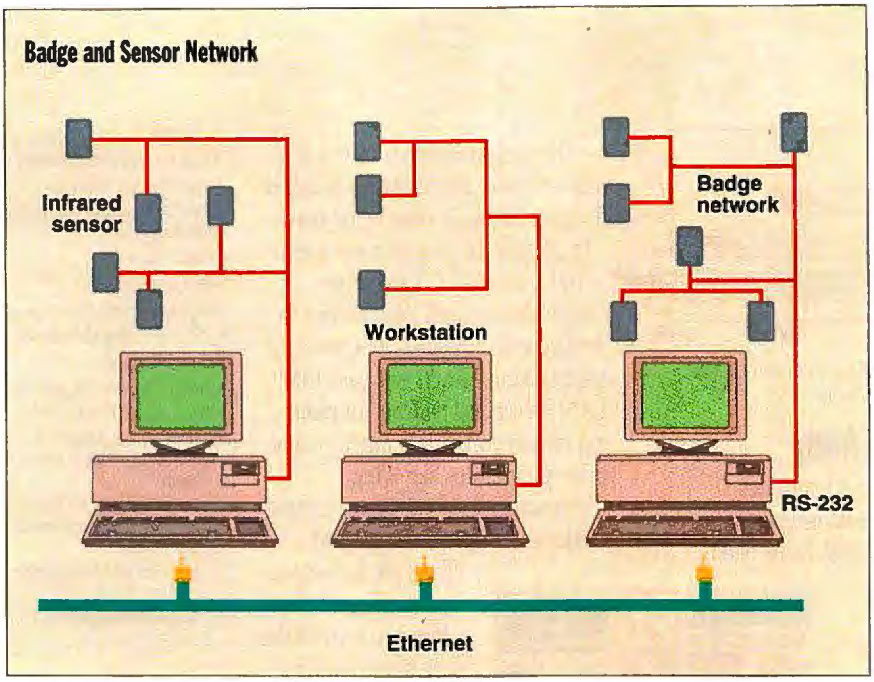
How we got the chart numbers: CPU—486/33 ALR Power/business VEISA machine equipped with 16 megs of RAM and running MS-DOS 6. Comparisons were done using the following memory managers: QEMM 7, QEMM 6.02, MS-DOS 6 MemMaker. In addition to the driver (or drivers) required by each memory manager, the following drivers, DOS resources and programs were loaded for all comparisons: in the CONFIG.SYS file: SETVER.EXE, DOS=HIGH, FILES=20, BUFFERS=10, STACKS=0,0, MVSOUND.SYS, SNDBK12.SYS, SLCD.SYS, DOS SHELL= statement, in the AUTOEXEC.BAT file: VSAFE, MSCDEX, UNDELETE, LSL.COM, NE2000.COM, IPXODI.COM, NETX OR EMSNETX, MOUSE.COM, SMARTDRV.COM, PRTSCCAP.COM.

Circle 141 on Inquiry Card.



The badge telemetry network *employs a simple four-wire, twisted-pair cabling medium and connects to a standard RS-232 port. Each workstation can control up to 128 infrared sensor units.*

a history of many sightings more often than those that show less activity.

The controller software time-stamps the badge IDs returned by the sensors and then stores them as records in the form {badge ID, location, time}. These records are kept in queues (one for each badge) in time-stamp order and get discarded after some maximum period—perhaps 5 minutes—to avoid overflow.

The next-higher layer of the network software inspects these queues and compresses the information by registering only the changes of location of each badge; it makes this information available to other workstations via whatever mechanism the LAN supports. A final visualization layer will display the location information, perhaps as a simple text-based list of personnel or maybe as a sophisticated graphical map of the buildings with moving icons.

An Experimental Installation

ORL's own experimental Active Badge installation at Cambridge now employs more than 100 badges with over 200 sensors in five networks spanning several geographical sites and three organizations (including DEC and the University Computer Lab). The sites can exchange location information via private WANs (wide-area networks) or even by a public network like the Internet. Badge wearers at a site can choose whether to make their whereabouts known to the other sites.

If you're starting a meeting and don't wish to be disturbed, you can press the test button on your badge twice to display a "busy" message on the location display. This busy flag persists until you change location. If you simply want to disappear for a while, you take off your badge and put it in a pocket or desk drawer.

The Unix software running on the ORL workstations provides five badge-related commands: `Find` returns the current location of a named badge and the full list of its locations during the last 5 minutes; `With` locates a named badge and a list of all other badges in the same location; `Look` gives information about the other badges in the area; `Notify` generates an audible alarm when a named badge is next sighted; and `History` generates a report of the movements of a named badge for the last hour.

Authentication, PiCOs, and the Future

The simple transmit-only Active Badge just described is highly effective, and over 1000 have been manufactured to date. Nevertheless, ORL has moved on to develop a more powerful badge with two-way communications, called the Authenticated Badge, which can act as a pager and a security device as well as a locator.

The Authenticated Badge contains two buttons and an audible beeper and can receive infrared "challenge" signals that check the badge's identity. You can, for example, use Authenticated Badges to automatically open doors to secure areas or automatically log onto a workstation by mere proximity.

The authentication check employs a type of public-key encryption, where the badge

Name	Telephone	Position	Seen	Status
P Ainsworth	343	Accounts	Static	Alone
M Chopping	410	R410 MC	Friday	
D Clarke	316	R316 DC	12:30	
D Garnett	218	R435 DG	12:20	
T Glauert	232	R310 TG	35 mins	
S Gotts	0	Reception	Static	With Jackson
D Greaves		Floor 3 corridor	Moving	Alone
A Hopper	334639	Univ Comp Lab R76	Static	
A Jackson	0	Reception	Moving	With Gotts
A Jones	210	Meeting Room	Static	At a gathering
T King			Yesterday	Away in Italy
J Martin	310	Machine Room	24 Dec	
O Mason	210	Meeting Room	Static	At a gathering
D Milway	BUSY	R211 DM	Static	Alone
J Porter	398	Library	Static	Alone
C Turner		Front Door	Yesterday	
R Want	308	R215 RW	7 mins	
M Wilkes	210	Meeting Room	Static	At a gathering
S Wray	204	R212 SW	Static	Alone
14.00 THURSDAY 10 JUNE 1993				

This workstation screen shows *typical location information from ORL's Cambridge badge network. All the fields except the first Name column are dynamically updated at 15-second intervals. The Telephone column shows the nearest extension for people in the main ORL building, while for people at remote sites (e.g., University Computer Lab on line 8), it gives the full external telephone number. The Position column identifies the location by room number and initials of the occupant. The Seen column indicates whether an attempt to reach a person at his or her current location is likely to be successful; the software marks a person as* Static *after five sightings (about 75 seconds) at the same location, while people with fewer sightings are marked as* Moving. *If 3 minutes pass with no sighting, this field displays the interval since the last sighting, and after an hour it changes to an absolute time of last sighting (e.g.,* 12:30*). After a full day with no sighting, the display changes to, for example,* Yesterday *or* Friday. *The last column, Status, can display an informative message entered by the user, such as* Away in Italy.

Why do they call it a dongle?

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

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

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

The Most Powerful Program in the World

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

So he sold a few. Only a few.

Back in Boston he waited. After a long year with only 13 orders he set out to see what happened. As he drove across the country and flew around the world he discovered everyone knew about his program. Everyone had it too.

The Global Marketplace

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

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

Call It What You Like

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

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

"Name it after you, Don!", urged his peers. So he did. Soon everyone was calling the key a dongle, after Don Gall—the lonely software developer who did what he had to do.

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Circle 143 on Inquiry Card (RESELLERS: 144).

returns a response signal formed by combining a secret password with the challenge, using a one-way or *trapdoor* function. The controller then compares the badge's actual response with a calculated one to verify that the badge is authentic.

This mechanism can prevent bogus access attempts using counterfeited badges or recordings of real badges (thanks to the random nature of the challenges). It could, of course, be fooled by a stolen badge. To secure against that, you need to add a personal ID number (PIN) that the wearer remembers—as with bank cards. However, that requires the wearer to perform a positive action (typing in the PIN), which destroys much of the charm.

The challenge/response exchange consumes more power than is needed for the simple transmit-only Active Badge. Therefore, to save power, the Authenticated Badge listens for challenges for only a brief period, just after sending its location beacon signal. To allow it to respond at other times, the badge contains, in addition to its infrared transmitters and receivers, a passive radio sensor sensitive to frequencies around 150 kHz. Small, low-power radio transmitters, which produce a field that extends only a few feet, are attached to security areas like doors or workstations. A badge that enters such a field is activated and becomes receptive to challenges.

The badge network controller can also distinguish whether a badge button is being pressed inside or outside such a radio field—that is, whether the wearer is directing the button press at the field-guarded device or merely at the room sensor, which opens up an extra level of signaling complexity. To cope with this extra sophistication, the Authenticated Badge contains an embedded microprocessor that allows its behavior to be customized.

ORL is using authenticated badges to create highly futuristic Active Office scenarios in which telephone calls automatically follow you around the building. When a visitor arrives in reception or E-mail arrives, your badge might beep once to tell you to walk to the nearest free workstation, which will display the necessary information automatically. You can write simple scripts that control the details of the interaction—for example, in what circumstances you do not want to be disturbed, or how many beeps to use for various events.

Active Badges are just the first members of a family of planned devices that ORL calls PiCOs (Portable Interactive Computing Objects). Another PiCO that already exists is Olivetti's Smart Tag, which is just a cut-down transmit-only badge without a button. You can stick Smart Tags onto office equipment such as workstations, printers, or photocopiers, making these resources visible to the badge network and the software. For example, you might have an incoming fax automatically print out on the laser printer nearest to your current location.

ORL describes future minipad or tablet PiCOs with built-in LCDs that begin to look like what everyone else is calling a PDA (personal digital assistant), Alan Kay called a Dynabook, and Captain Kirk called a Communicator. In essence, PiCOs are computers that know who you are, where you are, and what services are nearby to assist you. You may find this prospect beguiling or alarming, according to your temperament. My own view is that so long as they stick to passing information, they're fine, but I'd worry if they ever became able to throw things. ■

Dick Pountain is a BYTE contributing editor based in London. You can reach him via BIX as "dickp."

"Why on earth would this bozo think I'd want to buy a 1993 Pentium with a bus that's been dragging its butt since 1984."

INTRODUCING THE

"No bozo, PCI bus Pentium PC"

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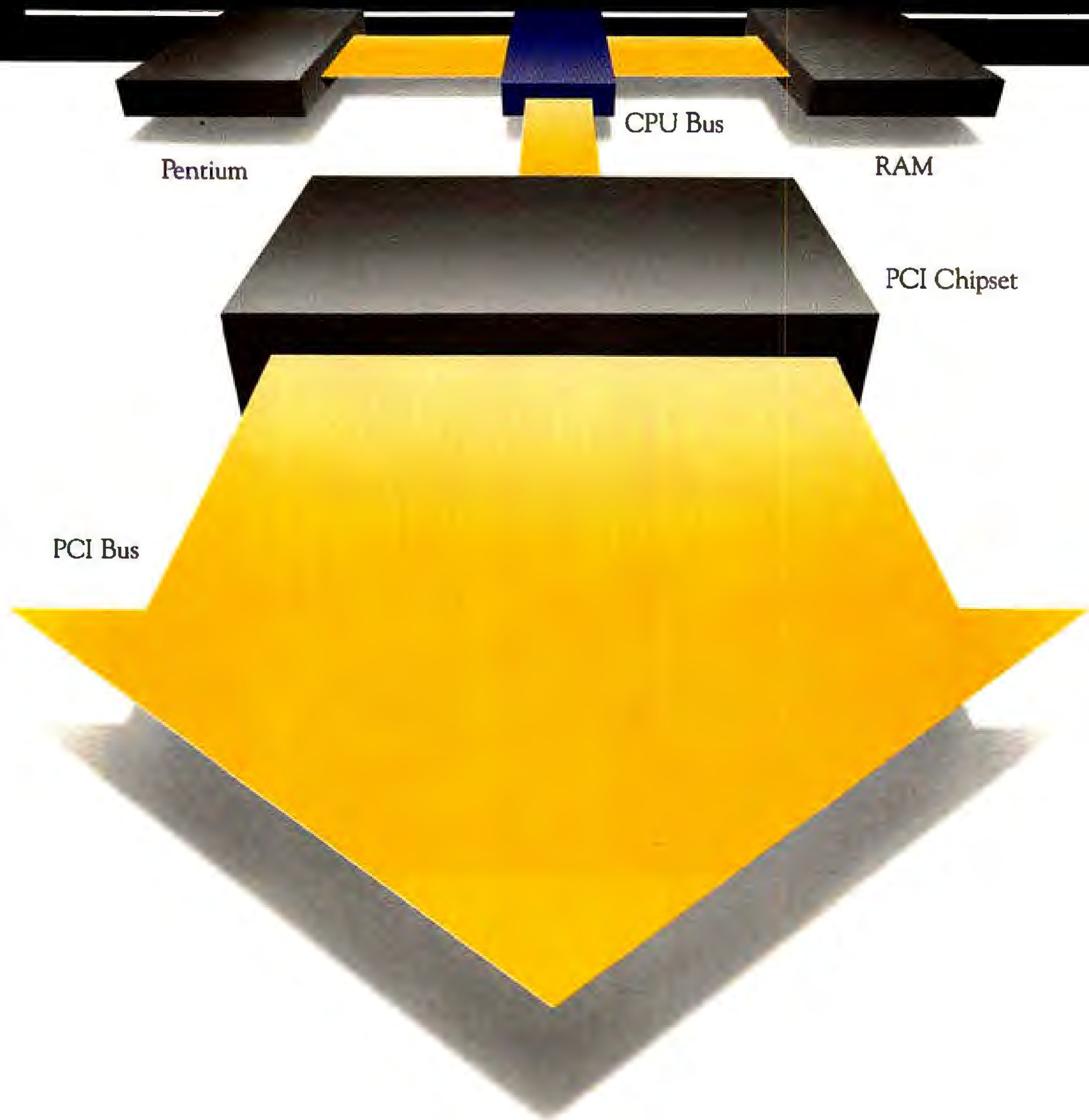

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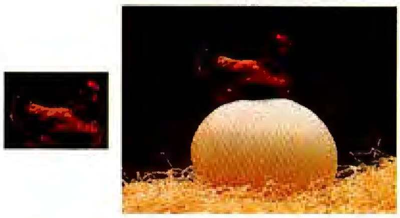

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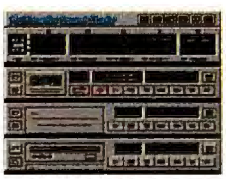

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Cover Story

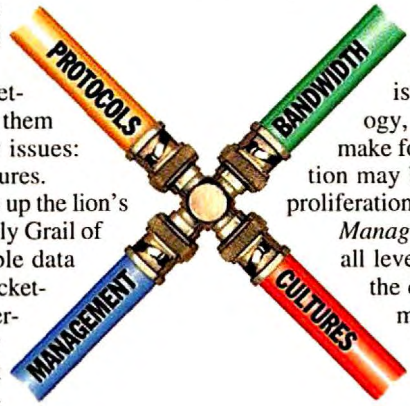
LINKING LANS

The four key issues of creating a wide-area network are bandwidth availability, protocol conflicts, management, and the effect on corporate culture. WAN pioneers say solutions exist, but they are riddled with compromises and don't come easily.

BEN SMITH AND JON UDELL

To compete in a national or global business, you have to move information over WANs (wide-area networks). Unfortunately, the LANs where users create and consume that information connect uneasily to the WANs that circulate it throughout far-flung enterprises. Where the two modes of networking collide—in an unstable fault zone of new technologies, products, and services—pioneers navigate painfully.

We asked consultants, integrators, and network managers about the problems that keep them awake at night. They highlighted four key issues: bandwidth, protocols, management, and cultures.



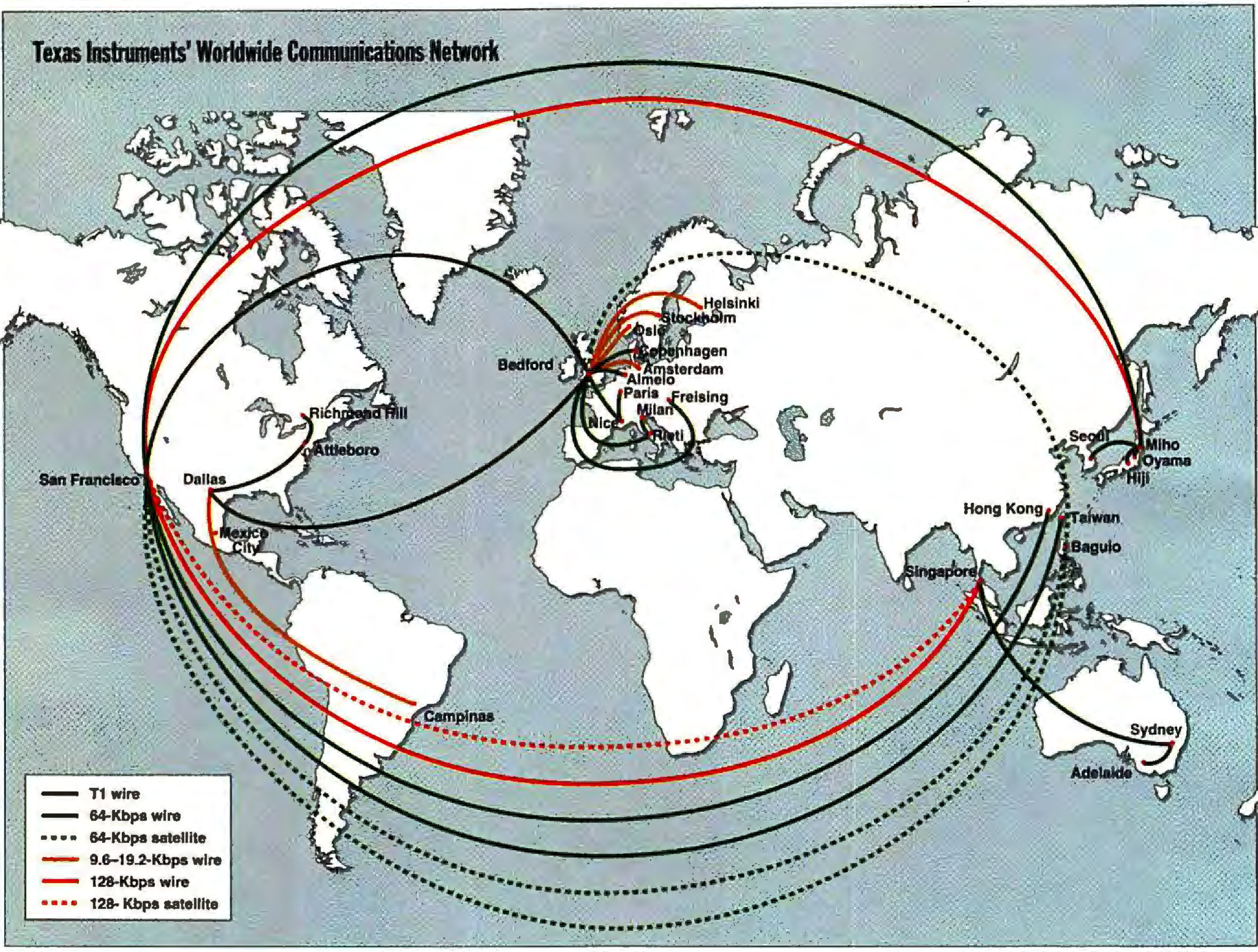
WAN *bandwidth* rents by the yard and eats up the lion's share of the WAN manager's budget. The Holy Grail of wide-area networking, therefore, is a flexible data pipe that stretches and shrinks on demand. Packet-switched, circuit-switched, and leased-line services all claim to offer this flexibility, but they deliver it in ways that may or may not suit your requirements. In any case, pipes can expand only so far. Applications built for cost-free LANs adapt poorly to costly WANs. Throwing bandwidth at a problem may provide temporary relief, but there's no substitute for smarter applications that treat bandwidth like the precious resource it is.

Protocols running on today's heterogeneous LANs typically include IPX, TCP/IP, SNA (Systems Network Architecture), NetBEUI, and AppleTalk. Juggling mixtures of these on Windows and Mac workstations gives LAN managers enough headaches. WAN managers suffer worse headaches when these protocols clog long-haul lines or, as with SNA and NetBEUI, require proprietary routing techniques.

If you decide that you must merge your legacy SNA network with a routed LAN internetwork, you'll wrestle with some of these issues; if you embrace client/server technology, you'll wrestle with others. Fewer protocols make for cleaner networks, but, although consolidation may be an option, reality often dictates a messy proliferation.

Management woes pervade wide-area networking at all levels. Here, the still-unattainable Holy Grail is the central console from which the manager can monitor and, more important, control the myriad devices, pipes, and programs that make up an enterprise network. Even just naming everything uniquely presents a formidable challenge.

The *cultures* of the LAN and the WAN differ radically. LANs often appear spontaneously and grow haphazardly, along with the collaborative workgroups they serve. WANs, like the organizations whose structure they reflect, arise deliberately and



Texas Instruments' global *communications network illustrates just how complex worldwide networking can get. The LAN internetwork spans several different transmission methods, from dedicated modem lines to satellite links.*

evolve in a measured, conservative way. LAN people mock the hulking hosts often enshrined at the center of the WAN, and WAN people jeer at the Windows PCs attached to LANs. It's not just mudslinging. Real technical deficiencies on both sides fuel the culture clash.

We found that organizations experience these issues and work through them (or around them) in very different ways. At CIGNA, where hundreds of NetWare LANs funnel IBM 3270 terminal-emulation traffic through an otherwise conventional SNA network, the conversion to a routed TCP/IP internetwork dominates the agenda. For Texas Instruments, whose sprawling WAN connecting 100,000 Ethernet devices grew up quite independently of the legacy SNA network, the priority is total interconnection of all LAN-attached devices.

At McGraw-Hill, loosely federated business units chart their own WAN destinies. Why not mandate a hierarchical scheme like CIGNA's or a fully distributed one like TI's? "While it's technically feasible to interconnect all our units," says Robert Alpaugh, McGraw-Hill's vice president of network services, "there are no significant overlapping topologies, and it wouldn't be cost-effective." That piece of common sense is all too easy to overlook. No technological imperative determines how to link LANs or even whether to do so. A network exists solely to meet the information requirements that a particular business model dictates.

BANDWIDTH

Stepping Up to Frame Relay

Last year, U.S. Generating, a power-plant developer owned jointly by Bechtel and Pacific Gas and Electric, forged its first WAN link. Microcom routers on either end of a leased 56-Kbps digital circuit sent IPX traffic between the company's Bethesda, Maryland, headquarters and a satellite office in San Francisco.

A year later, with E-mail, file transfer, and database applications straining the link's capacity, U.S. Generating is preparing to convert to a public frame-relay service. Unlike a terminal-to-host link that carries predictably regular flows of screen-oriented data, a LAN-to-LAN link experiences bursts of traffic as files, E-mail attachments, and sets of database records travel the circuit. A leased line with the capacity to handle these bursts solves the problem expensively and wastefully, because the circuit idles most of the time. Hence the need for bandwidth on demand.

Does a packet-switched service like frame relay (a descendant of X.25) really deliver bandwidth on demand? Yes and no. U.S. Generating plans to contract with a frame-relay vendor for a CIR (committed information rate) of 256 Kbps, and it expects that traffic may burst at times to 384 Kbps. While frame-relay vendors (e.g., AT&T, Sprint, MCI, and WilTel) can typically handle bursts, there's no guaranteed delivery once you exceed the CIR.

Moreover, to get that 384-Kbps port

speed on a CIR of 256 Kbps, notes Michael McParland, telecommunications manager at U.S. Generating, "We're going to need T1 [1.544-Mbps] access to the carrier's POP [point of presence]." The extra short-haul bandwidth will initially remain idle. With a T1-capable WAN access card in the Bethesda router, however, expanding the data transfer rate for that site will require no hardware or software changes—just a call to the carrier to boost the CIR (and the monthly bill).

Bandwidth on demand means different things to different people. Frame relay's claim to offer bandwidth-on-demand service rests neither on its modest burst capability nor on its expandable CIR. Frame-relay circuits, like X.25 circuits, are statistically multiplexed. That means a communicating device isn't restricted to a subset of the channel's capacity, as is true when a TDM (time-division multiplexer) splits a channel into fixed-width subchannels, but can instead contend for the full capacity of the channel.

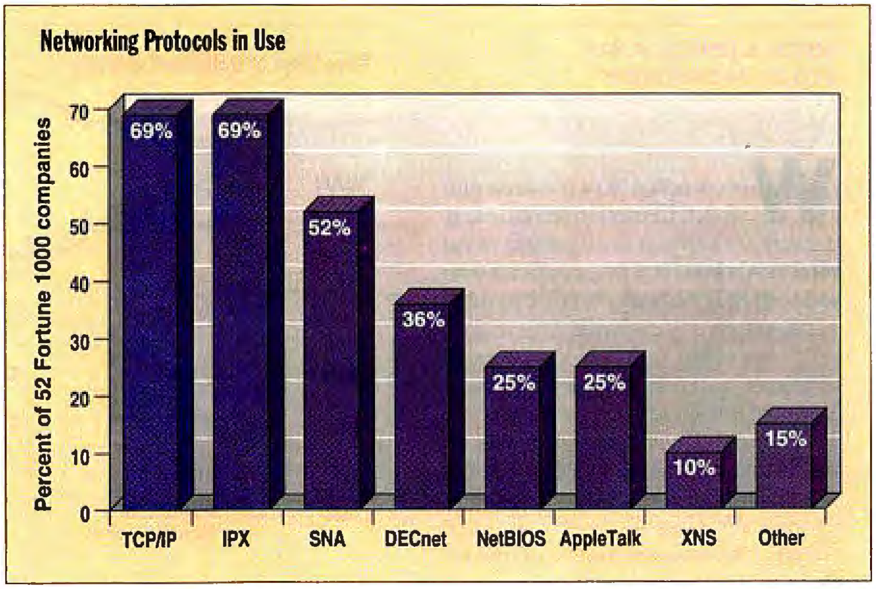
"Branch banks can typically afford no more than a 56-Kbps digital pipe," says Kevin Walsh, director of financial vertical marketing for data-communications equipment vendor Ascom Timeplex (Woodcliff Lake, NJ). "With a TDM, you'd have to carve off 9.6 Kbps for the ATM machine and another 9.6 Kbps for the teller controller, which means the LAN router can use only what's left over." Frame relay lets the router use the whole pipe if the legacy devices are idle, giving the LAN effective use of the full 56 Kbps.

This feature of frame relay isn't an issue for U.S. Generating, however, because its Bethesda-to-San Francisco link is dedicated to LAN traffic. In fact, if that were the only WAN link in the picture, the company might consider another way to achieve accordion-like bandwidth. Circuit-switched digital services (e.g., Switched 56 or ISDN) can also provide bandwidth on demand when coupled with inverse-multiplexing access equipment.

In contrast to a leased-line service that permanently links two locations, circuit-switched digital lines work like voice lines—you dial, converse, and hang up. An inverse multiplexer can build a variable-width pipe out of a bank of Switched 56 lines, recruiting and releasing lines on the fly in response to fluctuating demand for bandwidth.

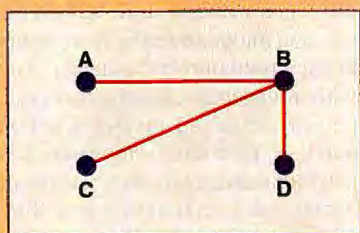
When an inverse multiplexer and a router cooperate, they can use digital dial-up services in an elegant way. Inverse multiplexers from Ascend Communications (Alameda, CA), for example, can cooperate with Cisco routers. "If the router sees a packet destined to go off-LAN," says Curtis Sanford, who is vice president of marketing for Ascend, "it consults a table that maps off-LAN destinations to phone numbers, then sends that number to the multiplexer, which dials and sets up the initial connection. Once the multiplexer is passing traffic between LANs, it can monitor channel traffic and decide when to add or reduce bandwidth."

While U.S. Generating might consider this kind of solution, its existing routers

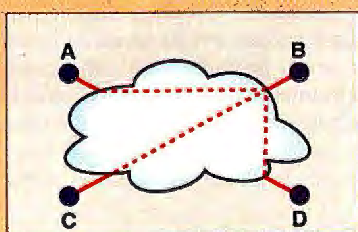


Connections between NetWare LANs *and enterprise-wide networks have kept TCP/IP and IPX at the top of the heap in this survey of IS professionals. While the chart does not reflect direction of growth, analyst Janet Hyland at Forrester Research believes DECnet and NetBIOS are losing ground—because of unreliable performance across WANs.*
(Source: Forrester Research)

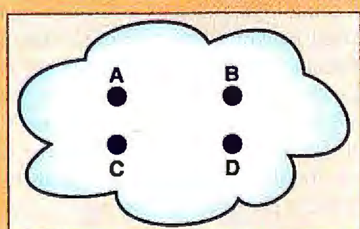
Three Flavors of Connectivity



Leased-line, point-to-point (e.g., fractional T1, T1/E1, or T3): Links are permanently open pipes. Installing a physical link can take days, weeks, or even longer. Failure of a link between two end points is catastrophic unless there is a redundant end-to-end link. If peer interaction among end points is a requirement, the number of links rapidly exceeds the number of end points as the network grows.



Packet-switched (e.g., X.25 or frame relay): Links from end points to the "cloud" (boundary of the packet-switching service) are usually open pipes. Within the cloud, connections among end points are usually PVCs (permanent virtual circuits). Configuring a new PVC, which requires no equipment changes, can take as little as a few hours. Redundant paths can exist among end points. For every-to-every connectivity, the number of links into the cloud does exceed the number of end points (however, the number of PVCs must grow).



Circuit-switched, or digital dial-up (e.g., Switched 56 or ISDN): Links form on demand and, for the duration of a dial-up session, behave as open pipes. Within a region of service, the cloud that defines the boundary of that service in principle includes all end points. Establishing a link requires only a few seconds. Redundant paths exist among end points. Peer interaction among end points requires that the number of links grows beyond the the number of end points.

Reducing Router Network Transmission Costs

NICK LIPPIS AND
JOHN MORENCY

Within a WAN (wide-area network), transmission costs may account for as much as 80 percent of the total WAN budget. For users faced with the task of connecting a large number of geographically dispersed remote sites, reduction of transmission costs through efficient use of circuit capacity becomes a critical objective.

A key trend in corporate networks today is that the routing function is moving toward the fringes of the network. There, a new class of product called IAP (internet access processor) will link remote users into enterprise-wide corporate networks.

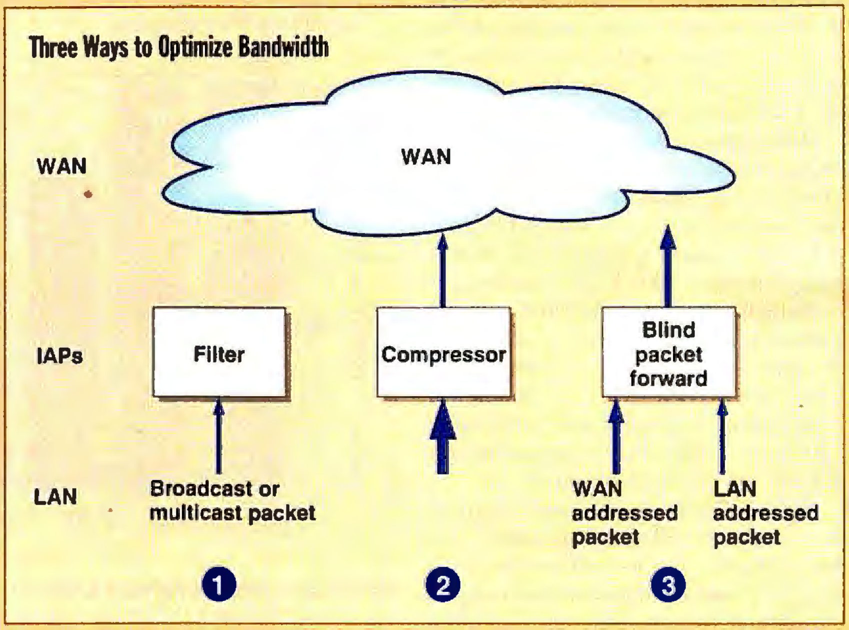
IAPs at remote sites will fan into new central-site IBWMs (Intelligent Bandwidth Managers), which are expected to provide higher transmission speeds, bandwidth-on-demand services, and predictable switching latencies. You can expect IBWM announcements from StrataCom, Newbridge, Codex, and Cascade by January.

Vendors such as 3Com, Proteon, Telebit, and Centrum have recently introduced IAPs priced in the $1500 to $6000 range. In addition to functioning as routers, these devices support off-site access for popular PC LAN protocols such as NetWare and AppleTalk. IAPs are appropriate for installation in corporate branch offices that serve from two to 20 employees.

Deployment of IAPs will increase the pressure on network managers to minimize remote-branch connectivity costs, and this will require careful analysis of the relative efficiency of competing IAP products.

Protocol Filtering

The three best tools for reducing router network transmission costs are protocol filtering, packet compression, and blind packet forwarding. Currently available IAP products perform these three functions in quite different ways.



The three main approaches *to squeezing the most out of expensive WAN bandwidth are: ❶ Filter broadcast and multicast overhead traffic from entering the WAN. ❷ Compress the size of packets before they are transported over the WAN. ❸ Pass only those packets that do not possess a local network layer address (blind packet forwarding).*

One problem often encountered in today's internetworks is unwanted broadcast and multicast traffic from protocols that are used only infrequently. To deal with this problem, most router products (and an increasing number of IAP products) are providing the means for the network manager to eliminate the origination and reception of protocol traffic that has no direct benefit to a company.

Some IAP products disable particular broadcast and multicast addresses for a given protocol type; other products eliminate support for that protocol type altogether. In either case, the decrease in protocol overhead makes more capacity available for end-user traffic.

Packet Compression

Technologies such as V.32bis have long used packet compression to maximize throughput over asynchronous links supporting Kermit, XMODEM, and YMODEM file transfers. However, many file transfers that depend on asynchronous protocols can be accomplished just as effectively over routing paths.

What has been lacking is a widely implemented set of standards in the TCP/IP protocol stack to support this same functionality. This support can be implemented in either system-to-system protocols (e.g., TCP, IP, or UDP); router-to-router protocols such as RIP (Routing Information Protocol), OSPF (Open Shortest Path First), BGP (Border Gateway Protocol), IGRP (Interior Gateway Routing Protocol), or EGP (Exterior Gateway Protocol); or both.

Until such standards are agreed upon, users whose networks are significantly burdened by remote file access and transfer may benefit from products that use proprietary compression algorithms.

All compression schemes increase transmission throughput at the expense of router processor efficiency. However, constant breakthroughs in processor technology promise to make this less of a concern for users.

Blind Packet Forwarding

Blind packet forwarding reduces packet overhead by avoiding the exchange of broadcast or multicast messages. Conventional multiprotocol routers incur incremental protocol complexity and processing overhead for each additional supported protocol.

A router that uses blind packet forwarding minimizes this overhead. When a packet that does not contain a local network layer address arrives at a router from a connected LAN, that packet is automatically forwarded onto the wide-area circuit.

Similarly, if the router gets a packet from a wide-area circuit, the packet is automatically forwarded to the attached LAN, based on the assumption that the packet would not be received by the router if it was not intended for some end station on the local LAN.

Blind packet forwarding is performed independently of the protocol, the topology of the attached LAN or WAN, or the capacity of the wide-area circuit. It offers significant benefits for remote-branch routers. These benefits include reduced management complexity for protocol routing tables and increased available circuit capacity as a result of reduced protocol bookkeeping overhead. When used with protocol filtering, blind packet forwarding can minimize unnecessary traffic. Also, when blind packet forwarding is implemented in a frame-relay environment, large cost savings can occur becauset of a much lower requirement for a base CIR (committed information rate).

Router Network Design Tools

Few of the network design tools available today let users predict network performance levels before making router purchase decisions. In addition, only one major partnership exists today between a router or IAP vendor and a network design tool vendor.

Wellfleet Communications and Make Systems have partnered to develop a device library for Make Systems' NetMaker network performance and configuration software product. NetMaker 1.2 will feature a device library for Wellfleet routers that the two vendors claim will let network managers perform the following tasks:

Assess the impact of network traffic loads. This lets the user determine router impact based on changes in traffic arrival rates. It does not, however, provide a general-purpose means to determine arrival rates or traffic distribution by packet type. This exercise is left to the user, who must determine optimal loading by means of an iterative trial-and-error exercise.

Determine how routers will respond to failed links. This is generally performed by a mapping of rerouted traffic onto a subset of routers and links, with the objective of determining if the routing infrastructure can safely handle the increased load.

Ascertain how susceptible networks are to link failures. This is generally derived from a statistical analysis of a combination of circuit and router failures to determine relative failure rates within the network and the resultant impact on end-to-end connectivity.

Validate network design decisions based on projected loads, sustainable forwarding rates by the various routers, projected error rates, and a sound understanding of peak-to-average packet ratios.

Partnerships between router vendors and network design software vendors are a step in the right direction. Such partnerships might enable network management data generated by a router to be easily integrated into design tools, thereby supporting trend and hot-spot analysis, as well as providing the basis for an effective accounting and charge-back scheme.

However, even network design software based on extensive multivendor device libraries will not enable network managers to build internetworks with complete confidence unless they are totally aware of all the modeling assumptions that are built into these software packages. These assumptions include distribution of packet arrival rate, distribution of packet service time at both the circuit and router levels, distribution of packet sizes, distribution of error rates, and relative independence of router service rates and times.

Nick Lippis and John Morency are president and principal consultant, respectively, at Strategic Networks Consulting, Inc. (Rockland, MA). SNCI provides custom network consulting and publishes the Internetwork Advisor *newsletter. You can contact them on BIX c/o "editors."*

couldn't be recycled, as will be possible when it upgrades to frame relay. Moreover, the company's growth is transforming the WAN's point-to-point topology into the more distributed one that is frame relay's strong suit.

McParland plans to transmit data collected by PC-based monitors on LANs at each power plant to the central Bethesda LAN. There are 10 plants now, and 10 more are expected soon. A fat T1 pipe from Bethesda into the frame-relay "cloud" will enable headquarters to consolidate operations data from all these sites; they in turn connect into the cloud using skinny 56-Kbps pipes. The point-to-point, leased-line solution would require a stack of routers and access cards in the Bethesda office, and it would provide no redundancy. Frame relay requires only a single central router, which the remote sites can reach via multiple paths.

If You Have ISDN, Use It

At West Virginia University in Morgantown, an FDDI (Fiber Distributed Data Interface) backbone links departmental LANs in 10 buildings. The sprawling campus includes another 90 buildings that WVU cannot afford to connect with fiber or bridged T1. Economics dictated low-bandwidth connectivity for departments located in these satellite buildings. While dial-up routers like Telebit's NetBlazer can use analog modems to link LANs over ordinary phone lines, 9.6-, 14.4-, or 19.2-Kbps circuits—even with compression—can support only the most casual sort of LAN interconnection.

WVU telecommunications engineer Jeff Fritz found a superior low-cost, low-bandwidth option: ISDN. C&M Telephone, which serves Morgantown, is part of Bell Atlantic, one of three regional Bell operating companies with significant deployment of ISDN (the other two are Ameritech and Pacific Telesis). Since 1990, the WVU campus has had flat-rate ISDN service. LANs in the satellite buildings connect to the FDDI backbone over ISDN lines using Combinet Ethernet bridges.

A T1 line would cost about $700 per month, plus $12,000 for a bridge and the cost of a CSU/DSU (channel service unit/data service unit). The ISDN alternative costs $40 per month for each line and $2100 for a bridge from Combinet that lashes together the two 64-Kbps ISDN "B" (bearer) channels to create a 128-Kbps pipe. With compression, throughput surpasses 200 Kbps. That's roughly the speed of a LocalTalk network. It's an order of magnitude slower than Ethernet, but an order of magnitude faster than an analog

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This is a story about a small computer engineered to be so dependable, you won't think twice about trusting it with your mission-critical applications. And to be this without filling a closet, much less a room. If you haven't thought of Compaq as an enterprise-critical platform before, we invite you to grab your bifocals and begin. (We'll be cramming a lot of information into this ad, which, given how much we managed to fit into our new servers, only makes sense.)

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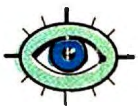

If the performance of a monitored component drops below a specified level, our unique Pre-Failure Warranty kicks in. We'll actually replace a Compaq warranted drive or memory system free. Before it stops working. No downtime. Ringing cash registers. Happy boss.*

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For example, Automatic Server Recovery 2 uses a historical record of server status and performance to perform an astonishing array of tasks. Like intelligently restarting the server, automatically correcting a variety of problems, and accessing a telephone pager to contact network administrators.

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*And finally, to accompany our new line of mission-critical servers, we're introducing mission-critical support. With ProLiant, we now offer extensive analysis, installation and service through our CompaqCare System Partners, a select group of highly trained systems experts backed by Compaq engineers. You can now choose 4-hour on-site warranty response upgrade** direct from Compaq. Again, there's our unique Pre-Failure Warranty. And, of course, all Compaq servers come with a 3-year on-site† warranty, and 7-day-a-week, 24-hour-a-day technical support.*

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Architecture	TriFlex/PC One Processor	TriFlex with up to two symmetric processors	TriFlex with up to four symmetric processors
Network Interface	Up to 12 High-Speed Channels; NetFlex 2 with Packet Blaster Technology Standard		
Standard Disk Controller	Integrated Fast SCSI-2 and Smart SCSI Array Controller (selected models)		
Storage Capacity	550MB–112GB Internal/external	1050MB–140GB Internal/external	1050MB–140GB Internal/external
Typical Usage	Departmental network services—primarily NetWare	Departmental network application services—NetWare, NT and Unix	Application services for preemptive downsizing—NT and Unix
Transaction Rating	50–150 TPS	200–300 TPS	300–400 TPS
Estimated Starting Street Price‡	$6,000	$8,900	$13,900
SERVER DEPENDABILITY AND AVAILABILITY			
Management	Second-generation Compaq Insight Manager (standard) combines with innovative hardware design to constantly monitor, assess and report server health and performance		
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SIMPLICITY, EASE OF OWNERSHIP AND SUPPORT			
SmartStart	Standard CD-based intelligent hardware configuration and system software installation, providing simplified server configuration for NetWare, NT or Unix. (CD-ROM drive standard)		
System Warranty	Free Three-Year, On-Site Limited Warranty		
Pre-Failure Warranty	Three-Year, On-Site Warranty replacement of designated components that fall below preestablished thresholds		
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Technical Support	Toll-free, 7 x 24 technical phone support from Compaq engineers		
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QuickFind/PaqFax	Proactive notification and delivery of new technical information/7 x 24 fax response for updated specification, configuration and settings data		

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modem—fast enough to feel to users like real networking. Remember, too, that ISDN communication is synchronous, Fritz says, so it carries a bigger data payload than does asynchronous traffic.

X Window System programs that are intolerably slow over dial-up SLIP (serial-line IP) or PPP (point-to-point protocol) connections become usable over ISDN. There's no absolute threshold, but, notes Gerry Hopkins, staff manager for ISDN planning at Bell Atlantic, "At some point a difference in degree becomes a difference in kind."

The availability of ISDN and inexpensive Ethernet bridging lets Fritz deliver the same class of service to selected users' homes. "I can use the bridge's filtering capability on the network side to send only EtherTalk and IP to my Mac at home," says Fritz. "By cutting out IPX and DECnet LAT, I often get better throughput than some users on campus."

Ad hoc collaborations with other universities are another intriguing application Fritz has explored. However, he laments the Balkanization of ISDN service in the U.S., which precludes the national and international connectivity available to European and Japanese users.

Understanding Bandwidth Consumption

WAN capacity will, for the foreseeable future, be a scarce commodity that users must carefully ration. LAN administrators, however, are ill-prepared to understand their bandwidth use—much less control it. "In the connection-oriented, deterministic WAN environment," says Frank Dzubeck, president of consulting firm Communications Network Architects (Washington, D.C.), "everything is measurable and tunable, and I can optimize my network. In the connectionless, nondeterministic LAN environment, I lack the tools to optimize." Steve Weidemann, who is assistant vice president for communications planning at insurance, health care, and financial services company CIGNA (Philadelphia, PA), similarly bemoans the lack of capacity-planning tools for interconnected LANs.

When LAN applications appear on WANs, it frequently spells trouble. Databases that are file-oriented rather than server-based are one major culprit. U.S. Generating's wide-area use of Superbase, which like any file-oriented database must pull entire data and index files through the narrow pipe, is a classic waste of bandwidth. "That's why we're moving to a Gupta client/server setup," says network manager Ethan Wilansky. Restricting transmission to SQL queries and results can reduce traffic dramatically. (However, as databases grow, so do result sets.)

Another culprit is E-mail, which Dan Gasparro, president of consulting firm Network Quality and Assurance (Chantilly, VA), jokingly considers "one of the primary dangers to network health." Messages themselves represent only a relative trickle of data, but the multimegabyte voice, video, and image files that desktop E-mail programs invite users to attach to their mail can wreak havoc. "We see the LAN segments that support mail servers getting hammered," says Gasparro, "yet people can't figure out why their WAN bandwidth is being eaten up."

Other consumers of bandwidth are even more subtle. Chatty LAN protocols that require back-and-forth acknowledgments on multiple layers are notorious abusers of WAN circuits. Network monitors that implement the RMON (remote monitoring) MIB (management information base) can also cause trouble. "SNMP is bad news on the WAN," says Dzubeck. "Polls are constantly going out, and devices may respond by dumping 5 Mb of MIB data onto the network." He also cites software distribution, database replication, and image transfer as WAN application categories that are particularly bandwidth-hungry.

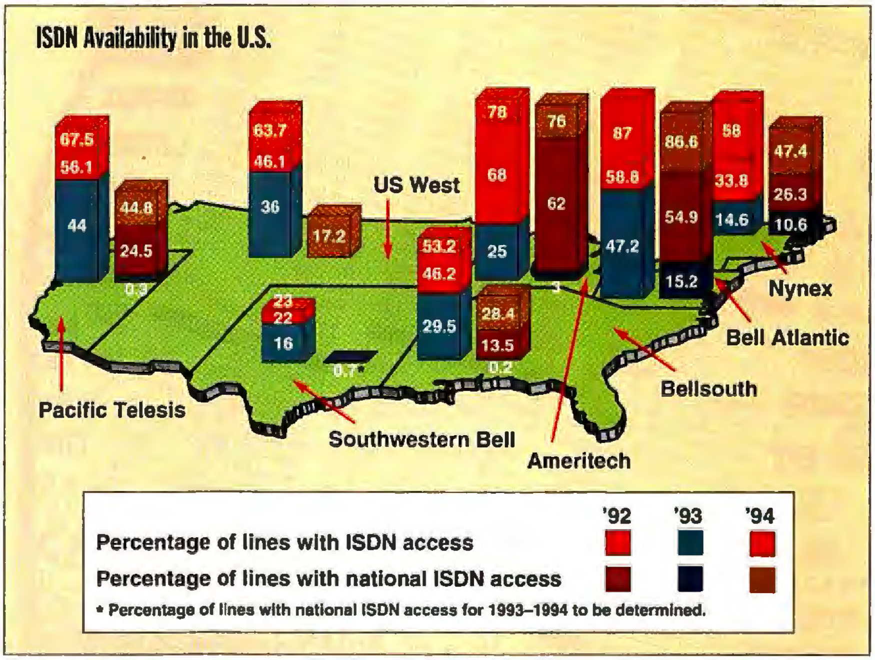
Conservation Measures

Client/server technology can be an excellent way to make better use of finite bandwidth. If you process data in place and transmit only results, the amount of data moving through a network can greatly diminish. The client/server model does, however, locate responsibility for rendering data on the client's end of the pipe. While requests are small, the result sets returned to the client can be enormous.

Ultimately, it makes most sense to locate data closest to its point of use. At Con Edison, New York City's electric utility, customer requests pour in from the five boroughs and Westchester County. Two years ago, all six offices accessed a central mainframe database. Today, each office has its own server. "The people serving Brooklyn do 99 percent of their work on the Brooklyn server," says Joseph Curtis, manager of office systems for Con Edison. "They rarely interact with Manhattan or Queens." What happens when users need to cross borough boundaries? NFS (Network File System) cross-mounts among the servers create a kind of distributed file system that makes remote data accessible to local users in the infrequent cases where they need it.

Within the realm of network management, there is an emerging class of tool that seeks to automate the migration of data to its point of use. "Novell's NetWare Management System takes a step in this direction," says Dzubeck, "and DEC's Polycenter does, too." In principle, such tools, when mature, will minimize unnecessary WAN traffic.

In practice, ironically, they may also become yet another source of bursts as data flows like water in search of its level. "That's fine on the LAN," says Dzubeck,



The Baby Bells control *access to most of the ISDN lines. This chart shows the projected ISDN penetration, both regionally and nationally. Many smaller localities are served by independent telecommunications companies, and their ISDN capabilities are not shown here. (Source: Bellcore)* "but not across the wide area." Another example of mass migration of data occurs daily, as 40 to 50 MB of Usenet articles roam the Internet en route to more than a million Unix machines. No one disagrees with the general proposition that data belongs where you use it. But no one really understands the optimal trade-off between the benefits of local access and the costs of transmission (see the text box "Reducing Router Network Transmission Costs" on page 70).

Other bandwidth conservation measures can be absurdly simple. Kindercare Learning Center, a day-care franchise based in Montgomery, Alabama, decided to use CompuServe's packet network to deliver a newly developed accounting application to each of its 1200 day-care centers. Users at multiple sites would share a 56-Kbps pipe into CompuServe's cloud, which in turn reached a Hewlett-Packard RISC host in Montgomery.

Kindercare had to determine how many 56-Kbps lines to rent. That depended on how many sites could share a single line. During initial testing, screen painting and data transfer rates were far slower than anticipated. Why? A second round of testing on a prototype WAN revealed that the decorative borders and colorful text Kindercare's programmer had added to make the application visually appealing were gobbling a startling share of the bandwidth. "Just by taking away the borders and the color, we were able to boost the number of users on a single line by up to 40 percent," says Roger Brunk, vice president of information systems for Kindercare. His advice? "Prototype it!" If you don't develop and test in a bandwidth-sensitive environment, it's hard to produce a WAN-friendly application.

PROTOCOLS

Old World, New World

The WANs that have for years carried worldwide corporate commerce use protocols and equipment associated with IBM's SNA. Recently, routed LAN internetworks have appeared in parallel with the legacy SNA networks. "But with WAN tariffs eating up 80 percent of the internetworking budget," says Ken Miller, president of consulting firm Prism Networks, "the question becomes, 'How can I merge my SNA net and my LAN internet?'"

Not every large corporation faces this issue. At McGraw-Hill, according to Robert Alpaugh, the SNA network that funnels accounting data to headquarters hardly overlaps with the X.25 packet networks that deliver McGraw-Hill information services to various units' customers. "While the technology exists to combine some of these networks," he says, "economics don't justify it." At CIGNA, however, where SNA and LAN internetwork topologies match up intimately, merging old and new networks is a front-burner issue. The only question is how to make it happen.

Recent InterOp shows have featured a variety of solutions. Most are variations on the same theme: Encapsulate the SNA traffic inside TCP/IP. That's easier said than done, given the strongly connection-oriented nature of SNA's two link protocols, SDLC (synchronous data-link control) and, in the token-ring environment, LLC2 (logical link control type 2). Another obstacle is the broadcast-intensive nature of *source-route bridging*, the dominant method for connecting local and remote token-ring LANs.

However, many experts think that router vendors will rally around *data-link switching*, the SNA encapsulation technique built into IBM's first multiprotocol router, the RS/6000-based 6611 Network Processor. In an SNA/token-ring environment, a router that implements data-link switching issues and acknowledges periodic LLC2 tickle messages.

This local termination, or *spoofing*, of LLC2 circuits prevents two problems that occur when the circuits stretch across a long-haul link: time-outs and congestion. Because the router violates the end-to-end integrity of LLC2, however, it must guarantee delivery of packets using a higher-level protocol. TCP, which IBM's 6611 employs for this purpose, is the usual choice.

In source-route bridging, token-ring stations and bridges are both active participants, and the work of routing is distributed throughout the network. Stations are responsible for inserting route information into token-ring frames. They discover routes by broadcasting *explorer frames* that bridges transmit throughout a LAN internetwork. SNA encapsulation strategies seek to minimize this exploratory route-discovery traffic.

Here too, data-link switching creates a fire wall between the local network and the enterprise network. The router maintains a table that pairs the MAC (media access control) address of each token-ring

Political Primer for Enterprise Networks

JOHN TIBBETTS AND
BARBARA BERNSTEIN

The process of integrating LANs into WANs (wide-area networks) is different for each company. In some places, LAN people want nothing to do with the wider enterprise; in others, they eagerly pitch their successful applications to other departments and lobby for access to companywide data. Some IS departments hang tough; others lose their self-confidence and capitulate to wholesale downsizing. But everywhere, the underlying politics of tying grass-roots LANs into enterprise-wide WANs are fundamentally the same. Here are the hard truths about this process:

Enterprise-wide distributed systems are your company's best hope for the future.

Companies that succeed in the 1990s will be the ones that bring their staff, suppliers, customers, and business partners into direct contact. Massively distributed information systems can eliminate many levels of cumbersome bureaucracy and let the business respond quickly and flexibly to emerging opportunities.

These systems take advantage of the skills and initiative of people throughout the organization. They put the marvelous power of PCs and LANs at the service of enterprise-wide strategies. A finely tuned distributed system lets every bit of data and function find a home at the appropriate level in the organization. Enterprises that remain rigidly centralized, or that downsize indiscriminately, will fail.

Putting these systems in place will upset many people.

In most companies, two different information-processing cultures coexist uneasily. In the future, the two cultures will have to work cooperatively, overcoming their mutual suspicion and reconciling two different sets of values. LANs have emerged among small groups of like-minded people (LAN applications are much more like upsize PC applications than like downsize mainframe applications), where the cardinal values are quick development, high functionality, and access to resources.

WAN culture, on the other hand, has evolved to serve the needs of a large and extremely diverse set of users. Security, data integrity, and highly scalable performance are what count here. Each side imagines everything it values and has worked for going straight to hell when the other side—that slow-moving, obstructive, arrogant glass house; those adolescent, irresponsible, arrogant hackers—starts messing around with their applications.

The imperial glass house is finished.

Many IS organizations deserve their reputation for stodgy high-handedness. They will never strike up a working relationship with the LAN administrators in their organization unless they acknowledge that the balance of power has shifted. People in the departments are happily building applications and wouldn't mind continuing to do so. The glass house has to plan and execute a strategic retreat. Redefine your job in the organization. Promote yourself as the maintainer of resource servers for departmental client/server applications, rather than trying to remain the exclusive provider of computing services to end users.

To rebuild credibility, IS must get out in front on new technologies.

Being the high priest of the IBM mainframe doesn't count for much these days. Wave after wave of new technology is sweeping the industry. The people a company pays to specialize in information systems ought to be as up to date on client/server, distributed transaction management, even object-oriented technology, as your average computer magazine reader. This means more than taking a crash course in Visual Basic or SQL Server; it means the development of a forward-looking, open-minded enthusiasm for new ideas. The function of the glass house is basically conservative, but technologically you should be anything but. Attract interest among the LAN administrators in your WANs by offering them expertise and cooperation.

LAN people do not understand many important things about enterprise computing.

IS professionals go justifiably crazy when people who have built an order-entry system in Powersoft's PowerBuilder think they can now run a company. Enterprise-wide systems are not just big LANs.

People who have learned computing at PCs and LANs have little conception of the complex issues that arise when millions of transactions, thousands of users, a mission-critical function, and crucial data are involved. Have some humility about issues like security, integrity, scalable performance, and large-scale manageability.

Don't expect the organization to keep its hands off important applications.

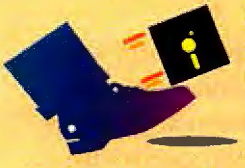
Once your application expands from a pet project to a corporate asset, you can't expect the organization to just leave you alone. If your application is important to the business—and we've never met a LAN designer who would say his or hers wasn't—the enterprise has to exert some control over it. They may want to expand it to other departments in the company. They may need to keep it in conformance with policy guidelines you don't know anything about—new laws, EPA requirements, or a management decision that frankly is none of your business.

The organization has to make sure your application keeps working. Would you want your paycheck processed on a LAN application that's not documented, not backed up, and not secure? If a company is cavalier enough to leave unduplicated crucial business functions and data in the hands of ad hoc architects out in the departments, on machines that anybody with a screwdriver could bring down, you certainly don't want to work there.

Workgroups can either work with IS or turn into IS themselves.

As LAN applications get larger and more ambitious, their overhead grows. They need archiving, management, version control, documentation, and even esoteric disaster planning. It becomes a full-time job, one you probably don't want to do.

Luckily, full-time people in the IS department have experience with this sort of thing. Approach them and ask for their help. In exchange, offer them your cooperation. After that, you can concentrate on designing buildings or selling products or planning employee benefit packages or scheduling shipments or whatever your department is supposed to be doing to move the business forward.



Proprietary approaches have to go.

IS has for years taken the rap for using the proprietary MVS operating system. But LAN applications are even worse. Client/server development relies on database-stored procedures or triggers that are written in highly proprietary, vendor-specific languages. The upshot is that business function has to live forever where it was born, and the system loses an important tool for fine-tuning applications. The flexibility to move function around—up to the enterprise for trust reasons, down to the business unit for performance reasons—is one of the strengths of distributed systems. This means open architectures on both sides.

Negotiation is the best course.

Companies must face these ugly issues head-on. LAN and WAN people should start talking to each other. Avoiding each other only makes things worse. Neither side need feel like the victim of a fiat from above or an uprising from below. Each side comes to the bargaining table with many chips. They should strike simple, commonsense bargains that balance the interests of empowered business units with the interests of the enterprise as a whole.

Be sure that you make any bargains you decide on specific: You back up and store our LAN data, and we'll use your procedures for updating the database. If the departmental folks are afraid that they will be forced to purchase expensive equipment, or of losing access to their own connections, this is a topic for negotiation. If IS feels strongly about getting LAN applications to standardize on its data-administration policy, they can make it part of the deal.

John Tibbetts and Barbara Bernstein are partners in the San Francisco–based consulting firm Kinexis, which specializes in distributed computing, computer architecture, and applying object technology to communications systems. They are the authors of Building Cooperative Processing Systems *(John Wiley & Sons) and are at work on a new book on open distributed systems. You can reach them on BIX c/o editors or on the Internet at KINEXIS@MCImail.com.*

device with the IP address of the device's access router. Once these mappings are established, the router can respond locally to explorer frames without broadcasting them onto the WAN.

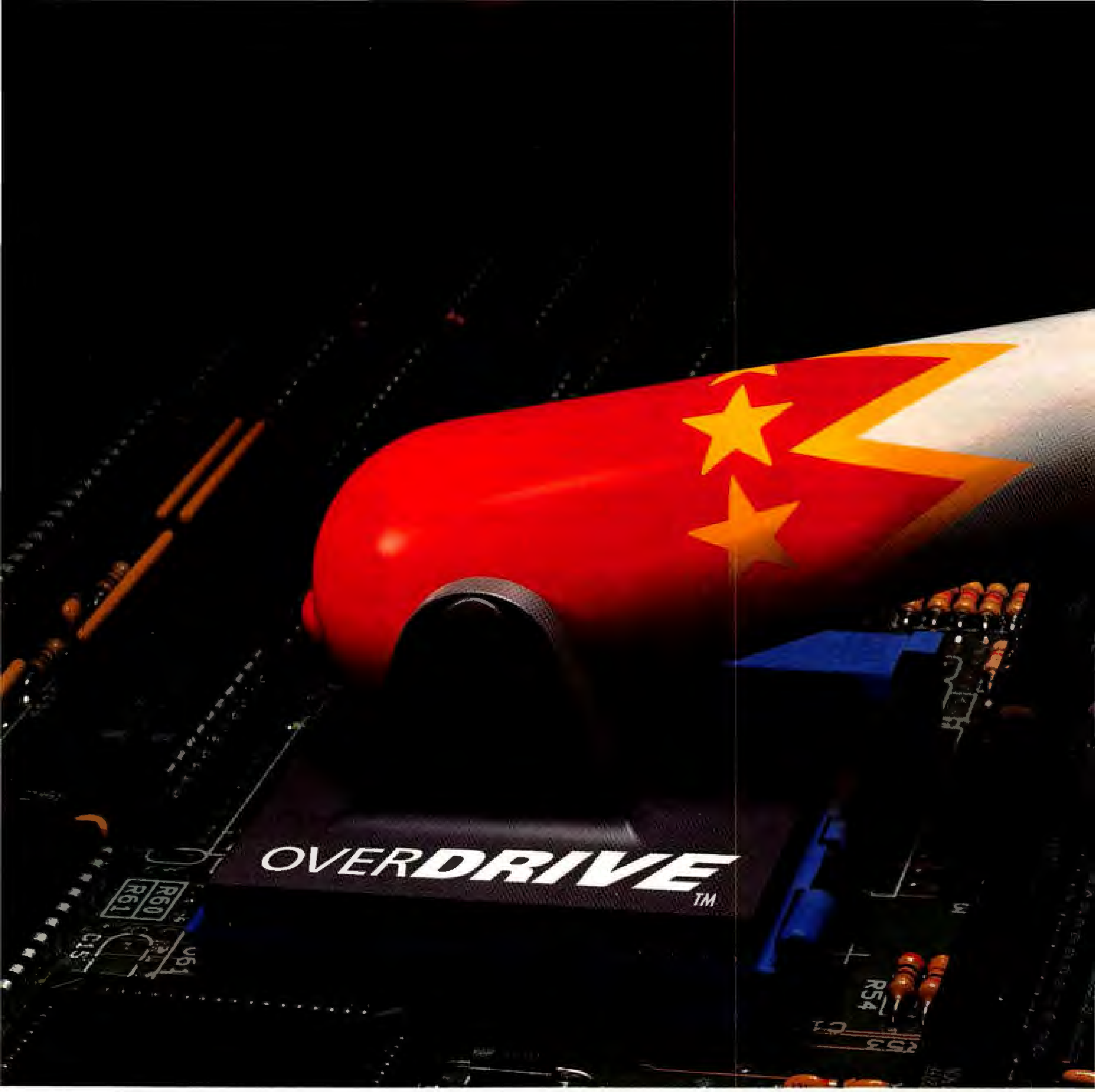
"Every router vendor has added his own twist [to SNA encapsulation]," says Frank Dzubeck, "but IBM's data-link switching looks like it will be the definitive encapsulation method." Prism's Miller agrees, but he expects that users will proceed cautiously because "people are scared to death to run their SNA net in a mode that's not reliable."

SNA's need for deterministic response time is one cause for concern. Router vendors address this issue by attempting to prioritize the SNA traffic on a mixed-protocol WAN. They do this in proprietary ways, however, and there's no clear standard on the horizon. For George Chrisman, manager of electronic communications at Texas Instruments (Plano, TX), that's a showstopper. "One of the barriers to collapsing the net [merging SNA and LAN internetworks], and the reason we have moved slowly, addressing only locations with little SNA traffic, is that the prioritization capability in existing bridge/router products is not mature."

For some businesses, the formidable obstacles to SNA/internetwork integration spur the decision to drop SNA altogether. "People should build networks around applications, not protocols," says Gasparro. When one of his clients opted to move from an IBM 3090 to Unix to take advantage of more flexible and powerful applications, Gasparro, the network integrator, was elated. "We were having to engineer around SNA on the LAN side," he says, "so we were glad to cut it loose." Another client, struggling to cram SNA, IPX, and TCP/IP traffic into a single leased-line link, is also reconsidering its dependence on the mainframe, an attitude Gasparro calls "healthy."

When LAN Protocols Meet the WAN

Walk into any corporate office, and you'll likely find a diverse population of desktop computers. As users join PCs, Macs, and Unix workstations to departmental LANs, the list of network protocols in circulation grows longer. Inevitably, there is pressure to cross-connect these environments. Mac users run Apple's MacTCP, and PC users run FTP Software's PC/TCP or Sun's PC-NFS, to establish terminal sessions with a Unix system or reach its file, print, or database services. The same PCs are likely using IPX to connect to NetWare servers or, maybe, NetBEUI to reach LAN Manager, LAN Server, Windows for



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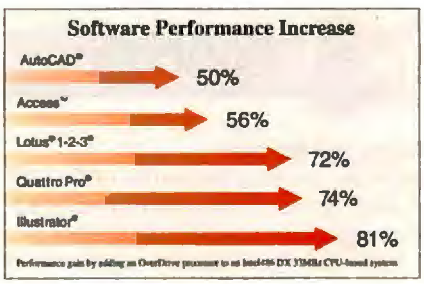

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Workgroups, or Windows NT machines.

This proliferation of protocols is, first and foremost, a logistical nightmare for LAN administrators. The protocols all have their own logical naming or addressing schemes, so multiprotocol clients require multiple configurations. While memory-constrained and less-than-robust Windows or Mac workstations can usually manage to multiplex protocols, the processing burden they must shoulder can be taxing.

WAN managers inherit these troubles, compounded by others that arise when broadcast-happy or unroutable LAN protocols find their way onto the WAN. "These protocols do not survive well in the harsh WAN environment," says TI's Chrisman. AppleTalk's RTMP (routing table maintenance protocol), for example, requires routers to exchange tables every 10 seconds, a behavior that is tolerable on LANs but deadly on WANs.

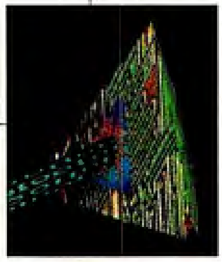
A newer protocol, AURP (AppleTalk update-based routing protocol), minimizes such exchanges but is not yet widely used. Another alternative, encapsulation of AppleTalk within IP, has for years been a mainstay of wide-area AppleTalk networking. But as WVU's Fritz points out, "If you've ever tried IP tunneling, you know it's no fun at all." He prefers Ethernet when it is an option.

NetWare's SAP (service advertising protocol) is another notorious offender. Once a minute, NetWare servers issue SAP broadcasts that enumerate available services. The small payload of NetWare's IPX transport protocol (576-byte packets), and its habit of acknowledging delivery of each packet, further compromise NetWare's utility on the WAN.

Tools are available to alleviate these problems. Novell offers an NLM (NetWare loadable module) that can filter SAPs, and many router vendors support SAP filtering as well. You can also retrofit NetWare 3.11 to accommodate both large IPX packets (up to 4 KB) and bursts of packets; large-packet IPX and burst-mode IPX come standard with NetWare 4.0. However, administrators must enable, configure, and monitor the operation of all these features.

Novell realizes that tinkering with IPX is a stopgap solution and is pursuing several alternatives. Running NCP (Netware Core Protocol) over TCP/IP, something Novell demonstrated at the Fall '93 InterOp, is one option many administrators find intriguing. Even if that setup performs well, however, full use of it will require conversion of IPX-specific applications to the TCP/IP sockets interface. Separately,

> **"Duplication of names and network numbers is my most serious problem."**
>
> **—Jim Curry, senior LAN specialist, McGraw-Hill**



Novell is developing a new routing protocol, NLSP (NetWare link services protocol), intended to remedy IPX's WAN deficiencies.

The Truth About Wide-Area NetBIOS

NetBEUI, the transport protocol used by LAN Manager, LAN Server, Windows for Workgroups, and Windows NT, presents its own peculiarities. NetBEUI isn't routable, a fact that greatly inconveniences many applications that use NetBIOS and that need to communicate over WANs.

While unroutability is often attributed to NetBIOS itself, however, NetBIOS in fact is just an interface layered on top of transport protocols that may or may not be routable. NetBEUI isn't routable, but TCP/IP, XNS, and X.25 are, and NetBIOS can run on all these protocols. Microsoft's LAN Manager and Windows NT, for example, can use NetBIOS over TCP/IP for WAN communication. Using a table that maps NetBIOS names to IP addresses, these products can extend NetBIOS sessions across the routed IP internetwork to remote partners.

Performance Technology's Powerbridge offers even more flexibility, joining NetBIOS LANs that may in fact use different transports—for example, LANtastic and NetWare (with Novell's NetBIOS emulation). While the company has discontinued the X.25 version of Powerbridge in the U.S. due to lack of demand, April Systems (Solna, Sweden) continues to develop the product under the name XPORT and to market it in Europe, where private X.25 is popular.

Jonathan Schmidt, vice president and chief technology officer at Performance Technology, recently visited Sweden, where he found XPORT being used nationwide to connect LAN Manager networks in OK Petroleum's 550 gas stations to LAN Manager and LAN Server networks in the home office. "By simply relaying the NetBIOS API across the wide-area link," says Schmidt, "XPORT eliminates ping-ponging and can buffer large blocks of data without violating any of the lower-level protocol dependencies or time-outs often encountered when stretching LANs across slow links."

LAN Manager's NetBIOS-over-TCP/IP and XPORT's NetBIOS-over-X.25 both rely on static tables of NetBIOS names. Administrators must agree which names to publish across the internetwork and must maintain the lists accurately over time—a difficult task in very large networks. Boeing, with 6000 LAN Manager nodes running NetBIOS-over-TCP/IP on a WAN, needed a more dynamic way to handle this name-to-address mapping. The company solved the problem with Network Telesystems' NetBIOS Name Server, an OS/2-based product that maps NetBIOS names to IP addresses on the fly. "People make the mistake of thinking that Microsoft's LAN Manager can solve their wide-area networking problem right out of the box," says Tim Gelinas, who worked on the Boeing implementation and is now vice president of engineering at Spry, a Seattle, Washington, vendor of Windows networking applications. "But you have to add a lot of intelligence to Microsoft's NetBIOS-over-TCP/IP to make it a workable solution."

The NetBIOS Name Server also ensures efficient distribution of NetBIOS datagrams over a TCP/IP WAN. John Davidson, president of Network Telesystems (a newly formed Ungermann-Bass spin-off located in Santa Clara), points out that NetBIOS applications rely on names not only to establish sessions, but also for the more frequent purpose of sending datagrams to individuals or groups. The Network Telesystems' datagram delivery service ensures that a datagram addressed to a remote group fans out to the group members.

NetBIOS is not the WAN-impaired unroutable protocol it is commonly misrepresented to be. It is, instead, simply a network API that relies on a distributed name table. And there are ways to spread those names across a routed internetwork.

MANAGEMENT

Names and Addresses

With the growing popularity of TCP/IP comes increasing strain on its limited addressing scheme. A TCP/IP address is a 32-bit quantity, so there are more than 4

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TCP/IP Addressing

TCP/IP addresses consist of 32 bits, traditionally divided into four 8-bit parts. A typical address might read as:

```
 1    2    3    4
123 . 203 . 54 . 117
```

One address in each segment of the address should be reserved for a broadcast address. If you are independent from the Internet, you can divide the 32-bit structure any way you want, like:

- 8 bits less one address: 255 addresses for the company
- 8 bits less one address: 255 addresses for buildings within each company
- 8 bits less one address: 255 addresses for departments within each building
- 8 bits less one address: 255 addresses for devices (host IDs) within each department

The sample address above, therefore, might represent a server (117) in the shipping department (54) in the warehouse (203) of an XYZ subsidiary (123) of the enterprise. It could even be:

- 10 bits less one address: 1023 addresses for organizations
- 10 bits less one address: 1023 addresses for departments within each organization
- 12 bits less one address: 4095 addresses for devices (host IDs) within each department

where the segmentation does not align with octets (not an intuitive division of the nnn.nnn.nnn.nnn address notation).
When you connect to the Internet, you lose some of that freedom because you have fewer bits to yourself. If you represent an entire region of the world or a very large network (e.g., MILNET or ARPANET), you might receive a class A network address; if the domain that you administrate is a country or an enterprise, you may receive a class B address; if you're a small organization, you may receive one or more class C addresses:

Class	Addressing form	Number of networks in the class	Host ID addresses
A	0nnnnnnn hhhhhhhh hhhhhhhh hhhhhhhh	128	16,777,216
B	10nnnnnn nnnnnnnn hhhhhhhh hhhhhhhh	16,384	65,536
C	110nnnnn nnnnnnnn nnnnnnnn hhhhhhhh	2,097,152	256

n: network address bit   0: fixed
h: host ID address bit   1: fixed

Remember that you must reserve one address in each of your addressing partitions for a broadcast address. Some addresses are reserved for special use by the TCP/IP protocol (e.g., 127.0.0.1 is for loopback to the local machine).

billion available addresses. But the hierarchical structure of the addressing system is wasteful and inflexible. Merrill Lynch, like many businesses, has registered one of the 16,384 class B addresses, which entitles it to assign 65,536 host IDs. While it's possible to subdivide that population of host IDs into subnetworks, it's tricky to balance the allocation of bits between subnetworks and hosts. Once you make that decision, you must live with it (see the above text box "TCP/IP Addressing").

