JUNE 1991

AT LONG LAST: MACINTOSH SYSTEM 7.0 Page 42

BYTE

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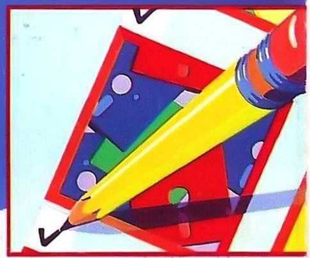

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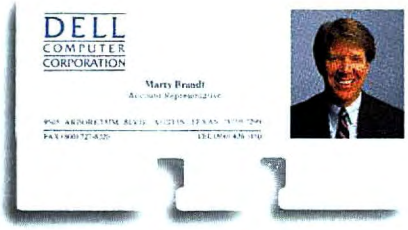

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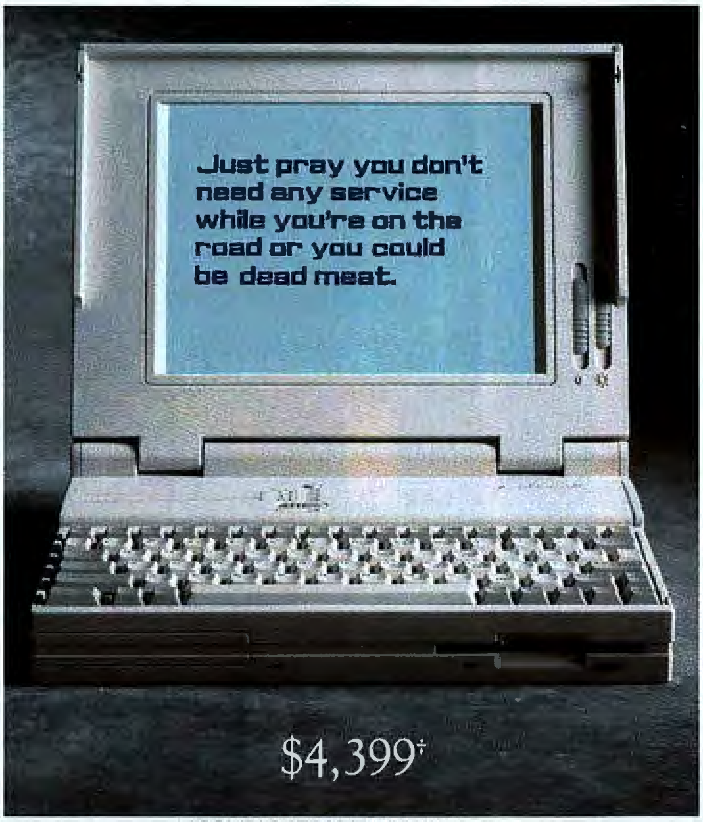

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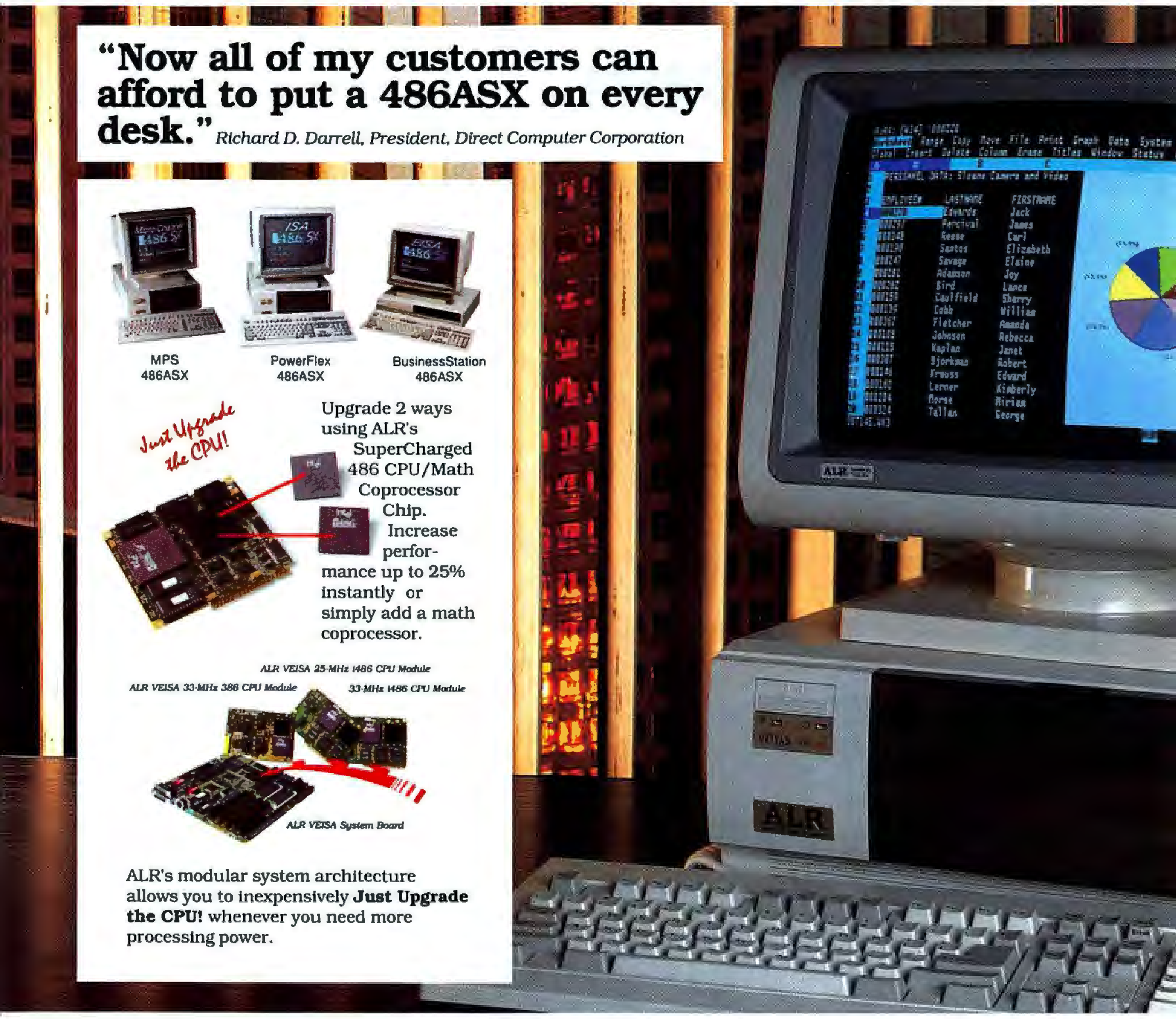

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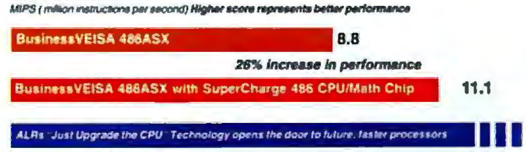

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Circle 15 on Inquiry Card (RESELLERS: 16).

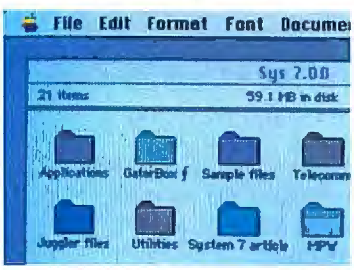
June 1991 Volume 16, Number 6

COVER STORY

FIRST IMPRESSIONS

The 486SX Falls Short

NEWS



FEATURES

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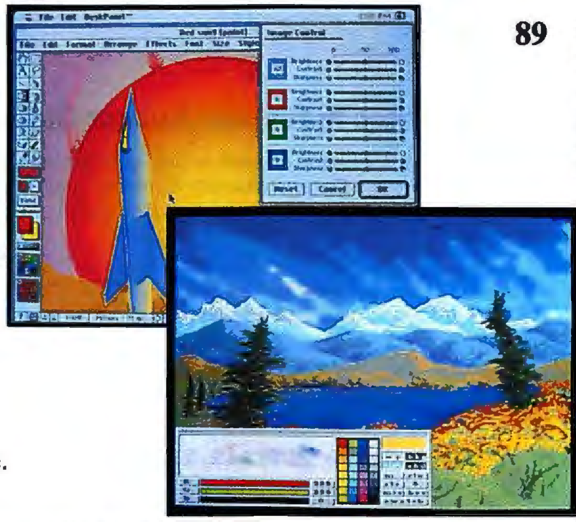
STATE OF THE ART

REVIEWS



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BYTE Topic Index and Author Guide

This index helps you find articles that contain information on each of the listed topics. (The topic list changes each month.) Combined with the table of contents (page 4) and the Editorial Index by Company (page 402), you can identify articles by type, subject, title, author, or product discussed.


THE RIGHT DECISION
FEBRUARY 18, 1991
PC WEEK \ REVIEWS
PAGE 92
PC WEEK LABS
PRODUCT REVIEW
Tri-Star Leads 33MHz 486 PC Pack
Eight Low-Cost Systems Perform Well; Video and Hard-Disk Components Va
By David Claiborne
"Tri-Star is king of the 33MHz 486 Mountain."
PC WEEK
Analyst's Choice, February 18,1991
Tri-Star Computer continues to outdistance the pack as America's prefered supplier of high-end 486 Workstations. Read the reviews and you will understand why Tri-Star is the undisputed 486 champ.
"Tri-Star's 486/25 rates honorable mention for its thoughtful design touches, two year warranty and excellent service program."
PC Magazine
Editor's Choice Honorable Mention, September 11, 1990
"Tri-Star's edge is its good documentation and excellent service policy."
PC Sources
486/33 Lead Review, February 1991
FLASH CACHE 486 COMPUTERS
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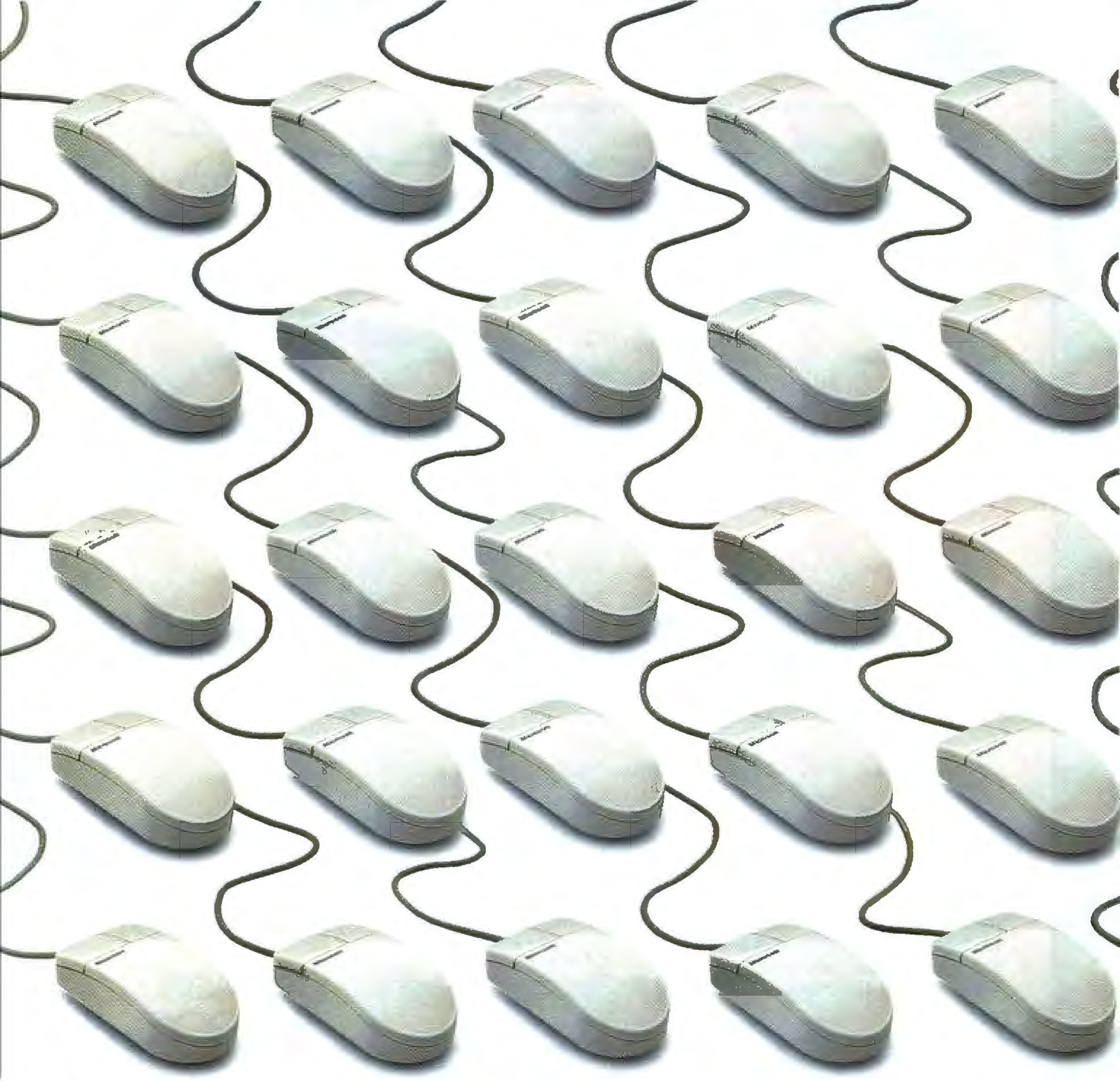

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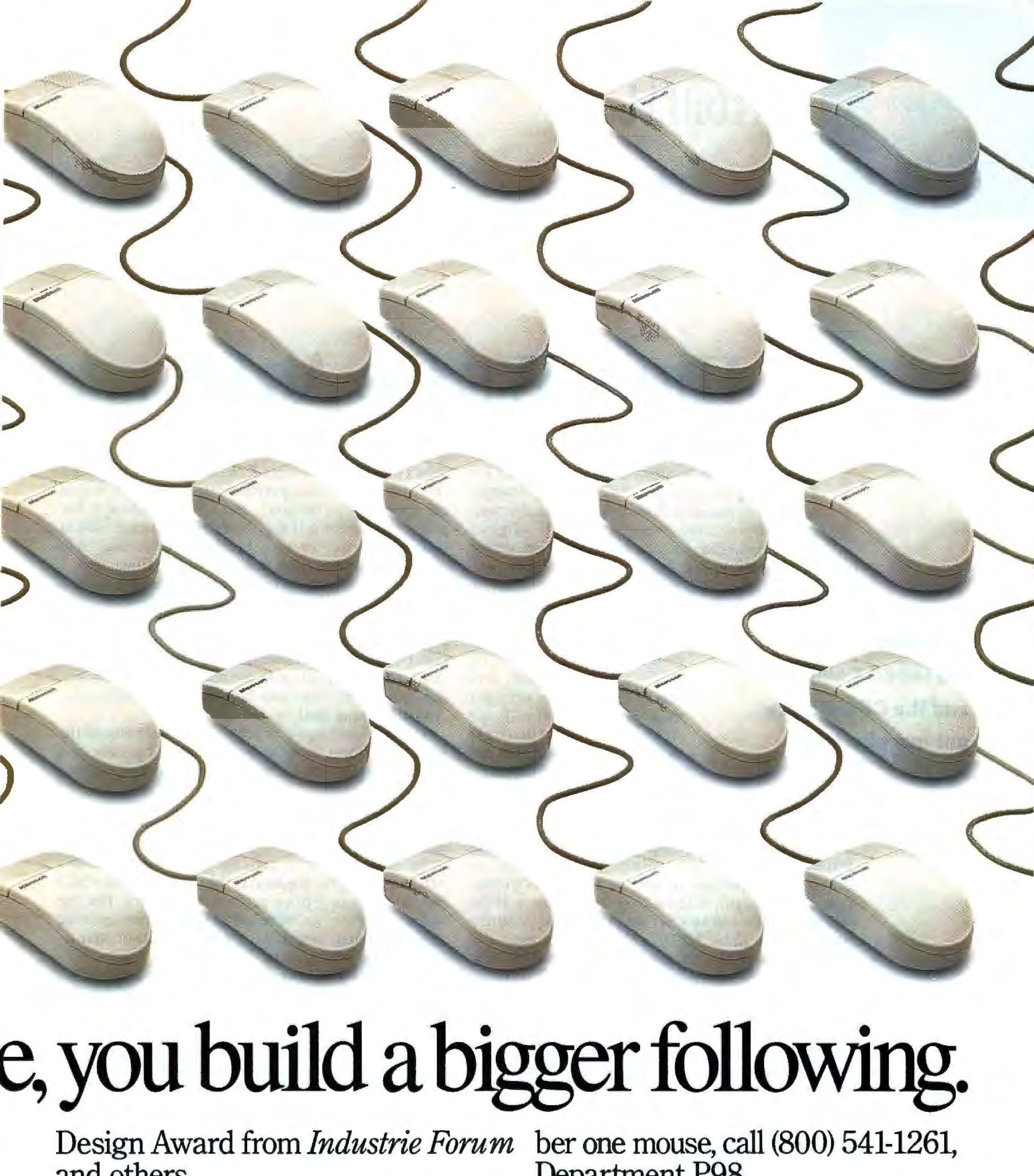

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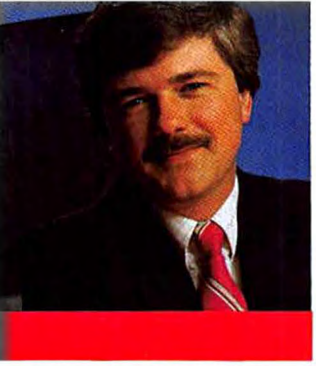

EDITORIAL

FRED LANGA

HERE WE GO AGAIN...

Intel delivers the i486SX chip, and the CPU waters get murkier still

I admire Intel. The company does a spectacular job of advancing technologies and delivering successful products based on those technologies. No matter where you stand in any of the CPU religious wars—segmented versus flat, big-endian versus little-endian—one undeniable fact remains: More people use Intel-based PCs than any other type. There's not even a close second. Time after time, Intel has set the de facto standard for what is acceptable on the desktop.

When Intel competes on technological grounds, I'm one of the company's biggest fans. Anytime Intel rolls out new computing technology, our options increase, we can do more with our computers, and the prices of older technologies go down. More computing horsepower gets into the hands of more people.

But sometimes, Intel competes by creating artificial distinctions among chips—distinctions not based on technological advances. In fact, the 386SX was technologically backward: a 32-bit chip stuffed into a 16-bit package. Intel could have served the low end by letting prices of true 32-bit 386DX chips fall, but instead it chose to prop up DX pricing and tried to kill off low-end competition from non-Intel 286 chips. When Intel ran ads that said "No 286," it really meant "No Advanced Micro Devices," and "No Fujitsu," and "No Harris." The ads also really meant "No competition."

Well, the competition struck back anyway, and AMD is now shipping a very nice, perfectly legal clone 386 chip. Other companies have clone 386 chips in the works, and Intel is feeling threatened.

Enter the i486SX. While the original i486 was a genuine technological advance, the i486SX is retro: a slowed-down i486 with its built-in FPU deliberately disabled. While the rest of the industry differentiates products through value added, Intel has chosen to differentiate this product through value subtracted. It's like an auto maker taking a perfectly good V-8 engine, disabling two cylinders, and selling it as a V-8SX.

So, like the 386SX before it, the i486SX is another chip with no technological reason for existence, but one that will have a huge market impact because of massive ad campaigns (watch for them soon) and knee-jerk responses from tub-thumping publications.

This kind of marketing game might be amusing if it didn't hit us in our wallets. Consider: If Intel can take a fully functional i486, perform extra work on it to turn off some of the functions, and sell it to you at a low price, Intel could sell you the fully functional i486 at that same price—or less, because the original chip doesn't require the extra step of disabling functions.

Once you get past the marketing games, what's left is the issue of price/performance. It's not a question of the i486SX being nonfunctional: Of course it works. Without the FPU and with a slower clock, what's left of the chip (which still does have the i486's improved instruction set and on-board cache memory) falls between garden-variety 386 chips and fully functional i486 chips. And that's what Intel wanted.

The first systems we've seen that are built around the i486SX perform about as you'd expect, but they cost much more than alternative systems that deliver equivalent performance.

This price/performance gap is much wider than I'd expected. I'd thought that—CPU pricing aside—the other parts for a 40-MHz 386 system would be substantially more expensive than the parts for a 20-MHz 486SX system. We'd gone into this 486SX versus AMD 386/40 expecting price/performance parity. But the system designers we've talked to said the parts-pricing differences aren't significant, and the fruits of their labors seem to bear this out.

In this month's cover story, you'll see how a Club American Technologies system built around AMD's new 40-MHz 386 clone chip easily matches and/or exceeds the CPU performance of i486SX-based systems from ALR and AST. But the Club system costs one-third to one-half less than the ALR and AST systems.

Other manufacturers have signed up for the AMD chip or for some of the other 386 clone chips that are in the works. Some of these will offer performance boosts and extra features that will leave the i486SX in the dust. The price/performance gap will widen.

The i486SX will have its day, and systems with good price/performance will emerge. But for now, if you feel yourself succumbing to 486SX fever, consider the alternatives before you reach for your wallet.

I'm waiting for Intel to return to technological leadership, with this summer's expected announcement of the 586 and higher-clock-speed i486 chips—*real* advances that are worth getting excited about.

—Fred Langa
Editor in Chief
(BIX name "flanga")

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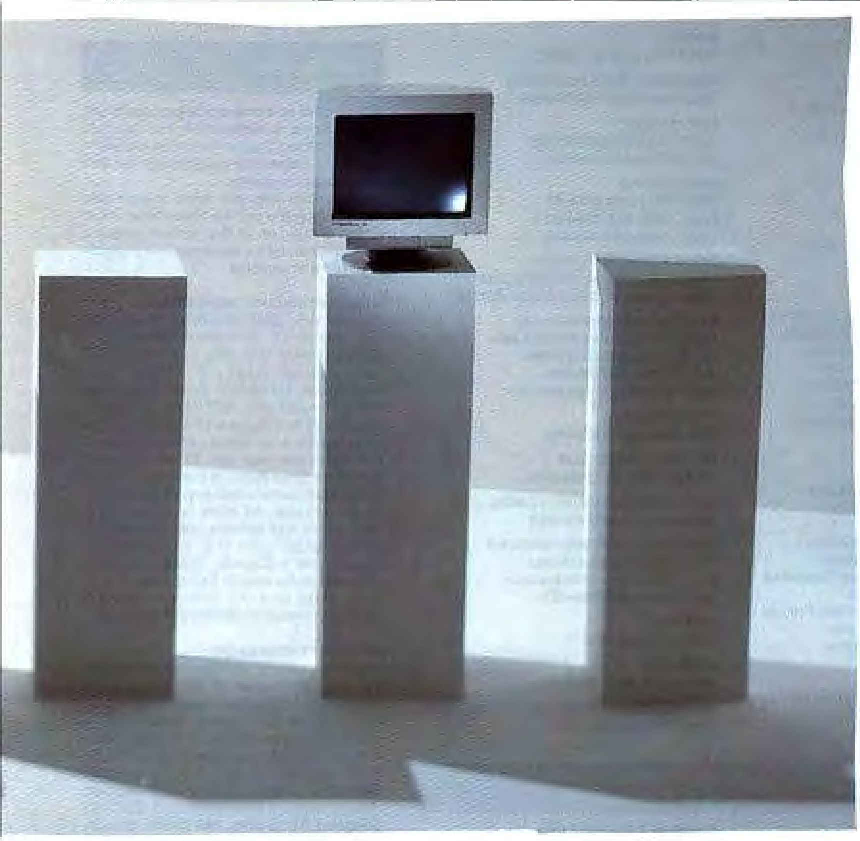

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See listing on page 405.

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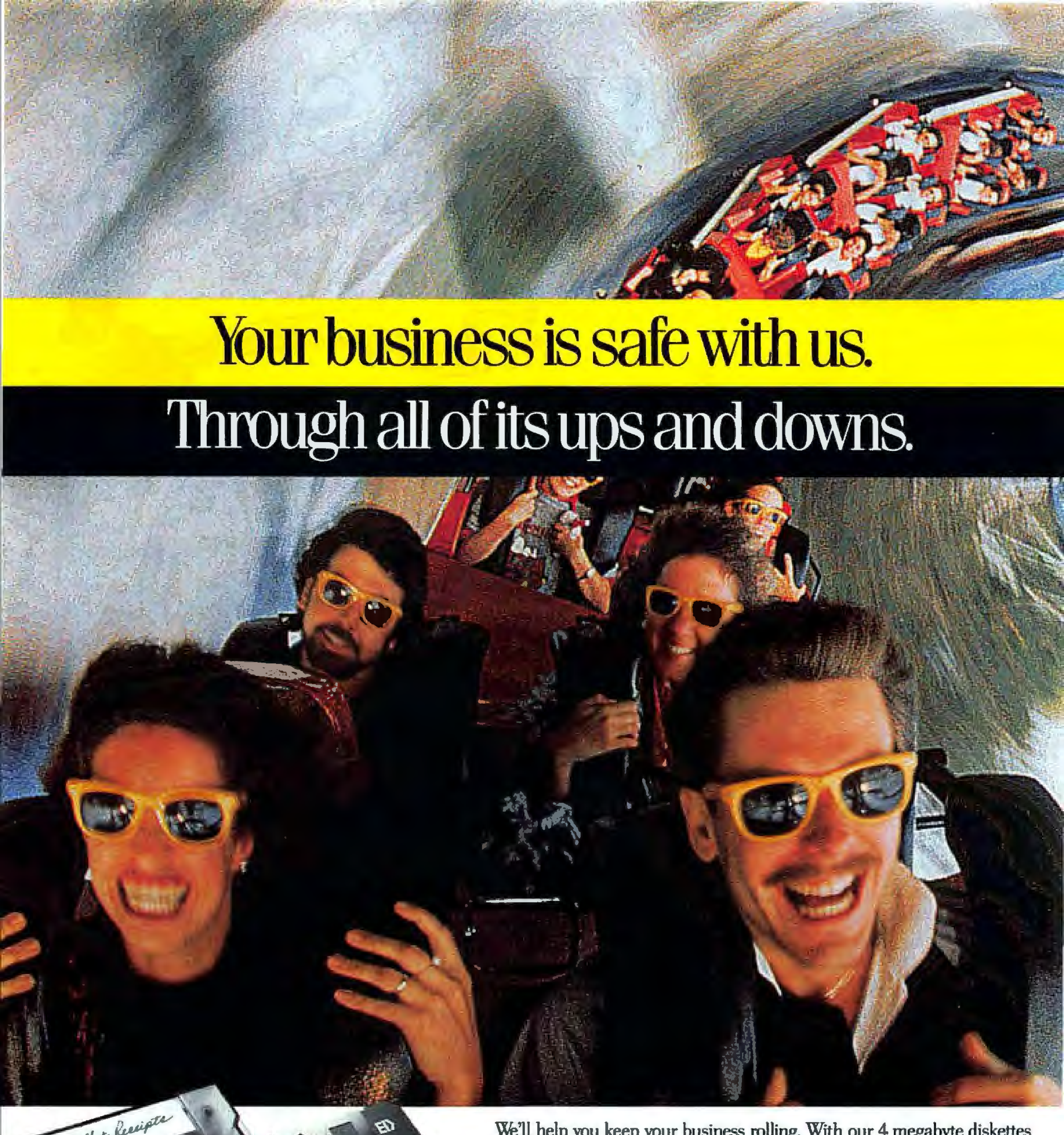

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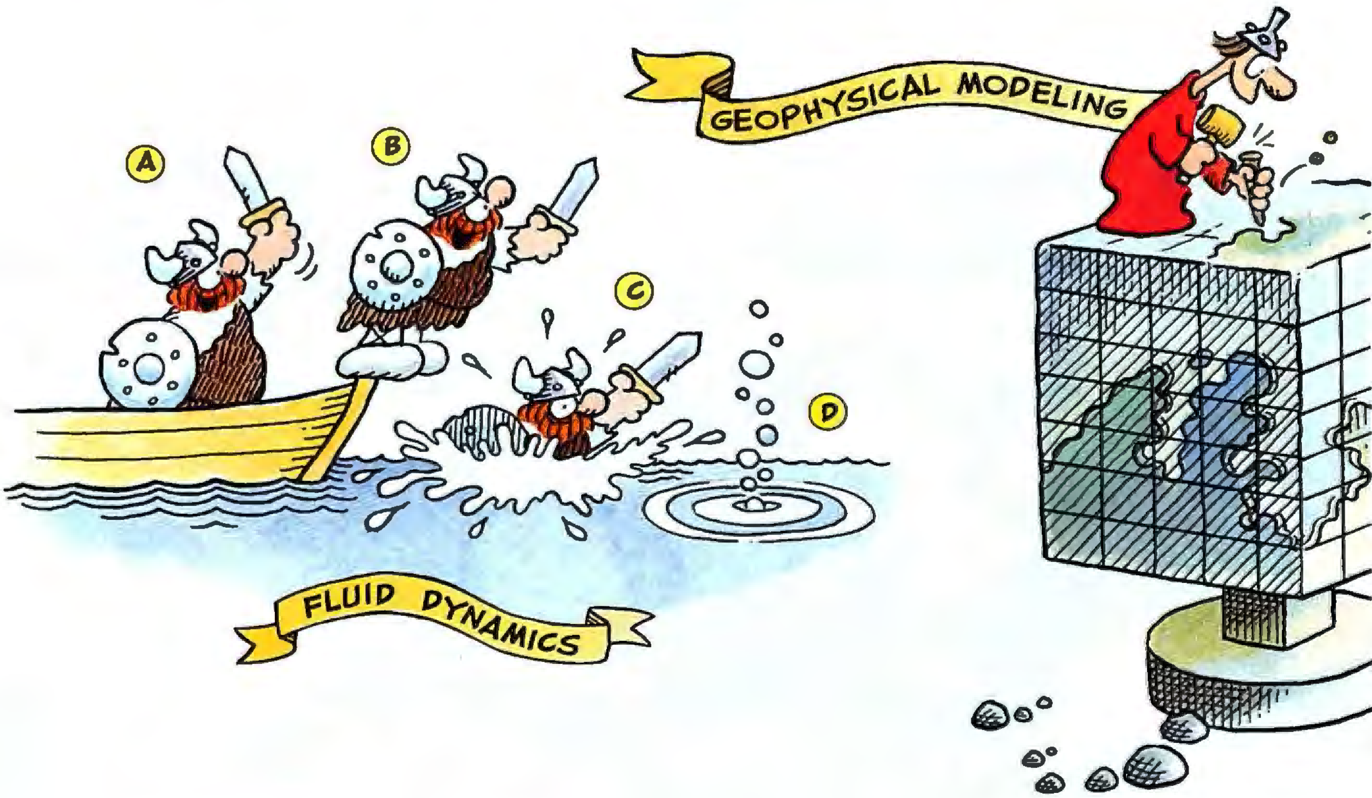

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DECstation 5000-200	3.7	24.2	18.5

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LETTERS

The Roundtable Continues

When I got my March issue, I turned straight to the new BYTE Roundtable discussion on why software doesn't work. A programmer by profession, I was very curious to read what you had to say on the subject.

Many in the forum completely missed the boat as to the real reason why software doesn't work these days. They pointed to tight schedules, poor testing, and a lack of user uproar over bugs. These factors are important, but the real problem is software maintenance. Software maintenance encompasses a lot, including bug fixes, user-requested enhancements, enhancements designed to keep current with the market, and the like.

The degree of maintainability of a software package has a direct bearing on how quickly, and how correctly, a package can be upgraded or debugged and brought to market. If poor programming practices are put in place when the package is first written or if poor maintenance practices are used, an upgrade is bound to have problems.

Here's an example: Almost every major textbook on software maintenance stipulates that the key is to write software in the highest-level language possible. What are most packages written in today? C. My experience with C is that debugging and validating chores are orders of magnitude greater than with such languages as Pascal or dBASE. This means that the chance a bug will slip through even rigorous testing is much higher. I believe this is why Windows 3.0 has so many problems even though it is called the most thoroughly tested piece of software to date.

In all fairness, the Roundtable participants' points are valid. However, because of its ripple effect on the next update of the product, maintenance cannot be overlooked. And I also believe that the world's fascination with C is a step in the wrong direction toward solving the software crisis.

Bill Jurasz Jr.
Applications Engineer
Texas Instruments
Dallas, TX

As the owner of two AST Premium 386SX/16 boxes, one fitted with a Conner 40-megabyte CP344 drive and the other with a Conner 10-MB CP3104 drive, I've been trying to figure out for over a year how to tell in advance whether software I need has any chance of surviving in this temperamental environment. My shelves are littered with highly rated software products that weren't worth the trouble created by system compatibility quirks.

Perhaps the problem is lack of testing and quality controls in the software, as was suggested in your March Roundtable. I suspect, however, that it's not that simple. In my case, the problems stem in substantial part from the way the Intelligent Drive Electronics (IDE) drives work and the drive vendor's failure to provide software purveyors with information about quirks that the software must accommodate.

Every time I have experienced a problem—and I have had a lot of them—it ends up being traced either to the IDE hard disk drive or to incompatibilities with the memory manager I am using (currently, Desqview 386 with QEMM). At this point, I must confess that, having been burned so many times by so-called state-of-the-art software and hardware, I am very reluctant to purchase anything that hasn't been out on the market for at least two years.

Susan A. Henderson
Chicago, IL

Two Views of DR DOS

Your review of DR DOS 5.0 by Lamont Wood ("DR DOS Offers Hope for the RAM-Crammed," December 1990) was at the very least enthusiastic—so much so that I ran right out and bought the product. I felt fairly safe because the article implied that this was a very DOS-compatible product with some nice enhancements.

DR DOS 5.0 has major compatibility problems. I am writing to you because I think you must be more careful with these product reviews. I trusted the information I read in your magazine. For the time being, at least, it's 200 bucks down the drain. No major deficit here; however, the money could have been spent on a product that works.

I hope that your reviews will be more thorough and more accurate in the future. They are a big responsibility.

J. Morton Stong
Potrero, CA

Problems are looked for and reported in reviews. On my system I encountered a problem only with the DR DOS COPY command, as I mentioned in the review. Further use (up to and including the writing of this letter) has revealed no other bugs.

In other correspondence, Mr. Stong has complained of Xerox Ventura Publisher (among other packages) crashing on him. I have used both the GEM and Windows versions of Ventura Publisher under DR DOS for some time now with no hint of difficulty.

Our different experiences just serve to underscore the fact that the PC world is a wilderness of partially compatible hardware and software where tiny things like the setting of an interrupt jumper on an add-in board can play havoc.

What's remarkable is that horror tales like Mr. Stong's are not (as far as I can tell) the norm. But, alas, they certainly happen.—Lamont Wood

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Your letter will be read, but because of the large volume of mail we receive, we cannot guarantee publication. We also reserve the right to edit letters. It takes about four months from the time we receive a letter until we publish it.

Compression Compatibility

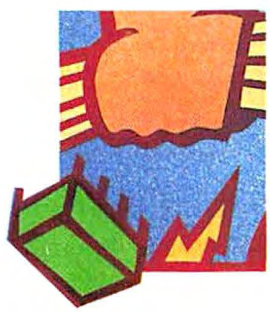
In "Getting Your Byte's Worth" (November 1990), Steven J. Vaughan-Nichols attempted to cover the important topic of hardware-based data-compression solutions. The article began nicely and was proceeding without flaw, when lo and behold, Vaughan-Nichols penned a whopper. "Advanced Hardware Architectures, InfoChip Systems, and Hewlett-Packard have also thrown their hats into the ring. Unfortunately, their chips are completely incompatible with each other."

I have difficulty believing this statement because AHA's and HP's data-compression chip technologies were jointly developed and, in fact, are exactly the same chip. If only the rest of the industry could tout such compatibility. The specially designed chip was based on the "lossless" Data Compression Lempel-Ziv adaptive algorithm, which was pioneered by HP. AHA and HP then customized a version of the DCLZ algorithm, which now offers a better than 2-to-1 average compression ratio and an average compression rate of 2.5 megabytes per second. That makes it the fastest data-compression product on the market today.

John C. Overby
President and CEO
Advanced Hardware Architectures
Moscow, ID

My face is red. My information, gathered in August 1990, was clearly incorrect. My notes indicate that I was told by HP engineers that their chips were purely HP creations. Clearly, I should have checked further. My apologies.—Steven J. Vaughan-Nichols

IDE Reliability



Roger C. Alford's article on Intelligent Drive Electronics disk drives (Under the Hood, "The IDE Hard Disk Drive Interface," March) was very informative but left one key issue unresolved. He states, "IDE drives are low-level-formatted at the factory, and you cannot employ any low-level-format utility to reformat the drive." This apparent fact has caused me to avoid IDE disk drives and recommend against using them.

Alford describes logic internal to the IDE disk drive that should improve reliability. Are there field surveys that can be used to compare the actual rate of replacement of the IDE relative to other types of disk drives? It simply does not make sense to buy a drive when you think there's a fifty-fifty chance of having to replace it within two years.

A final question: Table 3 shows Format Track as an IDE command and says it is not optional. Does this mean that there really are low-level-format capabilities in IDE drives? Are there utilities available for performing a low-level format on IDE drives? If so, it would make a big difference in my attitude toward these drives.

David Dunthorn
Oak Ridge, TN

A number of readers have expressed concern over the inability to perform low-level formats on IDE drives. Many users have encountered the infamous Sector Not Found error message and have taken the reformatting approach to solving the problem. Several available hard disk utilities also encourage periodic low-level formatting to "refresh" the magnetic sector ID information on the drive platters to avoid such errors.

Contrary to common belief, the primary cause of unreliable sector reads (often manifested through the Sector Not Found error message) is not the weakening of the magnetic sector ID information, but rather the misalignment of the drive read/write heads to the sector data. That is, the heads move slightly off the dead center of the track. This can happen because of thermal expansion or contraction of the drive platters or from mechanical changes that may occur as a drive ages.

Since the only functional purpose for a low-level format is to establish the sector interleave (which is always 1-to-1 for IDE drives) and to map out bad sectors, vendors perform this operation at the factory, and it should never need to be done again. As I mentioned in the article, most IDE drives include bad-sector remapping, so that if additional sectors are determined to be defective during the life of the drive, the sector data is recovered using the drive's error-correction algorithm, and the sector is logically remapped to another spare sector on the drive, disabling the defective sector.

IDE drives use the latest technology to achieve the greatest possible reliability. They have been around long enough that a substantial amount of reliability data is now available, and many drive manufacturers will provide reliability summaries of their products on request. The IDE manufacturers insist that the reliability of their drives is now proven and that low-level formatting of the drives by the customer is no longer necessary; no degradation in the long-term reliability will result from the inability to perform a low-level format.

One of the mandatory IDE commands I listed in the article is the Format Track command. This command is mandatory because it is used by standard ST506 drive subsystems, so the IDE drive must implement the command. Essentially, this means the drive must respond to the command to indicate when the command operation is complete. Originally, most IDE drives simply ignored the Format Track command and responded immediately with a command-complete indication. Some drives, such as those from Quantum, now zero out the data fields of the affected sectors (the sectors on the logical track being formatted), since some systems use the low-level format operation to remove drive partitioning information. The sector ID fields, however, are not touched when the sectors are zeroed.—Roger C. Alford

A Matter of Inches

My company manufactures geographic and geodetic products, including some software. Our work makes it necessary to calculate the lengths of various arcs of the earth's surface.

In "More Mathematical People" (March), Hugh Kenner made the statement, "If we're calculating the circumference of the earth, the difference between a 5-place pi and a 6-place is about half an inch."

continued

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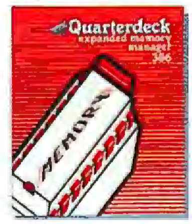

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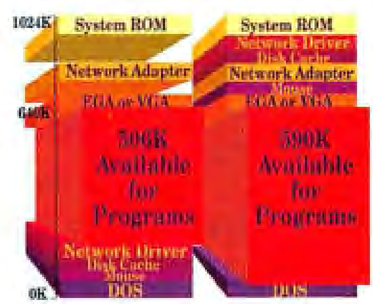

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This appeared suspect to me, as our calculations for arc lengths, using Taylor-series approximations of elliptic integrals, require at least 10 significant digits to achieve National Geodetic Survey standards of accuracy of 1 millimeter. I typically program using the IEEE 80-bit floating-point format of Turbo Pascal (19 significant digits).

When I calculate pi to 5 decimal places, the circumference is 1,577,755,230 inches; calculated to 6 decimal places, the circumference is 1,577,756,736 inches. The difference is 1506 inches, or about 125 feet. While in relative terms this is a small error (about 1 second of longitude), in our field it would be disastrously large.

I enjoyed Kenner's article nonetheless. Doubtless he could find numerous deficiencies in the sentence structure of this letter! I just could not resist pointing out his mistake, remembering all the *C*s I received in English.

Brad Neff, President
Neff Scientific
Lebanon, TN

You are quite right. So was my calculation. Two days later, though, I somehow misread my notes.
—Hugh Kenner

LANtastic Tale

Jerry Pournelle likes LANtastic, and so do I. We use the network mainly for printer sharing and file transfer, and it had not given us any trouble in the two years it's been running, until last week. We installed a Tecmar QT60e tape streamer for backup. With a QMS JetScript driver using Interrupt Request 7 addressed as LPT2, printers on LPT1 and LPT3, LANtastic using IRQ5, and DOS-reserved interrupts, I expected problems using the Tecmar default interrupt IRQ3. But everything worked fine.

Trouble came later that day. I had to install the LANtastic server on the local machines so the Tecmar station could see their hard disk drives. Suddenly, my local machine could log onto the server and read the server's hard disks but couldn't find any of the attached printers. Other local machines were OK. I didn't solve the problem that night, and when I came in the next morning, nothing was wrong. Temporary amnesia, silicon variety.