"There are plenty of addresses," says Laurence Sikon, vice president of technology strategies at Merrill Lynch, "but when you try to partition in a way that corresponds to your organization, you find that you rapidly run out of subnets." Logical limitations become physical limitations, and you must bridge or route between subnetworks. TCP/IP enforces a strong relationship between logical and physical components. That means LAN managers who relocate equipment need to do a lot of work.

Managing address allocation is a daunting problem. "TCP/IP isn't that clean on the administrative side," says Joseph Curtis. "There are a bunch of tools, but not necessarily any directions on how to use them." The best solution is to delegate the work to LAN managers and define rules by which they pick addresses for subnetworks and devices.

For example, George Chrisman has allocated a class B address for all TI's European operations. The European administrators handle their own subnetworks. TI maintains a very structured audit process, and conflicts must in general be resolved. If the company acquires a unit with preexisting connections to the Internet, however, an exception can be made.

Address conflicts can affect all networks, not just TCP/IP networks. "Duplication of names and network numbers is my most serious problem," says Jim Curry, senior LAN specialist in McGraw-Hill's network services department. Both AppleTalk and NetWare, for example, require not only unique names for workstations, printers, and servers, but also unique numbers for cable segments. Conflicts arise when existing AppleTalk or NetWare LANs join the enterprise WAN. Curry plans to use a Lotus Notes conference to help sort things out. Notes will let people post planned changes to the larger group, which might be affected by them.

At TI, where mainframe access involves 120,000 SNA LU (logical unit) addresses, Chrisman has reduced the labor-intensive and error-prone manual procedure for maintaining the address tables to a mail-enabled work flow. "Using our own electronic forms, along with C and C++ tools, we've managed to automatically build these tables," he says. A similar technique provides semiautomated address registration for TCP/IP. A user with a new Sun workstation, for example, mails a request for an IP address to a server-based application that dispenses the address.

Network protocols that identify users, devices, and services by name—IPX, NetBIOS, and AppleTalk are examples—potentially offer much more flexibility than TCP/IP. That's why IPX remains strategic for Merrill Lynch, says Sikon.

Even more strategic for the company is Banyan Vines, which leads all other network operating systems when it comes to naming services. Its renowned global directory, StreetTalk, now in its third generation, is enabling Merrill Lynch to expand its WAN in an orderly fashion. The company's Vines network has grown from 1000 to 3500 nodes in the past year and a half, according to Matthew Bernick, network administrator for Merrill Lynch's Operations, Systems, and Telecommunications Division. He expects that Vines will encompass most of the firm's 30,000 employee workstations within the next few years.

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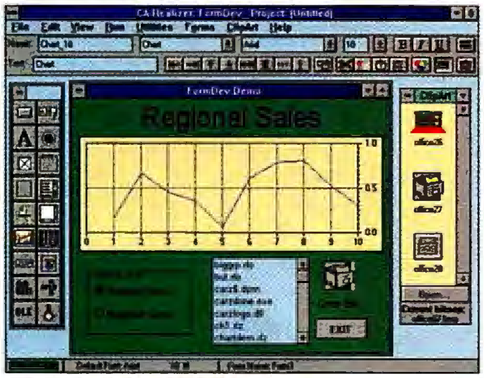

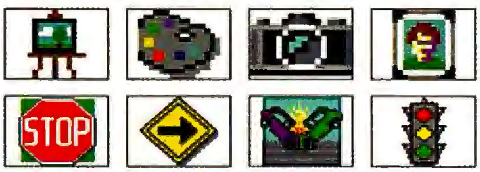

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Monitoring and Controlling the WAN

Local problems become global problems when you join LANs to create a WAN. Sadly, the tools available to monitor and control local networks work poorly, if at all, when applied to global networks. A remote device or service that is malfunctioning can be inaccessible for all sorts of reasons. The network might be opaque because network monitors can't see past routers or because a telecommunications provider owns it. Device management protocols are often proprietary, and the most open ones typically confine themselves to the TCP/IP components of a network.

The proliferation of SNMP agents means that, in principle, you can monitor and control routers, bridges, hubs, and even UPSes (uninterruptible power supplies). In practice, that's easier said than done. Pinpointing the location of a problem—which may be on a local or remote LAN—is tricky. And because MIBs are vendor-specific, there's a chicken-and-egg problem: You may not know which tool to deploy, or where to point it, until you've located the problem device the tool was supposed to help you locate.

Every WAN manager dreams of a single tool that enfolds all the protocols and devices found on a typically heterogeneous WAN. Unfortunately, no such tool exists. Fault isolation, traffic-flow control, and configuration management are tasks that can seldom cross equipment or protocol boundaries. However, WAN management systems like Network Managers' NMC Vision and NetLabs/Manager are moving in the right direction.

These products feature a three-tiered architecture that's becoming standard for modern network management systems: agents that perform vendor-specific monitoring, a central database to which agents report, and console applications that enable users to interact with the network by way of the database. NMC Vision has exceptionally broad support for management protocols, including SNMP, CMIP (common management information protocol), DME (distributed management environment), and CORBA (common object request broker architecture).

Just managing the devices on the network is not enough. TI's Chrisman says WAN management needs to extend beyond hardware to operating systems and applications. "I'm spending a million dollars this year building SNMP proxy agents, trying to strengthen my management capability in the client/server environment," he says. "It disturbs me to have to spend my own dollars on this."

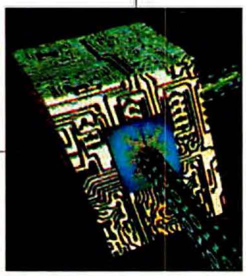
Passing the Buck

You don't necessarily have to become a telecommunications expert to operate a WAN. When you buy connectivity from AT&T, Sprint, MCI, British Telecom, or another provider, you can buy the management of it as well. Nordstroms, a chain of department stores in the Pacific Northwest, buys full LAN-to-LAN service from its supplier, MCI. While Nordstroms receives detailed reports on traffic flow and bandwidth utilization for its 20 linked sites, this information is superfluous. MCI handles all the management worries.

Dean Witter, the financial services company, similarly outsources all its WAN services to Advantis (Schaumburg, IL). The Dean Witter network people just have to manage the company's own LANs. Advantis takes care of everything else, including the routers.

"I'm spending a million dollars this year building SNMP proxy agents."

—George Chrisman, manager of electronic communications, Texas Instruments



If you use a service provider, though, it's important to understand exactly what you're buying. When Allied Signal went with WilTel's frame-relay service to connect plants in Tennessee and South Carolina to its South Bend, Indiana, headquarters, the any-to-any topology that frame relay can support was an attractive feature. "We thought we could connect all sites to one another," says Kevin Devine, network analyst with Allied Signal, "but what we found was that you have to pay for each PVC [permanent virtual circuit], so, in the end, we configured the PVCs in a star because that was cheaper."

WAN Meets LAN

Some of the toughest problems aren't the technical ones: They are problems of understanding, attitude, and politics. You can join LANs to a WAN with bridges, routers, and gateways; it's all just data. But no black box can turn a maverick LAN administrator into a team player comfortable with corporate policy meetings and the often glacial rate at which telecommunications carriers resolve problems.

For WAN managers accustomed to total control, things can be equally frustrating. "Suddenly, we no longer have full control from the user's terminal all the way up to the host system," says McGraw-Hill's Jim Curry. "We coordinate the network and deal with various LAN administrators, but we don't control the whole network." Moreover, the qualifications of those administrators can sometimes leave a lot to be desired.

"Managers of LANs have to understand their own present and future networking needs," says Merrill Lynch's Laurence Sikon. That's a problem if the person overseeing a LAN in a little department does not have a technical background.

When Merrill Lynch attached a new division to its network, its departments were all operating as little islands. "One group does something very, very specific," says Sikon, "like managing relationships with some of the Merill Lynch clients. They have never felt the need to be in tune, as far as technology goes, with most of the other departments within their division." This Balkanization made the job of building the WAN a lot more difficult, because integrators had to deal with 20 or 30 people rather than one or two.

Merrill Lynch solved part of the problem by creating a LAN technical-support group. The WAN implementation team recruited one person to head up the group. Some of its members came from within the division and others from outside (see the text box "Political Primer for Enterprise Networks" on page 78).

LAN Meets WAN

WAN managers, for their part, must realize that their methods frustrate their LAN counterparts. "It's a real step down for us," says Bruce Linker, president of the Microcomputer Managers Association and an employee of a large financial services company. Linker bemoans the fact that his people have to work with the MIS people and fit into their schedule—an accommodation they're trying hard to make. In the past, when he wanted to set up a dial-in mailbox, he did it himself with one modem. But now with WAN connectivity, he has to work through somebody else, fit into someone else's calendar of projects, and use their standards. "It does take

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longer," says Linker. "And when it goes down, you're going to get the phone call, but now you have to contact somebody else to get it fixed."

Linker is not alone in his sense of loss. Other LAN managers warn that you should understand what you're sacrificing when you tie into the MIS policies that come with the wide-area connection.

CIGNA's Steve Weidemann notes that training is the way to break down the barriers between the WAN and LAN cultures. "We have many MIS people with much experience in SNA and the enterprise computing centers, and many with PC and NetWare expertise," he says. Weidemann wants to educate each of these technical populations about the other's domain. "To build WANs from LANs, you have to understand, in depth, both worlds."

WAN Applications Design

Applications built to run on LANs often fail miserably when deployed on WANs. This infuriates TI's Chrisman. Many of the current crop of client/server applications were built as departmental solutions, he says, insulated from external forces. They lack robust error handling and cannot react appropriately to anomalies on the network. "There is never going to be a WAN that doesn't occasionally have a bad packet or some kind of glitch," he says, "but at the first sign of trouble, these applications just roll over and die."

Dan Gasparro echoes that frustration. He believes that hardware and software vendors don't understand how people really use their products, and thus don't test them realistically. As a result, "Users deploy Lotus Notes databases that replicate all the way down to the field level," he says, "and then administrators wonder why the net comes to a screaming halt at various times of the day."

Another common gripe has to do with the flaky interaction between Windows and NetWare. If you lose a connection to a NetWare server, Windows locks up. That's bad enough on a LAN, but it's worse on a WAN, where you're that much more likely to be attached to remote resources. "If I lose a connection, it shouldn't matter," says Allied Signal's Devine. "This business of having Windows lock up when the WAN glitches is really starting to aggravate a lot of people." To work around the problem, Devine advises users to connect only when necessary to WAN resources, and he spends a lot of time figuring out how to move data onto the LAN so it's accessible locally.

How can you work through or around these problems? Build and test your application in the same kind of WAN environment in which you'll deploy it. Kindercare's bandwidth snafu could have been avoided if the prototype WAN had been used for initial development.

The issues that concern WAN people—bandwidth, protocols, management, and cultures—are deeply intertwined. The LAN culture of free bandwidth, for example, creates management problems on the WAN. More than in other computer-related disciplines, hardware, software, and politics play equal roles. ■

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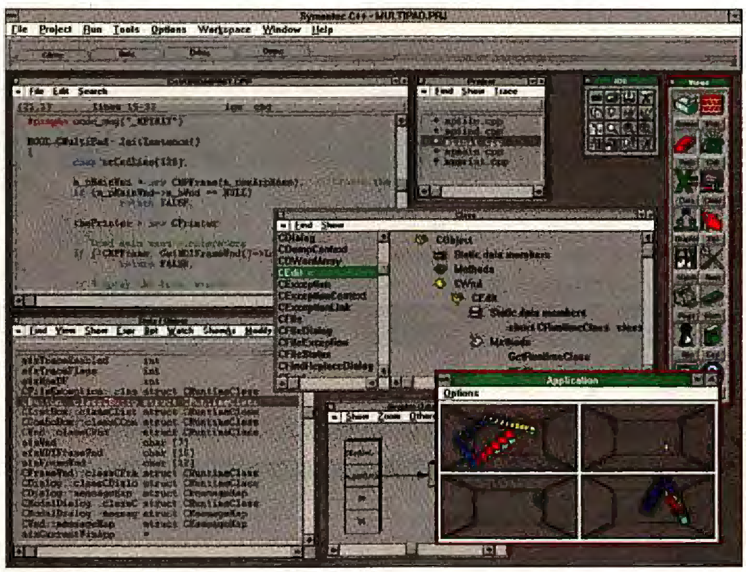

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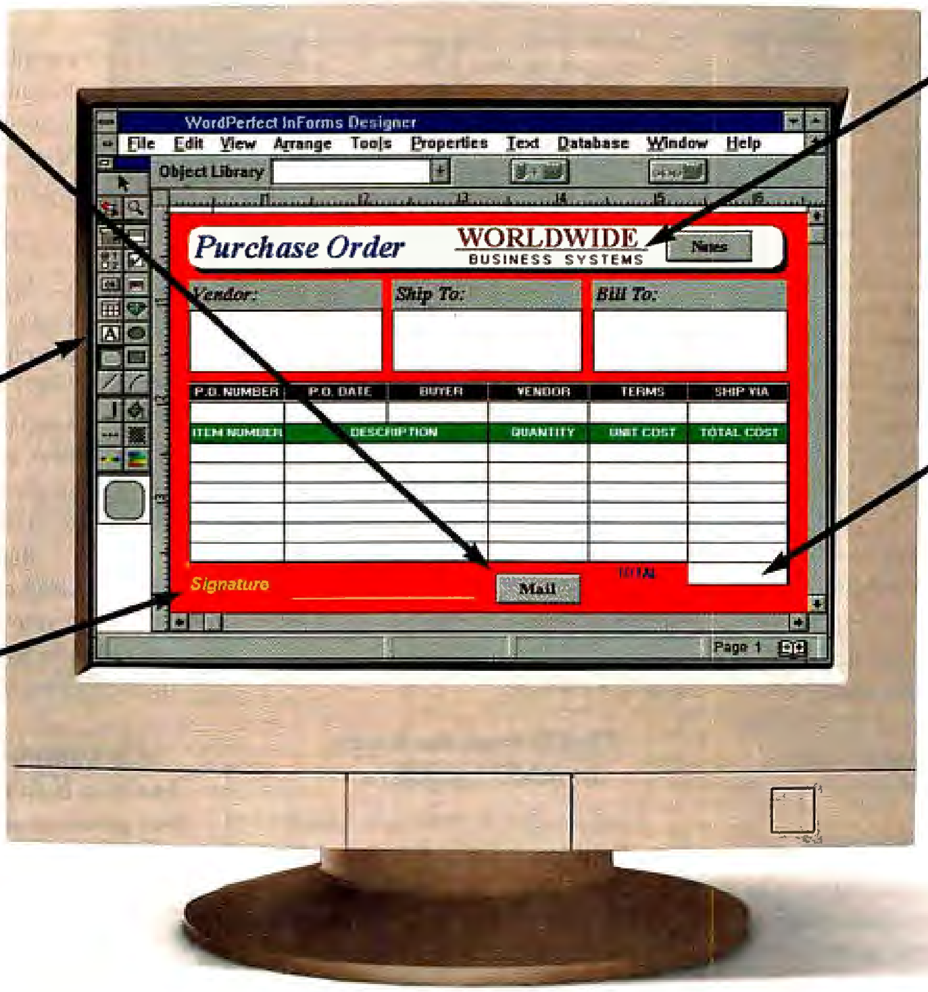

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PRINTERS IN TRANSITION

Graphical applications are forcing users to ask more of their printers in terms of speed, image quality, and ease of use. Vendors are beginning to deliver.

JOHN P. MELLO JR.

GUIs and the applications that go with them are causing users to take a second look at their printers. If they can work with rich color at a high resolution on their monitors, why shouldn't they get output to match?

As a result, users are demanding more from the printers they buy. It's not enough for a printer to produce better-quality images; it also has to be fast and easy to use.

Faster Is Harder

The speed issue has never been as challenging as it is now in the graphical applications environment. Higher resolution means you need to throw more processing power at producing a printed copy of an image.

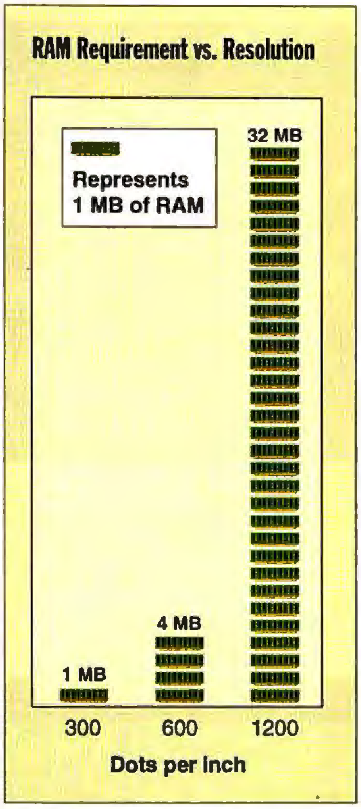
Greater performance, which translates into greater productivity, means getting hard output that mirrors what users have created on their computer display and getting copies of that output to their peers—in essence, to be minipublishers. As hot as color printing is right now, the publishing paradigm is hindering widespread acceptance of the technology.

Because high-quality color output is still in the minutes-per-page stage, users are still looking for a quick way to reproduce the dazzling documents they create. The speediest way to do that is through color photocopying. But color copiers are still exotic fare in most user environments. And color copiers are expensive—$25,000 and higher. "There's going to be a brake on color until it's inexpensive to make color copies," says Jim Butterworth, vice president of the Printer Business Group at Okidata in Mount Laurel, New Jersey.

Users have recognized that their demands for greater speed can be met if they abandon their personal printers. Network printers provide greater speed for more people, and because the cost involved in purchasing and maintaining a faster printer is spread across a group of users, it is easier to justify. "We see a huge cry for a 25- to 40-page-a-minute printer to solve this departmental concept versus personal printer concept," says Brian Platte, a senior technical staff member at Pennant Systems (Fairfield, CT), which is an IBM division that makes printers.

Network printers are fast enough that some users have taken to substituting them for copiers. That type of use has some printer makers including add-ons, such as collators and staplers, to their high-end printers. This approach is also a reflection of what many users are accustomed to with their desktop applications. Some word processors, when printing multiple copies of a document, allow users to collate the documents in their computer's memory.

Yet coping with the demands of a LAN puts a strain on network printers. Now you have PCs, Macs, Unix workstations, minicomputers, and mainframes connected to networks. Printers must be able to handle multiple protocols, multiple PDLs (page-description languages), and multiple font styles or formats. Having more than one data stream creates a host of new issues, all of which affect performance.



As print resolution goes up, *the amount of RAM needed to process a full-page image rises exponentially. For this reason, few people will make the investment and move beyond 600-dpi resolution.*

Image Building

In addition to wanting their output fast, users expect it to bear more than just a passing resemblance to what they've created on their screens. Not only are users asking for higher resolutions, but they want color, too. "In every other aspect of our lives, we live in a color world," says Gary Bailer of Star Micronics. "Why is it, when it comes to our output, it's mostly in monochrome?"

Although users are demanding better resolution from their printers, they will be reaching the practical edge of the envelope soon. Today, 300 dots per inch is the standard, but it will soon escalate to 600 dpi. But after that, memory overhead will deter users from pushing 1200 dpi as a common denominator for printers. The explanation is simple. It takes about a megabyte of RAM to image a 300-dpi page. If you increase the resolution to 600 dpi, then you need 4 MB of RAM. But to image a 1200-dpi page, you need a whopping 32 MB of RAM.

Users are also demanding that they be able to print their documents on plain paper. Ink-jet printers now have that capability, but some nettlesome drawbacks affect the output quality for those printers. For example, the ink can smear before it is dry, and a heavily

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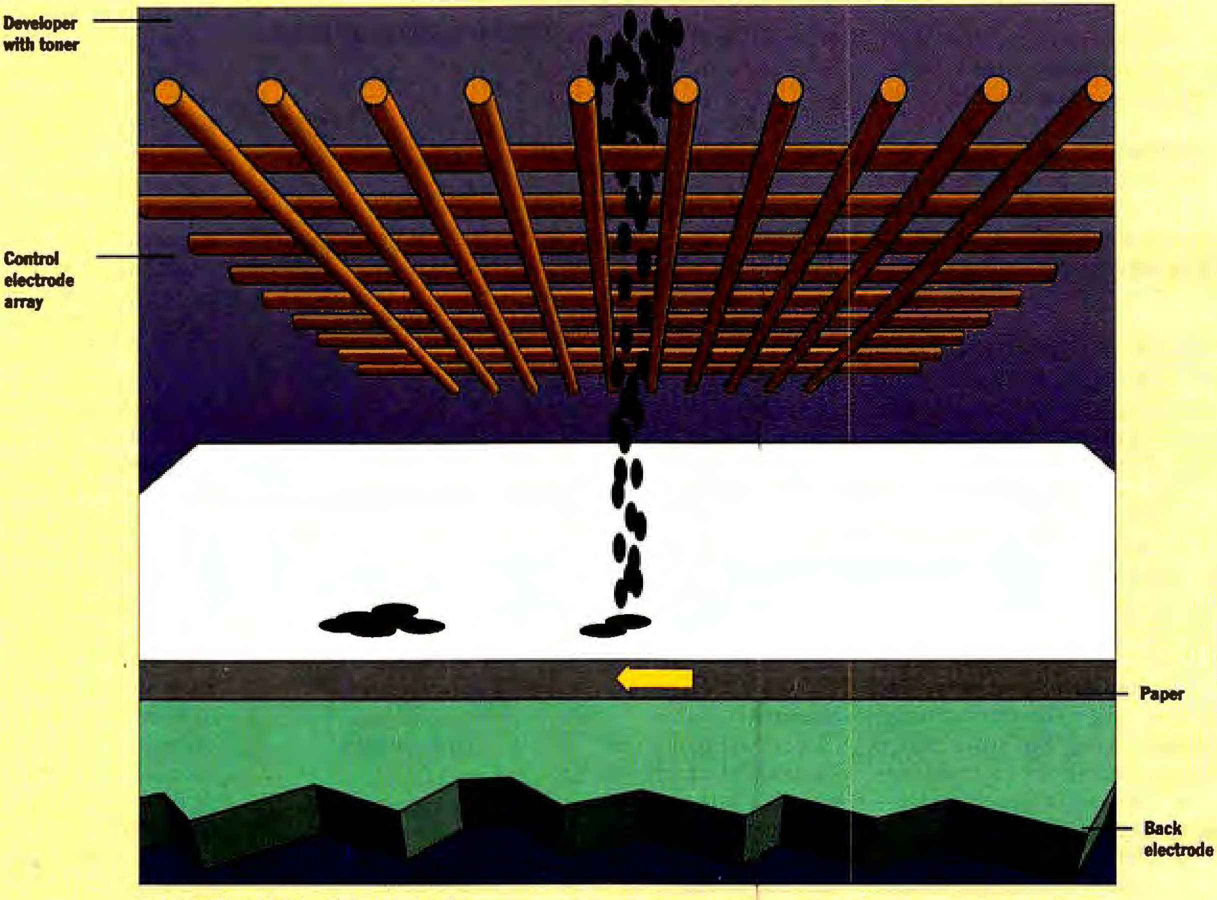
Laser Quality Without the Drum



Array's TonerJet by Array technology *places an electrically charged control electrode array, which can be either a wire mesh or a perforated flexible printed circuit board, between the toner and the paper. A back electrode beneath the paper attracts toner and pulls it through the holes in the control electrode array. The toner lands on the paper and forms a dot.*

Because laser-printer and ink-jet technologies contain the most potential for meeting the demands of users at an acceptable price/performance level, they will be unchallenged in the near future. But a promising toner-based technology may allow printer makers to further drive down the prices of their devices.

Both laser and LED printers produce the image of a page on a rotating drum before transferring the image electrostatically to paper. Array Printers of Mölndal, Sweden, has developed a way to affix toner to paper without having to create and store the image with light on a photosensitive drum.

Array Printers' new technology, called TonerJet by Array, uses either a fine mesh of thin, insulated copper wires or a thin, copper-coated plastic film. By connecting the wires to driver electronics, Array can create individual apertures in the electrode array that can be opened and closed electrostatically to allow or restrict toner passage. The computer-controlled voltage of the electrodes in the mesh of wires changes by hundreds of volts within a thousandth of a second, and the desired dots are developed on the passing paper.

According to Array Printers, its TonerJet devices cost 10 percent to 30 percent less to produce than laser or LED devices, are simpler than existing technologies (a laser printer requires nine mutually dependent process steps to produce a page; TonerJet requires only three), and eliminate the need for drums and other components that wear out. Array admits, however, that TonerJet output hasn't reached the quality of laser printing yet. A fax machine using TonerJet technology is expected to be released in 1994.

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inked page can "cockle" (i.e., curl and wrinkle) when the ink dries.

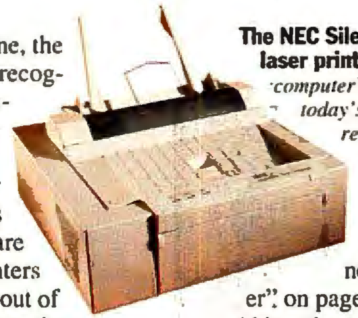
Thermal technology sidesteps those problems, but thermal printers have their own problems. They're expensive, and they don't often print on plain paper. However, thermal-printer makers are working on getting their products in line with the plain-paper and price-performance demands of users. For instance, Star Micronics' SJ-144, a color thermal-transfer printer, uses a polyester resin and sells for about $600 (see "Bargain Color Printers" on page 153).

It's Got to Be Easy

Another component that graphical applications have groomed users for is ease of use. Graphical environments have gone a long way to simplify the interaction between the user and the printer by creating a single driver for all the applications running under the environment. In turn, users are demanding this simplicity in the operation of their printers, no matter how complex the demands they're making on those printers are. Regardless of what hardware users have, what network protocols they are using, or what print PDL they are sending down the line, the printer must be able to recognize them and react accordingly without user intervention.

Also, users no longer want to be silent partners as far as their printers are concerned. If their printers tell them when they are out of paper or have a paper jam, they want to be notified about it at the desktop. Several initiatives are under way to provide this capability, including the NPAP (Network Printing Alliance Protocol). NPAP establishes a format that will allow printers on a network to communicate with individual users (see "The Printers Talk Back" on page 103).

Another way to make printers friendlier—not to mention faster and less expensive—is to move the intelligence from the printer to the user's computer. This not only increases a printer's speed but reduces the cost of the printer. This technique takes advantage of the ever-increasing performance of system CPUs, allowing printer vendors to eliminate a printer's controller and memory—two



The NEC Silentwriter Superscript 610 laser printer *is designed to use the computer's processor and memory. With today's faster processors, this feature reduces the cost of the printer, without degrading system performance for most users.*

rather expensive components (see "Print Pages Faster" on page 115).

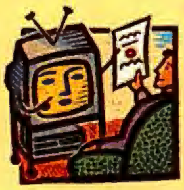
Although not yet widely accepted, these kinds of printers are beginning to appear on the market. NEC announced in August its Silentwriter Superscript 610 laser printer. The 610, through a printer driver/manager loaded with Microsoft Windows, prepares its documents for printing inside its host's CPU. "We found that most people do one task at a time and don't begin to utilize the processing power of their PCs," says John McIntyre, director of marketing for NEC's Printer Business Unit in Boxborough, Massachusetts. "So we took advantage of the unused processing power in the CPU and the capabilities of Windows."

Getting printouts of complex pages (e.g., a PostScript document) has always been relatively difficult. As printers get faster and their output gets closer to offset printing quality, users will want to print complex documents more often. A crucial element of reaching this goal will be the proliferation of device-independent image formats such as Adobe's Acrobat or No Hands' Common Ground.

Previously, no cross-platform architecture to present formatted information existed. The least common denominator was flat ASCII files, which do not preserve formatting from one platform to another. "The missing link was this viewing technology," says Platte of Pennant Systems. "[It's] the ability to look at a document just to give you a comfort level that you knew what the heck it was."

When users begin to reach that comfort level, Platte contends, a fundamental change will take place in the nature of computer printing and in the way people access and distribute information. Central printing will give way to information being available on-line and printed on demand, with the same richness of presentation that you find in a book or a magazine. ■

Your Next Printer Might Be for Your TV



The largest potential use for printers is one that doesn't exist today. But it's one that some printer makers say may develop as digital information begins to make inroads into the world's homes. These printers will be inexpensive—$300 to $400—color ink-jet devices designed to work with video off your TV.

As interactive services enter the home, consumers will want to do more printing on demand. Watching a show on the travel channel? Request more information and receive it immediately through your home printer. Punch up your bank account, do some transactions, and watch your printer spit out a transaction statement. A commercial by Snow White soap is aired, and if you respond to it immediately, a coupon worth 10 cents off the price of the product will come rolling out of your printer.

Then there's the digitizing of family history. Right now, photo-quality output can be done only by costly printing techniques (e.g., dye sublimation) or proprietary technologies (e.g., the digital exposure engine in Metrum's Fotoprint 1000). But conventional printer makers aren't sitting on their hands.

"I have seen prototypes [at Canon's R&D facility in Japan] of ink-jet output that rivaled a photograph," says Peter Bergman, vice president for marketing of Canon Computer Systems in Costa Mesa, California. "It uses enhancements in the number of print heads, special inks, and appropriate media, but you would look at it and say, 'this is a photograph.' "

Nevertheless, don't expect inexpensive photo-quality printers for your TV anytime soon. The complexity of these printers and the current lack of demand will keep prices high. For this reason, some analysts think the idea is a little far-fetched. Says Robert Fennell, director and principal analyst at Dataquest in San Jose, California, "[Photo-realistic printers have] been the pipe dream of the printer industry for a long time."

John P. Mello Jr. is a freelance writer who has written on technology for a variety of trade and general-interest magazines. You can reach him on BIX c/o "editors" or on the Internet at jmello@igc.apc.org.

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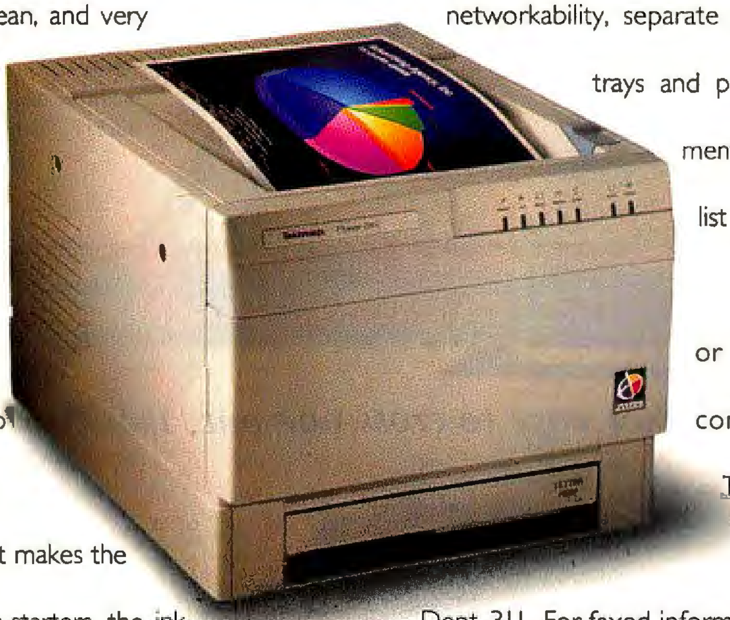

But what is it that makes the Phaser 200 so good? For starters, the ink coverage and image quality are, in a word, brilliant. We at Tektronix didn't get to be the award-winning leader in color printers by sitting on our hands. Then there's speed. You get all of this great color at two pages per minute, which is nearly as fast as a regular black and white printer. Can you say increased productivity?

On top of all this, the Phaser 200 is a work group printer that gives you the advantages of a laser printer. Including true Adobe® PostScript™ Level 2, networkability, separate paper and transparency trays and price (did we happen to mention the Phaser 200 has a list price of only $3,695?).

For more information or a free output sample, come into your nearest Tektronix dealer or call us at 800/835-6100, Dept. 31J. For faxed information, call 503/682-7450, and ask for document # 5001.

In closing, we just want to remind you that your competition is also reading this ad. And they're extremely hungry. So when choosing a presentation printer, the choice is quite simple. You can either eat, or be eaten. Bon appétit.

Tektronix

Circle 152 on Inquiry Card.

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(Not easy to cross one out, is it?)
No other network laser printer with all these features also gives you the option of printing on 11x17 paper. In other words, the Compaq PageMarq is truly the standard by which other printers are measured.
The most important type development since Gutenberg? 1- and 2-MB Programmable Font Modules (or an optional, internal 60-MB Hard Drive) let you customize your fonts. And all are stored permanently, eliminating the need to constantly download.

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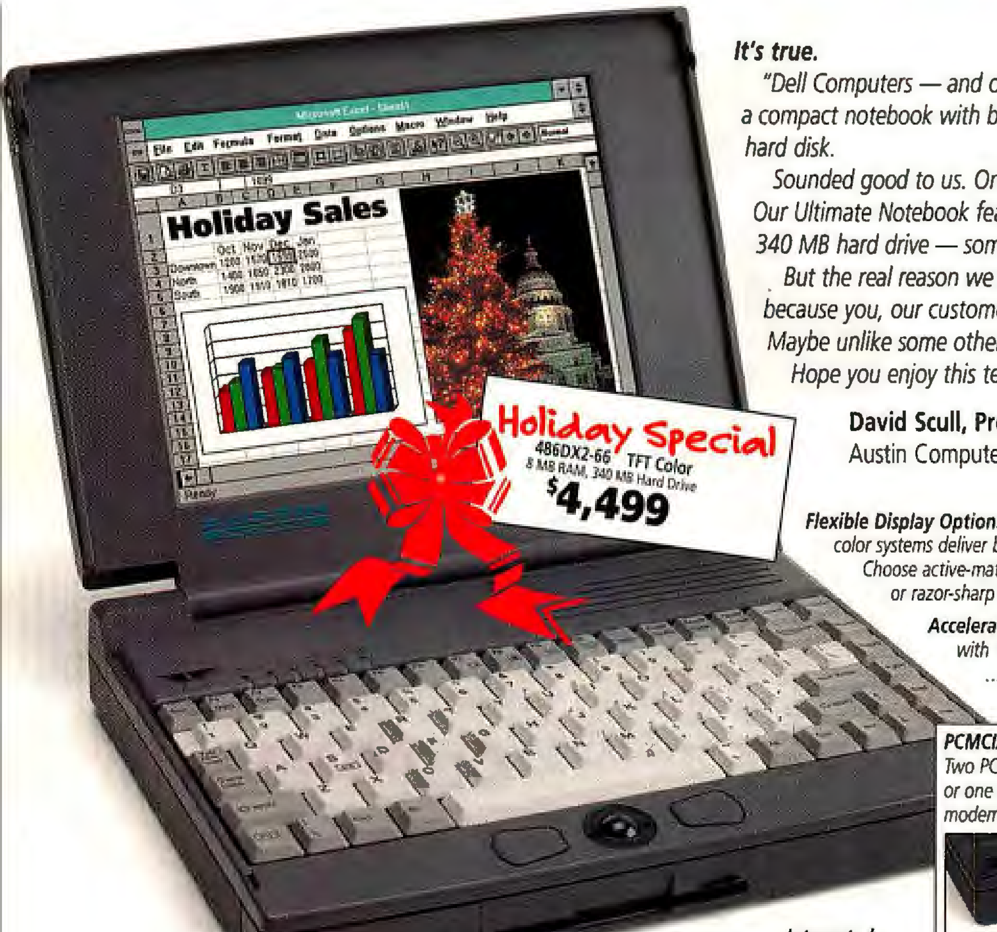

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THE PRINTERS TALK BACK

The printer interface has not kept up with the demands of connecting to a network

FRANK HAYES

SCOTT BALDWIN © 1993

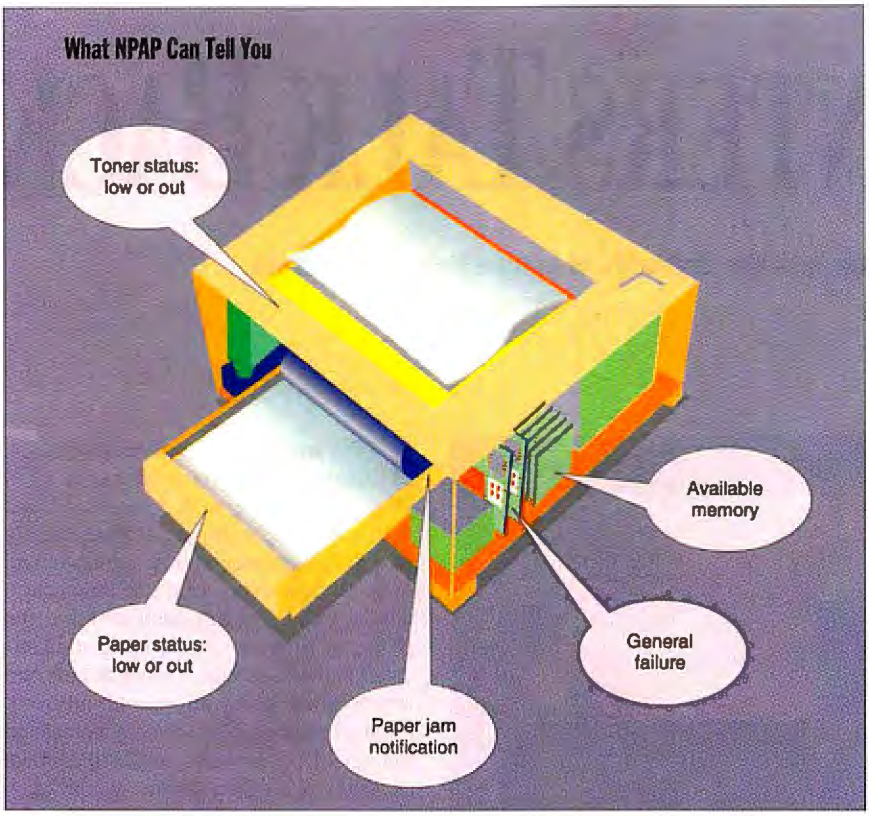
In the world of PC printer interfaces, dinosaurs still roam the earth. PRN might as well be called Jurassic Port. While desktop computers have rapidly evolved and printer engines are faster and more capable every year, the connection between the desktop computer and the printer is often not much more sophisticated than it was more than a decade ago at the dawn of the microcomputer era. Even when printers are directly connected to high-speed networks, most still behave as if they're attached to one-way PC parallel-printer ports. The data goes into the printer, but nothing comes back to you except the printed page. And if any problem develops that is more complicated than running out of paper, no one on the network ever hears about it—at least, not directly from the printer.

But a new approach to the computer-to-printer software interface should help bring printer connections out of the Stone Age and give them a good run at the future, too. The NPAP (Network Printing Alliance Protocol) is an effort by dozens of vendors to enable printers to talk back to the computers that send them data, whether it's across networks, over serial links, or through bidirectional parallel ports. NPAP lets printers report on how they're configured, job conditions, available memory, and other status and error information. The sponsoring group—including printer heavyweights such as Texas Instruments, Lexmark, Canon, Kyocera, NEC, Okidata, QMS, and Tektronix—says that NPAP-compliant products should reach the market this year.

Problem: Progress

The need for better communications between printers and computers comes largely because of improvements at each end of the printer connection. A typical computer 15 years ago sent nothing but alphanumeric characters to the printer, and the

The Printers Talk Back



The NPAP specification *gives printer vendors some leeway in deciding which features to implement, but you can expect a suite of basic functions. In addition to those shown here, your printer will be able to notify you about its configuration and the status of your print job.*

printer's most common problem was running out of paper. Those were the days when today's Centronics-style PC printer port gained its popularity. At the time, the Centronics port was a major improvement over using a serial port to drive a printer. Because it sent 8 data bits in parallel instead of 1 bit at a time as a serial line does, the Centronics port was much faster—150 KBps, compared to a serial port's maximum of about 1 KBps. And even though the Centronics port wasn't a two-way link, it still let the printer notify the computer if it was out of paper or off-line.

Today's printers face problems unimagined in those long-ago days: low toner level, wrong emulation mode, not enough memory, missing the correct font, paper jam, fuser wire overheating, and a host of other troubles. Many printers can indicate such problems on their front panel, which is convenient enough when a printer is in easy sight of the user. But when a printer serves a network, connected to it either directly or through a computer serving as a print server, things aren't so simple. Users across the network can't see that front panel, so they may start jobs that will never finish because the printer runs short of paper or toner, lacks the fonts they need, or is running in the wrong PDL (page-description language) or emulation mode.

Even PostScript printers—the one group of printers that *can* send information back to a host computer—usually send back information only about the status of PostScript, not about mechanical problems, supplies that are running low, and so on.

Faced with these printer communications problems, Intel, Texas Instruments, Lexmark, and Insight Development combined forces in April 1991 to form the Network Printing Alliance. One of the group's first priorities was to start work on what was then called the Printer/Host Control Specification—the protocol that has since become the NPAP.

Solution: NPAP

NPAP's basic function is to provide configuration and status information from the printer in a way that's independent of printer technology, PDL emulation, or other features of the printer. NPAP provides detailed, real-time status information on everything from fonts and toner supplies to critical problems that have shut down the printer.

In technical terms, NPAP is a block-structured packet protocol used for command-response communications between a host computer and a printer. Basically, under NPAP, a computer sends commands to the printer, and the printer sends responses back. The commands and responses are sent in *packets*—well-structured blocks of bytes that can serve either as envelopes for data to be printed or as carriers of instructions or information about the printer's status.

The host queries the printer to determine some of its characteristics. In response to the host's commands, the printer might return information such as its model name, serial number, resolution, emulations, number of fonts available under each emulation, and even how many paper trays it has. This exchange is just the beginning of the communication between host and printer; at this point, no data is sent to be printed. The host computer can use the information from the printer to update configuration tables, verify features and fonts, and confirm that adequate printer supplies are available. And once the host finally has all the information it needs from the printer, it can select an emulation mode (in this case, PostScript or the IBM Personal Printer Data Stream, or PPDS) and begin sending data to be printed. Or, if this printer doesn't have the right qualifications for the job, the host can look for another printer on the network that's more suitable.

The basic elements of any NPAP packet are the start-of-packet byte, the packet length, the flags byte, the command byte, additional data, and optional error-checking information. The start-of-packet byte is always the value A5h (165 decimal). This makes it easier for the computer and printer to be sure that they're in synchronization; if a "packet" doesn't begin with A5, it's

THE STRUCTURE OF AN NPAP PACKET

All NPAP packets have the same general structure, whether they are commands, responses, or alert messages.

BYTE 1	BYTES 2–3	BYTE 4	BYTE 5	BYTES 6–N	BYTES N+1
Start of packet	Packet length	Flags	Command or LU#	Data	Error checking (optional)

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NPAP Conversation Example

At the start of a typical NPAP-based session, the host computer first sets the NPAP packet size to 1024 bytes and then asks the printer for information on its capabilities and features. The printer responds with information that the host then uses for additional queries.

HOST COMMAND

Data stream	Description
A5 00 05 50 03 05 04 00	Set maximum host-to-printer packet size to 1024 bytes

PRINTER RESPONSE

A5 00 02 50 03	Acknowledgment of command

HOST COMMAND

A5 00 03 50 01 00	Request summary of device characteristics

PRINTER RESPONSE

A5 00 5C 50 01 00	Acknowledgment of command
01 00	NPAP 1.0
00	No printer-specific extensions
00	Marking technology=electrophotographic
01	Color capabilities=spot
00 00	One color supported
00	Two-sided printing=no
00 10	Maximum number of entries in queries-completed queue=16
00	Speed unit=pages per minute
0A	Speed of printer=10 units (10 pages per minute)
01	Length unit=0.01 inch
EA 60	Horizontal logical units per length unit=60,000 (600 dpi)
EA 60	Vertical logical units per length unit=60,000 (600 dpi)
00	Counter unit=pages
00 00 50 00 00	5 MB of memory
02 00	Maximum host-to-printer block size=512 bytes
00 01	Maximum number of outstanding commands=1
0A	Error-checking supported=CRC-16, CRC-32
02	Two PDL interpreters
01	One input tray
01	One output bin
00	Does not support request options in Characteristics subcommand
00	Printer language=English IS 8859-1 (Latin 1)
19 49 42 4D 20 4C 61 73 65 72 50 72 69 6E	
74 65 72 20 34 30 31 39 2D 30 30 31	Product name=IBM LaserPrinter 4019-001
14 31 34 32 34 30 32 33 2D 39 30 44 20 2D	
4B 33 2F 32 30 35 35	Product revision=1424023-90D-K3/2055
08 31 31 2D 41 34 33 37 36	Serial number=11-A4376

HOST COMMAND

A5 00 04 50 02 00	Request interpreter characteristics summary
FF	Return data for all LUs

PRINTER RESPONSE

A5 00 41 50 02 00	Acknowledgement of command
02	Number of LUs=2
01	Information for LU#1
19	Supports Font Details subcommand
FF FF FF FF FF	Maximum free memory unknown
00 0A	10 fonts
01	One input tray
01	One output bin
75 30	Horizontal print resolution=300 dpi
75 30	Vertical print resolution=300 dpi
0D 49 42 4D 20 50 50 44 53 20 34 30 32 39	LU#1 interpreter name=IBM PPDS4029
02	Info for LU#2
19	Supports Font Details subcommand
FF FF FF FF FF	Maximum free memory unknown
00 11	17 fonts
01	One input tray
01	One output bin
75 30	Horizontal print resolution=600 dpi
75 30	Vertical print resolution=600 dpi
10 41 64 6F 62 65 20 50 6F 73 74 53 63 72	
69 70 73	LU#2 interpreter name=Adobe PostScript

not really the start of the packet.

The next 2 bytes form the packet length. The packet-length value is an unsigned integer, sent most-significant byte first. (In fact, all multibyte values in NPAP are sent most-significant byte first.) The packet-length-byte count doesn't include the first 3 bytes of the packet (start-of-packet and packet-length bytes), so the largest possible NPAP packet is 65,538 bytes (i.e., 64 KB + 2 bytes). However, by convention, the maximum initial size of NPAP packets is 64 bytes until the host and printer negotiate a larger packet size.

The type of connection between host and printer may influence the choice of packet size. For a network connection, the packet size of the network is appropriate; that means NPAP packets will fit neatly inside the network's own packets. For direct connections using a serial or bidirectional parallel port, the NPAP specification recommends 128- or 512-byte packet lengths.

The next byte is a set of bit flags. For commands from the host, only the top four bits are defined as flags. However, for responses from the printer, all 8 bits of the flag byte are defined (see "The Meaning of Flag Bits" on page 108). In simple terms, the flags in a command packet indicate whether a packet should be disregarded, the destination of the packet (either the printer's NPAP receiver or a PDL interpreter), whether the packet's contents are continued in the following packet, and whether the printer is required to respond to the packet.

Networks can guarantee that each packet will be delivered, but direct connections don't have that level of reliability; thus, the NPAP specification recommends that the host always request positive acknowledgment for every packet of the message. That can be important for handling errors, since an NPAP message may take more than one packet, and NPAP error handling is on a message-by-message, not packet-by-packet, basis.

Flags in response messages indicate whether the previous command contained an error. If so, they include information about the error, the source of the response (either the printer's NPAP receiver or a PDL interpreter), whether the response packet's contents are continued in the following packet, whether the response was required, and information on the printer's status.

Next in the packet come the command and data bytes. Despite its name, the com-

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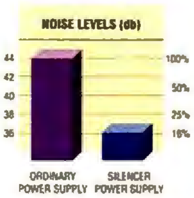

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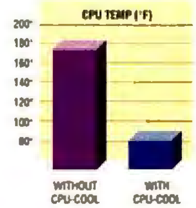

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Circle 131 on Inquiry Card (RESELLERS: 132).

mand byte may contain one of three things: an NPAP command, the identification number of a printer's PDL interpreter, or an indication that the packet contains an "alert" message from the printer.

The command byte's meaning depends on whether the packet comes from the host or the printer, and whether the destination/source flag (bit 6 of the flags byte) is set to 1. For host commands, if the destination flag is set to 1, the command byte contains an NPAP command, and the bytes following are subcommands or command data.

For printer responses, if the source flag is set, the command byte either echoes the previously sent NPAP command or contains an alert message. The printer's NPAP receiver generates alert messages that indicate printer status conditions that the NPAP receiver reports (e.g., low toner or a paper jam) or a message from a PDL interpreter (e.g., a PostScript interpreter's response to a query of what fonts are available).

If the destination/source flag is cleared to 0, the command byte isn't a command at all. Instead, it indicates which of the printer's PDL interpreters is the destination for a command or the source of a response. NPAP is designed to accommodate printers that can simultaneously accept multiple jobs using different PDLs. Each job is assigned its own LU (logical unit) number when the job begins; that LU number is used in some NPAP commands and responses to indicate which job or PDL particular data or status information belongs to. LU number 0 is the default interpreter (typically, the power-on default behavior).

In a host command, if the command byte contains an LU number, the remainder of the message is data to be passed directly to the appropriate PDL interpreter. In a printer response, if the command byte is an LU number, the remainder of the message is information from the LU's PDL interpreter to the host.

The NPAP commands are intended to provide information from the printer in the most product-independent way possible. For some printers, that will open up a whole new world of status information. For others, such as PostScript printers connected to networks, some NPAP commands provide information already available. For example, you can get a list of available PostScript fonts by either sending the appropriate PostScript commands or sending an NPAP command to generate the same information. NPAP generates the list of font names in a different format than PostScript, but the font names themselves are identical. And using the NPAP command has the advantage that one command works for all types of PDLs.

Room for Expansion

The current version of NPAP (Level 1) defines only six NPAP base commands and 32 subcommands. That leaves plenty of room for future expansion, since 240 different base commands are available in the single NPAP command byte, and each base command can have an endless variety of subcommands. Base commands numbered 00 through 7Fh are reserved for standard NPAP commands and extensions; commands 80 through EF are available to individual printer vendors to define for themselves. However, the six Level 1 commands can provide most of the information a host computer is likely to need from a printer today. The six commands are Request Device Characteristics, request Interpreter Characteristics, Printer Configuration Control, Request Device Status, Job Control Command, and Request Logical Unit Characteristics.

The 16 values not used as commands, F0h through FFh, are earmarked for indicating alert messages from the printer. Three types of alert messages are defined in Level 1 NPAP: device status alert, interpreter message alert, and job control alert.

A device status alert is a warning from the printer to the host that something has gone wrong. That "something" can range from low paper or toner supplies to major printer problems that require repair, such as a circuit-board failure. But although the category is broad, each NPAP alert message itself is specific about the problem, as well as how urgently it requires attention. An interpreter message alert indicates a message from a PDL interpreter (e.g., a response from a PostScript interpreter to a query or error).

A job control alert is a message from the printer indicating that a particular point in the job has been reached (e.g., that the job has been processed and is ready to

THE MEANING OF FLAG BITS

The flag bits in byte 4 of an NPAP packet have different values. These values can represent commands that come either from the host or from the printer.

COMMANDS FROM HOST

Bit 7: No Op (NOP). If set, the printer should disregard this message regardless of its contents. It turns any message into a dummy.

Bit 6: Destination (NPAP Component or LU#). If set, it means the command byte (byte 5) is for the NPAP receiver and is an NPAP command. If cleared, it means the message is data to be passed to the PDL interpreter, and byte 5 is the LU# that should receive the data.

Bit 5: Continue. If set, it indicates the next message is a continuation of this message—that is, this message is not completed in itself. If cleared, it means this message ends with this packet. Note that "completed in itself" is not the same as "complete in itself." Continue Clear just means that the message ends with this packet, not that it began with this packet.

Bit 4: Reply Required. If set, it means the NPAP receiver must respond, if only by echoing the command. If the message is data for an LU, the NPAP receiver will acknowledge the data as being received. The LU or PDL interpreter will not itself respond to this flag, since it's the NPAP receiver that sees and strips off the flag byte. If cleared, it means the NPAP receiver responds only to an error. In this case, the responses are unsolicited messages sent to the host. Remember that NPAP recommends that through a parallel interface, every message be sent with this flag set.

RESPONSES FROM PRINTER

Bit 7: Error. If set, this message contains error information about the command.

Bit 6: Source (NPAP Component or LU#). Similar to bit 6 of command flags. If set, it means the command byte (byte 5) is from the NPAP receiver and is an NPAP command. If cleared, it means the message is data passed from a PDL interpreter, and byte 5 is the LU# that sent the data.

Bit 5: Continue. Same as bit 5 of command flags.

Bit 4: Reply Type. If set, this reply was required by the host. If cleared, it means this message is due to an error condition in the printer or other response not generated by an NPAP command. An unsolicited error message is asynchronous and can occur at any time.

Bits 3 and 2: Command/Data Check Type. A 00 indicates that no errors were detected in command or data fields, but the command was rejected. A 01 indicates a data error. A 10 indicates a command error. A 11 indicates an error detected in the message with error-checking protocol.

Bits 1 and 0: Printer Status. A 00 indicates the printer is fine; no alert condition exists. 01 indicates the printer is still OK, but an operator-attention condition exists (e.g., low paper). A 10 indicates a condition exists that will prevent further printing, but the operator can fix it (e.g., out of paper). A 11 indicates a condition exists that will prevent further printing and a service call is required.

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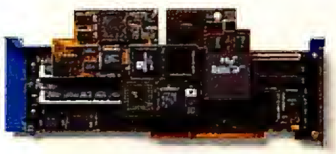

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SLC/Now!	PS/2 Model 50	With SLC/Now! 50	PS/2 Model 90-0H9	SLC/Now!
Landmark Speed 2.0: Recount: Retail Price:	13 MHz 3:34 Min.	114 MHz :29 Sec. $425	84 MHz :38 Sec. $3,280	IBM PS/2 Models 50, 50Z and 60
486/Now!	PS/2 Model 70-25MHz	With 486/Now! SX 25	PS/2 Model 90-0H9	486/Now!
Landmark Speed 2.0: Recount: Retail Price:	39 MHz :55 Sec.	84 MHz :39 Sec. $495	84 MHz :38 Sec. $3,280	IBM PS/2 Models 70 and 80, Compaq Deskpro Models 386/16, 386/20, 386/20e, 386/25, 386/25e, 386/33
MCMaster	PS/2 Model 55SX	With MCMaster SX 25	PS/2 Model 90-0H9	MCMaster
Landmark Speed 2.0: Recount: Retail Price:	16 MHz 2:47 Min.	84 MHz :36 Sec. $795	84 MHz :38 Sec. $3,280	IBM PS/2 Models 55, 56, 57, 65, 70, 80 and 90

All systems tested with 16MB installed except MCMaster, tested with 8MB on-board and 8MB on mother board. All system prices are MSRP at standard configuration as of 4/1/93. Processor upgrade prices are MSRP as of 4/1/93. Recount conducted on 3MB Excel for Windows spreadsheet generated by Kingston Technology.

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Circle 114 on Inquiry Card (RESELLERS: 115).

begin physically printing). Job control alerts offer the host an opportunity to abort the print job or to change how the job will actually be printed. For example, by the time a job has completed processing and is next in line to print, there may not be enough paper left in the tray to finish all 20 copies a user requested.

Job control alerts also offer one of the biggest advantages of NPAP for future printer features. Today, printers mainly compete on speed, resolution, and the number of emulations they support. What's missing are many of the amenities that have become standard for high-volume office photocopiers, such as automatic collating and stapling. Job control alerts support a standardized way of specifying such finishing touches at the appropriate time in the printing process. It's still up to printer vendors to actually add features like collating and stapling to their products.

Talking Printer Politics

Although the NPAP (Network Printing Alliance Protocol) looks like a well-developed solution to the problem of getting printers to talk back, there's no guarantee the next printer you buy will support it. That's because the list of NPAP's supporters is missing one of the biggest names in printers: Hewlett-Packard.

HP already has its own solution for getting information from a printer: PJL (Printer Job Language). PJL is more limited than NPAP, but it does provide many essential features for printer control and communication. PJL's biggest drawback is that control and status commands can be sent to the printer only before and after a print job runs, not while it's in progress. However, that weighs only lightly against PJL's biggest advantage: It's already available from HP, which dominates the laser-printer business. (NPAP isn't even second in line behind PJL; Compaq also has its own proprietary printer-control protocol.)

NPAP's partisans argue that HP's PJL isn't as robust as their protocol, especially for managing printers on a network. HP's recent answer was to select SNMP as its choice for managing networked printers. SNMP is already widely used for managing devices on Unix-based networks, and it's familiar to many network administrators. And while NPAP can be extended to control devices (e.g., fax cards and scanners), SNMP can work with almost any device on a network. At least one high-end printer vendor, QMS, has joined HP in endorsing SNMP, and with PJL on the low end and SNMP on the high end, HP seems to have NPAP surrounded.

But a new alliance has confused things even further: The NPA recently informally joined forces with the DMTF (Desktop Management Task Force). DMTF was started in 1992 to develop a standard management interface for desktop computers. HP is a DMTF charter member, but so are NPA founders Intel and IBM, along with DEC, Microsoft, Novell, Sun, and Synoptics. And the more than 300 other DMTF members will have their say before NPAP, PJL, SNMP, or any other protocol is anointed the winner.

In practice, of course, there may never be a single "winner" in networked-printer management. But the competition is guaranteed to spur improvements to both NPAP and its competitors. The only ones guaranteed to come out ahead are users. One way or another, your printer is likely to never be tongue-tied again.

Upside, Downside

With the wealth of new printer status information that it offers to host computers, NPAP clearly has many advantages, but there are drawbacks, too. The most obvious one is that, from the outside, NPAP appears to be yet another emulation for printers to support, even though it's really an "emulation" that supports other emulations. NPAP is not transparent; if a host or application mistakenly uses an NPAP driver with a printer that doesn't understand NPAP, the result will likely be pages of garbage, and a printer expecting NPAP and receiving ordinary ASCII text will report an error.

Although NPAP radically improves communication between a host and a printer, the price of that communication is *communication:* Significantly more bytes will pass between host and printer with NPAP than without it. However, NPAP also includes commands to turn off NPAP packet processing so that raw text can be sent to the printer, either until the current job is complete or until the printer is reset.

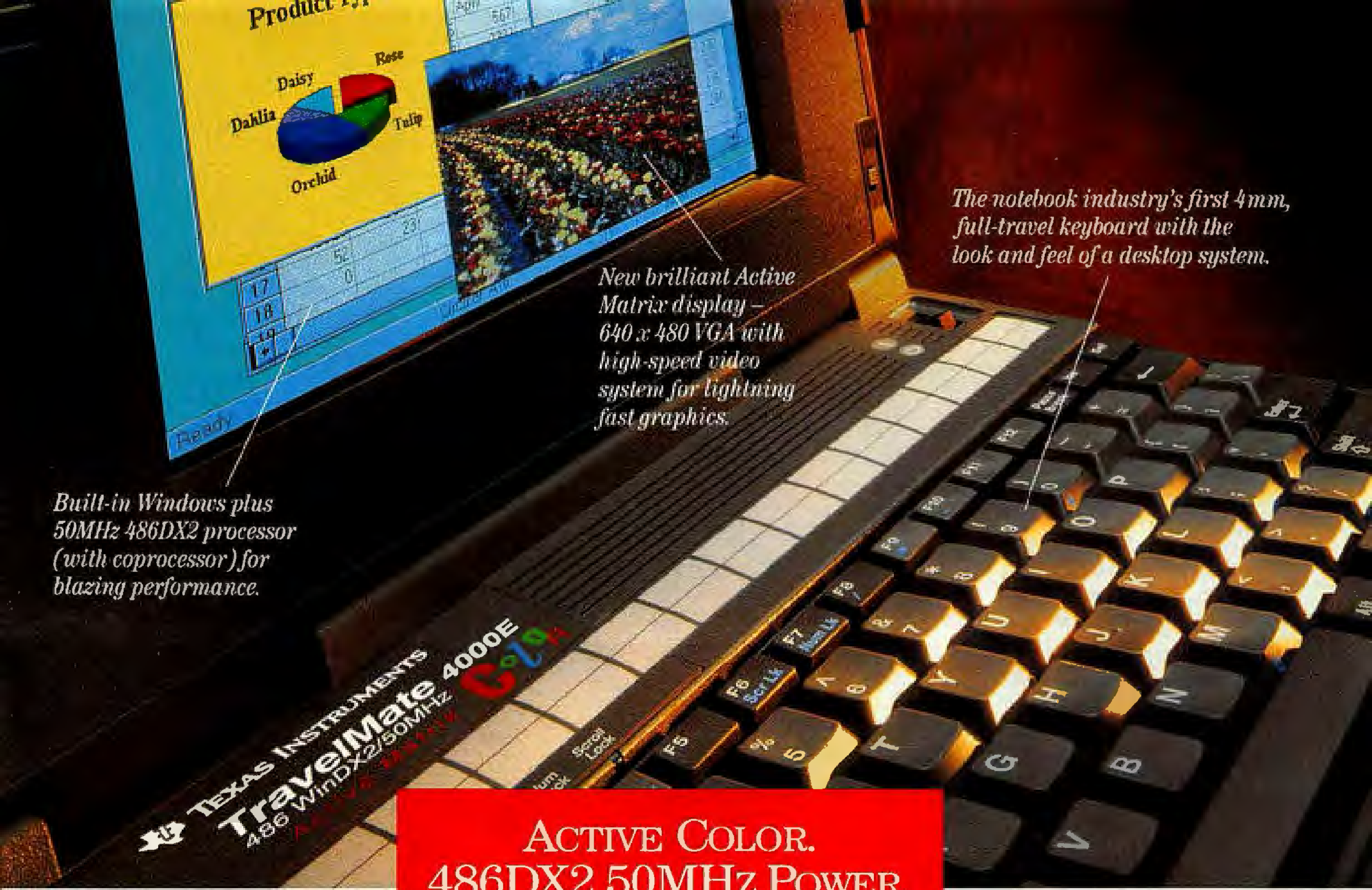
On the plus side, NPAP may help to cut some communications traffic. For example, with information provided through NPAP, a host may be able to avoid downloading unnecessary fonts or use a more effective emulation to reduce the data stream to the printer. NPAP also offers the chance for print management improvements, especially for large networks. More intelligent and communicative printers will save supplies that won't be wasted on incomplete jobs. They'll cut waiting time when printers aren't used for jobs they can't handle. And they'll no longer require babysitting by administrators or operators, who today must keep one eye on the printer's front panel; with NPAP, the printer can call for help when it's in trouble.

As much of an improvement as NPAP is today, it's already being extended for the future. NPAP can easily be stretched to support input devices as well as printers—including scanners and fax devices. Members of the Network Printing Alliance are continuing work on polishing the protocol and developing extensions. With the broad array of printer vendors planning new products that incorporate NPAP, it looks as though there may finally be a new and better standard for connecting computers and printers. Uncommunicative network printers may finally be headed the way of the dinosaur. ■

For More Information

The NPAP specification—including the current version of the protocol—is available for downloading from Lexmark International's BBS at (606) 232-5238 or by anonymous ftp over the Internet from ftp.lexmark.com in the directory /pub/npa. The specification is called NPAP.ZIP, which is a PostScript file that has been compressed using PKZip. The specification is also available on CompuServe via the Intel forum (just type GO INTEL). For information on joining the Network Printing Alliance, contact Mike Stilz at Lexmark at (606) 232-4817 or Ron Smith at Texas Instruments at (617) 774-6151.

Frank Hayes is a writer, communications consultant, and former West Coast news editor for BYTE. You can contact him on BIX as "frankhayes."



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Toshiba T4600C	6.9	SL	33MHz	Yes
Compaq LTE Lite 4/33c	6.5	SL	33MHz	Yes
IBM ThinkPad 720C	7.6	SLC2	50MHz	No

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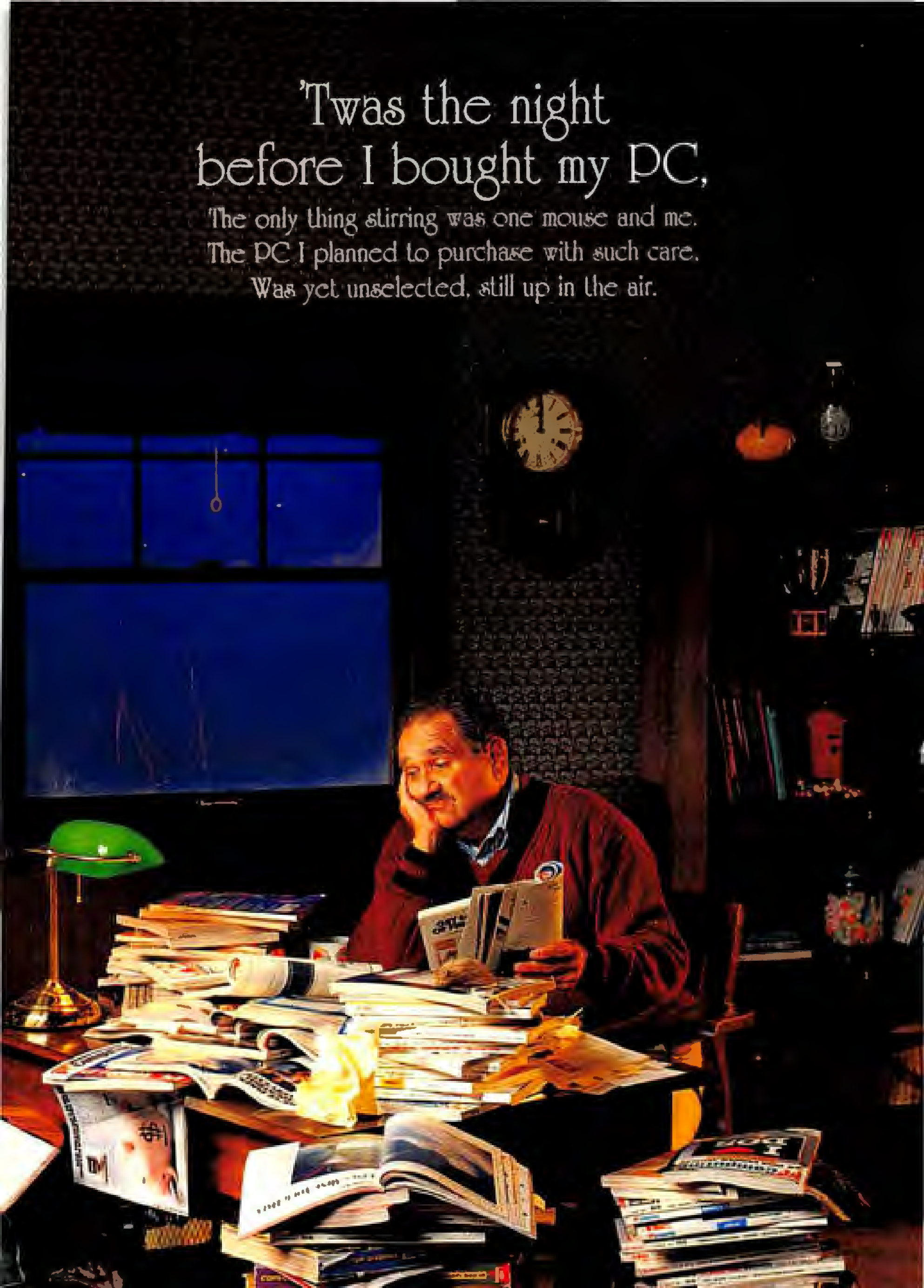
'Twas the night
before I bought my PC,
The only thing stirring was one mouse and me.
The PC I planned to purchase with such care,
Was yet unselected, still up in the air.


MICROSOFT
WINDOWS
Version 3.1
HANDBOOK

Santa Cow didn't speak, but went straight to her work,
Pulling PCs like magic from her bag with a jerk.
Then, what to my wondering eyes should appear,
But a miniature PC called the HandBook, I hear.
With VGA screen and performance so quick,
I knew at a glance 'twas a 486.
So how could they make a
computer this small?
The whole package weighs less
than three pounds in all!
This little gem would be perfect
for me,
Working hither and yon as I'm oft apt to be.
The HandBook would be a most marvelous gift,
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Its screen was a bouquet of colors so bright.
'Twas the 486 ColorBook under the tree,
Same price as mono from another company.
Performance and color at such a good price,
Is there something here that will
barely suffice?
It's light and still small, has a
built-in trackball,
With the ColorBook you really
can have it all!
I started to see that with all
Gateway's wares,
Although it sounds corny, there somebody cares!
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Compared to them I find the other brands ...
Well, they're just not as good.

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Mini desktops from Gateway are simply the best.
These systems' performance is tops in their class.
Just study the benchmarks,
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not that much money.
This deal would be easy to sell
to my honey.
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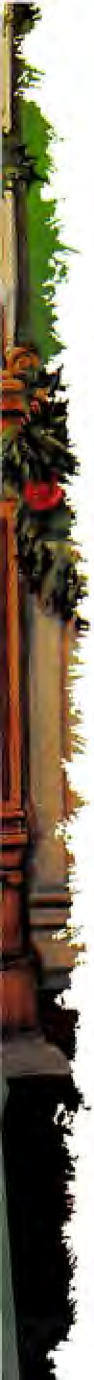

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- NiMH Battery & AC Pack
- Suspend/Resume Feature
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- 3.5" 1.44MB Diskette Drive
- Removable 170MB IDE Drive
- 9.4" VGA Dual-Scan STN Color Display
- NiMH Battery & AC Pack
- Suspend/Resume Feature
- 2 PCMCIA Type II Slots
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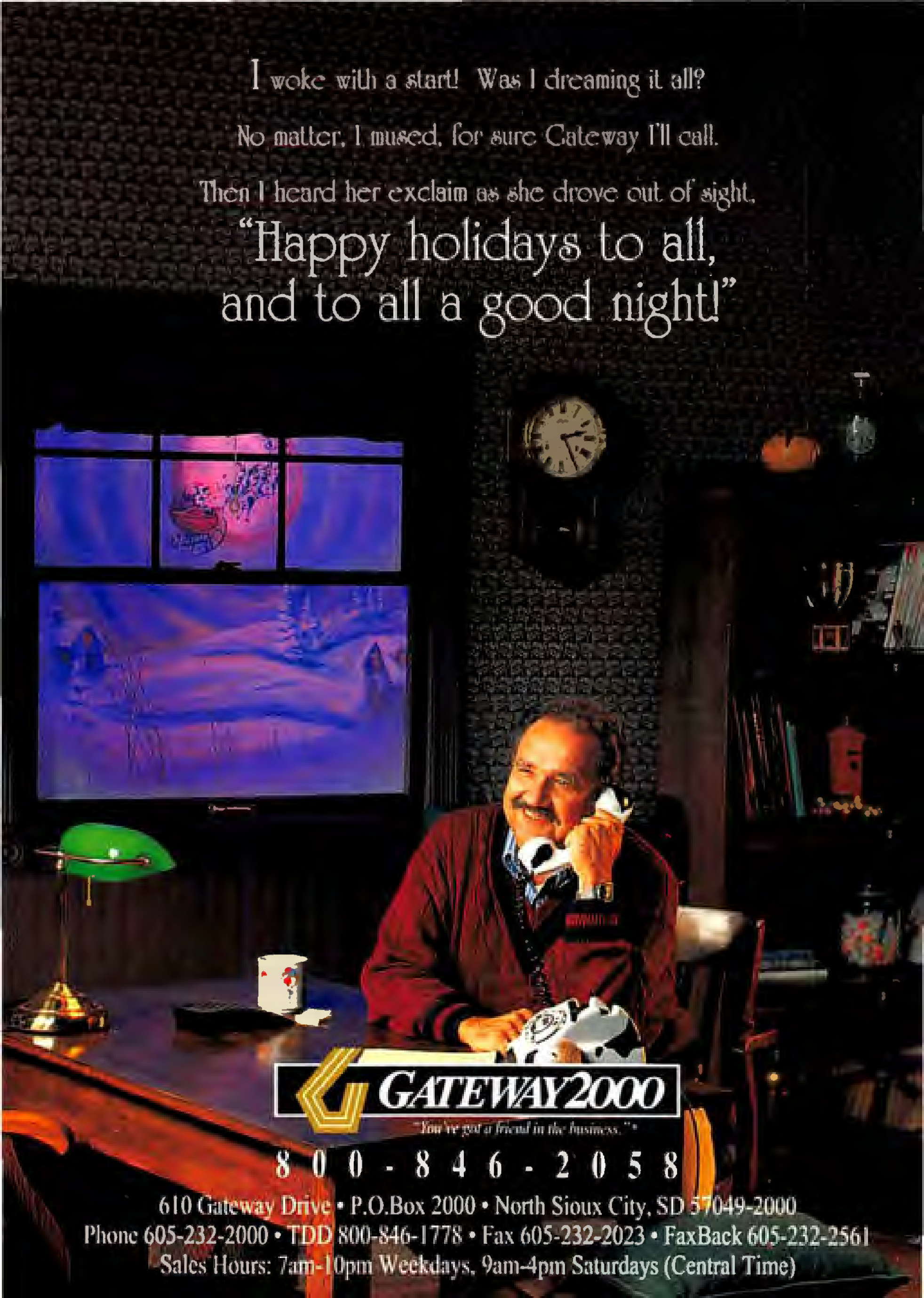
I woke with a start! Was I dreaming it all?
No matter, I mused, for sure Gateway I'll call.
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Getting output from your printer is usually a question of whether the image is processed locally on the printer or by the host computer

PETER WAYNER

SCOTT BALDWIN © 1993

The dynamics of printing are about to change radically in the next several years as electronic documents gradually take over the world. Many companies and publishers are investigating ways to distribute their information in electronic form using protocols for device-independent image formats like Adobe's Acrobat. Someday, when you want published information, you won't walk to the bookstore or library—you'll dial up a modem and send the document to your printer.

As the desktop printer takes on a larger role in the information food chain, the demand for speed will become greater. Complicated graphics and layouts slow today's standard printers to a standstill. Bit-mapped images are an especially imposing bottleneck. Many mainstream machines could never generate a customized version of the morning paper before late afternoon.

Printer companies are approaching the problem by optimizing printer software and evaluating specialized hardware. The PostScript PDL (page-description language), which encodes page images, dominates the printer market, so most of the efforts are aimed at optimizing it. Boosting speed by carefully rewriting the algorithms that lie at the core of the software is the most common technique; it is more flexible, and it can run on many platforms, including your own machine.

At this time, specialized hardware for fast page rendering is economically viable only on the high end of the printer market for users like graphic designers and typesetters, who must generate complicated images quickly. These specialized hardware systems are usually RISC processors that may also have additional custom chips designed to speed up halftoning and rendering.

In the past, most home and small-office users were content with the images from the least expensive printers. Most of the output was mainly text, and people could

Getting a Smoother Gray Scale

Creating a halftone *on a PostScript printer can be an ugly process. Simulating a continuous gray scale often results in banding, as shown in the top illustration. The change from light to dark is anything but smooth. Using the latest halftoning algorithms, however, results in a much better transition (bottom).*

wait for complicated images. This is bound to change as the new, highly formatted and graphics-rich electronic documents start straining the low-end machines. In the years to come, many of the techniques from the high-end printers will migrate toward the low-end printers as companies strive to find combinations of hardware and software that are inexpensive and powerful enough to get the job done.

So, to get the equivalent of the morning's newspaper printed in a reasonable amount of time—say 10 to 15 minutes—you will need throughput several times greater than what is available today. This performance level is still far away. Adobe's benchmarks show that if unassisted, PostScript interpreters can typeset a typical newspaper in 101 seconds; if they are using a PixelBurst processor, it takes 24 seconds. At this rate, to typeset the Sunday *New York Times*, it could take interpreters 20 hours without a PixelBurst processor and 5 hours with one.

The Printing Foundation

The core of the speed problem is in the PDL. Optimizing basic laser printers for text output is straightforward: The printer simply copies a rectangle of bits from one location in memory where the image of the font is kept (often on ROM cartridges) to the memory holding an image of the page. This operation is called BitBlt (pronounced "Bit Blit"). In pure text documents, the BitBlt routines can usually work faster than the printing mechanism can generate the next page.

Graphics and typesetting became important with the invention of the Interpress standard at Xerox and its cousin, PostScript, at Adobe. Rather than send a stream of text, these PDLs send a program that the printer uses to generate the data. PostScript is the dominant standard, but the principles used to build a fast PostScript printer apply to other standards. In fact, the generic term for PostScript processors is raster-image processor, or RIP, which refers to the pixelated nature of the final page.

The PostScript language is an interpreted, stack-based language with all the computational abilities of C or Pascal. In many ways, it is like Lisp, the flexible language favored in the AI community. Harlequin is not only a third-party supplier of PostScript interpreters for printers but also one of the largest suppliers of Lisp environments.

The programmatic nature of PostScript explains the vast differences in print speeds. Text documents may fly off the PostScript printer, but bit-mapped images and complicated line drawings take much longer. This is because the PostScript printer keeps a cache of font bit maps and BitBlts (i.e., copies) them into place in much the same way as a regular printer. However, lines, circles, and bit-map halftones must be computed each time they are encountered and then drawn on the page.

Speeding Up Software

In almost all cases, PostScript is interpreted entirely in software, whether it is on the host processor or on a separate dedicated processor at the printer. Therefore, finding and solving bottlenecks within the PostScript interpreter will show significant performance gains.

Much of the problem is similar to that of building a fast compiler. The PostScript program must be compiled into simple commands. That means the program must maintain a list of variable names and their values in efficient data structures. It must also have good garbage collection for

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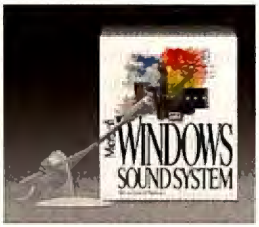

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To make the system as fast as possible, you must balance the amount of computation with the memory bandwidth.

removing procedures and variables that aren't needed anymore.

The most important part of the process, though, is the raw graphical operations that dominate the process. The interpreter must have well-designed routines that can draw lines and other primitives efficiently. This process can be quite complicated, because PostScript contains many features, such as the ones that allow you to govern the shape and structure of the corners where lines meet. The routines must be general enough to handle these problems in different circumstances.

The most time-consuming process is printing bit-mapped images. At first, this seems counter-intuitive. PostScript is slower because it needs to convert letters, lines, and other figures into bit-mapped images. Why should it be even slower printing a bit-mapped photographic image?

The problem is that most bit-mapped images come with multiple gray-scale values. Each pixel ranges from white to black. Laser printers, however, only have one shade of ink—black. They simulate the gray-scale values by speckling black dots in densities proportional to the desired gray-scale value. Darker values get more dots. Lighter values get fewer dots.

The process of computing this dot pattern is known as halftoning, and it can grow as complicated as you want. The simplest algorithms replace each pixel with a precomputed screen of dots at the right density. This is a fast solution, but it is often unattractive. The picture is left with a lightly cast, blocky grid defined by the borders between the adjacent pixels of different

gray-scale values. The transitions between one gray-scale level and another level clearly stick out. Poorly designed screens can also generate moiré patterns when the tiny dots line up in secondary patterns.

More complicated algorithms are now available, and many manufacturers offer their own proprietary halftoning systems. One popular algorithm defeats moiré patterns by randomly distributing the dots simulating the gray value of each pixel. Other algorithms "spread" the tone of each pixel with its neighbors by blending the dots along the boundaries to provide even texture.

The process of choosing the tiny dots to represent the gray value of each pixel is time-consuming. Each additional "blending" step that is used to ensure that adjacent pixels look good next to each other is what takes time.

Another difficult problem for a PostScript interpreter is clipping a region and filling it with a particular pattern. The RIP must find the boundaries of the polygon and then determine all the points that are inside. A pattern must be copied into place, but it must be done carefully. In almost all cases, some words of memory will contain some bits that lie inside the polygon and some outside the polygon. The RIP must be precise in copying the pattern into the correct bits.

The Memory/Processor Pas de Deux

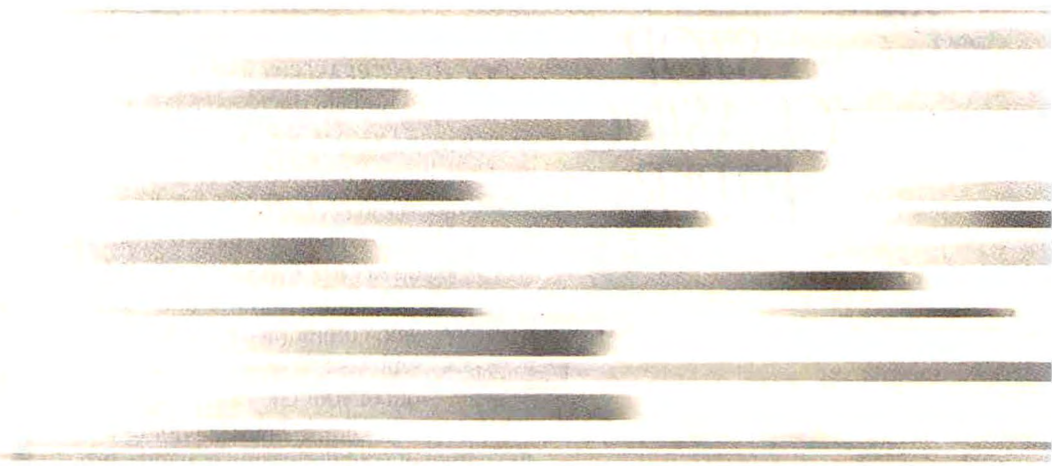
A programmer must use many other operations when designing the RIP. Developer Ian Kemmish created one of the fastest PostScript interpreters that 5D Solutions (London) sells to OEMs for repackaging. Kemmish says that to make the system as fast as possible, you must balance the amount of computation with the memory bandwidth. The amount of data that must be written out to memory limits the speed of most graphics operations. The processor/memory pathway is the bottleneck.

Many RISC processors, for instance, pipeline their operations so that they can perform many computational steps between each memory access. A good compiler will rearrange the sequence of these machine code-level instructions so that they are interleaved for maximum throughput. If the current version of an algorithm for drawing a line, for instance, can already perform all the necessary computation between the memory writes, then there is little reason to write a new algorithm. Faster computation won't matter because the processor will just be waiting for the memory to be ready to accept another block of pixels.

Other simple optimizations can make a big difference in throughput. Harlequin implemented an internal multitasking system that would allow its PostScript interpreter to send one page image to the printer while simultaneously building the image for the next page. Most systems don't start processing the next page until the last page is completely printed. Harlequin's system will also cache extra page images on disk if the processor gets ahead of the printing mechanism. This allows maximum throughput, and it reduces the interruption caused by especially complex images.

Placing the Processor

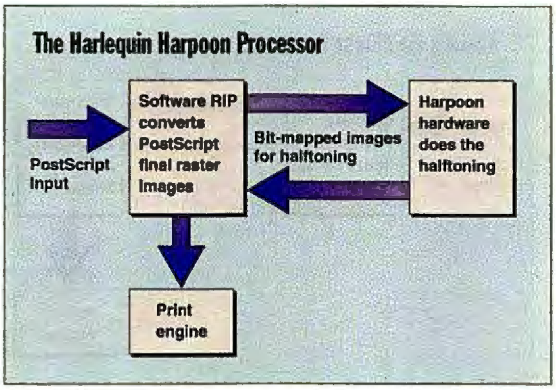
A hardware solution to getting faster page processing often depends on where the



processing occurs. Many high-end laser printers have their own processors—often RISC chips, which have a much better price/performance ratio. Placing a processor in a printer requires that the printer has enough memory to hold the image before it is sent to the printing mechanism.

Next decided that this setup was much too expensive, because the computer in the laser printer was often idle. Its Next Cube ran the PostScript image on the computer and sent the final image to the printer. This extra processing slows down the host machine, but it shaves thousands of dollars off the cost of the printer.

Host-based processing is used frequently today. Software like Harlequin's ScriptWorks, Color Age's Freedom of the Press, or the freeware Ghostscript implement a PostScript interpreter on the local machine. The computer is tied up while it computes the image, but you can get acceptable results on even a $300 ink-jet printer using this method. The host-based approach is often best for home or small-business users who print small numbers of documents with low complexity.



The Harlequin ScriptWorks RIP *works hand in hand with the Harpoon processor to increase the throughput and enhance the image of PostScript files. The Harpoon processor deals only with the halftoning process.*

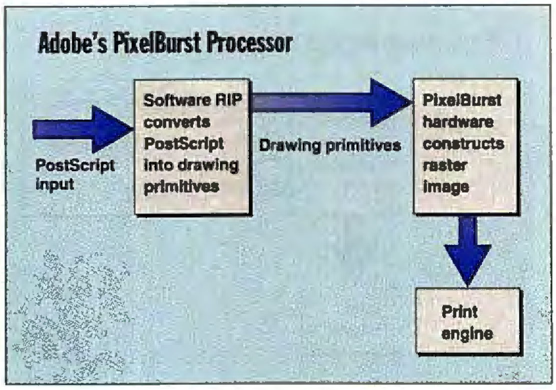
The speed that the RIPs render the pages varies significantly from chip to chip, and the internal structure of the RIP makes it simple to understand which processors will run PostScript imaging procedures faster than others. The bandwidth between the memory and the processor is always the limiting case. The greater this is, the faster the processor can draw dots when little computation is required. For this reason, chip sets with 64-bit-wide buses, such as the Pentium, the Mips 4x00 series, or the PowerPC, all offer substantial improvements in processing time. The extra bits might not make much difference when a word processor is running, but they will add substantial improvements when the processor's main job is moving bits from one place to another. Large sections of PostScript code are devoted to BitBlt patterns and bit maps of letters.

Another important requirement is floating-point performance, which many of PostScript's complex graphical routines require. Rotating graphical elements and scaling them to fit on the page all involve fractional arithmetic. A good floating-point-capable machine will be able to speed up these processes substantially. For instance, the 386 without a 387 may be only several times slower than a 486DX on integer tasks; however, the

speed difference is much greater on floating-point numbers, because the 486DX comes with a 487 floating-point coprocessor built on the chip.

Special Hardware Solutions

The fastest PostScript engines now use special hardware implementations of raster processors that handle many of the simple tasks at fast speeds. These processors are highly optimized machines that have many similarities to GUI accelerators. They maintain their own array of fast local memory for keeping the page image and are optimized for moving and setting large blocks of bits in this array of memory.



The Adobe PixelBurst processor *can significantly boost the processing speed of raster files. It uses the list of drawing primitives produced by the software RIP to construct the raster image sent to the printer.*

The two main chips used today take different approaches. Harlequin's Harpoon accelerator contains an Intel 960 and a collection of specialized ASIC (application-specific IC) chips. It runs hand in hand with the ScriptWorks software, but it will only help with halftone screenings. The Harlequin engineers decided that this was the only task for which they could use the additional processing power effectively.

On the other hand, the PixelBurst chip from Adobe contains a wide range of different capabilities. It can render all the primitive graphical components necessary to build up an image. These include lines, circles, Bézier curves, and pattern-filled areas defined by these primitives.

The software/hardware architecture of the Adobe PixelBurst is substantially different from the Harlequin ScriptWorks/Harpoon combination. The Adobe software running on the host processor performs the more general interpretive tasks but doesn't draw anything. The software merely breaks down the operations into primitive drawing tasks and stores them in a list. When this list goes to the PixelBurst processor, the main CPU can move on to the next page, while the PixelBurst processor handles the task of flipping the right pixels on and off.

Splitting off the pixel-drawing work to an entirely different processor can lead to some important speed advantages. PixelBurst can support its own memory subsystem to hold the page pixels. The communication between the PixelBurst processor and this subsystem can be highly optimized for drawing, and the needs of the main CPU do not hold it up.

One of the most work-intensive processes is filling an area with a pattern. The memory sections containing an area's pixels must be overwritten with the pattern. The speed of processor-to-memory pathway becomes the limiting factor when large areas are filled. In fact, the cost of building a separate, high-speed memory subsystem for the printer is one of the big limiting costs of these hardware accelerators. High-resolution pages require plenty of memory to hold their image, and this can be expensive. An 8- by 10-inch image rendered at 1200 dots per inch takes up about 14 MB of memory.

The classic trick that is used to reduce the need for memory in both hardware and software RIPs is to split the page into bands or subsections. If there are *n* subsections, then the page is rendered *n* times. In each new rendering, only the drawing operations that apply to the particular subsection stick. The rest are ignored. In these cases, throughput can be substantially increased by adding more memory. Doubling the memory will halve the number of times the page must be rendered. Adding more memory will continue to speed up the process until there is enough memory available to hold the entire page image at the desired resolution.

The Future Printer

The next generation of printers to hit the market will be substantially enhanced with software for handling sophisticated graphics. Already, Apple's ink-jet Stylewriter II (street price of about $350) contains special software for printing gray-scale images. Although this version is not PostScript-compatible, more low-end printers are emerging that offer this standard. Some are even priced starting at under $1000.

These low-end machines are still very slow. This next generation will need to find a way to provide the computational support for the user's increased demands for high-quality graphics. Some will simply bundle RISC processors into their machines and concentrate on improving the software significantly. The software should continue to improve in quality and speed, as the severe competition in this arena forces developers to tune, tweak, and engineer their software RIPs for maximum throughput. The theoretical limits that the memory-access bottleneck has set have not been reached.

Although specialized hardware like the Harpoon or the PixelBurst will keep a market niche for themselves in the high-end arena for the next year, they will come under increasing competition from RISC chips that offer substantial speed at mass-market prices. But if the market for low-end, fast printers with hefty graphical capability begins to grow significantly, the market may be able to support low-end specialized chips.

These changes, though, are many years down the road. To a large extent, the fate of the widely circulated electronic document is tied to the availability of printers that will make the documents available to people. High-quality, inexpensive, and fast printers that can render sophisticated graphics are absolutely essential to the emergence of this market. ■

Peter Wayner is a BYTE consulting editor. One of his latest projects is to hack on a Ghostscript, public-domain PostScript interpreter. You can reach him on BIX as "pwayner."

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COLOR BECOMES AFFORDABLE

Color printers of all types have become better and less expensive, and this trend will continue. Color specialists and average users alike will benefit.

MICHAEL ZEIS

SCOTT BALDWIN © 1993

Getting high-quality color output from a computer used to be the domain of specialists using expensive, high-performance systems. Lately, color printers have begun to shed their high-price image and are being applied in a wider range of applications. You can now purchase a color-capable printer at a relatively small incremental cost over monochrome printer prices.

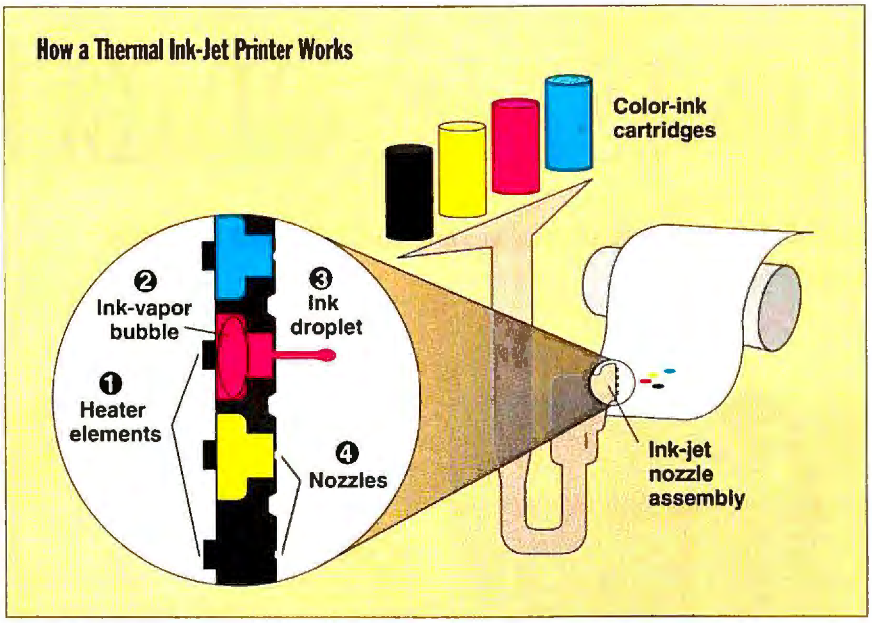
Applications drive the demand for color output, and the software industry is quickly bringing more and better color presentation packages, color drawing and painting packages, scanning and image-manipulation software, and color page-composition packages to the desktop.

However, many common office-based applications are still monochrome; billing, correspondence, and management reports often incorporate color only if they are preprinted on letterhead or forms. In mainstream business-document applications, color is still considered nice to have but not essential.

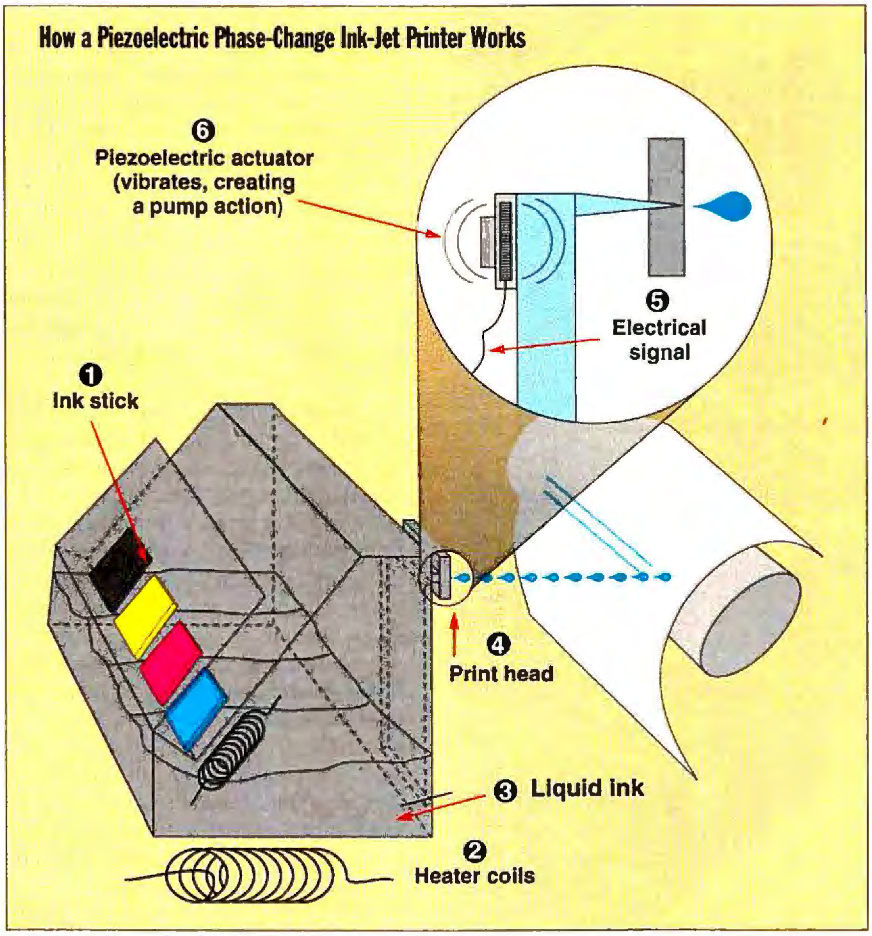
This will change, however. At the low end, color-capable ink-jet printers are poised to challenge dot-matrix printers in price. Although dot-matrix printers have long offered low-cost color, their color output is unattractive to most users. With color ink-jet printer street prices lurking at around $300, many people will consider color for their next printer purchase.

Thermal-transfer printers offer highly saturated colors and have been virtually unassailable as the color printer of choice for overhead-transparency printing. Recent thermal-transfer products have been designed to work better with common laser printer paper, increasing their versatility for other business applications, such as illustrating reports and proposals.

In 1994, new electrophotographic short-run printers at the high end (i.e., 35 pages per minute and faster, costing $200,000 or more) will begin showing up in quick printers and commercial shops, offering



Thermal ink-jet printers *use heat* ❶ *to create a vapor bubble* ❷ *that forces a droplet of ink* ❸ *through a nozzle* ❹.



Piezoelectric phase-change ink-jet printers *use a solid ink* ❶. *A heating element* ❷ *melts that ink* ❸, *which then goes to the actuator in the print head* ❹. *Pulses of electricity* ❺ *create a pumping action in the actuator* ❻, *and this forces the ink out onto the paper. The ink then solidifies as soon as it touches the paper, avoiding the spreading, or wicking, problems associated with liquid inks.*

the desktop document creator a means of reproducing full-color short-run documents. Other trends apply to all color-output technologies. For example, there will be a drive toward higher resolution. The latest monochrome office laser printers have a 600-dot-per-inch resolution specification, which will probably become a performance target for color printers as well.

As ever, printer vendors will compete on speed. The color print mechanism itself can be designed to go faster, but color printer performance will also be improved by advances in the silicon and in the software that prepares color images for printing (see "Print Pages Faster" on page 115).

Text-enhancement techniques and wider choices in halftone methods will help differentiate high-performance products. For instance, Hewlett-Packard uses its Resolution Enhancement Technology, which it developed for its laser printers, in its ink-jet printers to improve text printing. And prints of scanned images such as photographs now benefit from randomizing techniques called *error diffusion* techniques, which increase sharpness by removing conventional screening patterns.

Color Ink-Jet Comes of Age

Ink-jet printing is a robust and flexible technology. The essence of ink-jet printers is to place drops of ink on the page. The challenge for developers of ink-jet printers is control: They have to predict what will happen to the drops when they reach the paper. Developers also have to control evaporation of the liquid ink and erosion of the tiny nozzles through which the ink is projected. Ink-jet printers are, in fact, carefully balanced applications of chemistry and physics.

As with most color-imaging technologies, an area of considerable design attention is the interaction of ink and paper. Ink that is fluid enough to be projected through orifices is usually fluid enough to seep into paper fibers. Specially coated and treated papers were designed to combat *wicking* (i.e., ink seeping into the paper). Wicking vertically is the way in which colorant, usually dye, makes images. Wicking laterally, though, is undesirable, as is *bleeding* (i.e., inks mixing or running before drying).

Recently, ink-jet printers that can work with a broader scope of paper types have been introduced. The basic tactic for printing on plain paper is to hasten drying or to control the spread of ink while it dries.

continued

One approach is to pause between printhead passes; Lexmark uses this technique for the IBM Color JetPrinter PS4079's "high-quality" mode. Another approach is to heat the paper prior to printing and fan the paper after printing, which causes the ink to evaporate more quickly. HP uses this technique in the PaintJet XL300 and DeskJet 1200C color printers. A third method for gaining wider latitude in paper types is to use solid ink that is melted prior to projection and is returned to a solid when it strikes the paper. Solid ink-jet printers are available from Brother International, Dataproducts, and Tektronix.

Chemists at DuPont have developed pigment-based aqueous inks for HP; these inks may remove some long-standing performance barriers. Pigment-based inks promise to be more impervious to light and water, as well as giving the user more latitude in paper selection.

Most liquid ink-jet printers use dye-based inks. An important difference between dye-based and pigment-based inks is that dyes are soluble in their surrounding media, whereas pigments remain particulate. With pigment-based inks, the hope is that images will be more resistant to fading and moisture. In addition, pigment particles are opaque, giving pigmented inks the potential to produce colors that are more saturated. One problem in developing a pigment-based ink is that pigment particles tend to settle out of the ink solution.

To date, the only pigmented aqueous ink available is the black ink that HP ships with its DeskJet 1200C printer and DesignJet 650C plotter. This ink is more light-resistant than regular inks, but it is not completely resistant to moisture. In fact, until prints have dried for several weeks, they run just as much as prints made with dye-based inks. Pigments provide an observable benefit when printing fine lines, which are as dark as broad lines. Narrow lines printed with dye-based inks are often lighter than broader lines, since the dye tends to spread out into the paper fibers.

Because of their newfound ability to print with high quality on plain paper, ink-jet printers are expected to replace dot-matrix printers as the low-cost office workhorses. The cost increment to purchase color in an ink-jet is now around $100, about what the cost increment is for dot-matrix. But ink-jet delivers what dot-matrix does not—respectable color quality.

Ink-jet technology development has taken two branches. Virtually all office ink-jet printers are *drop-on-demand* printers, so-called because they produce a drop only when the image requires one. Ink-jet printers force liquid through small holes, or orifices. Drop-on-demand ink-jet printers use one of two principal methods to propel ink: Thermal ink-jet printers use heat to create a bubble that creates projection force, and piezoelectric printers use electrically driven actuators to pump ink from a chamber.

Color printers from Canon and HP are examples of thermal ink-jet printers. Brother, Dataproducts, and Tektronix sell solid-ink piezoelectric printers.

Epson is expected to introduce in 1994 a liquid-ink color printer based on its own multilayered-actuator piezoelectric head. An electrical charge excites an actuator in a piezoelectric print head to push or pump ink out of a chamber much as a piston would. In Epson's implementation, several actuators work on the ink cavity, forcing ink out of the chamber with a sharper and greater impulse. Epson claims that this process produces better dot shapes, making them as round as possible. Epson's monochrome Stylus 800, introduced last March, uses the new multilayer actuator head.

Epson also claims that the multilayered peizoelectric head eliminates *satellites*, tiny subdroplets of ink that are the bane of thermal-print-head designers. After forming, satellites are free to make their way to the paper, usually landing where they are not supposed to. "With monochrome," says Edith Dees, Epson's product manager for entry printers, "this results in indistinct characters. When you have four colors, the effect is worse, because the blends of colors are not accurate."

Since piezoelectric printers are mechanical devices and don't subject ink to repeated temperature cycling, they have more latitude in the inks that they can work with. The inks that Epson will provide in its new printer, for example, will work with both plain paper and recycled paper.

Another type of ink-jet printer sprays ink droplets continuously. The droplets are deflected toward or away from the paper, depending on the image requirements. Continuous ink-jet printers are available for industrial (e.g., package and product marking and addressing) and graphic arts (e.g., proofing) applications.

Iris Graphics (Bedford, MA) offers the only continuous ink-jet

Color Printing Trade-Offs

	PROS	CONS
Ink-jet	• Economical, especially with low coverage • Low purchase price	• Slow • Image fades • Banding (print artifacts) • Ink runs • Paper wrinkles
Laser	• Durable image • Name recognition • Synergy in manufacturing with high-production devices • Wide latitude in paper types	• Slow • Image "gloss" • Sensitive to variation, difficult to control • Expensive, especially compared to monochrome
Thermal-transfer	• Clean • Simple and reliable • High color saturation	• Somewhat paper-dependent • Dithered color • Must control paper travel for good color uniformity • Can be expensive
Dye-sublimation	• Near-continuous-tone images	• Expensive to buy and operate • Imaging and printing can be slow

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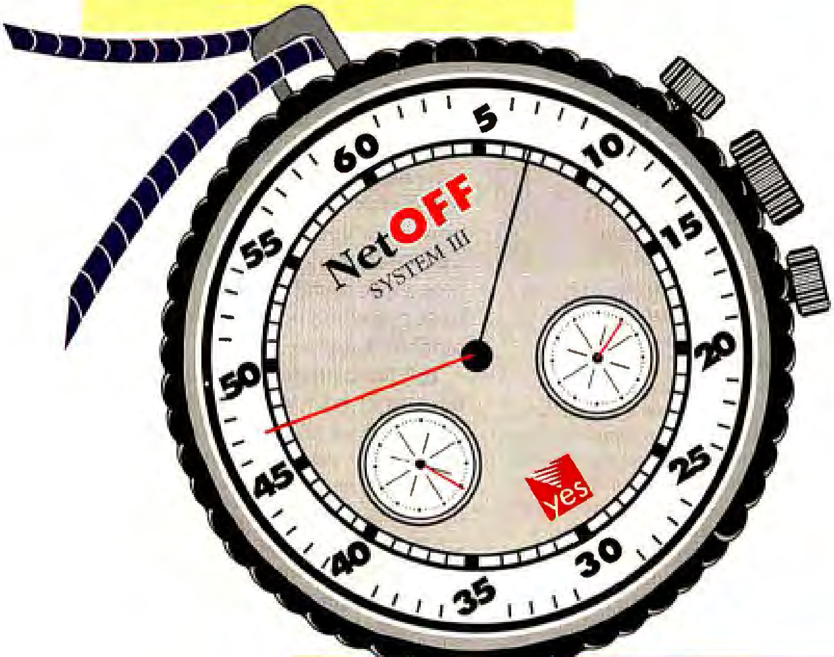

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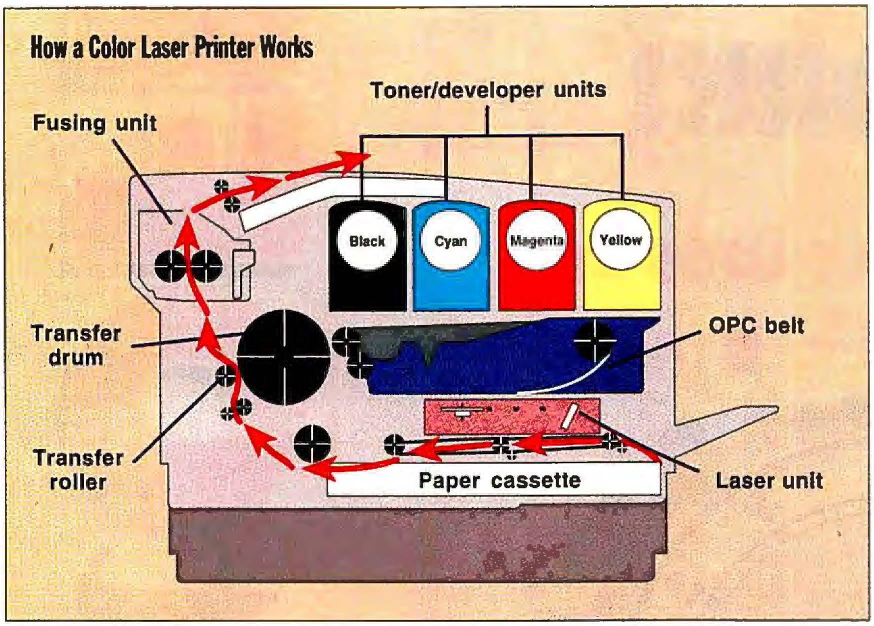

The only desktop color laser printer *currently available, the QMS ColorScript Laser 1000 uses a dry toner and a special OPC (organic photoconductor) belt. A precharger inside the OPC belt creates an even charge across the belt. The printer controller steps through one color plane of image data. This data controls the intensity of a laser beam as it sweeps a line across the OPC belt. When the beam is on, a corresponding spot on the belt is discharged. As the belt moves, a latent image composed of discharged areas is built line by line. The portion of the belt storing the latent image passes under four toner/developer units. The toner unit that corresponds to the color plane that was just applied to the belt opens. Toner sticks to the discharged areas and is repelled from the charged areas. For color images, this operation occurs several times as the belt rotates and all four process colors are applied. A complete color image exists on the belt after four rotations. The transfer drum is charged and peels the image off the belt. A bias voltage between the transfer drum and transfer roller pulls the color image off the transfer drum and onto the medium. The fusing unit uses heat and pressure to adhere the image to the medium.*

printers, a specialist's product line that uses variable dot-size capability to print continuous-tone images. Iris printers sell for $39,000 and up in the prepress proofing markets and several industrial markets, including industries needing artwork for signs and displays. Other than refinements to its ink and media and continued improvements in connectability, Iris has made few changes to its product line since its newest product, the SmartJet 4012, began shipping in January 1991.

Color Laser Printers a Challenge

Laser technology has proved quite robust in meeting monochrome document production and reproduction requirements. Extending this technology to color, however, is no easy task. Building a color image out of colored toner is delicate work. A key component in an electrophotographic print engine is the photoconductive element, a drum or belt on which the laser "writes" the image. Most color laser printers build these images sequentially, one color at a time. The built-up image is then transferred to paper and fixed.

Controlling toner is a design challenge. Environmental conditions complicate the process. The amount of toner attracted at a given charge level depends partly on the level of humidity, for instance. Therefore, process stability is important. Toner must be fine enough to make high-quality images, with low-enough mass to be attracted or repelled by the relatively low charges on the photosensitive drum.

Since color images are made sequentially, color laser print-engine designers have to find a way to "protect" the first pass of an image while the printer works on subsequent passes. A couple of things can complicate this task. First, the photosensitive drum must be free of the first pass of the image before a second pass can be imaged. The toner is removed and positioned on a belt or another drum, where it waits as the subsequent passes are produced and transferred. Second, until the image is fixed at the end of four image-building passes, the lightweight toner has to be protected.

In spite of such design challenges, serious development of color laser technology is under way. The desktop color laser printer literally did not exist until QMS's ColorScript Laser 1000 was introduced in mid-1993. HP is expected to join QMS in the desktop color-laser-printer market in 1994, and many other companies are also known to be working on such products.

Color laser printing has a brief history among a small set of manufacturers. For nearly five years, the only color laser printer available was from Colorocs (Norcross, GA). In addition to supplying color copiers to Savin and Sharp, Colorocs offers the CP 4007 console color printer, a product that has met with limited market success. Canon (Lake Success, NY) has been much more visible, offering digital color copiers that can be made into printers by adding computer interfaces, controllers, and memory. Xerox, Eastman Kodak, and Minolta now offer copiers with computer interfaces, too. Color copiers, without interface, cost around $50,000. Interface, controller, and memory can add $40,000 or more to that price.

But these products are not what people have in mind when they say they want a "color laser printer." People tend to expect a color version of their monochrome laser printers. And why not? Laser-produced pages are durable; per-page image costs are reasonable; and, by varying the amount of toner in the image, laser printing can produce continuous-tone images without halftoning. However, people don't often consider the fact that monochrome laser printers are not usually used for producing continuous or gray-scale images. Low-cost office printers produce black dots. With color printers, flexibility in shading is always a requirement.

In short, users expect color printers to have laser speed and laser quality and to carry a price in the neighborhood of what monochrome laser printers cost. These expectations will not likely be met in the near future. Most current color laser implementations print at one-quarter the speed of monochrome. And the success of the monochrome laser printer is due, in part, to the reliability that a disposable toner cartridge offers. Disposable cartridges for color laser printers might not be an economical alternative, since you need a separate cartridge for each color.

All signs point to slow acceptance of color laser printers, even after HP begins beating the marketing drum. "I don't expect to see $5000 color laser printers anytime soon," says A. J. Rogers, strategic marketing manager at Tektronix

(Wilsonville, OR). "Early color laser printers are not going to be personal printers," he adds. Of course, you do not have to own a color laser printer to use one. In Larry Hunt's *Color Copy News* newsletter, quick printers reported that 17 percent of the output of their Canon CLC 500/550 copiers was printed through the copier's computer interface.

In 1994, Xeikon (Mortsel, Belgium) and Indigo (Rehovot, Israel) will begin shipping printers for short-run color work such as brochures and manuals. These will appear in quick-printer shops, commercial printers, and forward-thinking in-plant print operations. Short-run color printers can be an important enabler for desktop color, in the same way that high-quality film recorders enabled the desktop presentation business.

"Everyone talks about bringing color printing to the masses," says Rogers. "In a real sense, some of these short-run presses are going to do a better job of enabling the market than any other technology, because they are going to make it possible to do short-run color printing where it was not possible before. Even if you don't use a computer, you may end up buying output from these devices."

Thermal-Transfer Prices Falling

As their name implies, thermal-transfer printers use heat to move colorant from a ribbon to the paper. A stationary print head contains heating elements; the number of elements per inch correlates with the printer's resolution. The printer's control electronics and software fire these elements at areas on the page that require ink.

Most thermal-transfer ribbons are made of sequential page-size bands of colors (either cyan, magenta, and yellow, or cyan, magenta, yellow, and black). Ink and paper travel together past the print head. After a pane of color is transferred, the paper moves backward (or is turned around) so that another color can be added to the page. Since the ink sheet and the paper or transparency are in contact when heat is applied, the waxlike colorant leaves the ink sheet and is transferred to the paper.

Thermal-transfer printers saw early acceptance as preview or proofing devices for desktop publishers. Especially with recent price declines (from around $20,000 for a PostScript printer in 1989 to as low as $3000 today), thermal-transfer printers have found wide acceptance for producing presentation overheads, where high color saturation and fixed printing costs are valued.

Even though most recent thermal-transfer printer models claim plain-paper capability, getting highly saturated colors usually requires special paper. In 1994, vendors will pay more attention to printing on plain paper. Paper manufacturers will play a role, too, as relatively smooth papers such as Nekoosa Laser 1000 and Hammermill Laserprint become more common. And while a fixed supplies cost is an asset when producing high-coverage transparencies, thermal-transfer is expensive for text documents.

Most thermal-transfer printers cannot modify dot size, so they use dithering patterns to produce shades. Panasonic Communications & Systems (Secaucus, NJ) produces a 203-dpi thermal-transfer printer with variable dot capability. General-

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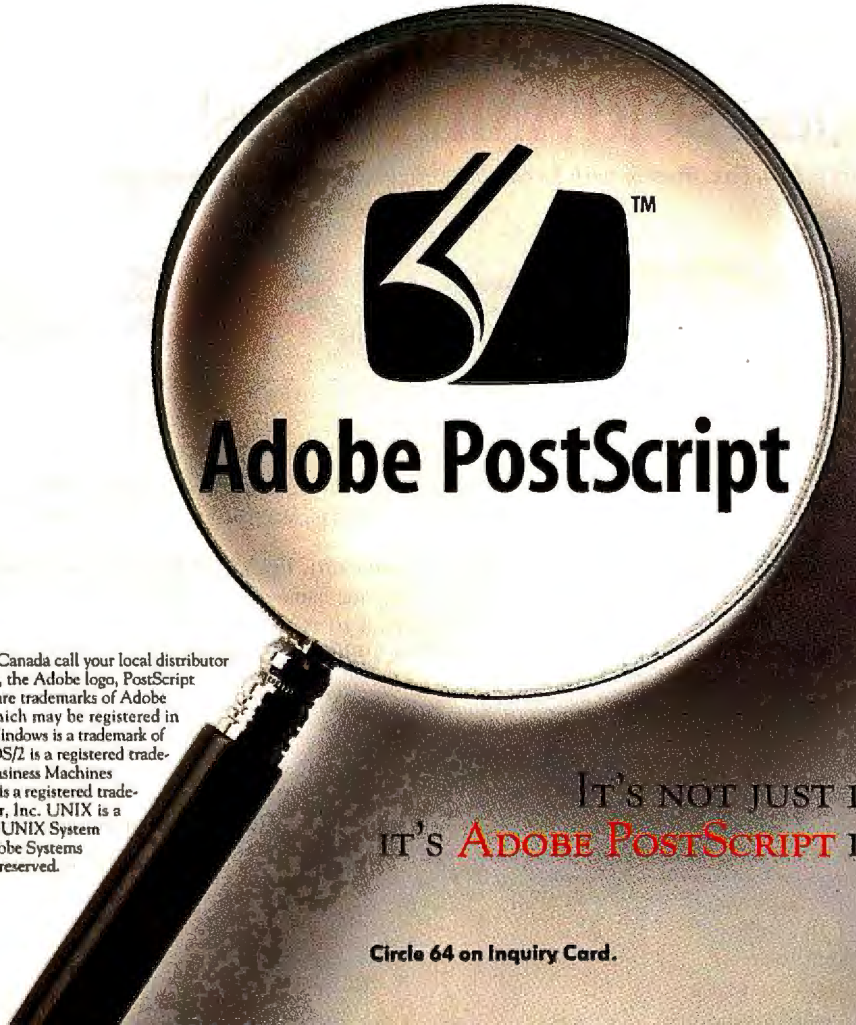

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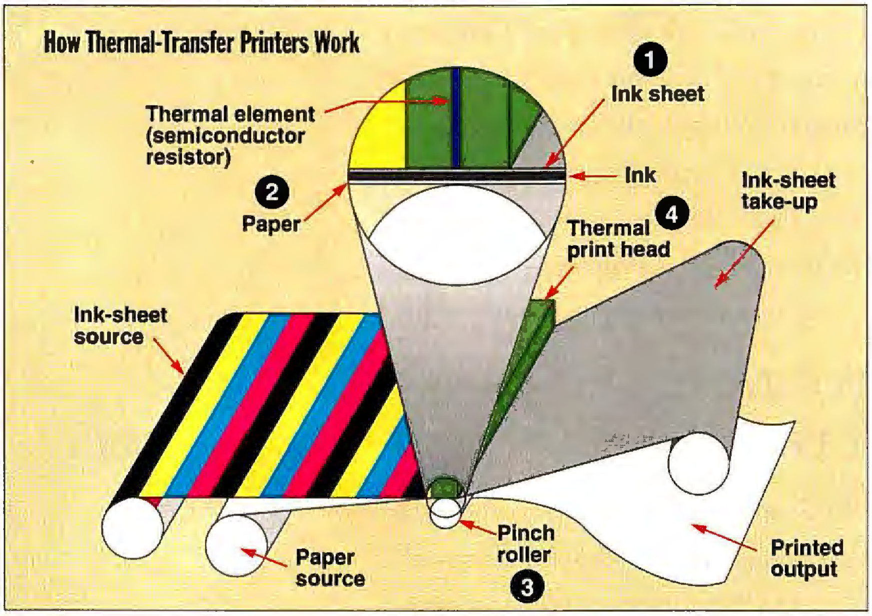

Thermal-transfer printers use a banded, multicolor ink sheet ❶ that rolls simultaneously with the paper ❷ toward a pinch roller ❸. This squeezes them together toward the thermal print head ❹. Commands from the computer or printer turn tiny semiconductor resistors in the print head on or off to melt or resolidify the ink onto the paper. After each pass, the ink sheet advances to the next color band and the paper retracts to its starting position until the full-color printing process is complete.

ly, the printer succeeds at printing pictorial images, but its ability to print text suffers due to its low resolution. At 300 dpi, shaded areas and scanned images almost always show some visible dither-pattern artifacts.

Thermal-transfer printers with higher resolutions should appear on the market in 1994, using the extra pixels to offer dramatic improvements in the appearance of pictorial and shaded images. In the next year, vendors will also be bringing thermal-transfer capability "down-market": This year, Star Micronics introduced a low-cost ($599) serial printer that has a moving head (see "Bargain Color Printers" on page 153).

Dye Diffusion Gets Faster

Like thermal-transfer printers, dye-diffusion (also called thermal-dye-transfer or dye-sublimation) printers use heat to move colorant from the ribbon to paper. Heat is applied to the ribbon, and the colorant diffuses into the receiver sheet, producing denser colors as more heat is applied. Most dye-diffusion printers can produce 256

Color Management Makes Color Easier to Use

Vendors have begun to address the fact that color can be difficult to use. One problem in particular is predicting what the color will look like on the final printed page. This problem is complicated. First, the set, or gamut, of available colors on a computer screen is usually larger than the gamut available with a color printer or offset press. Resolving screen-to-print matching problems is in the hands of color scientists, and for now there is no solution.

From a practical standpoint, the brightness and contrast controls on color monitors can be adjusted to a known and desired optimum point, which provides a "best-effort" match between the screen and a particular printer. These adjustments can be aided by an instrument such as a colorimeter attached to the screen with a suction cup.

A second issue is that the same color file printed on different printers can have different colors. Today's so-called color management systems address this problem. The functions of color management are not new; commercial printers and prepress service bureaus have at times used "closed-loop" color management to predict press results with their high-end graphic arts systems. What is new is the transfer of color management functions to the desktop, where it is common to move a color document from one system to another.

A key component of a color management system is the *device characterization*, or profile, which is a data file defining the colors that a given device can produce. Electronics for Imaging (San Mateo, CA), a pioneer in desktop color management, has developed profiles for 25 color printers as well as 52 monitors and scanners.

A color management system will compare the individual device characteristics to a *common color space* and manage the translations from one device profile to the other. (In 1931, an international body called the CIE [Commission Internationale de l'Eclairage, or International Commission on Illumination] instituted what EFI and most others use as a reference color space.) Eastman Kodak and the Agfa Division of Miles also offer color management tools.

As mentioned earlier, the set of achievable colors varies among devices. Therefore, an important function of a color management system is to determine how to handle "out-of-gamut" colors. The process for handling such colors is called the *color-rendering style*. The out-of-gamut instructions for printing are contained in a color-rendering dictionary.

By modifying the out-of-gamut instructions, color-rendering dictionaries can be fine-tuned for a particular intent. For instance, a file can be printed to yield the most saturated primary colors if the user is incorporating business graphics in an overhead transparency, or a photograph can be printed using the most realistic colors.

Last January, Apple Computer (Cupertino, CA) introduced ColorSync, an enhancement to its System 7 operating system that provides a common framework under which color management tools can operate. Microsoft is expected to offer a color framework for Windows in 1994. "My prediction," says Gerald Murch, Apple's director of imaging software, "is that we'll actually agree on what the common application programming interface should be [for color]. This will simplify writing color documents between Microsoft's and Apple's products."

shades of color at every pixel, making photograph-like prints.

As recently as 1991, dye-diffusion printers were selling in the $40,000 neighborhood, positioned as preview devices in the prepress environment. Early participants like Kodak and DuPont (DuPont having since discontinued its product) have been joined by a host of other companies, with list prices starting at about $8000.

Newcomer Fargo Electronics, recognizing the similarity in print-head design between thermal-transfer and dye-diffusion printing, offers a $250 photo-realistic upgrade kit that turns its $995 Primera thermal-transfer printer into a dye-diffusion printer. The upgrade kit includes media and driver software; no hardware changes are required to make the switch.

Dye diffusion is not a speedy technology; the fastest print engines can print a page in about a minute and a half. But with 24-bit color, engine speed does not define throughput. Vendors will compete by reducing the time it takes to transmit and interpret raster-image files that, at 300 dpi, measure 32 MB for an 8½- by 11-inch page. Printer architects are benefiting from advances in RISC processors, a downward trend in memory prices, and the availability of compact and reliable hard drives to build computers into the printers to process and move image files.

Dye-diffusion printers at the low end of the price spectrum put the processing burden on the host, often a dedicated host or print server. Issues such as work flow and the need to share the printer with other users are considerations that will help users decide whether to acquire a low-cost "dumb" printer or a printer with memory and processing power. In shared environments, for example, you want to avoid sending full-page, bit-mapped, continuous-tone images over a network.

Image-processing capability is a second benefit of increased processor performance. The soft subtlety that makes dye-sublimation prints look like photographs is not an asset when it comes to text and line art. In these cases, image-processing software can identify text and apply edge-enhancing algorithms.

Using color is becoming a lot easier, less expensive, and more common. With such developments as color management systems, people will be able to move their work from one type of printer to another, and even onto a press, with a pretty good understanding of what the final result will look like. Threshold products appeared this year, including low-cost dye-diffusion and thermal-transfer printers, thermal-transfer printers with plain-paper capability, ink-jet printers with improved colorants, and the industry's first desktop color laser printer. Thanks to price and performance improvements and the beginnings of a color-capable infrastructure, an ever-widening pool of people will be able to use these new capabilities. ■

Michael Zeis is president of Blackstone Research Associates (Uxbridge, MA), a market research and publishing company. He is the editor of the Color Business Report, *a newsletter on color products and markets. You can reach him on BIX c/o "editors" or on CompuServe at 72351,1712.*

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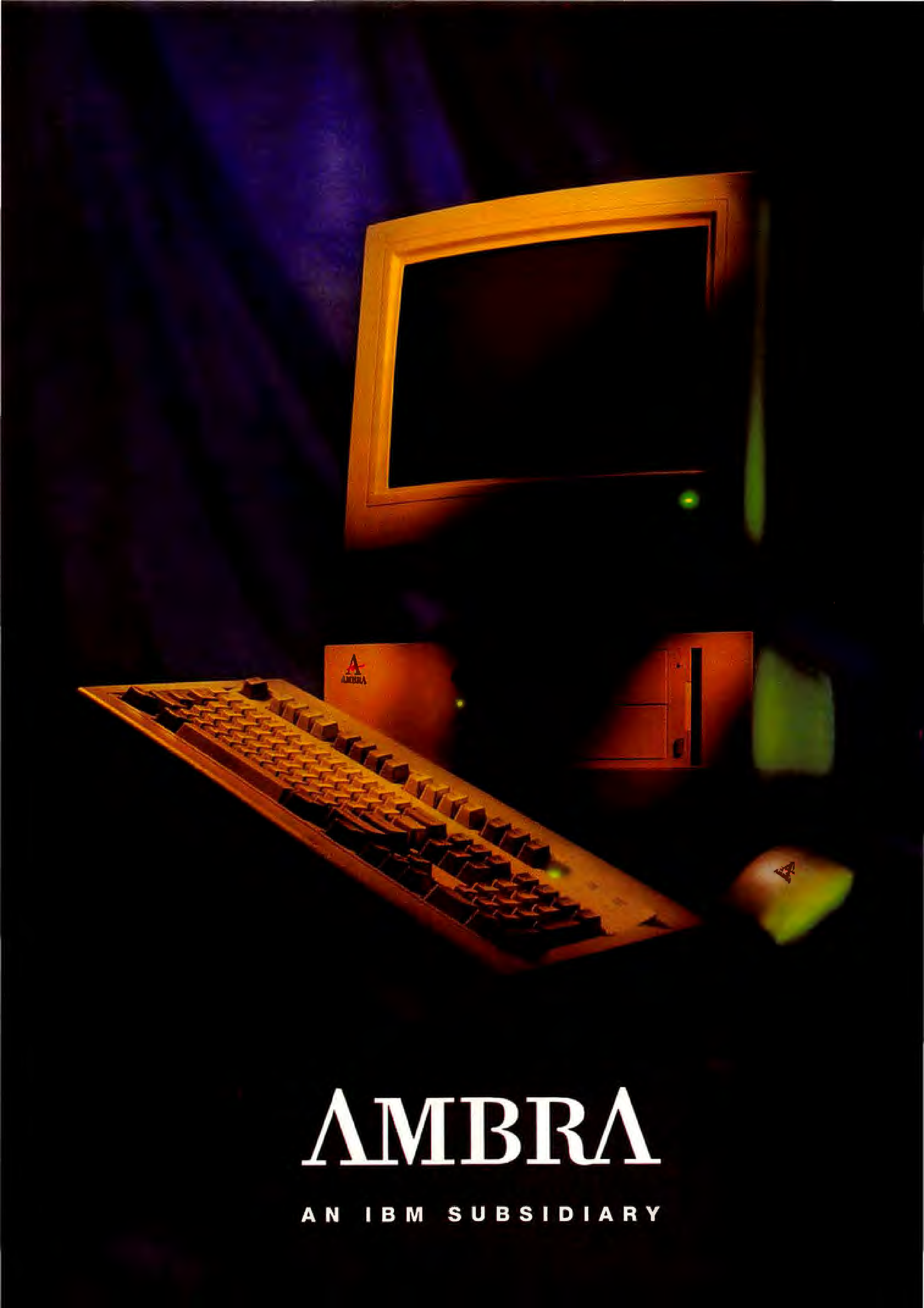
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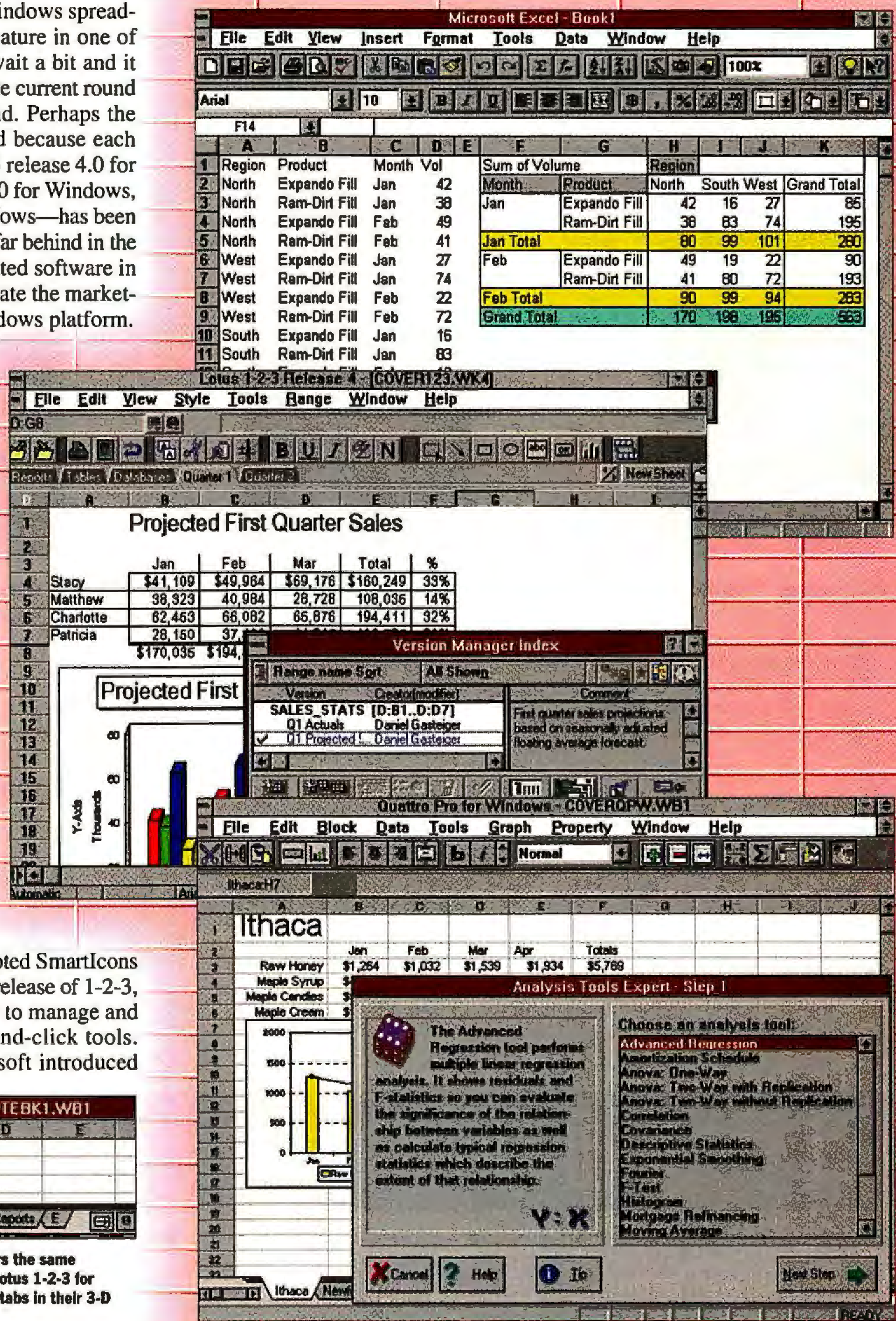
The Big Three Square Off

Borland, Lotus, and Microsoft have released major updates to the three market-leading Windows spreadsheets

DANIEL GASTEIGER

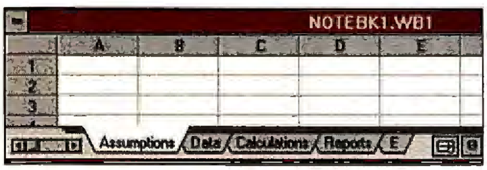
It's easy to summarize the Windows spreadsheet milieu: If you like a feature in one of the Big Three's programs, wait a bit and it will be in everyone's software. The current round of upgrades emphasizes the trend. Perhaps the similarities are more pronounced because each of the spreadsheets—Lotus 1-2-3 release 4.0 for Windows, Borland Quattro Pro 5.0 for Windows, and Microsoft Excel 5.0 for Windows—has been updated recently; none is lagging far behind in the upgrade cycle. With all this updated software in place, it is a perfect time to evaluate the market-leading spreadsheets on the Windows platform.



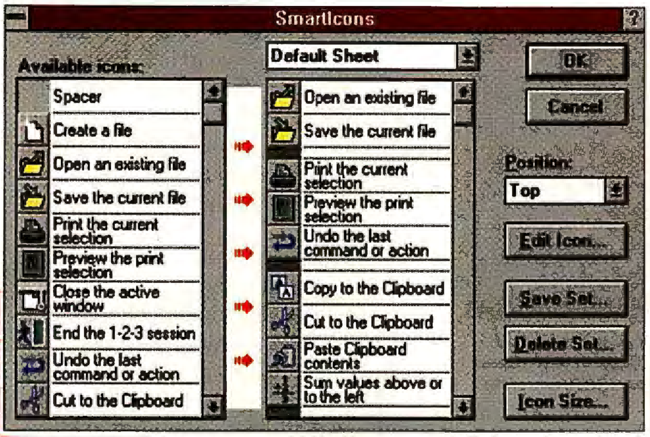
Monkey See, Monkey Do

Lotus popularized 3-D worksheet files with 1-2-3 release 3. Borland built 3-D into Quattro Pro for Windows but also added index tabs and the ability to name each sheet. Microsoft soon offered a 3-D environment that acted more like a stack of linked spreadsheets than a single 3-D file. This time around, Lotus and Microsoft validate Borland's expression of the 3-D concept: You will find nameable index tabs on all three Windows spreadsheets. Each product does 3-D in its own style, but the results are functionally equivalent.

All three spreadsheets emphasize icons more than their predecessors did. Lotus adapted SmartIcons from Ami Pro and, with the new release of 1-2-3, also provided a powerful facility to manage and create libraries of these point-and-click tools. Meanwhile, Borland and Microsoft introduced



Borland's Quattro Pro 5.0 for Windows offers the same spreadsheet tabs as its predecessor. Both Lotus 1-2-3 for Windows and Microsoft Excel include sheet tabs in their 3-D spreadsheet files.



Lotus has added a powerful SmartIcon management facility that lets you design and save libraries of icon palettes as well as draw your own SmartIcons. Both Excel and Quattro Pro offer similar capabilities. While Quattro Pro's icon facility may be the most powerful of the three, it is also the most challenging to customize.

speedbars and toolbars of icons to issue one-click commands. Quattro Pro 5.0 and Excel 5.0 provide even more powerful tools for customizing icon utilities.

Use of the right mouse button in Windows applications has been slow in coming, but all three vendors are now on the bandwagon. Borland was the first to offer *object inspectors* in the form of menus that appear when you highlight a block of cells and press the right mouse button. Now 1-2-3 and Excel offer similar functionality: You can highlight a range in a spreadsheet, click the right mouse button, and, from a menu, choose options such as cut and paste and range formatting.

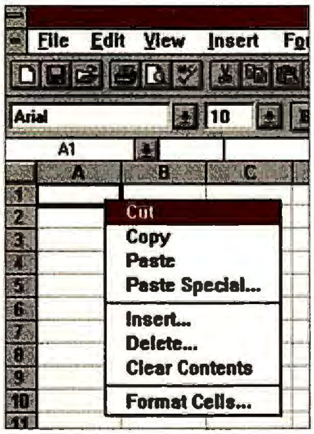
Buzzword Wars

The buzzword *drag-and-drop* is popular in the spreadsheet market. This capability lets you highlight a range and drag it to a new location without using menus or clicking icons. The three products implement drag-and-drop differently. In 1-2-3, the mouse pointer changes to an open hand when you move it near the edge of a selected range. Hold down the left mouse button, and the hand closes; you can then drag the range about on the sheet. It's cute, but it's a good way to give feedback to the user.

In Quattro Pro, you highlight the block, point anywhere within it, and hold down the left mouse button until the mouse pointer turns into a hand. Then you can drag the block. If you do not want to move the block, drag a little sooner after pressing the mouse button.

Excel allows you to move a range by selecting it and moving the mouse cross-hairs to its border. When the cross-hairs turn into an arrow, press the left mouse button and drag.

Looking for more @ functions? All three spreadsheets offer them. Microsoft has always led the field, offering more spreadsheet functions than you can shake a formula at. Now Borland and Lotus deliver similar volumes of functions. The expanded collections handle more database calculations, more business-related analyses, and many obscure statistical analyses.



When you select a cell or range and click the right mouse button, Excel pops up a menu like the one shown here. All of the Big Three Windows spreadsheets offer similar right-mouse-activated menus.

Handling of databases—both in-sheet and external—varies a bit from one spreadsheet to the next, but you can adjust from one approach to another without much effort. For external database access, Excel has dispensed with the third-party product Q+E from Pioneer software. Now it offers the Microsoft Query add-in, a database-querying application that you make available from the spreadsheet via an add-in manager.

Lotus has also changed its database access capabilities by building them into the 1-2-3 point-and-click interface. The new tools drive DataLens (which gives you access to external databases) far more easily than the old database Criteria and Output ranges, which have survived more than 10 years of spreadsheet technology. Borland's Database Desktop hasn't changed. It still lives as a stand-alone application program that ties to the spreadsheet with DDE links. All three database access facilities offer dialog box–driven and menu-driven interfaces to manipulate both spreadsheet and external database tables.

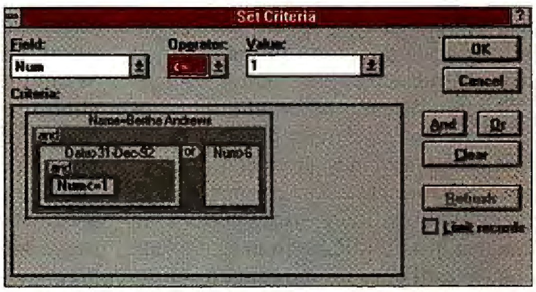
Icons Everywhere

While piling more and more features into their spreadsheet programs, the developers are also constantly tweaking basic aspects of the user interface. For example, consider the icon bars each program sports. It's nearly impossible for every one of these tiny pictures to convey its purpose, particularly when so many icons are available. So each spreadsheet provides clues to the use of an icon.

In 1-2-3, you point at an icon and press the right mouse button to display a description of the icon's purpose at the very top of the display—right where you're looking, if you work with the palette in its default location. But if the description isn't enough to clue you in, you're out of luck—there's no further help about an icon.

Simply pointing at an Excel icon and pausing for a moment causes a description of the icon to appear at the very bottom of the screen. That's a big trip for your eyes to make when you're trying to track down a useful icon. At the same time, an abbreviated icon description (called a *tool tip*) appears right next to the mouse pointer. The sum of the information is equivalent to what 1-2-3 tells you about its SmartIcons, but scanning to the bottom of the display and back while looking for a specific icon becomes tedious. Worse, those tool tips can become distracting. Lotus's help-on-demand approach seems less condescending than this Microsoft method.

Pointing at an icon in Quattro Pro is also enough to produce a description way down at the bottom of the display. To get more information, you hold down the Control key and press the right mouse button. That's a lot of finger gymnastics for the payoff: a description that's about as detailed as the ones that you get in Excel and 1-2-3. On the other hand, Quattro Pro's Object Help message boxes include help buttons that you can click on to get more



Lotus 1-2-3 for Windows release 4.0 offers a new dialog box–driven interface for querying both in-sheet and external databases. This interface lets you specify complex criteria to single out desired database information. Quattro Pro and Excel offer similar point-and-click query tools, although 1-2-3's is better integrated with the spreadsheet.

detailed information about the procedure the icon initiates. The detailed help is not about the icon, however—only about the menu commands for which the icon is a shortcut.

Calling On the Experts

"Ease of use" is a mantra of the Big Three spreadsheet suppliers. In Quattro Pro for Windows, a feature called Interactive Tutors offers on-line lessons for various spreadsheet tasks. These tutors let you work with your own data or with canned spreadsheets that come with the product. You can pop up an interactive tutor at any point in a work session and either retain the results of your lesson or dump them and return to your original spreadsheet. What distinguishes the approach is that you work in a live spreadsheet while following a lesson.

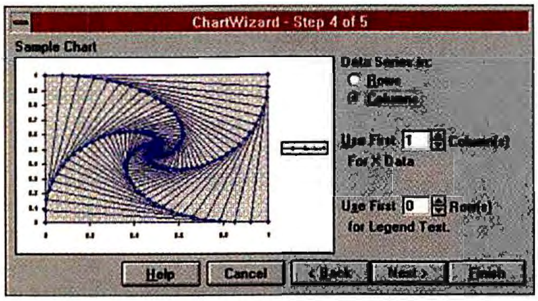
Quattro Pro's Interactive Tutors contrast with Excel's extended help system, which packs examples and demonstrations throughout. Once you've asked for help on a topic, you can sometimes order up a demonstration as well. There's a table of contents for the examples and demos, so you can quickly track down a topic.

Lotus 1-2-3 also offers a lesson facility. You simply pull down the Help menu and choose Tutorial to pull up a menu of options. There are only eight lessons, but they run alongside a live worksheet. Switching from the tutorial window to the spreadsheet and back is a bit awkward and might confuse a new user. Still, you can learn from the tutorials, so it's hard to give them bad marks.

Excel's Wizards are step-by-step instruction sets that lead you through procedures that traditionally have been difficult in a spreadsheet. For example, when you elect to add a graph to the worksheet, the ChartWizard appears, alerting you to the number of steps adding a graph will take, telling you what options you can apply, and prompting you for information Excel will need to display a finished graph.

The new version of Excel introduces Tip Wizards. This new tool analyzes your work and determines shortcuts for commonly performed tasks. For instance, if you resort to the menu bar to perform an operation that is available from the toolbar, a Tip Wizard pops up and suggests clicking on the appropriate toolbar icon. Tip Wizards will not suggest the same tip twice in one Excel session, so the tool is not overly annoying.

Quattro Pro's Experts are similar, but



Microsoft Excel's ChartWizard pops up automatically when you begin to build a graph based on spreadsheet data. The Wizard guides you through each step of the procedure.

unlike a Wizard, an Expert appears only on request. You can select from a small list to work through such tasks as graphing, consolidating data, and building financial or statistical spreadsheets. Interestingly, the financial spreadsheets you can build with Quattro Pro's Analysis Tools Experts resemble templates that you might build yourself or obtain from a user-group library or an on-line information service. They are, in effect, macro-driven spreadsheets that you retrieve when you wish to perform the calculations they provide. The Analysis Tools Experts can lead you to wonder why spreadsheets haven't always included collections of prebuilt financial models.

Lotus 1-2-3 for Windows offers no feature analogous to Wizards and Experts. Lotus has offered multimedia help with a version of 1-2-3 for Windows that comes on CD-ROM, but availability of such a CD for 1-2-3 release 4.0 for Windows hasn't been announced. If you're having trouble with any spreadsheet procedures, you have to rely on the software's more traditional help facilities. But don't sweat it; you can virtually bank on Lotus providing a Wizard or Expert equivalent in a future release.

The Similarities Are Endless

An article that discusses all the similarities among the Big Three Windows spreadsheets would fill a good-size book—bigger, perhaps, than the documentation sets that accompany these software programs. Each spreadsheet offers a version or scenario manager that lets you build several sets of assumptions into a single spreadsheet, and lets you switch from one set of assumptions to another quickly so you can compare their effects on the bottom line. Each offers such amenities as the ability to center labels across several columns rather than just within cells, or the ability to assign multiple fonts, font styles, lines, shadings, and colors to the ranges and entries in your spreadsheets.

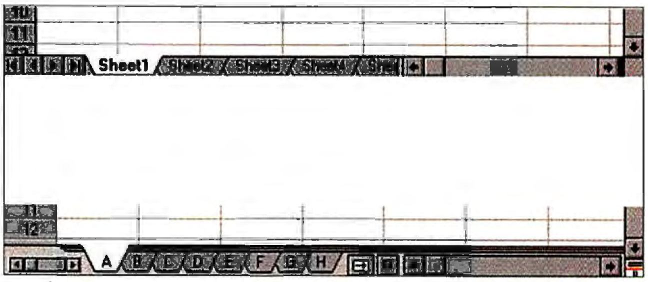
In each package you'll find a mechanism that automatically adjusts a column's width to fit the widest entry in the column. You'll also find a way to generate number series and label series rapidly: You can fill a range with successive weekdays, months, and number series such as Quarter 1, Quarter 2, Quarter 3, and so on. In fact, you can create your own fill series (e.g., lists of employees or of your company's product line) and automatically deliver the list to a spreadsheet by employing the quick-fill feature.

Sadly, neither 1-2-3 nor Quattro Pro provides a tool to let you create a custom sequence. You must use your knowledge of the spreadsheet to add entries in a disk file associated with the spreadsheet software. Excel, on the other hand, contains an easy-to-use editor that lets you add fill sequences by either typing them or importing them from spreadsheet cells.

Spreadsheet Subtleties

If the Big Three Windows spreadsheets share so many features, what could possibly set one apart from the others? Surprisingly little. The differences are subtle.

Consider 3-D spreadsheets. Borland calls its 3-D spreadsheet a *notebook*, and each new notebook you create contains 256 layers, or pages. The index tabs that identify pages appear at the bottom of the window that holds them. To accommodate the tabs, Borland introduced a scroll bar that doesn't run the full length of the object it controls. This takes some initial adjustment—and continued adjustment if you regularly work with several Windows programs. Every time you set out to scroll



Excel's arrangement of sheet tabs and controls (top) looks a lot like Quattro Pro's. In both products, the nonstandard horizontal scroll bar makes navigating a nuisance compared to getting around in 1-2-3.