Then a day or so later someone else reported problems. He could log onto the server, write to the server's disks, and print on the shared printers, but not read from the server's hard disk. I removed the Tecmar card from the server, but the problem didn't go away. I moved the local machine physically, and the problem moved with it—the cabling wasn't at fault. I tried setting up another machine as server and logging onto that—exactly the same problem. I switched LANtastic cards, and the problem didn't move with the card.

Finally, I noticed by chance that the problem machine was running an earlier version (1.91) of LANbios than another machine known to work (1.95). I installed a homogeneous LANbios version throughout the network, and the problem hasn't been seen since. The Tecmar station still works perfectly, too.

I phoned the Swedish LANtastic supplier, who hadn't heard that problem variant before but warned me that there are at least two LANbios versions available later than 1.95 which are not compatible either with earlier versions or with each other. In all your justified praise of an excellent LAN, you might find room to warn those who expand their LANtastic network and find themselves with a mixed bag of LANbios versions.

Francis Markey
Uppsala, Sweden

Thank you for the story. As I've noted before, LANtastic does have problems dealing with some devices, including my WORM drive. I have never had real *problems with it. Artisoft recently got a lot of new capital and is putting new people on the job, and I suspect you'll soon see some big improvements in what has always been a very good product.*—Jerry Pournelle

Stimulating C

For years, I've liked Jerry Pournelle's columns in BYTE because of their lively, thought-stimulating style. But I disagree with some of his remarks about C.

In "The BYTE Summit" (September 1990) he says that C is one of the biggest obstacles to the future of programming as it is "the last attempt of the high priesthood to control the computing business." I know many people who after years of using other languages have started programming in C, while I have not yet met a single person who was a good C programmer and then stopped using it. What sinister plot in a free society could possibly brainwash so many intelligent people into switching to a new programming language devoid of any redeeming features?

C is not a perfect language, and maybe much better ones will be coming. But I believe that one of the biggest obstacles to the future of programming could be a frame of mind that looks at the language instead of the ideas expressed in it, and a priori considers as unreadable any listing printed in an unfamiliar language, instead of feeling the desire to learn enough to understand it.

Dr. Gerd Blaesser
Ispra (Varese), Italy

You may be right, of course. Once again I can only go by experience. At the annual Hackers conference, I can get a good fight going by discussing C, which is interesting given that I get about as much support as opposition, and this among some of the best programmers in the world.
—Jerry Pournelle

FIX

In the article "Oberon" (March), the word *CASE* was inadvertently expanded to the acronym "computer-aided software engineering" on page 138. The correct sentence should read "a failing guard is fatal, like an array-bound violation or a failing CASE selector." ■

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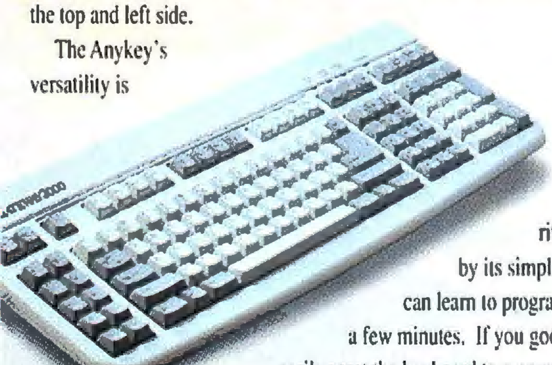

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- 16-Bit VGA with 1 MB
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- 1.2 MB 5.25" Drive
- 1.44 MB 3.5" Drive
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- 16-Bit VGA with 1 MB
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NEWS

MICROBYTES

Will ACE Become King of the Workstations?

A group of 21 major computer and software companies—led by Compaq, Microsoft, Mips Computer Systems, DEC, and The Santa Cruz Operation—has publicly revealed its intention to develop a set of specifications meant to define an "advanced computing environment" for the 1990s and beyond. Despite the big names, it's too early to determine what ACE will really mean to computer users and buyers. The group is still working on its technical specifications, and resultant products are 12 to 18 months away. Besides the headlining quintet, the other ACE members are Acer, Control Data, Kobuta, NEC, NKK, Olivetti, Prime, Pyramid, Siemens Nixdorf Informationssystemes, Silicon Graphics, Sony, Sumitomo, Tandem, Wang, and Zenith Data Systems.

The ACE group proposes that computer systems be based on the Intel 386/i486 architecture and the upcoming Mips R4000 64-bit RISC CPU. ACE machines will run either OS/2 3.0 (the "New Technology" version being developed by Microsoft) or SCO Unix (with the Open Desktop interface).

So far, the group has divulged only two relevant technical developments: a definition of a standard implementation for the Mips RISC CPU, which will be used by Compaq and others in new uniprocessing and multiprocessing systems (no sooner than 1992), and the first announced port of OS/2 to a non-Intel platform.

The ACE group has released few details about its Advanced RISC Computing specification, the part of ACE that defines binary compatibility for Mips machines. And none of the companies has said what kinds of capabilities or features might be typical of ACE machines—not even what size and shape they might take; nor have they ventured even approximate pricing.

The only major detail revealed was, however, of huge importance, especially in political terms: ACE will specify that compliant systems use a "little-endian" byte order, which is the one Intel chips use. Microsoft chairman Bill Gates said that adhering to the same byte order would simplify the interchange of data between Intel- and Mips-based machines and would make it easier to port applications from one machine to another.

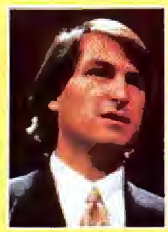
Only DEC currently uses Mips chips in their little-endian mode; all the other Mips users use big-endian byte ordering, which means that their systems will not comply with ACE. This, plus some Mips customers' desire to support Unix System V release 4 rather than SCO Unix, has already resulted in the emergence of a dissenting faction within ACE. This "Apache Group," which includes seven ACE members, has something going for it: On the same day as the ACE announcement, Unix Systems Laboratory (USL) revealed its effort to standardize Mips-based systems operating under SVR4.

Systems companies, including DEC, Silicon Graphics, NEC, Prime, and Tandem, have used Mips processors (R2000 and R3000) in incompatible designs. The different Mips-based systems lack a standard-applications binary interface, which would let software run unmodified across them. ACE and USL (like 88open and SPARC International) are both now proposing to supply the means by bringing "shrink-wrapped" compatibility to RISC workstations. The ACE environment would do that job for Mips chips.

Here's one angle of the ACE plan that holds the greatest promise for users and developers alike. Since OS/2 3.0 and SCO Unix will run on both the Intel and Mips chips, the ACE group says that it will be easier to construct mixed networks of DOS, Windows, OS/2, and Unix machines than by using competing choices. Software developers (and end users) will gain the benefits of binary compatibility across multiple implementations of the Mips processor within a

NANOBYTES

Releasing sales figures for the first time, **Steve Jobs** gave an upbeat appraisal of **Next**'s first quarter of 1991 and forecast a fabulous year. Next shipped 8000 units for the period ending March 31, Jobs told reporters recently; according to Next estimates, that's the same number DEC shipped



in the fourth quarter of 1990. Jobs predicted Next will sell **40,000 systems this year**. Next now concedes the scientific and engineering workstation market to Sun, Hewlett-Packard, IBM, and DEC. Instead, Next is targeting the professional workstation market, made up of publishing, database, legal, and financial applications. "I think that Next's estimate of 40,000 units is realistic, and perhaps somewhat conservative," said Bruce Webster, author of *The Next Book*. "My personal guess is that Next will ship at least 50,000 units this year." Nick Baran, editor of *Baran's Tech Letter*, a newsletter for Next users, said, "Those projections are definitely optimistic, but the Nextstation is better suited for the market than the original Cube." □

A veritable who's who of computing in Japan has joined a group that **IBM Japan** formed to promote IBM computing standards there. Members of the new **Personal Computer Open Architecture Developers Group** include the following: Toshiba, Hitachi, Fujitsu, Sony, Sanyo, Sharp, Canon, Ricoh, Matsushita, Mitsubishi, and Oki Electric. Observers say the objective is to form a united front against their common competitor, NEC, the IBM of Japan. □

given operating system.

ACE says that it will offer near-compatibility across different hardware platforms within a given operating system. This means that Windows and OS/2 applications will be able to run with a simple recompilation by the developer on either the Intel- or Mips-based systems, and the same will hold true for Unix applications on either hardware platform. Thus, the promise goes, customers may be able to buy a single box of shrink-wrapped software that contains two ready-to-go versions of the same application.

However, users and developers will still face incompatibilities between OS/2 and Unix, even on the same hardware. The ACE group did not announce any plans to release tools or libraries to facilitate porting applications between the two operating systems.

At this point, ACE is primarily a political action: the establishment of a new group of companies, many of them competitors, banding together to challenge the power of Sun Microsystems and, to a lesser degree, Intel, IBM, and Hewlett-Packard. For Compaq, it's also a business strategy for moving beyond commodity PCs into RISC workstations. The ultimate deciding factor in ACE's fortunes will be user acceptance and perception of the new systems, based on their price/performance, the features they include, and adherence to whatever standards are prevalent in 1992.

—Andy Reinhardt

Intel Cuts Cost, Capabilities of i486; Will Offer Companion Math Chip

After a year of rumor and speculation, not to mention the arrival of a real alternative to the profitable 386, Intel last month announced its cut-down version of the i486 processor. Like the 386SX, it is a less powerful version of its parent, but this time the drop in power comes from leaving off the math coprocessor rather than from reducing the bus width. (Despite the SX notation, the i486SX is a full 32-bit chip.)

Besides not having a math coprocessor, the i486SX differs from the i486 in one way: It's slower. The chip is available only at 20 MHz (the i486 comes in 20-, 25-, and 33-MHz speeds, with 50 MHz in the wings). Significantly, the i486SX retains the 8K-byte on-chip cache of the i486; as a result, it should offer respectable integer performance.

The i486SX retains other features of the i486, including the 32-bit burst-mode bus and the full 32-bit integer core. Intel claims that the new chip can achieve 16.5 MIPS, compared with 11.4 MIPS for the 386 at 33 MHz and 20 MIPS for the i486 at 25 MHz. The i486SX costs about the same as the chip it's most comparable to in real-life system performance: the 33-MHz 386. In 1000-unit quantities for OEMs, the i486SX costs $258, compared to $214 for the 33-MHz 386 (and $671 for the 25-MHz i486).

The i486SX will be available in much less expensive plastic quad flat-pack packaging (as is AMD's 386) rather than the more traditional ceramic pin-grid array, Intel says. This should result in an even lower cost once it is in full production. Like Intel's other chips, the i486SX is implemented in 1-micron CMOS, but faster versions could appear when Intel gets its 0.8-micron facility on-line.

For those users who want the floating-point functions, Intel has plans to offer a companion math coprocessor, the 487SX. Having a separate coprocessor would normally slow down operation, but Intel says that it gets around that because the 487SX is really a full-blown i486DX, with all processing capabilities built into one chip. The coprocessor will take over for the main processor, thereby avoiding the bottleneck of CPU talking to FPU.

Intel officials say they expect manufacturers to build two sockets onto their i486SX-based motherboards; one for the CPU and one for the FPU. The 487SX will not be offered to OEMs; it will be sold only to end users, who are expected to plug the chip into that second socket. They will have to really want those math capabilities, because the chip's suggested retail price is $799. As some observers point out, if you think you'll need the math, buy a regular i486.

Intel says that for the 1992 time frame it plans other products that could plug into the second socket and upgrade the i486SX functionality in other ways. Company officials refused to speculate on the sorts of things they might come up with to fit in this spare slot, but it's not too hard to imagine an intelligent secondary cache and controller that could pop in there.

—Owen Linderholm

NANOBYTES

The **DOS Protected Mode Interface Committee** has started shipping DPMI 1.0, an expanded version of the interface specification for protected-mode DOS applications. DPMI defines a standard interface that lets protected-mode DOS applications multitask on Intel-based PCs. DPMI-compliant operating environments include Microsoft Windows 3.0, Desqview, OS/2, Unisys CTOS, Merge, VP/ix on Unix 386, and Ergo DOS. The DPMI Committee—Borland, Ergo Computing, IBM, IGC, Intel, Locus Computing, Lotus Development, Microsoft, Phar Lap, Phoenix Technologies, Quarterdeck Office Systems, and Rational Systems—said that it has added enhanced memory management support to version 1.0 to take advantage of the paging and protection features of the Intel 386/i486. □

Apple Computer has again **lowered the U.S. prices** of certain Macintosh models—as much as 31 percent on some. The high-end Mac IIfx shed $1800 on a model with an 80-MB hard disk drive; it now costs $8069. A similarly equipped IIci fell $700 to $6669. And an SE/30 with a similar drive dropped by $1700 to $3869. Such cuts usually signify new systems coming soon. Apple's next big launch is likely to be its **68040-based Macs**. □

NCR, one of the developers of the SCSI connection, is now offering an assortment of SCSI-based disk-array products that should help boost the acceptance of Redundant Array of Inexpensive Drives. Two of the products are controller chips that, with NCR's SCSI chip set, will let system designers implement SCSI RAID disk arrays. The third is a RAID controller board for OEMs that attaches to a SCSI port and provides transparent control of a disk array using RAID 3, RAID 5, or RAID 1 (conventional mirroring). A disk array uses small, inexpensive drives and distributes data among them. □

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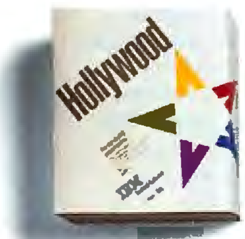

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String of 486SX Systems Begins

Is the i486SX this year's sliced bread? Or is it more a marketing move by Intel, hoping to generate a mass delusion that the 386 is deader than Intel wishes AMD were?

The truth, near as it can be approximated, will lie in the computers based on the i486SX. Several companies have announced systems based on the new chip, several told BYTE that they plan to do so in the next few months, and others said that they'll make their decisions based on chip availability and user interest. Officials at those companies said that they like the new Intel chip because its low price lets them build low-cost systems that have the i486 tag.

Besides the Advanced Logic Research and AST Research machines that are covered in this month's First Impressions, early 486SX systems will come from IBM, Everex, and Acer. Sources close to Everex said that the company was readying two new 486SX machines:

Acer's new AcerPower 486SX is one of the first systems to use Intel's new chip.

one in the Step line and one in the Tempo line. The Step model would be designed for upgrading to a full i486 or adding a 487SX, sources said. Prices weren't settled at press time, but one source said that the machines would sell for about the same as a 33-MHz 386 PC. This was the price point mentioned most often by companies that said they're working on 486SX systems.

Acer introduced its AcerPower 486SX the day after Intel announced the chip. The desktop system comes with Microsoft Windows, 2 MB of RAM, a VGA chip set on the motherboard, and the usual assortment of interfaces. There are two coprocessor sockets: one for Intel's new 487SX and one for Weitek's WTL-4167. Prices start at $2745.

IBM has already started selling its 486SX-based PS/2 Model 90s. The systems are a good bit more expensive than the other 486SX machines announced so far, but IBM says that they're about 25 percent less expensive than the company's 486-based counterparts. The 486SX Model 90s start at $8345.

Twinhead has "some sample systems using the i486SX" and plans to introduce a machine later this year, a product marketing manager said. The company planned to show a desktop system at Spring Comdex. A color laptop is slated for Fall Comdex, he said. Northgate is currently running the new chip in test systems. "We'll certainly offer it as part of our line," said company president Art Lazere. CompuAdd has a product under development but is waiting "to see if the customer demand is there," a spokesperson said.

Expect new arrivals from Dell (which staged a "technology demonstration" of a 486SX system the day after the chip's debut), Compaq, NEC, Texas Instruments, and Toshiba, with other makers following the pack.

As preliminary BYTE Lab tests indicate, in most ordinary operations, users will not be able to tell if their PC's engine is a 40-MHz Am386 or a 20-MHz Intel i486SX. But some vendors say the i486SX lets them design systems that can be easily upgraded to an i486. These systems will show whether the i486SX is a price/performance leader or just a numbers game with a little SX appeal added.

—D. Barker

JVC and C-Cube Show Video Decompressor that Goes Beyond MPEG

JVC and C-Cube have demonstrated what could be the first Moving Pictures Experts Group video decoder/processor chip. MPEG is an emerging technique and proposed ISO standard for compressing motion video at rates of up to 50 to 1. The prototype processor can decompress full-motion digital video in real time, said Mauro Bonomi, C-Cube's manager of product marketing. C-Cube

NANOBYTES

It's the information system you can wear. Designed by PC innovator **Lee "Osborne 1" Felsenstein**, Red is an assemblage of small components that make up a mobile information system. The $2500 package consists of a slim CD-ROM/CD audio drive; a proprietary 16-bit computer; a Smart Card drive; a pressure-sensitive mouse-like device; and Reflection Technology's Private Eye, a tiny screen that attaches to headgear and hangs a few inches in front of the eye, creating the illusion of a high-resolution computer screen floating in front of you. The idea is to provide an image that you can look back and forth at while concentrating on something else. For example, a mechanic might have a page from a repair manual on the screen while working on an engine. The repair manual would be stored on CD-ROM. Red will run for about 3 hours on its rechargeable nickel-cadmium batteries, Felsenstein said. Red is being sold by **Reddy Information Systems.** □

Slowly but surely, the **CD ROM industry continues to grow.** According to the research group **Infotech**, the installed base of CD-ROM drives grew to 1.25 million in 1990 and 2250 titles (up from 1500 in 1989). Industry sales more than doubled, reaching more than $1.5 billion in 1990, according to Infotech. □

Based on a survey taken at the recent Federal Office Systems Expo, **Datapro Research** estimates that **CD-ROM use in government installations** will take a giant leap in the next year. Only 26 percent of those polled said they now use CD-ROM products, but 82 percent said they plan to use them in the coming year. □

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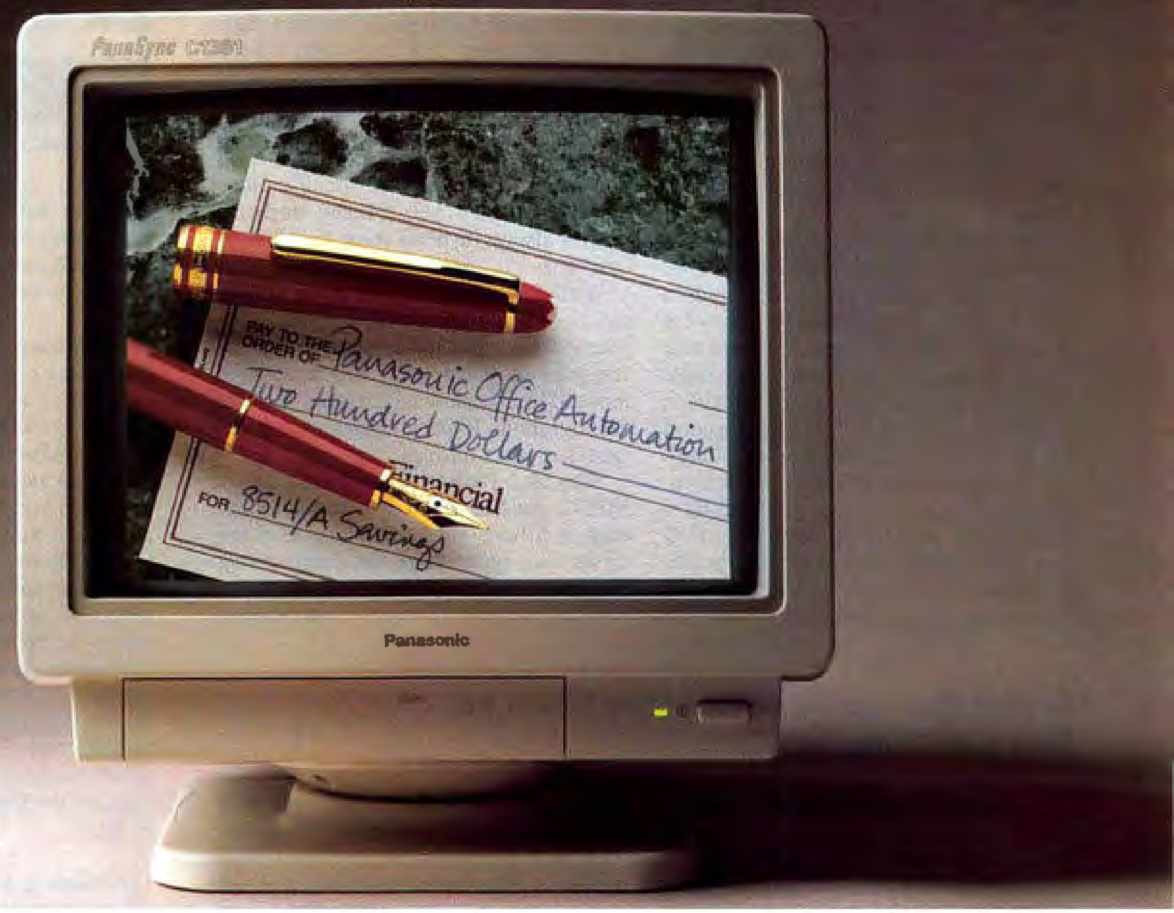

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M3-B

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demonstrated the technology at the recent Microsoft Multimedia and CD-ROM conference.

The chip is not a compression device. It is strictly for decompressing and playing back video that has been generated and compressed by other means. Compression will be handled primarily by the content provider; for example, the company that wants to squeeze moving pictures onto a CD-ROM will have to have the compression, or encoding, equipment. Users will need only the decoding device.

The C-Cube/JVC decoder will also implement the JVC Extended algorithm, which does MPEG one better with a transfer rate, after decompression, of 4 to 6 Mbps. MPEG's specified data rate is 1.2 Mbps. JVC Extended can handle four times the number of pixels specified by MPEG, Bonomi said. MPEG "is good for windowed broadcast-quality video" but is not fast enough for full-screen, broadcast-quality video, said Richard Young, JVC director of marketing. JVC says that its approach speeds up transfer of digital video to the point where it's fast enough and sharp enough to look like broadcast-quality images.

JVC and C-Cube are working together on the decoder chip. They've essentially added JVC Extended mode to the MPEG chip that C-Cube has been working on. The demonstration at the Multimedia and CD-ROM Conference was just that: a demonstration; the chip won't be a product until late this year, C-Cube officials said. Most observers at the conference said that they thought C-Cube was prematurely making an MPEG-related announcement, since the specifications are not finished yet. "Being early to market always involves some risk," Bonomi said.

While the demonstration of the MPEG circuitry was impressive, C-Cube's delivery dates, like the images in the decompressed video clip, are known to move. The company has delayed its Joint Photographic Experts Group compression chip several times.

Sony and Philips are working on an MPEG decoder, and according to rumors in Silicon Valley, Apple is working on its own technology for compressing images.

—D. Barker

Client/Server Architecture Seen as Not Catching On

Why isn't client/server architecture being more readily accepted?" When product managers raise that kind of question—as an Oracle product manager did at the recent DB/Expo conference—there must indeed be a problem. Of some 1700 people at one Expo conference session, only about 100 said they had implemented a successful client/server database application.

Despite a steady release of new client/server products, industry consultants interviewed at the Expo were downbeat about the future of the architecture. According to consultant Jeff Tash, "The tools are not there. The experience is not there." Structured Query Language standards are still an issue. The architecture requires that the buyer deal with multiple vendors for a single application. And then there are the problems with LANs. "Client/server computing is just dressed-up LAN, and people don't have enough LAN experience," said consultant Shaku Atre.

Presentations at DB/Expo by Oracle and Microsoft featured corporate testimonials for client/server solutions. This indicated that real, live companies are really using real, live client/server applications. But not everyone is sold. When asked for his view on client/server architecture, database expert and consultant Richard Finkelstein said, "I'm not sure I'm ready to recommend it to clients."

—Ellen Ullman

Quantum's Write Caching Offers Speed, but Is It Risky?

Quantum is incorporating write-caching technology in its new line of 3½-inch hard disk drives. Used in high-capacity drives for minicomputer and mainframe systems, write caching speeds up performance and frees the CPU to do other things. Critics, however, say that it entails certain dangers.

Write caching is similar to read caching in that data recently read from the

NANOBYTES

Just as the chrome bulldog guarantees it's a Mack truck, this new logo will certify it's a **Multimedia PC**. A system that meets the MPC standard (prime movers: Microsoft and Tandy) of at least a 286 processor, 2 MB of RAM, a 30-MB hard disk drive, a CD-ROM player with audio capability, and a VGA card and monitor, will qualify to wear the MPC brand. □

With so many 386s and 486s out there, how can a company distinguish its PCs? **Amkly Systems**, headed by AST Research co-founder **Albert Wong**, is trying to sell **serviceability**. Amkly's new 386s and 486s are based on a modular architecture that features a removable CPU complex with on-card single in-line memory modules, an EISA bus backplane, and a "peripheral platform," or removable mass-storage cage. The design simplifies making upgrades, from the quick-release thumbscrews that secure the cover, to the snap-in disk drive cage, to the programmable system ROM. □

Five vendors are forming a cooperative agreement to develop compatible applications based on Sun's **Network File System** protocols for letting different types of computers read each other's data. These applications will address areas not covered by existing protocols and applications. The vendors are Beame & Whiteside, for DOS; FTP Software, for OS/2; InterCon, for the Mac; Interlink, for IBM mainframes; and TGV, for DEC VAX minicomputers running VMS. The companies said that they will release specifications for the protocols to other vendors and develop "reference implementations" in Unix that others could use to develop similar applications for their systems. The new applications could provide functions such as letting a remote user retrieve E-mail, said David Kashlan, president of TGV. □

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hard disk is put into a memory buffer, where it can be accessed quickly, significantly reducing the overall access time. With write caching, however, data is written to a memory buffer instead of directly to disk. This frees up the processor to move on to other tasks more quickly. Then the data gets copied from the memory buffer to the hard disk separately, while the processor does something else.

Some companies have found this technique too risky. If something interrupts the process after the processor writes the data and before the data gets to the disk, the processor thinks the data is safe when, in fact, it is not. If a drive fails completely during a write operation, the processor will have written data to the cache that hasn't yet made it to the disk surface—but as far as the processor knows, the write has been successful. Quantum officials acknowledge this problem but say that the state of hard disk drive technology is good enough now that such an event is unlikely.

Quantum is offering a version of write caching, called WriteCache, on certain models of its ProDrive (200 MB or higher). Quantum claims that the technology can achieve improvements of between 50 percent and 200 percent in data throughput on write operations. WriteCache lets the drives finish a random write operation completely after it is issued in about 23 ms; the processor, however, completes the write to the data buffer in 3 or 4 ms, Quantum says.

WriteCache can simultaneously write data to disk from the buffer and write data to the buffer from the processor, Quantum says. This allows for a continuous data flow in a similar manner to the way a streaming tape drive operates.

—Owen Linderholm

Diamond Transistors and Coolers Come Closer

Diamond is coming closer to being a practical material for use in electronic applications. Scientists at Varian Research Center (Palo Alto, CA) have fabricated diamond transistors, and a company called Diamonex (Allentown, PA) is nearing commercialization of diamond heat sinks to help keep high-speed electronics cool.

Diamond transistors are potentially faster and can take more heat and radiation than even gallium arsenide devices. A diamond's hardness, high-insulation value, and superior heat-transfer properties make it important as a substrate and heat sink for electronics.

Varian researchers are now working on their second generation of diamond transistors. The first, which was announced last fall, was the first diamond transistor that could be turned off. The new transistor is similarly built by doping a natural diamond crystal with boron, but it's small enough to fall within the range of current ICs.

Varian is building metal semiconductor field-effect transistors. The transistors are three gold-titanium contacts applied to the surface of the boron-doped region of the diamond. The outer contacts, the source and drain, are annealed to make ohmic contact with the doped diamond. The central gate contact is not annealed. When a reverse voltage is applied to the gate, the current flow through the device can be reduced to zero. According to Varian officials, this is the first time that this has been done in a diamond transistor.

Varian's work is still experimental. The company hasn't built a commercial diamond semiconductor, and neither has anyone else, although both the Japanese and the Soviets have similar projects.

Meanwhile, artificial diamond could show up in electronic equipment in a few months in the form of thin-film heat sinks. (Natural diamonds are already used in some electronic applications, but they are very expensive.) Diamond's thermal conductivity is more than four times higher than the best presently used material, beryllium oxide. The chips are bonded to a small piece of diamond that spreads the heat from the chips to a larger conventional heat sink.

Diamonex has distributed samples of a diamond-coated heat sink to potential customers. According to David S. Hoover, vice president of technology, products built on the company's diamond heat sink could be in production by the end of the year. The first market, Hoover says, is "things like laser diodes and high-power FETs [field effect transistors]." Next, there would probably be multichip modules and eventually very dense circuits such as microprocessors using emitter-coupled logic.

The company grows its diamond films by passing a heated mixture of hydrocarbon gases (e.g., methane, ethane, and acetylene) over a substrate. If the process is properly controlled, diamond forms instead of graphite. ■

—Rick Cook

NANOBYTES

Three-dimensional graphics like those seen on workstations will be coming to personal computer users as a result of a new pact between **Microsoft** and **Silicon Graphics**, the companies say. Microsoft has licensed Silicon Graphics' Iris Graphics Library technology to incorporate it into its own systems and applications software. The Iris Graphics Library provides tools for developing applications that let users manipulate high-resolution, 3-D color images. "Silicon Graphics and Microsoft intend to integrate technology from the Iris Graphics Library with appropriate future Microsoft software products," a Silicon Graphics spokesperson said. □

With Sun's optimizing compilers priced at around $2000, **Lucid** should attract attention by offering its new ANSI C optimizing compiler at $495. Lucid C for Sun Sparcstations and compatibles offers ANSI C conformance and a Kernighan & Ritchie mode. A transition mode is also available, letting you write ANSI C code and link it with most K&R files. Lucid plans to release a C++ compiler later this year, as well as a C/C++ integrated applications environment. □

One of the most talked-about new titles at the Multimedia and CD-ROM Conference was **Desert Storm**, Warner New Media's audiovisual CD covering the war with Iraq. Assembled in conjunction with

Time, the CD includes the text of unedited dispatches from *Time* correspondents and the resulting stories as they appeared in print; audio segments, such as news reports and presidential sound bites; and about 300 photos. You can search the material using either an index or a time line. The $39.95 CD is out first for the Macintosh; a Windows version will be released later, a spokesperson said. ■

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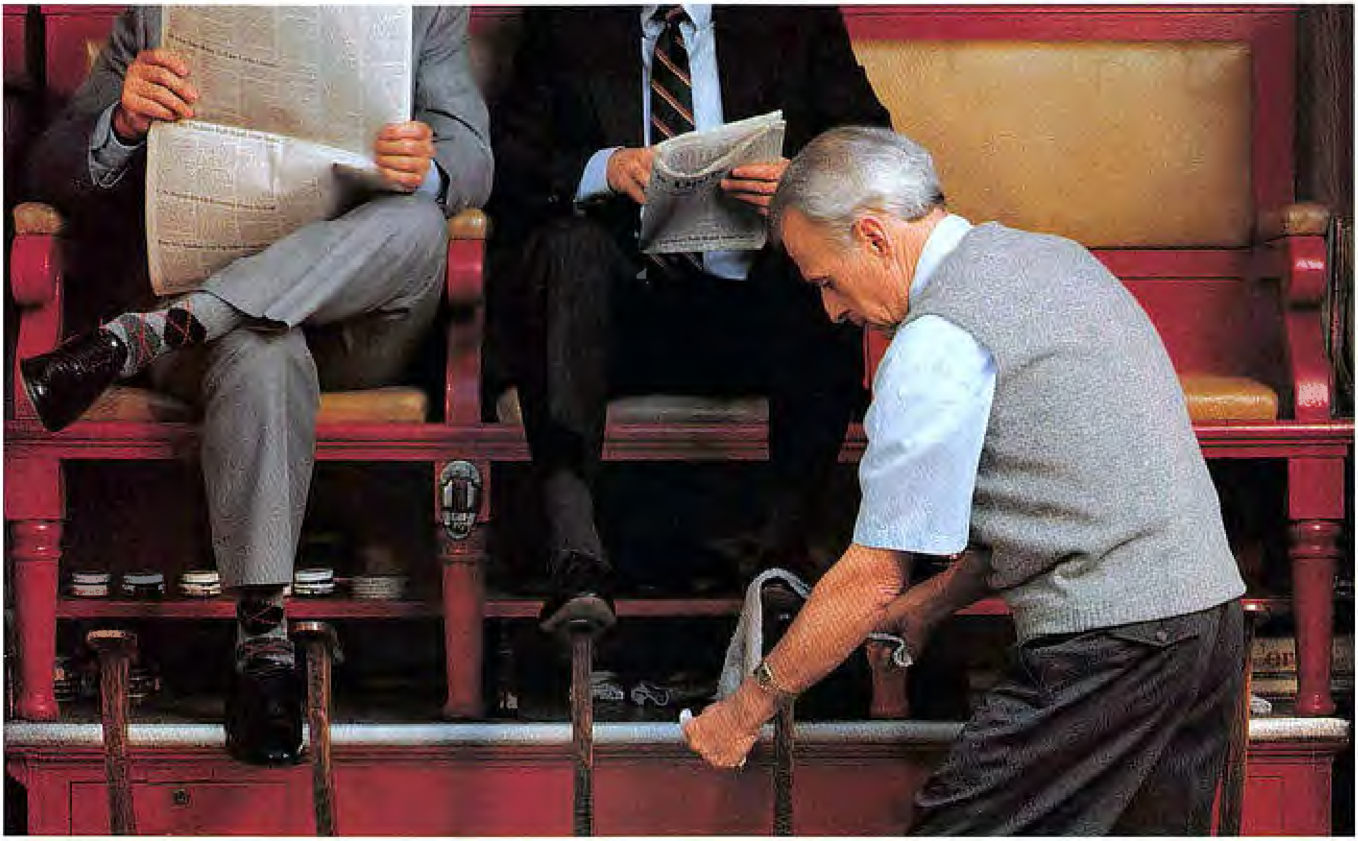

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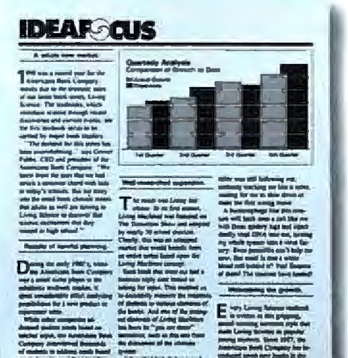
HP has picked up the throughput speed of this 4 ppm printer. Due to a considerably faster I/O rate, the LaserJet IIIP accepts data as quickly as your PC can transfer it. So you not only get your output faster, you get your screen back faster. The LaserJet IIIP also has a new 16 MHz processor and PCL5 for on-the-fly typeface scaling and fast vector graphics. These advancements mean this compact printer



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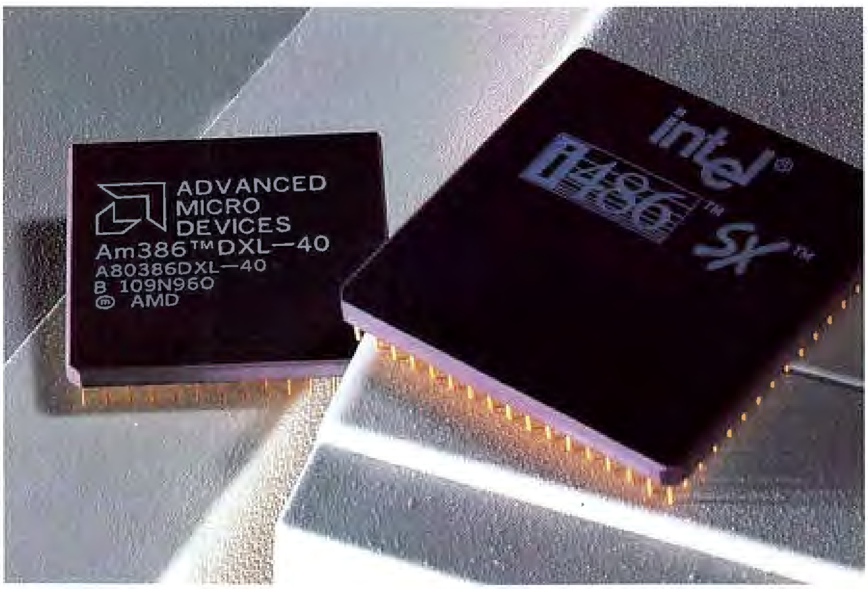
COVER STORY

The 486SX Falls Short

MICHAEL NADEAU AND ALAN JOCH



Surprise! A 40-MHz AMD 386 system offers better price/performance than either of two new 486SX systems

Hold onto your hats. The PC industry is in for another CPU war. After Intel effectively buried the 286 in favor of the 386SX, the PC CPU king appears to be positioning the new 20-MHz i486SX to do the same to its 386DX chip. Perhaps not coincidentally, this move comes at the expense of Advanced Micro Devices (AMD), as it did with the 386SX.

AMD is a licensed second source for the 286, which generated a great deal of revenue for the company in the 286's heyday. To counter the declining 286 market, AMD has cloned the 386DX—so well, in fact, that it can reliably boost the clock rate to 40 MHz; the best Intel offers is 33 MHz (see "The 386 Gets a Competitor," March BYTE).

Intel's i486SX is simply your garden-variety i486 sans working FPU functions (they are disabled) and running at 20 MHz. To add an FPU, you must buy an 80487SX, which is really an i486 CPU with its math coprocessing capabilities intact. An 80487SX retails for $799. An Intel 33-MHz 80387 math coprocessor (a 40-MHz version is not yet available) retails for $994.

The 386SX took sales away from the 286 because it let system vendors build more powerful PCs at a price competitive with those of 286-based machines. And the surging popularity of Windows 3.0 accelerated the demand for more powerful, inexpensive systems. But the case of the i486SX versus the Am386 will be different. BYTE has made preliminary tests on two prototype 486SX systems, from Advanced Logic Research (ALR) and AST Research, and a prototype Am386 system from Club American Technologies. Performance differences are minimal. All will run most business applications under DOS or Windows without working up a sweat. This battle will be won primarily on price and availability.

These machines also create a new performance niche between standard Intel 33-MHz 386 systems and 25-MHz 486 systems. The price range varies significantly, with the 486SX systems on the higher end. All three systems should be available by the time you read this.

ALR and AST: Similar Design, Different Prices

Comparing the ALR BusinessVEISA 486ASX and the AST Premium II 486SX/20 is interesting as much for their similarities as for their differences. Both feature expandable CPUs, offer a similar range of options and base configurations, and have roughly equal performance.

The main differences are in price and in the way the CPU and FPU upgrades are implemented. The ALR uses EISA architecture, while the AST has ISA slots; ALR also offers ISA and Micro Channel architecture versions of the Business-VEISA 486ASX. Both companies were among the first to offer an expandable architecture. (For a comparison of the companies' architectures, see "Two to Grow On," June 1990 BYTE.)

The BusinessVEISA 486ASX came with 5 megabytes of RAM, a 150-MB hard disk drive, 5¼- and 3½-inch floppy disk drives, a Super VGA adapter and monitor, and an UltraStor Ultra 22C EISA caching ESDI hard disk drive controller. As configured here, the ALR unit sells for about $7800 (pricing on the controller was not set at press time). As an introductory offer, ALR is bundling Windows 3.0 and DOS 4.01 with the system.

We also had ALR's SuperCharged 486 CPU/Math Chip (retailing for $1095). It is actually a fully functional i486/25 CPU that plugs into an empty socket on the CPU module. You can use a 20-MHz 80487SX in the same slot as the i486/25 (the module has both 20- and 25-MHz os-

PHOTOGRAPHY SCOTT PARKER / AVIS PHOTOGRAPHY © 1991 cillators), but for about $300 more than the price of the 80487SX, ALR is offering what amounts to a CPU upgrade.

We clocked the upgraded system's CPU index at 6.28—a respectable score for a 486/25 system. Doing the upgrade is not quite as simple as pulling one board and inserting another: The CPU module is actually two boards plugged into two proprietary slots and held together by one screw that threads into the floppy disk drive support. We had to remove the caching hard disk drive controller to gain access to that screw.

AST sent us the Model 213V, equipped with a 210-MB Intelligent Drive Electronics (IDE) hard disk drive, a 3½-inch floppy disk drive, 4 MB of RAM, and an integrated Super VGA adapter and monitor. This system will sell for $5090 with a monitor. Although ALR's base unit is significantly cheaper than AST's, there is little price difference between fully configured versions.

The unit will make use of AST's Cupid CPU boards, which lets you upgrade the system by swapping boards. The Premium II 486SX/20 uses a slightly different design than previous models. Prices for upgrade modules are not set, but AST expects them to be somewhat lower than earlier versions.

The AST machine edged out the ALR machine on the CPU index: 5.14 to 5.02. Both scored lower than the Club's 5.41, although mere mortals aren't likely to notice the differences in their applications among these systems. The AST and ALR systems showed better hard disk drive and video performance, which reflects more on the quality of the components used than on the CPU.

The ALR machine was ruggedly built. Its metal cover and frame make for a rigid construction. It is, essentially, the basic desktop BusinessVEISA design that ALR has been using for some months now. The AST machine is not as rugged as either the ALR or the Club. Its plastic base flexed considerably with the cover off, and it did not sit evenly on a flat surface.