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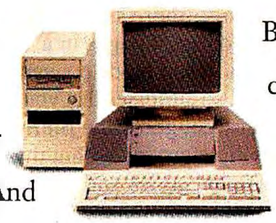

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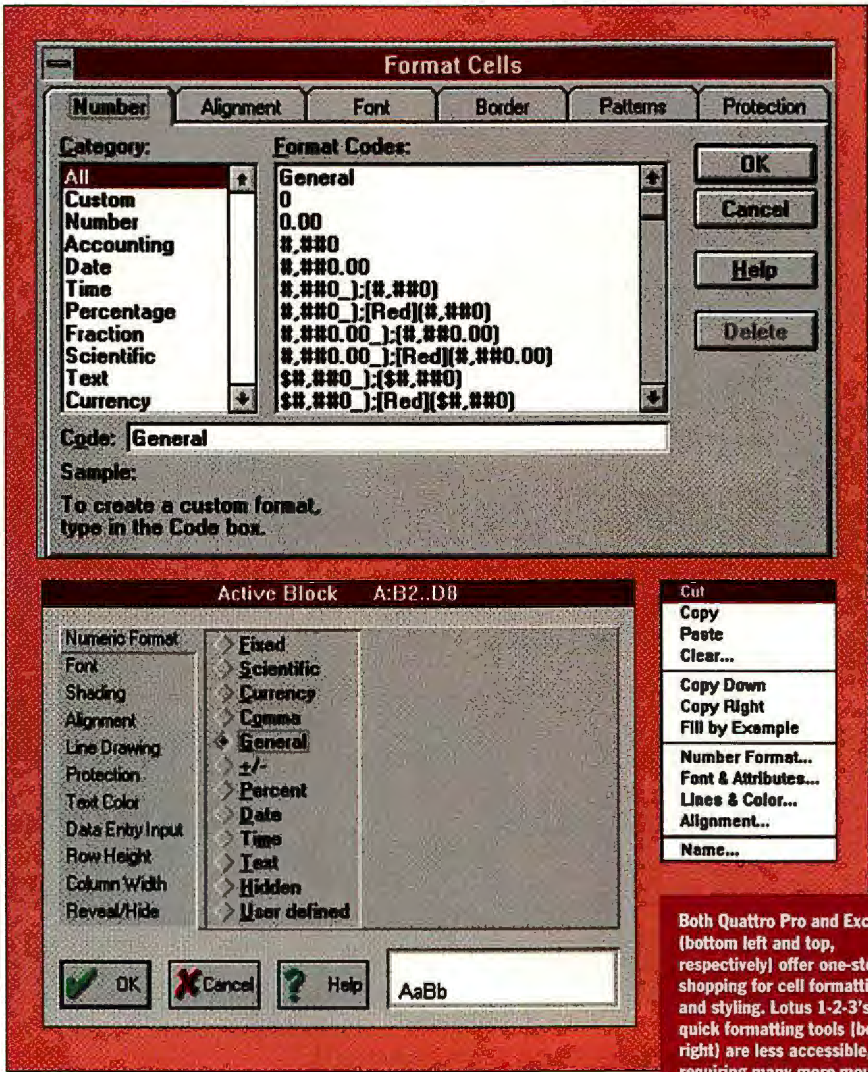


Both Quattro Pro and Excel (bottom left and top, respectively) offer one-stop shopping for cell formatting and styling. Lotus 1-2-3's quick formatting tools (bottom right) are less accessible, requiring many more mouse-clicks and keystrokes to get the job done.

across the Quattro Pro spreadsheet, you could find yourself pausing a moment to look for the undersize control.

Quattro Pro's notebooks have two great advantages. You can rearrange the pages in a notebook by simply dragging index tabs from place to place. And you can group any number of consecutive pages so that any formatting and styling you apply automatically affects the other grouped pages as well.

Lotus 1-2-3's 3-D spreadsheets are just files that can contain up to 256 worksheets. Unlike a Quattro Pro notebook, a new 1-2-3 file contains only a single sheet. You can add and delete sheets at will so that a file never contains more sheets than you need for the application you're building.

Another difference in 1-2-3 is that its index tabs appear across the top of the spreadsheet window, along with controls to navigate from sheet to sheet, add new sheets, and hide and display the index tabs. Placing the tabs at the top of the window leaves the bottom free to hold a full-width scroll bar. This design is much easier to use than Quattro Pro's short scroll bar.

Conversely, there is no easy way to change the order of pages in a 1-2-3 file. And 1-2-3's group mode connects all existing pages, so attributes that you apply on one appear throughout the file; you can't create multiple groups within the file and apply different styles and formats. Considering that Lotus was the first of the Big Three to offer a 3-D spreadsheet, it's surprising that it hasn't yet added these simple capabilities.

What of Excel's first serious rendition of 3-D? In terms of number of layers, Excel stakes out a middle ground. An Excel *workbook* starts out with 16 worksheets. You can change this default number, but the most sheets a new workbook can contain by default is 255. Once you open a new workbook, you can add sheets until you've filled RAM. Like Borland, Microsoft put the index tabs at the bottom of the worksheet window, and the worksheet navigation scroll bar extends only partway across the window.

The biggest quirk in managing worksheets in Excel arises when you insert a new sheet: The package automatically places the new sheet in front of the current one. This means there's no way to insert a sheet at the very end of a workbook. Lotus 1-2-3 lets you specify whether to add a new sheet before or after the current one, and the issue is moot in Quattro Pro since you always have a full notebook in that program.

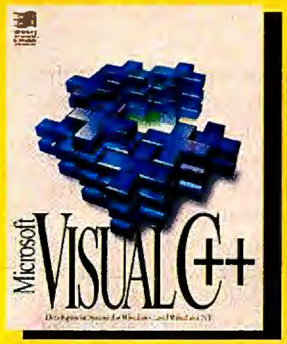
Quick Menus

Quick menus are another area of functionality that points up subtle differences between the Big Three Windows spreadsheets. The original Quattro Pro for Windows offered *object inspectors* that appeared whenever you clicked the right mouse button. You can still get to those object inspectors by clicking the right button, but there's an added step when you're working with block objects in the spreadsheet. Now, instead of the Attributes dialog box that lists such options as fonts, shading, colors, formatting, and so on, Quattro Pro presents a menu of options for cutting, copying, and pasting entries; inserting and deleting columns and rows; and filling cells with numbers or label series. The first choice on that menu is Active Block Properties, and it leads to the object inspector of the original Quattro Pro. That object inspector lets you work with 11 dialog boxes to establish formatting and other attributes of a selected block.

Lotus 1-2-3's right-button menu resembles Quattro Pro's menu except that 1-2-3 divides the Active Block Properties option into several subcategories. Still, by selecting from the choices Number Format, Font & Attributes, Lines & Color, and Alignment, you can eventually establish the same settings that you'd establish using Quattro Pro's block-object inspector. Because 1-2-3 doesn't group all the styling and formatting options in a single dialog box, establishing all desired options for a selected range can be more work-intensive in 1-2-3 than in Quattro Pro.

To upstage both 1-2-3 and Quattro Pro, Excel's right-button pop-up menu offers a Format Cells option. Choosing it leads to a stack of dialog boxes identified by

Microsoft



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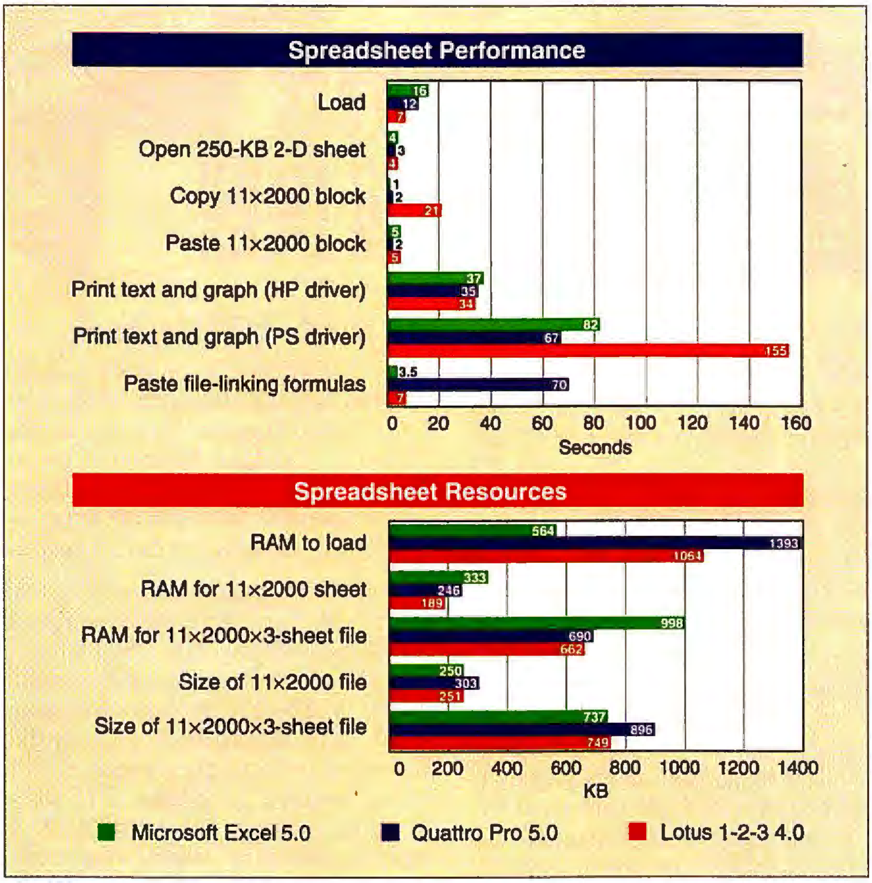
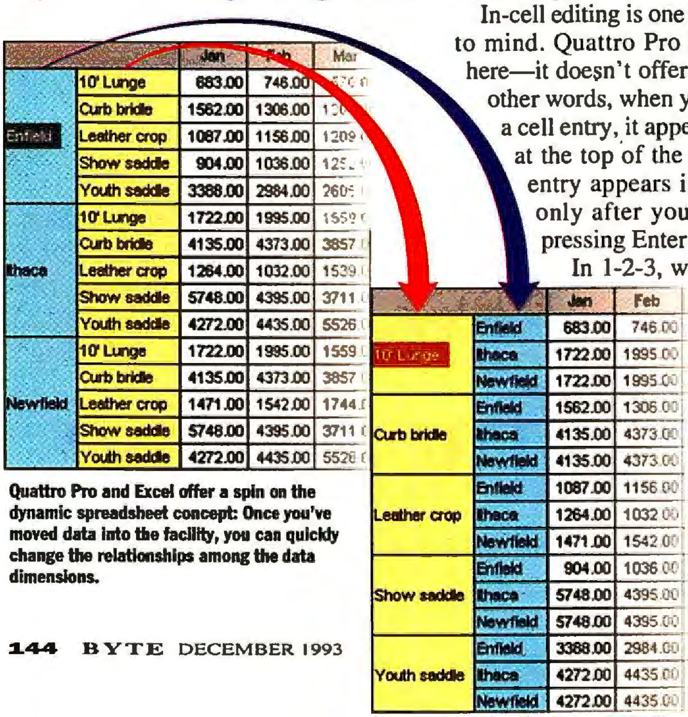


I performed some common tasks to compare the Big Three spreadsheets. The top graph displays performance; the bottom graph shows resource usage. Shorter bars indicate better performance.

index tabs. Click a tab to activate the Number Format dialog box, and when you're done there, click another tab to change a selected range's fonts and font styles. The approach is similar to Quattro Pro's all-in-one pick list of formatting options, and it speeds the formatting of a range of cells.



Quattro Pro and Excel offer a spin on the dynamic spreadsheet concept: Once you've moved data into the facility, you can quickly change the relationships among the data dimensions.

Distinguishing Characteristics

The similarities between the Big Three Windows spreadsheets are extensive. But there are a few significant differences between the Big Three spreadsheets; how important those differences are may be a matter of personal taste.

In-cell editing is one feature that comes to mind. Quattro Pro is the big winner here—it doesn't offer in-cell editing. In other words, when you type or modify a cell entry, it appears in the edit box at the top of the display. The new entry appears in the spreadsheet only after you store it there by pressing Enter.

In 1-2-3, when you start typing, the characters appear both in the edit box and in the spreadsheet. Having the entry appear first in the sheet is sensible; after all, this is where a user will be looking. On the other hand, in-sheet editing is at best confusing when the cell you're editing is surrounded by other data cells. Only by clicking with the mouse in the edit box can you switch to good old-fashioned editing in the control panel. Excel also employs in-cell editing.

None of the Windows spreadsheets' editing capabilities are as good as those of the original 1-2-3 for DOS. In that spreadsheet, you could see at least part of a cell's original contents unchanged right alongside the version you were editing.

Another area in which the products differ significantly is in their offerings of advanced data analysis tools. Each offers some type of problem-solving facility in which you specify a target result and the software figures out what numbers to plug into your spreadsheet to return that result. Each offers sophisticated database analysis tools for cross-tabulating databases and calculating subtotals. Each offers powerful tools for statistical problem solving, including the capability to perform rapid regression analysis. The great divergence occurs with the data slice-and-dice tools.

Lotus introduced slice-and-dice technology with Improv. Borland and Microsoft offer similar slice-and-dice functionality where any spreadsheet enthusiast would really need it: bundled with the spreadsheet software. Improv's slicing and dicing is far more sophisticated than that of Quattro Pro and Excel, but the facilities that come with these new spreadsheets may be all you'll ever need.

Slice-and-dice spreadsheets are sets of multidimensional data. For example, a list of product sales volumes by region and subcategorized by month would be a 3-D data set. With a traditional spreadsheet, once you have laid out the data, you face gargantuan effort to rearrange it so the spreadsheet shows sales volumes by month and subcategorized by region. With Quattro Pro and Excel, you can spin such spreadsheet data off into the Data Modeling Desktop or Pivot Table facilities, respectively. Then you can quickly rearrange data along any dimensions to gain more insights into the relationships among the numbers.

Perhaps what sets 1-2-3 apart from the other Windows spreadsheets is its accessibility to people making the transition from a DOS version of 1-2-3. While both Borland and Microsoft try to convince you that the transition to their Windows spreadsheets is easy, such claims are overblown. In 1-2-3 for Windows, you get 1-2-3 for DOS when you press the slash key; if you don't want to take the time to learn the

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—Ronald W. Evans
Publisher

Windows way of doing something, you needn't bother. In both Quattro Pro and Excel, you're going to spend time learning the equivalents of commands you're accustomed to using in 1-2-3 for DOS.

Office Suites

Instead of buying a stand-alone spreadsheet, many organizations are looking at bundles of office applications that work well together. This allows an organization to standardize on a set of common applications and to centralize support from a single vendor. Microsoft claims that over half of all copies of Excel are sold as part of Microsoft Office, so the trend toward office suites is clearly a significant one.

Lotus was first to include the newest version of its spreadsheet with a highly integrated suite of office applications. The company has incorporated many common features into all the products in SmartSuite release 2, its Windows bundle. This makes it easy for users of one Lotus Windows application to move among all the office applications.

Microsoft is redesigning the applications shipped with Microsoft Office so that they will share components and even a common menu structure. Thus, if you're working with Excel, Word, or PowerPoint, it will be easier to find certain menu options, since they will be in the same location in each application. To ensure even tighter integration, the new version of Excel, as well as Word 6.0 for Windows, supports OLE 2.0. OLE 2.0 will let you embed an Excel spreadsheet in Word (or any other word processor supporting OLE 2.0) and edit the spreadsheet without leaving the Word document. Only the menu will change. At this point, it looks as though Microsoft Office 4.2 (scheduled to ship in January) will be a formidable competitor in the office suite market.

The Borland applications suite is less appealing. It includes WordPerfect for Windows, from an independent software company. This makes the suite's synergy somewhat suspect. An initiative on the scale of Microsoft's—redesigning the interfaces to ensure consistency—is not likely to happen.

Connectivity is another area in which the Big Three are starting to battle. Lotus has mail-enabled its Windows spreadsheet, which means that you can transmit and receive E-mail from within 1-2-3. More important, you can send worksheet ranges, charts, and other drawn objects via E-mail when you have the right complementary software. Quattro Pro offers a similar

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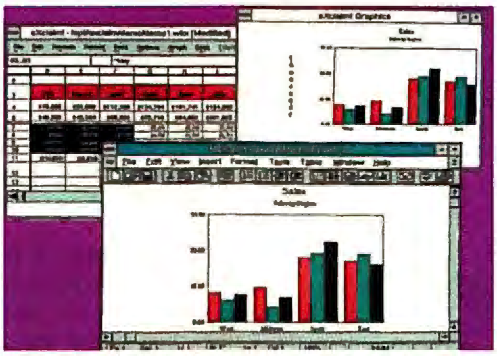

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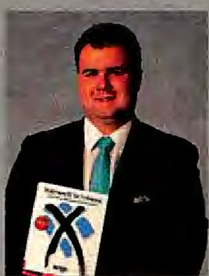
MicroAge Applauds 32-bit X Server for its Vim, Vigor and Very Good Value

Staten Island, NY — Michael Conroy, Systems Engineer for MicroAge, likes AGE's new *Desktop Edition*, but he loves its big brother — *XoftWare™/32 for Windows*. "We tell our customers it's the turbo-charged version — with the throughput and process power to handle a broad range of robust Unix applications and databases. It gives MS Windows PCs workstation-like functionality." Conroy says he was surprised at its ease of use. "You figure when you get the power, you sometimes lose friendliness, but that's not the case with AGE's products. I particularly like MPSS™ — the Multi-Process Start-up System, which lets users start multiple applications simultaneously, saving valuable time." Conroy says he likes the 32-bit offering's price point, $395 (or $495 with Novell's TCP/IP bundled). He's also looking forward to the upcoming 32-bit X server for MS Windows NT, which will be priced at $495.



MicroAge's Michael Conroy: If fast is good, faster's better!

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capability, with the added benefit that it manages data exchanges via MCI Mail. Excel also has a file-sharing facility; you can quickly create a routing sheet to manage distribution of a file over a network.

For Power Users

Microsoft is making waves by adapting Visual Basic as Excel's new macro language. For high-end developers, having the power of this Windows compiler available to drive a spreadsheet is an exciting prospect. Eventually, you'll be able to tie together all of Microsoft's Windows applications with Visual Basic programs. On the other hand, Visual Basic is a big step up from spreadsheet macros. Excel's macro language has always been the most challenging of the Big Three, but moving to Visual Basic is going to scare away a lot of spreadsheet users who lack formal training in programming.

To be fair, the macro languages in the Windows versions of 1-2-3 and Quattro Pro are less accessible than their DOS counterparts. Rather than extend the recorded keystroke metaphor into the Windows environment, 1-2-3 and Quattro Pro adopted keyword-driven macro languages. You can no longer stumble into macros by virtue of having learned the menu sequences for needed commands; now, you must learn several hundred keywords and their syntaxes. While most DOS users could master the languages of their respective spreadsheets, few Windows users will ever build sophisticated macro applications without constantly referring to the documentation.

Performance Measures

How well do the Big Three perform? I prepared a dozen or so worksheets that perform common spreadsheet tasks and used them to compare several processes. I performed tests on a 50-MHz 486 computer with 8 MB of RAM and on a 25-MHz 486SX with 4 MB of RAM. I changed none of the products' default settings before testing; I tested how the software works right out of the box. The graphs on page 144 summarize the results.

There are some interesting things to note about the test results. For example, while Excel uses only 564 KB of RAM to load, it eats up more system resources (in terms of percentages) than either 1-2-3 or Quattro Pro. And while Excel creates the smallest disk files, those files use up more RAM than the competitors' files.

Quattro Pro is quickest with many calculations, but it creates the largest disk files and calculates file-linking formulas abysmally slowly. Lotus 1-2-3 handles resources best, but it's dramatically slower at printing PostScript files. Lotus 1-2-3 is also way out of line in copying large amounts of data to the Clipboard: A simple copy command took more than 10 times as long as the next-slowest spreadsheet.

For the last performance measure, I tried to retrieve a large 1-2-3 WK3 file into all three spreadsheet products. Only 1-2-3 release 4.0 was up to the task. Although they can read the omnipresent WK3 file format, Quattro Pro and Excel took much longer to load large spreadsheet files. This may cause problems if you work with large spreadsheets in the native WK3 format.

Don't overemphasize the importance of these performance measures. None of the spreadsheets is so bad at anything that you should automatically rule it out. So that brings us to the primary question: Which Windows spreadsheet should you buy?

The answer depends on what you're already using. If you are working with an existing release of one of these three, you should just upgrade the product. DOS spreadsheet users have a tougher decision to make. Quattro Pro users will find it as easy to move to one Windows spreadsheet as to another. Lotus 1-2-3 users should not even consider changing product lines: Lotus 1-2-3 release 4.0 for Windows is well designed and easy to use, and it offers the most natural upgrade path from 1-2-3 for DOS into Windows. ■

About the Products

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Daniel Gasteiger is a spreadsheet consultant and copublisher of The Spreadsheet Consultant *newsletter. He can be reached on BIX c/o "editors" or on MCI Mail as "Daniel Gasteiger."*

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The NetWare CD-ROM Solution

Microtest's Discport provides plug-and-play CD-ROM installation on NetWare, letting people share CD-ROM drives

STEVE BOSAK

In a perfect networked world, administrators could add CD-ROM drives anywhere on the network without bringing down a server and without the hassles of juggling SCSI cards, jumpers, and several NLMs (NetWare loadable modules). They could run a simple software installation to choose local managers for these CD-ROM drives and leave the choice of applications to the workgroups. On the receiving end, the network user could call up a simple menu of available CD-ROM applications and click on the appropriate icon to run an application. And changing a CD-ROM application would be as simple as switching the disc and listing the new title for the group.

Microtest's Discport is a $695 hardware-and-software product that makes installing CD-ROM on NetWare 3.11 and higher this flexible and easy. The Discport hardware module attaches as a node on 10Base-T and thin Ethernet networks. You can chain up to seven external CD-ROM drives to one Discport box and control as many as 10 Discport units from any one server. An NLM loaded on a NetWare server controls access to the CD-ROM drives attached to the Discport. The NLM is small, about 150 KB.

Elegant Windows-based software, called Discview, handles Discport installation, as well as management and use of attached CD-ROM drives. The Discport also comes with a DOS version of Discview with a command-line user interface.

Microtest's Discport makes it easy to attach CD-ROM drives to a NetWare network. Drives attach to the SCSI connector on the front of the unit using the cable provided, while a twisted-pair or thin Ethernet cable attaches to one of the connectors at the rear (inset).

How It Works

The heart of the Microtest package is an AC-powered black box the size of a VHS videotape. Thin Ethernet and 10Base-T connections occupy one end of the Discport, and a standard SCSI port connector the other (see the photo). To install, you hook the box to the network through any BNC cable or RJ-45 connection available on the network. A CD-ROM drive (or a chain of them) plugs into the SCSI connector using the cable provided.

The compact Discport unit is a SCSI-2-to-Ethernet translator. Each Microtest box transmits a unique six-digit Ethernet ID when plugged into the network and looks like an Ethernet node to NetWare. CD-ROM drives physically attached to a Discport unit, however, appear logically attached to a NetWare server. Microtest's Discview NLM, loaded on the server, recognizes IDs under its control on the network, intercepts CD-ROM accesses directed to the server, and redirects them over the network to the appropriate Discport unit. The Discport box then translates the Ethernet request into the appropriate SCSI commands for the target drive.

The Discport system treats CD-ROM data similarly. During a SCSI read command, for example, the Discport takes data sent out from the active CD-ROM drive, converts SCSI blocks into Ethernet packets, and sends the packets over the network to the server, which then delivers it to the user node. Sending data over the network twice isn't usually a performance problem because of NetWare's drive caching and because bandwidth on most network cabling is underused. The result is to make CD-ROM drives available on the network with full NetWare management, but without bringing down a server to install them.

Easy Installation

You install the Discview software first. Logged on as supervisor, you run Windows and install the software from a floppy disk using the Setup program; the software checks to be certain you're running NetWare 3.11 or higher and that you're using the proper revision of CLIB.NLM (Discview requires that you have version 3.11d with a date of 12-16-92 or later). The installation kit includes a disk with the proper CLIB on it, and good thing—the test server was running an old version.

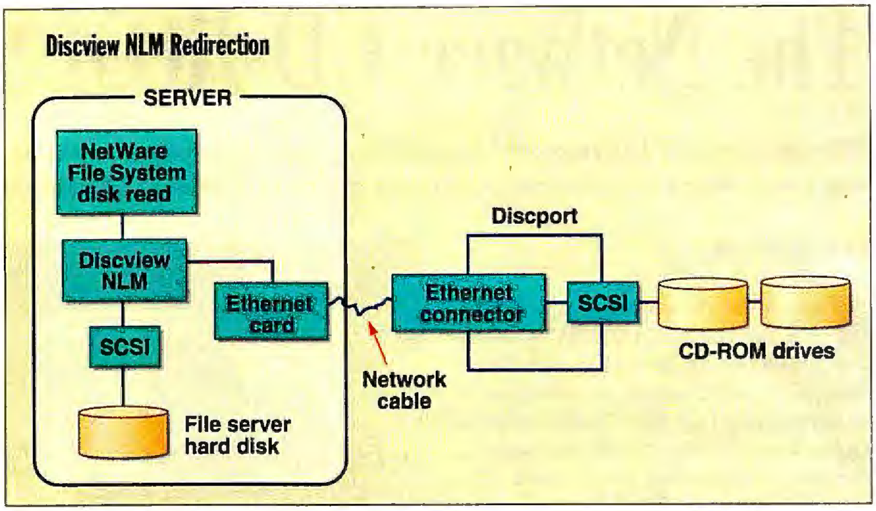
Once the Discview NLM is loaded, the installation program asks for the names of all managers you'd like to assign to the Discport. Users and groups are listed in a dialog box, so adding them to the management list is only a matter of clicking on the appropriate names. Users assigned to the Discport can add or remove drives, change CD-ROM applications, or physically move a Discport box to another location on the network.

The hardware is installed next, with up to seven CD-ROM drives per Discport. Plug in the drive or chain of drives and hook up the Ethernet or 10Base-T cable, and the box begins downloading its firmware information through the Microtest NLM. Because the Discport reloads its "smarts" each time it's turned on or the Microtest NLM is reloaded, updates and changes to the box's firmware are as easy as installing new software.

The Software

The Discport's underlying mechanism is clever, but the accompanying management software is where the Discport package shows its true worth for both LAN administrator and user. Users run the Windows-

Reviews The NetWare CD-ROM Solution



The Discport attaches *as a network node, but CD-ROM drives attached to it appear logically attached to a server due to Microtest's NLM. The NLM on the server reroutes CD-ROM accesses directed at the server to the Discport, which translates between Ethernet packets and SCSI-2 blocks.*

based Discview access and control program on each workstation as needed to connect to CD-ROM drives. There is no memory-resident component taking memory at user workstations.

The beauty of the Microtest system and software is that they enable users and group managers to configure the ports and the CD-ROM data any way they see fit. A manager loads the Windows-based Discview software and clicks on the Discview Map menu item; a graphical representation of available servers and all Discports appears. The manager clicks on the Discport icon, gives it a meaningful alias such as Marketing, and then assigns it to a server running the Discport NLM.

Once the port is configured, it appears as a tree attachment to the selected server, and all attached CD-ROM drives appear with the tag New Volume. Clicking on one of the new volumes lets you configure that volume. The software reads the disc in the drive and displays its name. The manager assigns an alias to the disc, allowing end users to "see" the disc as CorelDraw or Sales Database, for example, when they load their own Discview software.

Once mounted and assigned aliases, discs are ready for access by any user the manager grants access to. By default, mounted discs are assigned to Everyone, but the manager can limit access by selecting previously assigned groups or users from a pick list in the configuration.

End users access the CD-ROM applications by clicking on the Discview icon from within Windows. The main screen lists groups of CD-ROMs available and ready to run from within Discview, those previously mounted but no longer in a CD-ROM drive, and those that are in the CD-ROM drive but need to be assigned a drive letter before running. Users on the network can see only the discs that they have rights to, which appear in the list of available applications with their assigned aliases. On CompuServe and the company's own BBS, Microtest has made a number of batch files and icons available for making virtually any CD-ROM application run by merely clicking on its alias.

Installing, configuring, and using the Discport over my test network were much less painful than some experiences configuring stand-alone CD-ROM drives to a single PC. Texel and Toshiba CD-ROMs that I attached to the Discport performed much as they did when hung directly off the server. Applications ran smoothly, with acceptable speed. While Discport drives can run multimedia programs, Microtest doesn't recommend this; the resulting data can load down some servers.

Microtest's Discport is the fastest, easiest, and most flexible way to add CD-ROM to an existing NetWare 3.11 Ethernet network. Microtest has announced a Token Ring version and a Macintosh version for delivery next year. ■

About the Product

Discport......................$695
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Phoenix, AZ 85016
(800) 526-9675
(602) 952-6400
fax: (602) 952-6401
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Steve Bosak (Chicago, IL) is coauthor of The CD-ROM Book *(Que Books/Prentice-Hall, 1993). He can be contacted on BIX c/o "editors."*

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TOM THOMPSON

One fact dominates when you consider color printing: It's expensive. While you can expect to spend about $1700 for a good color ink-jet printer, prices can rise to $4000 for a high-quality thermal-wax printer and surpass $10,000 for a dye-sublimation printer. The price tag per page printed isn't cheap, either. Color ink-jet printing can cost as little as 8 cents per page (comparing favorably with around 5 cents per page for black-and-white laser printing), but the costs for thermal-wax consumables start at about 50 cents a page, and dye-sublimation costs can rise above several dollars a page.

Recently, several vendors have bucked the high-price status quo. Of note, Fargo's Primera thermal-wax printer with its dye-sublimation upgrade and Star Micronics' SJ-144 thermal-transfer printer have pushed the low end of the price range for these normally expensive technologies close to $1000 or below. You don't get something for nothing, however. Lower prices come with modest sacrifices in print quality and a bigger cut in printing performance.

Do low-cost printers deliver? I compared the Primera and the SJ-144 to Hewlett-Packard's 1200C color ink-jet printer, which is expensive for an ink-jet but low-cost for a color printer.

Clockwise from foreground: Inexpensive color printers from Star Micronics, Hewlett-Packard, and Fargo. Star Micronics' SJ-144 and Fargo's Primera break the $1000 price barrier for thermal-transfer color printing by leaving the image processing to the host system. With its photo-realistic upgrade, the Primera is the least expensive dye-sublimation printer by far.

Color Basics

Color printing's high costs arise from the complexity of the color printing process itself and the materials used. Compared to black-and-white, color printing consumes up to four times as many image-producing materials. That's because three or four colors instead of one are applied to the paper, using pigmented wax, dye, or ink. Further complicating the situation for ink-jet and thermal-wax technology is that the pigments are opaque, so spots of color can't be laid one atop another. Instead, colored spots are packed closely together in dithered patterns that visually approximate the desired color. Dye-sublimation printing mixes the pigments together within a special polyester paper to create the exact color. (For more information on color printing technology, see "Color Becomes Affordable" on page 123).

Although many factors make color printers expensive, an important one is the computing power needed to process color images, particularly when dithering is involved. In what seems like computing's Jurassic era of just a few years ago, generating a dithered color image on a simple printer (composed of just a print engine and a controller) severely taxed the processors of desktop computers. Most manufacturers solved this problem by equipping printers with a CPU and memory dedicated to the task of processing the image. This solution relieves the desktop computer of the job, but it also drives up the printer's price, since you're essentially buying a computer within the printer.

The processing power of desktop computers has improved dramatically in the last year, however. Today's 66-MHz 486-based and 40-MHz 68040-based computers can process reams of color data with aplomb. This lets the printer vendor, via the printer driver, harness the desktop computer's power and have it perform the color image processing. The vendor then reduces costs by eliminating the printer's processor and memory and instead using a simple controller to handle the incoming color data stream—a return to the simple printer design.

Both Star Micronics and Fargo use this strategy to break the $1000 price barrier. Star Micronics' SJ-144, a 360-dot-per-inch heat-fusion printer, costs only $599. Fargo Electronics' Primera, a 203-dpi thermal-wax printer, costs $995. For an additional $249.95—or $1244.95 total—you can purchase a photo-realistic option that converts the Primera into the lowest-priced dye-sublimation printer in existence. The HP DeskJet 1200C, a 300-dpi ink-jet printer that costs $1699, just squeezes under the bar as a low-cost solution. It costs more because it uses the computer-within-printer design. However, it's only about $450 more than the dye-sublimation version of the Primera, and its high-quality output and expandability make it valuable if you do lots of printing. All three printers use a standard Centronics parallel interface.

continued

For testing, I connected the printers to a 66-MHz 486-based PC equipped with 16 MB of RAM, a 340-MB hard drive, and Windows 3.1. For test output, I used three applications that these printers might be expected to handle. The first test prints a chart made in Microsoft Excel 4.0, and the second prints a large (1.6-MB) scanned 24-bit-color image from Adobe Photoshop 2.5. To create the scanned image, I used an Epson ES-800C scanner—known for its high-quality images—attached to a Mac Quadra 800. The third test prints a complex drawing with Adobe Illustrator 4.0. This last test creates a color wheel that gradually traverses the entire color spectrum and thus shows how well the printer reproduces various colors and handles subtle color gradations.

To judge how the print job affected use of the computer, I timed how long it took each task to complete. Two times were recorded: the interval from issuing the application's print command to when the imaging process finished and returned user control, and the "click to klunk" time, which comprised the first time interval plus the extra time it took for the finished page to pop out of the printer. To minimize overhead, I disabled Windows' Print Manager and ran only the test application during the timing tests. Since all these printers purport to print on plain paper, I used Hammermill laser-printer paper for my tests in addition to the special coated papers supplied by the vendors, which achieve noticeably better results.

COLOR PRINTING PERFORMANCE

The HP DeskJet 1200C with its built-in processor and memory proved fastest in nearly all tests even when running its Windows PostScript driver. One exception was the Illustrator 4.0 test with the PCL 5C driver. The host system was a 66-MHz 486-based PC with 16 MB of RAM; slower systems will result in longer printing times, especially for the Primera and SJ-144, which rely on the host CPU for image processing.

	EXCEL 4.0 CHART	PHOTOSHOP 2.5 IMAGE	ILLUSTRATOR 4.0 GRAPHIC
Star SJ-144			
Release application	135	218	289
Page eject	196	227	324
Fargo Primera (wax)			
Release application	187	198	305
Page eject	194	205	312
Fargo Primera (dye)			
Release application	579	544	837
Page eject	589	549	871
HP DeskJet 1200C			
Release application	3	61	1603
Page eject	90	182	1927
HP DeskJet 1200C/PS			
Release application	3	191	36
Page eject	95	295	363

Note: All times are in seconds.

Star Micronics SJ-144

The SJ-144 from Star Micronics is the smallest of the lot, measuring 12⅘ inches wide by 5½ inches deep by 6⁹⁄₁₀ inches tall, and it weighs only 5½ pounds. It also has the smallest price tag, $599. Its small size lets the SJ-144 fit easily on a desk in a small or home office. The vertical paper-supply tray helps preserve the printer's small desktop footprint, but there's no receiving tray for output. You'll have to provide space for a "landing zone" where the paper pops out of the printer's side.

Despite its low price, the SJ-144's innards are surprisingly sophisticated. There is a 35-KB buffer for caching fonts and bit maps, and a 176-KB data buffer. The printer's firmware also has eight built-in bit-mapped fonts. It supports automatic emulation detection for NEC Graphic Command, Epson LQ-860, and IBM Proprinter X24E emulations. For overseas users, the printer supports six IBM Code Page character sets (IBM character sets that support a number of foreign language characters). Star also provides 15 TrueType fonts for use with Windows applications.

The SJ-144 uses a 144-element print head that shuttles back and forth across the page to create 360-dpi output. A cartridge resembling an oversize audio cassette contains the four-color ribbon the printer uses to lay down color on paper. Printing on overhead-projection films and strip labels requires special cartridges. The pigmented material used in the SJ-144's heat-fusion printing process is not a thermal wax but a polyester resin, which makes the output immune to problems of thermal-wax prints such as scratching, flaking, and melting. The cost per page ranges from 5 cents for monochrome output to $1.80 for color output.

Printing times varied from a little over 2 minutes for the test Excel chart to nearly 5 minutes for the Illustrator drawing (see the table "Color Printing Performance"). The finished page arrived alongside the printer anywhere from 9 seconds to a minute later. During one test, the SJ-144 stopped in the middle of a job because the cartridge ribbon gave out. I popped the cover, removed the spent cartridge, and snapped in a replacement, and the printer picked up from where it left off. Kudos to Star for coping with this problem without wasting the customer's time and paper.

The initial prints I made suffered from white lines—minute breaks in pigment coverage. Fortunately, there's a quick fix. You can set the SJ-144 to an adjustment mode in which the paperfeed is modified in 1/720-inch increments. This mode prints out a black pattern that emphasizes the overlaps or breaks in the output. Using this pattern as a guide, you press buttons on the printer's top, tweaking the paperfeed rate to obtain uniform pigment coverage. Once I made some adjustments, the output looked lots better. But be prepared to make occasional readjustments. This problem is especially noticeable on scanned images and makes the use of the SJ-144 for image printing problematic.

To check out the resin's resistance to heat, I put several prints into BYTE's environmental test chamber and cranked the temperature up to 160°F. This is hotter than the inside of a closed car on a sunny day. The material on the hot prints didn't smear or smudge at all. Score another point for Star.

The overall print quality was decent, given the printer's price, and the text quality was good. However, the color-wheel test showed some color banding (abrupt jumps from one color to another), and the SJ-144 didn't do well with scanned images. Several test images printed fine, but most appeared highly posterized, with flat colors.

continued

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A Walk on the High End

If you're curious about what's happening on the high end of the color-printer scale, check out Kodak's ColorEase PS Printer. It's a 300-dpi dye-sublimation printer equipped with 16 MB of RAM and a 40-MHz SPARC RISC processor. An internal 120-MB hard drive lets you cache outline fonts on the printer, rather than having to repeatedly download different font sets for different print jobs. It has 35 Type 1 fonts and a PostScript Level 2 interpreter built in.

For computer connections, the ColorEase offers a Centronics parallel port, a DB-9 RS-232 serial port, and a mini-DIN-8 LocalTalk port. Two 50-pin high-density SCSI connectors let you attach an external SCSI hard drive. An Ethernet interface board is optional. Windows and Mac drivers are available.

The ColorEase prints on polyester paper and overhead-projection film. Costs for 100 pages of paper and overhead film are $65 and $115, respectively.

Ignoring the time it takes for the computer to shuttle image data to the printer, the ColorEase prints a page using three-color ribbon in about 3 to 4 minutes. The one flaw in the output is that the ColorEase's yellow is a rich gold color—resembling the yellow on Kodak's film boxes—rather than a lemon-yellow. This results in goldfish yellows on the BYTE Lab's color-wheel output test.

Naturally, at $7999, output is gorgeous. Typical of 24-bit-color dye-sublimation output, the color wheel had no banding and no dither patterns. Scanned images output on the ColorEase practically resembled photographs in quality, and complex drawings from Illustrator were splendid.

Professional artists, illustrators, and photographers will enjoy the ColorEase's high-quality output. However, due to the yellow color shift I observed, you might want to examine some test prints to see if the ColorEase can serve your color proofing needs.

Fargo Primera

The $995 Primera is somewhat larger than the SJ-144, measuring 13¾ inches wide by 10½ inches deep by 5⅘ inches tall and weighing 16 pounds. The length jumps to 17½ inches with the paper-supply and receiving trays extended. A Macintosh printer driver was in beta at the time of this review, and a special $200 serial-to-parallel adapter cable connects the printer to a Mac.

The Primera's guts are fairly minimalist. The printer has two internal fonts, Letter Gothic and, for overseas users, the IBM Code Page 850 character set. As is typical for thermal-wax designs, a three- or four-color wax-impregnated ribbon is drawn across a wide print head with multiple small heater elements that melt dots of wax onto paper. The Primera can print on plain paper or overhead-projection film. Its 203-dpi output resolution is the lowest in the group. Monochrome (black) prints cost you 10 cents per page, while the cost of color prints ranges from 46 cents (three colors) to 57 cents (four colors) per page.

Using a four-color ribbon, test printing times ranged from about 3 minutes for the Excel chart to over 5 minutes for the Illustrator graphic. Pages popped out of the printer after a further 7-second delay. The color-wheel test showed little banding; the Primera lays colors on the paper in a page-wide swath, so it doesn't have the striping problems of a poorly adjusted SJ-144. The Primera also dealt better with scanned images: Most were acceptable in quality, although some colors were a bit muddy when plain paper was used. This printer's weak spot seems to be text, which looked more like bit maps from an impact printer than something from a 203-dpi printer.

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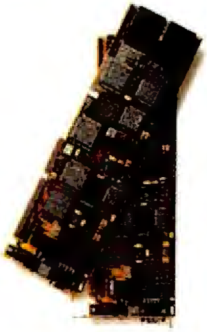

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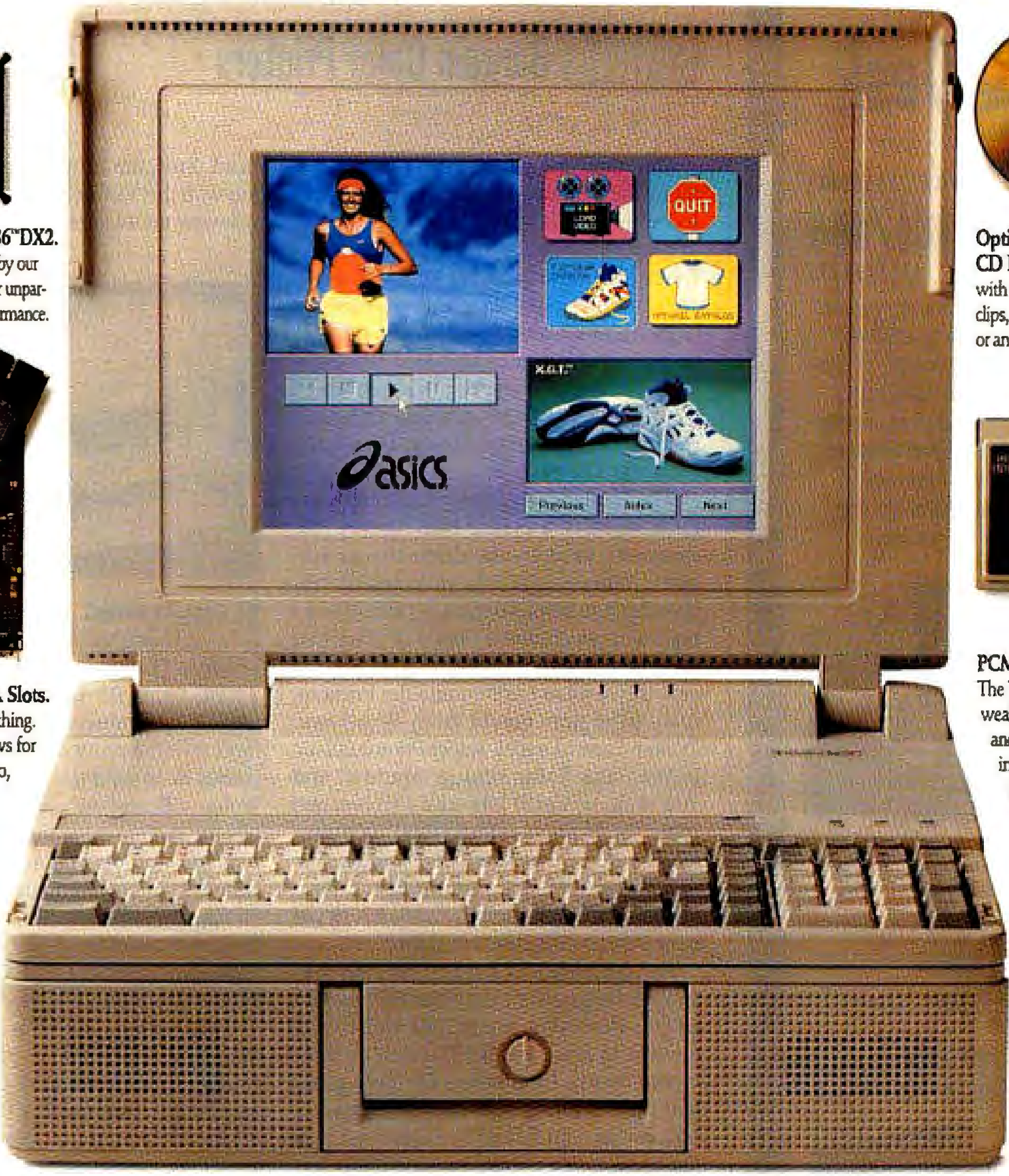

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One annoying glitch is that if you forget to put the paper in far enough for the paper feeder to pick it up, you don't get an out-of-paper message. Instead, Windows proffers an I/O error message stating that the printer isn't responding and advises you to increase the retry value. While the Fargo printer driver uses standard Windows printer-error messages to report problems, a simple out-of-paper problem shouldn't send you off into a blind alley. Hopefully, Fargo will fix this.

The Primera's dye-sublimation upgrade kit consists of a plastic holding tray (the same one used by the thermal-wax ribbon), a three-color dye-sublimation ribbon that can print 10 images, 10 pages of polyester paper, and a floppy disk with an upgraded Windows driver. You put the new tray with the ribbon into the Primera, install the new driver from Windows' Printer Control panel, select Photorealistic in the Page Setup dialog window, and you're done. Refill kits with a ribbon and paper for 25 prints ($89.95) and 100 prints ($279) are available. Cost per page skyrockets to $3.60 per page for the 25-page refill kit, dropping somewhat to $2.79 per page for the 100-page refill kit.

Printing slows to a crawl with the dye-sublimation option. Both the Excel chart and the Photoshop image took well over 9 minutes to print, and the Illustrator graphic took nearly 14 minutes. The only problem I had printing with the Photorealistic option was with Excel; it insisted on using the three-color thermal-wax ribbon setting, which hung the printer. I had to have Excel active while resetting the ribbon type to Photorealistic in the Printer Control panel, repeatedly resetting the ribbon type *again* in Excel's Page Setup window, and then attempting to print—all through a blizzard of Out of Memory warnings from Excel. Ultimately, I bludgeoned Excel into submission, and a page fell into the Primera's hopper 9 minutes later.

The Primera's dye-sublimation output is impressive. Scanned images looked terrific. Except for obviously bit-mapped text characters, the Excel chart looked professionally made. The color wheel showed virtually no color banding.

When you compare the page to the output from a Tektronix Phaser IISD or Kodak ColorEase, you can see some dither patterns in the Primera's output. That's because the Primera reproduces only 18-bit colors, versus the 24-bit colors used by the more expensive printers. There's also some faint streaking, a registration artifact of the page crawling past the print head. Still, the Primera does an excellent job with this technology for only $1244.95, whereas the Phaser IISD costs $10,000.

HP DeskJet 1200C

I've looked at this 300-dpi ink-jet printer before ("Testing the Colorful DeskJet 1200C," July BYTE, page 25), but a brief review of features is in order. It's the largest of the printers (19 inches wide, 7½ inches deep with the paper tray, and 11½ inches tall, and weighing 27 pounds) and has the largest price tag ($1699). A modular I/O slot lets you add a LocalTalk or Ethernet interface board so that several computers can share this printer on a LAN. Windows and Mac drivers are available. I looked at a DeskJet 1200C with the $700 PostScript option installed.

The DeskJet 1200C is representative of the pricey computer-in-printer design—pricey for ink-jet technology, that is. It has an 11-MHz Intel 960SA RISC processor, 2 MB of RAM, and 35 Intellifont and 10 TrueType typefaces. It also has HP's own PDLs (page definition languages), PCL 5C and HPGL/2, built in. SIMM sockets let you add more RAM and Adobe PostScript Level 2 support. Four cartridges supply colored inks to a print head that wipes back and forth, applying stripes of ink onto the paper. The cost per page varies from 8 cents to $1.61 per page, depending on the type of media (plain, coated, or glossy paper, or overhead-projector film) and the amount of ink applied to the page.

I used HP's PCL 5C Windows driver to print the three test files. The PostScript Level 2 option was already installed, so with a flip of two DIP switches and some mouse-clicks, I printed the files using the PostScript driver. As the times in the table indicate, the DeskJet's internal processor pays off in moving the print job from the computer onto the printer. Many times, the computer was finished in well under a minute, while the DeskJet labored for several more minutes until a page appeared.

A notable exception was printing the Illustrator test file using the PCL 5C driver:


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The computer ground away for nearly a half-hour on the job. What happens is that Illustrator (and other drawing applications) first generates PostScript code. When confronted with a non-PostScript printer, Illustrator has Windows perform a metalanguage rendition of the PostScript information. Then the printer driver converts this to PCL 5C. In other words, the image goes through three separate PDL conversions before appearing on the printer.

The DeskJet 1200C's output looks good. The dither patterns in the color wheel produced very little color banding. Scanned images looked good, as did the Excel color chart. There was, however, some very faint striping on plain paper. The DeskJet's bevy of built-in fonts and its resolution enhancement feature graced its output with the best-looking text. Printing quality on graphics images is superior to that of the SJ-144 but even on special coated paper doesn't approach the quality of the Fargo Primera's dye-sublimation output.

The Price Tag

For the home or small office on a tight budget, the Star SJ-144 and Fargo Primera offer the means of creating color reports or artwork. The SJ-144 is good at text, charts, simple artwork, and labels. In terms of output quality and price, the SJ-144 compares favorably with HP's 500c color ink-jet printer. If your work uses scanned images or complex drawings, consider the Primera. Also, the Primera is unique in delivering photo-quality output for folks operating on a shoestring budget.

A growing business handling lots of reports with text, artwork, or a mix of the two may want to take the price hit and buy the versatile HP DeskJet 1200C. It can be shared among computers as the office grows, and workers are spared the wait because the printer does the job, not their computers. While the DeskJet costs more, the cost per page for color output can often be lower than with the SJ-144 and the Primera, even using the more expensive coated papers. Keep this in mind if you plan to produce dozens of multipage reports.

The output of these printers says it all: You get what you pay for. This is not to disparage the SJ-144 or Primera. Star Micronics and Fargo are to be commended for their bold move to make color printing affordable. The Primera's inexpensive dye-sublimation output is nothing short of remarkable. The glitches I observed are representative of product start-up problems (neither printer has been on the market for a year); expect both printers' quality to improve. Some of the problems I experienced can also be chalked up to the contrariness of Windows.

To reduce printing times to a few minutes with the SJ-144 and the Primera, you need a fast 486 computer. And remember that the cost of consumables is steep. The real problem Star Micronics and Fargo face is not output quality but unrealistic expectations: You'll be disappointed if you purchase either printer hoping to get results produced by more expensive printers. If you accept their limitations, the SJ-144 and the Primera serve up decent color output without requiring a bank loan. ■

Tom Thompson is a BYTE senior technical editor at large with a B.S.E.E. from Memphis State University. Contact him on BIX as "tom_thompson" or on the Internet at tom_thompson@bix.com.

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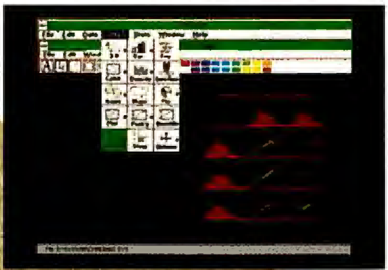

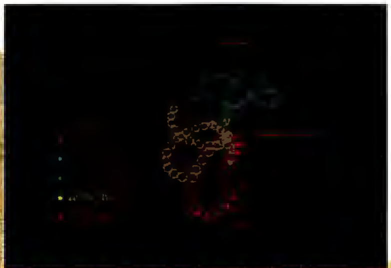

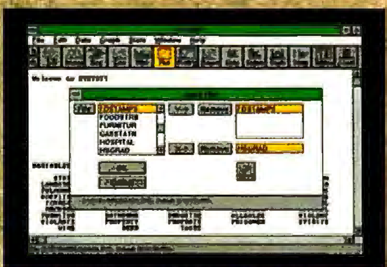

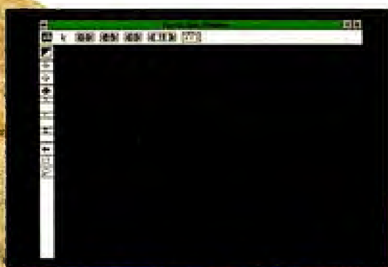

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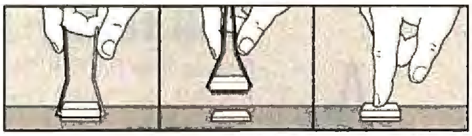

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Beyond Bit Maps

Innovative object technology in Picture Publisher 4.0 and Fractal Design PainterX2 delivers more power over bit-mapped images

CAL VORNBERGER

Micrografx Picture Publisher features an elegant, intuitive interface. Along with multiple object layers, version 4.0 includes innovative features for dealing with high-resolution images and extensive tools for creating image masks.

Fractal Design PainterX2 is an addition to Painter 2.0 for Windows that supports floating objects. The image includes a floating selection (the BYTE logo) with a custom-designed paper as a background. By copying the floating selection and blurring and darkening it, I created a soft drop shadow against the textured background.

Fractal Design, whose principal, Mark Zimmer, pioneered vector-based drawing tools in a Macintosh paint program called ColorStudio, has struck again with PainterX2, an add-on extension module for Painter 2.0 for Windows. Micrografx, known for its vector-based drawing program Designer, has recently released Picture Publisher 4.0 for Windows, an upgrade of the previous version of the image editor. Both of these upgrades are significant because of the huge strides made in functionality and ease of use, but the most significant addition is the introduction of object layers in a bit-map environment.

With most other paint programs and image editors (including Adobe Photoshop and the latest version of Aldus Photostyler), you can't move or reselect an object once it has been pasted into the bit map. If your client wants you to change the position of a pasted object, you have to start from scratch. Picture Publisher and PainterX2 let you maintain layers of floating objects. This lets you move and size multiple objects even after the objects have been dropped into the bit map. You can even change the front-to-back order of the objects and save a file with floating objects still active.

Once you start using object layers, you'll never want to go back. Pretty soon, almost every bit-map painting program and image editor will include object layers. They will become a necessary bullet in the features matrix. And they won't be required just because they're nifty; object layers are a truly useful innovation. Illustrators and designers will be asking why it took so long to happen.

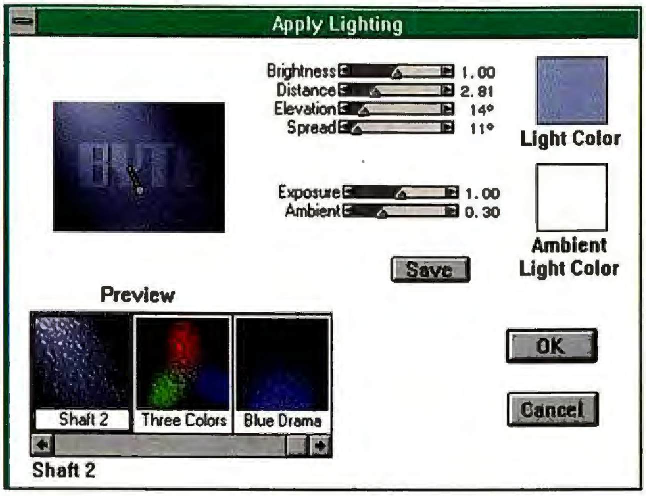
A More Powerful Painter

The two programs take slightly different approaches to adding object layers. The PainterX2 extensions require Painter 2.0 and enhance the base program with multiple floating selections. You create selections using a new floating selection tool that PainterX2 adds to the original toolbox. Any selection created with Painter's frisket tools can be turned into a floating selection. (A *frisket* is an irregular selection used to apply effects to a piece of your image.) You create shapes using these tools and then "float" them with the floating selection tool.

Using Painter's proprietary RIFF format, you can save floating selections with the image. You can also store floating selections in the new Portfolio palette. Portfolios can hold an unlimited number of floating selections and can be saved as libraries and reloaded as needed.

Floating selections are always "live": They can be moved, scaled, distorted, feathered, and given different levels of transparency, without ever being pasted down into the underlying bit map. They exist as layers on top of the bit-mapped layer and can be shuffled up and down as needed. A floating selection can contain its own background mask, which can be invoked from the Floating Selections window. This window contains several adjustments that affect the floating selection's interaction with the masking layer and the background. The Floating Selection window also contains a list of all floating selections.

continued



Fractal Design Painter mimics an artist's natural painting tools. Not only can you select brushes and media, you can even adjust the lighting effects.

PainterX2 can open Photoshop 2.5 files. If the Photoshop file contains any alpha channels, the first channel (after the RGB channels) is imported as a mask. This mask is referred to as a *background mask* to differentiate it from the floating selections that can also be masks. This is where Painter gets confusing; the manual doesn't do a very good job of explaining how these different masking tools interact. A simple Convert Mask to Frisket command would greatly enhance Painter's masking and frisketing. The program does let you import EPS files for use as friskets, although certain types of EPS files do not convert correctly.

PainterX2 has separate windows for floating selections, masks, and friskets, as well as a floating window or palette for just about every other set of features the program has to offer. When several windows are open at the same time, the underlying image is obscured. Constantly opening, closing, moving, and shuffling windows is a frustrating way to work. Some serious thought should be given to streamlining this program's interface.

Tools for the Artist

Painter shines brightest when it sticks to what it does best: mimicking natural painting tools and materials. No other program on the market puts such a powerful set of natural painting tools in the hands of computer graphics artists. Its extensive library of brushes and brush types is unrivaled. When Painter is combined with a pressure-sensitive graphics tablet, artists can create the look and feel of drawing and painting with pastels, chalk, oils, watercolors, charcoal, colored pencils, and other "real-life" media. I tested Painter with a Wacom tablet, and I found this to be an excellent combination.

Painter has all sorts of brush adjustments and controls. These dictate brush size, shape, and texture, and how the brush interacts with the surface it meets. There is a brush designer for creating custom brushes that can be saved and reloaded as needed. Fractal Design offers additional disks of custom brushes, and many custom brushes and paper textures are starting to show up on BBSes.

Brushes are important, but so are the surfaces they are used on. In addition to numerous built-in "papers," Painter lets you create custom textures. I created an image with a custom-designed paper as a background (see the opening screen). I scanned the texture as a gray-scale bitmapped image and imported it into Painter as a custom paper. I then created a color gradation and applied the paper texture to it. I imported an EPS version of the BYTE logo as a frisket and made it a floating selection. By making a copy of the floating selection and blurring and darkening it, I created a soft drop shadow against the textured background. Finally, I applied a simple color ramp to the foreground version of the logo.

As if control of paints and canvases isn't enough, Painter even lets you control the lighting of a work. A lighting control panel applies to an image various combinations of lights with colored filters. This effect can turn a mundane work into something dramatic.

PAINTERX2	PICTURE PUBLISHER
Fractal Design Painter 2.0 is a 24-bit paint program that simulates artistic media and tools, including felt pens, charcoal, watercolors, and oils. Painter also lets the artist work with a wide range of paper textures, lighting effects, and special filters. Image-editing tools are also provided. With the PainterX2 extensions, you can create multiple floating selections within a bit-mapped image.	Picture Publisher 4.0 is an image-editing program primarily designed for manipulating existing images rather than creating new ones. You can easily adjust the characteristics of an image (e.g., brightness and contrast), as well as apply special-effects filters. Creating composite images is a primary function of Picture Publisher, so the addition of floating objects lets you make changes or mend mistakes without starting from scratch.

The Micrografx Method

Picture Publisher is more direct in its handling of floating selections. It has an elegant interface that for the most part is intuitive and easy to use. Tools and functions are grouped together in a well-organized, logical manner. Micrografx refers to Picture Publisher's floating selections as objects, and the package has several tools for defining these objects. Along with a freehand drawing tool, it has rectangle and polygon tools and a magic wand, all grouped together under a single icon.

Like Painter, Picture Publisher lets you save floating selections with the image using a proprietary file format. And as with Painter, you can resize, duplicate, rotate, and group floating selections. Transparency and feathering adjustments control these parameters, and all floating selections appear in an Objects window. Layer controls are similar to Painter's.

Micrografx adds other controls to Picture Publisher's floating selections. You can merge floating selections with the bitmapped layer using a number of different operations. These options let you combine a floating selection with the background by adding, subtracting, multiplying, colorizing, or texturizing the foreground object into the background image. PainterX2 has similar features, but they are difficult to use because of poor interface design.

Picture Publisher has always included outstanding masking features. It has the usual magic wand for automatically tracing around objects, but you can also click from point to point on the object to direct the trace more precisely. Color Shields, introduced in version 3, let you use colors to define a mask. You can also create a mask channel (a gray-scale image of the mask itself) for editing and creating custom masks. And you can even use standard paint tools to add or subtract from a mask. The PaintOn tool makes it easy to fine-tune selections by using a familiar operation. You simply paint the mask onto the image.

Fun with Filters

Picture Publisher has some interesting algorithmic effects that can be applied to

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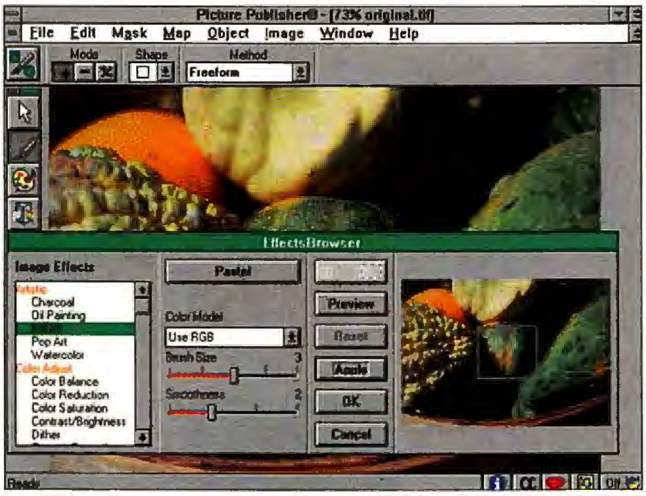

You can apply special-effects filters to your images from Picture Publisher's Effects Browser. From a single dialog box, you can apply effects, fine-tune them, and get a preview of the result. Over 40 effects come bundled with the program. Photoshop plug-ins are also supported.

images to create artistic results (Painter's cloning feature can produce similar results). Several of the more than 40 effects built into Picture Publisher 4.0 are unique. The Oil Painting and Pastel algorithms yield artistic results when applied to a scanned photograph. You can select an effect, set the effect's options, and preview the result from the Effects Browser. In addition, the program takes advantage of Photoshop Plug-ins (as does Painter). Although they show up in Picture Publisher's and Painter's menus, many of the Photoshop filters are not available, being specific to Photoshop 2.5.

Micrografx has given Picture Publisher the usual brightness and contrast adjustments, but with an unusual twist. If you choose the joystick mode, you can make changes to brightness and contrast in a highly interactive manner. Moving the joystick varies brightness and contrast simultaneously, depending on the up or down, left or right action of the mouse. This is the first interactive control that clearly demonstrates the relationship between brightness and contrast and lets you modify the two simultaneously. The color-balance control has a joystick mode that works the same way.

Picture Publisher handles text on-screen, unlike similar programs that force you to enter text in a dialog box and import it to the screen. You can enter text any place on-screen and, using the object layer, turn it into a floating selection. To use type in Painter, you have to create a type frisket; you can then save it as a floating selection and manipulate it as needed. Both programs can use TrueType and Type 1 fonts.

About the Products

PainterX2..............................$149
Painter 2.0 for Windows......$399
Fractal Design Corp.
335 Spreckels Dr.
Aptos, CA 95003
(800) 647-7443
(408) 688-8800
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Picture Publisher 4.0...........$595
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1303 Arapaho Rd.
Richardson, TX 75081
(800) 733-3729
(214) 234-1769
Circle 1077 on Inquiry Card.

One of the drawbacks in creating bitmapped computer graphics for print production is file size. A medium-size high-resolution computer image for print can be anywhere from 20 MB to 100 MB. Even on a 66-MHz 486 machine, working with files this size is slow and arduous. Fortunately, both Fractal Design and Micrografx have the same scheme to make working on these super-size image files more palatable: built-in macro recorders. The programs let you record your brush strokes, mouse-clicks, and keystrokes in a file. You can work on a low-resolution version of an image while recording your strokes and then play back the recording on a higher-resolution version of the same image.

With Picture Publisher's FastBits, you can load sections of an image into memory.

Picture Publisher has an added tool for working with high-resolution images: FastBits. This tool displays a grid over your high-resolution image, so you can work on sections of the picture one at a time. Only a small section of the image is loaded into memory, and any adjustment made to the small square of the grid is saved to the original file. This feature is most useful when you're retouching scanned images in which only small areas need work.

Common Ground

Although Micrografx claims that Picture Publisher can run on a 386 machine, the serious graphic artist will want at least a 33-MHz 486 with 8 MB of memory. Painter benefits greatly from a 486 processor; there is a noticeable lag between brush strokes and screen redraw on a 386-based machine. Both programs support the pressure-sensitive Wacom tablet; for Painter, it is almost a requirement. A 24-bit display adapter is also useful, although both programs work well in 16- and even 8-bit mode.

Both programs can open the standard graphics file formats, but only Painter can open Photoshop files in native format from both the Macintosh and Windows versions of the program. Painter can also open RIFF files from its Mac cousin. Picture Publisher, however, can open AVI (Audio Video Interleave) and edit the images in these files. This makes *rotoscoping* (the technique of drawing on individual video or film frames) possible.

Picture Publisher contains extensive printer and scanner support and includes closed-loop internal color calibration and support for external color management systems. PainterX2 adds support for the Pantone Color Matching System and an improved color tool. It also has special features for ink and paint specialists, giving animators much-needed color support for single-cel animation.

While you can create many interesting and painterly effects with Painter and its X2 extensions, the program is marred by a cluttered and disorganized interface. Despite the steep learning curve (and be warned: Adding the PainterX2 extensions makes the learning curve that much steeper), there is no other program like it on the market. The results can easily justify the time investment.

Picture Publisher is a feature-laden image-processing and manipulation program with a well-designed user interface. It is a solid, all-round competitor to such programs as Photoshop and Photostyler, designed especially for artists and designers using scanned images and outputting to print. The addition of object layers sets it apart from the crowd. ■

Cal Vornberger is a graphics designer and software developer based in New York. He specializes in multimedia applications and presentations. You can reach him on BIX c/o "editors."

A Tale of Two Alphas

DEC's new Alpha RISC chip provides high-end performance for both a Unix workstation and a Windows NT server.

RICK GREHAN

The first Alpha PCs *from DEC: the DEC 3000 Model 300 (left), a powerful Unix box, and the DECpc AXP 150, an EISA server that runs NT.*

Promising to bring to the desktop a level of computing power once available only from supercomputers, DEC's new Alpha AXP microprocessor recently arrived in two very different guises. The DEC 3000 Model 300 is a small but powerful Unix box with DEC's TurboChannel expansion bus; the DECpc AXP 150 is a compact EISA server that runs Microsoft Windows NT.

Lack of applications makes it hard to flesh out the full performance picture for these two Alpha systems, but a detailed under-the-hood examination and testing with BYTE's low-level benchmarks gets the process off to a good start. Both systems use a 150-MHz version of DEC's 21064 Alpha CPU, a 64-bit RISC chip.

The architectures of these two machines are quite different, however, with some resulting performance implications. The Model 300 channels data to its CPU via a 64-bit data bus. The AXP 150 provides the Alpha chip with a 128-bit external data bus and a 512-KB secondary RAM cache that is twice the size of the Model 300's. Although the two systems are aimed at different markets, the AXP 150 generally does a better job of getting the most power from its Alpha chip.

DEC 3000 Model 300

The Model 300 is the low end of a line of Alpha-based systems designed to run DEC OSF/1, a Unix operating system that supports the DECwindows GUI. DECwindows is more or less a variant of the X Window System. The Model 300's steep entry-level price of $9995 includes a 16-inch color monitor, 32 MB of RAM, a 426-MB SCSI hard drive, and built-in 1280- by 1024-pixel, 256-color accelerated graphics. DEC also provides OSF/1 and all necessary licenses.

Besides the model I reviewed, the DEC 3000 series includes the Model 500, Model 400, and several variants. Models differ in their initial hardware and ultimate expandability. For example, the Model 500 is capable of handling up to 1 GB of system memory, while the Model 300 tops out at just 256 MB. The Model 300 uses parity checking, while the 400 and 500 use ECC (error-correction code).

Compared to the 400 and 500, the Model 300's design sacrifices performance for the sake of cost. Its 64-bit external data bus and 256-KB external cache are half-size compared to those of the higher models. The even less expensive Model 300L forgoes TurboChannel expansion slots and runs its Alpha chip at 100 MHz instead of 150 MHz.

DEC provides several graphics configurations for the 3000 line; again, the exact configuration depends primarily on the particular model. The Model 300 system I tested came with a 16-inch color monitor driven by DEC's own HX graphics accelerator. This on-board accelerator provides eight planes of color (256 simultaneous colors on-screen), a frame buffer, and a graphics coprocessing system that off-loads from the main CPU such fundamental 2-D operations as drawing lines and rectangles. Resolution is 1280 by 1024 pixels with a 72-Hz refresh rate.

The Model 300's 150-MHz Alpha microprocessor communicates to the rest of the system through separate address and data buses (see the figure "DEC 3000 Model 300 Bus Architecture"). The 34-bit address bus contains a separate cache-tag address bus that feeds the cache circuitry; it provides the mechanism to associate memory blocks in the cache with physical memory in system DRAM.

The Model 300's external 256-KB cache is direct-mapped and write-back. The cache's write-back nature means that a write operation from the CPU does not necessarily trigger a write to the slower system memory. Data moves from the SRAM cache to the slower DRAM main memory only when absolutely necessary. This cache augments the Alpha chip's own internal 8-KB instruction and 8-KB data caches (the internal data cache is a write-through cache). For increased performance, the address-/data-control logic allows concurrent traffic between the TurboChannel bus and system DRAM and between the CPU and its memory cache.

continued

Results of BYTE's portable C benchmarks (which are still under development) for the DEC 3000 Model 300 and DECpc AXP 150. The numbers are normalized to the results of an NEC 60-MHz Pentium machine (results are indexed; Pentium results = 1.0). Higher numbers are faster. The Pentium machine's benchmarks were compiled using the Watcom C/C++ 32 compiler with its bundled 32-bit DOS extender.

TEST	DEC 3000 MODEL 300	DECPC AXP 150
Numeric sort	0.82	1.28
String sort	1.59	2.45
Bitfield	2.12	2.50
Emulated floating-point	0.99	1.17
Simple floating-point	1.00	1.81
Transcendental floating-point	1.57	1.16

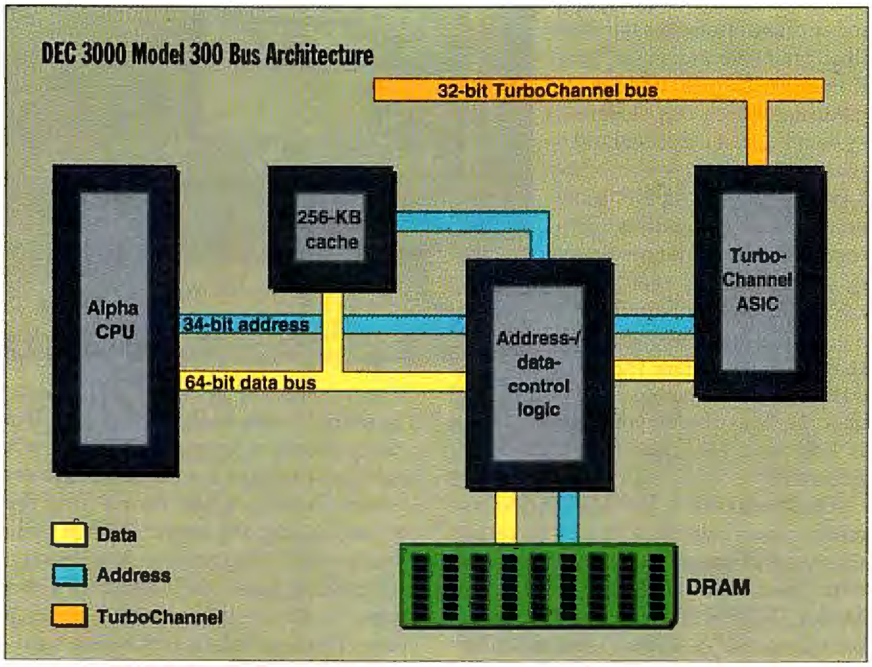
The TurboChannel expansion bus is a 32-bit peripheral bus developed by DEC. On the Model 300, peripherals plugged into one of the two TurboChannel slots can send data at speeds of up to 50 MBps. Again, the Model 300 is at the low end of the DEC 3000 line; at the high end, the Model 500, which has six slots, can pump data along its TurboChannel bus at 100 MBps.

DEC's documentation points out that 100 MBps is the TurboChannel's "architectural" throughput—that is, what the design says it can perform. Actual throughput achieved is somewhere around 90 MBps, which is still a respectable clip for a bus that multiplexes address and data lines and carries a total of 44 signal lines. As of this writing, there are between 70 and 100 TurboChannel-ready peripherals available, and although implementation of the TurboChannel requires no licensing fees, only DEC is making systems that incorporate the bus, according to a DEC engineer.

DEC's TurboChannel is not the DEC 3000 line's only conduit to the outside world. All models come with a twisted-pair Ethernet interface and, except for the Model 300L, an FDDI (Fiber Distributed Data Interface). All DEC 3000 models also include an ISDN interface, one or two serial ports, and one or two 5-MBps SCSI-2 ports. (The Models 400 and 500 have two SCSI-2 controllers.) Storage options include a 426-MB SCSI drive, and you can work your way up to over 36 GB using external storage on the Model 300, or up to 100 GB on the Model 500.

DECpc AXP 150

To the casual observer, the DECpc AXP 150 looks like a typical Intel-based EISA system. Even though it uses industry-standard PC peripherals, it is home to a 150-MHz Alpha CPU. The AXP 150 is another member of the growing ranks of systems that are counting on Microsoft's Windows NT operating system to run PC applications on a non-Intel CPU. It's also the first in an expected family of Alpha-based DECpc systems.



A simplified block diagram *of the DEC 3000 Model 300. The Models 400 and 500 have a larger cache (512 KB) and a wider, 128-bit data bus. The address-/data-control logic includes scatter-gather circuitry to manage mapping of logical addresses to physical addresses along with buffering for the TurboChannel bus and, in higher models, for interfacing the wider 256-bit DRAM data bus to the narrower 128-bit CPU/cache data bus.*

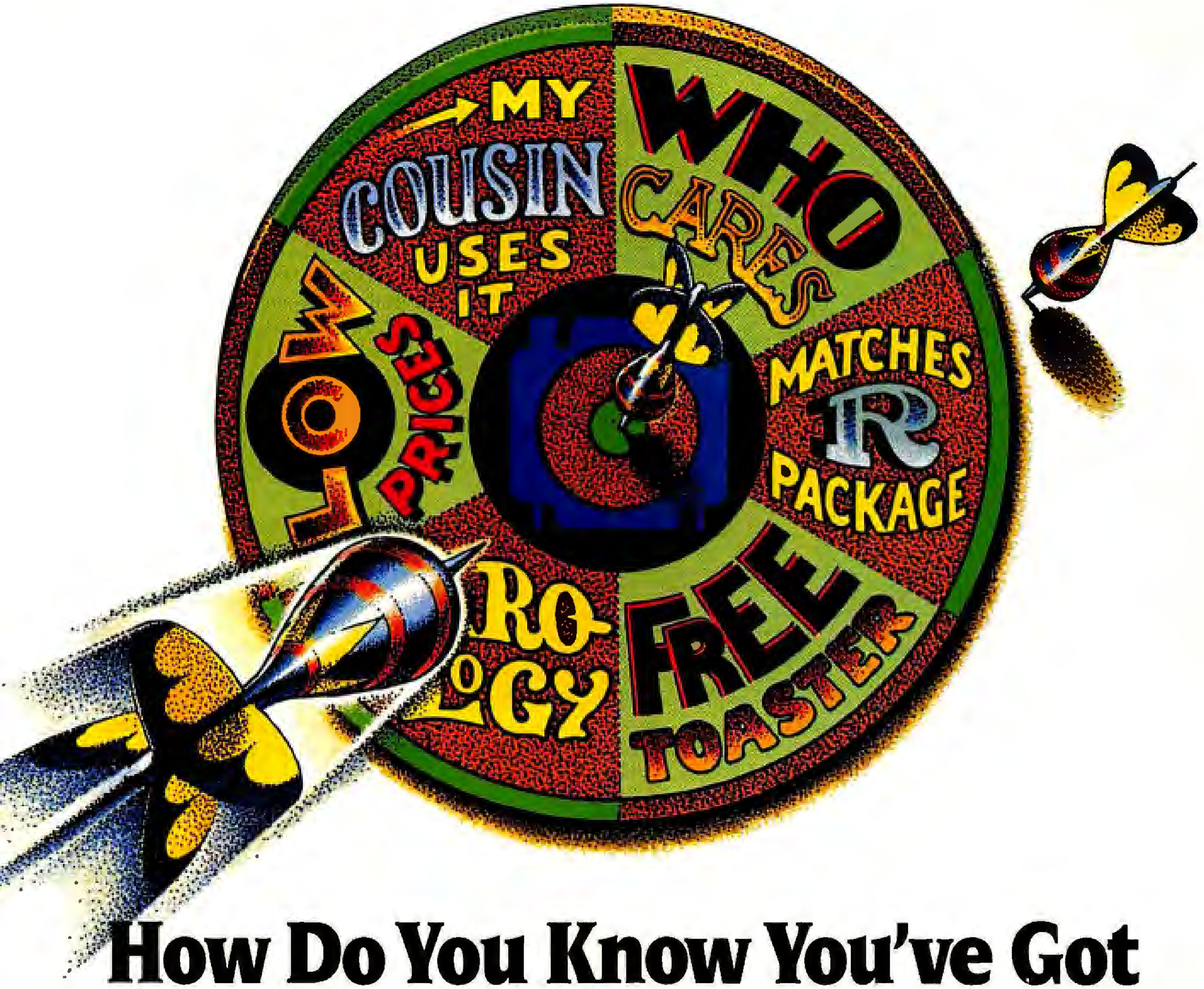
Inside the AXP 150's tower case, the packed motherboard surrounds its 150-MHz Alpha 21064 CPU with 512 KB of external write-back cache. As with the Model 300, the AXP 150's direct-mapped external cache is organized in 32-byte chunks. For system memory, there are enough SIMM sockets to take the machine from the base 16-MB DRAM configuration all the way up to 128 MB using industry-standard SIMMs.

Intel's 8235x EISA chip set manages the AXP 150's six EISA slots. Protocol-translation circuitry between the Alpha side and the EISA side of the system effectively tricks the EISA chip set into believing it's working with a 25-MHz 486 system. Buffers and interface logic handle the transitions between buses of different data widths and those using different signal protocols.

On the one hand, it is remarkable that the AXP 150 so easily links the Alpha CPU with the EISA bus. (The designer of the AXP 150 told me that attaching an EISA bus to the Alpha was actually an easy task and that there is "no rocket science in the AXP 150.") On the other hand, it's not the first time a non-Intel processor has electronically mimicked a 486 for the sake of adding an EISA bus: Witness the DeskStation Evolution RISC PC, which has its own method of marrying an EISA bus to a Mips processor (see "Mips Inside: The RISC PC," August BYTE).

For system components other than the EISA bus, a single chip handles the job of making the AXP 150 look to the outside world like a standard PC machine. VLSI Technology's VL82C106 chip provides the equivalent of two 38.4-Kbps serial ports, a bidirectional parallel port, PS/2-compatible mouse and keyboard interfaces, a real-time clock, and 66 bytes of battery-backed RAM for setup information.

DEC sells its DECpc NT systems either as complete packages with all the works or "à la carte," where you purchase the base system motherboard with case and then add drives, monitors, and other peripherals in building-block fashion. I reviewed the least expensive package, a \$6795 DECpc AXP 150 outfitted with 16 MB of DRAM, a 3½-inch floppy drive, a 245-MB SCSI hard drive, a 14-inch color monitor, a Compaq Qvision graphics card,



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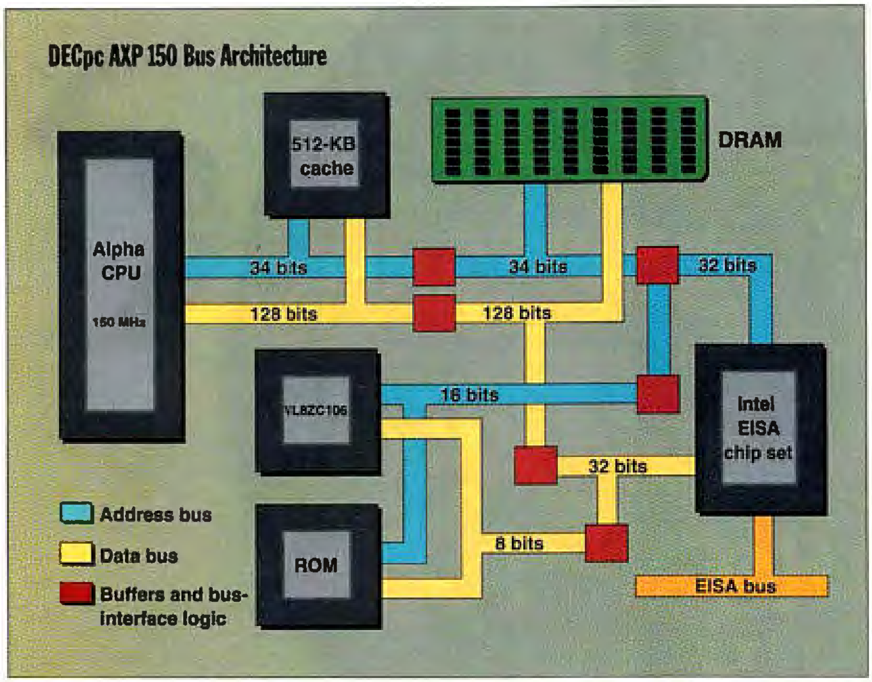

A simplified block diagram *of the DECpc AXP 150. The buffers and interface-logic components have the tricky job of connecting buses of different widths and carrying different signal protocols. The VL82C106 chip is a one-chip source of fundamental I/O devices (i.e., serial ports, a parallel port, and keyboard and mouse interfaces).*

a mouse, a keyboard, and Windows NT. The package price includes a one-year on-site warranty.

Testing

Just how well does the Alpha chip meet DEC's promise of the fastest desktop performance available? My tests of these two systems included a preliminary version of BYTE's portable CPU benchmarks. The results of these benchmarks for the Model 300 and AXP 150 are in the table. I indexed performance numbers to the results obtained running the portable C benchmarks on a 60-MHz Pentium system.

The Pentium versions of our benchmarks were compiled under Watcom's C/C++ 32 compiler, with optimizations set as recommended by Watcom for best performance on a Pentium system. Previous BYTE tests on the AXP 150 (see "Is There a Better Windows 3.1 Than Windows 3.1?," November BYTE) used an early beta version of Windows NT for the Alpha chip. An updated math library has since resulted in a significant improvement in the floating-point tests.

While differences in compilers, operating systems, and system-board architectures obscure performance differences between CPUs, it's at least obvious that the 150-MHz Alpha outperforms a 60-MHz Pentium in the context of performing low-level computing operations. It's only fair to point out, however, that some comparable Pentium systems also cost less. The 200-MHz Alpha chip in the DEC 3000 Model 500X should increase the speed difference.

It's also obvious that the AXP 150 had a better time of things than the Model 300. There are several contributing factors to the AXP 150's superior performance. First, the system has a larger secondary cache—twice that of the Model 300. Second, the data-bus width between cache and CPU in the AXP 150 is 128 bits; the Model 300's data-bus width to the CPU is 64 bits.

Finally, you should keep in mind that the compiler for the Model 300 handles long integers as 64-bit values. So, for example, the numeric sort benchmark sorts 32-bit values on the AXP 150, but more cumbersome 64-bit values on the Model 300.

To test the Model 300, I had to make a slight modification to the benchmarks to account for the fact that the Model 300's Workstation C compiler compiles long integers as 64-bit values, which is the bit width of the Alpha chip's registers. (In contrast, the C compiler running under NT on the AXP 150 handles long integers as 32 bits to retain compatibility with the NT environment.)

I recompiled the CPU and FPU portions of BYTE's portable C benchmarks under DEC's OSF/1 at the highest optimization level that the compiler would allow without crashing. I ran the tests on the Model 300 in single-user mode so that there would be a minimum of interaction with other processes on the system. (Even while running the benchmarks under multiuser mode in a Decterm Window, I saw barely a 5 percent—and often unmeasurable—drop in scores.)

I did encounter a problem in compiling the benchmarks; at the highest optimization setting, the compiler complained of a memory-segmentation fault and issued a core dump. A DEC engineer finally found a way to recompile the BYTE benchmark code without causing a crash under these conditions. He also pointed out, rightly, that the complex architecture of the Alpha chip necessitates a complex optimization process. He told me that recompiling a program at a higher optimization level might not necessarily yield a faster executable.

In other words, a different optimization level does not mean more intense optimization; it means a different mix of optimization strategies. And different programs will respond differently to each optimization level; the response depends on the nature of the algorithms implemented in each program. That's not a comforting thought, since processor complexity adds a less-than-scientific aspect to the act of generating an optimal application for the Model 300. I can only assume that as more superscalar, internally parallel, multipipelined processors hit the stage, this is likely to become the norm.

The full Alpha-chip performance story awaits the maturation of the operating system and applications software for Windows NT, as well as the recompilation of applications for the Alpha chip under OSF/1. ■

About the Products

DEC 3000 Model 300.....$9995
Digital Equipment Corp.
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(800) 344-4825
(508) 493-5111
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DECpc AXP 150 ....$6795
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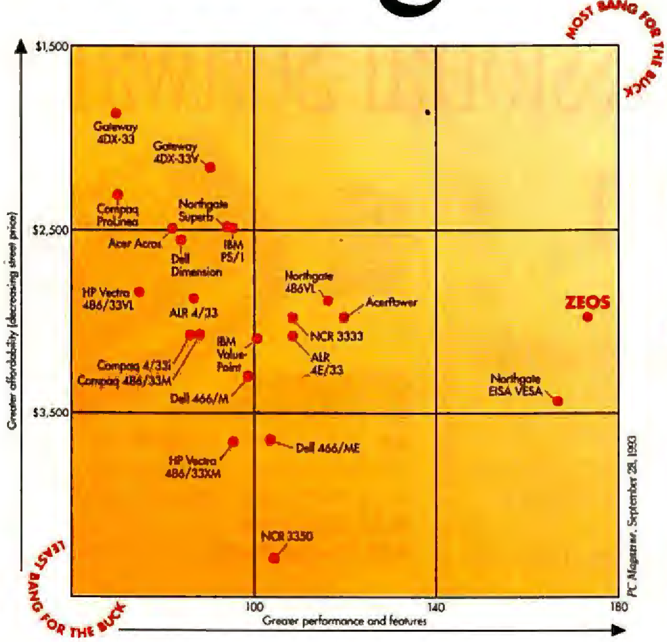

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Others pale in comparison. There's no way to dispute it! The results are in, and the ZEOS Upgradable 486DX2-66 is "the overall performance winner."

PC buyers expect low prices, top-quality, impeccable performance and prompt support. Basically, they want the most bang for their buck. *PC Magazine* recognized this and compared value-line PCs with more traditional systems to see if they were "truly good values or stripped-down machines trying to pass for good buys." The results are overwhelmingly in ZEOS' favor. In fact, *PC Magazine* said: *"ZEOS doesn't sell a separate value line, but the flexibility of its main system may be the least confusing solution of all."*

intel inside

Stacked against Gateway, Dell, Compaq, IBM and others, ZEOS stood alone. Using the benchmark tests as a guide, *PC Magazine* made these conclusions:

"As DOSmark scores are heavily weighted for processor and hard disk performance, the ZEOS garnered the first-place position in that category as well."

"The clear winner is...the ZEOS Upgradable, which turned in an incredible score of 55.01 megapixels per second."

"The real highlight among tested hard disks was the Seagate ST3600A, which has 12-ms access time and 256K of built-in cache. The ZEOS 486DX2-66 Upgradable's hard disk performance was almost 31 percent above the average in this roundup."

Of the *"systems that demonstrated the best agility under strenuous exercise of all their components... ZEOS (scored) 26 percent above average."*

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486DX-33	$1695 Lease $61/month	$1995 Lease $72/month	$2295 Lease $83/month	$2795 Lease $101/month
486DX2-50	$1795 Lease $65/month	$2095 Lease $76/month	$2395 Lease $87/month	$2895 Lease $105/month
486DX2-66	$1895 Lease $69/month	$2195 Lease $79/month	$2495 Lease $90/month	$2995 Lease $108/month
	■ ZIF socket upgradability to Pentium OverDrive CPU	■ ZIF socket upgradability to Pentium OverDrive CPU	■ ZIF socket upgradability to Pentium OverDrive CPU	■ ZIF socket upgradability to Pentium OverDrive CPU
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	■ Diamond SpeedStar Pro Windows-accelerated local bus video with 1MB RAM. 16.7 million colors.	■ Diamond SpeedStar Pro Windows-accelerated local bus video with 1MB RAM. 16.7 million colors.	■ Diamond SpeedStar Pro Windows-accelerated local bus video with 1MB RAM. 16.7 million colors.	■ Diamond SpeedStar Pro Windows-accelerated local bus video with 1MB RAM. 16.7 million colors.
	■ ZEOS 14" 1024 x 768 NI SVGA color monitor, .28mm dot pitch	■ ZEOS 14" 1024 x 768 NI SVGA color monitor, .28mm dot pitch	■ ZEOS 14" 1024 x 768 NI SVGA color monitor, .28mm dot pitch	■ ZEOS 14" 1024 x 768 NI SVGA color monitor, .28mm dot pitch
	■ Your choice of floppy drives	■ Both 1.2MB and 1.44MB floppy drives	■ Both 1.2MB and 1.44MB floppy drives	■ Both 1.2MB and 1.44MB floppy drives
	■ Microsoft DOS plus Enhanced Tools	■ Microsoft DOS with Tools, Windows & new Microsoft Mouse, plus choice of Lotus Windows application	■ Microsoft DOS with Tools, Windows & new Microsoft Mouse, plus choice of Lotus Windows application	■ Microsoft DOS with Tools, Windows & new Microsoft Mouse, plus choice of Lotus Windows application

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If you're looking for the best in desktop power, consider one of the 90 systems tested here. We evaluate ISA- and EISA-bus 486s with processors from Cyrix, IBM, and Intel. For most business and scientific applications, these systems represent the best balance in performance and price for single users (for a look at Pentium-based systems for the desktop, see "Pentium Performance" on page 188).

As with our last systems Lab Report (see "Desktop Dynamite: 116 Fast 486s," June BYTE), we used our custom low-level and applications benchmarks to choose the best systems for Windows, DOS, and Unix applications. The market has shifted in the last six months to make DX2/66 the dominant CPU for the desktop. Of the 90 non-Pentium systems that arrived for testing, only 10 ran at clock speeds slower than 66 MHz (one system, Destiny Computer's IBM 486 SLC2-40/80, ran faster than 66 MHz, although its overall speed in our Windows and DOS performance tests was undistinguished). What's more, all the systems we ranked as winners and runners-up in our applications categories used the Intel 66-MHz DX2 processor. Most systems with CPUs from Cyrix and IBM produced comparable results to an Intel 33-MHz 486DX system. However, these systems are typically $1000 less expensive than the Intel-based systems.

Overall, prices continue to drop for high-end systems, especially for EISA-based models. Today's average EISA system costs about $700 less than in June, while ISA models have declined a little more than $300 in that period. Nevertheless, falling prices have not stalled performance gains: The systems we evaluate here broke performance records set in the June issue for almost every test.

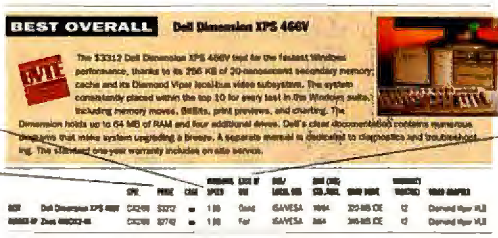
Improved drivers, more efficient memory architectures, and the integration of components on the motherboard have helped Windows performance rise an average of 15 percent. Overall, the average Unix performance rose the

How to use this guide

To locate the best 486 system, follow the main headings until you come to the applications category that most closely matches yours. Then look to the Best Overall, Most Expandable, or Low Cost summaries to find the appropriate rankings.

Speed scores are calculated from appropriate Windows, DOS, and Unix tests. Higher numbers mean better performance.

List prices for as-tested configuration.



Rates how easily you can reconfigure the system and the quality of the documentation.

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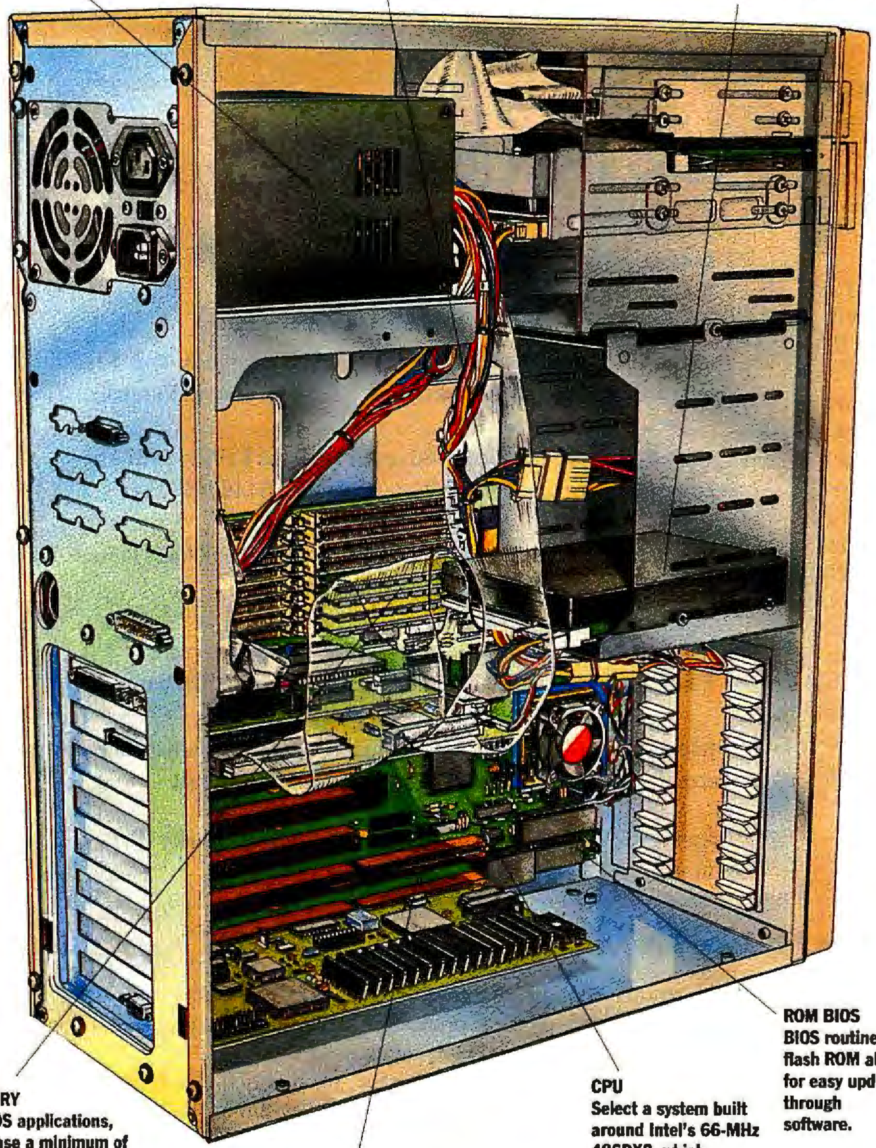
Inside a 486 System



equivalent of one SPECmark.

Another technological shift since June is the preponderance of VESA local-bus implementations to improve graphics performance. All but 17 systems were VL-Bus based; while eight of the remaining systems used a proprietary local-bus implementation, and the only ranked systems that did not use local bus are the Compaq Deskpro 66M and the Hertz 486/d66x2Ei. The Diamond Viper VLB local-bus video accelerator, based on the Weitek Power 9000 chip set, outclasses all other video hardware. The top 14 fastest systems for Windows performance used this adapter.

We also see more systems designed for energy efficiency. Three systems claimed Energy Star compliance, although we noted that a clear method of implementation could lead to compatibility problems (see "Energy Star Systems" on page 190).

DECEMBER 1993 BYTE BEST 486 SYSTEMS **BEST**

WINDOWS

Dell Dimension XPS 466V

Unexcelled in overall Windows performance, this $3312 system consistently placed at the top in application and low-level tests. Its local-bus implementation of Diamond's Viper graphics accelerator placed the Dimension among the leaders for fast BitBlts and other graphics tasks important for Windows. Clear documentation and an on-site service warranty add to its appeal. **PAGE 179**

WINDOWS HIGH PERFORMANCE

AST Premmia 4/66d

Although it wasn't the fastest EISA-based system we tested, the Premmia stands out for its combination of solid performance and standard features like a 256-KB secondary cache and a local-bus-based ATI Mach32 graphics adapter, one of the best video chip sets we tested. The system also is easily expandable, with room to hold 128 MB of RAM, four additional 32-bit EISA boards, and three additional 3½-inch drives. **PAGE 183**

DOS

Gateway 2000 4DX2-66V

This system outperformed every other ISA machine in our DOS tests thanks to an ATI Ultra XLR local-bus video adapter and 256 KB of secondary memory cache. System RAM can accommodate up to 64 MB and the tower case holds five additional drives. **PAGE 187**

UNIX

DECpc 466d2 MTE

This EISA-bus mini-tower posted the highest SPECmark scores and ranked near the top in performance in the BYTE Unix benchmarks. It uses an S3 86C924 video adapter on the local bus and can hold up to 64 MB of memory. Its three-year warranty, with on-site service, was one of the best seen in this report. **PAGE 193**

THE BEST SYSTEMS FOR WINDOWS APPLICATIONS

If you need a Windows system that performs screen redraws in the blink of an eye, the following 66-MHz 486DX2 systems represent the best balance of Windows performance, features, and ease of use.

This section only ranks ISA-bus 486s because we believe most Windows users do not need the added I/O performance and functionality of an EISA-bus system. With the widespread use of local-bus, ISA systems have been able to narrow the I/O performance gap with EISA for most Windows workstations. Second, ISA systems cost significantly less than EISA or Micro Channel architecture systems: The average EISA system in this review costs $1000 more than the average ISA-based 486. Nevertheless, EISA-based systems may be important to those who need the best in Windows performance and can justify the higher prices. If you fall into this category, see "High-Performance Windows" on page 180.

486S THEN AND NOW

Average price of an ISA-based 486 in June: $2972
Average ISA system price in December: $2632

Average EISA/Micro Channel architecture system price in June: $4359
Average EISA/Micro Channel architecture system price in December: $3652

Lowest- and highest-priced 486 system in June: $1950; $9374
Lowest- and highest-priced 486 in December: $1462; $5184

Percentage of total test sample represented by 66-MHz DX2s in June: 72
Percentage of 66-MHz DX2s in December: 86

Percentage of local-bus-based systems in June: 59 percent
Percentage of local-bus-based systems in December: 90 percent

Percentage of systems with video integrated on motherboard in June: 8 percent
Percentage with integrated video in December: 20 percent

Average SPECmark89 rating of Unix performance in June: 14.7
Average SPECmark89 rating in December: 15.6

Our primary consideration for selecting the Best Overall Windows system was performance in our Windows test suite. These tests include several popular business applications that provide real-world assessments of complete system performance (see "How We Tested" on page 184). The suite also includes low-level tests that gauge how well the video subsystem handles Windows graphics calls. The resulting composite score was worth 60 percent of the total evaluation. Each system's features set represented 30 percent of the final score, and ease of use made up the remaining 10 percent.

We judge systems for Most Expandable in the same way, but we required these machines to meet additional criteria. Each system had to have four or more available slots for expansion cards, such as network interface cards (NICs), sound boards, and SCSI adapters. We needed a minimum of three available drive bays for the addition of tape drives, CD-ROM drives, and hard drives. Support for 64 MB or more of system memory and at least a 200-watt power supply were also mandatory. We limited our ranking to tower-case systems for this category. Finally, only systems priced $2700 or less were considered for best low-cost Windows systems.

In the June issue, we reported that 486s using the Weitek Power 9000 video chip set outran all others for video performance. The Power 9000 continues to reign: Of the 14 systems ranked for Windows, 10 utilize the Diamond Viper VLB, which is based on the Weitek chip set. (Overall, the 14 fastest Windows scores in our entire test sample were turned in by systems using the Weitek 9000–based Viper.) None of the systems we received contained the Weitek chip integrated on the motherboard. Two vendors supplied different video adapters with the Power 9000, but performance for these systems didn't match the Viper's. The Windows-ranked systems that used an alternative video chip set were the Hewlett-Packard Vectra 486 PC with an integrated S3 86C928 on a proprietary local bus; Gateway 2000's 4DX2-66V, with an ATI Ultra XLR; Touché Micro's 5550T VLB 66 with the Orchid Celsius VLB; and Acma Computers' ATI VLB Mach32.

We identified several other technology trends among Windows winners and runners-up. All the ranked systems contained 256 KB of secondary cache RAM, which enhanced their performance over many of the slower unranked systems with 128 KB or less of cache. All ranked systems contain a VESA VL-Bus except for the Hewlett-Packard Vectra, which implemented a proprietary local-bus design. Finally, all the ranked systems were driven by Intel 486DX2 CPUs operating at 66 MHz.

In addition to impressive performance, however, we also encountered some hardware difficulties. During POST (power-on self test), the AcerPower 486V reported a problem with the SCSI host adapter, an Adaptec chip located on the motherboard. After a couple of calls to Acer, we traced the problem to an incorrectly set jumper on the motherboard.

The Cornell Windows NT Station had more serious trouble. When we attempted to boot from the MS-DOS 6.0 setup disk, error messages such as "Configuration too large for memory" appeared. After we manually installed DOS, data on the hard drive became corrupt. The company pinpointed the problem to a defective motherboard and shipped us a replacement. No problems were encountered once we installed the new system board, and the system performed well enough to become a runner-up in both the Most Expandable and Low Cost Windows categories.

The MicroSource Tempest 486 VLB-66, a runner-up for the Most Expandable category, showed some design flaws. Even though its performance and features scores were solid, it scored low for ease of use, because all three of its ISA slots were obstructed by the fan-mounted CPU that limited the slots to half-length cards. Its documentation was a conglomeration of a number of different manuals from the motherboard, video board, and drive controller manufacturers. Not surprisingly, we could not locate a technical-support telephone number anywhere in the documentation.

KEY

▬ Desktop ▮ Tower
□ Mini-tower

BYTE BEST | WINDOWS GENERAL PURPOSE

Need the fastest ISA system for Windows?

BEST OVERALL — Dell Dimension XPS 466V

The $3312 Dell Dimension XPS 466V tied for the fastest Windows performance, thanks to its 256 KB of 20-nanosecond secondary memory cache and its Diamond Viper local-bus video subsystem. The system consistently placed within the top 10 for every test in the Windows suite, including memory moves, BitBlts, print previews, and charting. The Dimension holds up to 64 MB of RAM and four additional drives. Dell's clear documentation contains numerous diagrams that make system upgrading a breeze. A separate manual is dedicated to diagnostics and troubleshooting. The standard one-year warranty includes on-site service.

		CPU	PRICE	CASE	WINDOWS SPEED	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	HARD DRIVE	WARRANTY (MONTHS)	VIDEO ADAPTER
BEST	Dell Dimension XPS 466V	DX2/66	$3312	▬	1.90	Good	ISA/VESA	16/64	320-MB IDE	12	Diamond Viper VLB
RUNNER-UP	Micron 466VL WinStation	DX2/66	$2649	▬	1.90	Excellent	ISA/VESA	16/64	345-MB IDE	12	Diamond Viper VLB
RUNNER-UP	NCR System 3333	DX2/66	$4290	□	1.80	Excellent	ISA/VESA	16/64	340-MB IDE	36	Diamond Viper VLB
RUNNER-UP	Acer AcerPower 486V	DX2/66	$3344	▬	1.80	Excellent	ISA/VESA	8/64	340-MB SCSI	12	Diamond Viper VLB
RUNNER-UP	CompuAdd C466D Desktop	DX2/66	$2694	▬	1.90	Good	ISA/VESA	8/64	340-MB IDE	12	Diamond Viper VLB
RUNNER-UP	HP Vectra 486 PC	DX2/66	$3531	▬	1.70	Excellent	ISA/Prop	8/64	240-MB IDE	36	S3 86C928 (integrated)
RUNNER-UP	Gateway 2000 4DX2-66V	DX2/66	$2995	▮	1.90	Good	ISA/VESA	16/64	340-MB IDE	12	ATI Ultra XLR
RUNNER-UP	Zeos 486DX2-66	DX2/66	$2742	▬	1.90	Fair	ISA/VESA	8/64	340-MB IDE	12	Diamond Viper VLB

For fast speed and room to grow...

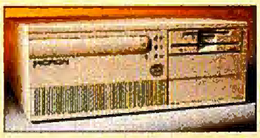
MOST EXPANDABLE — Touché 5550T VLB 66

This tower's expansion capabilities include support for six additional drives, up to 64 MB of RAM, and five additional 16-bit ISA boards. The system ranked second in this category for performance, and proved itself particularly proficient in the Lotus 1-2-3 for Windows application test, which stresses CPU and memory-architecture performance. Local-bus video and the SCSI hard drive contributed to the system's fast performance. (Only tower-case systems were considered for this category.)

		CPU	PRICE	WINDOWS SPEED	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	HARD DRIVE	AVAILABLE BAYS 3½/5¼	AVAILABLE SLOTS	VIDEO ADAPTER
BEST	Touché 5550T VLB 66	DX2/66	$2799	1.70	Fair	ISA/VESA	8/64	340-MB SCSI	4/2	5	Orchid Celsius VLB
RUNNER-UP	MicroSource Tempest 486 VLB-66	DX2/66	$2545	1.70	Fair	ISA/VESA	8/64	213-MB IDE	4/3	4	Diamond Viper VLB
RUNNER-UP	Cornell Windows NT Station	DX2/66	$2395	1.60	Fair	ISA/VESA	8/128	340-MB IDE	4/4	5	Diamond Viper VLB
RUNNER-UP	Amax 486 VESA max Power Station	DX2/66	$2699	1.80	Fair	ISA/VESA	8/128	210-MB IDE	1/4	5	Diamond Viper VLB
RUNNER-UP	Acma VESA Tower	DX2/66	$2495	1.60	Good	ISA/VESA	8/128	210-MB IDE	4/4	4	ATI VLB Mach32
RUNNER-UP	Amer. Multisystems Info Gold VLB 66	DX2/66	$2899	1.70	Fair	ISA/VESA	16/64	345-MB IDE	0/4	5	Diamond Viper VLB

Budget-conscious?

LOW COST — Micron 466VL WinStation



This $2649 system tied with the fastest performers in our Windows low-level and application tests. It supports up to 64 MB of RAM and uses a local-bus implementation of the Weitek Power 9000–based Diamond Viper video adapter. You can add an additional local-bus adapter along with five 16-bit ISA expansion boards. On-site service is included in the system's standard one-year warranty.

		CPU	PRICE	CASE	WINDOWS SPEED	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	HARD DRIVE	WARRANTY (MONTHS)	VIDEO ADAPTER
BEST	Micron 466VL WinStation	DX2/66	$2649	▬	1.90	Excellent	ISA/VESA	16/64	345-MB IDE	12	Diamond Viper VLB
RUNNER-UP	CompuAdd C466D Desktop	DX2/66	$2694	▬	1.90	Good	ISA/VESA	8/64	340-MB IDE	12	Diamond Viper VLB
RUNNER-UP	Zeos 486DX2-66	DX2/66	$2742	▬	1.90	Fair	ISA/VESA	8/64	340-MB IDE	12	Diamond Viper VLB
RUNNER-UP	MicroSource Tempest 486 VLB-66	DX2/66	$2545	▮	1.70	Fair	ISA/VESA	8/64	213-MB IDE	24	Diamond Viper VLB
RUNNER-UP	Cornell Windows NT Station	DX2/66	$2395	▮	1.60	Fair	ISA/VESA	8/128	340-MB IDE	24	Diamond Viper VLB
RUNNER-UP	Amax 486 VESA max Power Station	DX2/66	$2699	▮	1.80	Fair	ISA/VESA	8/128	210-MB IDE	12	Diamond Viper VLB

THE BEST SYSTEMS FOR

HIGH-PERFORMANCE WINDOWS

For Windows users who require the utmost in performance, we ranked the fastest 486s that support a 32-bit data bus. These EISA- and Micro Channel architecture systems possess several advantages over systems built around the 16-bit ISA bus. Foremost is the 32-bit path that sends data between peripherals and the CPU for greater throughput on I/O performance. Theoretically, the EISA bus supports data-transfer rates of up to 32 MBps, while the ISA architecture is limited to a maximum of 16 MBps. Moreover, EISA and Micro Channel architecture systems support bus-mastering devices; this allows peripherals to achieve greater data throughput by taking control of the expansion bus and accessing memory and other peripherals independently of the system's CPU. These architectures also are more functional and easier to use than the standard AT bus because adapter boards are software configurable so there's no messing with DIP switches or jumpers when setting IRQs (interrupt requests) and I/O addresses. This drastically reduces time spent troubleshooting conflicts. EISA adapter slots also accept ISA boards. On the downside, EISA and Micro Channel architecture systems cost considerably more than their ISA counterparts. EISA/Micro Channel architecture systems averaged $1000 more than the ISA-based units that we received for this review.

Although we ranked systems for best low-cost status in our other applications categories, we were unable to provide similar rankings here. We found a relatively small range in prices from the highest to the lowest costs ($5184 and $2529, respectively). Instead, choose one of the runners-up in either Best Overall or Most Expandable categories that meets your budget requirements.

System performance was our primary criterion for selecting the Best Overall system in this application. We tested 30 EISA and one Micro Channel architecture system using our Windows benchmarks. This suite of tests includes many popular business applications that provide real-world assessments of complete system performance. It also includes low-level tests that gauge how well the video subsystem handles Windows graphics calls. In addition, we also ran our exclusive PLATT (Page Level Availability Time Test) hard disk tests, which evaluate hard disk subsystem performance. The composite performance score was worth 60 percent of the total evaluation. Each system's features score accounted for 30 percent of our evaluation, and ease of use considerations made up the remaining 10 percent.

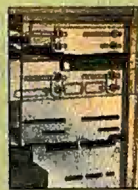
Out of the 90 systems in this review, 31 met

HOW TO BUY A FAST 486

Interested in Pentium upgradability?

Look for systems that can take full advantage of a Pentium CPU by offering an upgrade socket or the ability to put a Pentium chip on an upgrade card, along with memory and the secondary processor cache.

Need multiple hard drives or a large drive?



Purchase a SCSI drive. SCSI offers greater flexibility when installing drives, and SCSI drives typically outperform same-size IDE drives (see "32 High-Speed Hard Drives," September BYTE).

Need a system for multimedia?

A number of vendors include CD-ROM drives as standard components with their systems. Look for SCSI-based dual-speed drives that are MPC-compliant, multisession, and compatible with the Kodak Photo CD.

Want to give your eyes a break?

Purchase a system with a monitor and video adapter that support vertical refresh rates of at least 72 Hz at resolutions of 1024 by 768 pixels. Windows users should purchase at least a 15-inch noninterlaced monitor, which provides greater screen real estate than 14-inch displays (see BYTE's Lab Report on monitors next month).

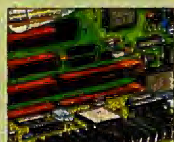
Want safeguards if the system fails?

Make sure any components integrated on the motherboard (e.g., the hard drive controller or I/O ports) can be disabled if a system's on-board IDE controller does not relinquish its I/O address and IRQ (interrupt request) line; otherwise, your only solution would be to add a SCSI controller *and* a new drive.

Do you need communications flexibility?

Look for a system that has a separate PS/2-style mouse port or at least two serial ports. This will allow you to attach a mouse, as well as a serial communications device such as a fax/modem.

Do you run graphical applications?



Local-bus video accelerators can dramatically speed up video operations in today's video-intensive environments such as Microsoft Windows, X Windows, or IBM OS/2. Make sure that your operating system supports your video adapter directly or by manufacturer-supplied drivers.

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Need the best for 32-bit EISA?

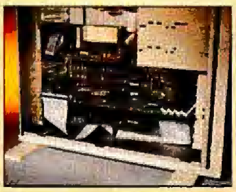
BEST OVERALL **AST Premmia 4/66d**

The AST Premmia 4/66d combines above-average performance with excellent features. The unit contains a 256-KB secondary memory cache, a Western Digital IDE hard disk subsystem, and an integrated ATI Mach32 local-bus video adapter. System RAM can expand to 128 MB, and four 32-bit EISA expansion slots are available. Users can install three additional 3½-inch drives. The system is backed by a three-year warranty that includes on-site service. System documentation is excellent with clear text, installation instructions, illustrations, and technical-support information.

		CPU	PRICE	CASE	WINDOWS SPEED	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	HARD DRIVE	WARRANTY (MONTHS)	VIDEO ADAPTER
BEST	AST Premmia 4/66d	DX2/66	$3532	▬	1.80	Excellent	EISA/Prop	8/128	340-MB IDE	36	Mach 32 (integrated)
RUNNER-UP	X I 466EVL Netserver	DX2/66	$3149	▬	1.90	Good	EISA/VESA	16/128	345-MB SCSI	12	Diamond Viper VLB
RUNNER-UP	Comtrade EISA 66	DX2/66	$2995	▬	1.90	Fair	EISA/VESA	8/128	340-MB SCSI	36	Diamond Viper VLB
RUNNER-UP	DECpc 466d2 MTE	DX2/66	$3398	▯	1.50	Excellent	EISA/VESA	16/64	240-MB IDE	36	S3 86C924 (integrated)
RUNNER-UP	Everex Step VL EISA	DX2/66	$3133	▬	2.00	Fair	EISA/VESA	8/256	240-MB IDE	24	Diamond Viper VLB
RUNNER-UP	Micron 466VL WinServer	DX2/66	$3249	▮	1.90	Poor	EISA/VESA	16/64	340-MB SCSI	12	Diamond Viper VLB
RUNNER-UP	Compaq Deskpro 66M Model 240/480W	DX2/66	$3861	▬	1.70	Excellent	EISA/None	16/136	240-MB IDE	36	Compaq QVision

Want a top-performing tower?

MOST EXPANDABLE **X I 466EVL Netserver**



This 66-MHz 486DX2-based system tied for the highest Windows performance score for this category. Its large tower chassis accommodates eight additional drives. Four of the bays offer front exposure, so you can easily add a CD-ROM and tape drive. The unit's EISA expansion bus offers three 16-bit and two 32-bit available slots; a VL-Bus slot is also unoccupied. System RAM expands to 128 MB, which is more than adequate for memory-intensive Windows applications. (Only tower case systems were considered for this category.)

		CPU	PRICE	WINDOWS SPEED	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	HARD DRIVE	AVAILABLE BAYS 3½/5¼	AVAILABLE SLOTS	VIDEO ADAPTER
BEST	X I 466EVL Netserver	DX2/66	$3149	1.90	Good	EISA/VESA	16/128	345-MB SCSI	3/5	6	Diamond Viper VLB
RUNNER-UP	DECpc 466d2 MTE	DX2/66	$3398	1.50	Excellent	EISA/VESA	16/64	240-MB IDE	0/3	6	S3 86C924 (integrated)
RUNNER-UP	Micron 466VL WinServer	DX2/66	$3249	1.90	Poor	EISA/VESA	16/64	340-MB SCSI	0/4	6	Diamond Viper VLB
RUNNER-UP	Microtech MT/EVLB 486DX2-66	DX2/66	$3699	1.70	Fair	EISA/VESA	16/64	341-MB IDE	1/4	7	Wizard 9000VL
RUNNER-UP	IDS 466E2VP	DX2/66	$2495	1.80	Fair	EISA/VESA	8/64	250-MB SCSI	0/3	5	Diamond Viper VLB

our specifications for the high-performance Windows. With superior I/O performance, it is not surprising that five out of the top seven performers on the PLATT disk subsystem test were EISA bus systems teamed with SCSI disk controllers. This proved to be a potent combination for hard disk performance. EISA and Micro Channel architecture systems outperformed ISA systems on many of the disk-intensive subtests, such as the Word for Windows file saves test where five of the top six fastest transactions were achieved by EISA-based systems. The top four performers on the PLATT test contained Seagate ST3390 hard drives, either with a SCSI or IDE interface. These drives were winners in our September Lab Report on hard drives.

The $3532 AST Premmia 4/66d won top honors in this category with outstanding all-around performance attributable primarily to its proprietary local-bus implementation of the ATI Mach32 video chip set and an efficient memory architecture. The Premmia outclassed all other systems by attaining the top scores on the five memory move tests in BYTE's hardware benchmark.

The $3149 X I 466EVL Netserver placed a close second behind the Premmia with superior performance scores in all the Windows tests. However, the Premmia's outstanding feature set offset its performance enough to overcome the Netserver. The Netserver didn't possess a flash ROM upgradable BIOS; its 12-month warranty pales in comparison with the 36 months that AST provides, and its FCC Class A rating excludes it from home use.

To qualify for Most Expandable considerations, a 32-bit system had to have four or more available adapter slots, at least three available drive bays, a 200-W or greater power supply, and the capacity for at least 64 MB of system memory. The Netserver from X I Computer exceeded all these specifications while producing Windows results that were 90 percent faster than the baseline Compaq Deskpro 4/33i.

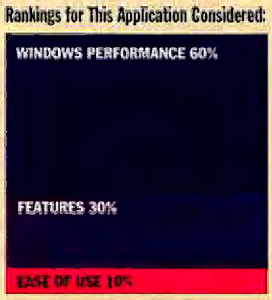
Through our testing, we found that just comparing system specifications on paper can be deceiving. For example, the Comtrade Electronics EISA 66, another close runner-up for Best Overall, clearly met the adapter slot requirement with five available places. However, three of those slots were obstructed by the power switch housing and hard drive assembly, limiting their usefulness to only half- or three-quarter-length cards. Moreover, the two serial ports that are attached to an I/O adapter card blocked an additional slot. This slot could have been easily freed up by using the port holes on the back of the case.

The Compaq Deskpro 66M reached the runner-up status for Best Overall thanks to its EISA-based QVision 1024/E video adapter, which is not local-bus based. Only one other ranked system in this roundup—the Hertz—did not incorporate local bus, and that was in the Unix category where no video tests were performed. QVision's ability to excel against its local-bus competition in a category that places emphasis on video-intensive Windows tests is a credit to its design. The Compaq Deskpro 66M achieved 70 percent faster Windows performance than its sibling, our baseline 33-MHz 486DX Deskpro 4/33i.

KEY

▬ Desktop ▮ Tower
▯ Mini-tower

Rankings for This Application Considered:



How We Tested

Testing Team (clockwise from front): Alan Joch, Siva Kumar, André Whittle, Richard Fox, and Stephen Platt

We tested each system under Windows 3.1, DOS 6.0, and SCO Unix 3.2.4. DOS and Windows performance ratings combined BYTE's low-level tests and NSTL's application tests.

The BYTE DOS low-level tests evaluate system performance by isolating CPU, FPU, memory, video, and hard disk subsystems. BYTE's Windows low-level tests exercise the Windows GDI (Graphical Device Interface) to determine how well a system executes basic Windows graphics tasks (e.g., drawing a line or executing BitBlts).

The NSTL application tests use popular business applications for a real-world representation of system performance. The DOS performance suite includes WordPerfect 5.1, Lotus 1-2-3 release 2.4, FoxPro 2.0, and Autodesk Animator Pro 1.0. The Windows performance suite consists of Microsoft Excel 4.0a, Microsoft Word 2.0b, and Lotus 1-2-3 for Windows 1.1. All applications execute macros that exercise common areas of each application. For instance, the Word for Windows test includes many subtests that measure a variety of activities, including file I/O, search and replace functions, changing fonts, scrolling by page and line, checking the spelling, print preview, and print to a file.

All Windows tests were executed in 1024- by 768-pixel resolution with 256 colors. The DOS tests were run in the standard VGA resolution (640 by 480 pixels at 16 colors). The BYTE Windows low-levels ran in both modes.

Finally, we performed our PLATT hard disk tests—custom benchmarks to measure hard disk response times (see "32 High-Speed Hard Drives," September BYTE).

For comparison, we scaled all test scores against a Compaq Deskpro 4/33i, a 33-MHz 486DX system, whose performance equals 1.0 in our index. Thus, a system with a performance index of 1.5 executed our tests 50 percent faster than the baseline Deskpro 4/33i. We produced a DOS and Windows performance index number for each system. Higher numbers indicate faster performance.

Each system was also tested under SCO Unix 3.2.4. The test suite consisted of the BYTE Lab's low-level Unix tests and SPECmark89. The Unix tests cover a spectrum of typical scientific and engineering tasks. Thus, the Unix tests evaluate each system as a workstation, not as a file server or database processor. Unix results are based on a DEC VAX 11/780 equaling 1.0.

FEATURES

We considered the following features most important for high-end 486 systems:

- 32 MB or more of system memory capacity
- Flash ROM upgradable BIOS
- Available adapter slots and drive bays after system configuration
- Hard drive capacity and performance
- A display resolution of 1280 by 1024 pixels
- Security features such as a power-on password or keyboard lock
- Free lifetime technical support
- A one-year parts-and-labor warranty, minimum
- Bundled software that includes DOS and Windows

EASE OF USE

We worked with each system to gauge how easy it is to configure and use. We assessed how easy it was to open up the system and install an adapter. We took off points for slots that were obstructed—often by a fan or a heat sink mounted on the CPU.

We also looked at several aspects of the documentation including did one integrated manual come with the system or was it a collection of manuals for each of the system parts? Could you find what you needed to know? Systems that received an "excellent" rating missed no more than two of these questions, while "poor" systems did well in only three of these areas.

Although keyboard feel is important, keyboard evaluation is subjective and thus was not part of our scoring. We also did not evaluate monitors for this report (see next month's Lab Report for the best color monitors from 15 to 21 inches). But the systems prices listed here are for as-tested configurations including a 14- or 15-inch, 1024- by 768-pixel (noninterlaced) monitor. Prices also include a keyboard and a mouse.

CONFIGURATION AND CATEGORIES

Our testing was open to all 486-class systems with a 40-MHz or greater internal clock speed. We accepted ISA, EISA, and Micro Channel architecture buses. We requested that all systems have at least 8 MB of memory but no more than 16 MB. We also specified that hard drives range from 200 MB to 350 MB. We required that the system contain no more than 1 MB of hard drive controller cache. Finally, we asked for each system's best video hardware that had at least 1 MB of video memory and support for 1024- by 768-pixel resolution at 256 colors.

Systems considered for Most Expandable honors had to provide at least four available slots for expansion cards and a minimum of three available drive bays. We also required that these systems support 64 MB or more of system memory and have at least a 200-W power supply. Best low-cost systems were the best performing 486s priced at $2700 or less.

OUR TEST TEAM

Michael P. Connors, *Contributing Editor of* PC Digest *(an NSTL publication), writes and researches reviews of systems and other hardware.*

Richard Fox, *Senior Test Engineer/NSTL, has spent the last two years testing high-end PCs, software, and operating systems for NSTL.*

Alan Joch, *Senior Editor/BYTE, coordinates combined testing between the BYTE Lab and NSTL.*

Siva Kumar, *Technical Analyst/NSTL, specializes in hardware and network operating-systems testing.*

Anthony Lennon, *Technical Editor/NSTL, evaluates systems, notebooks, and peripherals.*

Stephen Platt, *Manager of Unix Development/NSTL, directs testing of Unix hardware and software, Windows NT, and network operating systems.*

André Whittle, *Consultant/NSTL, has participated in large-scale hardware evaluations for the Canadian government.*

The Lab Report is an ongoing collaborative project between BYTE Magazine and National Software Testing Laboratories (NSTL). BYTE Magazine and NSTL are both operating units of McGraw-Hill, Inc.

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Scan Frequency	H: 30-38 KHz V: 50-90 Hz	H: 30-50 KHz V: 50-90 Hz	H: 30-60 KHz V: 50-90 Hz	H: 30-60 KHz V: 50-90 Hz	H: 30-60 KHz V: 50-90 Hz	H: 30-65 KHz V: 50-90 Hz
Max. Resolution	1024x768/87Hz	1024x768/60Hz	1024x768/72Hz	1024x768/72Hz	1024x768/72Hz	1280x1024/60Hz
Digital Control	--	--	--	--	Yes	Yes
Full Screen	--	Yes	Yes	Yes	Yes	Yes
Low Radiation	5468LR	1451LR	1461LR	1561LR	1560LR	Yes

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BYTE BEST

DOS GENERAL PURPOSE

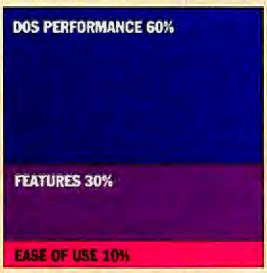
Performance in our DOS low-level and application tests was the key consideration for selecting the winners and runners-up in this category. From the low-level tests, we looked for a balance of fast CPU, memory, hard drive, and video subsystems performance.

Within the DOS applications suite, we placed the greatest emphasis on the WordPerfect 5.1 and Lotus 1-2-3 release 2.4 test results. These tests helped us produce a composite DOS performance score that was worth 60 percent of our evaluation.

Next, we factored in features scores, which represented 30 percent and ease-of-use rankings, which made up 10 percent of our evaluation. For this category, we only considered ISA-bus systems. We excluded EISA- and Micro Channel–bus architectures that are designed for higher I/O performance at a much higher cost. With the widespread use of local bus, ISA systems have been able to narrow the I/O performance gap with EISA architecture models.

Nine out of the top 13 DOS systems used local-bus ISA, the remaining were local-bus EISA systems. When weighting tests for specific DOS applications, including CAD, we saw no significant differences from the general-purpose rankings.

Rankings for This Application Considered:



KEY

▬ Desktop ▮ Tower
▯ Mini-tower

Want the best DOS performer?

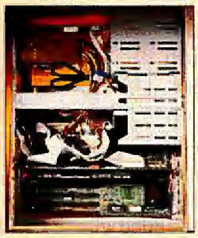
BEST OVERALL Gateway 2000 4DX2-66V

This 66-MHz 486DX2-based system posted the highest performance score of any system ranked in our DOS evaluations. It blazed through our DOS performance tests twice as fast as the baseline 33-MHz 486DX system. The Gateway system's speed is attributable to the system's ATI Ultra XLR local-bus video adapter and its 256 KB of secondary memory cache, which makes the system well suited for memory-intensive tasks, such as the Lotus 1-2-3 component of our application tests. Gateway's clear documentation is detailed. A chassis lock protects internal components and boot/keyboard password options help prevent unauthorized access. System RAM expands to 64 MB, and the unit's sturdy tower chassis supports five additional mass-storage devices.

		CPU	PRICE	CASE	DOS SPEED	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	RAM CACHE (KB)	HARD DRIVE	WARRANTY (MONTHS)
BEST	Gateway 2000 4DX2-66V	DX2/66	$2995	▮	2.00	Good	ISA/VESA	16/64	256/256	340-MB IDE	12
RUNNER-UP	HP Vectra 486 PC	DX2/66	$3531	▬	1.60	Excellent	ISA/Prop	8/64	256/256	240-MB IDE	36
RUNNER-UP	Dell OptiPlex 466/MXV	DX2/66	$3593	▬	1.80	Excellent	ISA/VESA	16/64	128/128	320-MB IDE	12
RUNNER-UP	DECpc 466d2 LPX	DX2/66	$3168	▬	1.70	Good	ISA/VESA	16/64	256/256	240-MB IDE	36
RUNNER-UP	IBM ValuePoint 6384-W71	DX2/66	$2919	▬	1.50	Excellent	ISA/VESA	8/64	128/256	325-MB IDE	12
RUNNER-UP	Touché 5550T VLB 66	DX2/66	$2799	▮	1.60	Fair	ISA/VESA	8/64	256/256	340-MB SCSI	24

For DOS with growth potential...

MOST EXPANDABLE Touché 5550T VLB 66



This system tied for the fastest DOS performance among the machines that qualified for most-expandable considerations. The efficiency of the system's memory architecture, which includes a 256-KB secondary memory cache, is evident in the fast performance logged for the Lotus 1-2-3 benchmarks. The tower chassis supports six additional drives. Both 1.2- and 1.44-MB floppy drives are included, and you can easily add a CD-ROM and a tape drive. Five 16-bit ISA expansion slots are available and up to 64 MB of RAM is supported for demanding applications. An AMI SCSI and an Orchid video adapter occupy the 66-MHz 486DX2-based system's two VL-Bus slots. (Only tower-case systems were considered for this category.)

		CPU	PRICE	DOS SPEED	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	HARD DRIVE	AVAILABLE BAYS 3½/5¼	AVAILABLE SLOTS
BEST	Touché 5550T VLB 66	DX2/66	$2799	1.60	Fair	ISA/VESA	8/64	340-MB SCSI	4/2	5
RUNNER-UP	Acma VESA Tower	DX2/66	$2495	1.60	Good	ISA/VESA	8/128	210-MB IDE	4/4	4
RUNNER-UP	Xinetron X/LAN Tower 4D66TE	DX2/66	$3985	1.60	Poor	ISA/VESA	16/256	340-MB SCSI	2/3	4
RUNNER-UP	Cornell Windows NT Station	DX2/66	$2395	1.30	Fair	ISA/VESA	8/128	340-MB IDE	4/4	5
RUNNER-UP	MicroSource Tempest 486 VLB-66	DX2/66	$2545	1.30	Fair	ISA/VESA	8/64	213-MB IDE	4/3	4

When cost counts...

LOW COST IBC VESA AD System

This $2369 tower system includes a Cardex W32 local-bus video adapter and a 256-KB secondary memory cache. System RAM expands to 32 MB (other, more expensive systems we tested could hold 64 MB or more). You can add one additional VL-Bus and four 16-bit ISA expansion boards, along with three mass-storage devices. A one-year warranty is standard; on-site service and extended warranties are available.

		CPU	PRICE	CASE	DOS SPEED	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	RAM CACHE (KB)	HARD DRIVE	WARRANTY (MONTHS)
BEST	IBC VESA AD System	DX2/66	$2369	▮	1.80	Fair	ISA/VESA	8/32	256/256	240-MB IDE	12
RUNNER-UP	Dyna Micro VL6 Business System	DX2/66	$2195	▬	1.70	Fair	ISA/VESA	8/32	256/256	345-MB IDE	12
RUNNER-UP	Micron 466VL WinStation	DX2/66	$2649	▬	1.40	Excellent	ISA/VESA	16/64	256/256	345-MB IDE	12
RUNNER-UP	CompuAdd C466D Desktop	DX2/66	$2694	▬	1.50	Good	ISA/VESA	8/64	256/256	340-MB IDE	12
RUNNER-UP	Aero T466VSB	DX2/66	$2150	▮	1.60	Fair	ISA/VESA	8/32	256/256	340-MB IDE	12
RUNNER-UP	Mega Eco 486DX2/66	DX2/66	$2289	▬	1.60	Fair	ISA/Prop	8/32	128/256	254-MB IDE	12

Pentium Performance

To see how much more power Pentiums offer over 486-class systems, we tested seven Pentium-based computers: the IBM ValuePoint P60/D, the Acer Computer AcerAltos 7000, ALR's Evolution V Pentium, the Tangent Pentium 60VL, AMS's InfoGold P60NT, and the Unisys PW² Advantage Plus. We divided our testing into tasks that challenged the processor directly and tasks that tested the hard disk and video subsystems.

PROCESSOR TESTS

To compare Pentium and 486 processor performance, we ran our standard DOS and Windows applications benchmarks. We also ran the SPECmark89 Unix benchmarks using code written for 486 processors and code that was optimized for Pentium computers.

The DOS/Windows applications show performance levels for standard business software. The SPEC tests show how Pentium-tuned applications may run.

[Editor's note: Rather than choosing a single 486 baseline machine for comparison, we used the best score attained for each test by any of the 486s in this report. Pentium results are averages of all the Pentium systems we tested.]

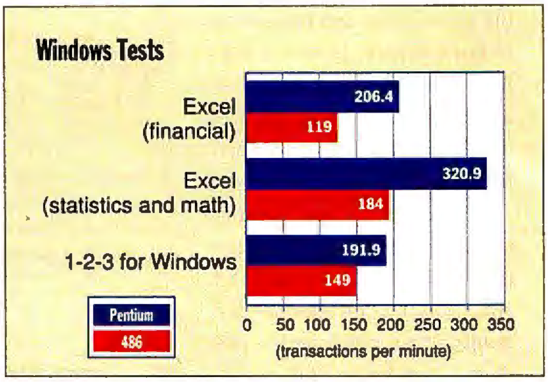
All the tested Pentium systems contained 16 MB of RAM except where noted. The Tangent and Unisys systems contained 340-MB hard drives; the others came with 520- to 540-MB drives. Prices include 14- or 15-inch monitors. The Tangent video system supports 1600- by 1200-pixel resolution.

Our application-test results in the Windows Tests bar graph indicate a 30 percent to 120 percent performance improvement with Pentium systems when compared to a fast 486. The tests called out in this graph are those that make significant use of the processor, primarily by executing mathematical functions. Users who will best benefit from Pentium performance will be those using large spreadsheets, CAD, and other financial and scientific/engineering applications.

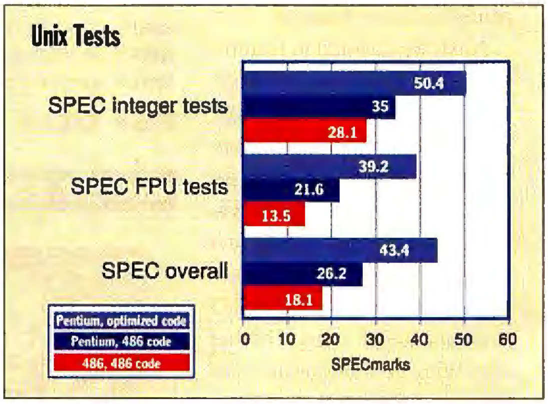
The Unix results in the Unix Tests bar graph show that Unix users can expect similar performance improvements. When comparing Pentium and 486 systems running 486 code, integer operations are 24 percent faster on the Pentium than on the 486, due to the multiple caches and the second integer ALU. However, floating-point-intensive tasks show a much greater level of improvement: They're almost 60 percent faster on Pentiums than on the fastest 486s. The wider 64-bit bus enables the Pentium processor to fetch and store double-precision numbers in a single access; multiple caches improve internal cache performance; and the FPU is vastly improved.

The Unix Tests bar graph also shows Pentium performance after we recompiled SPECmark89 using Liant's LPI FORTRAN compiler and The Santa Cruz Operation's Advanced Technology Optimizing C compiler. Both are Pentium-aware compilers.

Integer performance on a Pentium using Pentium-specific code is 44 percent faster than when running generic code on the same hardware. The average Pentium system using Pentium-specific code is 79 percent faster than a 486 running generic code. Floating-point performance shows an even greater improvement: 81 percent faster by using recompiled code, and 190 percent faster than the 486 running the older programs.



Excel results are processor-intensive subsets of the overall test. Higher values show faster speed.



Integer and FPU results are subsets of the SPECmark89 suite. Higher values show faster speed.

DISK AND VIDEO

Our disk-intensive tests showed a mixed bag: Sometimes Pentiums are faster, sometimes 486s are faster. The 486s that outperformed Pentiums in these tests all ran caching hard drive controllers.

In benchmarks that emphasized low-level operations such as the pixel and BitBlt tests, the system with the fastest video card won. Pentium-based systems had a decided advantage in tests of display and processor performance, such as the Polygon tests.

The bottom line: If your tasks are data-intensive (large database searches) or display-intensive (text and word processing), a Pentium system is probably not your best bet. Instead, get a 486 with the best graphics cards and disk subsystems you can buy. If your life is spent crunching numbers, perhaps in CAD problems, computer graphics, or engineering simulations, Pentium may be just the thing you need.

—Stephen Platt

PENTIUM PERFORMANCE

	Acer AcerAltos 7000	AMS InfoGold P60NT	ALR Evolution V Pentium	Compaq Deskpro 5/60M	IBM ValuePoint P60/D	Tangent Pentium 60VL	Unisys PW² Advantage Plus
SPECmark89	40.1	43.9	46.4	48.2	44.5	43.5	48.8
DOS	1.7	1.6	2.2	2.0	2.2	2.1	1.9
Windows	2.5	2.5	2.4	2.3	2.5	2.2	2.1
Price	$5550[1]	$5499	$4881	N/A	$5479	$4995	$8801[2]

[1] Estimated street price [2] Includes 40 MB of RAM N/A = not available.

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Energy Star Systems

According to the EPA (Environmental Protection Agency), computers account for 5 percent of all commercial electric consumption today. The agency says that figure could reach 10 percent by the year 2000. To combat this rising consumption, the EPA has developed its Energy Star Computer Program, which calls for vendors to voluntarily design systems that reduce power consumption.

The EPA's power-consumption specification for computers and monitors is simple: The product must be capable of entering a low-power state of 30 W or less when inactive. Starting last October, U.S. government agencies, under executive order, could only purchase products that met the Energy Star standard.

We tested power consumption for two systems that meet the Energy Star guidelines, the $2746 AST Bravo LP 4/66d Desktop and the $2299 486DX2-66 EcoSystem from Insight. For complete power savings, systems need to be matched with an Energy Star monitor, since monitors represent the greatest power draw in a computer system.


Insight EcoSystem: $95-per-year savings.

Although Energy Star defines power consumption guidelines, there isn't a common method for implementing them. Vendors have devised their own power-saving techniques, so not all Energy Star monitors are designed to work with all Energy Star computers.

For example, AST sells one of its low-emission monitors with the Bravo. The system communicates with the monitor through one of the pins in the video cable. The system's CMOS setup has settings for shutting down the hard disk and the system after a user-definable period of time. When the system shuts down, it sends the appropriate signal to the monitor to do the same. As the following table shows, both the AST monitor and system achieve the Energy Star required 30 W or less when in its low-power mode.


AST Bravo LP4/66d: $36-per-year savings.

To standardize the communications between the computer and monitor, the VESA (Video Electronics Standards Association) devised the DPMS (Display Power Management Signaling) Proposal. This technique, employed by the Insight EcoSystem, defines four different power management states and a clear methodology for the display controller to send signals to the display. The computer's video controller talks to the monitor by varying the horizontal and vertical synchronization signals.

We tested the Insight EcoSystem with a DPMS-compliant IBM 9521-21P monitor. Once the proper settings were configured in the EcoSystem's CMOS, all we had to do was press a simple hot key to shut down the system and the monitor. The system awakens at the touch of a key, but the monitor must be physically turned off and on again. When the monitor was in the low-power state (one step above the shutdown mode) it consumed 25 W of power and woke up instantly at the touch of a key.

Other monitors such as FlexScan models from Nanao offer a third communication process. The monitor enters into its low-power mode when it senses a blank screen such as those typically activated by a screen saver. After a user-definable period in its low-power mode, the monitor will then enter its shutdown or lowest-power consumption mode.

When buying Energy Star components (e.g., a system and a monitor), make sure that the communications technique used to initiate power-saving modes in one component is compatible with that used in the other. Focus your decision on the monitor's energy levels, since this component offers the greatest potential for power savings. Surprisingly, you won't pay a premium price for energy-efficiency. Both of these Energy Star systems were below the average price in this Lab Report.

POWER CONSUMPTION UNDER WINDOWS

The AST Bravo and Insight EcoSystem meet the EPA's specification for a 30-W or less power draw in conservation mode. The Compaq Deskpro represents power consumption of computers not designed for power savings.

	CONSUMPTION								COSTS			
	Full power (watts)				Power conservation mode (watts)				Full power		Power conservation mode (watts)	
486 systems	Computer	Monitor	Total	Watt-hours/ day (total)	Computer	Monitor	Total	Watt-hours/ day (total)	Per day (total)	Per year (total)	Per day (total)	Per year (total)
AST Bravo LP 4/66d with AST SVGA-LR monitor	36	61	97	2328	30	25	55	1656	$0.35	$127	$0.25	$91
Insight 486DX2-66 EcoSystem with IBM 9521 21P monitor	32	110	142	3408	28	6	34	1680	$0.51	$187	$0.25	$92
Comaq Deskpro 66m with NEC MultiSync 5FGe monitor	68	85	153	3672	N/A	N/A	N/A	N/A	$0.55	$201	N/A	N/A

N/A = not applicable.

Note: Full-power and conservation-mode numbers are based on BYTE/NSTL test results. The following assumptions are made on usage and cost estimates: $0.15 per kilowatt-hour; systems and monitors are left running 24 hours a day, 365 days a year; and systems and monitors with conservation modes are in that state for 16 hours a day and are configured for maximum conservation.

THE BEST SYSTEMS FOR

UNIX APPLICATIONS

Computationally intensive Unix tasks require all the data-processing power a CPU can muster. To find the best 486 systems for Unix, we combined the SPECmark89 and BYTE Unix benchmarks for insights into processing abilities. To gauge hard-disk subsystem performance, we used the PLATT disk drive tests developed for the September Lab Report on hard drives (see "32 High-Speed Hard Drives," September BYTE).

The SPEC tests consist of scientific and mathematical tasks such as the manipulation of large matrices and a simulation of a nuclear reactor. As such, these tasks are CPU-intensive and fast performance depends on efficient cache and memory architectures. The overall SPECmark rating is made up of two scores that divide the test suite into integer and floating-point tasks. The BYTE Unix benchmarks provide additional insight into the file- and pipe-based operations of subsystems. We developed an aggregate score based on an equal weighting of all these tests; this score represented 60 percent of our overall evaluation.

Our features rating counted for 30 percent of our evaluation. For Unix, systems scored high if they supported large amounts of memory (a minimum of 32 MB, with 64 MB or more being preferable). All but two of the systems ranked in this section supported at least 64 MB of RAM on the motherboard. The exceptions, which only supported 32 MB of memory, were both Low Cost runners-up: the Dyna Micro VL6 Business System and the Eco 486DX2/66 from Mega Computer Systems. The Hertz 486/d66x2Ei, a Most Expandable runner-up, can address the highest amount of memory—up to a whopping 384 MB.

Secondary processor cache is also essential for fast Unix performance due to its multitasking and heavy computational activities. All but three of our Unix-ranked systems accommodated a maximum of 256 KB of processor cache. Two systems supported only 128 KB of RAM cache, while the $3532 AST Premmia was a notable exception for its ability to hold up to 512 KB.

Our features scoring also considered the amount of available drive bays for additional CD-ROM, tape, and hard drives. Ease of use made up the remaining 10 percent of our evaluation. We rated how easy it was to open up the system and install adapter cards. We examined each system for obstructed slots and labels on the I/O ports. We also ranked each system's documentation for comprehensiveness and organization.

Unlike the other categories, all the systems in our test sample—no matter what bus architecture—were eligible for Unix ranking.

The $3398 DECpc 466d2 MTE from DEC took the top honors as the Best Overall Unix system thanks to a SPECmark89 of 17.80 and a score of "excellent" for ease of use. The $3133 Everex Step VL and the $2369 IBC VESA AD System also achieved a SPECmark of 17.80; however, both systems logged low features and ease-of-use ratings. They posted scores that placed them within the top 20 systems, which was enough to qualify the IBC as a Low Cost runner-up, but not

KEY SYSTEMS TERMS

Bus mastering
A bus-mastering adapter can take control of the expansion bus and access memory and other peripherals independently of the system's CPU. Greater data throughput can be achieved when the CPU is bypassed. This support can be found in EISA and Micro Channel architecture systems.

DMA
Direct memory access. Specialized circuitry in a system that allows devices to move information from one area of system memory to another without using the CPU. Like bus mastering, data can be moved faster through DMA than when the CPU performs the transfer.

Four-way set associative cache
One type of architecture for the processor cache or RAM cache. This configuration provides greater performance potential than the direct-mapped or two-way set associative RAM caches.