The AST machine offers a few advantages that the ALR machine doesn't. It comes standard with a set of excellent system utilities, as do all AST systems, including a software disk cache and system diagnostics. The Premium II's integrated

Club American Eagle

AST Premium II

ALR BusinessVEISA

THE FACTS

Club American Eagle Series 3/40
Without hard disk drive or monitor, $1895 (desktop) and $1995 (tower); with 100-MB IDE hard disk drive and Super VGA monitor and adapter, $2895 (desktop) and $2995 (tower)

Club American Technologies, Inc.
3401 West Warren Ave.
Fremont, CA 94539
(415) 683-6600
fax: (415) 490-2687
Circle 1174 on Inquiry Card.

ALR BusinessVEISA 486ASX
Model 101 (no hard disk drive or monitor), $2795; Model 80 (80-MB IDE hard disk drive), $3495; Model 150HP (150-MB ESDI hard disk drive, Super VGA controller, and 5 MB of RAM), $6195

Advanced Logic Research, Inc.
9401 Jeronimo
Irvine, CA 92718
(800) 444-4257
(714) 581-6770
fax: (714) 458-0532
Circle 1172 on Inquiry Card.

AST Premium II 486SX/20
Model 3V (no hard disk drive or monitor), $2995; Model 83V (80-MB IDE hard disk drive), $3695; Model 213V (210-MB IDE hard disk drive), $4395

AST Research, Inc.
16215 Alton Pkwy.
P.O. Box 19658
Irvine, CA 92713
(714) 727-4141
fax: (714) 727-9363
Circle 1173 on Inquiry Card.

PRELIMINARY BYTE BENCHMARK SCORES

While the Club's AMD Am386 CPU was a little faster than the i486SX in either the ALR or AST, the latter two systems outperformed the Club in both the disk and video tests. We've included the CPU and FPU scores for the ALR with the SuperCharged 486 CPU/Math Chip installed. Note that the ALR had an optional caching hard disk drive controller, which inflated its disk index. For each index, an 8-MHz IBM AT = 1.

	CPU	FPU	Disk I/O	Video
ALR BusinessVEISA 486ASX	**5.02**	N/A	**8.69**	**13.70**
ALR BusinessVEISA 486ASX (with SuperCharged Chip)	6.28	24.71		
AST Premium II 486SX/20	**5.14**	N/A	**2.91**	**11.12**
Club American Eagle Series 3/40	**5.41**	N/A	**2.76**	**8.04**
Tandy 4033LX (33-MHz 386)*	3.10	N/A	2.49	5.41
Compaq Deskpro 486/25*	6.40	24.80	3.80	16.20

* For comparison only.

VGA frees an expansion slot and allows for pass-through 8514/A graphics, should you want to use it for, say, CAD applications. A graphics controller is an extra-cost option from ALR.

Clone Afterlife

Club's new Eagle Series 3/40 systems preach a gospel of life after the 286 for PC clones. The 40-MHz Am386 DXL CPU controls Club's new tower system and a sleek desktop model. Based on our look at the desktop system, this CPU may offer enough performance and price difference to make potential customers think twice before committing to low-end 486s.

Out of the box, the Club does a yeoman's job as a midrange PC. A full configuration, at $2895 (well under similarly configured 486SX systems from ALR and AST), includes 4 MB of RAM, 64K bytes of cache memory, a 100-MB IDE hard disk drive and controller, a 1.2- or 1.44-MB floppy disk drive, one parallel port and two serial ports, a Super VGA monitor and graphics adapter, on-site service, keyboard, mouse, DOS 4.01, and Windows 3.0. Club also offers a stripped-down version without a hard disk drive, graphics hardware, or on-site service for $1895. The tower version costs $100 more in either configuration.

In our evaluation unit, Club matched the CPU with Cyrix's FasMath 83D87 coprocessor, a price and performance alternative to another Intel product (for a detailed comparison of math coprocessors, see "FPU Face-Off," November 1990 BYTE). The Eagle motherboard also accepts Weitek's 3167 coprocessor.

Club's Rainbow 4000 Super VGA adapter uses the Tseng ET4000AX chip for 800- by 600-pixel and 256-color resolution. This brings a welcome clarity to text and graphics applications. You can expand the standard 4 MB of system memory to 32 MB on the motherboard and a maximum of 64 MB using add-in cards. The standard power supply is a serviceable 200 watts. The motherboard provides one 32-bit slot (for memory upgrade) and seven 16-bit expansion slots.

Test Results

The alternative CPU/FPU team posted respectable results in the BYTE benchmarks (see the table). For starters, the Club machine posted a CPU index score twice as fast as the Tandy 4033LX's, a 386/33 machine. Disk index scores for the Club were marginally higher than the 33-MHz system, while the Club video index ranged about one-third faster.

The marketplace will also make comparisons to the new 486SX challengers, and in this competition, the Club faired well. It shined in the CPU tests and almost matched the AST in disk tests. But the ALR's optional caching hard disk drive controller made it a clear winner in the latter category. Video test results placed the Club behind the two challengers, particularly in the text display component. Overall, performance is not an overriding factor segmenting the systems.

Frugal Stability

Aside from a slight dark patch on the display screen and a lightweight chassis that borders on flimsy, the Club Eagle was clean and well designed. The company will use it to stake out low-range and mid-range CAD, animation, solids modeling, and fluid dynamics applications, where high-end performance isn't mandatory but economical pricing is important.

Club says that 40-MHz 386 chips plug into the same basic system as its slower 33- and 25-MHz 386 computers without any added costs for cooling or RFI shielding. Thus, the lower initial cost of the 386/40 chip compared to the i486 is not mitigated in the manufacturing process.

Confusing the Marketplace?

New CPU versions always seem to temporarily confuse the marketplace. Now, we have two new CPUs that offer roughly the same level of performance from two different companies. On top of that, one appears to have a significant price advantage to both system vendors and end users.

By comparing the three systems here, we can begin to predict where systems using either the i486SX or the Am386 will fall in the PC hierarchy. Performance-wise, there is no secret. All three fall between 386/33 and 486/25 systems at the CPU level. Advantages inherent to the i486SX (e.g., its built-in 8K-byte cache) will give it the edge in some applications. The AMD's faster clock speed will do likewise in others.

If you absolutely, positively must have the Intel logo on your CPU, you'll be satisfied with the performance of both the ALR and AST systems. (In fact, both machines had higher CPU scores than some 486/25 PCs we've tested.) Both also offer better-performing subsystems (e.g., video and mass storage) than the Club. However, prices on 486/25 systems are falling, and you can find some with prices as good as, if not better than, the ALR and AST systems' full retail price.

The Club Eagle will appeal to those hungry for more processing power but on a tight budget. The fact that its CPU is a 386 type and not an i486 should not be a big drawback. If you really need everything an i486 has to offer, you are better off buying a 486/25 or 486/33 in terms of price/performance.

These three systems will all appeal to the same kind of user: the businessperson or professional who wants the power to run today's demanding applications and operating environments without paying top-of-the-line prices. Whether the market goes toward the i486SX or the Am386 matters mostly to Intel and AMD. For end users, the competition between the two will mean more power at lower prices. In our book, that's a win. ■

Michael Nadeau is managing editor of the BYTE Lab, and Alan Joch is a technical editor for the BYTE Lab. They can be contacted on BIX as "miken" and "ajoch," respectively.

POPULAR PRAISE FOR THE PORTABLE DESKTOP

This new generation PC is remarkable for the performance and practicality it provides. Carry it from the office, to home, to multi-site locations so all your programs and files travel conveniently with you.

Customers and critics alike are praising the Brick for its portability, elegant design, whisper quiet operation and screamingly fast power. This diminutive PC with the unforgettable name is designed for the way you always wanted to do computing.

Here's a sampling from recent articles on the Brick.

"Every once in a while a PC product comes along in which the performance, design and concept are so uncommon that a little voice inside you says you really want to have one."

Jon Pepper,
PC Sources, *11/90*

"Engineered with the way people actually work in mind. It answers the question of how to transport an entire environment to and from several work sites, something no other product handles elegantly."

PC/Computing, *12/90*

"Overall the Brick represents a clever counter to conventional notebook designs. It solves the fundamental problem of two-location computing. You get to keep your home and away files in sync because they are the same."

Tracy Licklider
BCS UPDATE, *7/90*

"Ergo's Brick maintains the functionality of a desktop PC within a small form-factor...the Brick is a real performer, consistently outperforming both Compaq's and IBM's 16 MHz SXs on PC Labs computer benchmark tests."

Matt Ross,
PC Magazine, *9/25/90*

"The Ergo Brick—that delightfully small, full-featured 386SX™ machine. It's almost silent, it's fast... a great personal computer in every other respect too."

Bill Machrone,
PC Magazine, *1/15/91*

"The Brick is the first real innovation in DOS based computers in a long, long time."

Computer Shopper, *1/91*

"The philosophy behind the Brick is so obvious that I'm surprised that no one has thought of it before...you can keep a monitor and a keyboard at each work location, carrying only the computer guts (and your own data) between locations...in a world of boring and utilitarian PCs, the Brick stands out for both its elegance and its technological sophistication."

Stan Miastkowski,
BYTE, *6/90*

THE BRICK

"The Brick is a simple idea that is beautifully executed, resulting in a machine whose time has clearly come. You get the convenience of a laptop with the uncompromising performance of a desktop."

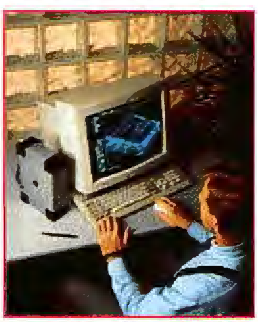
Jon Pepper,
PC Sources, *11/90*

"The Brick is first class all the way. Its appearance and feel suggest even higher quality than that of the Toshiba and Compaq... This system provides an amazing amount of features and support for the price."

Peter Varhol,
Personal Workstation *11/90*

"Using the Brick is a pleasure. In fact, several things about the Brick are terrific. By any standard it's a well equipped and competitively priced 386SX desktop; when you add the appeal of its diminutive size, it becomes adorable."

Eric Grevstad,
Portable Office, *12/90*



Hi-res video drivers are included for over 25 major applications including Windows 3.0, WordPerfect, Ventura, Autocad, Cadkey, and Lotus. The Docking Terminal ($349) permits instant hook-up of all cables and adds another 16-bit 3/4 length slot.

"The beauty of this arrangement is that you never have to worry about the consistency of your data files... you just take it all with you."

Henry Fersko-Weiss,
PC Magazine, *3/91*

"An ideal system for those who split their working time between home and office...The stylish "black granite" and beige cases look as if they came straight from the pages of a Sharper Image catalog."

PC Week, *9/24/90*

"...everyone who sees it falls in love with it... Recommended."

Jerry Pournelle,
BYTE, *1/91*

"Only slightly larger and heavier than a college dictionary, the Brick is a faux-granite-finished portable CPU that explores the middle ground between desktop PCs and portable computers."

Fred Paul,
PC/Computing, *8/90*

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20 MHz	add $445
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▲ Docking Terminal	add $349

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Seven's a Success

TOM THOMPSON AND OWEN LINDERHOLM

System 7.0 offers compatibility, new features, and a future growth path

Back in 1984, the Mac was the first microcomputer to make a windowing operating system available to a large audience. Over time, the Mac OS was enhanced with features such as hierarchical menus and 24-bit color. However, certain parts of the interface began to show signs of age, and by the late 1980s, some expert computer users were already running into the operating system's 8-megabyte memory limit.

In 1989, Apple announced its successor to the then-current version 6 software: System 7.0. It would fix the limitations while providing new capabilities. System 7.0 was supposed to be available in about a year, but some delays pushed back the launch date. However, Apple was making preparations for System 7.0's arrival: The base hardware configuration of the Mac LC and Mac IIsi made these machines ready for System 7.0.

System 7.0 has finally arrived, and the wait has been well worth it. System 7.0's new features make it an upgrade that is as significant for Mac users as Windows 3.0 was for Intel-based microcomputer users. What does System 7.0 offer, and why should you switch to it? Here are a few reasons:

• A more consistent interface that makes the Mac even easier to use.
• Compatibility with existing software. Since System 7.0 is a revision of the tried-but-true System 6.0.x, many existing Mac applications, desk accessories (DAs), and cdevs continue to work. You can immediately take advantage of its high-resolution TrueType outline fonts or peer-to-peer file sharing with no modification to the software. New interface features will completely change your Mac working habits.
• Old limitations removed. Suitably equipped Macs can run System 7.0 as a 32-bit operating system, expanding the program address space from 8 MB to 1 gigabyte. Virtual memory support—where the contents of inactive portions of RAM are swapped out to a hard disk and copied back into RAM as needed—lets you run applications that are larger than the computer's physical RAM.
• Future extensions. While System 7.0 preserves all existing OS calls for compatibility, it also augments its capabilities by supplying numerous new calls that let applications share data and communicate to other applications or computers. You'll be able to use off-the-shelf applications that dynamically exchange data with each other and provide seamless access to remote databases.

THE FACTS

System 7.0
Personal Upgrade Kit, $99;
Group Upgrade Kit, $349

Apple Computer, Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010
Circle 1167 on Inquiry Card.

The System 7.0 beta 4 software we saw occupies eight 800K-byte floppy disks. Its hardware requirements are simple: a Mac Plus or better with 2 MB of RAM and a hard disk drive. The Installer application is an enhanced version of the one used since System 6.0.4. It automatically identifies the Mac it's running on and offers to install the complete set of System software, utilities, and printing services. Installation is just a matter of feeding in the Mac disks until the job is done. A Network Install application lets you install System 7.0 over a network.

Not Just Another Pretty Interface

After you restart a color Mac, you're in for a surprise. The Desktop icons are in color. We're not talking about the seven color shades that you could use to tint icons using System 6.0.x. These icons sport many different hues, which imparts a dramatic three-dimensional effect to Desktop objects.

Similarly, the scroll and title bars on windows exhibit 3-D features, much like Windows 3.0 or Motif (see the screen shot). Naturally, Macs with black-and-white screens use the old bit-mapped icons and window dressing.

An application icon located on the right side of the menu bar hints that you're running MultiFinder. You have cooperative background tasking at all times now (see Don Crabb's Macinations column for further details). This new Finder has taken on additional interface duties besides managing the screen and files, while all the tasking switching code has been moved into a hidden Process Manager (more on this later). Clicking on the application icon presents a pull-down menu that lets you pick from a list of running applications.

Returning to the menu bar, a new icon next to the application icon resembles a balloon. Clicking on this icon gives you access to Balloon Help, a built-in context-sensitive help mechanism. When Balloon Help is enabled, cartoon-style voice balloons appear as you move the mouse over the screen. The balloon's tip points to the object selected by the mouse, and inside the balloon is a brief descriptive explanation of the object's function.

Consistency Is the Key

Apple has rediscovered the value of the keyboard: The cursor keys let you navigate around the Desktop, an icon at a time. Or, you can type the first character of a filename or folder name to select an item. This closely copies the behavior of the ubiquitous Standard File dialog box, and it provides a consistent way to select files whether you're in an application or at the

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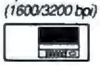

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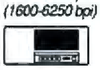

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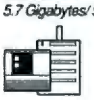

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Desktop. A new Desktop button in the Standard File dialog box gives you an overview of all the Mac's mounted volumes (i.e., disk drives, floppy disks, and servers), and, like the new application icon menu, it lets you choose from the list.

When you view a crowded folder's contents as text, new visual indicators help you sort through the blizzard of names. Folder names are prefaced by a right-pointing arrowhead. Clicking on the arrowhead opens the folder, showing its contents as text names indented slightly to the right. The arrowhead then points downward, indicating that the folder is open. This gives you a useful visual hierarchy of folder directories.

System 7.0 handles DAs and cdevs in a consistent manner. DAs were formerly invoked from the Apple menu, and cdevs hid out within the Control Panel DA's window. This made for a confusing interface for novices. DAs and cdevs now behave like miniapplications: Double-clicking on them launches them. The Apple menu can still be used to start DAs, even though they aren't part of the System file now. Instead, they live in a special Apple Menu Item folder. Cdevs are no longer accessed from the Control Panel DA, but from the Finder within their own Control Panel folder. This normalizes the Mac interface so that you can access files, launch applications, or modify system features the same way.

Easy Changes

System 7.0 also simplifies how you customize your system. Adding new fonts or DAs to a System 6.0.x file required the use of a Font/DA Mover application. Adding new sounds meant using either ResEdit, a developer's tool, or third-party INITs. Now you simply drag DAs, fonts, or sound resource files into the System Folder to install them.

New folders within the System Folder organize the population explosion of specialized files. The previously mentioned Apple Menu Item folder places objects on the Apple menu and is where DAs are copied by default.

The Control Panel folder is where cdevs go, and an Extensions folder holds the system extensions (e.g., AppleShare, printer drivers, and INITs). A Preferences folder contains all those preference files that applications create to store user settings. A Startup folder holds those applications and DAs that you want launched when the Mac starts.

The System file now lets you add or remove certain items easily. Double-clicking on it opens a window, displaying all the fonts and sounds. You can add sounds and fonts by dragging the files to this System window, or you can remove them by dragging the selected objects out of the window. However, the System file still does its old job of packing essential resources that the Mac OS needs to operate. A peek inside the System file with ResEdit 2.1 shows dozens of different resources. The System file window lets you view and manipulate resources (i.e., sounds and fonts) you're likely to change.

The System file now lets you add or remove certain items easily.

New on the Menu

If you go mousing around through the Finder menus, you'll discover some new items on the File menu: Sharing, Make Alias, and Find. The Sharing item lets you make a volume or folder available to any user on an AppleShare network on a peer-to-peer basis. You select the object's access rights in a window that appears. For folders and applications, the icon changes to indicate that it's shared. Users access these shared objects by connecting to them through the Chooser, exactly like file servers.

The Make Alias item lets you create and manage your information through the use of *alias files*. An alias file points to another Desktop object (e.g., a volume, folder, or file). Alias files are treated exactly as if they were the original files, but their names are italicized so you can tell them apart from the real files.

The Apple menu is hard-wired to launch DAs inside the Apple Menu Items folder. The exception is the Control Panel "DA," which is actually an alias to the Control Panels folder. This implementation of the Apple menu thus provides you with a way to access your most frequently used documents, folders, and applications. Drag any document or application (or its alias) to the Apple Menu Items folder, and it immediately appears in the Apple menu. Now anything you need is only a menu choice away.

The Find item does just what it says: It finds files. It has Boolean search operations for multiple files and can be set to locate files on a particular volume by name, kind, or date.

New Changes Inside

The changes to System 7.0's graphical user interface (GUI) are obvious. However, there are numerous modifications to the Mac OS internally that, while not as obvious, are just as significant. First, the Desktop file, with all its size and speed problems, is gone. All of a file's bundle information (the icon to display and the file's creator and type) is collected into a Desktop database.

Unlike the old Desktop file, which retained the icon of every file copied to the disk, the Finder updates the database as files are added or removed. Files and folders dragged to the Desktop are stored in a hidden Desktop folder, and Trash itself is now a folder.

There are a number of enhancements to existing Mac OS managers. The File Manager now assigns a file a unique ID number. Applications use this ID number to locate a file, even when it is moved to a new folder or renamed. New File Manager calls perform special file saves (so as not to alter the ID number), handle catalog searches, and control file access rights on foreign file systems, such as Unix volumes.

The Event Manager's role has been expanded beyond simply dealing with low-level events such as keystrokes or mouse-clicks. It helps to handle a new class of events called *high-level events*, which transmit commands to other applications. Another new event class, *OS events*, is used by the Process Manager and coordinates application switching (suspend/resume events).

The Resource Manager has new calls that enable it to read portions of a resource into memory, edit it, and write it back to disk. Formerly, the Resource Manager had to read an entire resource—regardless of its size—into RAM.

The new Memory Manager supports both 24- and 32-bit addressing modes. All applications that are "32-bit clean" (i.e., that use all 32 bits of the address and don't manipulate a memory block's characteristics directly) will run in the 32-bit mode without modification. Only Macs with 32-bit-clean ROMs (i.e., the IIci, IIsi, and IIfx) can operate in the 32-bit mode. System 7.0 operates in a 24-bit compatibility mode to support older Macs. The Memory Manager also supports virtual memory on 68030-based Macs or 68020-

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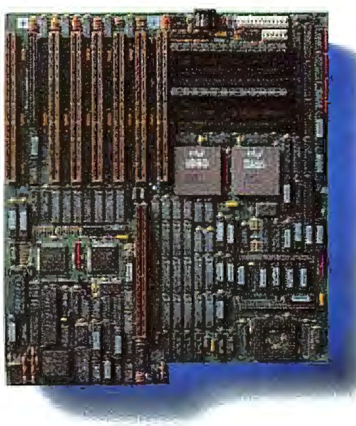

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based Macs equipped with a paged memory management unit.

The AppleTalk Manager now has AppleTalk Phase 2 network addressing and AppleTalk Data Stream Protocol (a full-duplex communications data stream) support built in. It also has enhanced protocol drivers and an Ethernet driver for Apple's EtherTalk NB board. System 6.0.x users need special INITs or cdevs to enjoy any of these network features.

The Font Manager now uses TrueType font technology to produce high-quality text up to 32,768 points in size on both the Mac's screen and any output device, regardless of the device's output resolution. The Font Manager achieves this by using special outline fonts that are similar in function to (but not compatible with) PostScript Type 1 outline fonts. Since the Font Manager is an integral part of how the Mac displays text, all applications immediately gain TrueType's benefits.

New System Additions

As you might expect, System 7.0 requires some new managers to implement many of its new features. Here's a quick rundown on some of them.

The Alias Manager creates and uses special alias records that store a file's directory and volume information. A file's ID number is unique only on the volume the file resides on; the Alias Manager keeps track of files across volumes or from backup devices by using an extensive set of search algorithms.

A Data Access Manager lets a Mac application access data sources on remote computers. Applications that have no concept of using a database (database-naive) can access database information by using a *query document* and DAM. This query document contains commands and data that organize an application's information request into a format suitable for the database. DAM establishes contact with a remote server, opens a query document, sends the query, and receives the returned data. Certain applications can also send data to the remote server.

An application can access different databases simply by using different query documents, and a Data Access Language (formerly called CL/1) supplies a Structured Query Language interface for communicating with database applications. The long-range potential of this manager can't be overestimated: DAM provides the basis for any Mac application to access databases or other data sources, whether it's located beyond a network gateway or on a distant mainframe.

A Process Manager handles the Mac's cooperative background-tasking environment, a job formerly accomplished by MultiFinder. It's responsible for building a partition in memory for an application, loading the code, launching it, and scheduling CPU time for it. It also manages access to shared resources. DAs, now considered applications, are launched into their own memory partition. The Process Manager assigns a 64-bit process serial number for each process and maintains context information on the process. Applications can use Process Manager calls to launch other applications and to obtain information on other processes.

Can We Talk?

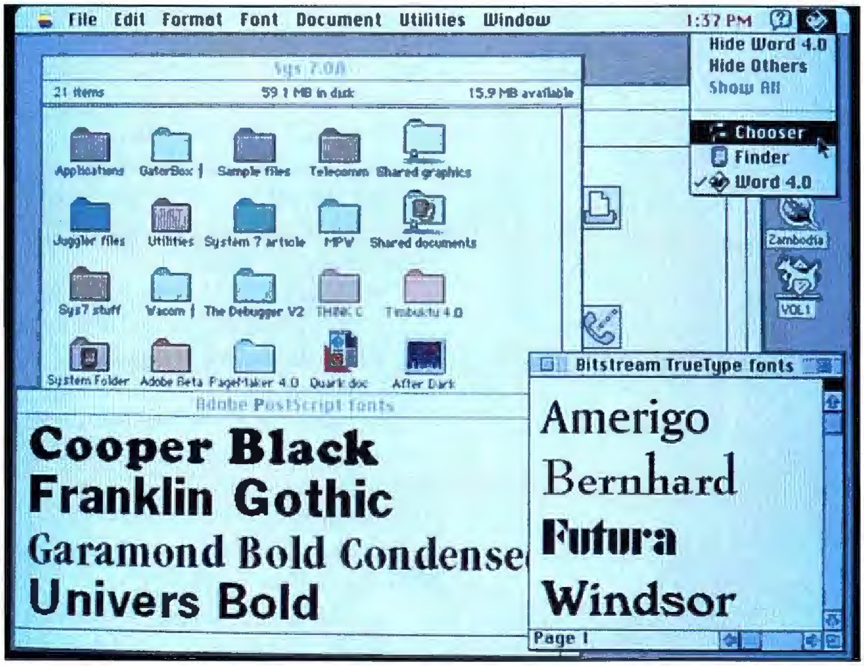
One of the most promising features of System 7.0 is its support of Inter-Application Communications. IAC lets applications exchange "live" (continually updated) information, unlike the static data snapshots taken during existing copy-and-paste operations. System 7.0 provides this IAC facility on several levels.

A Publish/Subscribe feature will see immediate use in office work. An application that is System 7.0-aware lets you "publish" (make available) all or a portion of your document. Other users "subscribe" to your document, and as you make changes to your work, they are relayed to the subscribers. Data flow is not two-way: It always progresses from the publisher to the subscriber.

The Event Manager description mentioned a new class of high-level events that are used for handling application communications. These are *AppleEvents*, and they're used by applications to request services from another application, respond to requests, or send messages. IAC is organized as a client-server relationship, where the requesting application is the client, and the application processing the request is the server. The Edition Manager uses other AppleEvents to support Publish/Subscribe operations.

A Program-to-Program Communications Toolbox lets applications communicate at a low level for tightly coupled control or to obtain services the Event Manager can't provide. Two applications use the PPC Toolbox to open communications ports and then establish a session.

Apple has provided a solid foundation



The two folders with cable icons indicate that their contents are shared across the network. An icon shows that someone is accessing the Shared documents folder.

of Mac OS–supported tools where applications can seamlessly exchange information or access data sources. It will be up to third-party vendors to lay the bricks of new applications on this foundation.

Road Test

Our tests of System 7.0 included four Macs: a Mac IIci with 8 MB of RAM and equipped with a SuperMac Technology 19-inch monitor and a Spectrum/24 PDQ board, a Mac IIfx with 8 MB of RAM and equipped with an AppleColor 13-inch monitor and an 8•24 GC board, a Mac SE/30 with 2 MB of RAM, and a Mac SE with 4 MB of RAM. We found that you're going to need at least 4 MB of RAM to reap the benefits of System 7.0. On the Mac SE/30, the Mac OS used about 1.5 MB, leaving only 500K to 800K bytes of RAM free.

Many of our favorite applications (e.g., PageMaker 4.0, FreeHand 3.0, Illustrator 3.0, and MacWrite II) worked fine. Lots of DAs worked, including Zedcor's DeskPaint 3.03 and CE Software's DiskTop 3.0.1. QuicKeys 2.0 works, but some features (e.g., a utility for mounting file servers) signaled an error and quit. INITs and cdevs were a mixed lot: Some performed fine in the Extensions folder, but others, such as Shiva's configuration INIT and Adobe Type Manager (ATM) 2.0, look for auxiliary files and must be placed in the System Folder.

System 7.0's Sharing feature worked reliably, and even System 6.0.x users were able to access shared folders and volumes. Our networking links to Unix via a Cayman GatorBox and to DOSdom via NetWare still worked. A beta copy of Farallon Computing's Timbuktu 4.0 worked fine, relaying color screens across a LocalTalk network. In fact, users running System 6.0.x can attach, view, and control System 7.0 Macs, getting a color preview of the situation. We use Shiva's networked NetModem to dial remote sites, and it operated fine, once we sorted out where the cdev had to go.

The TrueType fonts produced excellent output on both an Apple StyleWriter and black-and-white laser printers using the Adobe PostScript interpreter, and you can actually mix both font types in a word processing document. The new LaserWriter 7.0 driver no longer uses a Laser Prep dictionary file, and it remembers whether your last print job required color or just black and white. Bitstream generously provided us with a number of different TrueType fonts that produced gorgeous results, proving that the TrueType technology works.

ATM 2.0 still operates, so you have access to both PostScript fonts on top of the TrueType fonts. Adobe's Illustrator 3.0 also works, but if you use a TrueType font with its text tool, the text fails to appear. Adobe is working on a fix. FreeHand 3.0 works with both PostScript and TrueType fonts, down to setting the text's fill and stroke colors. However, printing color TrueType text from FreeHand 3.0 to a Tektronix Phaser II color printer (which uses a PostScript clone interpreter) gave the printer fits. We could print the file to an NEC Colormate PS, which uses Adobe PostScript 51.9. Both Illustrator 3.0 and FreeHand 3.0 printed color text and graphics fine on the Phaser II using PostScript fonts.

The upshot of these results is that, for most applications, TrueType does well. People who use graphics-intensive applications with text should check for potential problems, although the FreeHand 3.0 results hint that the situation isn't as bad as it seems. A bigger question mark for TrueType is if you have to send your work to a typesetting service, but for now the solution is to stick with PostScript fonts.

Should You Switch?

What does it cost to switch? Final pricing wasn't set when we went to press, but the latest figures provided by Apple indicate that the Personal Upgrade Kit, which includes eight floppy disks, manuals, and telephone support, is available for $99. A Group Upgrade Kit includes the Personal Upgrade Kit, plus software on a CD-ROM and the NetWork Install application. It costs $349.

It's crucial in these days of blazing processors and more powerful microcomputers to understand that hardware alone doesn't provide you with a working solution. Equally important is the software that makes the system go. Apple's System 7.0 solves the immediate problem of software compatibility while providing new interface and networking features that you can use immediately. Apple is to be commended for pushing the envelope for making its tried-and-true GUI more consistent and easier to use.

Over time, you can expect System 7.0–aware applications that will cooperate with one another in a powerful synergy. These applications will have transparent access to databases and exchange information with other applications, all while letting you work cooperatively with others in the office. Apple has taken the lead in showing that the office computer can still be a productivity solution—and not a problem. ■

Tom Thompson is a BYTE senior editor at large, and Owen Linderholm is a BYTE senior news editor. They can be contacted on BIX as "tom_thompson" and "owenl," respectively.

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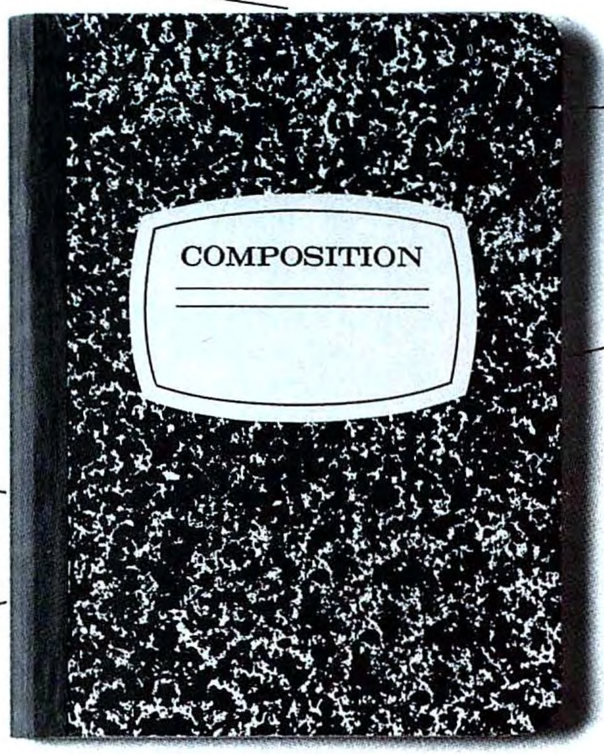

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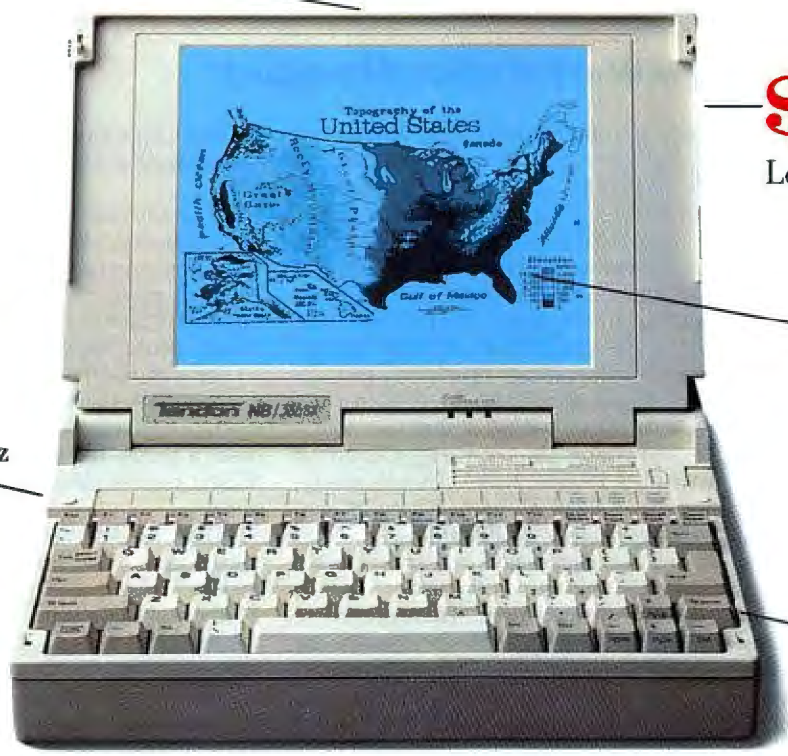

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A New Workstation Standard

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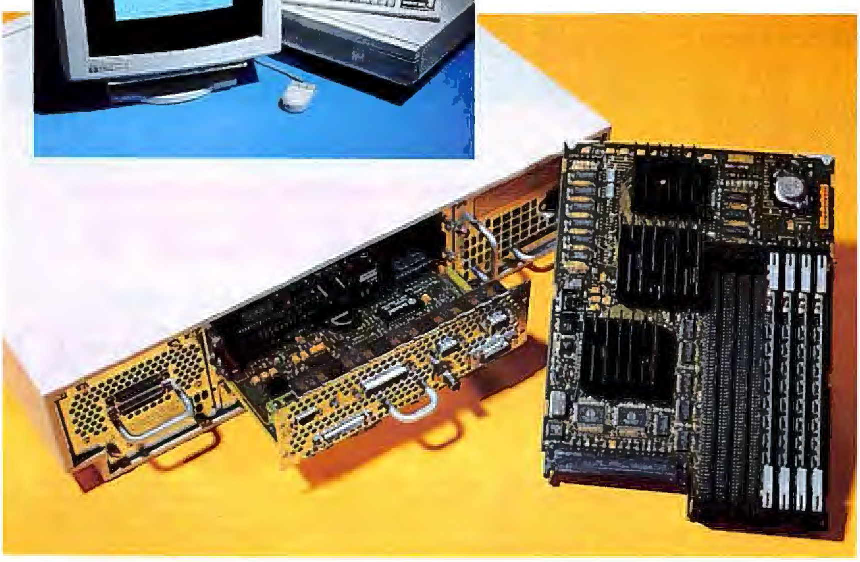
In the Series 700, the CPU board contains three fin-cooled large-scale CMOS chips: the FPU, the CPU, and the memory and I/O controller chip. High-speed graphics-related operations are integral to the design of the CPU board rather than being implemented as a separate unit. The FPU has special instructions for three-dimensional graphics, including inverse square root. The CPU includes the integer processing unit and the memory management unit. The memory and I/O controller chip is specially designed for high-speed graphics, including z-buffering. The 256K bytes of data cache and 128K bytes of instruction cache (256K bytes on the Model 750) are separate chips.

The CPU board can hold 64 megabytes of RAM (128 MB with a daughterboard on the Model 750). Because of the large amount of memory involved, HP/Apollo uses error-checking and correcting RAM. Any multibit memory errors can be diagnosed, and any single-bit errors are both diagnosed and corrected.

A few elements of the new PA-RISC design have migrated from Apollo's PRISM design: the multiply/add and multiply/subtract compound instructions (the RISC System/6000 has similar instructions) and graphics operations that are closely integrated with the CPU instruction set. The PA-RISC design does not include innate multiprocessing, a feature of Apollo's PRISM RISC. Unfortunately, the use of PA-RISC in the Series 700 signals the death of the PRISM.

Software designed for older versions of PA-RISC can run on the newer versions without recompilation. Therefore, more than 3500 applications are immediately available for the Series 700 workstations.

The HP/Apollo 9000 Series 700 consists of three models: the 720, a desktop design running at 50 MHz; the 730, a desktop design running at 66 MHz; and the 750, a deskside design also running at 66 MHz, but with an internal capacity of 192 MB of RAM and 2.6 gigabytes of disk storage. The system box for desktop designs is 20 inches wide by 17½ inches deep by 4½ inches high. All systems are highly modular: The separate elements (i.e., disk, CPU, power, communications, and video) are built as drawers that slide out of the back of the units. The SCSI-2 link between the disk drive module and the communications module is created with a short external cable rather than through an internal communications bus.



Besides the SCSI-2 port, the communications module includes two serial ports, a Centronics parallel port, thin and thick Ethernet ports, an audio speaker jack, and the HP interface loop jack for the keyboard, mouse, and user input devices.

The high-end models include from one to four EISA slots. Besides the array of existing third-party EISA boards, you can order a Series 700 with an optional fast SCSI-2 bus that delivers 10 MB per second.

When we designed the Unix benchmarks (see "The BYTE Unix Benchmarks," March 1990), the DECsystem 3100 was the fastest machine in the desktop workstation class. Our benchmarks seemed to have plenty of headroom for higher performance. Less than a year later, however, we found that the RISC System/6000 (with more than 50,000 Dhrystones) had driven the benchmarks to the limit, so we began developing a new set of benchmarks.

The HP/Apollo 720 exceeded many of our original tests. Unofficial tests show that it was giving more than 80,000 Dhrystones. Unfortunately, our new benchmarks are not yet released, so we can give only rough numbers on performance. But there is no question that these machines outperform not only all the Sun machines in their price range, but also the RISC System/6000, MIPS machines, and others. The HP/Apollo machine showed even higher floating-point performance over the RISC System/6000. We will publish actual figures along with our new Unix benchmarks. For the time being, there is no reason to doubt HP/Apollo's claims of from 57 to 76 million integer instructions per second (depending on the model) and from 17 to 22 million floating-point operations per second.

The Model 720 CRX with two 210-MB hard disk drives and 32 MB of RAM is the fastest workstation BYTE has looked at to date. Even with the low-end color display board, the Motif displays are instantaneous. Because the display processing is integral to the CPU design, the display speed is nothing less than phenomenal.

The User's Perspective

Despite IBM's effort to capture the lead in the RISC workstation market, Sun Microsystems still has a firm grip on the posi-

EEF

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Filing vs. Archiving

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Processing
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Output
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The EEF system opens a vast new world of opportunities for you. The possible applications are limitless, and to name a few:

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Software

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125-127 North 4th Street Philadelphia, PA 19106 USA Tel. + 1 215 627 7202 Fax. = 1 215 627 2342.

tion. Motorola-based workstations from HP and Apollo are commonplace, but they're certainly no match for the RISC market, which is dominated by SPARC- and MIPS-based machines. SunView and OpenWindows have attracted many developers and purchasers. Motif may be pretty, but it leaves much to be desired when compared to the Sun interfaces. Motif requires additional software for file management and session control.

HP's VUE has everything that is missing from Motif, including an excellent file manager that not only looks better than Looking Glass (Visix Software) and X.Desktop (IXI), but uses windows in an economical way. An outstanding (for Motif) feature of the VUE file manager is the drag-and-drop action associated with the file icons: Drag a text file to the printer icon, and the file prints. Drag it to root (background), and you are editing it.

The Workspace Manager is completely configurable, but only with some editing of two quite technical description files (a trait found with most Motif applications). But the default design and two other samples will cover the taste range of most users. The default VUE Workspace Manager control bar includes a clock, date, system load plot, mail, hpterm, printer, file manager, application manager, trash bin directory, help, terminal lock, resources control (Style Manager), and virtual screen menu.

The system administration and documentation interfaces aren't nearly as impressive as VUE, but they're still the best you will find on any system.

The version of HP-UX (HP's license of Unix) seems particularly robust. Unlike Apollo's Domain, this is a real Unix kernel and operating system, with HP's own mix of Berkeley Standard Distribution and System V utilities and system calls. HP is very much part of the Open Software Foundation camp and, along with DEC, is promoting the move to OSF/1. HP-UX 8 complies with more elements of more standards than I care to list here. I'll just say that this system will fit into any Unix environment. The speed of the display and X Window System implementation is so fast that applications running on remote machines are at least as fast as on the host, and in most cases faster.

The only criticism that I have as a user is focused on an inexpensive, although important, component: the keyboard. The keys feel loose, the tactile feedback is minimal, and the Escape key is combined with the Delete key (shifted) and placed in an unconventional position in the lower left.

Prices start at $11,990 for a diskless version of the Model 720 with 16 MB of RAM. The unit I saw lists at $34,490.

—Ben Smith

THE FACTS

HP/Apollo 9000 Series 700
$11,990 to $118,190

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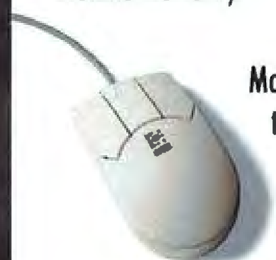

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power, there's a lot more than meets the eye in the 386SL. The 20-MHz processor and its associated I/O subsystem controller have quite a few power-saving tricks up their sleeves.

ZDS engineers have always specialized in designing systems with pioneering power-saving technology. They've taken the 386SL chip set, pushed it to the limit, and then added their own bells and whistles. The end result is a system that you essentially never need to turn off. There are standby and rest modes that will save your work for what the company claims is up to *three weeks*. This is done using a variety of interesting tricks.

For example, the system state is stored in two places. First, ZDS uses slow-refresh (128-ms) RAM that's one-eighth the speed of conventional RAM (and uses less power). Also, the system state is saved in a special secure area of the built-in Conner Peripherals 60-megabyte Intelligent Drive Electronics hard disk drive. The SL chip set can also dynamically turn ports on and off as they're needed.