Interleaved memory
One type of system memory architecture that speeds up sequential memory accesses by dividing the RAM into two or more separate banks. Each bank holds alternating words of data. This structure allows the bank that is not currently being read to be updated. The best memory design is both paged and interleaved.

IRQ
Interrupt request. Designated lines that are used by the hardware to notify the CPU that it requires CPU processing time.

Paged memory
A design of system memory that speeds up memory accesses by dividing the RAM into two or more banks of data. Each bank holds alternating blocks or pages of memory. The best memory design is both paged and interleaved.

PCI
Peripheral Component Interconnect. A local-bus standard devised by Intel that allows the addition of up to 10 local-bus devices and supports concurrent CPU and bus-master operation. PCI also supports the 64-bit Pentium processor. PCI will grow in popularity as more vendors incorporate the PCI bus with their Pentium systems. See VL-Bus.

Superscalar
A technique that allows the CPU to execute more than one instruction simultaneously. Programs that are optimized for this design can produce significantly faster performance.

UART
The universal asynchronous receiver/transmitter that transmits and receives all the data during serial communications. The older UART designs like the 8250 and 16450 can encounter problems with high-speed communications and operations in a multitasking environment. The 16550 design alleviates these problems by the incorporation of a 16-byte FIFO (first-in/first-out) buffer.

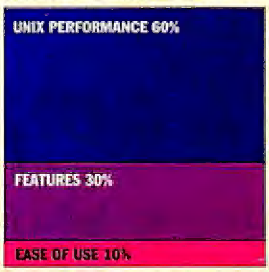
VL-Bus
A local-bus standard developed by the VESA (Video Electronics Standards Association) that allows devices to connect directly to the processor bus and operate at its clock speed. The VL-Bus can support up to three local-bus devices and is a simple extension of the standard ISA or EISA bus. The VL-Bus is utilized in many of today's high-performance 486DX2 systems. Many vendors produce VL-Bus adapters. See PCI.

sufficient for the Everex to be ranked.

By design, DX2/66 systems cannot achieve the floating-point performance of the traditional RISC-based Unix workstations. But many of the systems supply a Weitek math-coprocessor socket that will boost performance. Alternatively, you can bypass the 486 and look directly to Pentium-based systems that offer superior floating-point performance.

The DECpc 466d2 MTE also met all the qualifications for the Most Expandable category with six available EISA slots (one with the VL-extension), three free 5¼-inch drive bays, and support for up to 64 MB of memory. Its unmatched speed in our combined Unix tests, as well as its excellent features rating put the DECpc at the top of this category, too. No other system that ranked for Best Overall honors placed among the leaders in the Most Expandable category.

None of our tests were executed in a graphical windowing environment like SCO Open Desktop or X Windows. Thus, we did not address video performance in our rankings. However, users of such environments would greatly benefit from local-bus video accelerators present in most of the systems we tested. Make sure your operating system supports the video adapter you purchase; otherwise, you might be limited to operating in only standard 640- by 480-pixel VGA resolution and not the higher Super VGA modes the adapter is capable of driving.



KEY

▬ Desktop ▮ Tower

▯ Mini-tower

BYTE BEST — UNIX GENERAL PURPOSE

Need unexcelled 486 Unix?

BEST OVERALL — DECpc 466d2 MTE

DECEMBER 1993 BYTE BEST GENERAL PURPOSE UNIX SYSTEM

The efficiency of this system's memory architecture is evident in the SPECmark89 rating of 17.80, which tied the Everex for the fastest time among systems ranked for Unix. This test identifies systems with the best integer and floating-point performance. The DECpc is equipped with a Quantum IDE hard disk subsystem and an integrated S3 86C924 local-bus video adapter. DEC provides a three-year warranty that includes on-site service.

		CPU	PRICE	UNIX SPEED SPEC-MARK89	UNIX SPEED BYTE BENCHMARK	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	RAM CACHE (KB)	HARD DRIVE	WARRANTY (MONTHS)
BEST	DECpc 466d2 MTE	DX2/66	$3398	17.80	2.20	Excellent	EISA/VESA	16/64	256/256	240-MB IDE	36
RUNNER-UP	HP Vectra 486 PC	DX2/66	$3531	17.10	2.40	Excellent	ISA/Prop	8/64	256/256	240-MB IDE	36
RUNNER-UP	NCR System 3333	DX2/66	$4290	16.80	1.90	Excellent	ISA/VESA	16/64	256/256	340-MB IDE	36
RUNNER-UP	AST Premmia 4/66d	DX2/66	$3532	16.90	2.10	Excellent	EISA/Prop	8/128	256/512	340-MB IDE	36
RUNNER-UP	NCR System 3350	DX2/66	$5010	17.40	2.10	Excellent	MCA/Prop	16/192	128/128	340-MB SCSI	36
RUNNER-UP	Dell OptiPlex 466/MXV	DX2/66	$3593	17.70	2.40	Excellent	ISA/VESA	16/64	128/128	320-MB IDE	12
RUNNER-UP	Dell Dimension XPS 466V	DX2/66	$3312	17.50	2.30	Good	ISA/VESA	16/64	256/256	320-MB IDE	12
RUNNER-UP	Compaq Deskpro 66M Model 240/480/W	DX2/66	$3861	17.40	2.10	Excellent	EISA/N/A	16/136	256/256	240-MB IDE	36

Require a tower that's easy to upgrade?

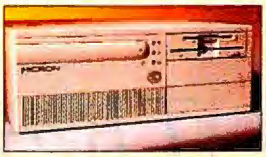
MOST EXPANDABLE — DECpc 466d2 MTE

Unmatched performance (see above) along with room to grow enables the DECpc to win top honors in this category. The system can handle up to 64 MB of RAM, and its tower chassis accommodates three additional 5¼-inch, half-height drive bays. The system also offers one available VL-Bus slot along with five 32-bit EISA slots; the 66-MHz 486DX2 processor resides on a card, which makes processor upgrading easy. Excellent security features include keyboard and boot password options, along with a keyboard and chassis lock. (Only tower-case systems were considered for this category.)

		CPU	PRICE	UNIX SPEED SPEC-MARK89	UNIX SPEED BYTE BENCHMARK	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	HARD DRIVE	AVAILABLE BAYS 3½/5¼	AVAILABLE SLOTS
BEST	DECpc 466d2 MTE	DX2/66	$3398	17.80	2.20	Excellent	EISA/VESA	16/64	240-MB IDE	0/3	6
RUNNER-UP	Touché 5550T VLB 66	DX2/66	$2799	17.50	2.20	Good	ISA/VESA	8/64	340-MB SCSI	4/2	5
RUNNER-UP	Hertz 486/d66x2EI	DX2/66	$5062	17.20	1.80	Excellent	EISA/None	8/384	340-MB SCSI	7/2	7
RUNNER-UP	X I 466EVL Netserver	DX2/66	$3149	16.80	2.50	Good	EISA/VESA	16/128	345-MB SCSI	3/5	6

Want the best Unix on a budget?

LOW COST — Micron 466VL WinStation



The $2649 Micron 466VL WinStation functions well as a Unix workstation. Its 64-MB memory maximum is adequate for many Unix tasks, and its standard 256-KB secondary memory cache can eliminate many wait states on memory accesses. Users can install another local-bus adapter along with five 16-bit ISA expansion boards. On-site service is included in the standard one-year warranty. The system's desktop chassis provides two additional 5¼-inch half-height drive bays in the front.

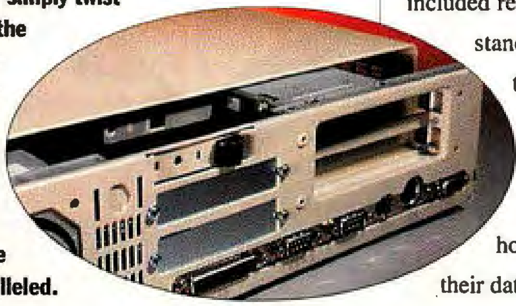
		CPU	PRICE	CASE	UNIX SPEED SPEC-MARK89	UNIX SPEED BYTE BENCHMARK	EASE OF USE	BUS/ LOCAL BUS	RAM (MB) STD./MAX.	RAM CACHE (KB)	HARD DRIVE
BEST	Micron 466VL WinStation	DX2/66	$2649	▬	17.40	1.90	Excellent	ISA/VESA	16/64	256/256	345-MB IDE
RUNNER-UP	CompuAdd C466D Desktop	DX2/66	$2694	▬	17.40	2.40	Good	ISA/VESA	8/64	256/256	340-MB IDE
RUNNER-UP	IBC VESA AD System	DX2/66	$2369	▮	17.80	2.20	Fair	ISA/VESA	8/64	256/256	240-MB IDE
RUNNER-UP	Zeos 486DX2-66	DX2/66	$2742	▬	16.60	1.90	Fair	ISA/VESA	8/64	256/256	340-MB IDE
RUNNER-UP	Mega ECO 486DX2/66	DX2/66	$2289	▬	16.90	1.80	Fair	ISA/Prop	8/32	128/256	254-MB IDE
RUNNER-UP	Dyna Micro VL6 Business System	DX2/66	$2195	▬	16.30	2.10	Fair	ISA/VESA	8/32	256/256	345-MB IDE

HONORABLE MENTIONS

Tired of swapping disks while installing software? Gateway 2000 has solved that problem for the CD-ROM–equipped systems it sells. Gateway includes a CD that contains a great deal of software such as Microsoft Windows, QAPlus diagnostic utility, Microsoft Multimedia Pack with sound and video samples, and several other useful applications. Not only is this technique more convenient than swapping floppy disks but it's also quicker. Two other vendors supplied CD-ROM drives, but neither included a CD.

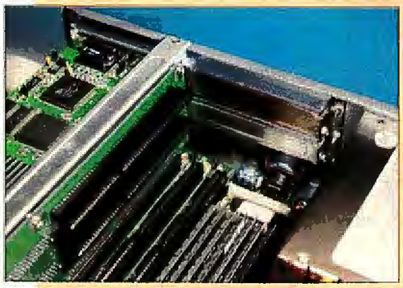
You can easily transfer or secure data with the systems from Diamond Technologies and Logisys, which included removable IDE hard drives. Both systems contained standard internal drives and an additional hard drive that is easily inserted or removed from the front of the case. This makes an ideal configuration for multiple users who need to share a system, users that need to repeatedly transfer data between home and office systems, or for those that require their data to be secured at the end of the day.

The AST Bravo's case is a cinch to remove. No need to search for a screwdriver, simply twist the knob on the back of the unit and the cover slides right off: No fist banging or wrestling is required. A couple of other system cases were removable without loosening screws, but the AST's design was unparalleled.



Dubious Achievements

This key is essential to users who wish to install SCO Unix 3.2.4 on the Grafika 4V2 from DTK. It was necessary to repeatedly press this key throughout the installation procedure for it to be successful. DTK recommended we use this tactic when we told them the system repeatedly locked. To avoid lockups during our DOS and Windows performance testing, DTK had us disable the external cache.



We did a double-take when we looked inside the Everex Step VL. In order to fit into its slimline case, the system's adapter slots must be horizontal. Everex achieved this by converting a standard vertical bus motherboard with a special adapter that fit into one of the VL-Bus slots that was fitted with five horizontal adapter slots. So at first glance, you see both horizontal and vertical slots, which looks baffling. To worsen matters, it's necessary to remove the power supply to get access to two of these rigged slots. This access problem was not unique to the Everex, other slimline designs presented the same obstacles to expansion.

Say what you mean. Several systems displayed the confusing message "486 at 66MHz, Setting at 25" during POST. We wanted top performance, so we changed the CPU frequency setting to 66 MHz. But this resulted in extremely sluggish performance. We later found out that this setting affects memory access and not the CPU—the higher the number the slower the memory access. So, we switched them back to 25 MHz.

ROLL CALL OF 486 SYSTEMS

EISA

VENDOR	MODEL	CASE	PRICE	CPU	MHZ	LOCAL-BUS TYPE	PERFORMANCE INDEX[3] DOS	WINDOWS	UNIX	SPECMARK89	EASE OF USE	RAM (MB) STAN.	MAX.
Acma Computers, Inc.	Acma EISA/VLB	▬	$2895	Intel 486DX2	66	VL-Bus	1.54	1.47	1.77	15.72	Good	8	128
Amax Engineering Corp.	486 EISA/KL PowerStation	▮	$2649	Intel 486DX	50	VL-Bus	1.39	1.36	1.67	13.43	Fair	8	128
American Multisystems	Info Gold E-VLB 66	▮	$3499	Intel 486DX2	66	VL-Bus	1.30	1.74	2.07	15.75	Fair	16	256
Ares Microdevelopment, Inc.	486-66DX2 EISA/ISA/VESA	▮	$3395	Intel 486DX2	66	VL-Bus	1.47	1.58	1.67	15.71	Good	16	256
AST Research, Inc.	**Premmia 4/66d**	▬	**$3532**	**Intel 486DX2**	**66**	**Proprietary**	**1.68**	**1.75**	**2.07**	**16.82**	**Excellent**	**8**	**128**
Compaq Computer Corp.	Deskpro 66M Model 240/480/W	▬	$3861	Intel 486DX2	66	None	1.59	1.70	2.05	17.40	Excellent	8	64
Comtrade Electronics	EISA 66	▬	$2995	Intel 486DX2	66	VL-Bus	1.14	1.86	2.27	12.97	Fair	8	128
Data Storage Marketing, Inc.	Data Storage 486-66 DX2 EISAVL	▬	$2805	Intel 486DX2	66	VL-Bus	1.62	1.68	2.03	16.79	Good	8	128
Data Storage Marketing, Inc.	Data Storage 486-66 DX2 EISAVL	▬	$2740	Intel 486DX2	66	VL-Bus	1.72	1.55	2.02	15.31	Good	8	128
Digital Equipment Corp.	**DECpc 466d2 MTE**	▯	**$3398**	**Intel 486DX2**	**66**	**VL-Bus**	**1.71**	**1.48**	**2.17**	**17.82**	**Excellent**	**8**	**64**
Duracom Computer Systems	MiniPro 486/66DX2E	▯	$3449	Intel 486DX2	66	VL-Bus	1.52	1.40	2.17	15.57	Fair	16	128
Everex Systems, Inc.	Everex Step VL	▬	$3133	Intel 486DX2	66	VL-Bus	1.38	1.96	2.02	17.82	Fair	8	256
FutureTech Systems, Inc.	462eV	▮	$2529	Intel 486DX2	66	VL-Bus	1.34	1.35	1.38	12.92	Fair	8	128
HD Computers	HD 486DX2-66	▮	$3045	Intel 486DX2	66	VL-Bus	1.29	1.77	1.82	16.15	Fair	16	256
Hertz Computer Corp.	Hertz 486/d66x2Ei	▮	$5062	Intel 486DX2	66	None	1.49	0.75	1.82	17.23	Excellent	8	384
Hi Quality Systems, Inc.	HI Q 4DX2-66E Ultra Graphics Station	▮	$2969	Intel 486DX2	66	VL-Bus	1.39	1.53	1.90	16.86	Good	8	256
International Data Systems, Inc.	IDS 466E2VP	▬	$2495	Intel 486DX2	66	VL-Bus	1.41	1.84	1.95	16.31	Fair	8	64
Logisys	L-Dream	▮	$3875	Intel 486DX2	66	VL-Bus	1.42	1.96	—[4]	—[4]	Poor	8	256
Micro Express	ME 486-YE/66	▯	$2774	Intel 486DX2	66	VL-Bus	1.40	1.68	1.70	14.56	Good	16	32
Micron Computer	Micron 466VL WinServer	▮	$3249	Intel 486DX2	66	VL-Bus	1.38	1.85	1.38	16.25	Poor	16	64
Microtech Computer Corp.	MT/EVLB 486DX2-66	▮	$3699	Intel 486DX2	66	VL-Bus	1.39	1.74	1.68	16.48	Fair	16	64
Microway, Inc.	Microway B3 486/66 EVL	▮	$4995	Intel 486DX2	66	VL-Bus	1.58	1.74	1.72	16.46	Poor	16	64
MIS Computer Systems	Promis ST	▮	$3180	Intel 486DX2	66	VL-Bus	1.57	1.53	1.90	16.42	Good	8	64
National Microcomputer Corp.	NMC Universal Power System	▬	$3719	Intel 486DX2	66	VL-Bus	1.40	1.56	2.00	15.11	Good	16	132
NCR Corp.	System 3350[1]	▬	$5010	Intel 486DX2	66	Proprietary	1.59	1.51	2.07	17.35	Excellent	16	192
Polywell Computers, Inc.	Poly 486-66EV2	▮	$2995	Intel 486DX2	66	VL-Bus	1.34	1.58	2.18	15.64	Fair	16	256
Softworks Development Corp.	Citus X-series Deskside	▬	$3695	Intel 486DX2	66	None	1.49	0.99	2.10	17.34	Excellent	16	128
Tangent Computer	Tangent EISA/VL	▮	$3895	Intel 486DX2	66	VL-Bus	1.71	1.76	1.43	17.55	Good	16	256
Uniq Technology	Uniq FileMaster	▮	$5184	Intel 486DX2	66	None	1.31	1.29	1.83	15.43	Poor	16	256
X I Computer Corp.	466EVL Netserver	▮	$3149	Intel 486DX2	66	VL-Bus	1.53	1.94	2.48	16.76	Good	16	128
Xinetron, Inc.	X/LAN Tower 4D66TE	▮	$3985	Intel 486DX2	66	VL-Bus	1.57	0.98	1.82	16.07	Poor	16	256

ISA

VENDOR	MODEL	CASE	PRICE	CPU	MHZ	LOCAL-BUS TYPE	DOS	WINDOWS	UNIX	SPECMARK89	EASE OF USE	STAN.	MAX.
Access Computer Technologies	Access 486-66MHz	▮	$2325	Intel 486DX2	66	VL-Bus	1.59	1.46	1.67	15.85	Poor	8	32
Acer America Corp.	AcerPower 486V	▬	$3344	Intel 486DX2	66	VL-Bus	1.29	1.79	—[4]	—[4]	Excellent	8	64
Acma Computers, Inc.	VESA Tower	▮	$2495	Intel 486DX2	66	VL-Bus	1.61	1.59	1.73	16.35	Good	8	128
Aero Computers	Aero T466VSB[2]	▮	$2150	Intel 486DX2	66	VL-Bus	1.60	1.61	—[4]	—[4]	Fair	8	32
Amax Engineering Corp.	486 VESA max Power Station	▮	$2699	Intel 486DX2	66	VL-Bus	1.30	1.75	1.65	15.97	Fair	8	128
American Multisystems	Info Gold VLB 66	▮	$2899	Intel 486DX2	66	VL-Bus	1.34	1.70	2.02	15.38	Fair	16	64
AST Research, Inc.	Bravo LP 4/66d Desktop	▬	$2746	Intel 486DX2	66	VL-Bus	1.55	1.17	1.93	15.80	Fair	8	64
Bell Computer/Alaris	Bell 4S6vC	▯	$1989	IBM 486SLC2	66	VL-Bus	—[4]	—[4]	—[4]	—[4]	—[4]	8	16
CAF Technology, Inc.	CAF Master 737 486DX2/66	▬	$2295	Intel 486DX2	66	VL-Bus	1.48	1.22	1.88	13.68	Fair	8	32
Commax Technologies, Inc.	Personal Workstation Model #4	▬	$1279	IBM 486SLC2	50	None	0.93	0.71	—[5]	—[5]	Fair	8	32
Compaq Computer Corp.	Deskpro 4/66i Model 240/480/W	▬	$3261	Intel 486DX2	66	None	1.39	1.53	1.88	15.77	Good	8	32
Compaq Computer Corp.	ProLinea 4/50 Model 240/480/W+	▬	$2667	Intel 486DX2	50	Proprietary	1.24	0.71	1.38	11.84	Good	8	32
CompuAdd Computer Corp.	C466D Desktop	▬	$2694	Intel 486DX2	66	VL-Bus	1.47	1.93	2.35	17.44	Good	8	64

[1] 32-bit bus, Micro Channel architecture
[2] Can run Unix if switched to a SCSI controller and SCSI hard drive
[3] Higher numbers indicate faster performance
[4] Couldn't complete tests due to unresolved hardware problems
[5] Lacked FPU to run Unix tests
N/A = not available.
= BYTE BEST.

▬ Desktop ▯ Mini-tower
▮ Tower

HARD DRIVE		MANUFACTURER	VIDEO ADAPTER	MAX. RESOLUTION (NONINTERLACED)	FCC RATING	WARRANTY (MONTHS)	PHONE	TOLL-FREE NO.	INQUIRY NO.
INTERFACE	SIZE (MB)								
SCSI	240	Seagate	ATI VLB Mach32	1280x1024	A	12	(510) 623-1212	(800) 786-6888	976
SCSI	240	Seagate	Diamond Stealth 24	1280x1024	A	12	(510) 651-8886	(800) 800-6328	977
SCSI	340	Maxtor	Diamond Viper VLB	1280x1024	B	12	(408) 524-9091	(800) 888-6615	978
IDE	340	Western Digital	Hercules Graphite VL	1280x1024	B	24	(313) 473-0808	(800) 322-3200	979
IDE	340	Western Digital	ATI Mach32	1024x768	B	36	(714) 727-4141	(800) 876-4278	980
IDE	240	Compaq	Compaq QVision 1024/E	1024x768	B	36	(713) 370-0670	(800) 345-1518	981
SCSI	340	Maxtor	Diamond Viper VLB	1280x1024	B	36	(818) 961-6688	(800) 969-2123	982
SCSI	345	Maxtor	STB Systems PowerGraph VL-24	1024x768	B	36	(303) 442-4747	(800) 543-6098	983
SCSI	245	Maxtor	STB Systems Horizon-VL	1024x768	B	36	(303) 442-4747	(800) 543-6098	984
IDE	240	Quantum	S3 86C924	1280x1024	B	36	(508) 493-5111	(800) 722-9332	985
SCSI	340	Maxtor	DFI WG-5000VL	1280x1024	A	12	(214) 518-1200	(800) 551-9000	986
IDE	240	Seagate	Diamond Viper VLB	1280x1024	B	24	(510) 498-1111	(800) 821-0806	987
IDE	340	Western Digital	Orchid Celsius VLB	1024x768	B	15	(201) 488-4414	(800) 275-4414	988
SCSI	340	Maxtor	Diamond Viper VLB	1280x1024	B	12	(408) 720-0493	(800) 347-0493	989
SCSI	340	Micropolis	Western Digital WD90C31	1024x768	B	12	(212) 684-4141	(800) 232-8737	990
SCSI	340	Maxtor	Diamond Viper VLB	1280x1024	B	12	(408) 245-5836	(800) 827-5836	991
SCSI	250	Seagate	Diamond Viper VLB	1280x1024	B	12	(714) 530-8677	(800) 777-6621	992
SCSI	240	Quantum	Diamond Viper VLB	1280x1024	B	24	(714) 693-1888	(800) 333-5679	993
IDE	300	Western Digital	Diamond Viper VLB	1024x768	B	24	(714) 852-1400	(800) 989-9900	994
SCSI	340	Maxtor	Diamond Viper VLB	1280x1024	B	12	(208) 465-3434	(800) 438-3343	995
IDE	340	Seagate	Wizard 9000VL	1280x1024	B	12	(404) 345-6508	(800) 342-6508	996
SCSI	344	Seagate	Diamond Stealth Pro	1280x1024	A	12	(508) 746-7341	N/A	997
SCSI	240	Quantum	ATI VLB Mach32	1024x768	A	12	(408) 730-9188	(800) 733-9188	998
SCSI	340	Fujitsu	STB Systems Pegasus VL	1280x1024	A	12	(801) 265-3700	(800) 424-2983	999
SCSI	340	Maxtor	Integrated NCR 77C22E	1280x1024	B	36	(513) 445-5000	(800) 637-2600	1221
SCSI	240	Quantum	Orchid P9000 VLB	1280x1024	B	24	(415) 583-7222	(800) 999-1278	1222
IDE	340	Western Digital	Western Digital WD90C31	1280x1024	B	12	(414) 242-8800	(800) 332-3475	1223
SCSI	339	Seagate	Hercules Graphite	1024x768	A	12	(415) 342-9388	(800) 800-6060	1224
SCSI	350	Conner	ATI Graphics Ultra	1280x1024	A	12	(510) 226-9988	(800) 866-3656	1225
SCSI	345	Seagate	Diamond Viper VLB	1280x1024	A	12	(714) 698-0858	(800) 432-0486	1226
SCSI	340	Maxtor	Color Designer Tseng ET4000	1280x1024	B	36	(408) 727-5509	(800) 345-4415	1227
SCSI	340	Maxtor	Diamond Stealth 24	1024x768	B	12	(408) 247-4444	N/A	1228
SCSI	340	Maxtor	Diamond Viper VLB	1280x1024	B	12	(408) 432-6200	(800) 733-2237	1229
IDE	210	Conner	ATI VLB Mach32	1280x1024	B	12	(510) 623-1212	(800)786-6888	1230
IDE	340	Western Digital	Diamond Stealth Pro	1280x1024	B	12	(212) 971-0285	(800) 232-1050	1231
IDE	210	Conner	Diamond Viper VLB	1280x1024	B	12	(510) 651-8886	(800) 800-6328	1232
IDE	345	Maxtor	Diamond Viper VLB	1280x1024	Pending	12	(408) 524-9091	(800) 888-6615	1233
IDE	170	Western Digital	ATI Mach32	1024x768	B	12	(714) 727-4141	(800) 876-4278	1234
IDE	245	Quantum	Cirrus Logic SVGA24	1024x768	B	12	(818) 909-3501	(800) 542-2355	1235
IDE	250	Maxtor	Cirrus Logic GD5426	1024x768	B	12	(818) 369-3690	N/A	1236
IDE	250	Conner	Western Digital WD90C31	1280x1024	B	12	(408) 435-5000	(800) 526-6629	1237
IDE	240	Conner	Compaq QVision	1024x768	B	36	(713) 370-0670	(800) 345-1518	1238
IDE	240	Compaq	Tseng ET4000/W32	1024x768	B	36	(713) 370-0670	(800) 345-1518	1239
IDE	340	Western Digital	Diamond Viper VLB	1280x1024	B	12	(512) 250-1489	(800) 627-1967	1240

ROLL CALL OF 486 SYSTEMS

VENDOR	MODEL	CASE	PRICE	CPU	MHZ	LOCAL-BUS TYPE	PERFORMANCE INDEX[3] DOS	WINDOWS	UNIX	SPECMARK89	EASE OF USE	RAM (MB) STAN.	MAX.
Computer Technology Link Corp.	Kim 486DX2-66	▮	$2159	Intel 486DX2	66	VL-Bus	1.43	1.43	1.68	13.64	Poor	8	32
Computers by Malone	CBM 466 VL	▮	$2399	Intel 486DX2	66	VL-Bus	1.15	1.41	1.48	12.55	Good	8	32
Cornell Computer Systems Corp.	Windows NT Station	▮	$2395	Intel 486DX2	66	VL-Bus	1.28	1.57	1.90	13.87	Fair	8	128
Data Storage Marketing, Inc.	Data Storage 486-50 ISAVL	▬	$2605	Intel 486DX2	50	VL-Bus	1.42	1.34	1.95	13.56	Excellent	8	32
Data Storage Marketing, Inc.	Data Storage 486-50 DX2 ISAVL	▬	$2290	Intel 486DX2	50	VL-Bus	0.64	1.19	1.75	13.19	Excellent	8	32
Data Storage Marketing, Inc.	Data Storage 486-66 DX2 ISAVL	▬	$2705	Intel 486DX2	66	VL-Bus	1.59	1.63	2.18	16.36	Good	8	32
Data Storage Marketing	Data Storage 486-66 DX2 ISAVL	▬	$2390	Intel 486DX2	66	VL-Bus	1.67	1.47	2.08	16.25	Good	8	32
Dell Computer Corp.	**Dell Dimension XPS 466V**	▬	**$3312**	**Intel 486DX2**	**66**	**VL-Bus**	**1.43**	**1.88**	**2.33**	**17.53**	**Good**	**16**	**64**
Dell Computer Corp.	Dell OptiPlex 466/MXV	▬	$3593	Intel 486DX2	66	VL-Bus	1.78	1.71	2.42	17.70	Excellent	16	64
Destiny Computers	IBM 486 SLC2-25/50	▬	$1695	IBM 486SLC2	50	None	0.80	0.54	—[5]	—[5]	Fair	8	16
Destiny Computers	IBM 486 SLC2-33/66	▬	$1845	IBM 486SLC2	66	None	1.15	0.75	—[5]	—[5]	Fair	8	16
Destiny Computers	IBM 486 SLC2-40/80	▬	$1995	IBM 486SLC2	80	None	1.31	0.91	—[5]	—[5]	Fair	8	16
Diamond Technologies	DT 486DX2-50 EVL	▮	$2099	Intel 486DX2	50	VL-Bus	1.31	1.27	1.67	12.53	Fair	8	128
Digital Equipment Corp.	DECpc 450d LPV 2	▬	$2268	Intel 486DX2	50	Proprietary	1.37	1.27	1.77	13.48	Good	4	64
Digital Equipment Corp.	DECpc 466d2 LPX	▬	$3168	Intel 486DX2	66	VL-Bus	1.65	1.51	2.07	17.27	Good	4	64
DTK Computer, Inc.	Grafika 4V2	▬	$2695	Intel 486DX2	66	VL-Bus	1.06	0.90	1.70	15.01	Poor	8	64
Duracom Computer Systems	DeskSaver 486/66DX2V	▬	$3099	Intel 486DX2	66	VL-Bus	1.50	1.41	1.65	13.93	Fair	16	32
Dyna Micro	Dyna Micro VL6 Business System	▬	$2195	Intel 486DX2	66	VL-Bus	1.74	1.49	2.13	16.28	Fair	8	32
Everex Systems, Inc.	Everex Step VL	▬	$3006	Intel 486DX2	66	VL-Bus	1.25	1.44	1.52	11.99	Fair	8	32
Gateway 2000	**4DX2-66V**	▬	**$2995**	**Intel 486DX2**	**66**	**VL-Bus**	**2.01**	**1.95**	**2.32**	**17.48**	**Good**	**16**	**64**
HD Computers	HD 486DX2-66	▮	$2745	Intel 486DX2	66	VL-Bus	1.22	1.55	1.62	13.27	Fair	16	32
Hewlett-Packard Co.	Vectra 486 PC	▬	$3531	Intel 486DX2	66	Proprietary	1.64	1.69	2.38	17.06	Excellent	8	64
IBM Corp.	ValuePoint 6384-W71	▬	$2919	Intel 486DX2	66	VL-Bus	1.54	1.56	1.73	13.57	Excellent	8	64
Insight	Insight 486DX2-66 EcoSystem	▬	$2299	Intel 486DX2	66	Proprietary	1.05	0.67	1.43	9.32	Good	8	32
Insight	Insight 486DX2-66 VLB	▮	$2699	Intel 486DX2	66	VL-Bus	1.34	1.79	1.90	16.13	Fair	8	32
Integrated Business Computers	IBC VESA AD System	▮	$2369	Intel 486DX2	66	VL-Bus	1.76	1.65	2.17	17.81	Fair	8	32
Liberty Research	Montana Big Horn	▬	$2999	Intel 486DX2	66	VL-Bus	1.73	1.05	1.97	17.54	Fair	16	64
Mega Computer Systems Corp.	Eco 486DX2/66	▬	$2289	Intel 486DX2	66	Proprietary	1.63	1.04	1.78	16.88	Fair	8	32
Mega Computer Systems Corp.	Impact 486DX2/66	▬	$2095	Intel 486DX2	66	VL-Bus	1.49	1.18	1.60	13.68	Fair	8	32
Micro Express	MicroFlex-VL/S	▯	$2274	Cyrix 486S	40	VL-Bus	0.96	1.00	—[5]	—[5]	Good	16	32
Micron Computer	Micron 466VL WinStation	▬	$2649	Intel 486DX2	66	VL-Bus	1.39	1.89	1.93	17.37	Excellent	16	64
MicroSource	Tempest 486 VLB-66	▮	$2545	Intel 486DX2	66	VL-Bus	1.33	1.70	1.58	14.59	Fair	8	64
MIS Computer Systems	Promis SL	▬	$2370	Intel 486DX2	66	VL-Bus	1.61	1.51	2.20	16.96	Fair	8	64
Mitsuba Corp.	MIT 486 PRO-66	▯	$2895	Intel 486DX2	66	VL-Bus	1.54	1.40	1.72	13.38	Poor	8	32
National Microcomputer Corp.	NMC Universal VL Bus Pro System	▬	$2349	Intel 486DX2	66	VL-Bus	1.55	1.55	1.77	15.05	Fair	8	37
NCR Corp.	System 3333	▯	$4290	Intel 486DX2	66	VL-Bus	1.40	1.83	1.87	16.75	Excellent	16	64
Olivetti North America	M6-460 Suprema	▬	$3315	Intel 486DX2	66	Proprietary	1.71	1.63	1.97	17.12	Fair	8	100
PKI (Pao Ku International)	PKI 66MHz VLB	▯	$2229	Intel 486DX2	66	VL-Bus	1.60	1.32	1.87	16	Poor	8	32
SAI Systems Laboratories	SAI 486 V/P	▯	$1995	Intel 486DX2	66	VL-Bus	1.54	1.24	1.65	13.98	Poor	8	32
Samsung Electronics America	Samsung SD 966V	▬	$2199	Intel 486DX2	66	VL-Bus	1.36	1.13	1.57	13.95	Good	8	32
Swan Technologies, Inc.	Swan 486DX2-66 Direct Bus Cygnet	▬	$2798	Intel 486DX2	66	VL-Bus	1.50	1.53	2.22	14.01	Good	16	64
Top Data, Inc.	Top Data 486 DLC 40 VLB	▮	$1499	Cyrix 486DLC	40	VL-Bus	0.96	0.76	—[4]	—[4]	Fair	8	32
Touché Micro Technologies, Inc.	5550T VLB 66	▮	$2799	Intel 486DX2	66	VL-Bus	1.63	1.68	2.15	17.54	Fair	8	64
Unitek Technology, Inc.	UT-486DX2 66 LB	▬	$2340	Intel 486DX2	66	VL-Bus	1.30	1.37	1.75	12.96	Poor	8	32
Xinetron, Inc.	SunMate	▬	$2410	Intel 486DX2	66	VL-Bus	1.45	0.82	1.53	13.02	Fair	16	64
Zeos International, Ltd.	486DX2-66	▬	$2742	Intel 486DX2	66	VL-Bus	1.42	1.89	1.92	16.56	Fair	8	64

[3] Higher numbers indicate faster performance
[4] Couldn't complete tests due to unresolved hardware problems
[5] Lacked FPU to run Unix tests
N/A = not available.

= BYTE BEST. ▬ Desktop ▮ Tower ▯ Mini-tower

HARD DRIVE									
INTERFACE	SIZE (MB)	MANUFACTURER	VIDEO ADAPTER	MAX. RESOLUTION (NONINTERLACED)	FCC RATING	WARRANTY (MONTHS)	PHONE	TOLL-FREE NO.	INQUIRY NO.
IDE	203	Western Digital	Premier 928	1280x1024	B	12	(503) 646-3733	(800) 642-3087	1241
IDE	340	Western Digital	Diamond Viper VLB	1280x1024	Pending	24	(402) 333-6783	(800) 842-0906	1242
IDE	340	Seagate	Diamond Viper VLB	1280x1024	B	24	(909) 594-5848	(800) 886-7200	1243
IDE	345	Maxtor	STB Systems PowerGraph VL-24	1024x768	B	36	(303) 442-4747	(800) 543-6098	1244
IDE	245	Maxtor	STB Systems Horizon-VL	1024x768	B	36	(303) 442-4747	(800) 543-6098	1245
IDE	345	Maxtor	STB Systems PowerGraph VL-24	1024x768	B	36	(303) 442-4747	(800) 543-6098	1246
IDE	245	Maxtor	STB Systems Horizon-VL	1024x768	B	36	(303) 442-4747	(800) 543-6098	1247
IDE	**320**	**Western Digital**	**Diamond Viper VLB**	**1280x1024**	**B**	**12**	**(512) 338-4400**	**(800) 289-3355**	**1248**
IDE	320	Western Digital	Tseng ET4000/W32	1024x768	B	12	(512) 338-4400	(800) 289-3355	1249
IDE	200	Conner	Western Digital WD90C31	1024x768	B	36	(510) 783-2727	(800) 337-8469	1250
IDE	200	Conner	Western Digital WD90C31	1024x768	B	36	(510) 783-2727	(800) 337-8469	1251
IDE	200	Conner	Western Digital WD90C31	1024x768	Pending	12	(510) 783-2727	(800) 337-8469	1252
IDE	200	Conner	Orchid Celsius VLB	1280x1024	B	15	(714) 533-9910	(800) 989-7253	1253
IDE	240	Quantum	S3 86C805	1024x768	B	36	(508) 493-5111	(800) 722-9332	1254
IDE	240	Quantum	S3 86C805	1280x1024	B	36	(508) 493-5111	(800) 722-9332	1255
IDE	340	Maxtor	ATI VLB Mach32	1280x1024	B	12	(818) 810-8880	(800) 289-2385	1256
IDE	340	Western Digital	ATI VLB Mach32	1024x768	B	12	(214) 518-1200	(800) 551-9000	1257
IDE	345	Maxtor	Genoa Systems WindowsVGA 24	1024x768	B	12	(408) 943-0100	(800) 336-3962	1258
IDE	240	Seagate	Diamond Viper VLB	1280x1024	B	24	(510) 498-1111	(800) 821-0806	1259
IDE	**340**	**Western Digital**	**ATI Ultra XLR**	**1280x1024**	**B**	**12**	**(605) 232-2000**	**(800) 846-2000**	**1260**
SCSI	340	Maxtor	Diamond Viper VLB	1280x1024	B	12	(408) 720-0493	(800) 347-0493	1261
IDE	240	Quantum	S3 86C928	1280x1024	B	36	N/A	(800) 752-0900	1262
IDE	40	Western Digital	S3 86C805	1280x1024	B	12	(914) 766-1900	(800) 426-2968	1263
IDE	346	Western Digital	Cirrus Logic GD5424	1024x768	B	12	(602) 902-1176	(800) 927-7848	1264
SCSI	213	Maxtor	Diamond Viper VLB	1280x1024	B	12	(602) 902-1176	(800) 927-7848	1265
IDE	240	Quantum	Cardex W32	1024x768	B	12	(818) 882-9007	(800) 468-5847	1266
IDE	340	Western Digital	Headland Technology HT-340	1280x1024	A	12	(406) 771-7736	(800) 424-7736	1267
IDE	254	Conner	Cirrus Logic GD5426	1280x1024	B	12	(619) 487-8888	(800) 487-6628	1268
IDE	254	Conner	Cirrus Logic VL34	1280x1024	A	12	(619) 487-8888	(800) 487-6628	1269
IDE	300	Western Digital	Diamond Viper VLB	1024x768	B	24	(714) 852-1400	(800) 989-9900	1270
IDE	345	Maxtor	Diamond Viper VLB	1280x1024	B	12	(208) 465-3434	(800) 438-3343	1105
IDE	213	Western Digital	Diamond Viper VLB	1280x1024	B	24	(818) 858-5161	(800) 848-5161	1106
SCSI	240	Quantum	S3 86C805	1024x768	A	12	(408) 730-9188	(800) 733-9188	1107
IDE	254	Conner	ATI VLB Mach32	1280x1024	B	24	(909) 392-2000	(800) 648-7822	1108
IDE	250	Western Digital	Actix Graphics Engine 32	1280x1024	B	12	(801) 265-3700	(800) 424-2983	1109
IDE	340	Maxtor	Diamond Viper VLB	1280x1024	B	36	(513) 445-5000	(800) 637-2600	1110
IDE	210	Conner	Mach32	1024x768	B	12	(509) 927-5600	(800) 633-9909	1111
IDE	245	Maxtor	Cirrus Logic 5426VL	1280x1024	B	12	(708) 369-5199	(800) 676-9632	1112
IDE	250	Western Digital	Cirrus Logic GD5426	1280x1024	B	12	(203) 929-0790	(800) 331-0488	1113
IDE	250	Samsung	Cirrus Logic GD5426	1024x768	B	12	(201) 229-4000	(800) 446-0262	1114
IDE	450	Seagate	ET4000/W32	1280x1024	B	12	(814) 238-1820	(800) 468-9044	1115
IDE	214	Seagate	Cirrus Logic 5426	1024x768	B	12	(408) 734-9100	(800) 888-3318	1116
SCSI	340	Maxtor	Orchid Celsius VLB	1280x1024	B	24	(815) 439-9000	N/A	1117
IDE	340	Western Digital	Diamond Stealth PRO	1280x1024	B	12	(909) 930-5700	(800) 944-5650	1118
IDE	245	Maxtor	Color Designer Tseng ET4000	1280x1024	B	36	(408) 727-5509	(800) 345-4415	1119
IDE	340	Western Digital	Diamond Viper VLB	1280x1024	B	12	(612) 633-4591	(800) 554-5226	1120

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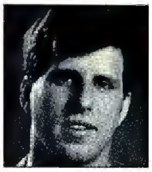
Optimal Character Recognition

An inside look at how optical character recognition works



PETER WAYNER

Reading is something we take for granted. In fact, as you read this sentence, you're probably not even cognizant of the work your brain is doing to convert the ink-mark patterns into thoughts. Computers, however, still struggle with this most basic of tasks.

Programmers have been working on OCR (optical character recognition) for many years now. But while the state of the art has advanced to a point where many systems can be quite reliable when they deal with clean, crisp text, computers are still far from offering the same flawless perfection to OCR that they apply to, say, arithmetic calculations.

Most OCR systems begin with a bit-mapped image that arrives via a fax modem or a scanner. The first step in the OCR process is to break the page into blocks of text based on typographical features such as right and left justification. These blocks are decomposed into the individual ink marks that often correspond to letters. The recognition algorithm makes its best guess as to what the ink marks mean, and then the page is reconstructed in the proper format.

The best OCR systems can achieve accuracy rates of above 99 percent for clean images composed of ordinary fonts. Although this number seems almost perfect, the error level is frustrating because there are approximately 1500 characters on a standard manuscript page. Thus, even a 99.9 percent success rate still generates one or two errors per page, requiring a human to proofread the results to ensure perfection.

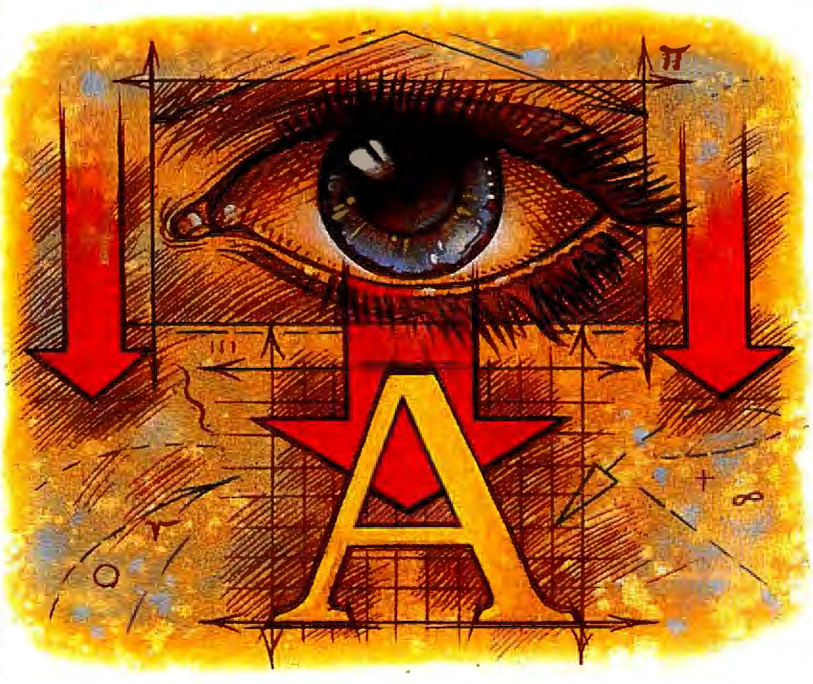
The real world, though, is often far from perfect, and accuracy rates for less-than-optimal text are often unacceptable for most applications. Dirty images are a major problem, because even small spots can obscure crucial parts of a letter or convert a *c* into an *o*. If a document has been photocopied repeatedly, the letters may be thinned to the point of breaking, or they may be fattened until they bleed together. Either of these effects can cause errors, because many OCR systems consider each connected black mark to be a single character. Also, a misaligned page creates slightly distorted character images that can confuse the recognition software.

Even when images are clean, certain typefaces can cause difficulties. Strange or decorative typefaces can cause problems because they stretch the letters into different forms for artistic effect. But even normal typefaces can have surprising variations—even among typefaces of the same name. The Times characters produced by a Hewlett-Packard DeskJet printer are different from the Times characters that come from an Apple LaserWriter.

Developing algorithms that can still recognize characters despite these problems is a difficult challenge. Software engineers must balance the need for flexibility against the demand for accuracy. If the software isn't flexible enough, it will break when it encounters slightly different typeface variations. On the other hand, too much flexibility can also cause errors. The difference between a lowercase *b* and a lowercase *h* is not very great, and a too-flexible algorithm may confuse the two.

Reconstructing a Page

OCR software generally works on a large bit-mapped image of a page from a scanner. Standard-grade images are typically scanned at 300 by 300 pixels per inch. An image the size of an 8½- by 11-inch piece of paper at this resolution requires 1.2 MB of storage.



CARY HENRIE © 1993

Finer-resolution images are possible with more expensive scanners, but they're often impractical for general applications because of the images' huge storage demands. Furthermore, upping the resolution of the scanner does no good if the original page's quality is poor. Coarser-resolution images often come from fax machines that

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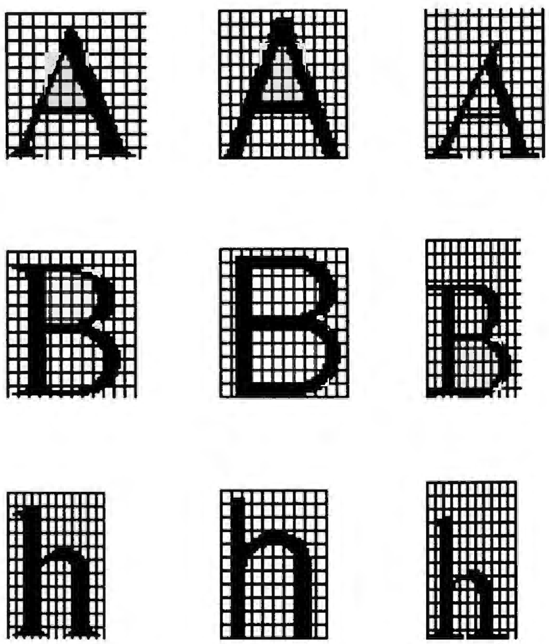
OCR Using Templates



Several typefaces *broken up into 10- by 10-pixel grids for recognition.*

send only 200 by 100 pixels per inch in standard mode and 200 by 200 pixels per inch in fine mode. These images are further blurred and degraded by the fax process itself. Many OCR software manufacturers attempt to handle this all-too-common situation by offering special software for fax images.

Each of the best OCR packages on the market claims to do "document recognition," because all these packages are able to construct a file that contains all the formatting information contained on the page. This process can be complicated, and many software developers use many different proprietary tricks.

Some examples from applications illustrate the complexity of this task. ExperVision's page-analysis routines begin at the bottom of the page after it is broken into its smallest connected ink marks. These marks are grouped into words, and the words are grouped into lines. This process depends on an accurate assessment of the page's orientation. ExperVision's algorithm is able to determine this to a precision of less than half a degree. (Some quick calculations should make it obvious that this type of accuracy is necessary because the lines of text are so long [approximately 200 mm] and so thin [approximately 3 to 5 mm].)

These lines can be aggregated into paragraphs by grouping those lines with similar justification, length, typeface, spacing, and typography. ExperVision's software also uses lines, boxes, different gray-scaled backgrounds, and graphics to delineate the paragraphs.

The final step of the document-recognition process is to determine the order of the paragraphs on the page. This is easy to do with a one-column manuscript, but the process becomes tricky when the document is a page from a magazine laid out with brio and verve. The algorithms start with the upper-leftmost block and move downward, marking each block along the way. When the bottom of the page is reached, the program moves to the page top and looks for another column. Inset quotes or tables can be a problem for these algorithms, and most software allows the user to edit the order of the paragraphs if the algorithms make a mistake.

Distinguishing between graphics and text is another problem that demands its own algorithm. Most software uses the statistical differences between text (black and white with a regular rhythm) and graphics (multiscaled with no regular pattern between dark and light). One simple algorithm used to do this looks at the percentage of completely dark pixels that are within 2 pixels of a completely light pixel. Most dark pixels in text fall into this category.

Caere's OmniPage system uses a similar technique to filter out gray-level backgrounds that are often used to highlight or differentiate different words or text blocks. This system, called AnyPage, adjusts the threshold for background gray on a local basis when the software receives a gray-leveled image from a gray-level scanner. The system turns the image into a binary image for processing by converting all values below the threshold to white and all those above it to black.

Choosing a single threshold for an entire page is often problematic. A high threshold might remove the gray in a text box correctly, but it will also thin all the characters on a white background. Why? Because the pixels on the edge of an ink mark will often be an average of dark from the character and light from the background. In these cases, the lowest possible threshold ensures that no extra detail will be lost through unacceptable thinning.

Detecting tables is also necessary if the software is going to read, say, an annual report. ExperVision's software recognizes tables by looking for several thin columns that are aligned with each other. In many cases, the columns are either centered or right-justified and filled with numbers. Recognizing this correctly allows the software to place the table in the proper tab-delimited format so that you don't need to edit the final text output with a word processor.

Crossing Your Eyes and to Dote on the T's

With page reconstruction done, the ink marks are then converted into characters. There are many different approaches to recognizing characters, but many of them fall into two main camps: *template-based* methods and *feature-based* methods. Template methods maintain a collection of sample letters and identify an ink mark in question by finding the closest-matching template. Feature methods try to break an ink mark into a collection of "features" by identifying where strokes join and curve significantly.

The classic template solutions compare each letter to a collection of models representing all possible letters in all possible fonts. These systems usually begin by constructing a matrix representation of an ink mark. ExperVision's system, for instance, uses a 10- by 10-pixel mask superimposed on the ink mark.

If the ink mark is small—perhaps the result of small, 6-point text—then it may take up only 4 by 7 pixels in the image. Large, 64-point typefaces, on the other hand, may measure several hundred pixels in either direction. In either case, the software divides the ink mark into 10 equal vertical and horizontal sections and determines whether the ink mark lying under each of the 100 mask pixels is generally filled or unfilled.

The character models, or templates, are constructed with the same 10-by-10 matrices, but with ideal versions of the different characters (see the figure above). The software recognizes a blob by looking for the template with the closest match.

The methods for comparison can vary. The simplest one is to

count the number of pixels that are different from the template. The smallest number is the closest match. Although this seems straightforward, it is prone to error if the typefaces are not exact matches. In such cases, the outline of the ink blob and the typeface will not match, no matter how good the image is.

There are bound to be pixels that disagree. This can cause interpretation problems where, for instance, the template for a lowercase *h* may be a better match for the printed lowercase *b*. The number of different pixels between typefaces could be greater than the small number of open pixels at the bottom of the *h*.

For this reason, most systems have templates created for different typefaces. After several words, the software determines the most-used typeface and looks for matches with this typeface only. In some cases, the software uses actual parts of the digitized image to define a new font. This can dramatically improve OCR performance until other type styles, such as italics or boldfaced words, are found on the page.

For its recognition software, ExperVision uses machine-learning algorithms to find the most important pixels for distinguishing between characters. The company takes 30 different versions of a letter that come from 30 different documents in various stages of degradation and then analyzes the 100 pixels in each of these 30 examples to determine which pixels are most likely to be characteristic for a particular letter.

The pixels on the bottom of a lowercase *h*, for instance, are always going to be clear, while the ones on the vertical stroke will always be dark. The edge pixels along the boundaries of the character are often ruled out by this analysis, because they may be dark in clean images but clear in degraded ones. The machine-learning algorithm ranks the 100 pixels from most to least consistent for each of the characters.

This step is not enough, however, because of similarities between letters. For instance, the lowercase *b, h, k, f, l,* and *t* all share long vertical strokes on the left side. Even if the pixels along this stroke remain constant through all phases of degradation, they will not contribute very much toward distinguishing among these six letters. For this reason, ExperVision's software finds the top 24 pixels that are most consistent across all letters in the alphabet and removes these from the list for the individual letters. The pixels that are left over are most likely to be both consistent and unique.

Feature-Based Matching

Caere's OmniPage Professional uses an algorithm that does not need to be tuned to the individual typefaces because it is based on finding particular features of the letters. The system contains 100 different "expert systems" that are really just algorithms for identifying 100 different characters (uppercase *A* through *Z*, lowercase *a* through *z*, numerals, and punctuation marks). Each of these expert systems looks for "features" such as islands; peninsulas; inflection points; long, straight strokes; or strokes of consistent curvature. The expert systems also look at the horizontal and vertical projections of the ink marks and note salient features in the constructed curves by summing the number of dark pixels that are in a particular row or column (see the figure at right).

The attraction of this type of algorithm, if it can be made to work, is obvious. Everyone knows that a lowercase *t* consists of a strong vertical stroke crossed with a horizontal stroke. A typeface designer may include serifs or a bent bottom or shift the location of the cross-stroke, but a human reader can figure out the difference. Template-based approaches must create templates for each possible font (ExperVision uses 2100 typefaces). Caere instead tries to find the essence of each letter in an algorithm.

The problem with these algorithms, of course, is that teaching a computer to identify long strokes, peninsulas, and islands can be just as tricky as getting it to read letters. A *k* may be made up of a long vertical stroke and two peninsulas in most normal cases, but in some cases a font designer could make the peninsulas too small for them to qualify for peninsula status in the eyes of the algorithm. They might just resemble serifs instead and thus be ignored.

Degraded text can be a particular headache for these algorithms, because a missing pixel could break a long stroke or curve. This missing pixel would be just one out of the many checked by a template algorithm, but it could fundamentally change a feature-based interpretation of a particular ink mark. Similarly, an extra spot of dirt could close the loop of a numeral 5 and make it look like a 6 to a feature-based algorithm. A template algorithm may not have a problem here, however, because the rest of the pixels in the 5 would still align correctly.

Either recognition process can encounter still other problems. Humans are able to quickly distinguish between lowercase *h* and *b* on paper because they know the context of the language. For this reason, all the major software OCR systems include dictionaries to assist their recognition algorithms when the going gets complicated. While these can be a big help in many cases, they quickly fail when the software encounters proper names that aren't in the dictionary or if it must distinguish between two equally valid choices, such as *if* and *it*.

Xerox Imaging Systems has one of the most sophisticated context-analysis software packages. Called Lexifier (short for "lexical classifier"), the package contains encodings of most of the major spelling rules and common patterns. Thus, it knows

OCR Using Features

The horizontal and *vertical projections of several letters in several different typefaces. The major features, such as vertical or horizontal strokes, appear as peaks.*

that there's always a *u* after *q* and that *i* often comes before *e* except after *c*. This helps it interpret proper names such as *Lexifier* that seem perfectly English-like but aren't in the dictionary.

Lexifier also knows many details about common usage, such as the fact that U.S. phone numbers must be listed in an XXX-XXX-XXXX pattern. The software even knows that area codes in the U.S. must have either a 1 or a 0 as the middle digit and that the first three digits of a local three-digit prefix, on the other hand, can't have a 1 or a 0 in this position. (This arrangement is slated to change in the latter half of this decade when the numbering solutions are expanded to cope with the explosion in the number of fax machines, pagers, and other new numbers. Xerox says it is ready to deal with this change.) This type of analysis can significantly reduce confusing numerical 1s with alphabetical lowercase *l*'s.

Degradation and Error Correction

Clean images can be easy to deal with, but degraded images can get very complicated because the rules that match one connected mark to one character rarely hold anymore. As mentioned earlier, fax machines and photocopiers can quickly thin and break characters or fatten them up and blur them together.

ExperVision's template approach is tuned to find the most significant pixels in a wide range of documents. Thinned and broken characters are found automatically, because the software avoids relying on pixels that may disappear in bad images. The software only needs to find places to break apart blurred characters. It finds them by looking for vertical locations where there are inflection points and then trying out the results. For instance, the blurred combination of *rn* looks like an *m* in many cases. There are three significant pixels that distinguish the two; ExperVision put these at the top of the list.

Caere also has a proprietary algorithm for breaking blurred-together letters. Its OmniFont technology, however, faces more trouble with broken characters. If the software doesn't find a match among the 100 possible characters, it feeds the ink marks in the region to an enhancing process to try and fix the broken characters. Missing pixels that fix long strokes are tried.

Unfortunately, even the best OCR systems make mistakes on each page. Degraded text becomes incredibly difficult to handle. At this point, the ultimate recognition system—yourself—must be brought into the process. You have to scan over the text to look for bad segments and mistakes.

ExperVision takes this problem seriously, and the company spent time developing a quick and easy-to-use interface for helping the user proofread the recognized file for errors. You can scan through all the lines in the text for errors with the Tab key. As you get to each one, the software places a clipping of the image next to the text so that you can compare the text to the original image without moving your eyes. There is no need to consult the paper version to see if a word is *if* or *it*.

I've found that a good user interface can make plenty of difference when you're checking for errors. This difference is important because most OCR packages allow you to put a document

in a multipage feeding scanner and come back later when all the recognition work has been done. Proofing then becomes the most time-consuming link in the OCR chain.

The software in an OCR system also keeps track of places where it suspected that it was guessing more than recognizing. These uncertainties are highlighted for you to check quickly. Integration of the knowledge from the recognition phase with the proofreading phase makes it much easier for you to become familiar with the software's capabilities and limitations.

Adapting to a Changing World

OCR is one of the first generally successful applications of AI research. Its results are good enough to be useful to anyone who often retypes clean manuscripts. Unfortunately, the best software still falls short of perfection and requires a human to check for errors. Clear, laser-printed pages can often be translated with very few problems, but faxed images and marked-up text can still lead to many errors.

This distinction illustrates just how hard it is to program computers to interface with the world as humans do. If OCR packages are made too strict, then they make errors when noise, dirt, or degradation causes the letters to be slightly different than the way they appear in the templates. On the other hand, if they become too flexible, they make mistakes, because the letters are often very close to each other.

To a large extent, humans make the process even more daunting by constantly reinventing the page styles of the world. Making documents look fresh and new often involves breaking or stretching the old rules. The hottest typefaces of today often tweak the parameters of the letters to change the visual rhythm of the page. This may involve moving the typeface's midline or moderating the intercharacter spacing for a decidedly different effect.

While all these changes can grab your attention, it can confuse an OCR package. ExperVision's package was trained with 2100 typefaces. This is certainly adequate—until someone comes along with the 2101st typeface. Caere's OmniFont algorithms can be very flexible until artists find new ways to break the old rules that these algorithms rely on—probably using Adobe's Multiple Masters technology.

In many ways, the best OCR packages show that it is possible to make computers sensitive to many human thought processes, if only in a very limited domain of text recognition. In the future, the best OCR systems will improve on their performance by using even more sophisticated content-based approaches such as Xerox's Lexifier. They will also learn to do a better job with poorly written characters and those degraded by marks like cross-outs or underlining. The end result will be more-refined processes that may eventually become good enough to trust. In the interim, it will be a long time before proofreading is gone. ■

Peter Wayner is a Baltimore-based BYTE consulting editor. He has worked at Xerox's Palo Alto Research Center developing advanced algorithms for OCR and document recognition. You can reach him on BIX as "pwayner" or on the Internet at pcw@access.digex.com.

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Using C++ for Directory Management

Use operator overloading to build C++ tools for managing your directories

ALLEN I. HOLUB

I've used my C++ `directory` and `dir_entry` classes to build tools that prune directories, recursively search for files, and perform other useful tasks. These tools use operator overloading to solve the age-old problem of iteration and exploit a few other interesting features of C++ as well. The list.cpp listing shows a simple directory-printing utility, which takes a path name on the command line and lists matching files. The directory listing shows a sample printout.

Here's the core of the program, the part that loads the contents of the target directory into a data structure, sorts it, and prints it:

```
directory d( path, filespec );
d.sort();
while( d )
   (d++)->print();
```

The analogy is that a `directory` object is a pointer to the first element of an array of `const dir_entry` objects, one for each directory entry. Once the constructor loads the array, you can access it using the normal array-access mechanisms. Since a directory object is an analog for a pointer, you can use `(d++)->print()`, `d[i++].print()`, or `(*d++).print()` to print the elements and to iterate to the next element.

The autoincrement (++) operator advances the virtual pointer from the current to the next directory entry. You can preincrement or postincrement. The virtual pointer evaluates false in a Boolean test when the pointer is positioned at the end of the list—it's used in this way in the while loop to detect end of list.

The tree.cpp listing shows another use of the `directory` class. The `trav_dir_tree()` subroutine traverses an entire directory tree recursively, calling a subroutine that you provide for per-subdirectory processing. You provide a root directory and a pointer to the callback subroutine, which receives the full path name of each subdirectory and the level of the subdirectory beneath the root. (This root doesn't have to be the \ directory—it can be at any position in the directory system.) If you pass NULL rather than a pointer to a callback function, `trav_dir_tree()` calls `def_callback()`, which just prints the full path name of each subdirectory that is visited.

Member Function or Global Function?

There are several implementation issues to discuss even at this level. First, `trav_dir_tree()` is not a member of my `directory` class. Generally, functions that don't access any private members (data or functions) of a class should not themselves be class members. This rule tends to simplify the class definition and improve *cohesion*—the degree to which members of the class are related to one another. A high level of cohesion simplifies maintenance.

My decision to make `trav_dir_tree()` global exposes a fundamental object-oriented design issue. An object is not just a haphazard collection of functions related arbitrarily. Rather, it encapsulates internal state (the data members) and message handlers (the function members) that modify or otherwise use that internal state.

KEN COFFELT © 1993

A Smalltalk programmer might argue that `trav_dir_tree()` should be a member of class `directory` because it implements the traversability property

list.cpp: *Listing a directory.*

```
#include <stdio.h>
#include <stdlib.h>
#include "dir.h"

main( int argc, char **argv )
{
  if( argc > 3 )
  {
      fprintf(stderr, "Usage: list [directory] filespec]\n" );
      return -1;
  }

  char *filespec = ( argc < 3 ) ? "*.*" : argv[2];
  char *path     = ( argc < 2 ) ? "."   : argv[1];

  directory d( path, filespec );
  d.sort();
  while( d )
      (d++)->print();      // can also use (*d++).print();

  return 0;
}
```

of the `directory` object, but that's not particularly good C++ style. Smalltalk functions must all be members of some class; C++ doesn't have this limitation. If you're a Smalltalk programmer, think of the C++ global level as the equivalent of Smalltalk's `object` class.

In general, a member function should do two things at once: use the object's internal-state information and mechanisms, and hide these things from the outside world. The second requirement means that supported messages should implement operations in a way that's independent of the underlying data structures. A function that does not fulfill these requirements has no business being a member of the class.

Privacy Issues

The next two issues are interrelated: privacy and default arguments. I've chosen to make `def_callback()` a `static` global (thereby limiting its scope to the current file) and then use `def_callback()` in `trav_dir_tree()` when NULL is passed as the second argument. If I had made `trav_dir_tree()` a member of the `directory` class, I could have made `def_callback()` private and then used the C++ default-argument mechanism to call it indirectly, like this:

```
class directory
{
static void def_callback
  (const char* name,int lev);

int trav_dir_tree
  ( const char *root    = "/",
    void (*callback)(const char*,int)
                        = def_callback,
    int do_depth_first = 0
  );
};
```

Note that `def_callback()` has to be `static` if you want to pass it using a normal function pointer. A member-function pointer, which is declared with a different syntax, would have to point to a member function of class `directory`. The fact that it's `static` is all the more proof that neither `def_callback()` nor `trav_dir_tree` should be members. The `static` functions exist in C++ only to provide access to `static` data (e.g., instance counts) that needs to be accessed even when no objects of the class exist.

For the sake of completeness, I should mention a third alternative. I could have achieved the same result with virtual functions:

```
class directory
{
virtual void callback
  (const char* name,int lev);

  int trav_dir_tree
    ( const char *root    = "/",
      int do_depth_first = 0
    )
  {
  //...
  callback();
  //...
  }
};
```

But this organization would force the user of the class to derive from the `directory` class just to customize `trav_dir_tree()`. Instead of simply declaring a function and passing a pointer, the user would be forced to create a complete derived-class definition that included copy constructor and `operator=()` functions. To my mind, this strategy adds needless complexity in pursuit of a dubious goal—the theoretical purity of using derivation to do all your customization.

Constructing the Directory Object

The constructor of the `directory` class takes three arguments and supplies defaults for all three. Here's the prototype:

```
directory (
  const char *path      = ".",
  const char *filespec = "*.*",
  attribute selector    = a_everything
);
```

The first argument specifies the path to the directory you want to load. The second selects which files to load. The third, an attribute/permission mask, refines the selection.

The arguments are ordered so that defaults give the most natural behavior: No argument gets everything in the current directory; only the directory name gets everything in that directory; the directory name and a file spec get only the matching files. You make an attribute mask by performing an OR operation on one or more attribute bits spelled out in the dir.h file (part of the downloadable listings for this month's column; see the editor's note at the end of the article).

One problem with loading the directory structure in the constructor is that you can't call a constructor directly; the compiler calls it indirectly as a side effect of a memory allocation. A statement like

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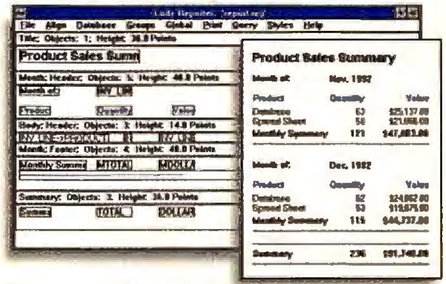

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A directory listing.

```
.rw.....     233 12/29/86 07:39:00 - c:/src/tools/alphanum.c
.rw.....     455 07/02/89 20:45:38 - c:/src/tools/bfgets.c
drw.....       0 06/17/92 18:08:30 - c:/src/tools/curses
.rw.....    2271 04/24/90 12:38:00 - c:/src/tools/cursor.c
.rwx....    2271 04/24/90 12:38:00 - c:/src/tools/foo.exe
.rw.m...     397 05/17/93 21:24:30 - c:/src/tools/pargv.c
.rw.m...    2661 05/26/93 13:40:08 - c:/src/tools/queue.c
.rw.....     247 12/29/86 07:39:46 - c:/src/tools/stoupper.c
.r...sh.      29 09/30/92 14:02:10 - c:/src/tools/hidsys
```

```
directory("some_path");
```

looks like a constructor call, but it's really a cast operation that creates a temporary variable of class `directory` and initializes the temporary variable using the constructor that most closely matches the arguments to the cast. The temporary variable is usually discarded when the implicit declaration (i.e., the cast) goes out of scope. Consequently, one constructor cannot call another, and you can't reconstruct an object by calling the constructor explicitly.

The solution to this problem is the following function:

```
void load( const char *path     = ".",
      const char *filespec = "*.*",
      attribute  selector  = a_everything );
```

which works like the constructor but can be used to add entries to an already-existing directory object:

```
directory d();  // load current directory

// add root directory contents to list:
d.load( "/", "*.*",
         directory::a_everything );
```

The constructor itself is actually an in-line function that does nothing but call `load()`.

Although you can't call a constructor directly in C++, you can call a destructor if you fully qualify the name (i.e., if you use the class name and a `::`). You can use this mechanism along with a `load()` call to clear out an existing `directory` object and reload it from a different directory, like this:

```
directory d; // load with current directory
//...
d.directory::~directory();  // clear it
d.load(/*...*/);            // reload
```

Using enum Instead of Macros

One interesting support function is the following:

```
int sort(
  sort_criterion int primary
               = directory::by_path,
  sort_criterion int secondary
               = directory::by_path,
  sort_criterion int ternary
               = directory::by_path,
  sort_criterion int quaternary
               = directory::by_path );
```

This sorts the directory entries according to the specified criteria, which are spelled out in an `enum` defined inside the `directory` class definition in dir.h. (The criteria are things like full path name, extension, last-modified time, and so forth).

What is interesting here is the idea of using an `enum` that's a member of a class instead of a sequence of `#define` statements. The disadvantage of a macro is its scope, which is effectively the entire module in which it's defined. This too-large scope causes maintenance problems when you want to reuse the name of a macro that's defined in a .h file in your own code. If you use MAX_BUF_SIZE in a .h, for example, you can't reuse that name in your own code without causing a maintenance problem.

You can solve this problem with an `enum`, like this:

```
class directory
{
  public:
    enum sort_criterion
    {
      by_path,
      by_extension,
      //...
    };
}
```

This approach has two big advantages. First, the class forms a scope with respect to the member functions. Consequently, the `enum`'s field names can be reused in other class definitions, and even globally, without causing any conflicts. You must access the field with a `class_name::`, as was done earlier, but that's a small price to pay. Second, although I don't do it here, you can make the `enum private`, effectively limiting access to it to the members of the current class. A macro would have global scope.

Note that you can take this strategy a step further and declare the `enum` locally (i.e., inside a function), thereby limiting the scope of a constant to the current function. Generally, if a constant value will fit in an `int`, you should use an `enum` rather than a `#define` to define the value. If an `int` is too small, use a `const` definition. You should never use a macro to hide a constant value in C++.

Operator Overloading

Several operator-overload functions are used to iterate over (i.e., visit every member of) a directory. Overloads of `[]`, `*`, and `->` access the current directory entry, and `++` advances to the next entry.

Here's the prototype for another useful overload:

```
operator int( void ) const
```

This function, which ostensibly defines a type conversion from `directory` to `int`, can be used in Boolean tests. For example, in the following,

```
directory d();
```

tree.cpp: *A recursive directory-traversal function.*

```
static void def_callback(const char* dir_name, int lev)
{
  // Default callback function for trav_dir_tree()-prints current
  // directory with an indent corresponding to the depth beneath
  // the root directory. The callback function is not reentrant.
  // Don't call tree() from your implementation of the callback.
  printf( "%*s%s\n", lev*4, "", dir_name );
}
//----------------------------------------------------------------
// trav_dir_tree(): Traverse a directory tree, performing a user-
//              defined operation in each subdirectory. Arguments are:
// root             The root directory of the search.
// callback         Pointer to a function to call for the root and
//                  each subdirectory. Passed full path name of the
//                  (sub)directory and the level beneath the root.
// do_depth_first   If true, do a depth-first traversal (recursively
//                  visit all subdirectories before visiting a given
//                  parent directory). Useful for pruning branches
//                  of a directory tree. The callback function will
//                  delete the contents of the directory, then the
//                  directory itself.
//
// Returns: True        if the entire directory tree was traversed.
//          False (0)   if a subdirectory can't be accessed so the
//                      traversal is incomplete.
int trav_dir_tree
    ( const char *root,                                   // = "/"
      void (*callback)(const char* dir_name, int lev),    // = NULL
      int do_depth_first                                  // = 0
    )
{
  static int  level = 0;                       // level beneath root
  static char full_path_of_root[_MAX_DIR];

  if( level == 0 )
  {
      // Load the full path name of the root directory. I'm doing
      // this in a somewhat roundabout fashion because the
      // Microsoft _fullpath() is unreliable. The third argument
      // to the constructor specifies attributes that a file must
      // have in order to add it to the directory list. By
      // specifying a_none, no files will be added. The full path
      // name of the root directory is computed, however, and is
      // available via the directory::cwd() message.

      directory rootdir( root, NULL, directory::a_none );
      if( !rootdir.cwd() ) // root directory doesn't exist
          return 0;

      strncpy(full_path_of_root, rootdir.cwd(),
                                     sizeof(full_path_of_root));
      root = full_path_of_root;

      if( !callback )
          callback = def_callback;
  }

  if( !do_depth_first )
      callback( root, level );

  // Allocate the subdirectory list inside its own scope. The
  // constructor call loads all subdirectories of the "root"
  // directory. You don't want to allocate the subdirectory list
  // in separate subroutine because that wastes stack during the
  // recursion. You don't want to do the allocation at the top
  // of tree() because callback() might need the memory that will
  // be used by the "subdirs" object.
  {
      directory subdirs( root, "*.*", directory::a_dir );
      if( subdirs )
      {
          // Traverse the list of subdirectories, calling tree()
          // recursively for each subdirectory. The subdirectories
          // are sorted alphabetically by name before traversing.
          // fullpath() evaluates to the full path name of each
          // subdirectory.

          for(subdirs.sort(); subdirs ; ++subdirs )
          {
              ++level;
              tree(subdirs->fullpath(), callback, do_depth_first);
              --level;
          }
      }
  }
  if( do_depth_first )
      callback( root, level );
  return 1;
}
```

```
while( d )
(d++)->print
```

the `operator int()` function is used to evaluate the `d` in the `while` statement. The `directory::operator int()` function evaluates false when it's at the end of the list of directory entries, thereby stopping the iteration.