Admittedly, few of us would leave a machine unused and turned on for three weeks. What the design of the MastersPort 386SL really means is that it's the first notebook that you can use battery-powered for a full day of note taking and other work. It's important to note that there's nothing particularly special about the battery system; it's all done through power management. When the system is resting, it draws a paltry 40 milliamperes of power. This sort of thing just wasn't possible before.

Physically, the system is a little wider than the now-standard 11½ inches of most notebooks. Its 12½-inch width leaves room for an almost-full-size keyboard. And it still fit easily into my briefcase. The MastersPort 386SL weighs in at 6¾ pounds and comes standard with 2 MB of RAM, a 1.44-MB floppy disk drive, and a 32-shade gray-scale VGA backlit supertwist display. There's also room inside for an optional 2400-bps MNP level 5 modem.

Innovation isn't inexpensive. Although the exact price of the MastersPort 386SL hadn't been set at press time, it's expected to retail for about $5800.

THE FACTS

MastersPort 386SL
about $5800
SupersPort 486SX
about $9000
SupersPort 486
about $11,000

Zenith Data Systems
2150 East Lake Cook Rd.
Buffalo Grove, IL 60089
(800) 553-0331
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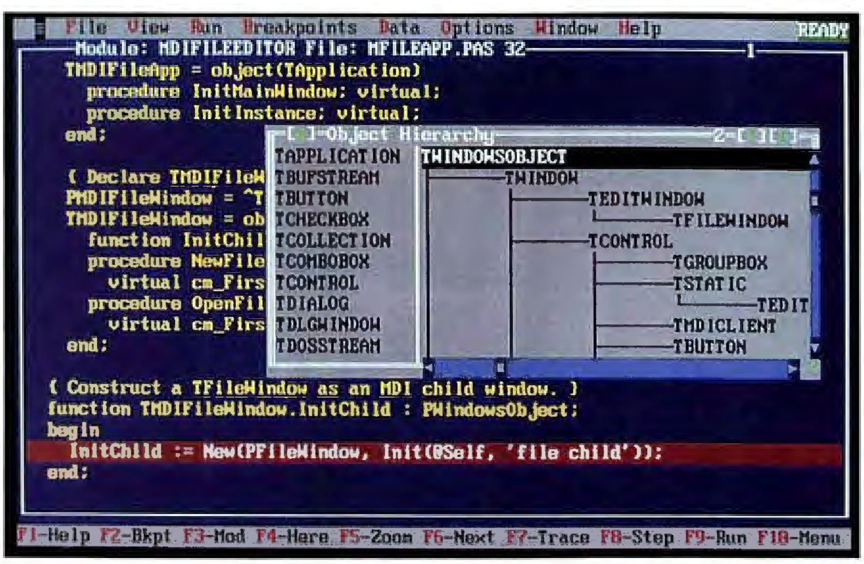
ZDS also introduced a top-of-the-line portable: the **SupersPort 486**. It's available in two incarnations: one based on the new 25-MHz i486SX chip (sans math coprocessor), and the other with a full-fledged 25-MHz i486 chip. If you remember the TurbosPort 386 (the first 386 portable), you won't be surprised by the design. The new machine is similar, with a detachable keyboard. The keyboard has a built-in IsoPoint, the interesting "roll-and-slide" substitute for a mouse.

The SupersPort 486 is loaded: 4 MB of RAM, a 120-MB hard disk drive, and a 64-level VGA display are standard. There is even room inside the case for a ¾-length ISA add-in card. The unit—complete with a magnesium case—weighs 15 pounds with its standard battery pack. Detach the pack, and it weighs 10 pounds. Most users are likely to use this behemoth near an AC plug, and there's an optional docking unit (with ports and power supply) for the deskbound SupersPort user. Its price hasn't been set yet.

Systems like these show that ZDS hasn't been sitting still while the rest of the industry moves ahead. With the MastersPort 386SL, it has leapfrogged the competition in one fell swoop. Certainly, many other manufacturers will soon introduce SL-based systems, but if you want one now (and I sure do), ZDS is the only game in town.

—Stan Miastkowski

Turbo Pascal Makes Windows Programming a Breeze



At last someone did it—brought out a relatively mainstream compiler that runs in the Microsoft Windows environment and produces Windows programs. The surprise is not just the company that did it, Borland, but also the language, a Borland mainstay—Turbo Pascal. Many people considered it a surprise that Microsoft didn't have a QuickBASIC for Windows included as part of Windows 3.0. It left a programming gap that couldn't quite be closed by the likes of The Whitewater Group's Actor or Microsoft C 6.0 and the Windows Software Development Kit. Fortunately, **Turbo Pascal for Windows** goes a long way toward closing that gap.

The program operates completely within the Windows environment. However, one major part, the debugger, is still a character-based application running

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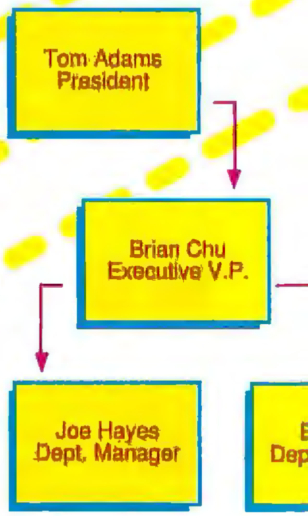

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under Windows, rather than a fully Windows-based program. In terms of the language, little has been changed. Many regular Turbo Pascal for DOS programs that stay in character mode will run right away with one tiny change—renaming the `Crt` unit as the `WinCrt` unit. These programs run in a default window under Windows that acts like a view onto a text screen but which can be moved, resized, scrolled, and so forth.

Programs that use the Borland Graphics Interface are out of luck, as are those that try to play lots of tricks with DOS or directly access machine hardware. They will have to be completely rewritten to use Windows calls instead. It also isn't possible to write applications that are intended to run just under DOS. Turbo Pascal for Windows will write programs to run only under Microsoft Windows.

Fortunately, Borland goes a long way toward making this an easy task. Only one tool, The Whitewater Group's Resource Toolkit, is required. It is included and also runs under Windows. Best of all, Borland has included a powerful and easy-to-use object library for Windows programming called ObjectWindows. ObjectWindows abstracts the development of Windows interface code so that it is much easier for the Turbo Pascal programmer to deal with. For example, a Hello World program written using Turbo Pascal and straight Windows calls takes about 100 lines of code. An identical ObjectWindows program takes only 16 lines of code. I found ObjectWindows a great benefit, especially for the user new to Windows programming.

Turbo Pascal for Windows can also write and use Windows dynamic link libraries. This lets you make use of existing code from other languages or write sections of another program in different languages, as appropriate. An in-line assembler is included, as is a command-line version of the compiler for use with make files. Full context-sensitive help is included.

All in all, Turbo Pascal for Windows is a powerful and straightforward way to do Windows programming, especially for the Pascal enthusiast. It offers a great deal of power and a good deal of help in dealing with the complexities of Windows. While it's not as powerful for programming Windows in depth as Borland's C++ or Microsoft C, it does make Windows programming more approachable.

—Owen Linderholm

THE FACTS

Turbo Pascal for Windows
$249.95

Requirements:
A 286 or better with Windows 3.0, 2 MB of RAM, and a hard disk drive.

Borland International, Inc.
1800 Green Hills Rd.
P.O. Box 660001
Scotts Valley, CA 95067
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fax: (408) 438-8696
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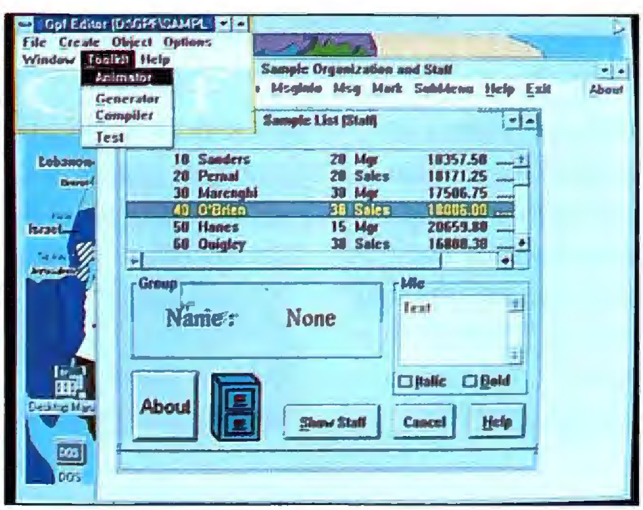
GPF Shortcuts Presentation Manager Development

When I think of France, I think of the cathedrals at Chartres and Mont-Saint-Michel, of the wines, and of bicycles and racing cars. I didn't think of software in connection with France, until now. From Microformatic in Montreuil-Sous-Bois comes the **GUI Programming Facility** (GPF), one of the more complete application generators for OS/2 Presentation Manager (PM) I've seen.

It's more than a little work to write an OS/2 PM application, especially one that queries databases. You have to copy the code skeleton from a sample application, edit your own menu structure, design all your dialog boxes, and finally write the code to tie menu actions and dialog box controls to actual operations.

Once you get to the point of writing code, the edit-compile-link test for a PM application of any size can be tedious. On a fast machine, even a small PM program can take several minutes to build; on a not-so-fast machine, a sizable PM program can take hours to build. Using embedded Structured Query Language slows down the process even more by adding SQLPrep and SQLBind steps to the already time-consuming compile, link, and resource compile steps.

GPF shortcuts the PM development process in several ways. First, you don't have to write any user-interface code. You design the menus and dialog boxes in GPF, and it generates all the UI and SQL source code you need: not only the resource files, but also the C code (with comments and embedded SQL), a skeleton help file for the Information Presentation Facility, and a make file.



Second, you don't have to go through the code-generation, compile, and link steps very often. GPF has an "animator" that interprets your interface definitions to simulate an actual running program.

And finally, you don't have to do nearly as much bookkeeping and debugging with GPF as you would writing the code by hand. GPF keeps track of all the information in one centralized database, and it always generates the correct code for the interface you've designed.

Quite a feat, actually. GPF combines a design facility with a design interpreter and a code generator. Add to that a large assortment of predefined actions, and you have a tool that can really save you time.

The version I'm working with has about 45 predefined

THE FACTS

GUI Programming Facility
$3500

Requirements:
OS/2 Extended Edition 1.2 or higher, 6 MB of RAM, IBM or Microsoft C compiler, and OS/2 toolkit.

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action objects, which are pieces of code to do a specific task—in other words, a *function*. I'm told that list is about to double, and it will continue to grow as the product evolves. Buyers of GPF get automatic updates for one year from date of purchase.

I should also mention GPF's support of the IBM OS/2 Database Manager. GPF knows all about making SQL database queries and automatically includes the SQLPrep and SQLBind steps when generating code for the DBM. That's a big plus for the product. The GPF Animator can run the SQL queries interpretively—another big plus.

On the negative side, the Animator requires you to have IBM's SQL dynamic link library on your machine, whether or not you want to develop database code. So, if you want the benefits of the Animator, you must have Extended Edition. You can use GPF without the Animator on Standard Edition, but you will waste a lot of time waiting for the C compiler. (A spokesperson for Microformatic says there will soon be a full-fledged version that will run on Standard Edition.)

GPF is similar to the less expensive CASE:PM from Caseworks, but it does more. GPF has its own window and dialog box editor; CASE:PM doesn't. GPF gives you more control over presentation objects, supports SQL, lets you place control in client windows (not just in dialog boxes), and animates your design. GPF's predefined action objects save you writing a lot of UI code that you would have to write with CASE:PM. And GPF links your custom code to the design at the design level, so you never have to edit the generated code; CASE:PM forces you to fiddle with the generated code, although it can usually recognize and preserve your custom code when it regenerates.

If you care at all about developing ordinary PM applications, GPF is a tool worth considering, assuming you can deal with the prerequisites. But if you want to develop small, fast PM applications that access IBM's DBM, GPF is likely to save you a lot of time and money. ■

—Martin Heller

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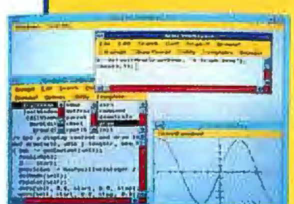

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Unleash 386 power on your Microsoft C code with WATCOM C8.0/386, a 100% ANSI C optimizing compiler and run-time library generating applications for 32-bit 386 protected mode. With C8.0/386, you can go beyond the 640K DOS limit. Library and source compatibility with Microsoft C simplifies porting 16-bit applications to the 386. Significant features include: full-screen source-level debugger; protected mode version of the compiler; execution profiler; linker; graphics library. Run-time compatible with WATCOM F77/386.

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BRIEF 3.1 ***New Version!***

The programmer's editor, from Solution Systems, adds support for Microsoft mouse, EMS caching, and step-for-step Redo to all the features that have made BRIEF the editor of choice for over 120,000 PC programmers worldwide. BRIEF features multiple windows, template editing, smart indenting, search/replace, complete keyboard configurability, editable keystroke macros, a C-like macro language with source-level debugger and a powerful Undo for faster, more productive programming.

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FAXcetera 1271-0001

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OS/386 Developer's Kit	695	625
WATCOM C 8.0/386 Prof. w/ 386/DOS Extender	1295 1790	969 1399
WATCOM C 8.0/386 Standard	895	719
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APPLICATION SOFTWARE

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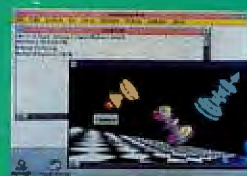

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List : $159 Ours: $139

FAXcetera: 3107-0002

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Circle 258 on Inquiry Card.

Power in a PeeWee Package

The PeeWee, a system that measures 1¾ by 10 by 8 inches and weighs just over 4½ pounds with a 40-MB hard disk drive, is designed to be transported without a monitor and keyboard. The manufacturer says the PeeWee is not a portable PC but a powerful system for office and home.

Each 12-MHz 286 unit includes 1 MB of on-board memory (expandable to 2 MB), a 40-MB Intelligent Drive Electronics hard disk drive (expandable to 200 MB), a 9- or 14-inch monochrome monitor, and a keyboard. Its zero wait states include dual speeds, and it has a built-in 110-/220-V switching power supply, two serial ports, a parallel port, and a 3½-inch floppy disk drive. Color and monochrome VGA monitors and a LAN adapter for E-Net are also available.

Price: $1095.

Contact: SAI Systems Laboratories, Inc., 911 Bridgeport Ave., Shelton, CT 06484, (800) 331-0488 or (203) 929-0790; fax (203) 929-6948.

Circle 1287 on Inquiry Card.

The lightweight PeeWee is geared for home and office.

Hand-Held with a Switchable Axis

Weighing less than 1½ pounds with batteries and measuring 7½ by 4 by 1⁹⁄₁₀ inches, the CT1000 hand-held computer operates at 10 or 4.77 MHz. The IBM XT-compatible device has 640K bytes of static RAM and uses memory cards in place of a disk drive.

The CT1000's battery-backed SRAM cards act as its disk drive.

The CT1000 includes a serial and a parallel port, a math coprocessor slot, and a clear resistive matrix touchpad over a 240- by 128-dot supertwist LCD. The display is software switchable for vertical or horizontal use. Current run-time libraries support only C, but you can develop an application in any language on your PC. Custom options are available.

Price: $2495; development kit, $4995.

Contact: CogiTech, Inc., 10 Birch Court, Goffstown, NH 03045, (603) 497-8898; fax (603) 497-8899.

Circle 1288 on Inquiry Card.

More Power for the T1200XE

A 40-MB hard disk drive version of the T1200XE 286 notebook computer is available from Toshiba. Running at 12 MHz, the system has 1 MB of RAM (expandable to 5 MB) and a 3½-inch floppy disk drive. Its sidelit supertwist LCD has a 640- by 400-pixel resolution.

Price: $3799.

Contact: Toshiba America Information Systems, Inc., 9740 Irvine Blvd., Irvine, CA 92718, (800) 334-3445; in Canada, (800) 387-5645; fax (714) 583-3437.

Circle 1289 on Inquiry Card.

Travel Light with a Touchscreen

The 4½-pound TraveLite 286 menu-driven touchscreen computer has a full-size backlit display with touch overlay and internal nickel-cadmium batteries. It has bar code, serial, parallel, keyboard, and docking connectors. Other features include integrated mouse emulation, zero wait states, 1 MB of RAM, and a 512K-byte EPROM. Options include digitized voice, a docking unit, and an integrated keyboard and case.

Price: $2495.

Contact: DFM Systems, Inc., 1601 48th St., West Des Moines, IA 50265, (515) 225-6744; fax (515) 225-7183.

Circle 1290 on Inquiry Card.

Desktop Features on a Laptop

A 12-MHz 80C286 laptop with 1 MB of single in-line memory module memory (expandable to 4 MB), the 9000LT uses a Chips & Technologies NEAT chip set and a 40-MB hard disk drive. The 640- by 480-pixel VGA page-white, backlit screen includes 16 gray scales.

The 9000LT's internal rechargeable nickel-cadmium battery runs for more than 3 hours on a single charge, according to the company. The 16¾-pound unit comes with a battery-status report, a low-battery alarm, automatic shutdown of the hard disk drives and screen, and a 110-/240-V auto-switching power supply.

The unit's full-size keyboard features 80 keys, 12 function keys, and an embedded numeric keypad. Its one serial and one parallel port let you attach an external keyboard or monitor so you can create a Docking Station or use the laptop as a desktop computer.

Price: $1699.

Contact: Leading Technology, Inc., 10430 Southwest Fifth St., Beaverton, OR 97005, (800) 999-5323 or (503) 646-3424; fax (503) 626-7845.

Circle 1291 on Inquiry Card.

NEWS

Personal Printing on the Mac

Low-cost, high-quality laser printing for the Mac is what GCC Technologies says you get from its $999, 4-ppm Personal LaserPrinter II. The PLP II features six Bitstream outline font families that let you reduce and enlarge text from 25 percent to 400 percent in 1 percent increments and rotate characters to any angle.

The print engine in the PLP II includes a patented toner recycling system, edge-to-edge printing, and a user-defined sleep mode. It also has an interactive LCD panel. An 8-ppm PLP IIS and a 4-ppm Business LaserPrinter II (BLP II) are also available.
Price: $999; PLP IIS, $1499; BLP II, $1999.
Contact: GCC Technologies, 580 Winter St., Waltham, MA 02154, (800) 422-7777 or (617) 890-0880; fax (617) 890-0822.
Circle 1292 on Inquiry Card.

The low-cost Personal LaserPrinter II is for Mac users.

CD-ROM Drive Comes Outfitted

An external CD-ROM drive for less than $500 is available from Genesis. The GenStar 2000 drive comes with Microsoft DOS compact disc extensions, audio software, device driver software, a caddy, computer cable, audio cables for stereo hookup, and an interface card.
Price: $499; bundled with CD-ROM software, $699.
Contact: Genesis Integrated Systems, 1000 Shelard Pkwy., Suite 270, Minneapolis, MN 55426, (800) 325-6582 or (612) 544-4445; fax (612) 544-4347.
Circle 1293 on Inquiry Card.

A Graphics Display in Three Frequencies

The Model RE9514 Super VGA color monitor for the PC offers three horizontal scanning frequencies (31.5, 35.2, and 35.5 kHz) and vertical frequencies of from 50 to 90 Hz. Compatible with VGA, Super VGA, and 8514/A cards, it has interlaced and noninterlaced resolutions: 1024 by 768 interlaced and 800 by 600 or 640 by 480 noninterlaced.

The monitor's 0.28-mm dot pitch of unlimited colors is combined on a nonglare screen with 90 degrees of deflection. Geometric distortion is held to less than 1.5 percent. Additionally, the Model RE9514's casing has a tilt-and-swivel base and a shallow silhouette.
Price: $695.
Contact: Relisys, 320 South Milpitas Blvd., Milpitas, CA 95035, (408) 945-9000; fax (408) 945-0587.
Circle 1294 on Inquiry Card.

A Desktop Video Publisher That's Portable

Mediator, from VideoLogic, converts computer graphics to NTSC or PAL video output. Able to change most PC or Macintosh display output signals into a composite or S-video signal, Mediator lets you record the output to VHS, S-VHS, Hi-8, and Video 8 tapes or display it on color or LCD video projectors, video monitors, or TVs.

The lightweight plug-and-play converter is easily transportable and automatically determines if the input source is PC graphics or a Mac. Using its backlit keypad menu, you can overscan or underscan, freeze a frame, sharpen the picture, align the graphics, and select the output.
Price: $2995.
Contact: VideoLogic, Inc., 245 First St., Cambridge, MA 02142, (617) 494-0530; fax (617) 494-0534.
Circle 1295 on Inquiry Card.

Feed Your Data to a Panther

Based on Tandberg's TDC 3800 and TDC 3600 quarter-inch tape drives, the Panther Tape Backup Systems have capacities ranging from 60 to 525 MB. Backup/restore rates range from 5 MB per minute to 12 MB per minute. The high-end Panther model can back up 525 MB of data in less than 45 minutes, according to Tandberg.

For the PC, the Panther systems are available in internal and external configurations. Panther software is compatible with DOS, OS/2, Novell, Unix/Xenix, Pick, and LAN Manager.
Price: 60-MB internal system, $995; 525-MB external system, $2695.
Contact: Tandberg Data, Inc., 2649 Townsgate Rd., Suite 600, Westlake Village, CA 91361, (805) 495-8384; fax (805) 495-4186.
Circle 1296 on Inquiry Card.

Tandberg's Panther quickly backs up your data to tape.

Motherboard Convertibility

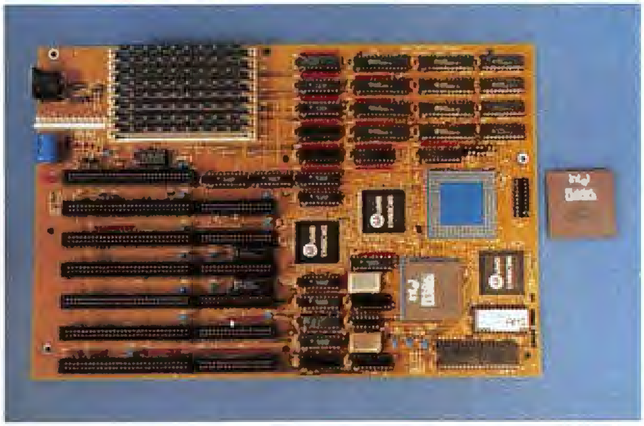
A two-in-one motherboard lets you have a 386 or 486 machine at the snap of a CPU. The board is based on the 386/i486 AT chip set from United Microelectronics. You can upgrade the board from a 386 to a 486 by changing the CPU and some jumpers.

The board includes selectable cache memory from 64 to 256K bytes and eight single in-line memory module sockets for up to 64 MB of RAM. It supports shadow RAM and the 80387.

Price: $635, without a CPU.

Contact: Zeny Computer Systems, Inc., 4033 Clipper Court, Fremont, CA 94538, (415) 659-0386; fax (415) 659-0468.

Circle 1297 on Inquiry Card.



Snap out a 386 CPU to make way for an i486 CPU on Zeny's new motherboard.

This Digitizer Captures in Color

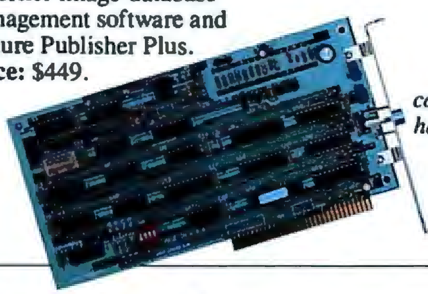
The VIP 640C video digitizer board captures resolutions of 640 by 480 pixels with a color resolution of up to 24 bits. Designed for AT compatibles, the board lets you capture, manipulate, and store images from a source such as a video camera.

The color-enhancement hardware on the VIP 640C simulates more than 125,000 colors and produces real-time display of the video image on any standard VGA monitor. The company bundles the board with Fotofiler image-database management software and Picture Publisher Plus.

Price: $449.

Contact: Ventek Corp., 31336 Via Colinas, Suite 102, Westlake Village, CA 91362, (818) 991-3688; fax (818) 991-4097.

Circle 1298 on Inquiry Card.



The VIP 640C's color-enhancement hardware produces real-time display of a video image on any standard VGA monitor.

A Cache Card for the Mac IIci

A 1½- by 4¾-inch cache card for the Mac IIci, Cache-In uses only nine active components, increasing its reliability while decreasing power consumption. The company says that performance gains should be most noticeable when you use applications such as CAD, desktop publishing, and programs requiring recalculation.

Price: $299.

Contact: Applied Engineering, 3210 Beltline Rd., Dallas, TX 75234, (214) 241-6060.

Circle 1299 on Inquiry Card.

Refresh Quickly on a Super VGA Board

PH6 Technologies has released the PH6 Super VGA board. The 16-bit board, with 1 MB of onboard memory, has a refresh rate of 70 Hz, which is said to be easier on the eyes than the standard 60-Hz rate.

Designed to provide up to 1024- by 768-pixel resolution in 256 colors, the board has a palette of 16.7 million colors. Features include automatic backup of the Setup program and built-in password protection. It supports CAD, desktop publishing, and word processing applications.

Price: $245 to $395.

Contact: PH6 Technologies Corp., 5819 Uplander Way, Culver, CA 90230, (213) 216-0055; fax (213) 216-4931.

Circle 1300 on Inquiry Card.

Work in DOS on Your Mac

The Orange386, a DOS coprocessor for the Mac, is a single-slot card that works in any Mac II, including the IIsi. The card, which features a 16-MHz 386SX processor and 1 MB of expandable RAM, lets you run DOS in a Macintosh window as if it were a Mac application.

Two AT slots on the card let you attach any half-size or three-quarter-size (depending on your style of Mac) IBM add-on card, according to the company. You can also add an optional 80387 math coprocessor. The expandability of the RAM allows fully independent processing, according to Orange Micro, letting the Mac and the Orange386 work simultaneously on different applications.

An optional peripherals kit includes PC interface hardware.

Price: Starts at $2299; peripherals kit, $199.

Contact: Orange Micro, Inc., 1400 North Lakeview Ave., Anaheim, CA 92807, (714) 779-2772; fax (714) 779-9332.

Circle 1301 on Inquiry Card.

Add Hand-Drawn Data to a Computer Image

Color Writer, a color electronic chalkboard, lets you add hand-drawn comments to a projected computer image. The board combines your hand-drawn information with the computer image. It then simultaneously sends the combined image to a projector and to a local computer monitor.

With Color Writer, you can combine eight colors and four line sizes as well as highlight, hide, or reveal portions of the computer image. You can also use the product as a remote mouse.

Color Writer is compatible with VGA, MCGA, EGA, CGA, MDA, and Hercules graphics monitors. It works independently of your operating system and application.

Price: $2995.

Contact: Chisholm Corp., 910 Campisi Way, Campbell, CA 95008, (800) 888-4210 or (408) 559-1111; fax (408) 559-0444.

Circle 1302 on Inquiry Card.

Color Writer merges your handwritten input with a projected computer image.

Create Multipart Forms on Your Printer

An alternative to standard cut-sheet paper, carbonless paper for laser printers lets you quickly create multiple-part forms. You load the cut laser sheets as you would conventional paper. The paper is available in two sizes: 8½ by 11 inches and 8½ by 14 inches.

Price: Starts at $20.85 per 500-sheet package of 8½- by 11-inch paper; starts at $26.50 per 500-sheet package of 8½- by 14-inch paper.

Contact: Great Lakes Business Forms, 2480 Walker Ave. NW, P.O. Box 1157, Grand Rapids, MI 49501, (800) 950-9530 or (616) 791-0100; fax (616) 791-1131.

Circle 1303 on Inquiry Card.

Data Linkage in the Palm of Your Hand

Data transfer and storage are now possible between systems normally regarded as incompatible, according to Cadent Technology. A hand-held data-transport device with 64K bytes of RAM, Datalync is designed to transfer data between systems and devices with fixed-media storage or between systems with incompatible disk formats.

Completely self-contained in a palm-size case with a replaceable 9-V battery, Datalync uses an RS-232 interface. It captures, stores, and transmits data by emulating a file server or bulletin board. The unit's embedded software supports standard modem transfer protocols.

Price: $379.

Contact: Cadent Technology, 2021 West Commonwealth Ave., Fullerton, CA 92633, (714) 738-7756; fax (714) 738-7992.

Circle 1306 on Inquiry Card.

Vacuuming Tools Fit for Your Computer

If you're wondering how to easily and safely rid your computer of accumulated dust, you may find the answer in a set of minitools from Eureka. The mini vacuum attachments are available in a kit.

The minitools fit onto a 36-inch clear flexible tube that attaches to your vacuum cleaner. The specialized tools include an oval brush for screens, a round brush for keyboards, a straight extension pipe, a curved extension pipe, and a crevice tool for hard-to-reach areas.

Price: $10.87.

Contact: Eureka Co., 1201 East Bell St., Bloomington, IL 61701, (800) 525-9991 or (309) 828-2367.

Circle 1304 on Inquiry Card.

An Oscilloscope on a Bus Card

CompuScope Lite is a single-slot bus card that adds full digitizing oscilloscope functions to your PC. It lets you store, analyze, print, and communicate the data you acquire. The CompuScope Lite also can digitize 40 million samples per second on one channel and 20 million samples per second on two channels, as well as provide auto-calibrated A/D conversion.

Price: $595.

Contact: Gage Applied Sciences, Inc., 5465 Vanden Abeele, Montreal, Quebec, Canada H4S 1S1, (514) 337-6893; fax (514) 337-8411.

Circle 1305 on Inquiry Card.

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An integrated UNIX® System environment.

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It doesn't take a computer to forecast the platform that's going to put graphical workstations on the vast majority of business and engineering desktops in the next decade:

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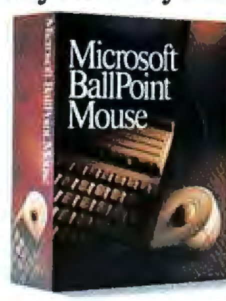
We've launch
solve proble

The new Microsoft® BallPoint™ mouse represents one giant step for you and your laptop computer.



That's because new BallPoint is the first and only mouse specifically developed for laptops. It's compact, yet includes all the features that made the

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And for a limited time, you can get a free BallPoint mouse when you purchase a COMPAQ notebook or laptop PC.

Just call (800) 541-1261, and ask for Dept. P40. They'll send you everything you need to know about the mouse designed to go where no mouse has gone before.

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Microsoft
Making it all make sense™

Replaceable RIMs for Token Ring Adapter

A 4-Mbps Irmatrac Token Ring Adapter that's convertible to 16 Mbps is available from Digital Communications Associates. The interface card uses the company's Ring Interface Module technology, which lets you switch between 4 and 16 Mbps by removing one RIM and replacing it with the other.

The Irmatrac 4-Mbps provides dual ISA and Micro Channel architecture bus support, bus-master support, on-board processing of logical link control, Token Ring industry-standard support, IBM software interface compatibility, and 128K bytes of on-board memory. The board also supports 10Net Plus, PC LAN, LAN Manager 2.0, 3+ Open, and NetWare 286 and 386.

Price: $795; 16-Mbps RIM, $99 with coupon; $195 without coupon.

Contact: Digital Communications Associates, Inc., 1000 Alderman Dr., Alpharetta, GA 30202, (800) 348-3221 or (404) 442-4000.

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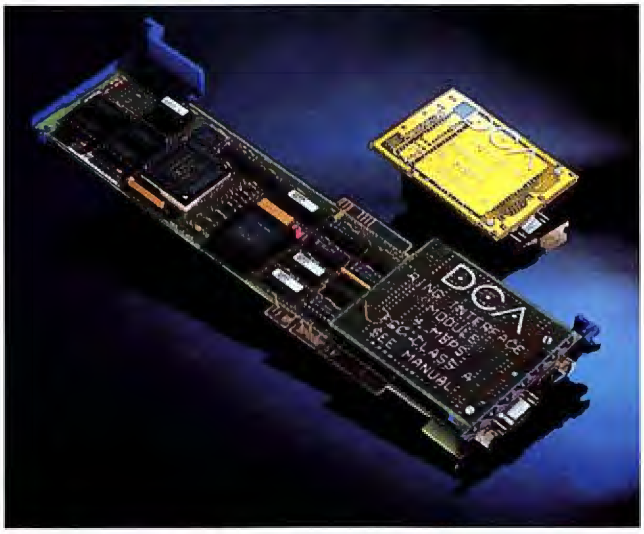

You can convert the Irmatrac 4-Mbps Token Ring adapter to 16 Mbps by changing the Ring Interface Module.

Faxes Change Direction in Windows

LanFax Redirector for Windows uses print redirection to convert Windows files into fax format and transmit them to any fax machine worldwide. LAN users send the WYSIWYF (what you see is what you fax) messages peer-to-peer.

Available for 8, 25, or unlimited users, LanFax Redirector for Windows is compatible with Novell, 3Com, Banyan, and IBM systems and the NetBIOS interface. It supports intelligent fax cards such as SpectraFax, Satisfaxtion, and Connection Coprocessor.

Price: Starts at $995.

Contact: Alcom Corp., 2464 Embarcadero Way, Palo Alto, CA 94303, (415) 493-3800; fax (415) 493-6185.

Circle 1308 on Inquiry Card.

A Micro Channel Architecture and OS/2 Fax Team

SuperFax for OS/2 is a complete Micro Channel bus-master fax communications package, according to its manufacturer. The combination of Micro Channel architecture and OS/2 lets you easily use such applications as Lotus 1-2-3/G, WordPerfect, and PageMaker while SuperFax works in the background.

On a network, SuperFax works in a variety of configurations. With SuperFax on the server, any workstation running in OS/2 or running Windows within a DOS shell can use the respective software version to send and receive faxes via the server.

Price: Stand-alone, $750; with hardware, server software, and four workstation licenses, $995.

Contact: Pacific Image Communications, Inc., 1111 South Arroyo Pkwy., Suite 430, Pasadena, CA 91105, (818) 441-0104; fax (818) 441-2370.

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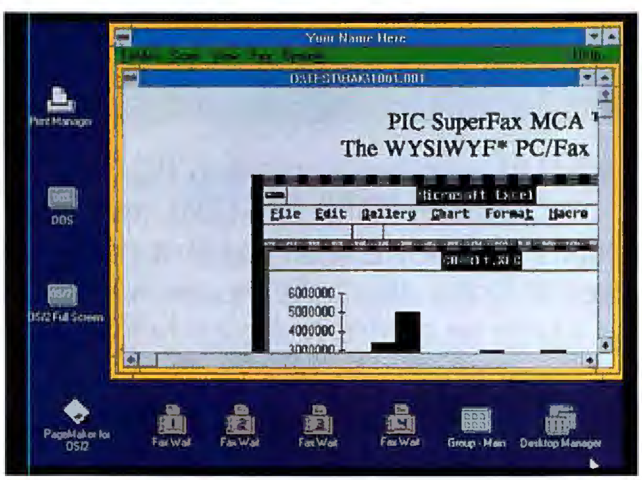

SuperFax for OS/2 views faxes locally before sending them out.

Transparent Printer Language Switching

Two connected PCs and an AppleTalk network can share the Hewlett-Packard LaserJet IIISi printer via the BridgePort 2674 intelligent switching device. Once the device is connected, you can send files to the printer without designating whether you're using PostScript or Printer Command Language.

On a printer equipped with the Adobe PostScript upgrade kit from HP, the BridgePort 2674's automatic language switching transparently senses and analyzes the data stream to determine the language of the incoming data. It then configures the printer for the appropriate language.

The BridgePort 2674 plugs into the modular I/O slot of the HP LaserJet IIISi. Its three input ports are a mini-DIN-8 AppleTalk port, a 36-pin Centronics port, and a port that incorporates Extended Link.

Price: $595.

Contact: Extended Systems, 6123 North Meeker Ave., Boise, ID 83704, (208) 322-7575; fax (208) 377-1906.

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Redefining the price-performance ratio in high-resolution color monitors

For the whole sweep of advanced, demanding applications: CAD/CAM, graphic design, desktop publishing, medical and scientific imaging, and Windowing.

Flat square technology and innovative focus system virtually eliminate distortion and flicker and reduce eye strain. Both 17" and 21" monitors offer brilliant color and automatic scanning over wide frequency ranges (30-65KHz). VGA-, 8514A- and Mac II-compatible with resolution up to 1280 pixels x 1024 lines. Smart, compact design with handy controls and easy adjustments.

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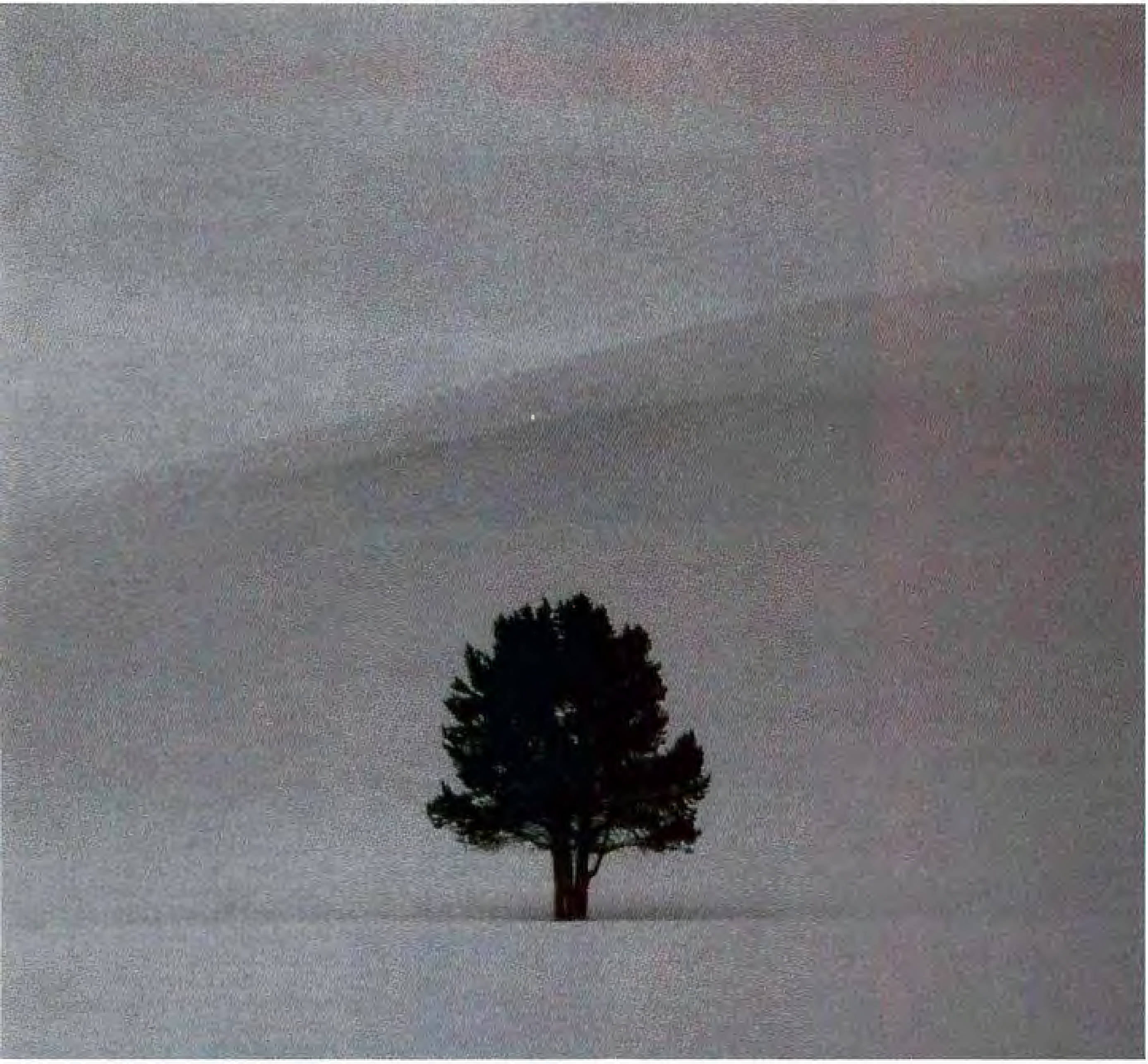

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Toshiba America Consumer Products, Inc. 1010 Johnson Drive, Buffalo Grove, IL 60089

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Let Your Laptop Take the Bus to the LAN

External Ethernet and Token Ring LAN adapters from Megahertz connect to the 100-pin bus connector on Toshiba 1000SE, XE, and LE, 1200XE, and 2000SX notebook computers. The adapters are completely compatible with existing software packages, according to the company.

The 10-MB Ethernet adapter supports thick and thin Ethernet cabling via a 10Base-5 15-pin female connector and a 10Base-2 BNC connector. It uses Western Digital's Ethernet chip set. Systems supported include NetWare, 3+ Open, Vines, OS/2 LAN Manager, and Unix.

The 4-MB Token Ring adapter includes software drivers for PC LAN and NetWare version 2.1x. It also supports the NetBIOS interface.

Price: Ethernet version, $599; Token Ring version, $999.

Contact: Megahertz Corp., 4505 South Wasatch Blvd., Salt Lake City, UT 84124, (800) 527-8677 or (801) 272-6000; fax (801) 272-6077.

Circle 1311 on Inquiry Card.

The external laptop Ethernet adapter connects to the Toshiba's 100-pin bus-expansion connector.

Full Fax Features on a Modem Board

The Twincom 24/96 modem/fax board with Rockwell International's RC9624 chip set combines a Hayes-compatible 2400-bps data modem with a 9600-bps Group 3 send/receive fax modem. Bundled with Quick Link II Fax, Twincom 24/96 features true background fax operation, pull-down menus, mouse support, full call-progress monitoring, macros, and automatic answer/dial and log-on scripting.

Price: $149.

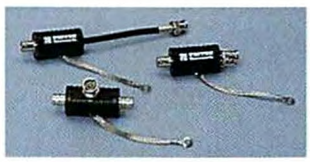
Contact: Image Communications, 6 Caesar Place, Moonachie, NJ 07074, (800) 666-2496 or (201) 935-8880; fax (201) 935-6548.

Circle 1312 on Inquiry Card.

The Twincom 24/96 uses the Rockwell RC9624 chip set.

Protect Your LAN Line

Two LAN data-line surge protectors available from Patton are the Model 531 for Ethernet and the Model 533 for ARCnet. Both surge protectors are for thin coaxial cable and can handle 1.8K watts of energy per wire.



Key to the design of the protectors are silicon avalanche diodes in the passive, high-speed hybrid circuitry. These SADs allow the devices to respond in less than 5 ns. The devices, encased in ABS plastic, do not require additional cables for hookup. Configurations available are in-line and T-splitter.

Price: Starts at $50.

Contact: Patton Electronics Co., 7958 Cessna Ave., Gaithersburg, MD 20879, (301) 975-1000; fax (301) 869-9293.

Circle 1313 on Inquiry Card.

Integrated Motherboard for Workstations

Two new 16-MHz Triumph 386SX workstations are available for use on Novell NetWare LANs. The Triumph SX-Lite and Triumph SX-Tra feature a motherboard with an integrated Intelligent Drive Electronics hard disk drive controller; a floppy disk drive controller; a VGA chip set; and serial, parallel, and mouse ports.

Each workstation comes with 1 MB of RAM (expandable to 8 MB) and 40 MB of hard disk storage (expandable to 135 MB). Each includes a Phoenix BIOS, math coprocessor support, and a 14-inch monochrome VGA monitor.

The Triumph SX-Lite, measuring 2½ by 14½ by 15 inches, has two half-height disk drives (one floppy and one hard) and one expansion slot. The Triumph SX-Tra, which measures 5½ by 14½ by 16½ inches, has one full-height 5¼-inch and one half-height 3½-inch floppy disk drive or three half-height 3½-inch floppy disk drives, plus four expansion slots.

Price: Basic configuration of 1 MB of RAM, 40-MB hard disk storage, and a floppy disk drive, $1395; with VGA color monitor, $1625.

Contact: The Network Connection, 1324 Union Hill Rd., Alpharetta, GA 30201, (800) 327-4853 or (404) 751-0889; fax (404) 751-1884.

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CARRY-I

The New Standard

The Carry-I 9000 series comes complete with 80386SX/80286-16/80286-12 microprocessor (Co-Processor optional). 1024 × 768 VGA/MGA & CGA display interface, 1/2/4 MB RAM, one 3.5" 1.44 MB FDD or one FDD plus one 40/80 MB HDD, one 8 bit expansion SLOT, one parallel and two serial I/O ports, and one 30W auto range switching power adapter, all in the traditional 240mm × 185mm × 45mm (9.4" × 7.3" × 1.8") casing of Carry-I. Each package includes two mini-tower stands and a carry bag. The 81 key mini keyboard with 101 functions and 9 inch color or monochrome VGA monitor are optional.

Other Carry-I products include the 8000 series XT & AT book-size personal computers and the 6000 series XT and AT book-size LANstations. All Carry-I product lines are bundled with DR DOS 5.0

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Circle 114 on Inquiry Card.

Control for Controls

DialogCoder, the Windows 3.0 programming tool for managing how dialog controls should interact with the end user, now lets you test and simulate your dialog without compiling or linking. Using DialogCoder's point-and-click interface, you can design and then generate the source code for dialog controls ranging from simple WYSIWYG dialogs to those with stacked, overlapped, hidden, and disabled controls with multiple triggers.

DialogCoder 2.0A integrates with Caseworks' Case:W and Blue Sky's WindowsMaker application builders. It generates code for Microsoft C and Borland C++ 2.0.

Price: $499.

Contact: The Software Organization, Inc., 56 Kirkland St., Suite 3, Cambridge, MA 02138, (617) 354-2012; fax (617) 354-0667.

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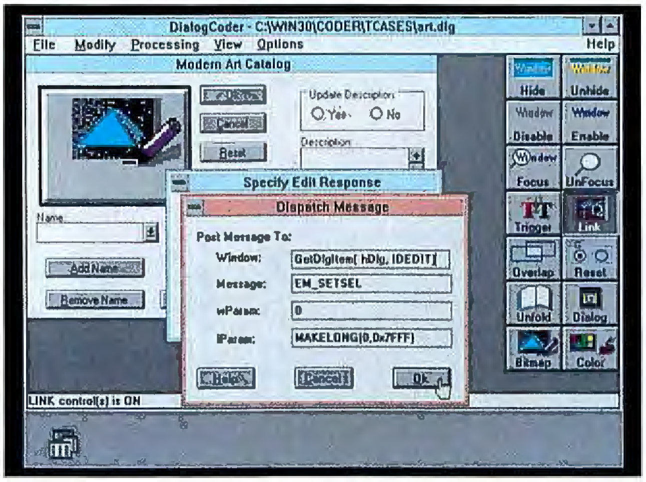

DialogCoder 2.0A adds enhanced edit-control validation, optional generation of dynamic link libraries, and trigger/link relationships involving bit maps.

Create 32-bit Applications for Windows

With Objectworks\Smalltalk release 4 for Windows 3.0, you can develop true-color graphical interactive applications for Windows, the Mac, and Unix without needing intimate knowledge of the low-level windowing application programming interface for each platform. Applications created for Windows will run unchanged on a Mac or a Unix workstation running the X Window System, ParcPlace says.

The environment is the first to exploit the 32-bit linear mode of Windows 3.0, the company says. While you could previously write applications to take advantage of 32-bit capabilities by using the Winmem32.DLL dynamic link library in the Windows Software Development Kit, Objectworks\Smalltalk has the tools to make the job much easier. The environment also provides a migration path to future 32-bit versions of Windows.

Objectworks\Smalltalk provides more than 350 types of Portable Objects and 7400 reusable methods. It also has third-party tools from Tigre Object Systems and for creating graphical user interfaces, and Synergistic Solutions' SQLTalk/80, which provides a link between SQL Server and the Objectworks environment. An Objectkit\Smalltalk advanced programming kit has analysis and programming tools, additional browsers and classes, and terminal-emulation capabilities.

Price: Objectworks\Smalltalk release 4, $3500; Objectkit\Smalltalk, $500.

Contact: ParcPlace Systems, 1550 Plymouth St., Mountain View, CA 94043, (415) 691-6700; fax (415) 691-6715.

Circle 1272 on Inquiry Card.

WindowsMaker Pro's embedded dialog box editor lets you interactively move, size, and align controls in a dialog box.

WindowsMaker Turns Pro

WindowsMaker, the application C code generator for Windows 3.0, now includes an animation test mode and the ability to work interactively. With the animation test mode, you can simulate your designs without wading through the traditional compile/link process, Blue Sky says.

WindowsMaker Pro lets you attach functionality to your buttons, custom controls, bit maps, and icons. It supports almost unlimited nesting for menus. Blue Sky also lets you collapse all the nested menus with one keyclick.

WindowsMaker Pro requires Borland C++, the Microsoft Software Development Kit 3.0 with Microsoft C 5.1 or higher, or Zortech C++ 2.1.

Price: $995.

Contact: Blue Sky Software Corp., 2375 East Tropicana Ave., Suite 320, Las Vegas, NV 89119, (702) 456-6365; fax (702) 434-0580.

Circle 1273 on Inquiry Card.

CASE for Real-Time Mac Applications

Excel's new CASE package for the Mac provides real-time analysis, object analysis, and a requirements database.

By generating state-transition diagrams, decision tables, process-activation tables, state-transition matrices, and state-transition tables, MacAnalyst/Expert lets you more quickly develop time-critical real-time applications for embedded control systems, avionics, defense, and manufacturing, the company says. With the database, you can identify, specify, and trace requirements throughout the development cycle.

The program supports C++, Object Pascal, and other object languages on a Mac.

Price: $1595.

Contact: Excel Software, P.O. Box 1414, Marshalltown, IA 50158, (515) 752-5359; fax (515) 752-2435.

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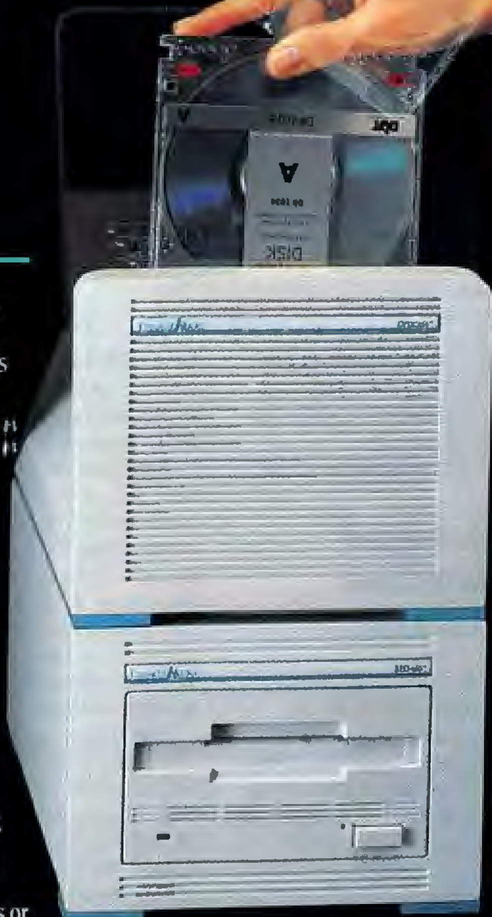

REO-650 with Opticase Disk Holder

There is no optical illusion when choosing the best rewritable optical storage system. Pinnacle Micro's REO-650 was rated the #1 ISO/ANSI standard optical drive by *PC Digest* & NSTL (National Software Testing Laboratories) - and for good reason. Pinnacle is 100% dedicated to leading the optical storage revolution.

With Pinnacle's optical drive solutions, there is no need for hard disk or tape drive systems ever again. Optical mass storage technology provides fast reliable storage for the future.

The REO-650 is ideal for storing on-line, network or backed up databases. Each optical disk can hold 650 Megabytes of spreadsheets, CAD/CAM files or millions of pages of desktop publishing graphics. Since optical disks are removable, the applications and capabilities are virtually endless.

Now all of this is Novell Lab's Tested and Approved. This allows users to utilize removable media in a network environment.

Pinnacle offers the largest selection of optical storage systems, from the world's first 3.5" optical drive, to the most popular 5.25" optical drives and disk changers. Interface kits are available for IBM, MAC, SUN, and DEC computers.

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The Relaxing Legacy of No More Downtime

Although top-quality disk drives experience an approximate failure rate of only 6 percent per year, even this relatively high reliability is unacceptable to many businesses with installed networks. Mirroring is one solution, but it requires you to invest in twice as much storage to hold your data and programs.

RAID (redundant arrays of inexpensive disks) offers another solution to this problem. RAID provides improved performance and the ability to withstand the failure of a single disk drive by means of check bytes, which reconstruct the failed drive's data from the remaining drives.

Tense Lectronix says that its Legacy Array Software 1.0 achieves Level 5, the highest level of RAID. LAS 1.0 lets you rebuild a replacement drive in the background while reads and writes continue, making it suitable for transaction processing, financial institutions, and other businesses.

The system supports DOS, Novell NetWare, Unix, SunOS, and OS/2. For RAID Level 5, LAS runs on the Legacy Hot Fix Device (HFD) SCSI-based storage subsystem that connects directly to file servers and workstations.

Price: $1495 to $1595.
Contact: Tense Lectronix Corp., 200 Butterfield Dr., Unit B, Ashland, MA 01721, (508) 881-6442; fax (508) 881-4116.
Circle 1275 on Inquiry Card.

With the Legacy HFD storage subsystem and complementary RAID software, you can store up to eight backup devices and replace a failed drive without downtime.

SQL Added to Windows Database

Precision adds an embedded Structured Query Language command set to the new version of its Superbase 4 Windows database. The SQL command set, along with the new Superbase SQL Library, lets version 1.3 of the database link to and operate on popular SQL database servers.

Precision says that the new SQL support, along with support for Windows Dynamic Data Exchange and dynamic link libraries, lets Superbase act as a graphical database center for businesses. A revised networking scheme is based on standard DOS locks.

The library now supports Microsoft SQL Server on OS/2; Sybase; and Gupta SQLBase on DOS, OS/2, and Novell NetWare's NLM. A future release will support other servers.

Price: SQL Library, $495; Superbase 4 Windows, $695; network extension, $995.
Contact: Precision Software, 8404 Sterling St., Suite A, Irving, TX 75063, (214) 929-4888; fax (214) 929-1655.
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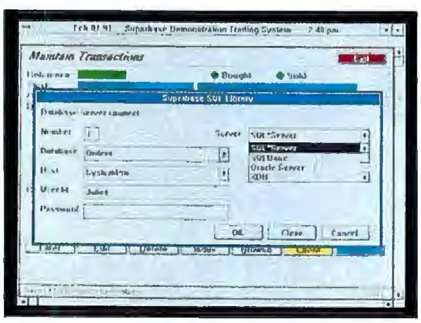

Superbase 4 Windows 1.3 lets you build custom dialogs and connect to several SQL database servers.

New R:base Acts as a Control Center

Microrim's Express 3.1A R:base upgrade lets you run any dBASE, word processing, spreadsheet, or graphics application from within a database.

For network administrators, the company developed R:scope, a database, diagnostic, and network utilities package that uses Dynamic Application Integration to bind itself to R:base.

Price: R:base, $795; Upgrade Express subscription (three a year), $129; individual upgrades, $99 each; LAN Pack users, $149 per subscription, $99 for runtime; R:scope, $129.
Contact: Microrim, 15395 Southeast 30th Place, Bellevue, WA 98007, (206) 649-9500; fax (206) 746-9350.
Circle 1277 on Inquiry Card.

Link the Wizard and B.O.S.S. to Windows PIMs

With IntelliLink/DDE, you can link the Sharp Wizard or Casio B.O.S.S. with a Windows 3.0–based personal information manager and upload and download information between the two. You can use IntelliLink/DDE to upload and download from the hand-held PC either through an Asymetrix Toolbook application or via Dynamic Data Exchange to applications such as Excel and Microsoft Word for Windows.

Price: $99.95.
Contact: IntelliLink, 7 Parker St., Acton, MA 01720, (508) 264-9943; fax (508) 369-6900.
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First off, let's get one thing straight. We totally agree with Apple.* A truly powerful computer is measured in how often it's used.

IF YOU LISTEN TO APPLE, THIS IS THE MOST POWERFUL COMPUTER IN THE WORLD.

But while Apple has taken great strides in making the personal computer more useful, we've gone substantially farther.

Introducing the T2000SX notebook computer.

Quite simply, the T2000 SX is a more useful personal computer because it allows you to work how you want to work. When you want to work. And where you want to work.

Painstakingly engineered with you clearly in mind, the T2000SX will help you work more efficiently than ever before.

Virtually every feature you can find on a desktop computer, you will

Our technologically superior battery can be fully recharged in a mere ninety minutes.

find on the T2000SX: An 80386™SX processor with a math coprocessor socket, VGA compatible display, 1 MB (expandable to 9MB) of 80 nsec RAM, a 40 MB hard disk with 19 msec access time and 1.5 MB/sec data transfer rate.

The T2000SX has a 40MB hard disk with 19 msec access time.

But more important than the specs themselves, is the way the T2000SX lets you use them. Which is more often.

Our fluorescent side-lit screen provides even distribution of light. (Actual size.)

Welcome to the next generation in personal computing.

Because the T2000SX can fit easily into a briefcase (it weighs a scant 6.9 pounds), you can take it anywhere you go and use it in more ways than you can imagine.

Need to make revisions to a

Our internal AutoResume back up battery automatically saves your work if your main battery runs out.

business proposal? The T2000SX gives you the freedom to do it from a train. The client wants an estimate on costs? You can give it to him right then and there—wherever there is.

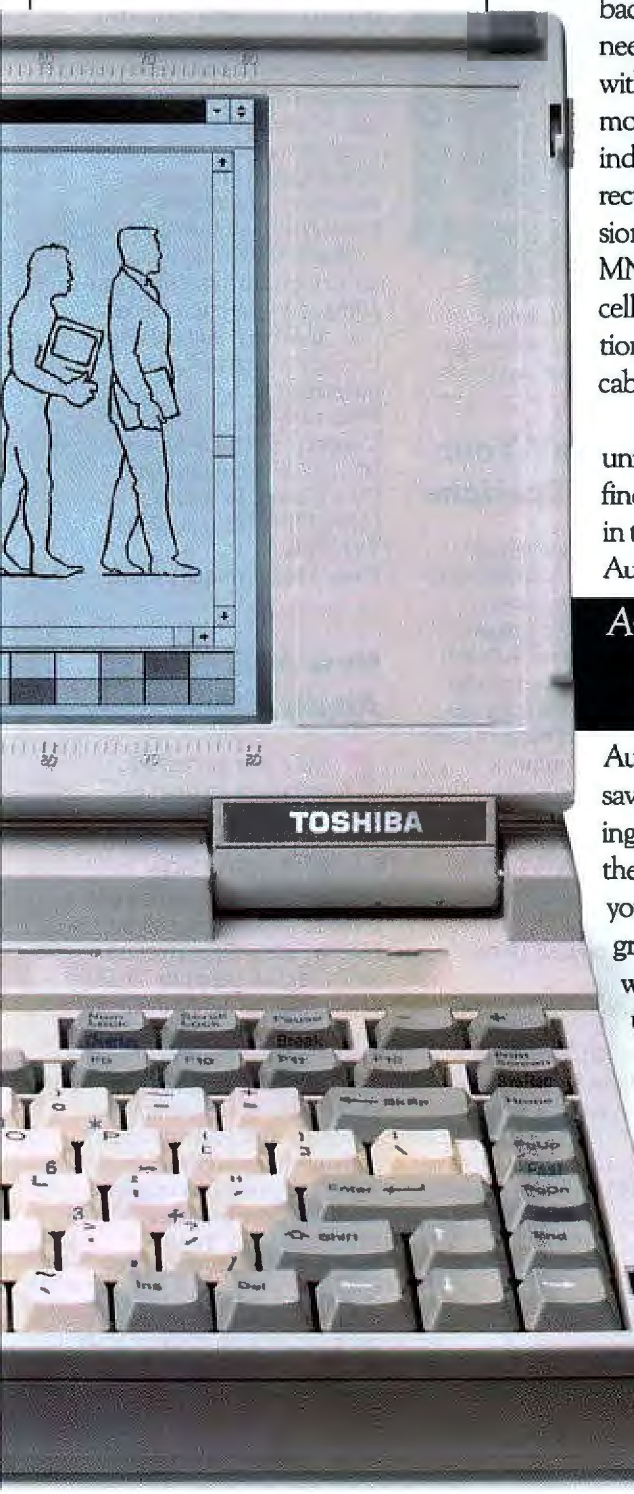
No more wasting time running back to the office. Because the office is always with you.

But just in case there's something

Our user-installed memory card allows you to add up to 8 MB of memory yourself.

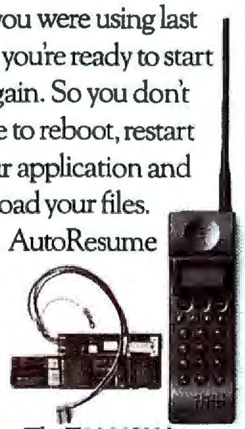
back at the office you still need, you can get back to it with our optional built-in modem. Which supports industry standard error corrections and data compression (CCITT V.42, V.42bis, MNP® 5). It even supports cellular data communications via our optional smart cable adapter.

The T2000SX also has a unique feature you won't find on any other computer in the world. It is called AutoResume.



AutoResume: Think of it as a bookmark for your computer.

AutoResume automatically saves whatever you're working on whenever you turn the computer off. And it lets you go directly to the program you were using last when you're ready to start up again. So you don't have to reboot, restart your application and reload your files. AutoResume also helps save on battery life and it allows you to change batteries without losing an ounce of information.



The T2000SX has an optional modem that allows data communications via a cellular phone.

The T2000SX comes complete with Hypertext on-line documentation.

As for batteries, the T2000SX touts the latest in battery technology—Nickel Hydride. Nickel Hydride delivers 22% more watt-hours per pound than NiCad and it doesn't suffer from memory effect.

In keeping with the Toshiba tradition, the T2000SX also offers superior ergonomics. Like full-size, standard-spaced keys on a keyboard which has a full set of 12 dedicated function and 8 cursor control keys. And a VGA compatible, reversible black on white or white on black high resolution display.

Okay, let's wrap this thing up.

These are just a few of the reasons why we believe the T2000SX is the most useful, and therefore, most powerful computer in the world. And why P.C. Week* Labs said, *"the T2000SX offers performance comparable to the LTE 386s/20, plus many of the design features that have made Toshiba a market leader in portable PCs."* PC WEEK

We invite you to learn more about the T2000SX and Toshiba's best-selling line of portable computers by calling us at **1-800-457-7777** for a complete information kit.

In closing, we'd like to thank you for reading our ad.

We'd also like to thank our friends at Apple for giving us such a wonderful endorsement.

In Touch with Tomorrow
TOSHIBA

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Gräbert Blitzes the AutoCAD Stair-Step Effect

The AutoPack Blitz combines software drivers for AutoCAD and Edsun Laboratories' Continuous Edge Graphics technology to let you display photo-realistic graphics on VGA-type displays. The combination of drivers and a single-slot board eliminates the stair-step effect in AutoCAD drawings by mixing more than 750,000 colors and shades at a virtual resolution of 2048 by 2048 pixels.

AutoPack Blitz also provides BirdsEye View capabilities; its display-list capabilities let you pan, zoom, and generate images as much as 10 times faster than with AutoCAD alone, the company claims.

Price: $595.

Contact: Gräbert Systems, Inc., 4330 North Civic Center Plaza, Suite 203, Scottsdale, AZ 85251, (800) 521-0240 or (602) 949-9722; fax (602) 949-9937.

Circle 1279 on Inquiry Card.

On a normal VGA display, this CAD drawing would appear jagged. But AutoPack Blitz, which uses Edsun Labs' technology, displays the drawing at a virtual 2048- by 2048-pixel resolution.

AEC Products for Generic CADD

Softdesk, developer of AutoCAD add-ins for civil engineering, surveying, and other architectural, engineering, and construction disciplines, now offers similar add-ins for Generic CADD 5.0 for the PC.

The GenCADD architectural program performs such tasks as layouts, drawing of walls and footings, addition of doors and windows, and the creation of building elevations. The GenCADD FF&E module provides furniture, fixtures, equipment, and other symbols.

GenCADD CoGo performs coordinate-geometry tasks, such as setting points, drawing lines, performing closures, and labeling metes and bounds.

Other products will include Landscape, Structural, HVAC (heating, ventilation, air conditioning), Electric, Plumbing, Data Collection, Input Reduction, Site Design, and DTM (digital terrain modeling).

GenCADD programs include the Generic CAD 5.0 engine. If you already have Generic CADD 5.0 or another GenCADD program, modules without the CAD engine are available at a reduced price.

Price: GenCADD packages, less than $1000 each; GenCADD modules, less than $500 each.

Contact: Softdesk, Inc. (formerly DCA Software), 7 Liberty Hill Rd., Henniker, NH 03242, (603) 428-3199; fax (603) 428-7901.

Circle 1280 on Inquiry Card.

"Hydrate" Your CAD Applications

Nth Graphics' Hydra View/AC visualization software lets you view, shade, and rotate images from within AutoCAD 386 release 11. You can render the model, check it for design flaws, and hot-key back to AutoCAD for quick editing.

A stand-alone version called Hydra View works outside AutoCAD and works with VersaCAD, MicroStation 3-D, and AutoCAD release 10 and 11 models.

Price: $595; Hydra View, $495.

Contact: Nth Graphics, 1807-S West Braker Lane, Suite S, Austin, TX 78758, (800) 624-7552 or (512) 832-1944; fax (512) 832-5954.

Circle 1281 on Inquiry Card.

Hit the Road, Mac

Vector Systems' latest version of the MacRoad interactive road-design package lets you lay out multiple roadbeds on a single contour map. The program can now save drawings in the DXF format for use in AutoCAD. For logging companies, Vector has added support for survey-data entry in standard forestry survey formats.

MacRoad 3.6 supports digital terrain modeling, profiling, cross-section views, plan drawings, and the ability to calculate earthworks quantities.

Price: $4000.

Contact: Vector Systems, Inc., 3700 Vanguard Dr., Fort Wayne, IN 46809, (219) 478-8088; fax (219) 747-5894.

Circle 1282 on Inquiry Card.

New ASG Applications

ASG's new surveying, terrain modeling, and road construction modules now support AutoCAD 386 release 11. ASG CoGo (surveying) features multiple traverse and sideshot capabilities. ASG Topo (terrain modeling) incorporates 3-D digital terrain modeling techniques for cross-section modeling and slope analysis.

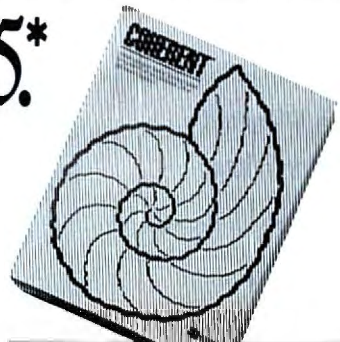
ASG Roads features programmable design templates for earthworks calculations and multilane highway design. The programs require the ASG Core program.

Price: CoGo or Topo, $1250; Roads, $2900; Core, $750.

Contact: ASG, 4000 Bridgeway, Suite 309, Sausalito, CA 94965, (415) 332-2123; fax (415) 332-2146.

Circle 1283 on Inquiry Card.

Everything You Ever Wanted In UNIX. And Less. $99.95*



OK. We know it's hard to believe. So just consider this. Coherent™ is a virtual clone of UNIX. But it was developed independently by Mark Williams Company. Which means we don't pay hundreds of dollars per copy in licensing fees.

What's more, Coherent embodies the original tenet of UNIX: small is beautiful. This simple fact leads to a whole host of both cost and performance advantages for Coherent. So read on, because there's a lot more to Coherent than its price.

SMALLER, FASTER...BETTER.

Everybody appreciates a good deal. But what is it that makes small so great?

For one thing, Coherent gives you UNIX capabilities on a machine you can actually afford. Requiring only 10 megabytes of disk space, Coherent can reside with DOS. So you can keep all your DOS applications and move up to Coherent. You can also have it running faster, learn it faster and get faster overall performance. All because Coherent is small. Sounds beautiful, doesn't it?

But small wouldn't be so great if it didn't do the job it was meant to do.

LESS IS MORE!	Coherent For the IBM-PC/AT and compatible 286 or 386 based machines.	Santa Cruz Operation's XENIX 286, Version 2.3.2
No. of Manuals	1	8
No. of Disks	4	21
Kernel Size	64K	198K
Install Time	20-30 min.	3-4 hours
Suggested Disk Space	10 meg	30 meg
Min. Memory Required	640K	1-2 meg
Performance*	38.7 sec	100.3 sec
Price	$99.95	$1495.00

*Byte Exec1 benchmark, 1000 iterations on 20 MHZ 386.
Hardware requirements: 1.2 meg 5¼" or 1.4 meg 3½" floppy, and hard disk. Does not run on Microchannel machines.

EVERYTHING UNIX WAS MEANT TO DO.

Like the original UNIX, Coherent is a powerful multi-user, multi-tasking development system. With a complete UNIX-compatible kernel which makes a vast world of UNIX software available including over a gigabyte of public domain software.

Coherent also comes with Lex and Yacc, a complete C compiler and a full set of nearly 200 UNIX commands including text processing, program development, administrative and maintenance commands plus UUCP.

CRITICS AGREE: IT'S AN INCREDIBLE VALUE!

"Mark Williams Co. seems to have mastered the art of illusion; Coherent comes so fully qualified as a UNIX clone, you find yourself thinking 'I can't believe it's not UNIX.'"
–Sean Fulton, UNIX Today!, November 26, 1990

"...(Coherent) may be the best thing that has happened to UNIX yet."
–William Zachmann, PC Week, November 5, 1990

"If you want to come as close as you can to real UNIX for a low price, COHERENT can't be beat."
–Warren Keuffel, Computer Language Magazine, November 1990

"If you want a UNIX-like development and learning system for less than $100...I don't see how you can go wrong with Coherent."
–David Fiedler, BYTE Magazine, November 1990

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*Plus shipping and handling. Coherent is a trademark of Mark Williams Company. UNIX is a trademark of AT&T. XENIX is a trademark of Microsoft.

Travel to the Planets on Your Mac

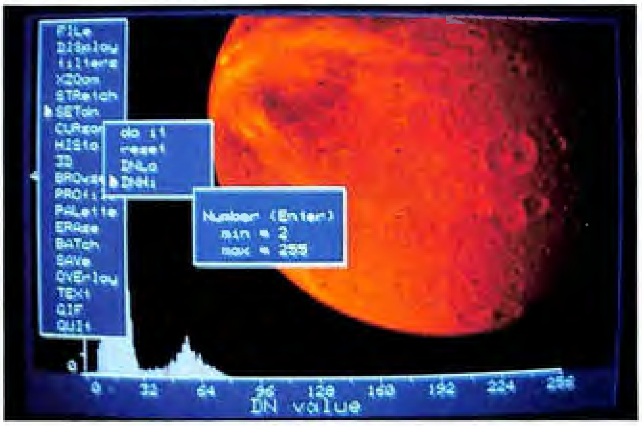
CD-ROM Voyage to the Planets, a collection of three CD-ROMs full of images from Mars, Jupiter, Neptune, and other planets, is now available for the Mac.

Each disc has more than 500 images. Volume 1 contains images of Jupiter, Saturn, Uranus, and its moons; Volume 2, Mars; and Volume 3, Neptune and its moons. Each disc (also available for the PC with a VGA, SVGA, or EGA display) provides 3-D displays, zoom, and histogram analysis.

Price: For the PC: $120 each volume, all three for $300; for the Mac: $180 each, all three for $400.

Contact: Astronomical Research Network, 206 Bellwood Ave., Maplewood, MN 55117, (612) 488-5178.

Circle 1284 on Inquiry Card.



The CD-ROM Voyage to the Planets, for Macs and PCs, displays an image of Dione, a satellite of Saturn.

Unix GUE for Real-Time Engineering

A new graphical user environment (GUE) for the aerospace and manufacturing community lets you develop front-end displays of real-time or database-residing data in a distributed computing environment over several platforms and operating systems.

The Sammi GUE lets you modify the display without requiring complex programming and source code modification. Unlike traditional graphical user interfaces, the Sammi GUE is not embedded into the code of applications software programs, Kinesix says.

Sammi consists of a run-time environment, a format editor, and an application programming interface (API). With Sammi, you can create a graphical interface in front of application data in a client/server computing environment. It does this through the X Window System version 11 and remote procedure calls.

The system lets you access and modify a series of color-coded meters and gauges, bars and graphs, push buttons, and other widget objects. The system also supports data plotting and alarm handling. Through windowed displays, you can view data in a format tailored for the operator or industry.

Building an interface with the included format editor first involves defining the background, using either your drawing created with Sammi's tools or a scanned X bit-map, GIFF, or CGM file. Without programming, you can define dynamic fields using the library of objects that are tied to data.

If you need complex relationships with the data source, the included API utilities let a C programmer create a customized interface between the data-source application and Sammi. Sammi acts as a stand-alone task.

Sammi will run on a variety of IBM, Sun, DEC, and Hewlett-Packard/Apollo platforms.

Price: $12,500 to $25,000, depending on configuration.

Contact: Kinesix, 10333 Richmond Ave., Suite 1100, Houston, TX 77042, (713) 953-8300; fax (713) 784-4159.

Circle 1285 on Inquiry Card.

The Sammi graphical user environment lets you create applications such as this pipeline-control system without programming.

Labtech Expands to Unix and Windows

Labtech Notebook, for data acquisition, analysis, and control, and Labtech Control, for industrial-process monitoring and control, are now available for Windows 3.0. The new versions support virtual memory and flexible multitasking, Laboratory Technologies says.

The company has also released Chrom/RT, a program for gas, high-pressure liquid, and ion chromatography. Chrom/RT supports the X Window System, Windows 3.0, and Presentation Manager under OS/2.

Another new program, Notebook/XE for DOS, X Window, Windows 3.0, or OS/2, supports multiple real-time screen displays, remote instrumentation support, and real-time data transfer to foreground programs.

Price: Notebook for Windows, $1495 before July 31; Control for Windows, undetermined at press time; Chrom/RT: DOS/Windows or OS/2 version, $2495 before July 31, $2995 after; Unix version, $7000; Notebook/XE: $2495 and up.

Contact: Laboratory Technologies Corp., 400 Research Dr., Wilmington, MA 01887, (508) 657-5400; fax (508) 658-9972.

Circle 1286 on Inquiry Card.

SPREAD THE WORD

Your new product is important to us. Please address information to New Products Editors, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Better yet, use your modem and mail new product information to the microbytes.hw or microbytes.sw conferences on BIX. Please send the product description, price, ship date, and an address and telephone number where readers can get more information.

A Familiar Look for Your Desktop

A new front end for Windows takes desktop familiarity to the extreme with the goal of expediting the learning curve for new Windows 3.0 users. The deskMinder program provides the ability to launch applications, managers, and utilities from what appears to be an actual office desk.

You can place up to four applications on the deskMinder bookshelf and configure four shelves so that you can launch up to 16 Windows and non-Windows applications from your hard disk. On top of the desk, you have access to a notepad, time manager, help file, and clock. By clicking on the pencil cup, you activate a paint program, and by clicking on the PC that resides on the deskMinder desktop, you open a link to your file server, minicomputer, or mainframe. When you click on the phone, you can take phone messages or activate the modem.

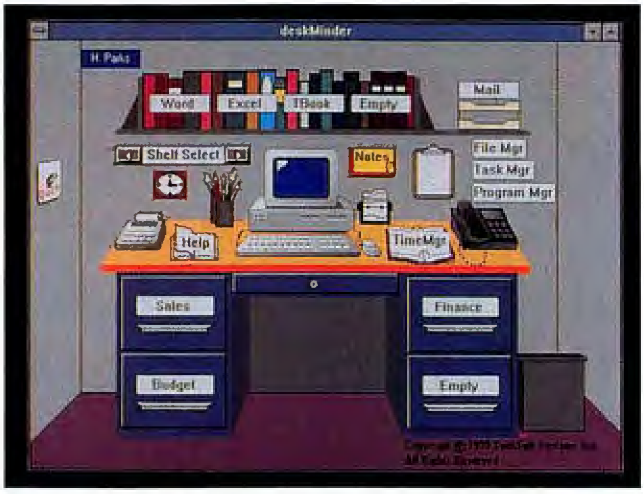
In the file drawer, you can create folders to hold your files and projects, indicate which application to launch from each file, and search and sort through files. Clicking on the out basket activates E-mail.

Of course, when you're done working in the deskMinder environment, the way that you quit is by turning out the lights.

Price: $199.

Contact: TechSoft Systems, Inc., 1375 Kemper Meadow Dr., Suite 11, Cincinnati, OH 45240, (800) 825-8386 or (513) 825-8386; fax (513) 825-9726.

Circle 1002 on Inquiry Card.



With the deskMinder front end, developed with Asymetrix's ToolBook software construction set, file drawers are file drawers, a notepad is a notepad, and a clock is a clock.

Join the 1990s with Electronic Click-It Notes

If the personal computer was supposed to automate the office environment, why do you still put sticky notes all over your desk and computer?

A new groupware program, called Pinboard, lets you create on-screen notes for pinning to the Windows desktop or sending over the network.

On a network, each Pinboard user can password-protect a private board, while shared boards are accessible to several people simultaneously. Pinboard supports all disk-sharing networks, including LAN Manager and Novell NetWare. For power users, Pinboard supports Dynamic Data Exchange. You can also attach programs and documents to a note.

Perhaps the best thing about Pinboard is the way it lets you dispose of messages: When you receive a nasty note from your boss or colleague, after you read it and place it in the wastepaper basket, you can watch it burst into flames.

Price: $129.95; 25-user extension, $1495.

Contact: Raindrop Software Corp., 845 Arapaho, Suite 105, Richardson, TX 75081, (214) 234-2611; fax (214) 234-2674.

Circle 1003 on Inquiry Card.

Pinboard comes with more than 40 styles of notes, such as phone messages, to-do lists, and urgent memos.

A New VUE for Sun

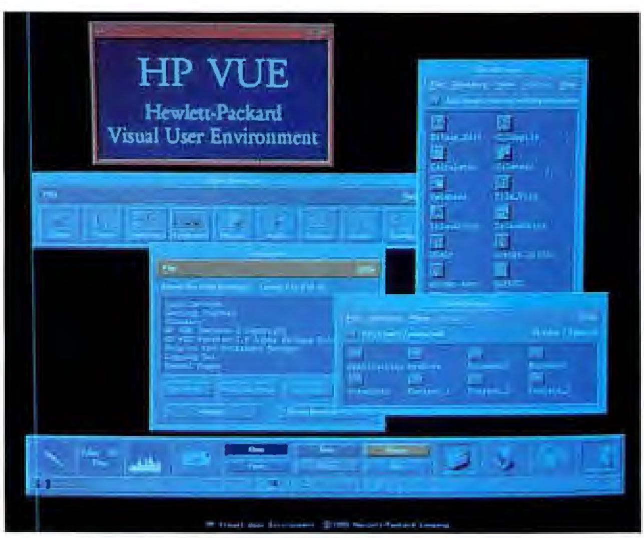
Hewlett-Packard will soon have a version of its Visual User Environment that will support Open Look and Motif applications running on Sun Sparcstations.

HP VUE, previously available only for HP computers, offers multiple workspaces, a front panel that holds frequently used applications, and systemwide help. Five main components include a log-in manager, file manager, workspace manager, style manager, and help manager.

Price: $550.

Contact: Hewlett-Packard Co. Inquiries, 19310 Pruneridge Ave., Cupertino, CA 95014, (800) 752-0900.

Circle 1004 on Inquiry Card.



The Visual User Environment for Unix now supports Sun Sparcstations. The five basic VUE tools are shown here.

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Circle 560 on Inquiry Card (RESELLERS: 561).

NEWS

WHAT'S NEW • PROGRAMMING TOOLS

Software Tester for Character Applications

Automator QA, the CASE-like tool for testing software, is now available in the U.S. The program provides software testing that will improve your application, increase your productivity, reduce development time, and cut validation and quality-assurance costs, Direct Technology says.

The program offers a full range of test services: Regression, which ensures that features of a previous release are still present; Performance, which checks minimum, average, and maximum acceptance criteria; Response, which checks interference, error handling, and math and system functions for adherence to specification; and Volume, which provides the benefits of beta testing at an earlier stage by testing over a wide range of tasks with random or sequential input. The product resides in a PC workstation, which is typically attached to the host as a terminal.

Automator QA was designed for testing complex character-based applications. You can test any application that is accessible from a PC workstation in terminal-emulation mode, including MVS, VM, VMS, and Unix. Test-system requirements include a 286- or 386-based system with 640K bytes of RAM, DOS 3.0, and an 80-MB hard disk drive.

Price: $5495.

Contact: Direct Technology, 10 East 21st St., Suite 1204, New York, NY 10010, (800) 992-9979 or (212) 475-2747; fax (212) 529-4941.

Circle 1008 on Inquiry Card.

With Quinn-Curtis's real-time graphics tools, you can simulate real-world applications, such as this dashboard.

Real-Time Graphics, Control for C and Pascal

The Real-Time Graphics and Measurement/Control Tools for Microsoft C, Turbo C, Borland C++ 2.0, and Turbo Pascal combine real-time graphics routines with measurement and control algorithms. Quinn-Curtis says you can use the tools to create graphics-based programs that perform process-control, data-logging, and instrument-interface operations.

Price: $200 each version.

Contact: Quinn-Curtis, 21 Highland Cir., Needham, MA 02194, (617) 449-6155; fax (617) 449-6109.

Circle 1005 on Inquiry Card.

Add Breathing Space for Your Applications

Rational's new utility, called Oxygen, binds the company's DOS extender technology to Microsoft's C compiler and linker.

The utility lets you compile and link large applications from Windows, your editor, or the Programmer's WorkBench without having to remove network drivers, TSR programs, and other tools from your environment. With Oxygen installed, the Microsoft compiler and linker consume less than 50K bytes of the first 640K bytes of RAM, with the remaining portion running in extended memory.

Oxygen conforms to the Virtual Control Program Interface, DOS Protected Mode Interface, and EMS interface standards. It operates alone or with Windows 3.0, QEMM, 386Max, and other extended memory managers with Microsoft C 6.0.

Price: $199.

Contact: Rational Systems, Inc., 220 North Main St., Natick, MA 01760, (508) 653-6006; fax (508) 655-2753.

Circle 1007 on Inquiry Card.

Brief Gets Expanded, Redone

Solution Systems adds mouse support, EMS caching, a Redo command, enhanced window capabilities, and support for Microsoft's C 6.0 Advisor in the new Brief text editor for the PC.

By supporting EMS, Brief 3.1 lets you edit larger files and hold macros in memory throughout the editing session. Mouse support provides faster cursor placement and the ability to control where and how your windows appear on the screen.

A new Redo command complements the Undo command. Other features include support for more than 40 compilers, smart indenting, and template editing. With template editing, you can type in an abbreviation, and Brief will expand it into a programming construct.