Operator overloading makes traversal very clean, but its use is controversial, so a defense of it is in order. Operator overloading is one of the most abused features of C++, and you should keep yourself sane by using it sparingly and always obeying the "no surprises" rule: Expressions that look like C expressions should act like C expressions. You would never overload `operator+` to subtract (at least I hope not), but you might be tempted to overload + to do set intersection and * to do union. You'll never keep them straight, though, and even if you can, users of your code won't be able to. If you want a good example of how not to do things, look at the Microsoft Foundation Class's `CRect` class, which uses operator overloading inappropriately to implement things like intersection.

The current implementation has a reasonable C analogy for the operator overloads. A directory object acts like a pointer to an array of `const dir_entry` objects, so the operator overloads work in an unsurprising way.

Querying Objects

The various directory-element functions all return pointers or references to `dir_entry` objects. Interestingly, the constructors for the `dir_entry` class are all `private`. The copy constructor and `operator=()` functions are also `private`, so you can't make a copy of a `dir_entry`, either. Since a `dir_entry` is really part of a `directory`, it shouldn't be possible to separate one from the other by making a copy.

Although you can't modify one, you can access the information encapsulated in a `dir_entry()`. Access to internal member data is poorly understood by C programmers, who think of a class as a super `struct`—really a collection of fields—rather than a black box that you send messages to. A good analogy is to a `float`, which is really a packed structure that has three fields: a sign, a mantissa, and an exponent. You would never consider accessing these fields directly; rather, you treat the structure as a singular object. You should treat all C++ objects the same way. All data members of a C++ class must be `private`—there are no exceptions to this rule. Because the Microsoft Foundation Classes violated this rule, users who accessed member data directly under version 1 had to rewrite their applications when those members vanished in version 2.

So, the `dir_entry` class provides no direct access to the internal fields. The next question is how to grant access to the data. You should first ask yourself if direct access is even necessary. Take the example

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MORE DIR_ENTRY ACCESS METHODS

`const char *fullpath(void) const;`	Full path name
`const char *name(void) const;`	Name and extension
`const char *drive(void) const;`	Disk drive only (no colon)
`const char *dir(void) const;`	Directory component of path
`const char *root(void) const;`	The part of the filename to the left of the dot
`const char *ext(void) const;`	The extension part of the filename
`const time_t mtime(void) const;`	Last-modified time
`const off_t size(void) const;`	File size (0 if directory)
`const directory::attribute attrib( void ) const;`	Attribute mask

of an employee record. A C programmer would probably (incorrectly) write an employee-record class so that you could access the name and address fields directly. A C programmer new to C++ would read the rule about no direct access to data and probably do something like the following:

```
class employee_rec
  {
  char *name;
  public:
    const char *getname(){ return name; }
    void setname(char *n){ name = n; }
};
```

But that's exactly the wrong thing to do—hardly different from just making the name field public, with all the problems that entails.

There is one advantage: You could change the internal type used to store the name without changing the external interface, like this:

```
class employee_rec
  {
    CString name;
  public:
    const char *getname()
          { return (const char*)name; }
    void setname(char *n){ name = n; }
};
```

A little more analysis reveals that you really don't need direct access to the name at all, however, and it's only at that point that the employee_rec becomes a true object. If you add messages like "display yourself," "print yourself," and "update yourself interactively by querying the user," you can eliminate all external access to a name field. The system sends truly high-level messages to the employee_rec object, and that object takes care of the details. For example, the object could interpret "update yourself" as "put up a dialog box that will allow the user to change the name field." This way, the object itself takes over the mechanics of an update.

In another operating environment, the same message might have a completely different effect. The program that uses the emp_record doesn't care about any of this as long as the record gets updated. Changes to the update methodology won't affect the surrounding code.

The dir_entry takes essentially this approach, exporting data through two messages: "print yourself" and "print yourself to a string." Here are the prototypes:

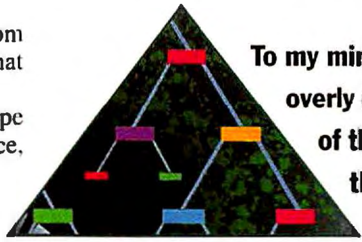
```
void sprint(char *buf,
   const char *format=def_format)
          const;

void print (FILE *stream = stdout,
   const char *format=def_format)
          const;
```

Here, print() writes to the specified FILE (not iostream), and sprint() writes to a buffer. The format string works much like printf(), but it also adds strftime() conversions for printing the last-modified date and time, along with a few other directory-specific conversions.

Prototypes for additional data-access methods appear in the table "More dir_entry Access Methods." Two of these, dir and name, further illustrate why it's better to use messages (i.e., member-function calls) to access attributes of a class than to permit direct access to the member variables. These functions evaluate to pointers to arrays that hold, respectively, the directory and root-name components of a file or subdirectory name.

Space for these arrays is not allocated until you call name() or dir(), however. That means you won't incur the memory overhead—or the processing overhead of isolating the name and directory components from the full path—unless you actually



To my mind, iostreams are an overly complicated reinvention of the wheel and an abuse of the operator-overloading mechanism.

need this information. A more naive implementation would do this allocation and initialization in the dir_entry constructor.

Problems and Improvements

Although I've found the directory classes pretty useful in their current form, the current implementation lacks autodecrement (-) operators and support for adding or subtracting ints to directory objects (e.g., d+=1). I haven't written these functions because I haven't needed to use them, but my "no surprises" rule dictates that they probably should exist.

The implementation also does not support << overloads to print directory and dir_entry objects. I detest the iostream system, so I don't use it. To my mind, iostreams are an overly complicated reinvention of the wheel and an abuse of the operator-overloading mechanism. You wouldn't call an output function shift_left_formatted(), and you shouldn't overload << to mean "output."

The abuse also causes problems. For example, the following code

```
cout <<  x & 0x7f;
```

does not output the masked character, and

```
CString s1, s2;
cout <<   s1 += s2 ;
```

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does not output the concatenation of the two strings, because the shift operator has higher precedence than both `&` and `+=`. I'd feel better if a very low-precedence "output" operator, such as `<-` or `:=`, was added to the language, but I don't think that will ever happen. In any event, I/O overloads of the shift operators are easy enough to add—they don't even have to be friends of the `directory` or `dir_entry` classes, because no access to internal data is necessary.

Here's another problem. The `directory` objects store the `dir_entry` objects internally as a linked list. (Each `dir_entry` has a `next` field, and a `head` pointer is stored in the `directory` object. I didn't use Microsoft's list functions because they're inefficient, error-prone, and difficult to use.) The linked-list approach is convenient when loading a directory because there's no easy way to determine the size of a directory without reading it in. But the linked-list approach makes the `[]` operator very inefficient—it counts over from the head of the list—and would make the `operator-()` function difficult to write as well. A related problem is the time required to allocate and initialize the array used for sorting.

These problems can be solved by storing the `dir_entrys` in an actual array rather than a linked list, but this solution introduces problems of its own. First, you don't know how long to make the array until after you've read in all the `dir_entrys`. You could just allocate a worst-case array, but every time I've done that, I've ended up needing more array elements than I had available. You don't want to make the worst-case size so large that you waste most of the space most of the time so you can accommodate an occasional very large directory.

You could move the code that creates an array of `dir_entry` pointers and initialize the elements to point at the `dir_entry` structures from `directory::sort()` to the constructor, but then you're wasting the space used by the "next" pointer in each `dir_entry`, and you're adding unnecessary overhead in those situations where you don't need to sort things.

As a third alternative, you could isolate the "next" pointer into a base class and everything else into a derived class, create a properly sized array of derived-class objects, and then copy only the derived-class component from the linked list to the array. That's a lot of work, though, and the `delete` needed for each linked-list element would slow things even further.

The `[]` behavior can be improved, if not fixed completely, by using a doubly linked list and keeping a most-recently accessed-via-`[]` pointer and associated index in the `directory` object. You can then count forward or backward from the pointer rather than from the beginning of the list. This strategy works fine for improving sequential access, but it doesn't help much for random access.

The real question is whether efficient support of `[]` and any support of `-`, `+`, `+=`, `-`, and `-=` are required. I think not, but if you disagree, they're easy to add. Even in the current form, however, I've found these classes very useful in my own work. ■

Editor's note: *The complete listings for this article are available in electronic format. See page 5 for details.*

Allen I. Holub teaches C++ and compiler design at the University of California–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.*

JERRY POURNELLE

Clean Water and Dirty Keyboards


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After a trip to Sweden, Jerry returns to Chaos Manor to clean keyboards, look at Symantec's Q&A line, reinstall OS/2, and maybe find a killer application for that operating system

It has been a hectic month, with many trips. The most notable was to Stockholm, where I got to fire a Karl Gustav recoilless cannon and visit the home of my legendary Norman ancestors.

We arrived in Stockholm for the Water Festival. Stockholm is built on a number of islands, at the junction of a very large freshwater lake and the Baltic Sea. The festival celebrates the fact that the waters—fresh, salt, and brackish—are all clean and clear. You can swim right off the pier by the Royal Castle or down by the yacht landing near Embassy Row. You can fish anywhere and safely eat the fish, and, for that matter, I suppose you could drink the water from the lake.

The way they manage that is by using a great deal of public transportation, most of which is electric; much of the electricity is generated by nuclear power plants. We took the X-2000 bullet train from Stockholm to Göteborg; very fast and very smooth. We went to the southwest so that we could visit the town of Falkenberg; those familiar with my novels will understand why that was important to me. Falkenberg is in the part of Sweden that was Danish in the ninth century. That's the area from which Rollo led his Vikings off to France to found the Duchy of Normandy. My remote ancestors were part of that trek, but when I named one of my major characters John Christian Falkenberg, I didn't know the town existed. Anyway, we took the electric train to Göteborg, and we noted that much of Sweden uses electric trains and streetcars.

It's a law of physics that EMFs (electromagnetic fields) form closed loops, and there are more electromagnetic lines of force inside the field loop than outside; meaning that all the passengers, and the drivers, of electric transportation are exposed to one whack of a lot more EMF radiation than you can manage by sitting next to a computer, or living near a power transmission line, or operating electronic appliances. Somehow, those who worry excessively about low-level EMF radiation never think about such things; they choose instead to look at high percentage increases in tiny numbers of rare events. Ah, well.

I visited the Swedish Royal Air Force base at Uppsala, and on the way back I needed an aspirin, so we stopped at a large department store. It had a computer department, so I had to go look. What I saw was an area about 30 by 30 feet. Against one wall was a pile of Atari ST machines. More prominently displayed was a larger pile of Amiga computers; that included a floor dump right at the entrance to the computer section. There were some stacks of software, perhaps 20 items for each kind of machine. The rest of the room, about 75 percent of it, was filled with Nintendo and Super Nintendo machines and game cartridges, with an enormous floor dump of Super Mario Brothers.

I'm told that the Amiga is quite popular in

Sweden as a home system. Professional offices mostly use European- and Swedish-made PCompatibles. Microsoft is the major software publisher; indeed, I found out after I got there that Microsoft was one of the sponsors of the science and science fiction convention I attended as guest of honor. Many of the attendees came from the newly liberated Baltic republics, and there were a few from as far away as Bulgaria. The economy being what it is, the convention was a low-key event, but I had a great time. And it sure is nice to see a city that is celebrating its clean and sparkling water.

I got back just in time for another disaster, with my computer complaining of memory errors on start-up. This time I remembered what does it: I turned off the machine, disconnected the keyboard, turned it upside down, and beat on it for a while. A bunch of junk fell out. I connected it back up, and Lo!, no more memory errors. Even the newest machines use the keyboard encoder chip as part of the A20 handler (address line 20, which accesses high memory), so if there's any kind of short or low power in the keyboard, the computer can believe it has a memory error. If you get memory errors on start-up, be sure the keyboard is all right before you open up the computer. You may save yourself a lot of work.

Incidentally, I have a whole bunch of new keyboards that incorporate trackballs. Key Tronic makes the Trak101 with a good feel and layout, with the trackball in a convenient place. Of course, keyboard feel is a personal thing: I happen to like the noisy snap action of IBM and Northgate keyboards, rather than the softer and more quiet action of the Key Tronic keyboards, but many have the opposite view. I also like having the function keys on the left side rather than across the top. My partner Larry Niven, on the other hand, wants his on top. The solution to that is the Northgate OmniKey Ultra, which has them in both places.

Having the trackball on the keyboard makes a lot of sense, particularly if you use furniture with a keyboard drawer. But there is one drawback: while a mouse has to pick up junk off the table when it wants to gum itself up, the trackball collects crud from above. If you do use a trackball, you'll probably have to clean it daily.

Trips are an opportunity to test portable computers. This time, I carried the Gateway HandBook to use as a very portable notebook and an old, battered Zenith Mastersport 386SL for heavier-duty work. Alas, my HandBook needs a new battery pack; it used to hold a charge for hours, but no longer. This is a pity, because it fits in a shoulder bag and can be carried to museums and other places you don't want to take a heavier machine. When it's working, I love it, and I'm sure a new battery will fix everything.

The Mastersport, like the ubiquitous bunny, just keeps going and going. I have much faster portables with larger screens, but I keep coming back to that old machine. The screen, although smaller than those on some new machines, is very readable, more than good enough, and I love that keyboard. Also, the Mastersport is extremely reliable. One of these days, I'll upgrade to a newer model just so I'll have that to write about, but meanwhile, I sure like that ancient laptop.

My mail is pretty heavy this month, with a number of complaints about my criticism of Symantec's new Q&A Write for Windows. Typical of them is Joel Fritz, who says, "I can understand

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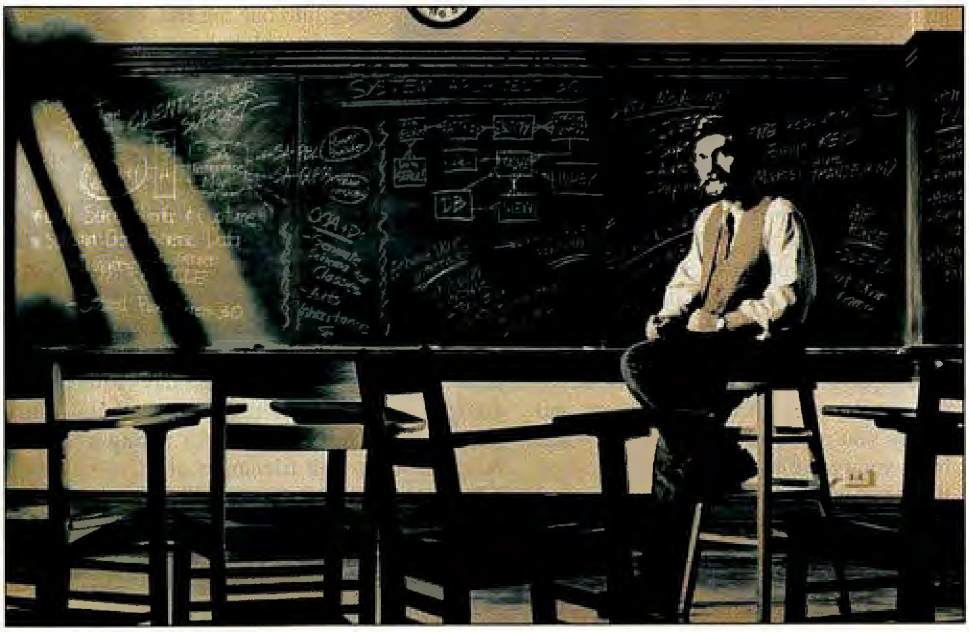

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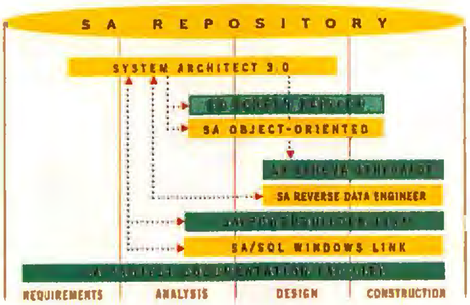

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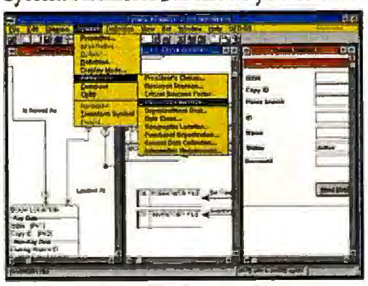

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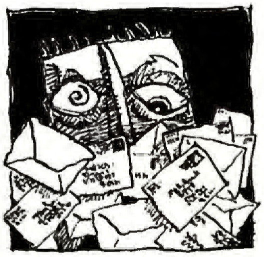
your disappointment at Symantec's having abused the name of a program you loved, but if you think of it as having another name and think of the market niche it's aimed at, it's a good tool at a fair price." On reflection, he's right: the program is a pretty good little editor. I do miss bookmarks, but otherwise, it has about all you need, and it's a refreshing step toward smaller programs in these days of galloping featuritis.



There's also a new Windows version of the Symantec Q&A 4.0 database and word processor. It's compatible with older versions and will convert DOS-version files. I have only a beta copy so far, so I'll hold final comments until it ships. Q&A has always been the best flat-file database in existence, bar none, and unless you really need a relational database, you may find that Q&A does everything you need. It's certainly the easiest database program to learn; and the mail-merge program is very powerful as well as absurdly easy to use.

Niven and I still do most of our text creation in character-based Q&A Write; the only reason we need anything else is that Q&A Write for DOS doesn't print very well, and it works only on files of 30,000 words or so, meaning that we have to make each chapter of a novel a separate file. Q&A Write for Windows will read those files into one big file, so we can do a global search and replace. It will also do a proper job of printing.

However, it doesn't have the old WordStar command set that Q&A Write for DOS incorporates. There are other limits. The result is that we're not really tempted to change over from our present if clumsy system in which we use Word for Word to convert Q&A Write files into Word for DOS and then let Word for Windows read them in. One of these days I'm going to use REXX (more on that another time) to write a full routine for taking a bunch of files with filenames of `FILENAME.NUM`, where `NUM` is the chapter number; using Word for Word to convert them; and reading them into Microsoft Word as one big file with page breaks between chapters.

I still recommend Q&A, database and editor, as one of the best bargains in PC programs. It's easy to learn and powerful enough for most purposes. Those interested should get *PC World Q&A Bible, Version 4* from IDG Books; this comes with templates, examples, macros, tips and tricks, and about all you'll need to make Q&A really useful. It's written by Tom Marcellus, technical editor of the *Quick Answer* (Pinnacle Publishing, P.O. Box 888, Kent, WA 98035). This is a Symantec-independent newsletter on Q&A applications, well worth your attention if you use Q&A much.

One reason I continue to like Q&A Write for DOS for my first drafts is that it combines easily with both Definitions/Plus (which is *The American Heritage Dictionary*) and Microlytics' Word Finder, making both available right in the word processor. This means I can use Word Finder to pop up synonyms and then use Definitions/Plus to look the word up; and all that's available on a DOS laptop.

All that and more are available with Microsoft Bookshelf, particularly the CD-ROM version that combines Microsoft Word for Windows; but while I can and do sometimes carry a SyDOS Personal CD

drive on trips to use with a portable, the combination takes setting up. It's a long way from a laptop.

Alas, lately I've had some odd problems with Definitions/Plus. It works just fine on this machine, a 33-MHz 486 Cheetah with an Intel OverDrive processor. I built a Windows PIF (program information file) for it and use a batch file to load Definitions/Plus, Word Finder, and Q&A Write 3.0 as a DOS program under Windows. The batch file loads Definitions/Plus with the /e switch, which puts it into high memory. I'm using that now to write this, and it works just fine.

However, when I did that on the 33-MHz Gateway 2000 486, even though I used the identical PIF and batch file from Big Cheetah, I got a screwy message about "Incompatible Mouse Driver," and it wouldn't work. I could load Definitions/Plus without the /e switch, but that uses memory. The obvious remedy was to be sure I used the same mouse drivers in both machines, which turns out to be the MOUSE.SYS that comes in Windows. There are probably reasons to use some other mouse driver, but so far, I haven't found them.

Incidentally, I have pretty well converted over to the new-and-improved Microsoft Mouse, the larger one that's shaped like a teardrop. I still like the old "Dove soap bar" Microsoft Mouse, but the new one is a definite improvement: easier to hold and easier to use. It's a definite candidate for a User's Choice award.

I've been doing intensive tests of OS/2, so I installed my Definitions/Plus, Word Finder, and Q&A Write combination on Ozzie, the IBM PS/2 Model 77 that is my main OS/2 machine. OS/2 has great flexibility. It creates a new virtual DOS machine for each major DOS session. Each session can have a number of settings, including control of access to COM ports, priority in multitasking, memory size, and a whole bunch of stuff I don't fully understand yet. (Fortunately, I don't have to worry much about them: OS/2 is pretty smart about defaults.)

One setting will give expanded memory to your virtual machine. I set that and used my old batch file, including the /e switch for loading Definitions/Plus into high memory. That seemed to work: it would load, and I could summon the dictionary while still at a DOS prompt, both before and after loading Word Finder; but when I loaded in Q&A Write and tried to pop up Definitions/Plus, I got a file error message.

If I remove the /e switch, everything works fine. Thus, there may be some obscure setting I can use that will allow Definitions/Plus to go into high memory with Q&A Write, but if so I haven't found it. What I did find, thanks to IBM's OS/2 guru Dave Whittle, is a nifty OS/2 feature. Among those settings is one that's called Video_Mode_Restriction. I set that to CGA Only. Since Q&A Write is a character-based editor, that turns out to have no effect whatever on screen quality, but it frees up something more than 100 KB of memory. The result is that without the /e switch, I've got about as much working-space memory in Ozzie as I do running the same deal in Windows on Big Cheetah.

OS/2 2.1 is now stable and has a lot of nifty features. There are also annoying problems, but once you get it installed, you're unlikely to encounter a disaster.

Proper installation is important. That usually means a complete new installation, including repartitioning and reformatting the hard disk. If you're upgrading from version 2.0 to 2.1 and have never used any of the beta versions, IBM says you're safe in doing an upgrade installation. I suppose I believe that, but if I were installing or upgrading OS/2, I'd go whole hog.

Anyway, I'd installed several beta versions of 2.1, and it was clear that some of the odd results I'd been getting were due to remnants of old beta code. On advice from Whittle, I saved everything off onto a Maximum Storage Duette optical drive, got out a new shrink-wrapped package of OS/2 on CD-ROM, and started from scratch.

It all went swimmingly. Of course, I was working with an IBM PS/2 Model 77, which was pretty well designed for OS/2, so it blooming well ought to have gone smoothly. All told, it took less than an hour to reformat the hard disk and install OS/2 from the CD-ROM. If you have to use floppy disks, it will take considerably longer.

Once that was done, I installed LapLink Pro from a floppy disk and connected to one of the machines on my network, which effectively gave me access to every drive out there. I then began reading in stuff from the Duette. The original plan had been that I'd connect the Duette directly to Ozzie; the PS/2 Model 77 has SCSI on the motherboard, and there's a SCSI port in back.

Alas, I can't connect to that SCSI port, because IBM has for no discernible reason used a proprietary plug for the SCSI port; and no store in Los Angeles has either a cable to fit that plug or an adapter to turn it into something a normal cable will fit. Worse, when I called Eagle Electronics in Glendale, they said they did have one, and it was only after I drove there that they discovered they didn't. I don't know what SCSI controllers are selling for, but the cable costs about $75, a substantial part of the cost of just buying a Future Domain SCSI board with a standard cable.

To add something to the SCSI port on the motherboard, you need an IBM cable; the outlet is very nonstandard. The cable is huge and not cheap.

The Duette is the fastest optical drive I have ever seen, faster than the Pioneer, faster than my network, as fast as hard disks were only a few years ago; but that hardly mattered, since I had to connect it with LapLink through parallel ports. The result was that it took no little time to save and restore my applications files.

When I got the cable, I tried again to connect the Duette directly to the PS/2 Model 77. While there are no OS/2 drivers, I thought it should work in a DOS window under OS/2. One of the nifty features of OS/2 is that each DOS window is a different virtual machine and can have its own CONFIG.SYS and AUTOEXEC .BAT files independent of any other. Of course, that means that the Duette won't be available as a general system asset, but within that window, it can be a very fast backup system.

After I got a cable, I found that the Maximum Storage drivers for the Duette won't load into an OS/2 DOS session. I was advised by IBM to try booting the PS/2 with a DOS disk and see if these would load with *that.*

Alas, I had used Stacker on the D drive (logical drive) because the PS/2 has only about 200 MB on it, and given the amounts of software I test, having 100 MB on the D (DOS) drive wasn't enough. This means I have no access to that drive in DOS. I suppose I might be able to load the DOS Stacker drivers on boot-up, but I am understandably afraid to do that, since it might mess it up for access by OS/2.

The upshot is that the only way I can use the Duette drive with the OS/2 system is to attach it to a DOS machine and link the DOS machine and the OS/2 machine with LapLink on a parallel cable. Needless to say, this sort of negates the speed of the Duette drive. IBM has such wonderful stuff, all about 90 percent ready to use. But that last 10 percent can be a bear.

The results of my OS/2 reinstallation have been worth the effort. All the odd and mysterious glitches, problems that not even Whittle understood, have gone away.

Of course, that makes the design faults stand out more clearly. One of the worst is the way OS/2 treats DOS programs running in the background. Unlike Windows, which right out of the box iconizes background programs and puts them in a line across the bottom of the screen, OS/2, even after customization, does strange things with those program icons. Having made it easy to assign fancy icons to DOS programs, OS/2 then proceeds to ignore them. When it iconizes a DOS program running in the background, it shows only the generic DOS icon with your program label under it. Clearly, the OS/2 design team didn't spend much time thinking about why people use a GUI. You might as well have a menu. *continued*

On the other hand, if you like menus, OS/2 has a deal for you. Under OS/2, you can create elaborate menus and attach them to any program, folder, or virtual machine that you like. You can put all the productivity tools and applets onto a menu available on the general desktop. You can cascade menu items. I've only just discovered this feature, and I love it.

I've also installed a number of Windows programs under OS/2, and they work. They seem slower on the PS/2 Model 77 (a 486DX/2) than under Windows on the Gateway 2000; whether that's hardware or my lack of understanding of fine-tuning, I don't know yet. They're not all that much slower; I'll do some fiddling and report next month. The important thing is that all the Windows programs I've tried work just fine in Win-OS/2.

OS/2 is a fine operating system, a better DOS than DOS, at least as good a Windows as Windows; but the most important factor for its future will be the availability of applications. People don't buy computers for an operating system, they buy them to get work done. OS/2 will sell when there are killer applications that won't run on anything else.

I'm a little out of touch with the business-modeling community, but I think that if you're in business analysis, Quantum Leap may be just that essential killer application. There may be a more advanced business-modeling and problem-solving system available for mainframes, but I don't know of any that are available for small computers.

I suppose that's not strictly true: a mathematician or trained operations research person could use Macsyma or Mathematica to build matrix models of similar complexity and power, but it wouldn't be easy. One of Quantum Leap's advantages is that you can start doing some useful work in a couple of hours.

Quantum Leap combines a powerful math tool set, including simplex and reduced gradient solution algorithms, with an easy-to-use spreadsheet interface, what appears to be a fully relational database, and the capability to incorporate expert-system rules. The result is a multidimensional analytical tool you can use to model quite complex systems in a fairly short time. Just build up tables of data (or import them from ASCII or SQL files) and follow the instructions for turning them into a model by specifying relationships. I won't say it's simple, but it's not rocket science, either. (Actually, rocket science isn't that hard, but I'll leave that for another time.)

You can use modeling programs for making decisions. The big advantage of explicit modeling is that you must specify your decision factors. You can then vary them (what if this didn't happen?) and find out how important they really are. Back when I was in aerospace strategic analysis, we used more primitive modeling tools, and even then we'd sometimes find the traditional "intuitive" decisions were often determined by nearly irrelevant factors. You can always strain like a gearbox and overrule the recommendations the model gives you if you're certain it's wrong; better still, you can look to see why you and the model disagree. That usually results in a better model.

I've had Quantum Leap up for a few days now, and I'm impressed enough that I'll keep it for my own use. It's probably not the killer application that will do for OS/2 what VisiCalc did for the Apple II, but it's another good reason to consider

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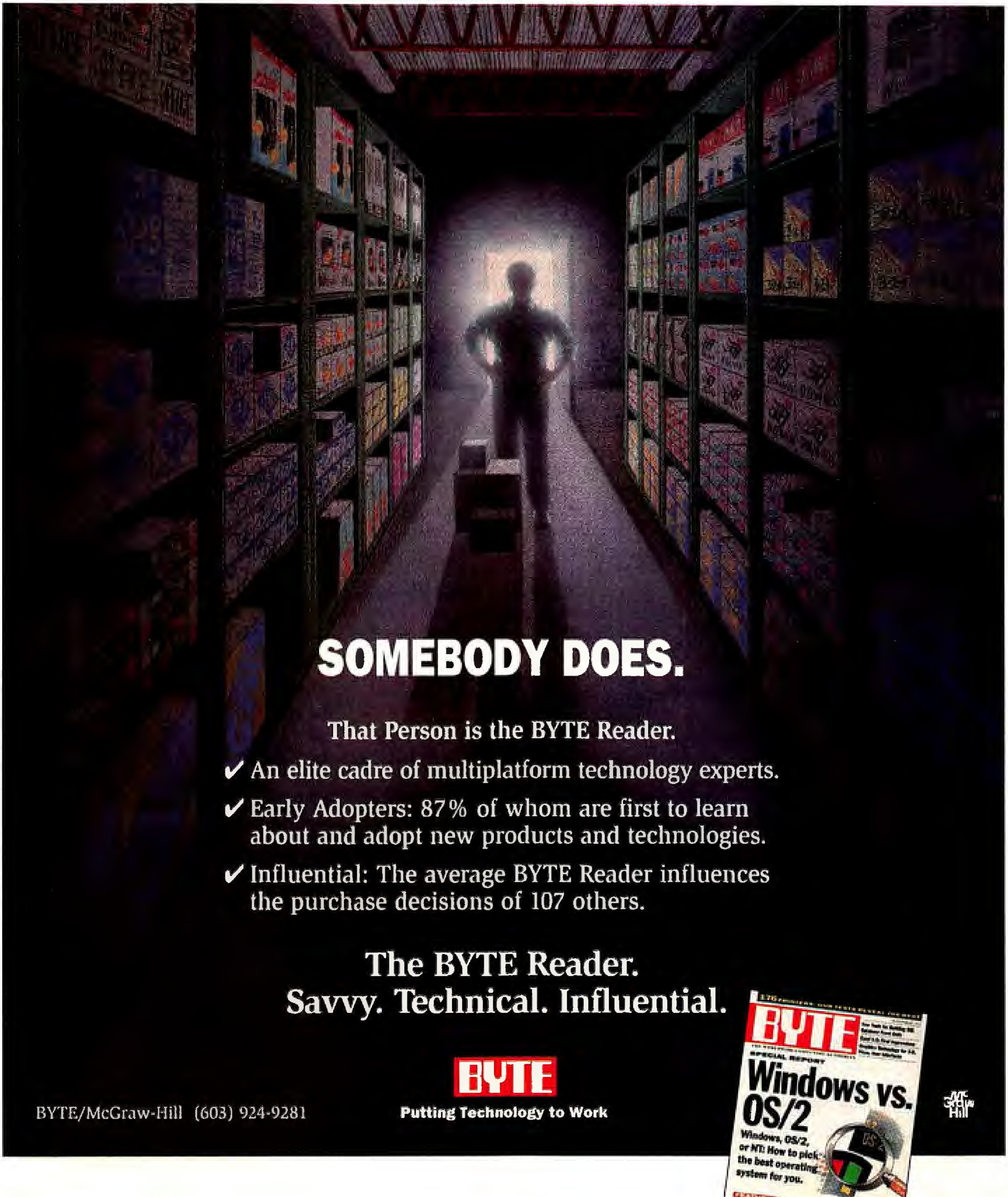


OS/2 when you're deciding on operating systems.

I also installed Stacker for OS/2. It works. In fact, it works so smoothly that there's not a lot to say. The installation program is complete, the instructions make everything easy, and it all goes just as you expect. Because I am forever experimenting with new stuff, I have my OS/2 machine partitioned into a C (boot) drive for the OS/2 system and applications and a D drive for DOS and Windows. I decided to let Stacker work only on the D drive.

If you're not using your OS/2 machine as an experimental test-bed, there's no reason not to let OS/2 compress all the drives it can find, and one of these days I'll probably do that. Meanwhile, Stacker works quietly and invisibly. It's wise to back up all files before letting Stacker work on a disk, but you don't have to clean or reformat the disk when you install. Stacker preserves all your files as it goes.

Stacker comes with its own repair tools. Fortunately, I haven't had any need for them, but I presume they work. The company has put a lot of time and effort into making file compression safe and reliable, and in my judgment, they understand these things very well. I still prefer hardware to software solutions, but Stacker is an inexpensive way to get a lot more hard disk space at very little risk, and, after considerable study, I'm willing to use it. Recommended.

The multimedia blitz is starting, and there are a hundred programs out there for creating presentations. Most have one or another great feature, and I've written about some of them, just as I've written about a number of Windows applications-builder programs.

In both cases, I've given up trying to decide which programs are best; but I can tell you what's good enough. If you want to build up Windows applications, use Asymetrix's ToolBook, and if you're after multimedia presentations, use the same company's Compel. Neither one is as fast as I would like, but they're both reasonably easy to learn, have more features than I'm likely to need, and get the job done. Because of the close association between Asymetrix and Microsoft—Paul Allen and Bill Gates were partners in founding Microsoft—you can be sure that Asymetrix products will track any new developments that occur in Windows, and you won't be left behind.

Compel can get images from Autodesk animations, Kodak Photo CD, Microsoft Video, and most other standard sources. It understands MIDI, and, in fact, Asymetrix has formed a close relationship with Turtle Beach. Turtle Beach makes excellent high-quality sound cards for the money. Compel comes with a bunch of templates and a good tutorial.

When the multimedia standard came out, a great deal was made about being able to do multimedia on 286 machines. That has fallen by the wayside: Compel works on 386 machines and higher only, needs Windows 3.1 or higher (it works fine with Windows for Workgroups), and wants 4 MB of RAM, although you can do presentations on a color laptop with 2 MB if you have to.

There are faster multimedia programs with more features, but they cost a lot more, and most people don't need the extra features anyway. If you're planning to perform multimedia presentations, Asymetrix's Compel is a real bargain. Recommended.

There's a new edition of the *Microsoft Developer Network News* and a new CD-ROM (Disk Three) of software, tips, and sample code for Windows, Chicago, and NT; tips from Dr. GUI, telephone numbers for getting hold of Microsoft, letters to the editor, documentation for Visual Basic 3.0, Access, and FoxPro; the NT and Windows 3.1 resource kits; and a partridge in a pear tree.

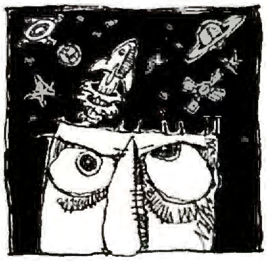
If you're a software developer and you don't subscribe to it ($195 a year), if for no other reason than to see what the opposition is up to, you're out of your mind. (To subscribe, call (800) 759-5474. Have a credit card handy. The fax number is (303) 443-5080.)

They've already let the DC/X take a "bunny hop," and now it's about to do a longer flight. DC/X is the McDonnell Douglas one-third-scale model of the SSX experimental spaceship I've been promoting as chairman of a space advisory council. One of the council members is longtime aerospace engineer and writer G. Harry Stine. Harry provided technical expertise for the new Broderbund program Discover Space and wrote the companion book that comes with the program. It's an excellent package.

Discover Space runs under DOS. It will work with almost any decent sound board and needs a VGA or Super VGA graphics card, 7 MB of hard disk space, and 560 KB of free memory. It wants a mouse, although it can run without one, and it really needs a 386. It's not a Windows application, but it will run just fine as a DOS

application under Windows, and it comes with its own PIF and icon. Whether you run it in DOS or Windows, it's easy and intuitive to learn and use.

This program will tell you a great deal about space: history, mythology, constellations, solar physics, orbital mechanics, and orbits of planets, comets, and asteroids. Want to see what will happen to earth if you hit it with various sizes of asteroids at various astronomical speeds? This will simulate the crash and show you the crater. Want to see the planets move around the solar system? Want to know what kinds of pictures the various planetary probes sent back to earth? It's all here, and it's all fun, as painless a way to explore the solar system as I know of.



Get this as a Christmas present for any kid of just about any age. Open it early and use it yourself. Recommended.

Another fun, if perhaps overpriced, program is Gravitator Pro from Zephyr Services. This runs on almost any PC system, from a 256-KB CGA machine and up, and lets you simulate planetary systems. Objects can have different colors or can be made invisible (it's fun to model a system with an enormous black hole at the center). Input masses, distances, and so forth in almost any units; add multiple bodies: and let fly to see whether you have a stable system. You can save your work. All told, it's more fun and a bit more flexible than Gravitation for the Mac.

Zephyr has a good reputation for solid software, and this is one of their better efforts.

My mail also had several tips on how to handle proportional spacing for the LaserJet III in both QuickBasic and CBASIC CB86. Doug VanNatter's tip from Hewlett-Packard's PCL 5 (Printer Control Language) manual is to send `<esc>*pnxmy`, where *n* is the distance from the left side of the page and *m* is the distance from the top (in 300-dot-per-inch units). You can also send `<esc>*pnx`, and it will stay on the line it was last at. Thus, `<esc>*p1950x375y` will put the next printed character 1¼ inches from the top and 6½ inches from the left. I've got a couple of minor errors in my check-writing program, and next time I work on it, I'll use that to pretty things up and use a nicer font than Lineprinter.

Weldon Bailey reminds me of a trick I used in CBASIC to get several things right on a line:

```
  PRINT "Something to print";
CHR$(13);
  PRINT STRING$(100," ");
$100.00
```

The `CHR$(13)` moves the print head to the beginning of the line, after which it will space 100 to the right and print the value. Since the value of a space won't change as long as you don't change fonts, once you figure out the number of spaces needed, this will line things up nicely. Tab doesn't work in this situation. This works with QuickBasic if you use the `LPRINT` statement, and I should have thought of it. It won't fix the situation in which one or another of the `"Something to print"` lines is longer than 100 spaces.

I read a lot on airplanes, so I got through a number of books this month. Two interesting ones are Richard Grenier's *Capturing the Culture: Film, Art, and Politics* (Ethics and Public Policy Center, 1991) and Michael Crichton's *Rising Sun.* Grenier is a film critic who thinks a lot about what's going on in Hollywood. His book comes with recommendations from both Senator Moynihan and Pat Buchanan, and if there's anyone in the nation who agrees with everything Grenier says (including Grenier), I'd be much surprised. I don't often say a book is important, but I think this one may be.

There have been accusations that the movie *Rising Sun* is Japan bashing, which is interesting because what Crichton says about Japan in the book is considerably harsher. About 20 years ago, Rand did two studies on the concept of "hostile trade." Both included case histories of Japan back as far as the twelfth century, when trade policy was deliberately used as a weapon in international conflict. Crichton's book is a novel and proves too much. It's surely frightening enough. I'm not at all certain I agree with him, but the matter is far too important to ignore.

The two games of the month are Warlords II and Carriers at War with the

Carriers at War Construction Set, both from the Strategic Studies Group, the Australian outfit that keeps producing quality computer games and simulations. The two games are as different as they can be: Warlords II is an upgrade of the best-selling fantasy war game, while Carriers at War is a simulation of carrier warfare in the Pacific. (The Construction Set lets you make up your own scenarios.)

Carriers at War suffers from not having a campaign plan, so there's no incentive to cut and run so that you'll have assets to fight with another time, but it certainly makes you feel like you're in a carrier battle. Warlords II is just fun.

There's also an enhanced CD-ROM version of The Lord of the Rings from Interplay Productions. If you at all liked the original game, you'll love this. Simulating Tolkien's masterpiece has inherent limits: you can't surprise people who've read the book, and any change from the work of the master is going to be criticized. This is about as good as you'll ever see.

I have a new version of the Supra modem; it works wonderfully on noisy lines. There's a huge pile of CD-ROMs worth looking through, and this month I really do hope to get the Novell network going, so I can link OS/2, Mac, DOS, and Windows systems. Now I'm off to White Sands to see the spaceship fly. ■

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."

For More Information

If you're contemplating multimedia presentations, **Compel** ($295) is a bargain. The program can get images from Autodesk animations, Kodak Photo CD, Microsoft Video, and most other standard sources, and it understands MIDI. It comes with a bunch of templates and a good tutorial. Recommended. Contact **Asymetrix,** 110 110th Ave. NE, Suite 717, Bellevue, WA 98004, (800) 448-6543 or (206) 637-1500; fax (206) 455-3071. **Circle 1146 on Inquiry Card.**

I use **Definitions/Plus** ($47.95) to look up words because it combines easily with Q&A Write for DOS, making it available right in the word processor. Contact **Quinton Systems, Inc.,** P.O. Box 249, Quinton, VA 23141, (804) 932-8380. **Circle 1147.**

An excellent package, **Discover Space** ($44.95) tells you a great deal about space: history, mythology, constellations, solar physics, orbital mechanics, and orbits of planets, comets, and asteroids. Recommended. Contact **Broderbund Software, Inc.,** 500 Redwood Blvd., Novato, CA 94948, (800) 521-6263 or (415) 382-4400; fax (415) 382-4671. **Circle 1148.**

The fastest optical drive I have ever seen, Maximum Storage's **Duette** (from $2790) is as fast as hard drives were only a few years ago. Contact **Maximum Storage, Inc.,** 518 North Nevada Ave., Suite 203, Colorado Springs, CO 80903, (800) 843-6299 or (719) 442-6674; fax (719) 442-6671. **Circle 1149.**

I like the **Gateway HandBook** (486DX2-40, $1995; 486SX-25, $1495) because it fits in a shoulder bag and can be carried to museums and other places you don't want to take a heavier machine. Contact **Gateway 2000, Inc.,** 610 Gateway Dr., North Sioux City, SD 57049, (800) 846-2000 or (605) 232-2000; fax (605) 232-2023. **Circle 1150.**

Gravitator Pro ($149.95) is more fun and a bit more flexible than Gravitation for the Mac. Input masses, distances, and so forth in almost any units; add multiple bodies; and let fly to see whether you have a stable system. One of Zephyr's better efforts. Contact **Zephyr Services,** 1900 Murray Ave., Pittsburgh, PA 15217, (800) 533-6666 or (412) 422-6600; fax (412) 422-9930. **Circle 1151.**

If you liked the original **The Lord of the Rings** game, you'll love the enhanced CD-ROM version ($64.95). This is about as good as you'll ever see. Contact **Interplay Productions,** 17922 Fitch Ave., Irvine, CA 92714, (800) 969-4263 or (714) 553-6678; fax (714) 252-2820. **Circle 1152.**

The CD-ROM version of **Microsoft Bookshelf** ($195) combines Microsoft Word for Windows with pop-up synonyms and definitions. The new-and-improved **Microsoft Mouse** ($109; Serial Mouse with PS/2 Adapter, $125) is larger and shaped like a teardrop. It's easier to hold and easier to use. It's a definite candidate for a User's Choice award. Contact **Microsoft Corp.,** 1 Microsoft Way, Redmond, WA 98052, (800) 426-9400 or (206) 882-8080; fax (206) 883-8101. **Circle 1153.**

Whether you like your function keys to the left side or across the top of the keyboard, the **OmniKey Ultra** ($129) is the solution, with function keys in both places. Contact **Northgate Computer Systems, Inc.,** 7075 Flying Cloud Dr., Eden Prairie, MN 55344, (800) 858-8819 or (612) 943-8181; fax (612) 643-6965. **Circle 1154.**

OS/2 2.1 ($224) is now stable and has a lot of nifty features. Contact **IBM Corp.,** 1 Old Orchard Dr., Armonk, NY 10504 (800) 342-6672 or (914) 765-1900. **Circle 1155.**

I can and do sometimes carry the **Personal CD** ($355) on trips to use with a portable. Contact **SyDOS,** 6501 Park of Commerce Blvd., Suite 110, Boca Raton, FL 33487, (800) 437-9367 or (407) 998-5400; fax (407) 998-5414. **Circle 1156.**

Q&A for Windows ($249.95; Network Pack, $499) is the Windows version of Q&A 4.0, the best flat-file database in existence, bar none. Unless you really need a relational database, you may find that Q&A does everything you need. Symantec's **Q&A Write for Windows** ($69.95) is a pretty good little editor with about all you need, and it's a refreshing step toward smaller programs in these days of galloping featuritis. Contact **Symantec,** 10201 Torre Ave., Cupertino, CA 95014, (800) 441-7234 or (408) 253-9600. **Circle 1157.**

Quantum Leap (from $995) combines a powerful math tool set, including simplex and reduced gradient solution algorithms, with an easy-to-use spreadsheet interface, what seems to be a fully relational database, and the capability to incorporate expert-system rules. There may be a more advanced business-modeling and problem-solving system available for mainframes, but I don't know of any for small computers. Contact **Quantum Development Corp.,** P.O. Box 970, Claymont, DE 19703, (302) 798-0899; fax (302) 798-6813. **Circle 1158.**

Stacker for OS/2 ($140) works. It is an inexpensive way to get a lot more hard disk space at very little risk, and, after considerable study, I'm willing to use it. Recommended. Contact **Stac Electronics,** 5993 Avenida Encinas, Carlsbad, CA 92008, (800) 522-7822 or (619) 431-7474; fax (619) 431-0880. **Circle 1159.**

Key Tronic makes the **Trak101** keyboard ($224) with a good feel and layout, and the trackball is in a convenient place. Contact **Key Tronic Corp.,** North 4424 Sullivan Rd., Spokane, WA 99214, (800) 262-6006 or (509) 928-8000; fax (509) 927-5248. **Circle 1160.**

The games of the month are **Warlords II** ($69.95), an upgrade of the best-selling fantasy game, and **Carriers at War** ($69.95), a simulation of carrier warfare in the Pacific, with the **Carriers at War Construction Set** ($60), which lets you make up your own scenarios. Warlords II is just fun, and Carriers at War sure makes you feel like you're in a carrier battle. Contact **Strategic Studies Group,** 8348 Monticello Dr., Pensacola, FL 32514, (904) 469-8880; fax (904) 469-8885. **Circle 1161.**

PICTURE WINDOWS.

New: MaxResSave for the highest quality images

Picture This ... a real-time television monitor built right into your PC ... Now, picture using this monitor while running Windows™ applications at the same time ... And, picture taking that crystal clear video image and resizing (right down to icon size!) or clicking and dragging it to any position on the screen as easily as moving any other Window ... This is *Win/TV™*, the video overlay, frame and clip capture board from Hauppauge Computer.

Picture Perfect ... Using *Win/TV* and Microsoft's Video for Windows™, you can capture full motion video, saving synchronized audio and video clips to disk. With *Win/TV*'s "frame grabber" you can capture any video frame and save it to disk in the most popular formats like TIFF, TGA, PCX and BMP. Seemlessly integrate still and full motion video clips into multimedia applications such as databases, marketing and training presentations. Great for Microsoft PowerPoint, Asymetrix Compel, Corel Draw, Tempra and lots more!

Picture Yourself ... owning your own "Windows on the World"! Access 122 channel television with *Win/TV*'s built-in cable ready tuner, plus two optional video sources (video cameras, VCR's, laser disks, etc.) Maybe you want to work on you spreadsheets but don't want to miss an important news flash or a current stock market report. Keep an eye on current events while keeping control of your inventory!

Whether you're enjoying live TV, grabbing a frame and exporting it to a desktop publishing document, or creating your own video clips with Microsofts' Video for Windows, you'll be wowed by the clarity of Win/TV images.

Get Win/TV and open a window on some fresh, new and exciting possibilities.

Suggested retail: $495.00 ($549.00 with Video for Windows)

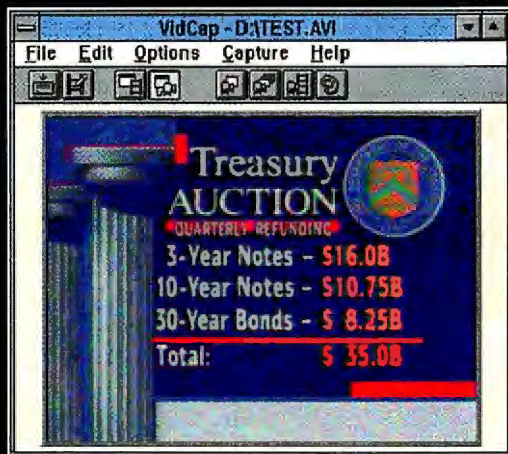
Available from PC Connection, Microwarehouse, PC Zone, plus many other computer stores throughout the U.S., Canada, Europe and Japan.

GSA# GS00K92AGS6156 PS01

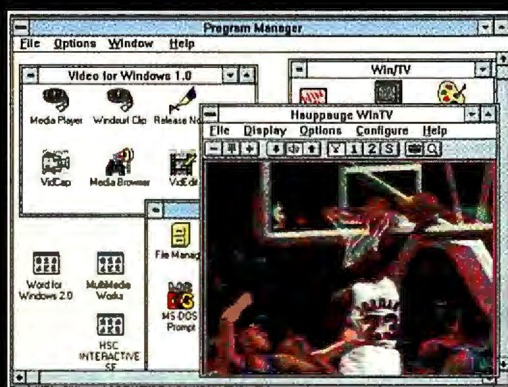
Trademarks: Win/TV: Hauppauge Computer Works; Windows, Video for Windows: Microsoft Corp.; Photoshop: Adobe Corp.; XPress: Quark.

Circle 99 on Inquiry Card (RESELLERS: 100).

Capture the perfect video image with Win/TV's "frame grabber" - great for desktop publishing and presentations with impact!



Capture full motion video clips with Video for Windows (optional.)



Resize or reposition your Win/TV window anywhere on the screen. The "always-in-front" mode allows the video image to always be viewable.

Hauppauge!

Hauppauge Computer Works, Inc.
91 Cabot Court Hauppauge, NY 11788
In N.Y. tel: (516)434-1600 fax: (516)434-3198
800-443-6284
In Europe: (49)2161-17063 In the U.K.: 071-378-7309

What's New Hardware

FAST, FLEXIBLE SCANNING

A color and gray-scale scanner, Hewlett-Packard's ScanJet IIcx ($1179) scans images and text at 1600-dpi enhanced resolution and 400-dpi optical resolution. Gray-scale scanning is at a speed of 8 seconds per page, HP says. The TWAIN-compatible ScanJet IIcx connects to the SCSI port of a PC with a switchless adapter that automatically seeks an available address on the computer. When you plug the scanner into a Mac, it is ready to use.

The scanning software that comes with the ScanJet IIcx is HP's DeskScan II 2.0; other software bundled with the unit includes Aldus PhotoStyler Special Edition for Windows and Adobe Photoshop Limited Edition for Macs. Also available for the scanner are an optional transparency adapter ($759) and a 50-page automatic document feeder ($559).

Contact: Hewlett-Packard Co., Santa Clara, CA, (800) 722-6538.

Circle 1060 on Inquiry Card.

FAST NETWORK RUNNERS

The first network workstations in Tangent's (Burlingame, CA) NetRun line, the VL NetRun ($1895) and the Universal Bus NetRun ($2195) have a 32-bit disk interface, a VL-bus graphics accelerator, and a 16- or 32-bit Parallel Tasking Ethernet interface. Each 40-MHz unit also has 4 MB of RAM, a 120-MB 19-ms hard drive, a 3½-inch floppy drive, a 14-inch color monitor, a ZIF socket, and MS-DOS 6 and Windows 3.1 installed.

Phone: (800) 800-6060 or (415) 342-9388.

Circle 1065 on Inquiry Card.

TWO PRINT SERVERS

The PS4 Print Server Plus ($595) from BayTech (Bay St. Louis, MS) lets you connect four peripherals, such as parallel printers, serial printers, and modems or other asynchronous devices, for use by anyone on the network. Parallel printing speeds go up to 100,000 cps, and serial speeds go as high as 46,000 cps. The unit supports asynchronous speeds of 115.2 Kbps.

Phone: (601) 467-8231.

Circle 1070 on Inquiry Card.

From Lantronix (Irvine, CA), the palm-size EPS2 Universal Print Server ($795) lets you connect up to three printers, modems, or other peripherals via an Ethernet protocol. Users of NetWare, AppleTalk, TCP/IP, and LAT can access print resources via the server without reprogramming; the server supports three devices simultaneously in any combination. Full modem control is implemented on the server's two parallel ports and one serial port. The EPS2 is flash PROM based.

Phone: (714) 453-3990.

Circle 1071 on Inquiry Card.

DESKTOP COLOR PRINTING

The Model 7025 color wax-thermal printer ($995) from Genicom (Chantilly, VA) is designed for printing presentations and overhead transparencies created with Windows 3.1. The 203-dpi, 2.5-minute-per-page 7025 prints on transparencies or on letter or A4-size plain paper. The unit includes a Mac interface kit and a dye-sublimation option.

Phone: (703) 802-9200.

Circle 1067 on Inquiry Card.

CAPTURE IMAGES TO YOUR NOTEBOOK ▶

A real-time portable frame grabber that attaches to the parallel port of your notebook or desktop system, ComputerEyes/LPT ($399.95) lets you capture 8-, 16-, and 24-bit color images from any standard video source such as a VCR, camcorder, laserdisc, or still-video camera. From Digital Vision (Dedham, MA), the device has a capture time of 1/30 second and a 640- by 480-pixel capture resolution at up to 24 bits per pixel. The unit has built-in JPEG and can save images in formats such as TIFF, TGA, PCX, GIF, and BMP. Video inputs are for composite video and S-video; NTSC and PAL versions are available.

Phone: (617) 329-5400.

Circle 1064 on Inquiry Card.

IMMERSE YOURSELF IN 3-D ▼

The Immersion Probe (from $1085) interface tool provides natural manual interaction with 3-D computer environments. The desktop system has a stylus mounted on the end of a series of mechanical linkages. You hold the stylus between your fingers like a pencil to convey spatial position (x, y, and z) and orientation information (roll, pitch, and yaw) to the host processor. From Immersion Human Interface (Palo Alto, CA), the device is self-calibrating with sensors that are immune to noise, interference, and shadowing.

Phone: (415) 599-5819.

Circle 1066 on Inquiry Card.

SURGE SUPPRESSOR FITS UNDER YOUR MONITOR

The Command Console Compact under-monitor surge suppressor ($79.95) includes Isobar surge suppression with four spike- and noise-filtered AC outlets. Advanced diagnostics indicate faulty wiring, reverse polarity, and damage to protection circuitry. Two fingertip switches on the Tripp Lite (Chicago, IL) unit let you quickly organize and control your connected equipment, which is guaranteed against surge damage of up to $5000 via the company's Ultimate Lifetime Insurance.

Phone: (312) 329-1777.

Circle 1069 on Inquiry Card.

EISA ETHERNET ADAPTER

The software-configurable TC5047-T Ethernet EISA adapter ($339) from Thomas-Conrad (Austin, TX) uses bus-mastering technology to transfer data directly to and from host-system memory. Auto-configuring drivers for NetWare and workstation drivers for DOS comply with Novell's Open

What's New Hardware

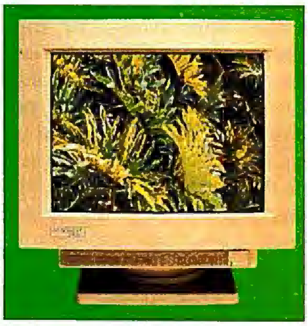
Data-Link Interface specification. Four LEDs indicate transmit, receive, collisions, and link integrity; Ether Tools let you quickly test the main functions of the unit.

Phone: (800) 332-8683 or (512) 836-1935.

Circle 1072 on Inquiry Card.

COLOR MONITOR MANAGEMENT

Optiquest's (Walnut, CA) newest 15-inch flat-square color monitor, the 2000DC ($499), includes a color management system that lets you independently adjust each electron gun. This gives you the capability to match colors to printed output, standard color schemes, and other monitors. With a dot pitch of 0.27 mm, the



monitor has a horizontal frequency scan rate of 30 to 65 kHz that supports noninterlaced resolutions of up to 1280 by 1024 pixels; its 1024- by 768-pixel resolution has a 76-Hz refresh rate. The 2000DC is VESA DPMS compliant and meets Energy Star guidelines.

Phone: (800) 843-6784 or (909) 468-3750.

Circle 1068 on Inquiry Card.

MAC MOUSE

The Action Mouse for Macintosh ($72.50) is a two-button mouse on which both buttons are available for customization via the Action Mouse Control Panel menu. You can simulate a third button by pressing both buttons simultaneously. From PoinTex (Walnut, CA), the device lets you program the buttons for normal click, double-click, click-lock, single-axis movement, command keys, and one-trigger launch.

Phone: (909) 594-6321.

Circle 1073 on Inquiry Card.

PRINTING FLEXIBILITY

The Facit PowerPrint-405 high-speed printer ($3495) has a throughput speed of 600 cps at 10 characters per inch and a patented 24-pin print head. From the Facit Division of Ahearn & Soper (Manchester, NH), the unit has a straight paper path and automatic paper-thickness compensation that lets you print on thick paper, envelopes, pressure-sensitive labels, and six-part forms. You can feed paper into the PowerPrint-405 from five paper sources and have it exit from one of three output destinations. Interchangeable Personality Modules provide different host interfaces and emulations, including connectivity options.

Phone: (603) 647-2700.

Circle 1074 on Inquiry Card.

RECORDABLE CD SYSTEM

The PlayWrite multiplatform, multiformat CD-Recordable system ($3899) comprises Ricoh's CD-Recordable drive and Dataware Technologies' CD-Record 2.0 software. From MBi of America (Carver, MN), the system is compatible with DOS, Unix, and Macs. The unit has an incremental write capability for use with CD-ROM applications such as audio CD mastering, multimedia business presentations, desktop publishing, and archival storage.

Phone: (800) 225-4414 or (612) 448-9800.

Circle 1131 on Inquiry Card.

FAN REGULATOR

The No Noise fan regulator ($49.95) from Cartaco (Austin, TX) provides smooth, variable regulation of your computer fan. As the temperature goes up inside your computer, No Noise increases the fan speed to ensure the correct amount of cooling. A safety circuit prevents interrupts to system cooling.

Phone: (512) 280-7131.

Circle 1134 on Inquiry Card.

PRESENTATION PREVIEWS ON A REMOTE CONTROL

The VideoShow Presenter ($1649) is a remote-control device that lets you pace and control your presentation while you're walking about the room, free of a mouse or keyboard. The hand-held unit has a built-in, full-color, 4-inch LCD that lets you preview the next slide without letting the audience see it. Currently compatible with PowerPoint, Harvard Graphics, and Freelance, the VideoShow Presenter plugs into the parallel port of any PC or notebook. You can connect the unit to color monitors, LCD overhead panels, and video projectors.

Contact: General Parametrics, Berkeley, CA, (800) 223-0999 or (510) 524-3950.

Circle 1061 on Inquiry Card.

MULTIPROCESSING PCS ▼

The symmetrical multiprocessor PCs (from $2199) in the VTech Platinum SMP series employ a 486DX2/50 or 486DX2/66 motherboard with a ZIF socket for adding a second processor board. If the second board is the same as the built-in processor, the addition will double the PC's processing power. From VTech Computers (Lake Zurich, IL), the Windows NT–ready machines include a built-in VESA local bus, two cooling fans, 256 KB of copy-back cache, self-sensing setup, and SCSI-2 and Intel standard multiprocessing implementation.

Phone: (708) 540-8086.

Circle 1137 on Inquiry Card.

COMPLETE HAND SCANNING

OmniScan ($449 for Windows, $595 for Macs) is a 400-dpi, 8-bit, hand-held scanner with 256 levels of gray. The OCR-capable OmniScan lets you merge and fax documents, scan and save text and graphics, modify images for incorporation into other documents, and scan text directly into a document that you are creating. OmniScan installs directly into the Windows application file menu or the Apple menu. Software that ships with the unit includes OmniPage Direct, Image Assistant, and FaxMaster.

Phone: (800) 535-7226 or (408) 395-7000.

Circle 1135 on Inquiry Card.

What's New Hardware

486SLC COLOR NOTEBOOKS

The 33-MHz 486SLC notebook from Identity (Richardson, TX) comes with a 500-MB Maxtor hard drive with an access speed of 8 ms. The $2995 unit has 4 MB of RAM (expandable to 8 MB); 256 KB of video memory; a supertwist backlit VGA LCD; a socket for an optional math coprocessor; ports for an external color monitor and keyboard; and DOS 5.0, Windows 3.1, and Microsoft Works. An optional pocket 9600-/2400-bps send-and-receive data/fax modem is available.

Phone: (214) 235-3330.

Circle 1138 on Inquiry Card.

The VAR 486SLC-33MHz Dual Scan Color ($2350) and the VAR 486SLC-33MHz Active Color ($3299) notebooks have 4 MB of RAM, a 200-MB hard drive, and a built-in coprocessor. From Logisys (Anaheim, CA), the notebooks include a SCSI port for connecting peripherals such as a CD-ROM or DAT drive, a scanner, and up to seven SCSI hard drives. Available as options are a fax modem, a second serial port, a trackball, and Ethernet 10Base-T.

Phone: (800) 333-5679 or (714) 693-1888.

Circle 1139 on Inquiry Card.

UPGRADABLE SOUND BOARD

From Creative Labs (Milpitas, CA), the Sound Blaster 16 Basic audio board ($199) has a built-in ROM interface and an expansion connector for Wave Blaster, the company's MIDI-compatible sampled-wave-synthesis daughterboard. You can add the company's DSP for real-time hardware compression and decompression. Other features include 8- and 16-bit CD-quality stereo sampling and playback at up to 44.1 kHz and an enhanced four-operator, 20-voice, OPL-3 stereo FM synthesizer.

Phone: (408) 428-6600.

Circle 1140 on Inquiry Card.

PORTABLE MO DRIVE

The Model RO128 rewritable magneto-optical drive ($1495) from Analog & Digital Peripherals (Troy, OH) stores 128 MB of data per disk. The 5½-pound portable unit has an access speed of less than 28 ms and includes parallel-printer and SCSI ports. The Model RO128 supports DOS, Macs, OS/2, and Novell LANs.

Phone: (513) 339-2241.

Circle 1136 on Inquiry Card.

FULL-MOTION VIDEO AND CD-QUALITY SOUND

ReelMagic ($449) from Sigma Designs (Fremont, CA) is a multimedia playback controller card that lets you use your PC and a standard CD-ROM player to play back full-screen, full-motion, full-color video. Able to coexist with a second sound card, ReelMagic provides 8- and 16-bit PCM sound. The card displays at resolutions of up to 1024 by 768 pixels at 30 frames per second. An on-board processor performs MPEG decompression, allowing the card to work with 386 machines and delivering simultaneous audio and video. The card attaches to the VGA feature connector on VGA and Super VGA cards.

Phone: (510) 770-0100.

Circle 1142 on Inquiry Card.

GRAPHICS ACCELERATOR

Genoa Systems' (San Jose, CA) VideoBlitz VESA Local Bus graphics accelerator ($549) provides 24-bit color at a resolution of 800 by 600 pixels and refresh rates of up to 75 Hz at 1280- by 1024-pixel resolution. The card can deliver noninterlaced resolutions of up to 1600 by 1200 pixels. Used with overscanning monitors, the card's Safescan utility lets you eliminate the black border around the perimeter of the display. VideoBlitz works under Windows and OS/2 and has drivers for Ventura, 1-2-3, Word, and WordPerfect; it supports Autodesk programs such as AutoCAD, AutoShade, AutoSketch, and 3D Studio.

Phone: (800) 934-3662 or (408) 432-9090.

Circle 1144 on Inquiry Card.

PLOTTER POWER ▲

The Intelli-Plot InkJet plotter from AMT (Camarillo, CA) plots C-size (i.e., ISO A2–size) drawings in less than 5 minutes. Based on an enhanced Canon BJP-50 bubble-jet engine, the $1995 desktop plotter provides variable plot resolutions of up to 360 dpi, a select-dial control panel that lets you manipulate drawings, and automatic scaling and positioning of drawings to best fit the page. You can scale drawings horizontally, vertically, or proportionally, position them up or down and left or right on the page, and rotate them around the page.

Phone: (800) 992-2264 or (805) 388-5799.

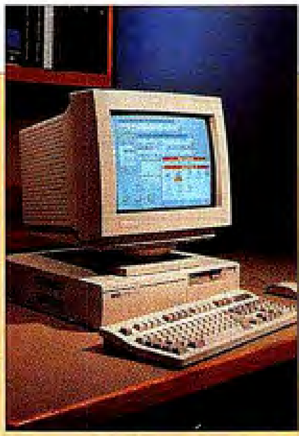
Circle 1132 on Inquiry Card.

The Solus 4 monochrome, plain-paper, large-format LED plotter ($19,995) from CalComp (Anaheim, CA) plots A-size drawings at 10 ppm and D-size drawings at 3 ppm. Designed for CAD/CAE, architectural, and other graphics applications, the freestanding plotter prints on plain paper as well as on film and vellum. Dual paper rolls let you use any combination of A- to D-size media, and automatic data-format recognition and load-and-save user numbers let you easily configure and operate the unit. Standard hardware connections include parallel, serial, and OPCOM. Expansion slots permit you to upgrade to Ethernet.

Phone: (800) 932-1212 or (714) 821-2000.

Circle 1133 on Inquiry Card.

PERSONAL CHOICES



DEC's DECpc LPv line (from $1049) and the DECpc LPx line (from $1299) of PCs offer low-cost choices for businesses that need current technology and are looking for an upgrade path. Features common to both lines of 486 machines include 4 MB of RAM (expandable to 64 MB via SIMMs), 8 KB of write-back cache on the processor, and 128 or 256 KB of optional external direct-mapped write-back cache. The units use 170-, 245-, or 525-MB IDE hard drives and 245-MB, 525-MB, or 1-GB SCSI drives with an optional SCSI board. A 525-MB SCSI tape backup is available, and you can choose from several 14- to 19-inch monitors. The LPv units have a built-in S3-805 local-bus GUI accelerator; the LPx units have a VESA VL-Bus GUI accelerator.

Contact: Digital Equipment Corp., Maynard, MA, (800) 722-9332.

Circle 1062 on Inquiry Card.

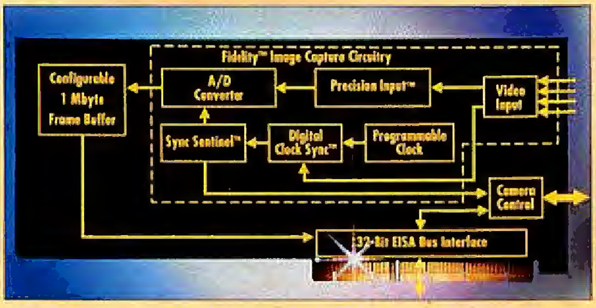
What's New Hardware

FRAME GRABBER FOR PRECISION IMAGE ANALYSIS

Designed for use with EISA-bus computers and Windows 3.1, the Fidelity 100 frame grabber ($1495) includes proprietary circuitry that lets it digitize images from diverse video sources. With spatial resolutions of up to 1000 by 1000 pixels, it can handle image-analysis applications such as microscopy and metrology. The circuitry comprises Ultra-Sharp Acquisition for crisp edges; a digital clock that generates a pixel clock with jitter of less than ±5.5 ns; Precision Input for superior gray-scale resolution; and Sync Sentinel for VCR performance. The Fidelity 100 ships with Global Lab Acquire Software for Windows, a subset of Data Translation's GLIDE (Global Lab Image Development Environment).

Contact: Data Translation, Marlborough, MA, (800) 525-8528 or (508) 481-3700.

Circle 1063 on Inquiry Card.



TCP/IP TERMINAL SERVER

Initially available with TCP/IP, Arnet's (Nashville, TN) NetTrax (from $1995) is based on a 32-bit Motorola processor that enables up to 16 MB of storage (1 MB is standard). The 16-port terminal server for multiple network protocols supports 16 RS-232D ports via modular RJ-45 connectors at speeds of up to 115 KBps and has AUI and 10Base-T interfaces. All serial ports include surge protection.

Phone: (800) 366-8844 or (615) 834-8000.

Circle 1145 on Inquiry Card.

UPS WITH LONG-LIFE BATTERY

Deltec Electronics' (San Diego, CA) PowerRite Pro family of UPSes (from $449) incorporates the company's microprocessor-based technology, Advanced Battery Management, which Deltec says extends battery life to up to 10 years. ABM also recharges batteries quickly so that you won't be without backup power, the company says, and alerts you up to 60 days prior to battery depletion. Designed to protect LAN file servers, PowerRite Pro notifies the network administrator of battery status via LEDs on the front panel. Optional power-monitoring software is also available.

Phone: (800) 854-2658 or (619) 291-4211.

Circle 1274 on Inquiry Card.

COMPACT FAX SERVER

A compact one-line fax server designed for use by as many as 100 network users, FaxPress 1000 ($1995) supports DOS and Windows 3.1. The server works with NetWare 2.x, 3.x, and 4.x and supports 10Base-T and thin-coaxial Ethernet. The self-contained unit from Castelle (Santa Clara, CA) lets you fax any document that you can print on a Hewlett-Packard LaserJet or compatible printer. You can also securely send and receive faxes from any workstation on your LAN. Features include auto-routing and user-definable options.

Phone: (800) 289-7555 or (408) 496-0474.

Circle 1272 on Inquiry Card.

ETHERNET SWITCHING HUB

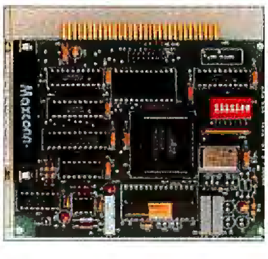
The FastSwitch 10/100 workgroup switching hub ($7250) from Grand Junction Networks (Union City, CA) provides servers with 100-Mbps Ethernet ports and private 10-Mbps ports to clients. The hub eliminates bottlenecks that occur when many clients are simultaneously accessing one or two servers. The FastSwitch 10/100 has an aggregate forwarding bandwidth of 220 Mbps and up to 22 times the throughput of existing 10Base-T hubs, according to the company.

Phone: (800) 747-3278 or (510) 487-5985.

Circle 1273 on Inquiry Card.

DATA ACQUISITION

The DAS-800 Series of DSP boards (from $349) have four-location FIFO memory that helps maintain an acquisition rate of up to 40,000 samples per second by overcoming variations in your PC's interrupt response time. The boards have eight analog inputs, either single-ended with a fixed input range of ±5 V or individually switch-selected for single-ended or differential operation. A/D conversions can be triggered by software, directly by the on-board timer, or by an external clock. All boards include three digital inputs and four digital outputs. They're from the Data Acquisition Division of Keithley Instruments (Taunton, MA). ▼



Phone: (800) 348-0033 or (508) 880-3000.

Circle 1143 on Inquiry Card.

TROUBLESHOOTING TOOLS FOR FIBER-OPTIC LANS ▲

The Fiber Solution Kit ($1595) from Microtest (Phoenix, AZ) combines the FiberEye optical power meter and the FiberLight calibrated light source to help you install, maintain, and troubleshoot your fiber-optic LAN. FiberEye measures the power of light injected into or emerging from the fiber network, as well as measuring signal loss. FiberLight, used in conjunction with FiberEye, has two LEDs with external connectors; one transmits at the wavelength of Ethernet and token-ring networks, the other at the wavelength used in FDDI networks.

Phone: (602) 952-6400.

Circle 1271 on Inquiry Card.

DESKTOP FILM PRINTER

The FilmPrinter turbo PC film recorder ($4995) is a desktop unit for making 35mm slides from your PC, Mac, or PS/2 computer. From Mirus Industries (Milpitas, CA), the FilmPrinter turbo PC connects to your computer's parallel port. The software, which includes 35 scalable fonts, is compatible with graphics and presentation programs such as Freelance for Windows, PowerPoint, and Harvard Graphics. Imaging time is 1 minute per 67-KB image with 36-bit color resolution and image resolution of up to 4000 lines.