The company has also released Charge, a profiler with a direct interface to Brief. You can use Charge to identify often-used routines and optimize them for a faster-executing application.

Price: $249; Charge, $99.

Contact: Solution Systems, a division of Software Developer's Co., Inc., 372 Washington St., Wellesley, MA 02181, (800) 821-2492 or (617) 431-2313; fax (617) 740-0089.

Circle 1006 on Inquiry Card.

E-Mail in Windows Word Processor

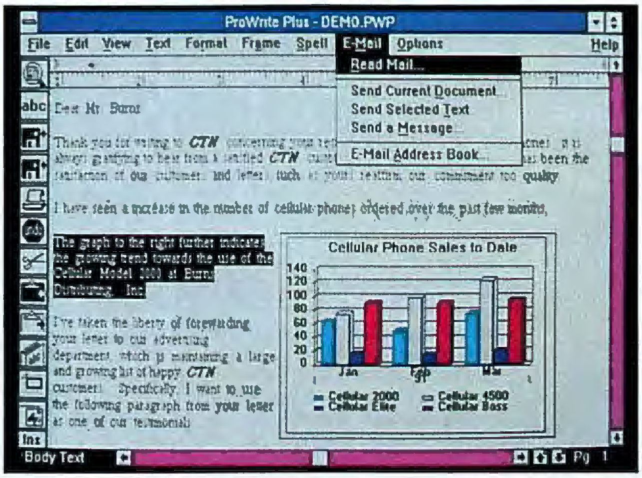
After composing your document with Professional Write Plus for Windows, you can activate an integrated E-mail function to send the file anywhere in a network without exiting the word processor. The program from Software Publishing uses technology licensed from Samna in a one-time deal to let you retain the file's formatting and graphics.

You can paste graphics or text on frames that you can drop anywhere on the page, with surrounding text wrapping around the frame. Software Publishing added document- and image-file filters to support its own applications, including Harvard Graphics and First Publisher. The E-mail front end supports any Message Handling Service–based system.

Price: $249.

Contact: Software Publishing Corp., 1901 Landings Dr., P.O. Box 7210, Mountain View, CA 94039, (415) 962-8910; fax (408) 980-0729.

Circle 1009 on Inquiry Card.



Professional Write Plus's E-mail front end lets you send and receive a portion of a working document without exiting your word processor.

Check Your Government Style

The new version of Grammatik Windows 2.0, Government Edition, for Windows works within Microsoft Word for Windows and Ami Pro from Lotus, letting you check your spelling, grammar, and style without quitting your word processor. The spelling checker includes more than 1000 government-specific spellings and acronyms and a proposal proofreading style for government contractors, Reference Software says. The new version also locates thousands of additional errors, including redundant phrases, clichés, and syntactic mistakes.

The Windows version and the standard Grammatik IV 2.0 Government Edition, which are available for DOS, the Mac, and Unix, let you access the user spelling dictionary of most word processors, allowing the checkers to recognize words, acronyms, and other special words that you've already added.

Price: Single-user version, $99; Government Pack for five users, $245; standard version, $99 and $245.

Contact: Reference Software International, 330 Townsend, Suite 123, San Francisco, CA 94107, (415) 541-0222; fax (415) 541-0509.

Circle 1012 on Inquiry Card.

Correct Your Grammar in Windows

Keeping track of the players in the word processing market is like riding a merry-go-round. Lotus acquired Samna, but not before Samna licensed technology to Software Publishing. Now WordStar has bought Lifetree, maker of the Correct Grammar checker. Lifetree will become part of WordStar's new Writing Tools Division.

That division's first product is Correct Grammar for Windows, which was already available in DOS and Mac versions. By using Dynamic Data Exchange, Correct Grammar lets you check any text, in any application, on the Windows Clipboard, WordStar says. You can select and check just a portion of a document, such as a sidebar.

Price: $99.

Contact: WordStar International, Inc., Writing Tools Division, One Harbor Dr., Suite 111, Sausalito, CA 94965, (415) 332-8692; fax (415) 332-8780.

Circle 1010 on Inquiry Card.

Prepare Documents in Unix GUIs

Intended for technical and business users, Asterix 1.1 offers low-cost but powerful document processing, with capabilities falling somewhere between those of a high-end word processor and a full-blown desktop publishing system. The system for Unix workstations runs under Motif and Open Look on SPARC-based and DEC RISC systems, the Sun-3, the Hewlett-Packard 9000 series 300, and Mips RISC System workstations.

Asterix Words is a WYSIWYG word processor, with style guides, X Clipboard cut and paste, advanced formatting, and book production capability. Asterix Graphics lets you create, edit, and modify graphics. You can create drawings in the graphics module or capture Hewlett-Packard Graphics Language, TIFF, or Encapsulated PostScript screen images.

An optional spreadsheet module supports inter-spreadsheet data links, projected tables, goal seeking, and multiple views.

The Asterix application set has a common group of macro tools and a programming language. Other features include audio for voice annotations, color images, fax support via macros, and interprocess communications. The company is also developing E-mail capabilities.

Price: $695; with optional spreadsheet, $995.

Contact: Applix, Inc., 112 Turnpike Rd., Westborough, MA 01581, (800) 827-7549 or (508) 870-0300; fax (508) 366-9313.

Circle 1011 on Inquiry Card.

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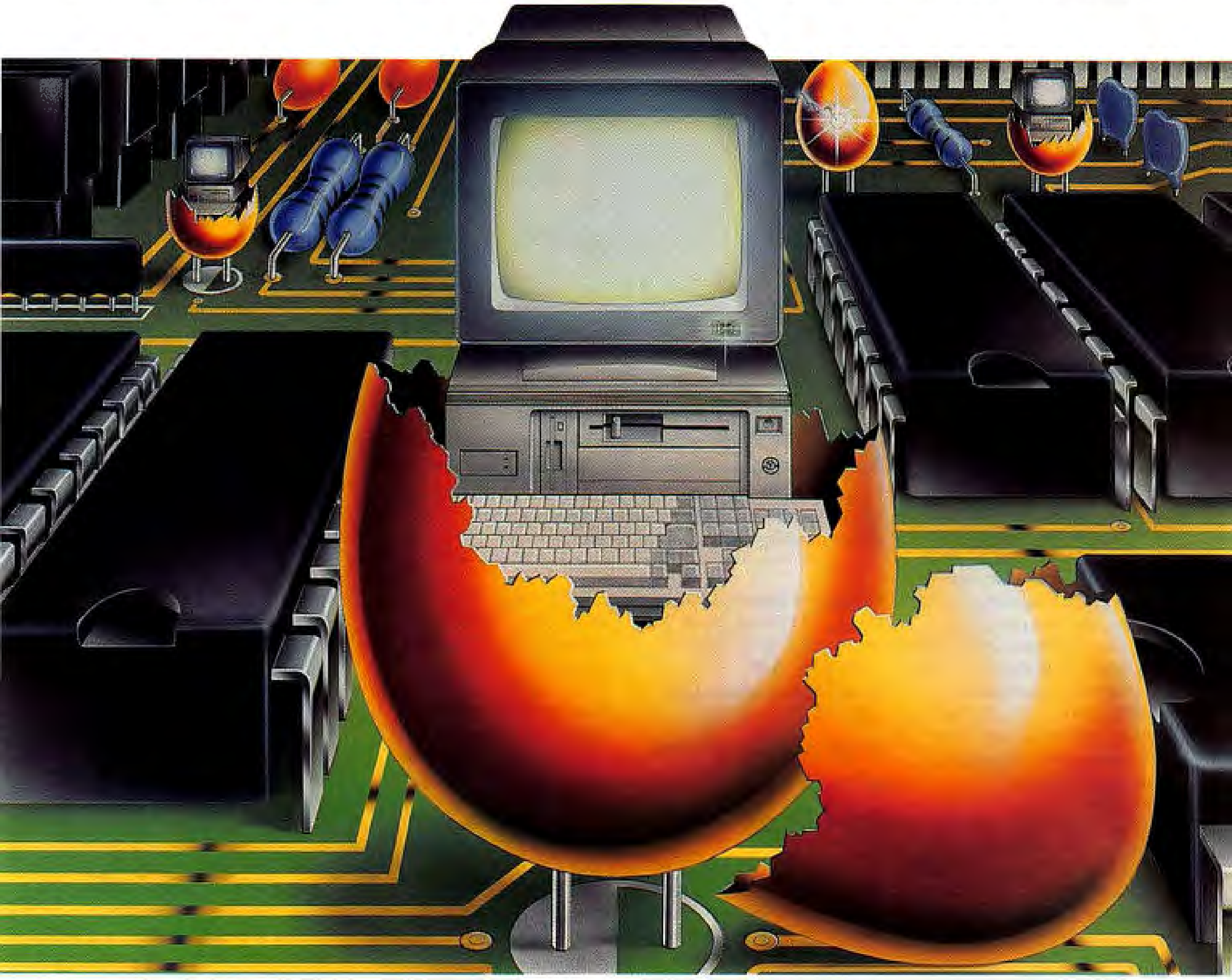

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Distributor Inquiries Welcome

Circle 558 on Inquiry Card (RESELLERS: 559).

New Clipper Library Supports Vector Objects

Flipper 5.0, the graphics library for Clipper developers, now lets you include vector objects (e.g., circles, polylines, and boxes) and text in a drawing. The library lets you create maps, facility layouts, and other CAD drawings to better display data in your application, ProWorks says.

The company improved Flipper's printing capability by adding a PostScript driver and a virtual print driver that lets you print at the resolution of the printer, instead of at the lower resolution of the traditional print screen, the company says. You can also place PCX files anywhere on the screen.

Other Flipper features include 2-D and 3-D graph types, auto-scale axis and log scales, and unlimited points on a graph.

Price: $295.
Contact: ProWorks, P.O. Box 1635, Hermiston, OR 97838, (503) 567-1459; fax (503) 567-8820.
Circle 1013 on Inquiry Card.

Flipper 5.0 lets you put a CAD-like interface on your database application. By clicking on a green on the golf course, you can access watering and maintenance data.

Analyze Paradox Scripts

ScriptView 2.01 provides Paradox users with an advanced tool for analyzing and documenting scripts, Farpoint says. The utility generates graphical diagrams and comprehensive reports, including action diagrams, hierarchical-tree flowcharts, procedure relationship reports, and extensive variable cross-references and tables.

The new version supports the new language extensions of Paradox 3.5, including the Structured Query Language commands.

Price: $149.95.
Contact: Farpoint Systems Corp., 335 Grove, Suite 260, Jersey City, NJ 07302, (201) 659-7613.
Circle 1015 on Inquiry Card.

Communications Library for Clipper

SilverClip SPCS (SilverWare Professional Communications Series), SilverWare's newest communications library, brings interrupt-driven control of asynchronous communications to Clipper applications. SilverClip SPCS lets you access an unlimited number of communication ports and comes with source code.

Features include support for a 115,000-bps baud rate. Supported hardware includes DigiBoard's 4-, 8-, and 16-port boards, the AST 4 Port, and the IBM Dual Async Adapter. Terminal emulation includes ANSI, TTY, VT100, and VT52. The library also supports XMODEM, YMODEM, YMODEM batch, and ASCII. Other features include interrupt 14 redirection, for LAN compatibility.

Price: $299.
Contact: SilverWare, Inc., 3010 LBJ Freeway, Suite 740, Dallas, TX 75234, (214) 247-0131; fax (214) 406-9999.
Circle 1115 on Inquiry Card.

More Than 90 Commands for xBASE

The xBASELIB command library enables you to perform low-level DOS and BIOS commands from the dot prompt, the FoxPro command window, and programs like FoxBase+, dBASE III Plus, and dBASE IV version 1.1.

Sparkle developed the library to help you support and install your application and to help your application communicate with the printer. If you include the GETPCENV.PRG program in the application, for example, you can quickly obtain information about your client's PC environment.

The xBASELIB commands are written in assembly. You can move the commands from one version of dBASE to another without modifying them, Sparkle says.

Price: $195.
Contact: Sparkle Software, 610 East Bell Rd., Suite 2136, Phoenix, AZ 85022, (602) 780-2208.
Circle 1014 on Inquiry Card.

More Than 1000 dBASE Utilities

EMS Professional Shareware Libraries' dBUtility Library has more than 1400 public domain and shareware utilities designed specifically for dBASE language developers, including dBASE III/IV, FoxBase, FoxPro, Clipper, QuickSilver, and others.

The product includes a database and search program for these and 800 additional commercial dBASE-related utility programs. With the database, you can search by name, type, vendor, or any text string when you need to find a particular type of utility or code routine. This way, if you can't find the utility you need in the shareware library, you can find it in the database of commercial vendors. The dBUtility Directory also lists dBASE BBSes, journals, and other information sources.

Price: $99.50.
Contact: EMS Professional Shareware Libraries, 4505 Buckhurst Court, Olney, MD 20832, (301) 924-3594; fax (301) 963-2708.
Circle 1016 on Inquiry Card.

Make Your Graphs Leap off the Page

You'll gain perspective on your graphical data when you use Bloc Publishing's chart maker to plot it. 3-D Charts To Go! is compatible with Windows 3.0 and lets you create pie, bar, ribbon, and area charts. Each chart can exhibit a value range of up to 15 by 150 units, and you can merge up to 10 charts into a single display. A split-screen function lets you see your data as you produce a chart.

3-D Charts lets you transfer data from Windows software (e.g., Excel and Wingz) without leaving the program. You can also import directly from Lotus worksheet files.

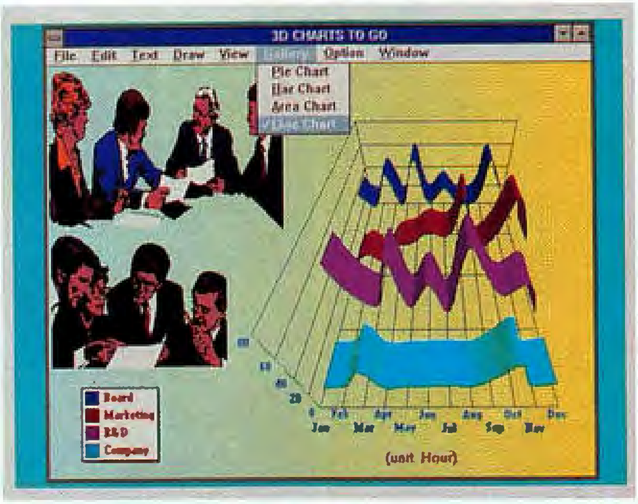
The program offers 17 chart-drawing patterns, as well as eight foreground and eight background colors. It supports Windows Meta File, PCX, and Windows Bit Map formats, so you can add clip art to your charts. You can rotate, size, or move the charts in different dimensions and use different colors, sizes, and fonts for all text.

3-D Charts To Go! requires Microsoft Windows 2.0 or higher, a display adapter that supports Windows, 640K bytes of RAM, and a mouse or tablet.

Price: $99.95.

Contact: Bloc Publishing, 800 Douglas Entrance, Executive Tower Penthouse, Coral Gables, FL 33134, (305) 445-0903; fax (305) 444-5010.

Circle 1017 on Inquiry Card.



3-D Charts To Go! gives your data depth and individuality with a wide range of color and art options.

An Eyeful of Imagery for the Mac

New clip-art collections from Newton Technology and SoftAge Publishing bring finesse to your professional presentations.

Newton Technology's GEOvista creates color or black-and-white maps that display information geographically on the Mac. You can import data from text files, spreadsheets, or databases and assign it to the maps that are included in the program. GEOvista features pull-down menus, cut-and-paste editing, and interfaces with most Mac word processors and desktop publishing applications. The program is CD-ROM-compatible.

Price: $249.

Contact: Newton Technology, Inc., 70 Walnut St., Wellesley, MA 02181, (617) 239-8202.

Circle 1018 on Inquiry Card.

Professional Clip Art Gallery, from SoftAge, features 1000 images for either Mac or DOS systems. The program features 18 categories of images, including business, sports, and holidays. Clip Art Gallery will support any program that imports DOS PCX or Mac TIFF files, including WordPerfect 5.0 and PageMaker. SoftAge also offers a 77-image sampler of Clip Art Gallery's artwork.

Price: $299; Sampler Pack, $24.99.

Contact: SoftAge Publishing, 1753-C East Palmdale Blvd., Suite 433, Palmdale, CA 93550, (800) 736-7103 or (805) 945-0051; fax (800) 869-1434 or (805) 723-7156.

Circle 1019 on Inquiry Card.

Presentation Team Makes an Impact

Presentation Team 2.0 offers slick improvements to its predecessor, thanks to Novell NetWare support and integrated text charting, drawing, and graphing. The program includes hundreds of clip-art images that can be imported to and exported from many applications, including GEM and Windows Meta Files.

Presentation Team lets you create, edit, and store images in a single file, letting you page through a series of visuals as you would a document. You can use Presentation Team to create overhead transparencies, 35mm slides, printed copy, and on-screen presentations. The package offers direct software linkup via modem with MAGICorp, a company that will create presentation materials from your visual files.

Price: $495; each network site, $395.

Contact: Digital Research, Box DRI, 70 Garden Court, Monterey, CA 93942, (408) 649-3896; fax (408) 646-6248.

Circle 1020 on Inquiry Card.

ANIMaxx Brings Graphics to Life

ANIMaxx brings low-cost animation to your PC. The program runs under Windows 3.0 and is compatible with Autodesk Animator .FLI format. The program comes with eight animations, or you can design your own.

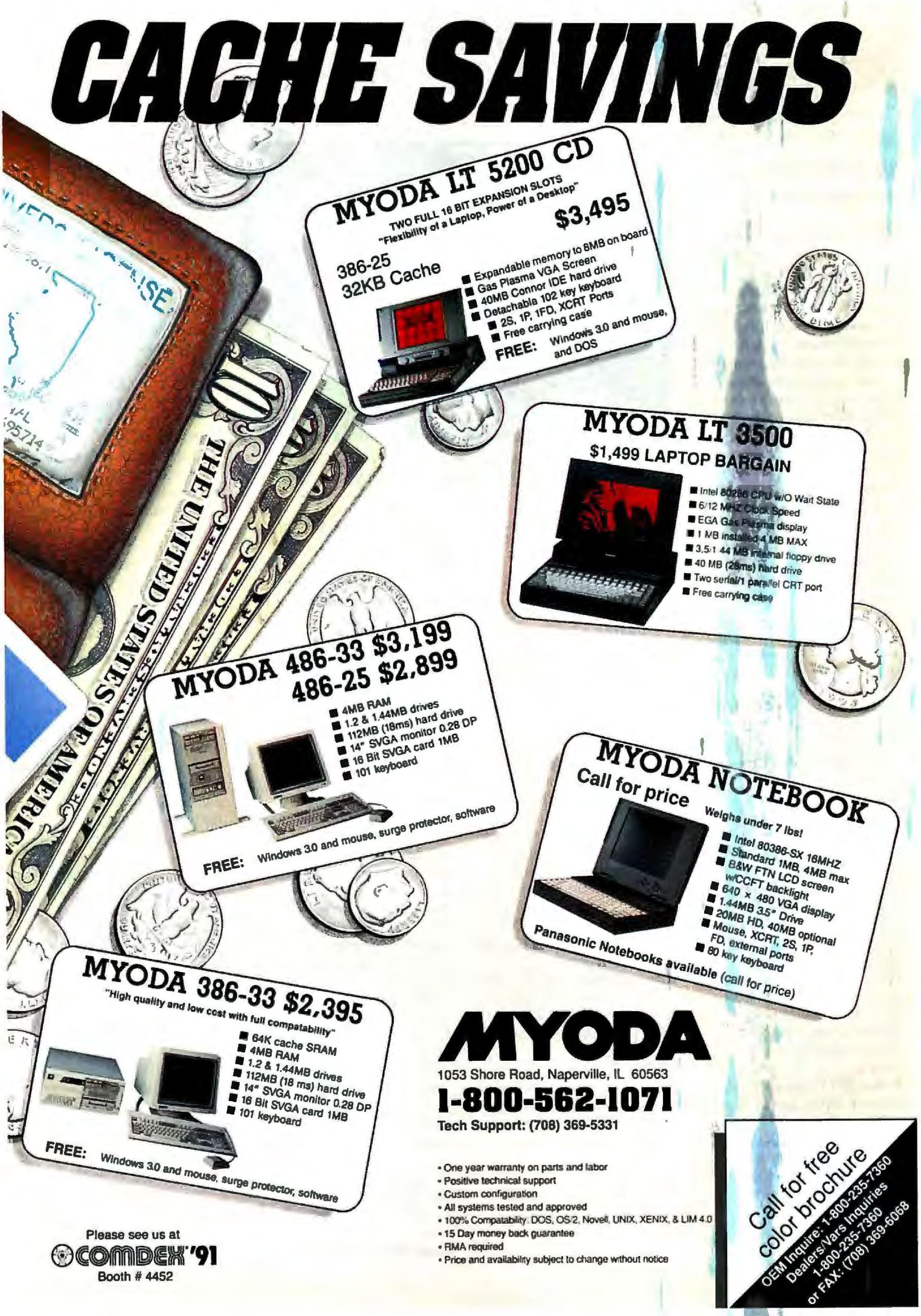
ANIMaxx features frame flipping, single frame stepping, and continuous cycle functions, and it will animate images at rates of up to 15 frames per second. The program supports up to 256 colors and works with 2-D graphics tools or 3-D shapes and volumes.

ANIMaxx will run on a 286, but a 386 is recommended. The program requires a VGA, Super VGA, EGA, or 8514A video board.

Price: $33.95.

Contact: North Coast Software, P.O. Box 343, Barrington, NH 03825, (603) 332-9363; fax (603) 332-2137.

Circle 1021 on Inquiry Card.



Circle 563 on Inquiry Card (RESELLERS: 564).

Sync Sound to Autodesk Animations

The MediaSync multimedia system for the PC lets you attach trigger points to spoken words and phrases or to other events in a soundtrack, synchronizing animations and images to sound. The trigger points can actuate an audio response from a video event or vice versa, Genesis says.

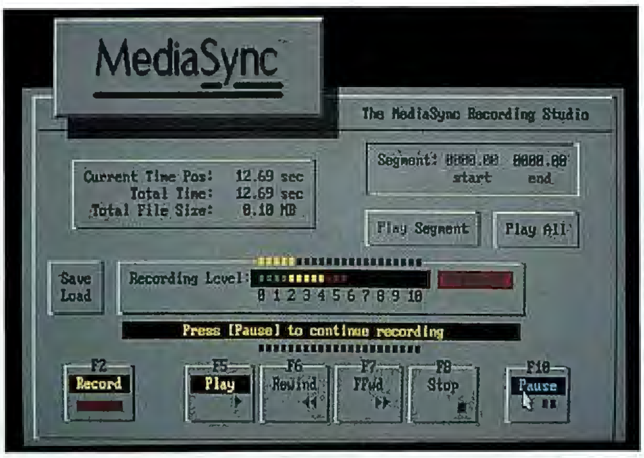
The program's Frame-Accurate Audio Scheduling feature lets you synchronize soundtracks, audio effects, and volume changes from one or more frames in an Autodesk Animator or Autodesk 3D Studio animation. With the system, you can assign voice annotations to key frames during a building walk-through and synchronize footsteps and other sound effects right in the PC, eliminating the need to manually dub audio to the video portion after you record it to tape.

The MediaSync system includes a digital audio capture and playback board that samples at 16 kHz, offers 10-bit resolution, and uses 500K bytes of hard disk space for 1 minute of digital audio. A professional version of the program lets you organize presentations into interactive, hypermedia applications. If you don't require full-fidelity audio, the company offers MediaSync: Sound Blaster for owners of the 8-bit Sound Blaster audio card who want to play .VOC files.

Price: $695; professional version, $895; Sound Blaster software, $199.

Contact: Genesis Development Corp., 15850 West Bluemound Rd., Suite 307, Brookfield, WI 53005, (414) 796-1005; fax (414) 797-0727.

Circle 1022 on Inquiry Card.



The MediaSync Recording Studio lets you vary the volume of a sound effect for Autodesk's Animator and 3D Studio.

A Librarian for Your Floppy Disks

For that moment when you need a file but can't determine on which floppy disk the file resides, Stuart-Matlock developed Floppie Librarian V.

The utility helps you manage your floppy disks by letting you locate any file on any disk sorted by disk number, category, user code, and disk description title. The company claims you can categorize a disk in 3 seconds, or about 500 disks in 2 hours. When you put the floppy disk in its drive, the program seeks out and identifies executable, data, and other files to create the database. A memo pad lets you attach a description of up to 65,000 characters for each disk.

Floppie Librarian V generates five reports, including disk directory, evaluation, capacity, category, and comprehensive media information.

Price: $59.95.

Contact: Stuart-Matlock Corp., P.O. Box 541, Mt. Laurel, NJ 08054, (609) 866-7699; fax (609) 866-7598.

Circle 1023 on Inquiry Card.

BYTE-Article Database on a Disk

A new program for the PC lets you search for BYTE articles by selecting from over 5000 keywords. You choose a keyword from the list or begin typing, and Bindex will jump to the closest keyword. Then Bindex lists the volume, number, date, page number, author, title, and description of each article in a given BYTE year that relates to the keyword you have chosen.

Every article is indexed, as are Letters, Ask BYTE, Chaos Manor Mail, Microbytes, Nanobytes, What's New, and more. Bindex for 1990 includes references to more than 1700 separate articles.

Price: 1990 and 1991 editions, $49.95 each.

Contact: Esc, 6197 Highway E, Abrams, WI 54101, (414) 826-5362 ("ecolantonio" on BIX).

Circle 1024 on Inquiry Card.

Two Disk-Duplicating Programs

FormGen's disk-copying utility offers companies, services, and publishers a way to quickly format and duplicate disks. The program manages the entire process, including formatting, serialization, duplication of program masters, and statistics gathering.

ProCopy requires a PC with an automatic disk-loading device. FormGen claims the program can reduce disk-duplication time to less than 10 seconds per disk.

Price: $295.

Contact: FormGen Corp., 13 Holland Dr., Bolton, Ontario, Canada L7E 1G4, (416) 857-4141; fax (416) 857-4531.

Circle 1025 on Inquiry Card.

Micro System Designs says its DiskDupe Pro can duplicate 62 disks per hour, and up to 200 disks per hour if they have been formatted. The company says the utility reads the master disk into memory and onto the hard disk drive, making as many copies as necessary without having to re-read the disk. DiskDupe uses the hard disk as a buffer without slowing down the copying speed, according to MSD.

Price: $179.

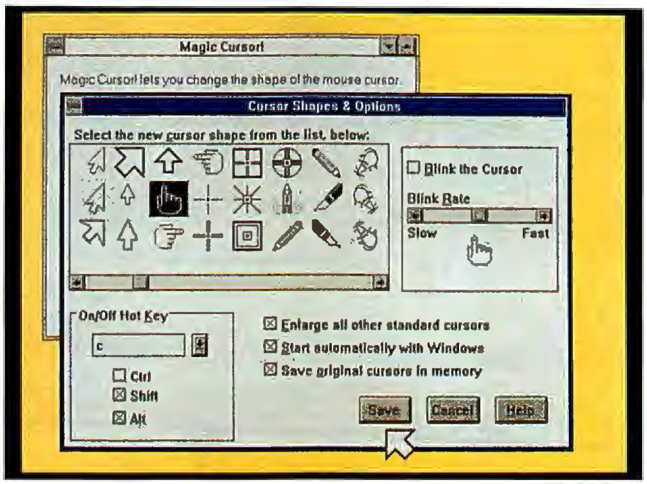
Contact: Micro System Designs, Inc., 4962 El Camino, Suite 204, Los Altos, CA 94022, (415) 964-2844; fax (415) 964-4529.

Circle 1026 on Inquiry Card.

A Big Cursor and Two Whisker Ticklers

Two companies, Fanfare and Numbers, have released utilities that can reduce the time you spend mouse-clicking. Fanfare's Magic Cursor! also diminishes squinting.

Fanfare's Right On!, a mouse utility for Windows 3.0, lets you make better use of the right and middle mouse buttons. You can set the right or middle button to simulate a left-button double-click, send any keystroke, or run any program. By simulating a left-button double-click with a single click, you can save time, Fanfare says. You can program up to eight different actions for the two buttons, for a total of 16 possible settings, Fanfare says.



Magic Cursor! lets you enlarge a Windows arrow cursor by five times or choose from 40 different cursor shapes.

With the Magic Cursor!, you can enlarge and customize a standard Windows arrow, making it easier to see.

Price: Right On!, $49.95; Magic Cursor!, $49.95.

Contact: Fanfare Software, 9420 Reseda Blvd., Suite 828, Northridge, CA 91324, (818) 886-8787.

Circle 1027 on Inquiry Card.

Numbers' enhanced version 3.01 of Whiskers for Windows 3.0 lets you reprogram the middle and right buttons of the mouse and simulate a middle button on a two-button mouse. You can assign a left double-click to either the right or the middle button. You can also assign commands to the mouse, as well as instruct Whiskers to automatically turn itself off in applications that already use the right or middle button.

Developed for the two- or three-button mouse, Whiskers 3.01 works with any Windows 3.0 application. You can toggle Whiskers on and off.

Price: $24.95.

Contact: Numbers & Co., Route 1, P.O. Box 59A, Oroville, WA 98844, (509) 476-2216.

Circle 1028 on Inquiry Card.

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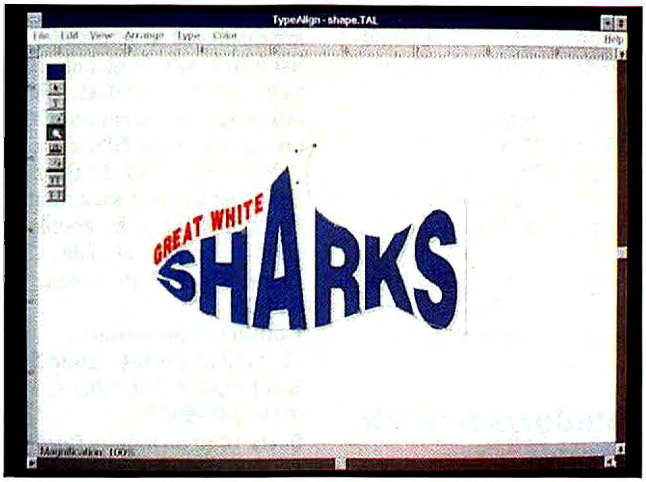
Circle 553 on Inquiry Card (RESELLERS: 554).

A Tool for Manipulation

Adobe's TypeAlign for Windows lets you creatively control type by rotating and shaping words with type. You can also add color or gray-scale effects.

You can paste the typographic effect into a Windows word processor or desktop publishing package via the Clipboard or save it as an Encapsulated PostScript file. You can take a "snapshot" of the target document and use that as a template in TypeAlign. The type object you create will fit perfectly into the document.

From the tool palette, you can draw straight, oval, or curved freehand lines for entering text. The software calculates the path and puts the text on the line.



TypeAlign for Windows lets you conform text to fit a line or curve around a sphere and create other typographical effects.

TypeAlign requires Adobe Type Manager for Windows (ATM).

Price: $99; ATM, $99.

Contact: Adobe Systems, Inc., 1585 Charleston Rd., P.O. Box 7900, Mountain View, CA 94039, (800) 833-6687 or (415) 961-4400; fax (800) 235-0078.

Circle 1029 on Inquiry Card.

FaceLift Gets a Face-Lift

Bitstream has answered the wishes of WordPerfect users who've been waiting for a version of FaceLift that supports on-the-fly font generation for dot-matrix and ink-jet printers. FaceLift 1.5 for WordPerfect supports the Hewlett-Packard LaserJet series of printers plus the HP DeskJet, Canon BubbleJet, and other printers.

FaceLift 1.5 for WordPerfect ships with three Symbol typefaces plus the 13 typeface outlines provided in the original package.

Price: $99.

Contact: Bitstream, Inc., 215 First St., Cambridge, MA 02142, (800) 522-3668 or (617) 497-6222; fax (617) 868-4732.

Circle 1030 on Inquiry Card.

A Window to the World of DDE

The Dynamic Data Exchange method of passing information to and from Windows applications is a powerful, yet somewhat mysterious, communication technique. A tool for Windows 3.0 called DDEWatch lets you monitor DDE messages and validate DDE macros and programs.

DDEWatch lets you view any detail of a DDE message. It displays the message type, the name of the application, the topic, the item, and the symbolic name for each bit flag, TechSmith says.

DDEWatch also provides a list of all active sessions. You can use the utility to verify flag settings, memory allocation, atoms, and data.

TechSmith has also released SnagIt, a screen-and-capture program for Windows that can capture a partial or whole screen.

Price: DDEWatch, $85; SnagIt, $79.

Contact: TechSmith Corp., 1745 Hamilton Rd., Suite 300, Okemos, MI 48864, (517) 347-0800; fax (517) 347-0230.

Circle 1031 on Inquiry Card.

Windows Search Utility

Searcher lets you check multiple disks using a variety of techniques to find files or text.

You can search for a file created before or after a certain date, for a file larger or smaller than a given size, or for a specific text string. Files that match your criteria are displayed in scrollable list boxes, which include filename, path, size, date, file attributes, and location of the text string in the file.

When you find the file, Searcher lets you execute the file's application by double-clicking on the data file.

Price: $14.95; site license, $29.95.

Contact: Cognitronix, 10750 Rickert Rd., Suite 5, San Diego, CA 92126, (619) 549-8955.

Circle 1033 on Inquiry Card.

Four Utilities for Windows 3.0

The Gedys Windows-Tool File Management package offers four Windows utilities.

TextSearch locates specific occurrences of text within files, directories, and networks. It supports wild-card and regular expressions.

MultiCopy lets you copy disks without swapping. The utility lets you copy a large application onto your hard disk, and it will split files when copying onto floppy disks. MultiCopy can also copy disks in different formats.

SystemInfo graphically depicts the amount of space occupied by programs, data, and directories. HexEdit lets you view and edit files in hexadecimal or ASCII format.

Price: $98.

Contact: Oxko Corp., P.O. Box 6674, Annapolis, MD 21401, (301) 266-1671; fax (301) 266-6572.

Circle 1032 on Inquiry Card.

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286/12 Hires	Special	$1,149	$1,199	$1,499	$2,349
286/16 Mono VGA	$849	$999	$1,049	$1,349	$2,199
286/16 Hires	Special	$1,199	$1,249	$1,549	$2,399
386SX/16 Mono VGA	$1,099	$1,249	$1,299	$1,599	$2,449
386SX/16 Hires	Special	$1,449	$1,499	$1,799	$2,649
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Background Images for All

ImageTects has released a CD-ROM disc with texture maps, images, and backgrounds for Amiga, DOS, Mac, and Unix graphics and desktop publishing applications.

The ImageCELs disc includes images and textures stored in subdirectories for the following file formats: TGA 16-, 24-, and 32-bit; TIFF 8- and 24-bit; CEL 16- and 32-bit; Apple PICT2 24-bit; Amiga IFF; GIF; PCX; I16 (for Intel DVI); and DIB 8-bit (Windows). The disc offers more than 1150 texture maps and images.

One of the benefits of the disc is that ImageTects has included a proprietary matching technology for the seamless integration of images in your drawing. For example, if you need to map a large wireframe model of a building wall with brick, the technology would merge four brick swatches so that it would appear seamlessly as one large brick surface.

On floppy disk, the com pany offers a people module ($99) and two modules of 160 textures ($149 each), each in DOS TGA 16-bit or PICT2 24-bit formats. The company has also released three modules of evergreen, deciduous, and indoor plant libraries for DOS TIFF and TGA 16-, 24-, and 32-bit files ($249 each).

Price: ImageCELs CD-ROM, $395.

Contact: ImageTects, 7200 Bollinger Rd., Suite 802, San Jose, CA 95129, (408) 252-5487; fax (408) 252-7409.

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Mo' Better System 7.0 Graphics

Of all software categories, painting programs usually have a philosophy of more is better. SuperMac Software's PixelPaint Professional 2.0 holds true to this dictum while compensating with logical and intuitive design. The company says it rewrote the product to take advantage of System 7.0. The program is the first from SuperMac Technology's spun-off software company, formed in March.

The program sets out to provide approximations of real-world artist's tools, such as brush and paper types, while supplementing these with capabilities only achievable on computers. Artists can duplicate the effects of watercolors, pastels, and charcoal sticks, for example. A PixelPaper feature lets you mimic painting on different mediums (e.g., linen, concrete, rice paper, and user-defined paper). PixelPaint Pro includes standard image-processing capabilities, like color correction and contrast controls.

The program supports the Wacom digitizer tablet and can use its pressure information to control the flow of ink on some of the tools. PixelPaint Professional supports type kerning and CMYK (cyan, magenta, yellow, black) color separation.

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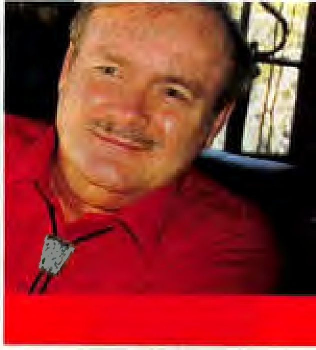


JERRY POURNELLE

DOS DECISIONS

I have major deadlines, so the phone is ringing. It never fails: whenever I have tight deadlines and try to write in the daytime, the phone rings. This time it was the *Los Angeles Times* wanting me to subscribe. The fact that I have been a subscriber for 25 years at this address means nothing to them. Their solicitor has a computer doing the calling, and apparently there is no one at the *Times* smart enough to have their computers cross-check with the subscriber list, thus saving me time and them the money they pay for both the phone calls and the solicitor. The solicitor isn't allowed to *cancel* subscriptions; apparently, quite a few people get angry enough to try that. I've recently been getting two *Times* calls a week, and I've begun to fantasize about guerrilla warfare.

As it happens, I was the keynote speaker at CASE World yesterday, and while there I went through the exhibits. It looks to me as if there are plenty of companies who could sell the *Times*, at fairly low cost, computer-aided software engineering tools that would generate programs that could take the *Times* solicitor list and eliminate numbers corresponding to subscriber addresses. It wouldn't even cost all that much. I wonder how I can get their attention so they'll do that?

Arche and Friends

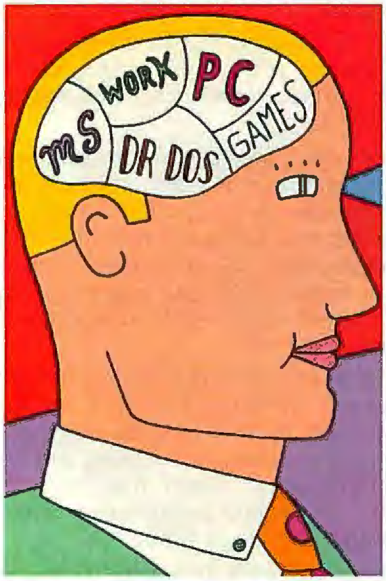
Years ago I was involved in studies of thinking; I believe that has since become known as cognitive psychology. An early giant in the field was Sir Frederic Bartlett of Cambridge, whose book *Thinking* (Basic Books, 1958) has an experimental study of strategies on how people approached intellectual problems. The studies involved various games in which you try to deduce rules from card layouts (a very simple rule might be one red, two black, and so forth; a more complex one might be one heart, two black, one diamond, one spade). The idea was to guess the rule at the earliest possible moment, and one of the studies was the effect on strategy caused by changing the cost of incorrect guesses.

When we get new machines here, we tend to fill them up with boards and use them as test-beds; this corresponds to the strategy of wild guessing, since, if something doesn't work, it's hard to know just why when you're trying seven new things at once. On the other hand, it's a lot of fun if things do go right.

When we got the Arche Legacy 486/33, we opened it up. The machine I have is the tower configuration. Getting it open required the removal of several obvious screws and digging around to find two more hidden screws. There's nothing particularly wrong with this arrangement, but it does slow things down a mite when you want to make hardware changes.

The internal layout of the Arche 486 is logical and quite solid. The VGA card has 512K bytes of memory; it will hold more, but we didn't have any handy, so I left it as is. There is one fan in the case, but all the hardware for a second fan has been included. I'm thinking of getting another fan because we stuffed the machine full of boards.

Jerry gets yet another new computer, the Arche Legacy 486/33, and ponders which DOS to use



We installed a Corel Optical Disk Interface Board, which connects to a Pioneer DE-S7001 external optical disk drive; a Sound Blaster; an Artisoft LANtastic board; Intel's Satisfaxtion coprocessor board; and a Microsoft Mouse on the COM2 serial port. I wanted to put in a CD-ROM board as well, but I didn't have one handy. What I really want is to daisy chain the Pioneer six-pack CD-ROM drive to the DE-S7001; Corel says that's possible, and they'll send the drivers. More next column.

DOS Hang-Ups

When PC-/MS-DOS 1.0 was first developed from the Seattle Engineering rewrite of CP/M, it had major limits. One was the 640K-byte memory boundary: since existing machines could use only 64K bytes, surely going up a whole order of magnitude would be enough for decades, right? Another was the 32-megabyte disk partition size. In those days, hard disk drives were rare, and a 10-MB drive was a big one. Even so, they should have known better than to limit logical disk size to 32 MB. They didn't, though, and we were stuck with the result.

The Arche 486 came with MS-DOS 3.3, so that the 348-MB hard disk drive was partitioned into logical

ILLUSTRATION: STEVE TURK © 1991

drives C through M. I used to prefer having a number of logical drives. Partitioning makes many disk operations faster. Search programs have fewer files to look through, and the disk heads have shorter distances to travel. On the other hand, partitioning can make finding things difficult. Over the years, I have come to the conclusion that the advantages of small partitions are outweighed by the disadvantages. Therefore, at some point I will probably reorganize my main machine to one big disk partition.