Phone: (800) 942-9770 or (408) 944-9770.

Circle 1141 on Inquiry Card.

What's New Software

FREELY MIX DOS AND WINDOWS

An integration tool that allows DOS and Windows applications to interact in a client/server framework within Windows, WinGate ($295) lets you directly and seamlessly access Windows features and functionality. The WinGate Technologies (Morristown, NJ) developer's toolkit lets you launch and terminate any DOS or Windows program from your DOS box and read and write data to the Windows Clipboard directly from your DOS program.

Phone: (800) 946-4283 or (201) 539-2727.

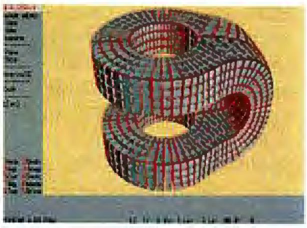
Circle 1282 on Inquiry Card.

INTEGRATE X WINDOW SYSTEM WITH OS/2

With Hummingbird Communications' (Palo Alto, CA) eXceed PC X-Window-System server software for OS/2 ($595), you can use an OS/2-based PC to connect to and display applications from X-based computer systems running Unix or VMS. The 32-bit X server program integrates seamlessly within OS/2 and takes advantage of OS/2's multitasking architecture. You can cut and paste data and bit-mapped images among X, Unix, Windows, DOS, and OS/2.

Phone: (415) 617-4560.

Circle 1283 on Inquiry Card.



GAIN ACCURACY IN FEA MODELING ▲

Hexagen finite-element-analysis software (from $800) automatically builds 3-D hexahedral, eight-node "brick" finite-element models from a quadrilateral surface-mesh paving to produce FEA models with high accuracy, according to Algor (Pittsburgh, PA). The DOS-, Unix-, and Windows NT–compatible Hexagen can use a quadrilateral surface mesh from most CAD/CAM/CAE sources, such as AutoCAD, Pro/Engineer, and Superdraw II. Since the output is in a neutral file format, Hexagen can also prepare models for FEA software from other companies. Hexagen supports stereo lithography files via its capability to convert triangular surface meshes to quadrilateral surface meshes.

Phone: (412) 967-2700.

Circle 1281 on Inquiry Card.

PREMIERE FOR WINDOWS

Premiere 1.0 for Windows ($295) from Adobe Systems (Mountain View, CA) offers tools for combining video footage, audio, animation, still images, and graphics to create digital movies in Microsoft Video for Windows AVI or Apple's QuickTime format. You can use the software to insert dissolves, wipes, and other digital transitions and special effects.

Phone: (415) 961-4400.

Circle 1284 on Inquiry Card.

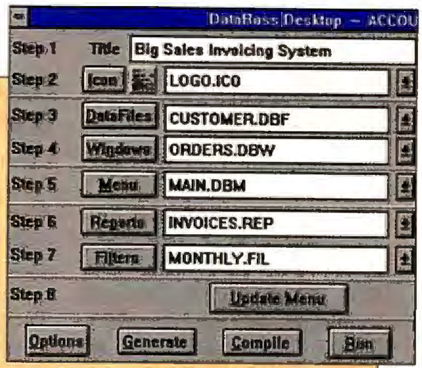
BUILD NEURAL NETWORKS

From Design Sciences (Vienna, VA), the DS2000 artificial-neural-systems-based tool lets you build sophisticated multiple network systems for DOS, OS/2, and Windows 3.1. Working with data from sources such as databases, spreadsheets, image files, expert-system shells, and simulation/modeling tools, DS2000 ($995) has the latest ANS models available for modeling complex processes and building data-driven decision-support systems. Models include real-world scientific, engineering, and business examples.

Phone: (800) 473-3744 or (703) 848-9247.

Circle 1285 on Inquiry Card.

DATABASE DESIGNING

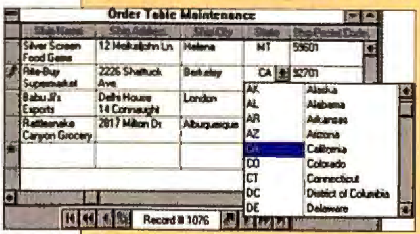


DataBoss for Windows ($695) automatically generates industry-standard C++ code when you develop your Windows database applications. After the code is generated, you have the option of letting the program compile it for you. Network support is built into the program.

Contact: Kedwell Software, Portsmouth, NH, (603) 433-4777.

Circle 1276 on Inquiry Card.

Data Widgets ($129), for use in the Visual Basic 3.0 development environment, is a set of bound data controls that also lets you design your database applications without writing code. The software includes DataGrid, Enhanced Data Control, DataCombo, and 3-D buttons.



Contact: Sheridan Software Systems, Melville, NY, (516) 753-0985.

Circle 1277 on Inquiry Card.

CUSTOM CONTROLS FOR GUIS

A set of custom controls that you incorporate into a user interface as you're developing it, XVT-PowerObjects (from $395) provides high-level functions such as table, spreadsheet, and toggle/picture-button objects; a toolbar; and a status bar. From XVT Software (Boulder, CO), PowerObjects is for PCs and Sun Microsystems workstations.

Phone: (303) 443-4223.

Circle 1286 on Inquiry Card.

DEVELOP APPLICATIONS FOR WINDOWS NT

Smalltalk/V for Win32 ($995) is a set of tools for developing 32-bit graphical, portable applications for Windows 3.1 and Windows NT. From Digitalk (Los Angeles, CA), the software lets you develop applications incrementally and gives you a high level of source code portability among Windows, OS/2, and the Mac, the company says. Built-in objects speed up your applications development, and a large class library supports Win32 functionality.

Phone: (800) 922-8255 or (310) 645-1082.

Circle 1287 on Inquiry Card.

LONG-DISTANCE FILE DRAGGING

File Express, The Worldwide Desktop ($149), displays the directories of local and remote hard drives on your Windows desktop and then allows you to click and drag a file from one desktop and drop it on a second desktop via modem or direct link. From Synergy Communications (Santa Barbara, CA), File Express lets you transmit documents, color photographs, sound or multimedia messages, and business presentations. Once the file is sent, the receiving person double-clicks on the file. File Express then automatically launches the appropriate application on the receiving machine to read the file.

Phone: (805) 964-1755.

Circle 1303 on Inquiry Card.

What's New Software

AN EXPANDED PIM FOR THE POWERBOOK

Field Assistant 1.0 for the Apple PowerBook ($249) is both a PIM and a contact manager with a relational database architecture. From FIT Software (Santa Clara, CA), the program's relational technology lets you attach unlimited contacts, addresses, activities, and phone numbers to a specific record. Designed for the mobile user, Field Assistant includes a correspondence module and automatic mail-merge capabilities.

Phone: (408) 562-5990.

Circle 1296 on Inquiry Card.

NUMBERS AHEAD

A utility program for Macs, Datica II ($99) from By Design (Middleton, WI) has a unit-conversion module that will build and save any physical measurement conversion you want, according to the company. Also included are an equation solver, a periodic table, and a table feature that lets you view, edit, and create tables as well as import and export data.

Phone: (800) 527-7472 or (608) 831-5259.

Circle 1299 on Inquiry Card.

PRESENTATION GRAPHICS TOOL ▶

Completely redesigned, Charisma 4.0 ($495) from Micrografx (Richardson, TX) makes it easier to create presentations in Windows. The program provides visually driven charting and graphing for creating customizable charts and graphs; multimedia capabilities that allow you to add video, sound, and animation directly into your presentation; and illustration tools. You can represent and edit data in 3-D format, borrow from the music and video CD-ROM clips, and scan images directly into Charisma from any TWAIN-compatible source.

Phone: (214) 234-1769.

Circle 1288 on Inquiry Card.

REAL-TIME MULTIMEDIA

Passport Producer Pro ($1495), a real-time, interactive multimedia production tool from Passport Designs (Half Moon Bay, CA), provides synchronized animation, video, sound, music, and presentation graphics. Capabilities include external device control, path-based object animation, overlaying text onto graphics, importation of standard Mac file types, and SMPTE support.

Phone: (415) 726-0280.

Circle 1291 on Inquiry Card.

PC-TO-UNIX LINK

CenturyTCP ($199 per user) implements the TCP/IP network protocol with the required elements for linking PCs to Unix hosts. From Century Software (Salt Lake City, UT), CenturyTCP includes TinyTerm Telnet, which provides terminal-emulation options for access to Unix. Designed for simultaneous use with NetWare, the software is also compatible with networks such as Vines, LAN Manager, LANtastic, and Pathworks.

Phone: (801) 268-3088.

Circle 1292 on Inquiry Card.

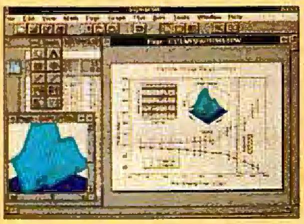
AUTOMATED PROPOSAL PREPARATION

The Automated Proposal Generator (from $10,000) is a database publishing system for the Mac that lets you quickly and accurately prepare and price complex business proposals. The software, from R. M. Dudley (Burlingame, CA), tracks proposal preparation with such features as an integrated word processor; automatic layout, formatting, and table-of-contents generation; centralized control of template creation and updates; and management tracking and reporting of previously generated proposals.

Phone: (415) 697-1650.

Circle 1293 on Inquiry Card.

GRAPHS FOR SCIENCE



SigmaPlot for Windows ($495), OLE 1–compatible scientific graphing software, lets you customize your technical graphs for publication. With SigmaPlot's full range of scientific features, you have access to automatic error bars, huge data-set handling, nonlinear curve fitting, axis breaks, multiple axes, regression lines, confidence intervals, and reference lines. You can create 2-D graphs and 3-D mesh and scatter plots by selecting from pictures of graph types, and you can view multiple data sets with their graphs in sizable windows. You can merge, open, close, size, and position these worksheets as you wish.

Contact: Jandel Scientific, San Rafael, CA, (800) 874-1888 or (415) 453-6700.

Circle 1278 on Inquiry Card.

Software Update

SmartLeaf/Compare 3.0, DataBase Publishing Software (Woburn, MA), adds user-interface changes, an enhanced comparison engine, and new choices in defining the rules for comparing documents. $4995.

Phone: (617) 938-0018.

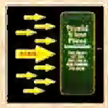
Circle 1305 on Inquiry Card.

CoSession ACS 6.2, Triton Technologies (Iselin, NJ), adds support for intelligent multiport serial cards and the capability to share modems on workstations running Windows 3.x in enhanced mode. From $345.

Phone: (800) 322-9440 or (908) 855-9440.

Circle 1306 on Inquiry Card.

WorldView 2, Interleaf (Waltham, MA), adds Outline Navigator, advanced hypernavigation tools, Standard Generalized Markup Language capabilities, redlining, international user interfaces, and the ability to display Japanese kanji documents. From $4995.



Phone: (617) 290-0710.

Circle 1307 on Inquiry Card.

DP Umbrella 1.1 for Windows SQL, Vycor (College Park, MD), adds a link to CasePoint from Inference for case-based reasoning, a cc:Mail interface, unlimited user-defined field labels, and zoom or access tables to which a field is associated. $6995.

Phone: (800) 888-9267 or (301) 220-4450.

Circle 1308 on Inquiry Card.

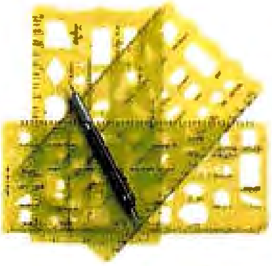
LanRover/E 2.0, Shiva (Burlington, MA), adds support for TCP/IP, shared dial-out for modem pooling, and enhanced management capabilities. From $2499.

Phone: (800) 458-3550 or (617) 270-8300.

Circle 1309 on Inquiry Card.

Visio 2.0 is the easiest way to make great business drawings.

Now, it's also the easiest way to make a great business decision.



If you've used a stencil, you know how to use Visio. Visio stencils address virtually all your business drawing needs.

You're looking at some great drawings and diagrams made by a bunch of people who can't draw.

All were created with Visio,™ Shapeware's® award-winning drawing program for Windows™ 3.1 users.

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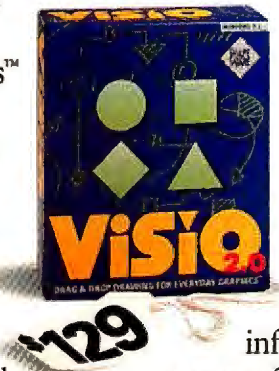
Unlike clip art, Visio's 600-plus SmartShapes have built-in intelligence. So they resize without distorting, connecting lines stay glued and integrated text makes labeling and editing a snap. You can even create and customize shapes of your own.

Visio's drag and drop SmartShapes take the "drawing" out of business drawing.

And since Visio supports OLE 2.0, you can easily integrate drawings with other Windows applications. Creating great business drawings has never been simpler.



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Here's an easy business decision: Purchase Visio 2.0 by December 31, 1993, and save $170. Visio also comes with a 60-day, money-back guarantee.

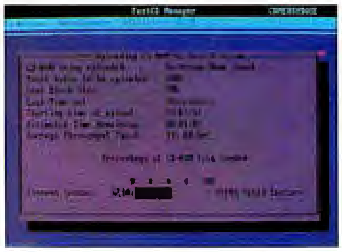
To order, for more information, or for the names of authorized Visio resellers near you, call toll-free:

1-800-446-3335, ext. EP9

SHAPE WARE

Circle 181 on Inquiry Card.

What's New Software



CD-ROM NETWORKING

LanCD (from $1995) supports up to four network protocols simultaneously while providing access to CD-ROM applications to everyone on the network. From Logicraft (Nashua, NH), LanCD has a manager utility that lets server administrators remotely monitor LanCD-server operation and use. The included FastCD software creates virtual CD-ROM discs on physical SCSI hard drives and supports up to 254 virtual discs per server.

Phone: (603) 880-0300.

Circle 1290 on Inquiry Card.

MAC TOOLS

A set of eight system utilities that help you organize and manage daily desktop functions on the Mac, Aladdin Desktop Tools ($89.95) accelerates and streamlines basic file management chores. From Aladdin Systems (Watsonville, CA), the Desktop Tools include SpeedBoost, Shortcut, Printer, Makeover, MagicTools, SecureDelete, Toys, and Stuffit Expander.

Phone: (408) 761-6200.

Circle 1302 on Inquiry Card.

NETWARE VIRUS DETECTOR

A NetWare loadable module, Norton AntiVirus for NetWare ($995 per server) provides unobtrusive virus protection for your server without affecting network performance. LAN administrators can configure the program from Symantec (Santa Monica, CA) so that when it's hunting down viruses, key applications will continue to operate efficiently while remaining protected. The NLM scans DOS, Windows, and Mac files. The customizable real-time monitoring feature lets you send out alerts over a pager or via E-mail.

Phone: (310) 453-4600.

Circle 1295 on Inquiry Card.

SCIENTIFIC ANALYSIS IN WINDOWS ▼

DADiSP for Windows ($995), graphical data-analysis software from DSP Development (Cambridge, MA), allows you to run a DADiSP worksheet within Windows to collect, analyze, and display scientific and technical data. The intuitive, spreadsheet-like environment is menu driven and lets you work with data series of almost any length. You can automate DADiSP worksheets for background operation, run multiple applications, set and read operating-system settings, and invoke the string-manipulation and data-type-conversion capabilities, among other functions.

Phone: (617) 577-1133.

Circle 1289 on Inquiry Card.

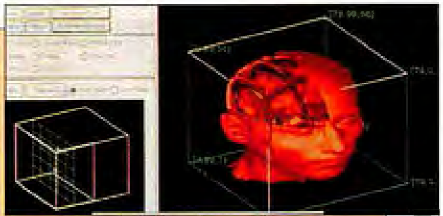
AUTOMATIC CHARTING

The allClear for Windows package (from $299.95) automatically creates flowcharts, organizational charts, cause-and-effect diagrams, and decision trees from your written description of the procedure you want drawn. From Clear Software (Newton, MA), allClear for Windows lets you open multiple diagrams. The split-screen capability lets you edit text in one window and immediately see the changes in the chart in the other window.

Phone: (617) 965-6755.

Circle 1300 on Inquiry Card.

ANALYZE LARGE DATA SETS AND BUILD CUSTOM APPLICATIONS



IDL for Macintosh ($1500) integrates mathematics, advanced visualization, and custom application development capabilities to let you analyze large data sets and build custom applications on your Mac. Scientific computing features include a built-in GUI toolkit, an editor/debugger, and an array-oriented language that lets you interactively test what-if analyses.

The program's analysis and visualization capabilities include math and statistics; comprehensive plotting; volume visualization for disciplines such as medical imaging and earth sciences; gridding; and mapping. You can transfer customized applications to any hardware platform running previously written IDL or PV-Wave programs under Windows, Unix, other Macs running System 7.0 or higher, VMS, and supercomputer environments.

Contact: Research Systems, Boulder, CO, (303) 786-9900.

Circle 1279 on Inquiry Card.

Software Update

LapCAD for Windows R4, LapCAD Engineering (San Diego, CA), adds layering, the capability to handle up to 800 different loading conditions, and import/export capability for the IGES finite-element entities. From $195.

Phone: (619) 467-1947.

Circle 1310 on Inquiry Card.

WordPerfect 6.0 for Windows, WordPerfect Corp. (Orem, UT), adds a customizable interface; templates; WordPerfect Draw; a charting module; Coaches; and enhanced compatibility, integration, and file management. $495.

Phone: (800) 451-5151 or (801) 225-5000.

Circle 1311 on Inquiry Card.

TechKnowlogy Imaging Software for Windows 4.0, TechKnowlogy (Salt Lake City, UT), adds a flexible GUI with hot keys, navigation-control buttons, and Query by Thesaurus. $395.

Phone: (801) 261-8850.

Circle 1312 on Inquiry Card.

LANauditor 3.0, Horizons Technology (San Diego, CA), adds client auditing for Macs and OS/2, as well as expanded auditing for DOS/Windows workstations and file servers. From $495.

Phone: (619) 277-7100.

Circle 1313 on Inquiry Card.

Zylndex 5.1 for Windows, ZyLab (Buffalo Grove, IL), adds a sorting feature, flexible index sets, and hyperlinking. From $395.

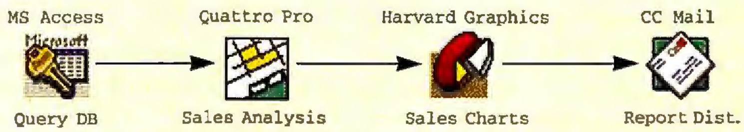
Phone: (800) 544-6339 or (708) 459-8000.

Circle 1314 on Inquiry Card.

Your software programs were barely speaking. Then something clicked.

If you're tired of playing matchmaker to software applications (even ones from the same vendor), you'll be pleased to hear this. There is a product that does it for you, now. Prodea Synergy™ makes the programs you already have, and what you've built with them, work together. A few points and clicks, and applications will exchange just about everything but valentines.

Mr. R. Lee Allen of Schering-Plough, a company already using Prodea Synergy, put it less romantically although no less enthusiastically. "It's not like anything out there before. It's more than OLE or DDE. It transcends both languages and APIs."



Drag and drop the icons, connect them with arrows. Data flows automatically.

You should also know that what you build is easy to pass on to others, without worrying about hot links, paste links or file location. Prodea Synergy runs under Windows,™ costs $495 and has a 30-day money-back guarantee. For a limited time you also get a $200 introductory cash rebate. Call us at 1-800-PRODEA-1. Your software programs will never look at one another the same way again.

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What's New Software

SMART FILE KEEPER

SmartSync ($169.95) file-synchronization and data-sharing software for Windows lets you maintain the currency of the files you work in on two or more computers. You can set up a schedule for SmartSync to automatically keep your files up to date and to synchronize individual files or collections of files and directories. By sending only the changes made to the files rather than overwriting entire files, the program reduces data-transmission time and costs.

The software's RemoteCopy feature lets you remotely browse and copy files; TeamSync lets you synchronize and share data with coworkers. An auto-recovery feature automatically reestablishes a broken connection and continues transmission where the session was interrupted. Security checks are included to prevent loss of data.

Contact: Nomadic Systems, Mountain View, CA, (415) 335-4310.

Circle 1280 on Inquiry Card.

E-MAIL PC-TO-PC

An E-mail program that lets you exchange E-mail with another PC user over standard phone lines, Personal-E Mailbox (from $49.95) can run in the background receiving mail while you are working in an application. Personal-E Mailbox is portable and capable of running from a floppy disk. You can broadcast messages to groups of users, and those who are hearing-impaired can use a special chat mode for interactive E-mail over TDD-compatible phones. Utilities can convert messages to text and database formats. From AmerCom (Portland, OR).

Phone: (503) 452-8196.

Circle 1294 on Inquiry Card.

REAL-TIME DESKTOP CONFERENCING

InPerson desktop-conferencing software (single-user license, $495) from Silicon Graphics (Mountain View, CA) is designed for use with the company's workstations. Application-independent, InPerson lets you import an image for review and markup. It is fully equipped with multiway conferencing and messaging indicators that let you receive notification of calls missed, put a current call on hold, and join active conferences. Used with Indigo Magic, InPerson lets you interact with multiple conference participants using live video and audio.

Phone: (415) 960-1980.

Circle 1298 on Inquiry Card.

THROW THE PROGRAM MANAGER OUT THE WINDOW ▶

The McDesk for Windows utility ($149) eases the use of Windows by replacing the Windows File Manager and Program Manager with a point-and-click system of icons. From Granite Software (Austin, TX), such routine functions as print, save, open, and run become invokable by a keystroke. For instance, if you grab a file and drag it to the printer icon, the file goes to the printer. You can add any application or McDesk menu item as a button.

Phone: (512) 258-3570.

Circle 1297 on Inquiry Card.

TAKE NOTES NATURALLY

InkWare NoteTaker ($195) from Ink Development (San Mateo, CA) is a pen-based application that runs under Windows for Pen Computing on any Intel-based computer that supports pen input. The software's free-form approach to note-taking and information management lets you take notes using the pen or the keyboard and then edit, copy, and move either type of note. You can tag notes with SmartStamps or keywords; the marked notes are then automatically made into to-do lists.

Phone: (415) 573-6565.

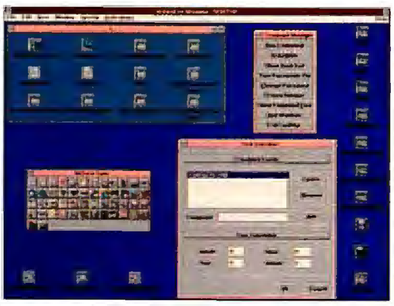
Circle 1301 on Inquiry Card.

SMALLER WINDOWS APPLICATIONS

Rosenthal WinLite ($149) does for Windows 3.1 what PKLite did for DOS: It compresses applications on disk and decompresses them into memory upon execution. Windows programs (even those run within NT or OS/2) shrink to a fraction of their original size, reducing LAN traffic and improving cache efficiency. Solitaire, for example, condenses to 43 percent of its original size, according to Rosenthal Engineering (San Luis Obispo, CA).

Phone: (805) 541-0910.

Circle 1304 on Inquiry Card.



Software Update

PSI-Plot 2.1, Poly Software International (Salt Lake City, UT), adds batch-mode processing, alignment of objects, column/row transposition, and a bigger user-defined model for curve fitting. $299.

Phone: (801) 485-0466.

Circle 1315 on Inquiry Card.

Media Suite Pro 2.0, Avid Technology (Tewksbury, MA), adds a 60-field option, an edit-decision-list option, and additional effects such as motion control. $9995.

Phone: (508) 640-6789.

Circle 1316 on Inquiry Card.

XTreeNet 3.0, XTree (San Luis Obispo, CA), adds Oops! undelete for NetWare, integrated ZIP 2.0 support, and a multiwindow text editor. $495; server extensions, $295 each.

Phone: (805) 541-0604.

Circle 1317 on Inquiry Card.

Close-Up 5.0, Norton-Lambert (Santa Barbara, CA), adds photographic memory, video translation between PCs, and AI to compress video function calls. $199.

Phone: (805) 964-6767.

Circle 1318 on Inquiry Card.

TNT DOS-Extender 6.0, Phar Lap Software (Cambridge, MA), provides the capability to implement DLLs, use Visual C++ 32-bit Edition, write Windows NT character-based applications, and more. $495.

Phone: (617) 661-1510.

Circle 1319 on Inquiry Card.

Netroom 3.02, Helix Software (Long Island City, NY), adds remote network installation, multiuser licenses, and automatic detection of network adapters. From $99.

Phone: (718) 392-3100.

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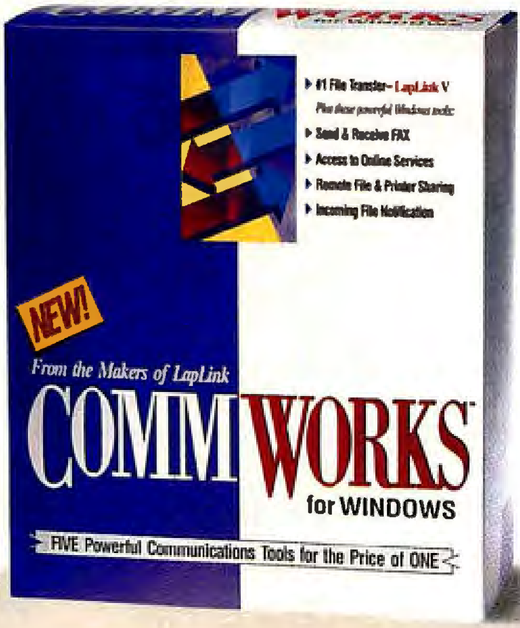

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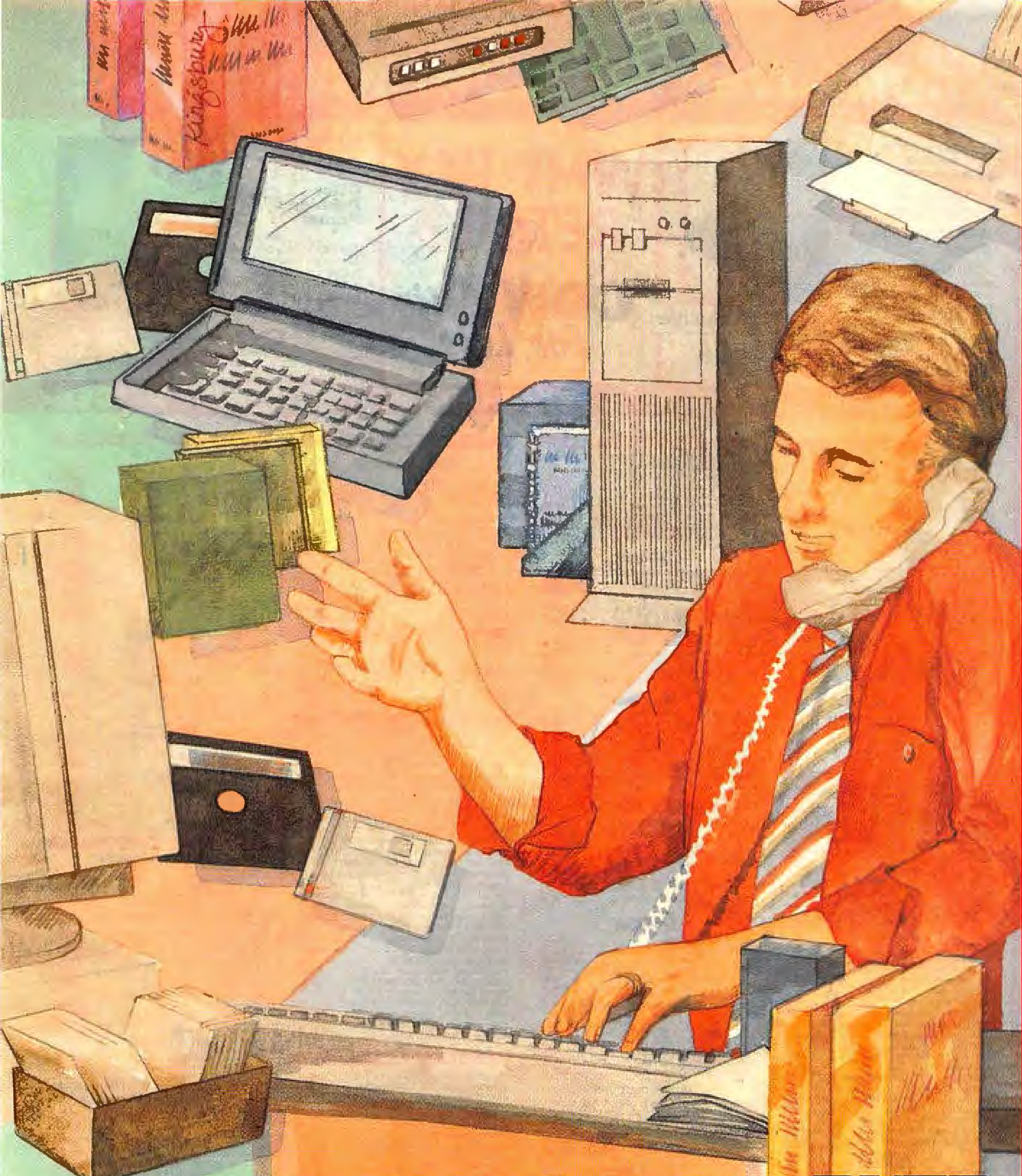

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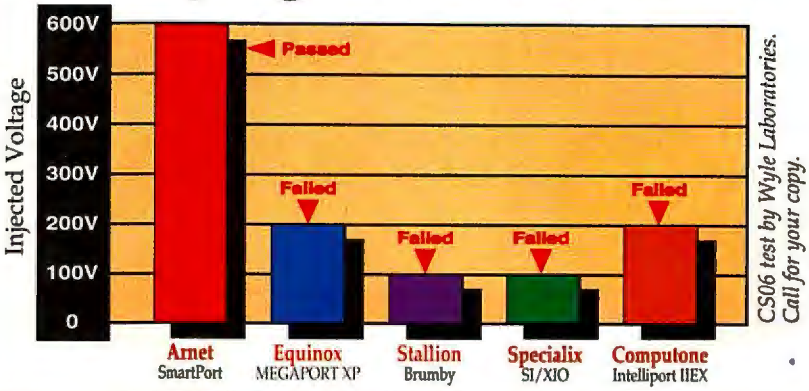

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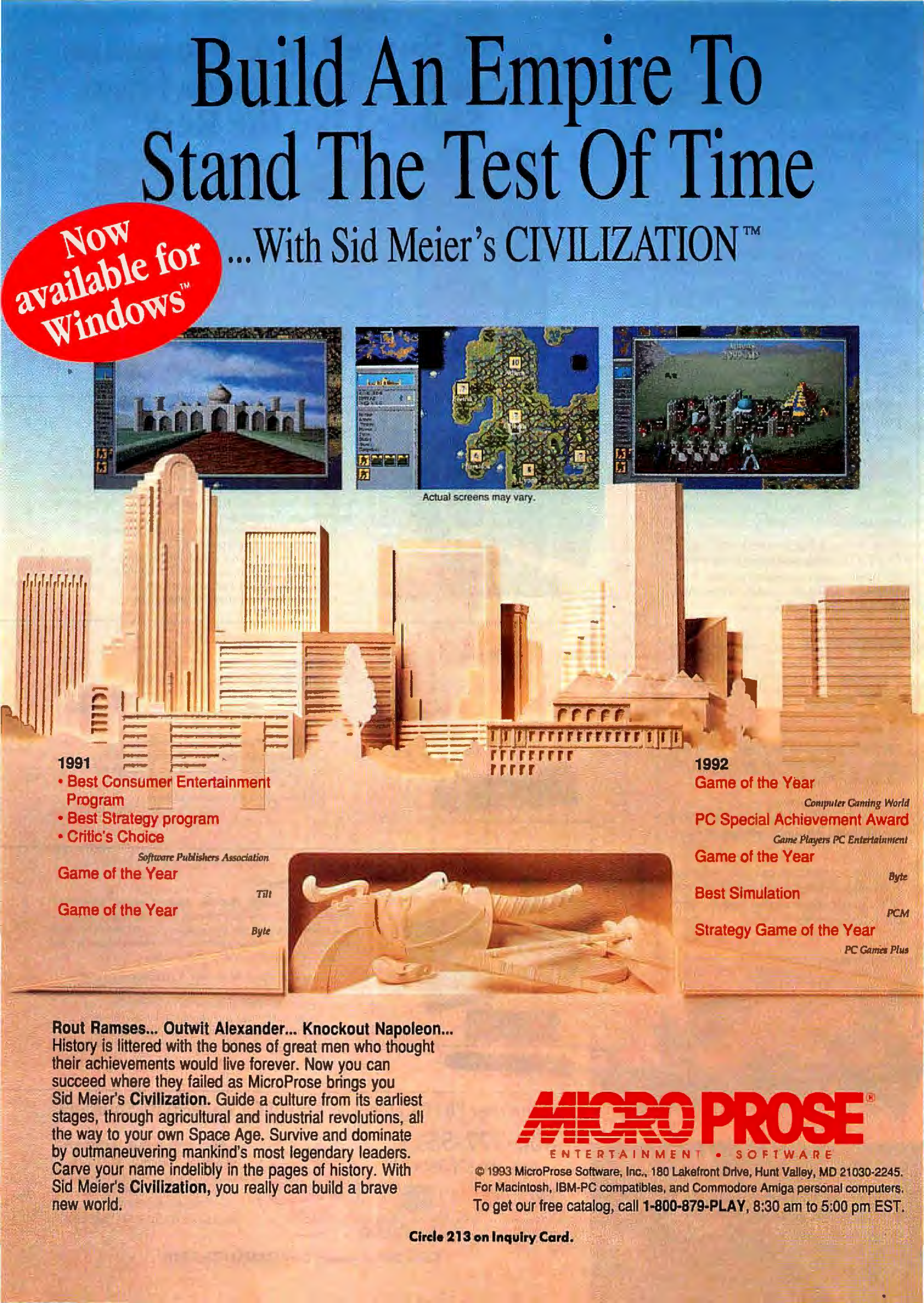

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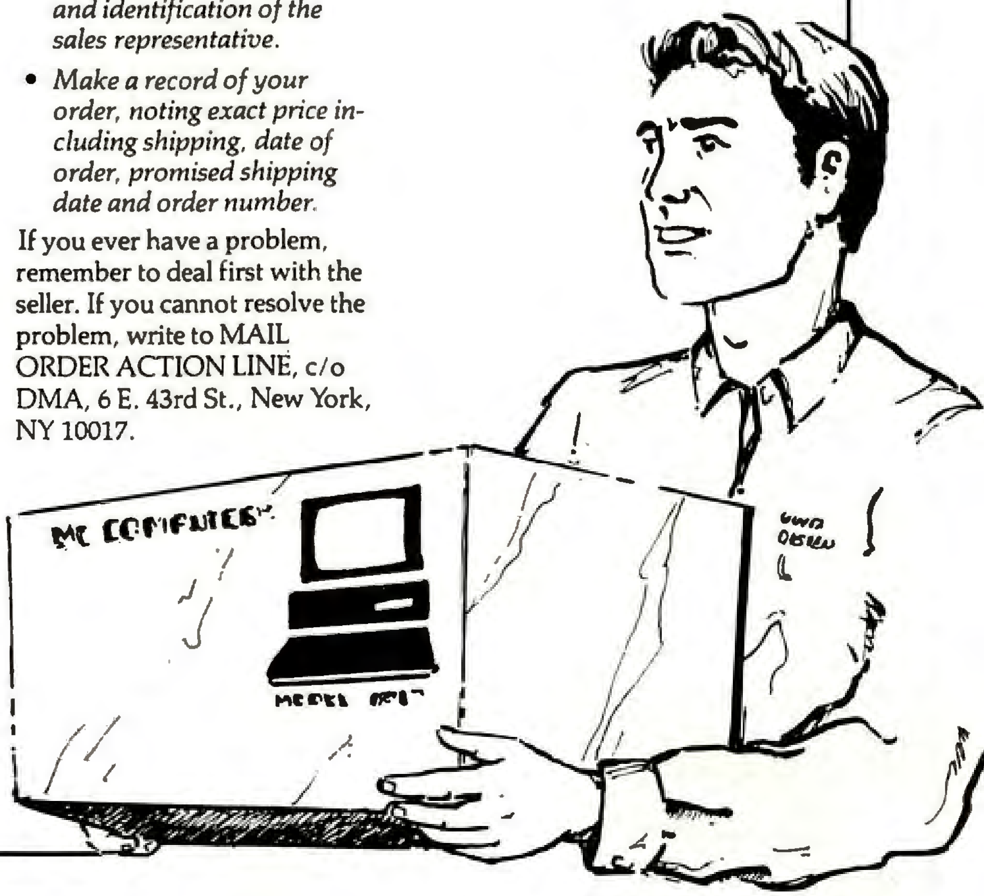

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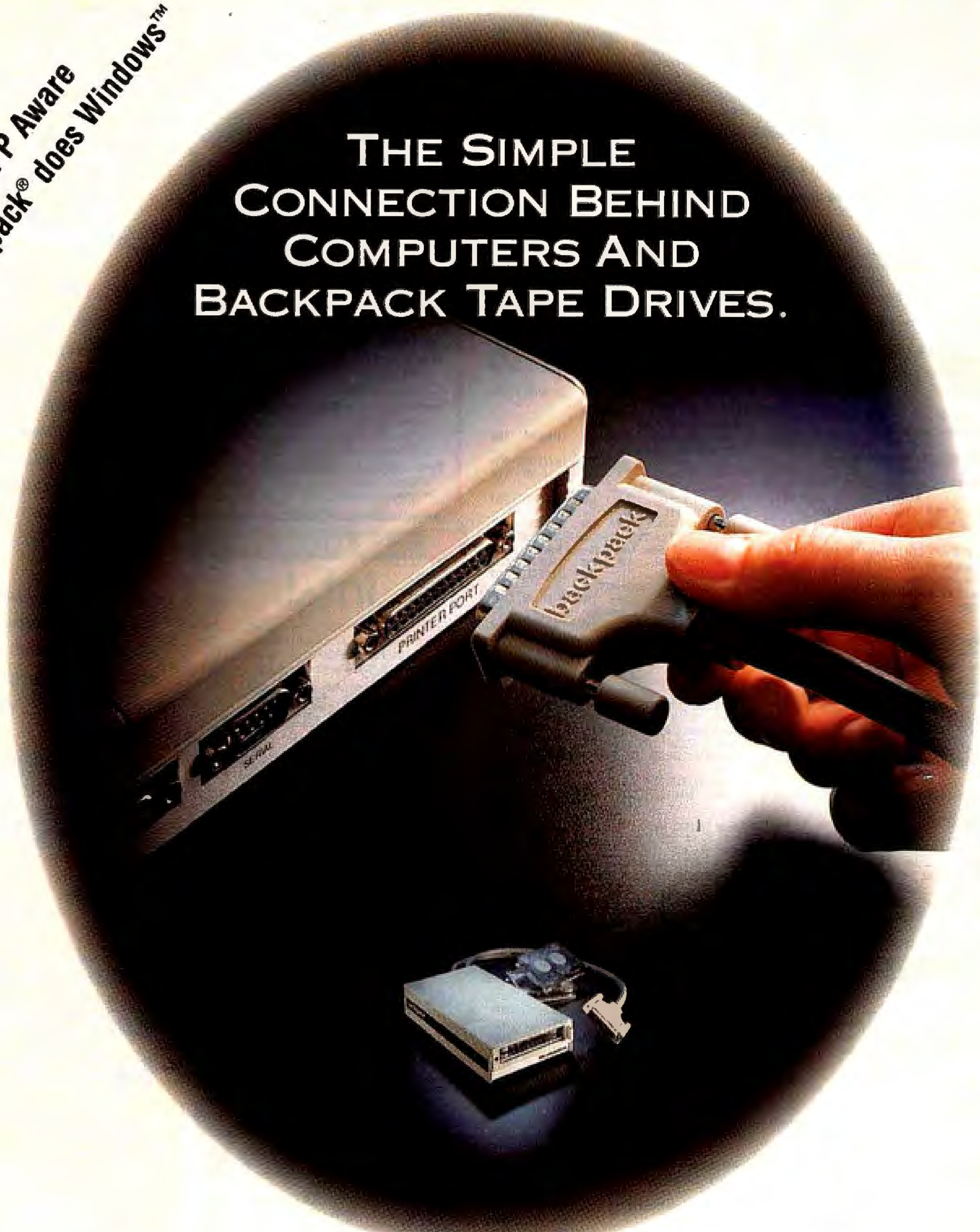

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PS/2 90 XP, 95 XP, P75 (pairs), 56, 57 (all), PS/1 Pro M2123
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ST351A (1" high)	42MB	28MS	IDE 3.5"	$125
ST3144A (1" high)	130MB	16MS	IDE 3.5"	$188
ST3243A	213MB	15MS	IDE 3.5"	$249
ST3283N	249MB	12MS	SCSI-2	$399
ST3290A	**260MB**	**15MS**	**IDE 3.5"**	**$258**
ST3390A	360MB	12MS	IDE	$369
ST3390N	343MB	12MS	SCSI-2	$479
ST3550A	452MB	12MS	IDE 3.5"	$489
ST3550N	457MB	12MS	SCSI-2	$598
ST3655A	545MB	12MS	IDE 3.5"	$698
ST4096	80MB	28MS	MFM Full HT	$399
ST4144R	125MB	65MS	RLL (FULL HT)	$399
ST9096A	85MB	16MS	IDE 2.5"	$298
ST9144A	128MB	16MS	IDE 2.5"	$348

CONNER

MODEL	SIZE	SPEED	TYPE	PRICE
CP30084	80MB	17MS	IDE	$175
CP30104 (1" high)	120MB	19MS	IDE	$199
CP30174A (1" high)	170MB	17MS	IDE	$208
CP30254 (1" high)	209MB	12MS	IDE	$278
CP30540	540MB	10MS	SCSI	$678
CP30544A	540MB	15MS	IDE	$698

Maxtor 2 YEAR WARRANTY

MODEL	SIZE	SPEED	TYPE	PRICE
7131A (1" high)	130MB	15MS	IDE	$198
7213A (1" high)	213MB	15MS	IDE	$234
7213S (1" high)	213MB	15MS	SCSI	$275
7245A (1" high)	245MB	15MS	IDE	$269
7345A (1" high)	345MB	15MS	IDE	$339
MXT540SL	540MB	13MS	SCSI/IDE	$798
PANTHER (FH) P0125	1000MB	13MS	SCSI	$998
PANTHER (FH) P117	**1500MB**	**13MS**	**SCSI**	**$1358**

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MODEL	SIZE	SPEED	TYPE	COST
2622A/S (3.5")	330MB	12MS	SCSI/IDE	$565
2623A/S (3.5")	420MB	12MS	SCSI/IDE	$738
2624A/S (3.5")	520MB	12MS	SCSI/IDE	$725
2266S (FH)	1080MB	15MS	SCSI	$999
2652S (FH)	1750MB	11MS	SCSI	$1888
2654S (FH)	2060MB	11MS	SCSI	$1998

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2105 (3.5")	560MB	10MS	SCSI/IDE	$869
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1528-15 (FH)	1350MB	14MS	SCSI	$1098
1548 (FH)	1748MB	14MS	SCSI	$1548
1924 (FH)	2100MB	11MS	SCSI	$2279
1936 (FH)	3300MB	11MS	SCSI	$2895

WESTERN DIGITAL 2 YEAR WARRANTY

2200 (1" high)	212MB	13MS	3.5" IDE	$235
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8 Bit	2 Hard Drives RLL	$69
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SCSI	DTC 3280 (Supports 7 drives)	$139
SCSI	Adaptec 1742A 32 BIT	$418
SCSI	Adaptec 2842 BLK (VLB)	$349
SCSI	Adaptec 1542 CF Bus Mastering	$219
ESDI	DTC6282 24	$149
IDE	Hard and Floppy	$19
IDE	**Hard and Floppy w/IO**	**$29**
Cables	Hard Drive	$9
Cables	Hard and Floppy	$14
SCSI-2	ULTRA14F, ISA BUSMASTER	$149
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IBM PS/2 Memory

MODEL	MEMORY	PART#	PRICE
AMBRA Enterprise 386, Hurdle 386, Sprinta 386 (all models)	2MB	N/A	$129
	8MB	N/A	$419
AMBRA Enterprise 486, Hurdle 486, Sprinta 486 (all models)	4MB	N/A	$259
	16MB	N/A	$829
PS/1 and 386/SX (2121)	2MB	92F9935	$118
	4MB	92F9694	$228
PS/2 30/286;25/286; Adpt Brd 1497259	512K	30F5348	$39
	2MB	30F5360	$114
PS/2 35SX, LS, 40SX,70-E61; 061, 121, Adpt Brd 6450609, 34F3011; 34F3077, 502, 55SX, 655SX, P70, 55LS, 65LS XStation 120 & 130	1MB	6450603	$57
	2MB	6450604	$104
PS2 50, 50Z, 55SX, 60, 65SX	2-8MB	1497259	$317
	2-16MB	6450609	$368
2-8 MB FOR PS/2 50 & 60, 2MB $159, 4MB $259, 8MB $489			
PS/1 Consultant, Essentials & Expert models x43, x44 & PS/Valuepoint all models except Cxx series	4MB	96F9290	$298
	16MB	96F9291	$968
PS/2 70-A21; A61; B21; B61; PS/1 Consultant, Essential & Expert models x11, x13 & x14, PS/Valuepoint Cxx series	1MB	6450603	$49
	2MB	6450608	$109
PS/2 35SX; LS, 40SX, 55SX; LS, 65SX;	4MB	34F2933	$218
PS/2 90 XP, 95 XP, P75 (Pairs), 56 57 (all) 76, 77, PS/1 Pro 2123	2MB	6450902	$117
PS2 90, 95 XP, P75 (Pairs) 56, 57, (all) PS/1 Consultant, Essential, Expert x11, x13 & x14, PS/1 Pro 2123, RS/6000	4MB	6450128	$218
	8MB	6450130	$488
PS2/2 35SX; LS; 40SX	8MB	6450129	$488
PS2 70's and 80's	2-8MB	6450605	$297
32 BIT BOARDS	2-14MB	34F3077	$388
32 BIT BOARDS	4-16MB	34F3011	$448
PS/2 80-A21; A31; A61	4MB	6451060	$248
PS/2 80-041	1MB	6450375	$88
PS/2 80-111; 311; 121; 321; 081; 161	2MB	6450379	$118

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IBM Laptop Memory

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	8MB	33G9289	$499
Thinkpad 700T	2MB	53G6958	$138
	4MB	53G6959	$298
	8MB	53G6960	$499
CL57SX	2MB	07G1419	$168
Thinkpad 700, 700C, 720, 720C	4MB	07G1420	$298
	8MB	07G1421	$498
Thinkpad 710T	4MB	N/A	$228
	8MB	N/A	$448
PS/Note N45	2MB	92F8804	$108
PS/2 Model N51, Notebook SLC, SX	2MB	07G1826	$108
	4MB	07G1827	$268
	8MB	07G1828	$448
Laptop N33SX, L40SX & PSNOTE 182	2MB	79F0999	$108
	4MB	79F1000	$268
L40SX, PSNOTE 182 ONLY	8MB	79F1001	$488

TOSHIBA Laptop & Notebook Memory

MODEL	MEMORY	PART#	PRICE
T1000 SE/LE/XE	2MB	PA8312U	$104
T2000 / T2000SX	2MB	PA8317U	$104
T2000SX/T1000 LE	4MB	PA8314U	$238
	8MB	PA8315U	$447
T1200 XE	2MB	PA8306U	$112
T1600	2MB	PA8302U	$105
T2000 SXE/T2200SX/T1800 T1850, C	2MB	PA2000U	$109
	4MB	PA2001U	$239
	8MB	PA2002U	$447
T3100	2MB	PA7135E	$178
T3100 E	2MB	PA8341U	$108
T3100 SX	2MB	PA8308U	$108
	4MB	PA8310U	$234
T3200 SX	2MB	PA8307U	$108
	4MB	PA8309U	$214
T3200 SXC	2MB	PA8318U	$108
	4MB	PA8319U	$214
T3200	3MB	PA7137U	$186
T3300SL	2MB	PA2006U	$118
	4MB	PA2007U	$238
	6MB	PA2008U	$278
	16MB	PA2009U	$998
T4400 SX, SXC, T6400 SXC, DXC	2MB	PA2003U	$125
	4MB	PA2004U	$238
	8MB	PA2005U	$448
	16MB	PA2010U	$989
	32MB		$1999
T4500, T4600, T1900C 3.3VOLTS	4MB	PA2012U	$288
	8MB	PA2013U	$478
	16MB	PA2014U	$1398
T5100	2MB	PA8301U	$104
T5200/T5200C/T8500	2MB	PA8304U	$109
	8MB	PA8313U	$448

COMPAQ Memory

MODEL	MEMORY	PART#	PRICE
Deskpro 386/16	1-2MB	108069-001	$338
	2MB	108069W71	$448
	4-8MB	108070-001	$498
Deskpro 286E, 386-20, 20E; 25, 25E	1MB	113131-001	$59
	4MB	113132-001	$238
Deskpro 386S	4MB Board	113634-001	$299
	4MB Module	112534-001	$259
Deskpro 386-20E; 25E	4MB	113645-001	$299
Deskpro 386/33; 386/33L 486/25, 33L,50L, Systempro	2MB	115144-001	$124
	8MB	116561-001	$449
	32MB	116568-001	$1999
Systempro, Deskpro ....6 SKT EXP BRD W/2MB		116569-001	$399
Compaq "M"	2-64MB	129160-001	$448
Deskpro 286N, 386N, 386SX/20, 20N, Portable 486c, Deskpro M, Systempro LT Series 129160-001, Compaq Pro Signia	1MB	118688-001	$49
	2MB	118689-001	$105
	4MB	118690-001	$238
	8MB	128877-001	$444
Prolinea 3/25 & 25Z	2MB	141738-001	$139
	8MB	141742-001	$499
Prolinea 4/25si, 4/33, 4/50	2MB Module	141683-001	$118
	4MB Module	141684-001	$238
	8MB Module	141685-001	$408
Compaq Pro Signia	16MB	149320-001	$995
	32MB	149147-001	$2395

COMPAQ Laptop & Notebook Memory

Contura 320, 325	2Mb	139497-001	$108
	4MB	139498-001	$238
	8MB	139499-001	$418
Contura 4/25CX	4MB	146520-001	$228
	8MB	146521-001	$471
	16MB	146532-001	$948
SLT/286	1MB	110235-001	$79
	4MB	110237-001	$208
SLT386	1MB	118303-001	$79
	2MB	118304-001	$108
	4MB	118305-001	$238
Lte 286	1MB	117081-001	$79
	2MB	117081-002	$109
	4MB	117081-004	$238
Lte 386S/20	1MB	121125-001	$98
	4MB	121125-002	$258
Lte Lite/20, 25, 25C	2MB	129769-001	$138
	4MB	129769-002	$248
	8MB	129769-003	$421
	16MB	129769-004	$1395
LTE Lite/20 & Lite/25,25C	16MB	N/A	$1045
LTE Lite 486/25C	4MB	142337-002	$259
	8MB	142337-003	$478
	16MB	142337-004	$1198

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DESCRIPTION	100NS	80NS	70NS	60NS	53NS	40NS
256X9	$5	$12	$15	$17		
1MEGX3		$47	$49	$52	$59	$64
1MEG X 9	$44	$57	$60	$64	$69	$78
4MEG X 9		$168	$178	$188		
16MEG X 9 (36 CHIP)			$999			
256X36 1MEG (72 Pin)		$69				
512X36 2MEG (72 Pin)		$114	$124	$129		
1X36 4MEG (72 Pin)		$208	$218	$288		
2X36 8MEG (72 Pin)		$418	$447	$478		
4X36 16MEG (72 Pin)		$748	$798	$848		
8X36 32MEG (72 PIN)			$2150			

D-Ram Chips

DESCRIPTION	150NS	120NS	100NS	80NS	70NS	60NS
64 X 4	$1.95	$2.25	$2.45	$2.95		
256X1 STATIC				$1.95	$2.25	
256 X 1	$1.45	$1.85	$2.40	$3.00	$3.15	$3.20
256 X 4			$6.45	$7.95	$8.45	$8.95
1MEG X 1		$2.95	$4.50	$5.75	$6.45	$6.75
1MEGX1 STATIC				$4.95	$5.25	
1MEGX4				$32.00	$35.00	$39.00

CACHE MEMORY

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8KX8	5.95	5.45	4.95
32KX8	9.95	8.75	
64Kx1	10.95	9.45	8.95
64Kx4	11.95	9.95	8.95
16Kx4	9.95	6.45	5.95
128Kx8		60.00	50.00

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512K $98.00 1MB $148.00 2MB $284.00

Laser Printer Memory

MODULE	1MEG	2MEG	3MEG	4MEG	5MEG	8MEG
Apple Laserwriter	CALL					
Brother HL-10V/DV		$165		$264		
Canon LBP4, 4 Lite & 4+	$118	$184				
Compaq Pagemark 15 & 20				$289		$420
Epson Action Laser II, 8000	$95		$163		$229	
Epson + 6000 and many more		$98		$168		
Epson Action Laser 1000 & 1500		$138		$276		$399
Fujitsu 7100 & 7200	$199	$279				
HP Deskjet 500, 500C and 550C		$59 (256K)				
HP2, 2D,		$89		$159		
3, 3D, 3P, 2P, 2P+		$123		$169		
HP Laser Jet 4, 1115i, XL300, 1200C		$218				$448
IBM Laser 4019, 4019E (3.5MB)		$139		$198		
IBM Laser 4029 ALL MODELS		$139		$198		
NEC 90, 290		$128				
NEC 95		$118				
OKI 400	$78	$98				
Packard Bell PB9500		$145		$208		
Panasonic 4410/4430		$149		$208		
Panasonic 4420/4450		$128		$208		
Panasonic 4450	$115					
Panasonic 4455		$129				
QMS 410	$119	$159		$249		
Star LS04	$129	$179		$269		
StarScript 4	$128	$178		$258		
Tosiba Page Laser 6		$99		$168		
TI XL/PS17/PS35	$48					

Major Laptop & Notebook Memory

MODEL	MEMORY	PART#	PRICE
AT&T Safari	2MB	37650	$148
	4MB	37651	$298
Bondwell B-310	1MB	23050-09100	$128
Dec pc 320 Notebook	2MB Mod	FR-PCIM-BA	$149
	4MB Mod	FR-PCIM-BB	$298
	8MB Mod	FR-PCIM-BD	$498
Dell Laptop 212, 320N, 320N+	2MB Mod	310-3204	$129
Dell 325N, NC	2MB Mod	310-3210	$139
Dell NL20 & NL25	2MB Mod	310-3213	$148
Epson NB-3 Notebook	4MB	A808511	$238
Epson NB SL/	2MB Mod	A808771	$138
EPSON 25C Notebook	4MB Mod	A808781	$228
Everex Tempo LX, LX20	2MB	00160	$98
Everex Carrier	2MB	00263 00	$98
Grid 1500	4MB	52587	$238
Grid 1450SX	2MB	6200203	$148
Goldstar GS520, 386SX16	1MB	N/A	$98
	4MB	N/A	$298
NCR 3120 Notebook	4MB Mod	3120-K104	$299
NCR 3170 Notebook	4MB Mod	3123 K104	$399
Packard Bell, Magnavox, Mitsubo	1MB	N/A	$88
	4MB	N/A	$248
Panasonic CF170/270/370	1MB	CF-BA165	$64
Samsung Notemaster 386S	2MB	SNM002	$195
	4MB	SNM004	$395
Sanyo 17NB, 18NB & ZEOS	2MB	MBC-NBMEM2	$98
Sharp 6220	1MB	CE-621B	$98
Sharp 6640	2MB	N/A	$178
Sharp 4700MZ-200	1MB	CE-471	$198
Sharp 8501 Colorstar	2MB	N/A	$398
TI Travelmate 2000	1MB	2568034-0011	$108
TI Travelmate 3000SX, WINSX	2MB	2566996-0001	$118
TI Travelmate 4000, WINDX/25 SX/16, SX25, DX2/40	4MB	2581265 001	$298
DX2/50	16MB	**AVAILABLE**	$1995

AST Memory

MODEL#	MEMORY	PART#	PRICE
PREMMIA	4MB	501159-001	$247
	8MB	501159-002	$478
MANHATTAN SMP	16MB	501143-001	$968
BRAVO 3/25S	2MB	500710-004	$126
	8MB	500824-002	$468
ADVANTAGE 386SX/20,25, PRO SX/25 BRAVO 3/33S	2MB	500962-001	$135
	8MB	500962-002	$434
ADVANTAGE PRO 486DX/33,SX/25, BRAVO LC 4/25S, 33, 33S, 50D, 4/66D	2MB	500987-001	$108
	4MB	500987-002	$238
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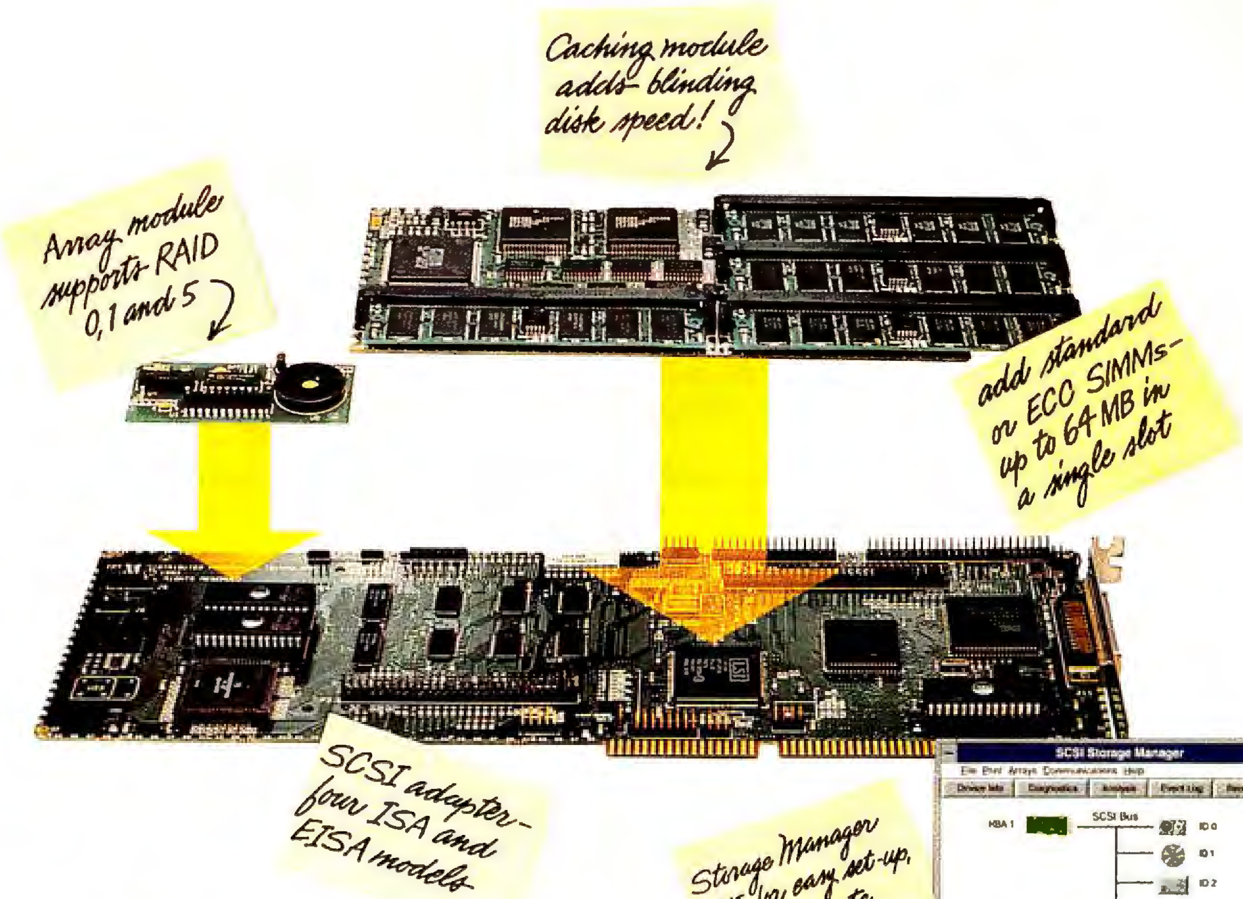

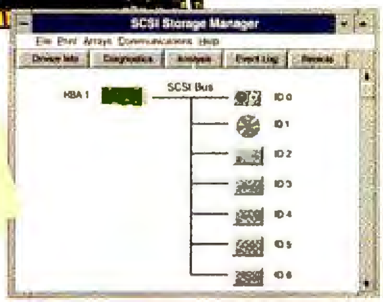

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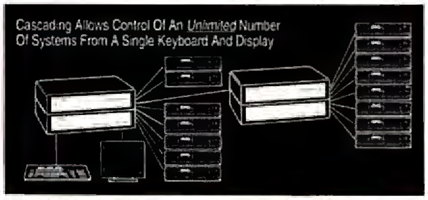

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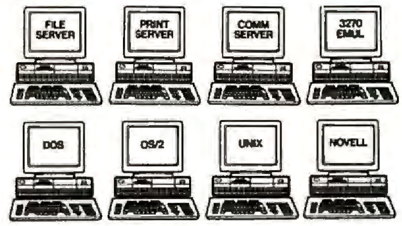

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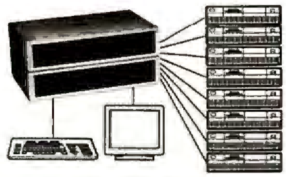

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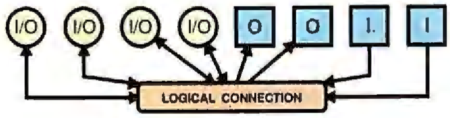

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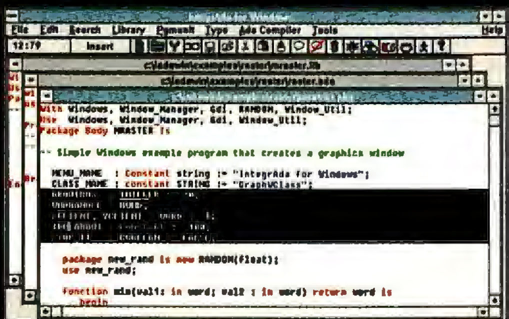

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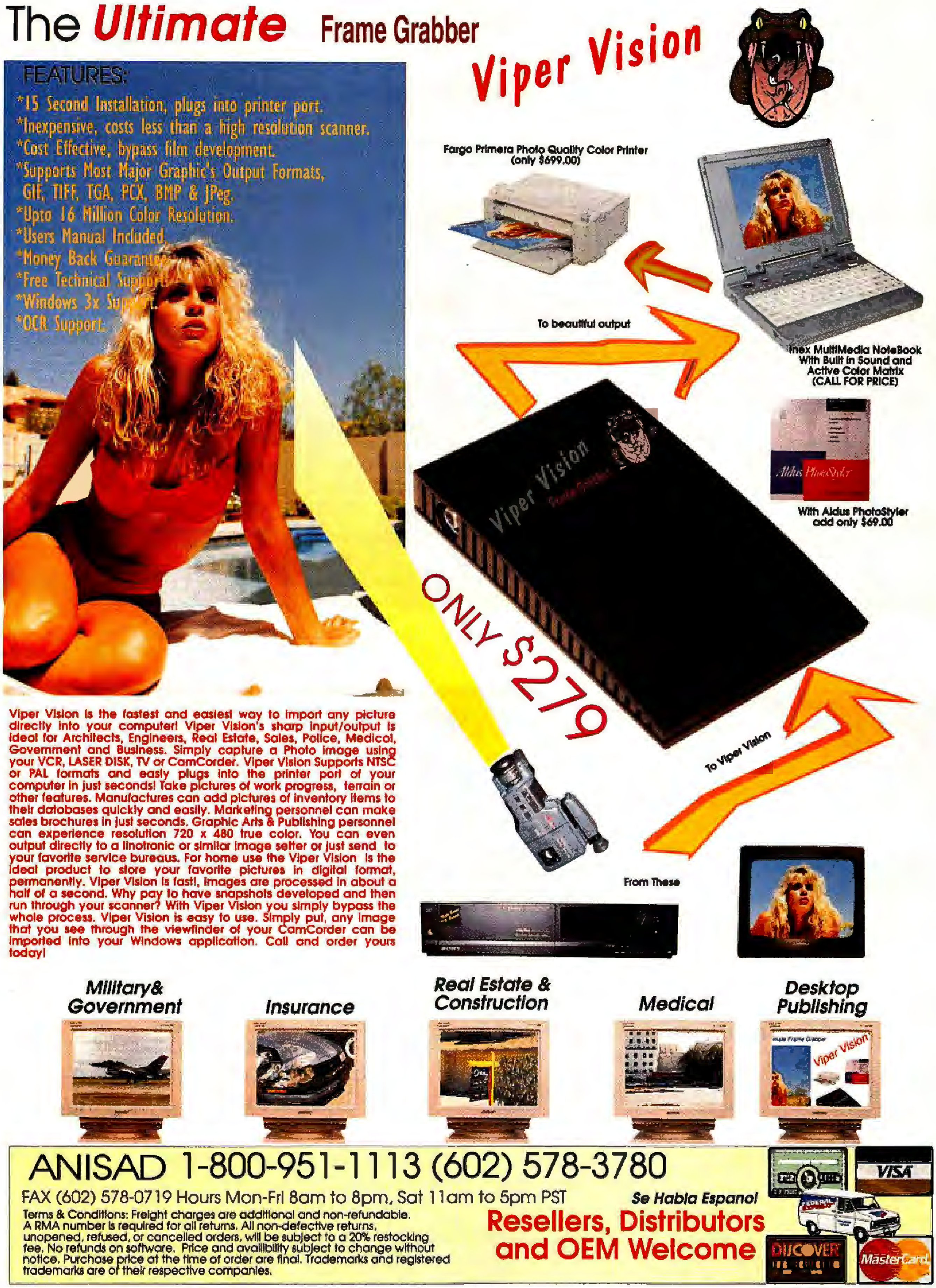

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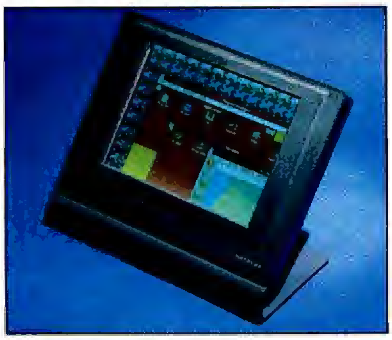

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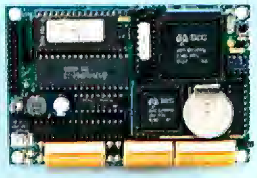

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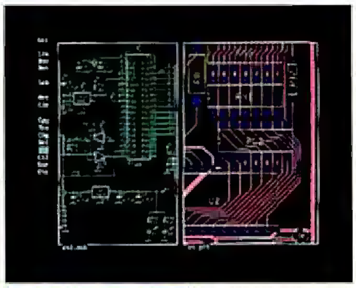

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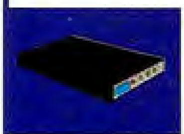
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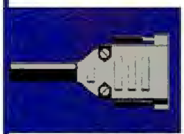
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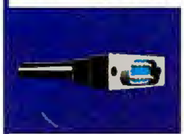
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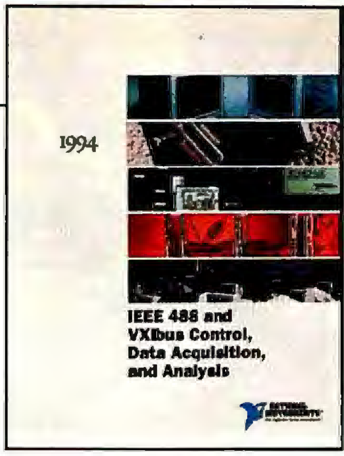

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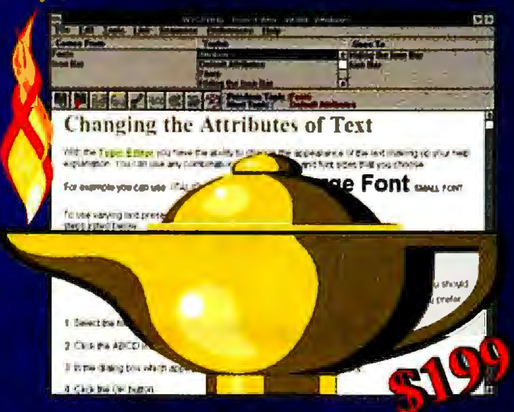

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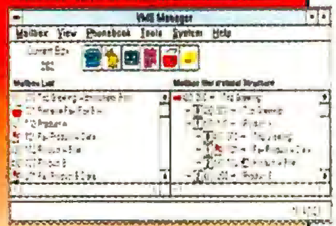

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 Edward R. Swart

"How Are You at Interfacing?"

You may like it or not, but computers are changing the English language

JOHN HARQUAIL / BLACK STAR © 1993

One of the reasons English has become the international language of science is because of its willingness to incorporate new words. There are over 500,000 words in the *Oxford English Dictionary*, and if we add all the current technical and scientific terms together with place, personal, and family names, this escalates to over 1,000,000 words.

Of course, English is a natural language, as opposed to programming languages like FORTRAN, C, Ada, and BASIC. Not everyone wants to learn how to program in a computer language. Much effort has been expended on attempting to provide natural-language interfaces for database packages and other applications software. The advent of better voice-recognition technology will no doubt accelerate this trend. But long before complete computer fluency in natural languages appears, a more subtle and profound change occurring in the English language itself may erase the boundary between natural and computer languages.

The interaction between English and computers is a two-way street. Although some grammarians undoubtedly abhor the use of the word *interface* as a verb, nowadays it's quite common to hear that people who don't get on well with each other don't interface as they should. Words that have languished because of neglect sometimes return with renewed vigor, and people talk of "the default option" in contexts that have nothing to do with computers. Phrases concocted by computer buffs have come to serve a generally useful purpose.

Even a language like French, which resists the incorporation of English words and phrases, speaks of *les applications batch* and *le semiconductor*. The extent of the interaction between English and the world of computers can be gauged to some degree by the *Oxford Dictionary of New Words*. It contains detailed explanations of some 200 scientific and technical terms that have entered the popular vocabulary over the last decade, the vast majority from the world of computers.

The purpose of computer languages is to facilitate human/computer communication, and those who have taken the trouble to learn how to program can think algorithmically. It is tempting to imagine that this is the only way to communicate with computers. However, in the face of fuzzy logic and neural networks, the hard programming of traditional procedural languages is giving way to a softer programming style in which computers can cope with words like *tall*, *heavy*, *old*, and *hot*—which have no specific numbers associated with them.

Such changes will bring about dramatically new modes of communication with computers and cannot help but narrow the gap between English and computer languages. In the end, if English becomes even more of an international language, computers may contribute largely to this achievement.

In its written form, English is an alphabetic language. But many dead languages (e.g., ancient Egyptian) used pictographs or hieroglyphs in their written versions. Even today, languages like Chinese and Japanese are wholly or partly ideographic. Computer-screen icons thus have a long lineage, and it will be fascinating to see to what extent they creep into English by virtue of their extensive use in windowing systems.

When multibyte Unicode, which embraces the alphabets, syllabism, and ideographs of all the world's languages, replaces the existing ASCII code, we may well find a wider range of individuals using a much more extensive set of letters and other symbols. It will be interesting to see if English starts to make more liberal use of characters lying outside its 26-letter alphabet.

The most efficient method of transmitting information is via the spoken word, and the most efficient and useful method of receiving information is via the written word. In the future, perhaps we will speak our messages into the computer, and they will reach recipients in written form complete with a smile and other symbols to indicate emphasis and emotion.

English is changing as I write this article—and more rapidly than it has ever changed before. In the end, the distinction between natural languages and computer languages will fade away, and it will become impossible to draw a line that demarcates one from the other. ■

Edward R. Swart led the team that developed the CoSy electronic-conferencing system on which BIX is based. He is a faculty member in the computing and information science department at the University of Guelph and is acting dean of the College of Physical and Engineering Science. He can be reached on BIX as "tswart" or on the Internet at tswart@snowhite.cis.uoguelph.ca.

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