The question then becomes, what DOS will I use when I do that? The candidates are one of the extended MS-DOS 3.3 versions, MS-DOS 4.x, MS-DOS 5.0, and DR DOS 5.0. We can dismiss MS-DOS 4.x immediately. It's big, it's slow, and it has real problems. I don't recommend it to anyone.

The extended versions of MS-DOS 3.3 work pretty darned well, but their problem is that they tend to be machine-specific. The Compaq version seems to work on most other machines, but can you be sure it will work on yours? Compaq certainly isn't going to support its use on non-Compaq machines. Zenith's MS-DOS 3.3+ works fine on Zenith equipment, but it just plain doesn't work on most non-Zenith machines. Similar problems apply to every MS-DOS 3.3 extension I know of.

At present, MS-DOS 5.0 exists only in a beta-test version. That leaves DR DOS 5.0. Up to now, I had been reluctant to use DR DOS because it didn't work with LANtastic. I like LANtastic because it does about all I need a network to do and doesn't eat up all my RAM doing it. However, Digital Research now offers a "business upgrade" to DR DOS 5.0 that is supposed to work with LANtastic.

DR DOS has a number of advantages on a 386 (or 486): in addition to supporting enormous hard disk partitions, DR DOS stuffs the command kernel up into high memory, thus increasing memory available for programs. It comes with an EMS manager, so programs that know how to use that kind of memory can do so. It has a neat full-screen editor to replace the execrable EDLIN. There are a bunch of convenient commands, such as using up-arrow to go back through the most recent commands you've issued in case you want to repeat one. The old Norton Utility Directory Sort works just fine with DR DOS. And so forth.

I wasn't sure that it would work with LANtastic, but I won't be able to link to the Arche 486 with LANtastic for a while anyway, so this seemed like a good opportunity to give DR DOS a try.

Lots of Memory

DR DOS installation is simple; just follow instructions. Optimizing the system to get a maximum temporary program area can be a bit more difficult, depending on what you've installed; in our case, with all those boards stuffed into the system, it took a while.

The biggest problem was the Corel software. For reasons not clear to us, the automatic installation didn't work. (It didn't work with the MS-DOS 3.3 the Arche 486 came with, either.) When we tried doing it by hand, we got a whole bunch of contradictory switches into the DEVICE= line in the CONFIG.SYS file. This greatly increased the size of the Corel driver, which made it impossible for DR DOS to stuff the driver into high memory.

Taking care of that problem required phone calls, which gave me a highly favorable impression of Digital Research's technical support. It's a toll call, but when you get someone, you get someone who really knows DR DOS. The Digital Research people even called Corel for us, which is how we found out that we had contradictory switches in the command line.

The result was that after a good bit of tweaking, I have the Arche 486 running the Satisfaxtion board, Microsoft Mouse, and Pioneer optical disk drive, with over 600K bytes of usable memory.

Optical Disk Drive System

The Pioneer drive takes two kinds of cartridges: read/write and WORM (write once, read many times). Both hold 330 MB (per side if double-sided). The drive appears (on this system) as the N drive, and so far it seems to work fine. In read/write mode, I have copied stuff into it, copied that back off onto the hard disk drive, and checked that copy against the original; all's well. I've also reformatted the read/write cartridge a couple of times and done the tests again, with the same result.

It works, both as read/write and as WORM.

Having said that, let me add some cautionary notes.

First, when this box is used as a WORM drive, all's well. WORM technology is well understood, and once a file is written, the WORM record is as permanent as anything done electronically can be.

I'm not quite as certain about optical read/write files. Everything seems to work, but I want to do a lot more testing over a much longer period of time before I'll trust that as the only backup copy of

an important file. It's a newer technology and requires a great deal more precision than WORM storage.

Incidentally, if you want an introduction and exposition on the whole optical-storage field, *A Guide to Optical Storage Technology* by John A. McCormick (Dow Jones-Irwin, 1990) is as good as anything I've seen—a good balance of readability and technical information.

Anyway, we did have one glitch. One way I test equipment is through visually intensive games, and one of the best for that is Wing Commander, which really flogs both the computing and visual-imaging capabilities of the machine. When we got DR DOS up and running, we tried Wing Commander, which worked (as did Sound Blaster with its game port). I then copied Wing Commander onto the N read/write optical drive and tried running the game from there.

The machine locked up tight, with hardware reset required. Moreover, the Pioneer drive was no longer accessible, and attempts to access it hung the system again. I had to turn the Pioneer drive off and back on, as well as reset the computer, to get things working properly. It wasn't the files: I copied the files from the N drive onto the K partition of the hard disk and ran the game off that copy; it worked fine.

Today I had occasion to call Alex Karahalios, Artisoft's technical expert, and we speculated about what could cause that to happen, but we couldn't come to any conclusions. "Timing errors" is one obvious phrase. "BIOS calls" is another; but what those mean isn't clear. More when I know more. Read/write optical is likely to be the wave of the future, and I'm glad to have the Pioneer DE-S7001 for testing; I'll let you know how it comes out. Meanwhile, my advice on read/write optical is, "Be not the first by whom the new is tried, nor yet the last to lay the old aside." Make a WORM copy of important files.

Fooling Around

Once I had the system working under DR DOS, it was time to experiment with Desqview. For a few years, my main machine has been the Cheetah 386/25 with a Distributed Processing Technology (DPT) hard disk drive controller. Some of you may remember that I also have a Cheetah 486/25 with a Perceptive Solutions, Inc. (PSI) controller and wonder why I don't use that as the main machine here.

The answer is that I probably will, but it's not as simple as you think. For some weeks now, my partner Larry Niven and I have been working on a pair of novels. One, *Fallen Angels*, is finished and ought to be in bookstores about the time this column comes out. The other, *The Moat Around Murcheson's Eye*, is about half done, and we're hard at work on it. Niven and I are often asked how we collaborate; we generally answer, in unison, "superbly," and let it go at that. But, in fact, it's a reasonable question: we have probably used every conceivable means, from talking things out and working alone to working in the same room with one looking over the other's shoulder.

Lately, a modification of that latter technique has been working very well: Larry has one machine, I have another. I write a chapter and put in block notes where I don't write scenes; he goes over that to convert notes into text and adds notes of his own; I go over it again; and so forth. That technique often produces a

full chapter a day from absolute scratch. It will generally be a good chapter, too, since each of us rewrites as he goes along, with the result that by the end of the day, the text is as polished as it's ever likely to be.

The secret of this technique is two machines connected in some way: in our case, by "sneaker net," in that we save off onto floppy disks and hand them back and forth. (This automatically makes a backup, it's nearly as fast as any other network would be, and I don't have to teach Niven anything new.) As it happens, I can't stand to have anyone look over my shoulder while I work; while Larry rather likes an appreciative audience. Thus, he has grown quite fond of the big 19-inch VGA Hitachi monitor that goes with the Cheetah 486.

Of course, I could simply attach that monitor to another computer, but Larry is also used to the blinding speed of the Cheetah 486; in particular, the PSI controller saves even the largest text files so quickly that Larry will often save them twice, since he's convinced it couldn't have saved it the first time. Even when it writes the file to a floppy disk, that PSI controller does it faster than many older machines save to a hard disk.

The result is that the fastest machine in the house is, during the day, not much more than a dedicated word processor. At night, after Niven goes home, it becomes the perfect instrument for playing Railroad Tycoon, Wing Commander, and War Lords, all of which are spectacular on that 19-inch screen. The moral of this story is that it doesn't matter what you use your computer for: once you get used to speed and power, you never want to give them up.

Which brings me back to the Arche 486. As you'd expect, this thing is spectacularly fast; Wing Commander, for instance, is simply unplayable unless you use AT-Slow (shareware available on BIX), a program that, as the name implies, will turn your fast machine into a slower one when you want to play the kind of game that's affected by speed. The hard disk access isn't so spectacular, but still, it's fast enough. However, when I'd copy stuff from a floppy disk into the Arche 486, it seemed to take a lifetime. Finally, I got curious about that; what I found is an interesting lesson in personal psychology.

The Arche 486 doesn't really access floppy disks slower than most other machines in Chaos Manor; it's just that when you log onto the floppy disk, or ask for a floppy disk directory, nothing happens for long enough that you notice it; then, suddenly, it all happens quickly. This makes it seem as if it has taken longer. So it goes. As to copying from floppy disks, the Arche 486 has about the same speed as the Arche, Premier, and Zenith 386s. Alas, that's considerably slower than my Cheetah 386 with its DPT controller, and a *lot* slower than the Cheetah 486 with the PSI controller. Once again, when you get used to speed and power, you don't want to let go.

However, I have a new DPT controller, which the company swears is as fast as the PSI controller (I love it when two good companies compete in technology rather than lawsuits), so there's an obvious remedy to the situation; indeed, the DPT controller is a SCSI device, and I'm told that I can daisy chain the Denon CD-ROM drive to it, thus saving a slot.

Tweaking the System

If the Arche 486 ever does replace the Cheetah 386 as my main system, it will have to run Desqview. I may one day switch over to Windows, but not just yet. For now, Desqview seems quite stable and very useful.

For instance, as I write this, I have the Norton Commander MCI Mail Manager off uploading several MCI letters and downloading any mail I may have, and all that happens invisibly. In another Desqview window, I have Samuel Butler's *The Way of All Flesh* up on the Library of the Future CD-ROM, and I can change over to that (or to any CD-ROM I like) almost instantly. Info Select is waiting for notes. Norton Commander is available if I want to do file management and can run in the background to do long backup copies to the WORM drive; and switching from one of those windows to another takes less than a second. I can open a second Q&A Write window, a Sidekick window, or whatever I might want in seconds. This is convenience I simply will not give up.

The question is, then, does DR DOS work with Desqview? The answer is yes, but a story goes with it.

First, if you use Desqview, you will probably want to use QEMM-386, Quarterdeck's 386 memory manager, rather than the EMM386 that comes with DR DOS; even Digital Research's technical-support people advise this, since QEMM and Desqview have some secret handshaking that other memory managers can't use. The easiest way to get that running is to use the Desqview installation program, which does the job nicely.

Next, you have to edit CONFIG.SYS to remove all the DR DOS EMM386-specific commands and drivers. One way to do that is to preface each line with a question mark. DR DOS has the nifty feature that if it sees a statement in CONFIG.SYS preceded by a question mark, it asks you if you want to do that, and if you say no, it skips it. This feature can be an extremely handy one when you're tweaking the system, as well as a way to let you configure the system for special purposes.

What I did was to REM-out everything nonessential and boot up with QEMM; after which I put back in the Corel and Intel drivers, the mouse, and all the other stuff, and let QEMM's Optimize take over. I was also careful to keep a boot floppy disk because Optimize is notorious for hanging up your system, and, sure enough, it managed to do that a couple of times. Eventually, though, that stabilized. Then I used DR DOS's HIDOS.SYS to stuff the DR DOS kernel up into high memory. When you do this sort of thing, make liberal use of the question-mark preface to CONFIG.SYS statements, and fool around until you've got what you want; and if that doesn't seem like very precise advice, it's still about the best I can give.

Eventually, I had a system with over 600K bytes of free memory before loading Desqview and 560K-byte Desqview windows, with the mouse, the Pioneer optical N drive, and the Satisfaxtion coprocessor board accessible to any of them. This is as large a Desqview window with that many resources as I've ever achieved with any system. That's the good news.

The bad news is that sometimes when I try to quit Desqview, I manage to hang up the system and have to reset. Now understand, that's hardly a fatal problem. After all, if you're dumping out of Desqview, you've presumably saved all your work, since anything ongoing will certainly be lost when you exit. Still, it's annoying, and I haven't figured out just what's going on. Something is clearly overwriting something else, but that's like saying "timing errors": it's probably true, but it's not a useful diagnosis. Eventually, I expect I'll figure out what is happening, and until then I'll just keep on playing with the system.

What I do know is that if I adapt the Arche 486 by installing the DPT controller and then hang the CD-ROM and Pioneer optical drives on a remote network server accessed by LANtastic, I ought to have enormous Desqview windows as well as a very fast machine. More on that next month.

Meanwhile, my tentative conclusion on DR DOS is that it's quite solid for single-application users and very likely solid under Desqview. I had a similar problem with Desqview hanging up the Cheetah 386 (under PC-DOS 3.3) until I put in the statement X=C600-C7FF in the QEMM CONFIG.SYS line (i.e., exclude memory locations C600 to C7FF from the area managed by QEMM). Since then, this system has been as solid as a rock, and I make no doubt that something similar will do the job with the Arche 486 under DR DOS.

Next week, I'll test DR DOS and the Arche 486 with LANtastic. I've been assured by Digital Research management that if this update version of DR DOS doesn't work with LANtastic, they'll keep on working until it does; but, in fact, I've heard from people I trust that this one does. More as things develop, but my first impression of DR DOS 5.0 (with the business update revision) is quite favorable indeed, and I'm likely to use it on my main machine, whatever that turns out to be.

Digital Research Grows Up

I recall my astonishment, back in 1979 or 1980, when a famous columnist said, "Pournelle in BYTE has pronounced CP/M the new standard, and that seems to settle that." It was the first intimation I'd had that anyone in the industry took me seriously, and since my first "official" pronouncement was about Digital Research, it left me fond of the company. Lately, though, it hasn't been the leader it once was.

I've always been impressed with Digital Research's technical capability, but the marketing left a little to be desired; in past years, its idea of marketing was to develop good products and wait. If you deserved to have anything that good, you'd find out about it and buy it; if you didn't find out, it served you right.

Digital Research president Dick Williams is changing all that. He's got an aggressive marketing strategy that takes advantage of his company's small size and thus quick decision times, as well as the staff's high technical abilities. I think we can look for good things from them once again.

Sound Blaster

One of the boards we installed in the Arche 486 was Sound Blaster. With its associated software, it has quietly (no pun intended, but what the heck) become the standard sound system for advanced PCs. The Roland board has much higher sound quality for a higher price, but for anything short of professional music quality, Sound Blaster is good enough.

One use, of course, is games. Sound Blaster comes with a game port, making it nearly ideal for Wing Commander.

Some days you have all the time in the world.

When the pressure is on, pour on the speed. With Hewlett-Packard's new LaserJet IIISi printer. A powerhouse that delivers at a throughput speed of 17 pages per minute.

With the LaserJet IIISi, you're up to speed the moment you give the "print" command. HP's RISC-based formatter and the PCL5 printer language, with vector graphics and on-the-fly typeface scaling, yield fast results. This printer also represents a new standard for I/O performance with optional Network Printer Interface cards for either Ethernet or Token Ring.

The LaserJet IIISi is specifically designed for shared-use environments. Its high-volume paper handling features include two 500-sheet input trays and a monthly duty cycle of 50,000 pages. HP offers software-selectable language switching between PCL5 and optional Adobe* PostScript*. For added versatility, your options include

For more serious work, you can get the MIDI Connector Box from Brown-Waigh Publishing. This is a tiny thing that plugs into Sound Blaster's game port. It has a joystick port continuation (so you can still play Wing Commander), one MIDI input, and five Thru MIDI outputs. It also has considerable music software. The result is that your PC with Sound Blaster becomes a kind of music studio. I've had a lot of fun with the included software, and, no, I haven't at all given up the idea of writing an opera someday.

There are lots of other accessories you can get for Sound Blaster, including musical instrument software and a voice editor. Sound Blaster has become the standard sound board, if not for the industry, at least here at Chaos Manor. Recommended.

Satisfaxtion

I've mentioned Intel's Satisfaxtion coprocessor board before, so it suffices to say it works fine under DR DOS. Satisfaxtion will take a file, which can include PCX graphics, and send it out as a fax. This means you can send letterheads, diagrams, scanned images, and the like, all created on your PC. Moreover, the board, having its own coprocessor, will send and receive in the background or send your messages in the dead of night (presuming you leave your computer on, of course).

The manual is extraordinarily complete and clear, making it quite easy to set this system up. I do find it more convenient to send text-only fax through MCI Mail (using the Norton Commander MCI Mail Manager feature), but you can use the built-in 2400-bps modem on Satisfaxtion to do that. All in all, this board is a great bargain. Recommended.

Language Systems FORTRAN

About a year ago, I was the keynote speaker for a conference of supercomputer users. I doubt they learned much from me, but I sure learned a lot from them. One thing I learned is that using supercomputers boils down to writing FORTRAN programs. Big FORTRAN programs. As one fluid-dynamics scientist put it, "After you've written 60,000 lines of FORTRAN, you no longer care much about your original problem."

All of which is probably true, but FORTRAN remains the Language That Will Not Die, and I just know that 20 years from now, we'll be programming the Connections Machine version 22, with 5 million parallel processors, by feeding it a half million lines of FORTRAN generated with computer assistance. Seriously: anyone contemplating going into science should be familiar with FORTRAN, because a very great deal of work is done with it. I'd rather work with Macsyma or Mathematica, the symbolic algebra programs, but I don't have to try to model fluid dynamics or large weather systems, which strain the capacity of the largest supercomputers.

I don't say you have to learn FORTRAN, but it can't do any harm to have some familiarity with it; and if you have any desire to do FORTRAN on your Mac, whether to learn the language or do serious work (or both), there is the Language Systems FORTRAN compiler, which, according to Language Systems, works on any Mac with 2 MB of RAM and a hard disk drive. The compiler accepts ANSI 77 FORTRAN and most large computer extensions, including VAX. It has lots of switches for optimization. Tools and libraries are included.

If I seem vague, I am: I haven't done much with FORTRAN since Z80 days, when MacLean and I experimented with RATFOR, the Rational FORTRAN precompiler. I don't have anything against FORTRAN, it's just that I don't have a great deal of need for it. Others, however, do; and if you have a Mac and want FORTRAN, this is, so far as I can tell, about as good a compiler as you'll get. It comes with lots of tools to access the Mac interface and about a foot of manuals. You can also get MPW as an option.

Say Whaaat?

You say you want to do some OS/2 applications programming, but you can't stand C? You say you got the OS/2 Developer's Toolkit but you never get around to writing the programs you planned? Is that your trouble, Bucky? Cheer up. Help is at hand. An Italian company, Artel Informatica, has developed Pronto! PM, a set of drawing tools for the Microsoft BASIC 7.0 compiler for OS/2.

Pronto! PM includes dialog boxes, radio button status inquiries, and tools for drawing lines and boxes. You write your source code in Microsoft BASIC, include the Pronto! PM library, compile, link, and then—well, and then you sort of have to understand the OS/2 and Presentation Manager (PM) developer tools after all, more's the pity. You aren't totally liberated from C.

Still, this toolkit can go a fair way to taking the sting out of PM programming.

It's Back...

The original Sidekick was indispensable when it first came out. I recall I couldn't

live without it. Then came Desqview. After that, there was no need to have a TSR program to give access to a calendar, notebook, and address book/telephone dialer because you could always use Desqview task switching to go to a program tailor-made for the particular purpose. Tornado, GrandView, Time Line, and so forth each worked better for its particular purpose than Sidekick did at any one of them.

There was an update to Sidekick, but I had a lot of trouble installing it, and I never used it; and over the years, I stopped thinking about Sidekick, although Borland says there are still 3 million people using it.

Now it's back, and this time it's a bit different. First, Sidekick 2.0 uses the Paradox engine. Paradox is, in my judgment, the relational database of choice for PC users; that is, if you can manage with a simple flat file manager, Q&A is simpler to set up and learn, but if you really need full DBMS capabilities, get Paradox.

Sidekick 2.0 will also interact with Quattro Pro, which is the spreadsheet of choice, in my book anyway. The new Sidekick will allow data exchange with Quattro Pro and Paradox files. It will also import all your Sidekick 1.0 and Plus files simply and easily.

So far, of course, there's not all that much reason to use Sidekick as opposed to Paradox and Quattro Pro with Desqview; but Sidekick 2.0 was designed in part to work with notebook computers, most of which don't have and can't use Desqview. The new Sidekick Time Planner is easy to use, what with windowing and pull-down menus and suchlike, and about the right thing to put on a Poqet or other PC palmtop machine. There's also the Reconciler, a program for reconciling schedules, as, for instance, when you've got one copy of Sidekick on the road and another on the base machine back home. That has always been one of my major problems with any scheduler, and I'm very happy to see this.

I was once a Sidekick fanatic; this new version may convert me again because I sure need help managing my schedule.

Sim Everything

I expect everyone knows about SimCity. At the Los Angeles Science Fantasy Society, it got so popular that we had to forbid people playing it on the club machines on meeting nights; they'd get involved with their "city" and want to take it home, which, of course, we can't allow, and all kinds of arguments would start.

I now have two more SimCity templates, Ancient Cities and Future Cities, and I can say instantly they're worth getting. SimCity is a lot of fun, provided that you understand it's a game and not a lesson in urban planning. (Having been involved in city management, I assure you that trash removal, which isn't in SimCity at all, weighs very heavily on the mayor's mind. . . .) The Ancient Cities packages are even less realistic, but they sure are colorful and just plain fun. The Moon Colony in Future Cities is also fascinating.

The versions I have are for the Amiga; there are versions for the Mac and PC, but I don't have them.

I do have SimEarth for the PC; as my son Alex says, it's the only game program that ought to come with a one-week seminar on how to use it. That's actually meant as a compliment: this program is

complex. The best way to learn about its features probably isn't to take classes, though: just start it up and let it run. Nothing will be harmed, and as you begin fooling around with things—ever want to make continents drift? send a monolith down to aid in the development of intelligent dinosaurs?—you learn what you can and can't do. At least, that's what I did.

Once again, it's a game, not a real simulation; but it's a pretty instructive game, even so. Just the thing to get bright youngsters interested in science, as well as a good way to relax after getting a column written. Recommended.

Winding Down

The final draft of *Go Tell the Spartans* (Baen Books, in bookstores as you get this) is due this weekend: Jim Baen is doing the final editing and typesetting in-house. The Great Hall is a wreck, with the Arche 486, and unopened mail, and software boxes, and cables and wires, and just general junk filling all the available space. My desk is a disaster. I'm going to file this column and run off to the beach house, where I hope to do some fiction.

The game of the month is War Lords from the Strategic Studies Group. This features up to eight human players, but the computer will play all but one (or even all for that matter) part. It's a medieval fantasy, and it's strangely fascinating, even when played as one human against seven computer players. I fiendishly gave a copy to the British author Terry Pratchett (if you haven't read his Discworld novels, you are in for a treat).

The computer books of the month are the Que Quick Reference series: I have them for AutoCAD, Q&A, and a dozen other popular programs, and they're better than the quick reference guides that the software publishers furnish. It's worth having one for anything you use a lot. ■

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

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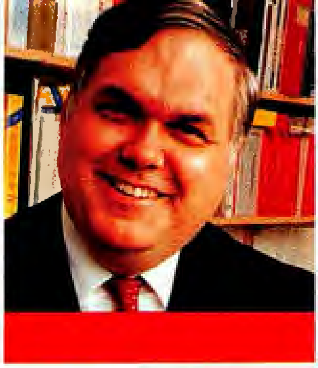


WAYNE RASH JR.

A LAN AWAY FROM HOME

One of the biggest problems with business travel is that you leave your office behind. Of course, this may also be one of the biggest advantages of business travel, but that depends on what your office is like. In any case, in addition to your office and its telephones, you leave your company's computer system, along with the information that's stored on the file servers, the notes in E-mail, and the scheduling information in the groupware package. While it's nice to do without telephones from time to time, it's hard to do business without the support system you've become used to having.

A few of the better hotels have started to cater to the computer user, providing extra phone jacks and power outlets in rooms. A few places, such as United Airlines' Red Carpet Clubs, even provide personal computers for the use of travelers. These services are helpful, but without access to information you need, they're not as useful as they might be otherwise.

The problem is that traveling doesn't go all that well with a fixed installation such as a LAN. Just what are you supposed to do when you're on the road with your laptop computer, or even when you're visiting another of your company's offices? In the past, you were out of luck, but now, at least, there's some hope.

Now that portable computers will fit into your briefcase, and facilities exist away from home to support them, a few products have arrived that are good enough to cement your relationship with your office, even from a distance.

You still need to use a modem, of course. But where once you dialed the company VAX and emulated a VT-100 terminal, now you can log onto your LAN and work as if you were really attached. The difference is new software designed specifically for this purpose, such as DMA's pcAnywhere IV. While packages that mirror keystrokes and screen images have been around for years, only now are they good enough to use in a serious business setting.

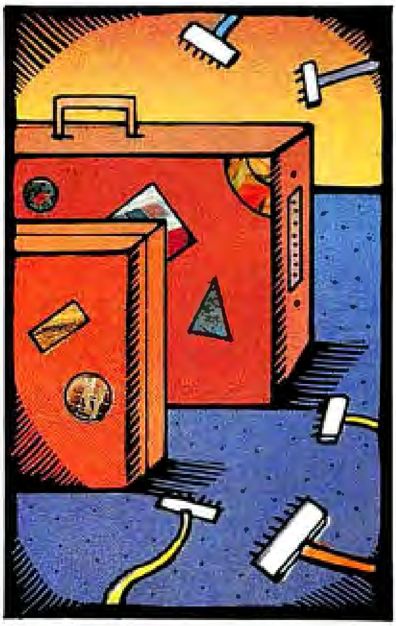
When you arrive at some business locations, you have exactly the opposite problem. There you are in the office with your computer, and there's a LAN in the office, but because you have a laptop computer, you're out of luck. Fortunately, hooking your laptop computer to a LAN has also gotten easier over the years.

Anywhere, Anytime

There was once a time when setting up a remote communications facility for a LAN was difficult and expensive. You needed special software from the LAN operating-system manufacturer, and you needed a lot of dedicated hardware. A typical dial-in installation would be based on an asynchronous communications server, which in turn would use something like Novell's WNIM+ card. This card supports four RS-232 ports to which you connect modems.

Then, using a package such as Novell's NetWare AnyWare, coupled with Novell's Asynchronous Communications Server software, you could have remote dial-in communications. The problem with this approach is that it required both a dedicated communications server and a dedicated workstation for each user who wanted to call in. In other words, a user calling in with a laptop computer was using three computers to run a single LAN session: the laptop itself, the communications server, and the workstation on the LAN that was serving as a host to the communications session.

You don't have to give up your LAN while you're on the road



As you might imagine, this hardware-intensive approach met with some resistance. Customers who wanted to dedicate a high-end communications facility needed a way to do it without tying up a room full of computers. Low-end users just wanted a gateway that was simple to set up and easy to use.

The NetWare Access Server was the first realistic solution to the requirements of high-end users. Quarterdeck Office Systems teamed with Novell to create a server that could have up to 16 DOS sessions running at the same time. The multitasking Desqview kernel formed the basis for the Access Server. Each session supported communications software developed by Novell. The Access Server required a standard 386-based system with as much as 12 megabytes of memory to support its 16 sessions, but it was (and continues to be) effective.

continued

ILLUSTRATION: RANDY LYHUS © 1991

The Access Server is a good solution to dial-in access, but it's far too expensive for small users who just want a one-line gateway. For these people, DMA's pcAnywhere IV/LAN is just the answer. It lets you create an asynchronous communications gateway anywhere you've got a computer and a modem connected to a network. This means that the network users can have access to a PC's modem as a background process, so the PC's user doesn't have to stop working to free up the workstation for communications use.

The pcAnywhere IV/LAN solution allows both dial-out and dial-in use on the network using the gateway. For a small company that needs the capability to access its LAN without spending a lot of money, this works well. Remote access to the gateway is via the remote version of pcAnywhere IV.

With either pcAnywhere IV/LAN or the Access Server, you can run the same software remotely that you could run on a workstation if you were actually there on-site with the LAN. But there are some limitations. Because screen updates are limited to the speed of the modem you're using, you might want to avoid complex user interfaces, simply because of the time it takes to update the screen at modem speeds. This is less of a problem with 9600-bps modems, but with slower speeds, screen updates can be excruciating.

Unfortunately, virtually all portable computers give you a choice of a 2400-bps modem or one that's even slower. Some machines, such as those with PC-style expansion slots, can accept a high-speed modem card.

One final complication is the screens that are available for most portable computers. I used a Toshiba 1200XE to test the items you're reading about here. The Toshiba has a very nice backlit LCD, but it's only CGA resolution. While this is supported by both the Access Server and pcAnywhere IV, it still looks pretty sad when trying to deal with screens that have a high graphics content.

Portable Connections

Once you've reached your destination, few things are more frustrating than being in an office with a perfectly good computer but being the only person there who can't get on the LAN. As you've probably noticed, once offices begin to accept the LAN, nearly all the peripherals become LAN resources. No longer can you print the results of a spreadsheet calculation by unplugging someone's printer and attaching it to the back of your portable. Now that printer belongs to the LAN, and unplugging it will bring the wrath of the other LAN users. On some LANs, the network is the only way you can print, communicate with the mainframe, or have access to other peripherals.

Two years ago, a small company in California, Xircom, invented a network interface card that would plug into your parallel port and therefore would support nearly any laptop computer. The Xircom pocket LAN adapter has become so popular that I've seen it used in areas far removed from portable computers. One popular use is to give LAN connectivity to computers without expansion slots, such as the Zenith Z-148 desktop.

The only problem with the Xircom adapter is speed. The parallel port is used as the communications channel, and it is limited to about 300,000 bps. For many routine uses, this is entirely adequate, but if you really have to move a

lot of data, then you'll notice the difference. This is where cards like the Ethernet and Token Ring adapters from Megahertz are handy.

Megahertz makes a pair of external cards for Toshiba laptop computers. Unlike the LAN adapters from Xircom, the Megahertz devices attach to the Toshiba expansion bus connector that is accessible from the rear of each Toshiba portable. You do this by removing a metal plate and simply plugging in the 100-pin connector on the LAN adapter. The connector is made fast by tightening a pair of thumbscrews. You can remove the adapter in seconds when you're ready to go on the road.

The most important difference between the Megahertz cards and the Xircom adapters is speed. The Megahertz adapters operate at the full speed of the LAN, which is 10 megabits per second for Ethernet or 4 Mbps for Token Ring. This is possible because the Megahertz adapter connects directly to the expansion bus and isn't restricted by the speed of the parallel port. On the other hand, the Megahertz adapter works only on Toshiba portable computers, so you lose a lot of flexibility. In addition, installation of the Xircom adapter is easier, since on most networks the shell is already configured, so you just have to plug and play. Installing the Megahertz adapter is more like installing a standard network interface card.

Both Ethernet adapters work well. As you might expect, using the Megahertz adapter isn't any different from using any other Ethernet card on another computer. For most uses, the Xircom adapter isn't any different either. The speed limitation of the parallel port isn't obvious in routine use unless you're moving some very large files.

Otherwise, the differences between the Xircom and Megahertz adapters are mostly in the way they attach and in their physical size. The Xircom adapter is hardly larger than the plug on a printer cable and attaches directly to the printer port. The Megahertz adapter is somewhat larger, about two-thirds the size of a Hayes modem, and it has a very short length of stiff ribbon cable permanently attached to one end.

Unlike the Xircom adapter, which uses an external power supply similar to the ones used by calculators, the Megahertz adapter draws power directly from the Toshiba to which it's attached. Both approaches have disadvantages. You have to find an electrical outlet for the Xircom. You'll probably have to find one for the Megahertz as well, since the extra power requirements aren't going to help the Toshiba's battery life, and the larger Toshibas don't have batteries anyway.

The Xircom adapter has a very successful history behind it. When the U.S. Army went looking for a way to use Ethernet in the desert, it found that the Xircom Pocket Ethernet Adapter was one of the few computer peripherals that would function in the heat and harsh environment of the Saudi desert. That it could be changed between computers in seconds, and would work with everything from Zenith laptops to CompuAdd 486 desktop machines, quickly made it a favorite.

Either way, once you have your portable adapter card, you're ready to hook up to the office LAN at your destination. There are a few catches, such as convincing the local LAN administrator to let you in. You're on your own there.

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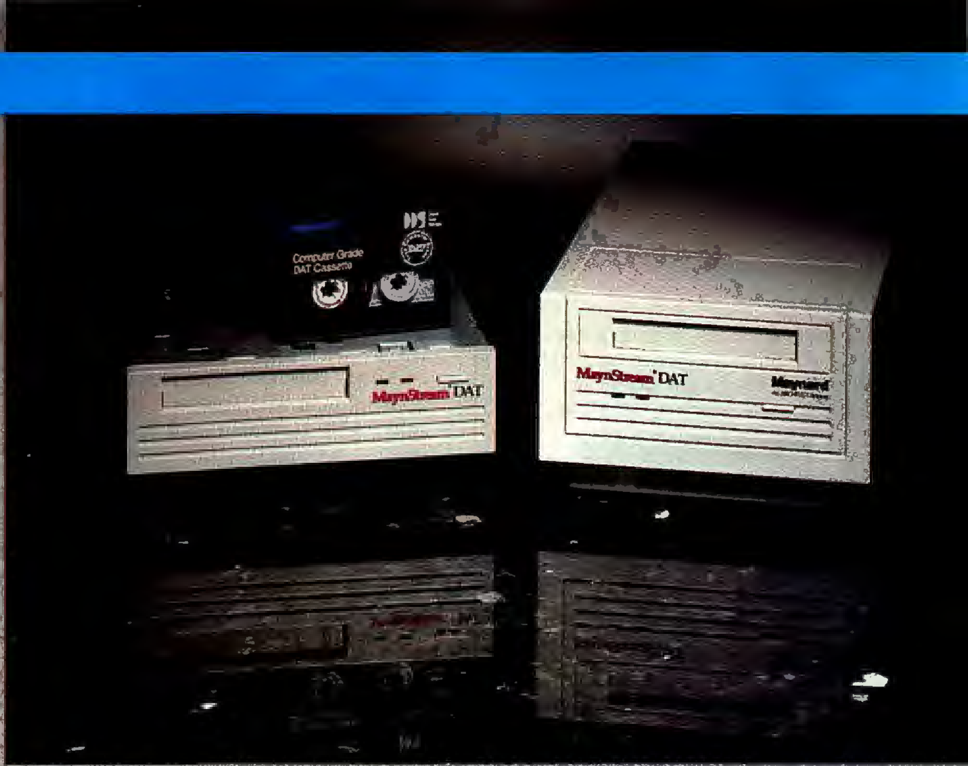

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The Portable Office

Meanwhile, the communications capabilities of portable computers continue to grow. Worldport now has a pocket-size fax modem that will support normal 2400-bps Hayes-compatible communications; plus, it will work as a 9600-bps fax card. AST Research will now install a similar fax modem inside its Premium Executive notebook PC.

It used to be that you could wait until you returned to the office after a trip before you did the paperwork. Now there's no excuse, unless you stay in hotels so sleazy that there's no way to plug in your modem. Tough choice, isn't it?

The Office Portable

Frank Mara was looking for a different sort of solution to his portable computing needs. Frank has headed development of some SQLWindows applications, and he needed a machine on which to demonstrate them. Because the machine had to support both a database engine and the Windows front end, he didn't think that a 386SX-based computer was adequate. He also had plans to use OS/2 for some future applications and wanted the portable computer to support those as well.

For a while, Frank tried shipping his IBM PS/2 Model 70, but it was developing a disturbing tendency to be inoperative when it reached the other end of the trip, which made running demonstrations difficult. Clearly, another solution was needed. Initial looks at Compaq and others showed them to be bulky, heavy, and expensive. Toshiba portables were out, due to a heavy government client list. Finally, on the suggestion of BYTE editor Rob Mitchell, we looked at the Micronics Mport 325.

The Mport 325 386/25 weighs only 13 pounds and is a fully functional 386-based machine. While it's certainly no notebook-size computer, it's lighter and slimmer than the competition. Equally important, it supports a 120-MB hard disk drive and has VGA graphics and an AT-compatible expansion slot for things like LAN cards. We're going to bring it up to 12 MB of RAM and load the hard disk with both DOS and OS/2. It looks like the perfect machine for traveling demonstrations. I'll let you know how it does after we've tried it out under actual field conditions for a while.

Next month: A look at the real world of network management. ■

Wayne Rash Jr. is a contributing editor for BYTE and a principal and technical director of the Network Integration Group of American Management Systems, Inc. (Arlington, VA). He consults with federal and private sector clients on microcomputers and communications, and he is coauthor of two books for business network users: The Executive Guide to Local Area Networks *and* The Novell Connection. *You can contact him on BIX as "waynerash," or in the to.wayne conference.*

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

ITEMS DISCUSSED

External Ethernet Adapter ... $599
External Token Ring Adapter ... $999
Megahertz Corp.
4505 South Wasatch Blvd.
Salt Lake City, UT 84124
(801) 272-6000
fax: (801) 272-6077
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Mport 325 386/25
40 MB ... $6299
120 MB ... $7499
Micronics Computers, Inc.
232 East Warren Ave.
Fremont, CA 94539
(415) 651-2300
fax: (415) 651-5666
Circle 1222 on Inquiry Card.

NetWare Access Server ... $1995
WNIM+ ... $895
Novell, Inc.
122 East 1700 South
Provo, UT 84606
(801) 379-5900
Circle 1223 on Inquiry Card.

pcAnywhere IV ... $179
pcAnywhere IV/LAN ... $495
(includes license for two nodes; additional nodes, $25)
DMA
1776 East Jericho Tpke.
Huntington, NY 11743
(516) 462-0440
fax: (516) 462-6652
Circle 1224 on Inquiry Card.

Pocket Ethernet Adapter ... $695
Pocket Token Ring Adapter .. $895
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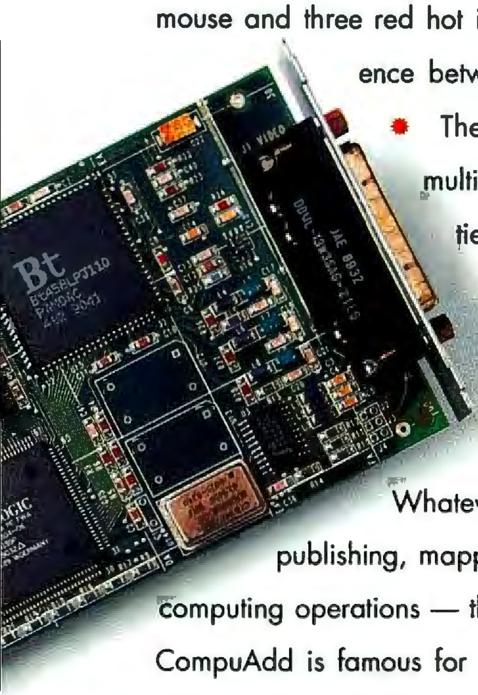

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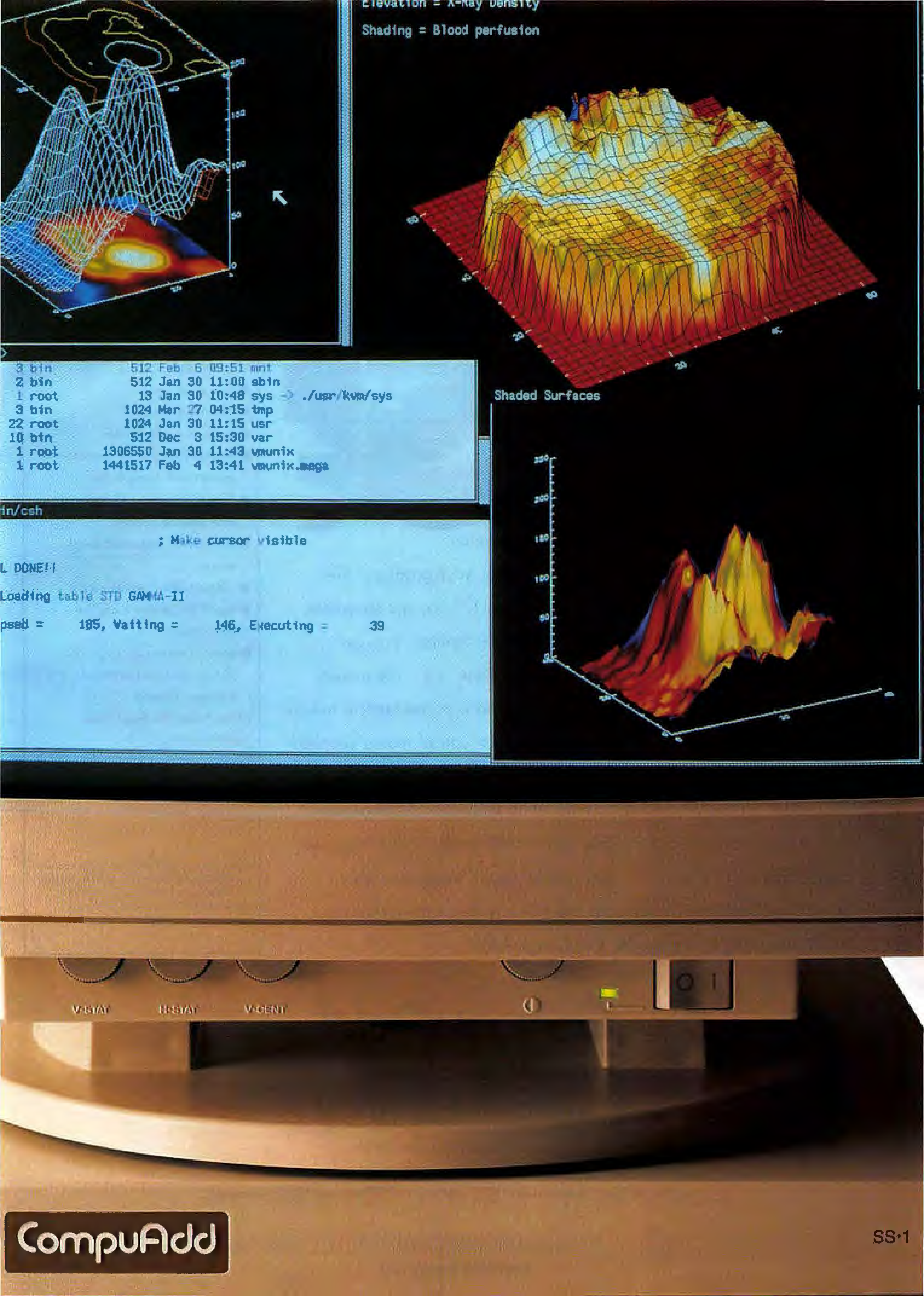

Shading = Blood perfusion
3 bin 512 Feb 6 09:51 mnt
2 bin 512 Jan 30 11:00 sbin
1 root 13 Jan 30 10:48 sys -> ./usr/kvm/sys
3 bin 1024 Mar 27 04:15 tmp
22 root 1024 Jan 30 11:15 usr
10 bin 512 Dec 3 15:30 var
1 root 1306550 Jan 30 11:43 vmunix
1 root 1441517 Feb 4 13:41 vmunix.mega
Shaded Surfaces
in/csh
; Make cursor visible
L DONE!!
Loading table STD GAMMA-II
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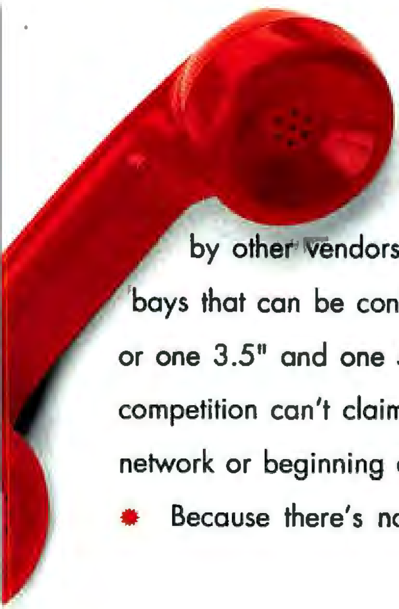

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BYTE columnists, staff, and contributors debate the issues

WHO NEEDS GUIs?

Roundtable is a forum in which BYTE editors, columnists, and contributors debate key issues that affect how you purchase and use hardware and software. The "conversations" take place on BIX, where you can participate in the round.table conference.

KEN SHELDON: This month, BYTE has several articles on graphical user interfaces. In the course of pulling them together, a question occurred to me: Does a GUI really make a computer easier to use? Case in point: I was one of the first people at BYTE to get a Macintosh (a 128K-byte model) because I was enthralled by the GUI concept. Do I use a Mac now? Only occasionally, usually if I have to do something graphically oriented. And I've no great need to move to a DOS-based GUI like Windows, since all I really need is access to lots of memory, and task-switching ability.

So the question remains: Who needs a GUI? Do they make computing any easier?

DON CRABB: Do you need a GUI? Do you need oxygen to breathe? Microsoft didn't come out with Windows 3.0 because it hadn't done its market research. Regardless of what high-power users might think, most Joe and Mary average computer users work smarter and faster under a GUI—*any* GUI—than under a command-line interface (CLI). Using a GUI to control your computer has absolutely nothing to do with the need for doing "something graphically oriented."

The whole point to a GUI is interface consistency. Learn one application and you have learned them all. The other point to a GUI is simple command availability. Want to delete a file? Drag it to the trashcan. GUIs are proving that graphical computing metaphors aren't only for graphic artists or desktop publishers.

The bottom line is accessible power. Some people who grew up with CLIs will always find them more palatable and programmable, no matter what the GUI. But that's simply not the majority of people who have to get real work done each day with a computer. Even some power users, like me, find that the consistency of the Mac's GUI (along with some third-party programmability hacks) makes the Finder the interface of choice.

SHELDON: I got tired of the endless hand-holding, the prompts, and so on. It was like going to the city with a strong-willed, very opinionated (though well-meaning) maiden aunt: "Oh, you don't want to go over *there*, you want to go over *here*. Are you *sure* you want to do that?"

I suspect that the issue has largely to do with who will be using the machine. Novices will find that a GUI makes a computer much easier to use. Those who are already wedded to a CLI, however, have fingers that are conditioned to type in certain phrases. (It always amuses me to hear a Unix whiz say, "Oh, I can do that. I merely switch my root directory to /foo and redirect the output to LPT1: and type Ctrl-Alt-Del while holding my left hand over my head and . . .") And sure enough, he usually can do it as fast as I can with a "friendlier" utility, because he has been doing it so long.

FRED LANGA: What a can of worms, Ken. I wonder if there really aren't two separate elements to your question. First, I'll admit it: Little frills like scissors and pastepot icons drive me nuts. I tried and ultimately abandoned a GUI-based word processor. I like to see as much text as possible when I'm writing, and any interface that starts encroaching on the text display has a major strike against it.

But my wife loves her Windows-based WYSIWYG word processor and uses it nearly exclusively in her consulting business for everything from simple all-text memos to complex reports with embedded graphics. But she's not a professional writer, and that may be a key difference.

So, maybe there are two separate things going on here, Ken. A GUI may not be an obvious win when all you're doing is substituting "click-on-an-icon" for "press-the-function-key." But if clicking on an object

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Senior Editor at Large

saves writing a couple dozen lines of code, then using a GUI seems a pretty clear win to me.

LARRY LOEB: GUIs help remove what I refer to as the human-executed code in a program. That's what you expect the user to do when you give him or her a prompt of some sort; but you may count on them to remember the name of the file ("remember and type") as opposed to selecting it from a scrolling list ("point and click").

Less strain on the user to point and click doesn't mean that people who wish to program in assembly should be forced to use a GUI to do that unless they want it. Generating the *G* in *GUI* takes lots of code. It's not for everyone. But it seems to widen the usage base.

I'm still trying to figure out what some of those cute little icons mean.

JON UDELL: There's GUIosity within applications, and GUIosity between applications—a distinction that's often lost. The latter is why Windows makes sense as an environment, even with a heavy mix of DOS applications: You can have that wonderful Chooser-like interface to, for example, network printer queues.

The former depends on the application. I have no use for GUI-type features while writing. Text is streamlike, not chunklike. It presents nothing I want to point at and click on. I type like the wind; give me EMACS and to hell with menus, buttons, and the mouse.

But spreadsheets and databases are chunky; they create landscapes that (for me) are much more usefully navigable with a mouse. So here's the irony: I'm still waiting for a good EMACS for Windows. Meanwhile, I get lots of use out of the GUIosity of FoxPro running under Windows, even though it isn't a Windows application, because even in character mode (in fact, bit-mapped versus character has little to do with this aspect of GUIosity) I can navigate that chunky landscape (columns, rows, partitions)

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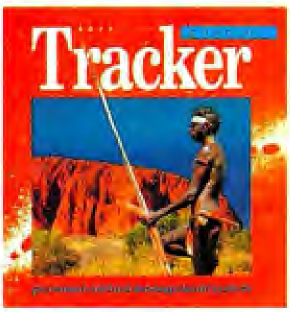

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far more effectively with a mouse than without.

MARTIN HELLER: I wonder if the issue isn't GUIs per se: It's more the implementation. I've used (and written) both GUI and character-based programs. I've used GUI programs that were delightful, and GUI programs that were a royal pain in the butt. Same for character-based programs.

I hate being forced to point and click endlessly once I know the score.

GUIs aren't exactly intuitive, either. People have to learn to use icons and mice—some never can. But the general structure of good Windows and Mac programs is pretty easy to learn and wears well: You can explore the menus easily, you can learn the accelerator keys as you go, and so on.

I think the key point is that once you do learn how to pull down menus, how to click and double-click and drag, then you can pick up almost any program that follows the conventions without reading any manuals.

STAN MIASTKOWSKI: I'm getting the very uneasy feeling that GUIs are actually the biggest con job that the computer industry has ever put over on us. In the early days of GUIs (Windows 2, OS/2 Presentation Manager 1.1), I was a big proponent. But lately, the more I use them, the more they infuriate me. Why? I feel that my screen is treating me like a six-year-old or a partially literate adult. After all these years, I'm still trying to figure out what some of those cute little icons mean or how to manipulate them. If the industry wants us to fall into lockstep with its feeble attempt to emulate the international language of graphical signs, it's failing miserably.

BOB RYAN: The point of GUIs is not to be cute. The point is to make it easier to get your work done by having all the applications you use work in a similar manner. I think the biggest problem with those of us in the industry is that we're so familiar with computers that we forget how intimidating they are to the vast majority of users.

TOM THOMPSON: I can do all the things on my Mac that other people can do with Desqview on their PCs: I can download in the background, print in the background, and write in a word processor window. My word processor window has very few icons: These icons manage text alignment, word wrap, and line spacing. They're up and out of the way, and I get a full screen of text to work with. It works, and it's fast. I can grab a chunk of text from my word processor and paste it to BIX through the telecomm application's window. Or I can grab a screen of BIX messages and drop it into a document.

Sure, the screen can get a little complicated; that's the equivalent of sorting through all those DOS commands, but a lot easier. I like my add-ons. They're useful, and they augment the Mac's capabilities much like that DOS add-on, Norton Commander, does for a PC. Finally, there's stuff that the mouse makes easier: drawing graphics and laying out pages. Computers are used for more than text. If you want to discuss the capabilities of a GUI, you must consider all computer users, not just writers or number crunchers.

UDELL: In the great either/or GUI/CLI debate, the real answer is that we need both. I love the fact that I can pick up almost any of the Mac applications (and many Windows applications) by poking around, without documentation. I hate being forced to point and click endlessly once I know the score. I especially hate the lack of universal transapplication scripting that would make automating my work easier.

The Mac's the worst culprit here: no CLI at all. Unix has a great CLI, but little integration of that with the GUI. Windows isn't much better yet: weak CLI, some integration with the GUI possible (e.g., Bridge Batch). Give me a good CLI and a good GUI, and have uses for them both.

But most of all, give me a universal script language that spans the two domains comprehensively and cleanly. It's fun to lasso a bunch of files in Windows' file manager and then delete them. It's fun once. But after that, give me "del *.obj." More important, give me ways to say "del *.obj when date < value, every Thursday night at 11." ■

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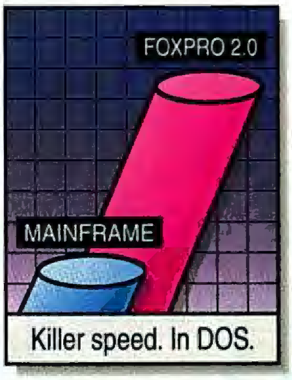

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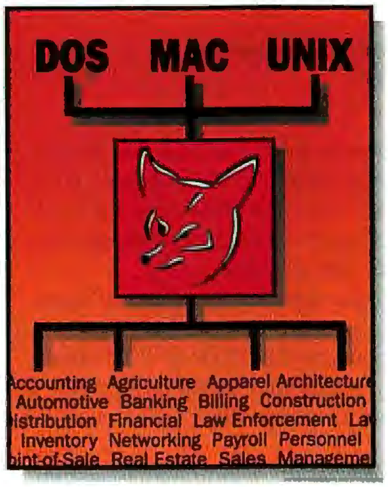

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Window Wars

Which GUI is for you? We stood the leading contenders side by side and compared their most important features.

KENNETH M. SHELDON, JANET J. BARRON, AND BEN SMITH

The term *graphical user interface* seems to be an unlikely candidate for the Buzzword Hall of Fame. Use the acronym *GUI* around someone who doesn't already know what you mean, and you'll probably get a glazed look. When discussing such systems, it's easier to resort to what has become a standard analogy and simply say they are "like the Macintosh."

"Like the Macintosh" means, of course, that you use a mouse, point to icons that represent programs and files, pull down (or pop up) menus of commands, and do this within separate windows on the display screen. There are variations on the theme, but these four elements (codified in yet another unappealing abbreviation, WIMP—for windows, icons, menus, and pointing device) are the basic tenets.

The history of the GUI doctrine is legend by now: Xerox's Palo Alto Research Center pioneered the concept. Steve Jobs thought it was "insanely great" and enshrined it in the Apple Macintosh. Bill Gates agreed, and his vision—though taking longer to catch on—culminated in the marketing and development juggernaut, Windows 3.0. Along the way, the entire computing world went GUI in one form or another, including such unlikely operating-system converts as Unix. (IBM—with its Common User Access—is even trying to drag mainframes and minicomputers, kicking and screaming, into the act.)

All this inevitably leaves the average person with a lot of questions: What's the difference between all the GUIs now available? Which features do I need, and which ones can I do without? Which GUI is best?

To help answer these questions, we take a close look at the GUIs available for the major categories of personal computers: IBM PC compatible, Macintosh, Unix, and Amiga. First, we look at them from a user's perspective, comparing the features that might make you choose one over the other. Then, we look at them from a programmer's perspective. (See "Tools for Window Workers" on page 139.)

Applications: The Chicken and the Egg

You can plan a great party, but if no one attends, it will be a bust. On the other hand, once people hear about a good party, everyone wants to go to it.

That's the way it is with a GUI: Developers don't want to spend time developing programs for an interface that no one uses; yet, unless a lot of programs run

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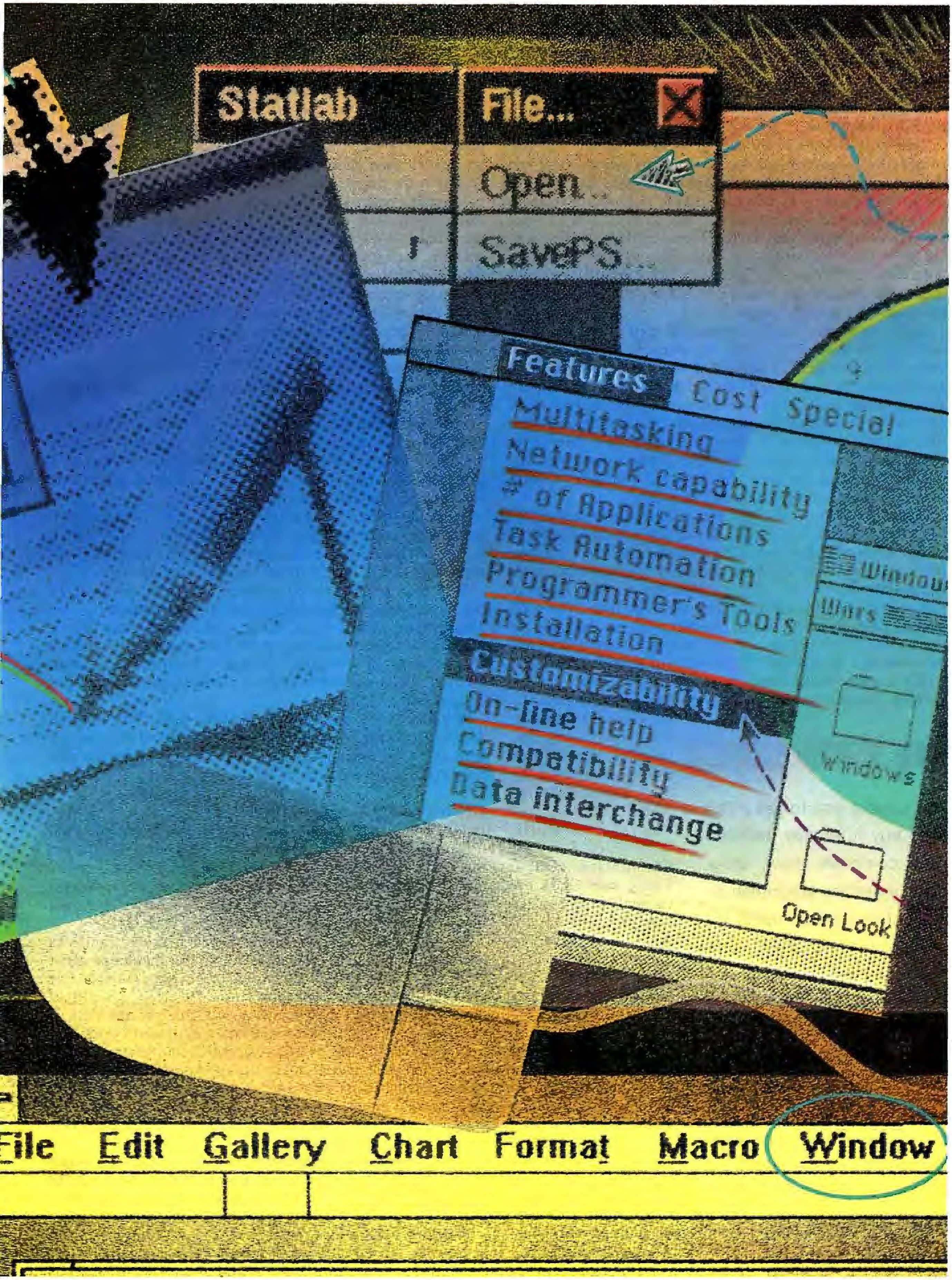
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on it, you're not likely to buy it. On the other hand, if the interface is introduced with enough fanfare, it will convince developers to write software *before* there's a guaranteed market.

That's what happened with Windows 3.0. Microsoft was able to sell developers on Windows 3.0 before its introduction, and the number of Windows programs released since then, according to Dataquest, is approaching 1200. This figure includes some of the nicest applications that run on PCs, such as Word for Windows, Excel, and Wingz. Compare that situation with OS/2, Windows' older sibling. According to IBM's National Solutions Center in Austin, Texas, which is compiling an applications guide for it, OS/2 has accumulated only about 100 Presentation Manager (PM) applications.

Ensemble is another PC-compatible GUI that's wrestling with the chicken-and-egg problem. Because it runs on older systems (such as the XT) and comes bundled with a number of applications (such as GeoWrite, GeoDraw, and GeoComm), Ensemble has been called the "poor man's Windows." However, only two companies other than its publisher, GeoWorks, have released programs that run under Ensemble. More may come; and if you're happy with the GeoWorks programs, you may not care that the most popular word processor, spreadsheet, or database program doesn't run on it.

In the non-DOS world, early Macintosh users can remember when there were exactly two Macintosh applications: MacWrite and MacPaint. Today, according to Dataquest, there are over 8000 applications for the Mac. Similarly, there are thousands of applications for the Amiga's Workbench. Don Hicks of Amazing Computing estimates that there are over 2100 commercial programs, with public domain programs bringing the total to over 4300. (By the time you read this, Commodore will have released Amiga OS 2.0, which will provide an all-new look to the Workbench interface.)

GUIs for Unix systems have slowly been adding to their stable of available applications. The leading contenders are Open Look—developed by Sun Microsystems, AT&T, Xerox, and others—and Motif, from Open Software Foundation (OSF). These two GUIs are currently in an applications race, and it is difficult to say which one has more programs running under it. Both run on top of the X Window System, so any commercial X application will run under either Open Look or Motif. (Evidently, it isn't that difficult for a software publishing company to create a GUI interface for one program if it has already worked on the other. For example, there are versions of WordPerfect for both.)

BYTE ACTION SUMMARY

The easiest way to get a GUI is to buy it already installed on a computer. New, lower costs make the Macintosh an attractive option here, although vendors of PC compatibles are now selling systems with Windows 3.0 already installed. For "preowned" PC compatibles, your choices are more limited: Windows 3.0 will allow you to run lots of applications if your hardware will support it. If not, you might consider Ensemble.

A fair count for Motif versus Open Look should include only applications that exclusively use the "widget sets" of one or the other. Ideally, only applications that conform to the style guide should be counted. (The Motif Window Manager doesn't do this.) There are certification checklists, but they are just now being approved by the respective companies.

When it comes to installed base, far more Unix vendors sell their systems with the Motif Window Manager (and development tools) than with Open Look. But Sun Microsystems is the leader in workstation sales, so more RISC-based workstations will probably be sold with Open Look. Open Look is also the default GUI with AT&T Unix System V release 4, although several SVR4 vendors ship Motif (e.g., Commodore's Unix system, the Amiga 3000UX, comes with SVR4 with Open Look, while the Sony Microsystems' News workstation BYTE recently reviewed ran SVR4 with Motif). There has been a great market for 386 Unix stations, and if these get a GUI, it tends to be Motif.

OSF claims that there are 200 Motif applications, but a close look at this list indicates that many of the programs don't use the Motif toolkit, which means they would run under any X manager, including Open Look. Sun estimates that there are currently 30 genuine Open Look applications.

While the Next computer is, technically, a Unix-based system, the Next user interface, NextStep, is in a class of its own. It is not X Window-based and does not support X protocols or applications, and, thus, will not run any X applications.

Still, there are roughly 80 commercial applications available for Next computers, including some popular applications like Mathematica, WordPerfect, Wingz, and FrameMaker. This is probably because prototyping on the Next computer is easy (see "Tools for Window Workers" on page 139), so the Next is often the first platform developers choose to evaluate the porting of an application to Unix.

NextStep is also available for the IBM RISC System/6000, and Next estimates that approximately 10 percent of those systems are being shipped with NextStep. The rest, if they are running a GUI at all, are running Motif.

Getting Along: Compatibility

Having all the applications in the world won't do you any good if they don't run well or get along with each other. Sometimes this has to do with the programming guidelines laid down by the GUI's developers: If the guidelines are mandatory, the programs are likely to look alike and be "well behaved" (i.e., not likely to crash or interfere with each other's operation).

Macintosh programs, for example, tend to be very similar in appearance and quite stable, since Apple maintains strict guidelines for developers. (You can almost always count on File and Edit to be the first two options on a Mac menu.) Usually, if the application isn't built to the specification of the GUI, it won't work at all; half-baked applications just won't work.

Like the Macintosh, the Next computer requires strict adherence to its guidelines to make an application function. The Next's excellent software development tools and toolkits (NextStep) make it almost foolish to "roll your own" user interface design for a Next application. As a result, Next applications tend to be stable and robust.

OS/2 PM also has fairly strict developers' guidelines, which can mean headaches for developers but tends to make OS/2 PM programs very compatible with each other. They may be slow, but they are generally robust and stable, and they don't crash.

Windows applications, on the other hand, can be a mixed bag. Some run perfectly, while others crash frequently. You'll generally have more trouble trying to run Windows 2.0 applica-

X for the Desktop: Desqview/X

Steve Carpenter

As this article was being prepared, another GUI contender entered the ring: Desqview/X, from Quarterdeck Office Systems (Santa Monica, CA), provides a full client/server X Window System for MS-DOS systems.

Quarterdeck's previous product, Desqview, is a nongraphical environment that lets you multitask MS-DOS programs. This background gave the company a running start on Desqview/X, since the X Window System requires multitasking. (Without multitasking, other X Window System products running under DOS can only implement the X Server to handle the local display. This means that you can only access X client applications available on the network, much like an intelligent terminal. In a sense, the network provides the "multitasking" capability that the local system can't.) Desqview/X also gives you access to the applications available on a multitasking DOS system—even to local DOS clients written to use the GUI capabilities of the toolkits running over the X Window System.

Besides the X Server and Desqview Window Manager (DWM) software, Desqview/X includes Desqview and QEMM software, which means it will be about as hard (or easy) to install as those products are in stand-alone mode. A network can raise the installation complexity even more, depending on the type of network you use.

GUI/window systems eat memory and processor cycles, so Quarterdeck recommends that you have a minimum of a 286-based system with 2 megabytes of memory. Although an 8088/8086 is sufficient to get Desqview running the X Server, a 20-MHz 386 system with 4 MB of memory should be a solid platform for Desqview/X.

Desqview/X will let you take advantage of the X Window System in three ways. First, on a stand-alone system, Desqview/X provides a complete GUI environment. Desqview plus X can support applications written to use buttons, sliders, menus, and the rest of the GUI paraphernalia. DWM even gives Desqview users a bonus of a three-dimensional graphical "look and feel" around windows containing conventional DOS applications. You can also add window managers like Open Look and Motif to Desqview if you want a different look and feel.

Second, on a PC LAN, Desqview/X lets you transparently access applications running on another MS-DOS system. Networked users who can't yet bear to part with their 16-bit 286 systems but want to use a 32-bit application like Paradox/386 have an economical solution with Desqview/X. Just one 386 system on the network gives everyone a window to the applications on that system.

Third, on a TCP/IP LAN, Desqview/X lets you share all resources in the enterprise, from supercomputer to word processor, and not just other MS-DOS systems. The configuration possibilities are endless.

Desqview/X has the potential of being the PC GUI/window system of choice for networked users. The question is, can Quarterdeck win a marketing war with Microsoft?

Steve Carpenter is an independent consultant specializing in event-driven software and open systems technology. He can be reached on BIX as "scarpenter."

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tions in Windows 3.0, and some programmers just don't follow the rules, regardless of the environment they're programming in. But as developers get used to the environment, Windows applications are getting better, and the majority of them now run fairly well.

Guidelines for developing programs for Amiga Workbench-, Open Look-, and Motif-based systems are all optional. Thus, the compatibility and consistency of applications is dependent on the design of each application. (In fact, you can sometimes run a Motif application in an Open Look window, or vice versa. They just won't *look* right.) In general, GUI-based Unix applications are as robust as the underlying implementation of the X server, some of which are a little flaky.

Up and Running

How hard is it to get a GUI up and running? That depends largely on the hardware you're using. The easiest way is to buy a system that comes bundled with a GUI. The Mac and Amiga each walk you through a simple installation procedure that involves putting in floppy disks and pressing the Return key. The Next computer is even easier: Turn it on, and you're ready to go. (The first Next systems loaded their operating systems from an optical disk, a procedure that was easy but took hours.)

Things are more complicated in the DOS and Unix worlds. You can buy systems from third-party vendors that have preinstalled Windows, OS/2 PM, Motif, or Open Look on their machines. But if you want to install one of these on a machine you already own, life could get interesting.

Windows has a good setup program that simply requires you to answer routine questions. If, however, you have an odd clone or an older AT and a CGA display, or if you have a lot of RAM-resident programs running, installing Windows 3.0 may be impossible. In the best-case scenario, installation is easy and takes about 20 minutes. In the worst case?—call a consultant.

OS/2 PM's installation procedure is similar to that of Windows. Although the setup software presents you with some esoteric questions, the manual helps you with most of them. Technically, you can run OS/2 PM on a 286, but it will be slow.

For older systems, Ensemble may be the GUI of choice. Installation takes a while—you have to copy seven 360K-byte disks—but the process is relatively painless. The installation program makes it easy to select and test all the appropriate drivers for the screen, mouse, and printer.

Loading Open Look or Motif is no more difficult than loading any other Unix program. For an experienced system administrator, the process might take 5 minutes.

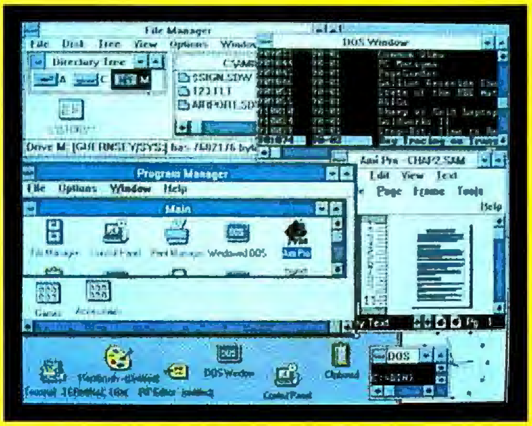
Have It Your Way: Customization

Once you get a GUI running, you can usually adapt it to suit your own tastes, changing things such as the background color and pattern. However, the degree of changes and how easy they are to make vary from system to system.

continued

The Best of GUIs; the Worst of GUIs

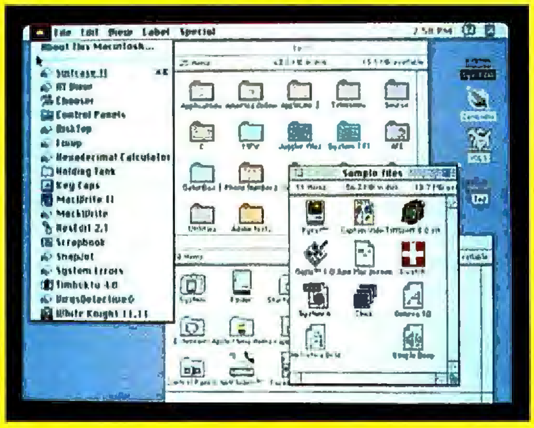
Every graphical user interface has its good and bad points. Here, in a nutshell, are the pros and cons of the major GUIs.



Windows 3.0

BEST POINTS
- many applications available
- runs older DOS applications and new Windows-specific programs
- in enhanced mode, can multitask DOS applications
- macro and task-automation capabilities included
- provides on-line help
- relatively inexpensive to buy (but see below)

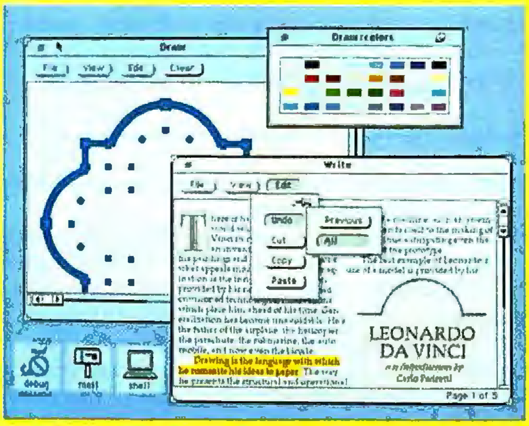
WORST POINTS
- requires a lot of hardware and memory to take full advantage of features



Macintosh

BEST POINTS
- system is integral to machine; easy to install
- many applications available
- applications are stable and compatible with each other
- network capability built in

WORST POINTS
- cooperative multitasking is only as good as worst-written program



Open Look

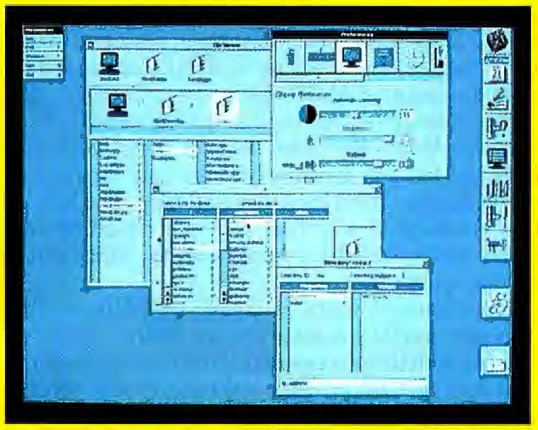
BEST POINTS
- multitasking capabilities built in from the ground up
- network capability built in
- easy to configure for personal preferences

WORST POINTS
- no macro or task-automation features included
- developer guidelines not mandated; applications may not appear consistent

Ensemble

BEST POINTS
- inexpensive, easy-to-use package
- runs on older-model 8088 machines
- includes a number of basic applications that work well together
- multitasking capabilities built in from the ground up

WORST POINTS
- lack of "power" applications, such as database, spreadsheet, or heavy-duty word processor
- no macro or task-automation features included
- no programmer's tools
- no network capabilities included



NextStep

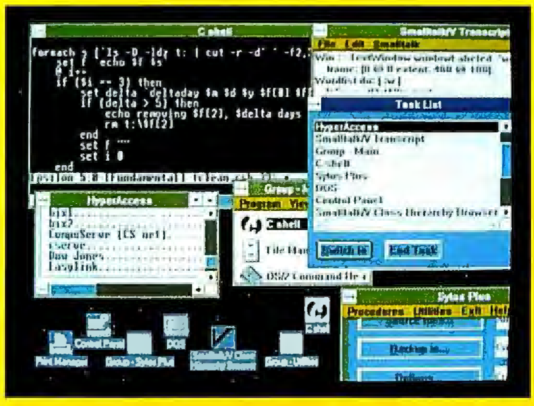
BEST POINTS
- system is integral to machine; comes already installed
- applications are stable and compatible with each other
- multitasking capabilities built in from the ground up
- provides on-line help
- network capability built in
- good support for interprocess communication

WORST POINTS
- only available on the Next computer and the IBM RISC System/6000
- few applications available
- no macro or task-automation features included

Motif

BEST POINTS
- multitasking capabilities built in from the ground up
- network capability built in

WORST POINTS
- no macro or task-automation features included
- no file manager included
- developer guidelines not mandated; applications may not appear consistent



OS/2 Presentation Manager

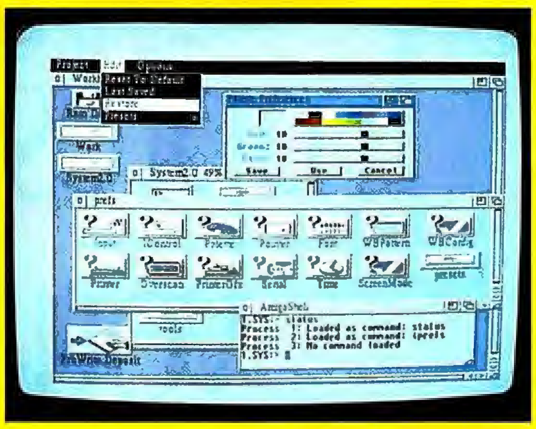
BEST POINTS
- applications are stable and compatible with each other
- multitasking capabilities built in from the ground up
- provides on-line help
- macro and task-automation capabilities included

WORST POINTS
- sold only through IBM dealers, and many don't sell it
- few applications available

Amiga Workbench

BEST POINTS
- system is integral to machine; easy to install
- many applications available
- easy to configure for personal preferences
- multitasking capabilities built in from the ground up
- macro and task-automation capabilities included
- good support for interprocess communication

WORST POINTS
- lack of consistency across applications
- lack of 8- and 24-bit color
- no network capabilities included



Almost all GUIs let you change the background screen—the "desktop" upon which your files and program icons are located. Windows comes with a Wallpaper menu option. OS/2 has more-limited color choices, and choosing them is more difficult (e.g., there is no wallpaper).

Some GUIs—the Amiga Workbench and Windows 3.0, for example—let you choose the font the desktop uses. (You can change Macintosh Desktop fonts, too, but it isn't easy.) In fact, the Amiga could win a "user-configurable award," with its 13 Preference Editors that let you change such options as font, mouse speed, color, and resolution of the Workbench screen.

With Open Look and Motif, *everything* is customizable, but you have to be a bit of a hacker to make changes. The menus and environment variables are described in a text file called `.Xdefaults` and several initialization, configuration, and menu files that you can have in your home directory. Open Look makes things a little easier than Motif: You can change some configuration parameters, such as background color, directly through the window manager. On some Open Look systems, you can even customize your menus through menu operations.

Here is where the Next environment falls short of the other window managers and GUIs. Like the Macintosh environment, you can do little more than show which applications you want to have immediately available to your user account and how the icons will stack. The benefit is that the few configurable resources are configurable with window manager utilities. All changes can be made through utilities that are part of a window manager, and most of these operations can be done with mouse motions and clicks.

Make It Easy

You win some and you lose some with a GUI. Some tasks get easier, while others—like creating macros or scripts to repeat commonplace procedures—become difficult or impossible.

Longtime PC-DOS users invariably have a host of batch files, keyboard macros, and other time-savers that depend on receiving a steady stream of ASCII characters rather than a bit-mapped image. Transferring that capability to Windows means using a utility like Macro Recorder, an accessory that comes with Windows and lets you record keystrokes and mouse motions so that you can play them back automatically. The Macintosh interface comes with a similar program called MacroMaker, and you can also purchase Apple's MPW, which offers good ways to manipulate files.

For more sophisticated users, a couple of GUIs provide scripting languages that let you automate procedures. OS/2 PM version 1.3 comes with Rexx, a powerful, interpreted-scripting language, and AmigaDOS provides a version called ARexx. (See "Rexx in Charge," August 1990 BYTE.) The Unix-based GUIs and PC-compatible Ensemble do not have built-in macros or scripting facilities.

Doing Double Duty

Multitasking—the ability to run more than one program at a time—is often a main reason to get a GUI. However, multitasking is largely a function of the operating system on which the GUI is built, and not all systems handle multitasking the same.

Some operating systems use *cooperative* multitasking: When the system isn't busy with the application you're currently running (say, between keystrokes), it can give attention to background tasks, such as downloading a file. The "gold standard" for multitasking, however, is called *preemptive* multitasking. In this approach, the system divides processing power into time slices and allocates portions to each application. The advantage of preemptive multitasking is that it tends to isolate tasks; if one application crashes, the system won't necessarily come down.

Operating systems like Unix, OS/2, and the Amiga Exec employ preemptive multitasking, so GUIs that run on them have more-advanced multitasking features. Even the entry-level Ensemble is built on an operating-system layer (PC/GEOS) that provides preemptive multitasking.

Interestingly, the system that started the GUI revolution—the Macintosh—uses cooperative multitasking in its MultiFinder (a multitasking version of the Finder that comes with the system). The disadvantage of such a system is that it is only as good as the best-behaved application that you're running.

Similarly, Windows uses cooperative multitasking, unless you are running in enhanced mode on a 386 system. If this is so, you can run multiple programs—including DOS—in "virtual" 386 systems, and the programs are protected from each other's quirks. Without a 386, you can run only one DOS application at a time, and you can't run it in the background while running a Windows-specific application in the foreground.

Talk to One Another

If you're running more than one application, you might want to pass information back and forth between them. This could be something as simple as copying text or graphics into a "clipboard," exiting the application, opening another application, and copying the data from the clipboard to the new application. Almost all GUIs allow this kind of data transfer.

Beyond that is *interprocess communications*, a more active kind of data swapping. For example, if you have a communications program that's receiving a constant stream of data about your stocks, the program passes that data to a spreadsheet, which alerts you if prices fall below a certain point.

This kind of linkage is easier for operating systems with preemptive multitasking (and GUIs built upon them), because the applications are running as truly separate tasks. Thus, it should be easier for programmers to write applications that share data under OS/2 PM, Open Look, Motif, NextStep, and the Amiga Workbench.

Unfortunately, only a few programs take advantage of interprocess communications. Lotus's 1-2-3/G and Freelance Graphics, which run under OS/2 PM, are notable exceptions. In fact, the two programs actually load some of the same code when you start them up. OS/2 PM uses a technique called Dynamic Data Exchange to pass information between applications (see "Hot Links to Go," November 1990 BYTE). Windows 3.0 uses a slightly different technique for DDE (in part, because its multitasking model is different), but the end result is the same: You can establish "links" between programs to perform tasks such as automatically updating databases and spreadsheets or downloading E-mail.

Microsoft recently announced a new technology based on DDE, called *object linking and embedding*, which will go beyond linking and let you combine various types of data in a

A GEM by Any Other Name

Janet J. Barron

In 1985, Digital Research, Inc. (DRI), released a graphical user interface system software called GEM. At that time, GEM ran on top of the operating systems for the Atari ST and PC-compatible machines. Since then, Atari has continued its own development of the software, and GEM is now built into the ROMs of all Atari ST computers. The company continues to upgrade both the base operating system and the Atari version of the GEM interface. It releases its new ROMs through retail outlets.

On the PC-compatible side, GEM has largely been superseded by Windows and OS/2. As a result, DRI is leaning away from the GEM name and original concept and choosing instead to release new applications that overlay and use some of the former GEM functionality. These include Presentation Team 2.0, a $495 presentation program available as a stand-alone package or as a network server version, and Artline, a graphics illustration program available only as a stand-alone package for $595.

Currently, the only way to obtain the GEM system software by itself is to purchase the GEM programmer's toolkit. At a cost of $500, this kit is designed for developers who want to incorporate the GEM engine into their applications.

single document. This is part of a new "document-centric" world view (as opposed to "application-centric"), in which you manipulate a document with a variety of tools, rather than "opening" an application and working with a single type of document. So far, only two Microsoft products incorporate OLE—Excel 3.0 and PowerPoint—but the company says that it expects all future releases to incorporate the technology.

Interestingly, the types of features that OLE offers have been available for some time from Hewlett-Packard's NewWave, a sort of "super-GUI" that sits on top of Windows. So far, however, the only applications that run under NewWave have come from HP. That leaves NewWave users in the same boat as the lower-end Ensemble users; thanks to preemptive multitasking, Ensemble has the capability to provide true interprocess communications. Until developers create programs to take advantage of that capability, though, it won't do you much good.

Another issue is how strong the links are between two applications. Under Windows, DDE links require one document to remember the location on the hard disk of another document. If you reorganize your hard disk, change a path name, or delete a file, the link breaks. That isn't true of NewWave, which tracks files more carefully.

On the Amiga Workbench, the ARexx macro language lets you share data between two or more Amiga programs equipped with ARexx message ports. (Such ports have lately become de rigueur on Amiga applications.) ARexx lets you create "meta-applications" using stand-alone Amiga programs.

Networks and Windows

These days, more and more of our personal computers are connected to other systems via LANs. Another consideration about GUIs is, therefore, how well they work with networks. Ideally, a GUI should let you attach to a network easily and should thereafter treat network resources (e.g., hard disk drives and printers) as if they were peripherals attached to your own machine.

We have to recognize two different approaches here: X Window System and the rest of the world. The X approach is inherently network-oriented, so GUIs based on it will operate over networks more easily and efficiently.

In the non-X world, the ease or difficulty of attaching to a network varies. Of course, you first must have the right hardware installed. The software can, however, make it easier to change networks or reconfigure the network you're attached to. The Macintosh's Chooser menu lets you select a network, enter your passwords, and go on from there. Windows 3.0 provides the same capabilities through its control panel and print manager. OS/2, on the other hand, doesn't provide those kinds of user-friendly network reconfiguration tools. (Note that the only network software currently available for OS/2 is LAN Manager.)

The Amiga Exec doesn't provide specific support for networking. Each network implementation and application must provide its own hooks into the operating system. However, Commodore is currently developing a layer for Exec called the Standard Amiga Network Architecture, which will provide a common application programming interface for networking functions. SANA will make it much easier to network Amigas.

Ensemble has no network capability at this time, although GeoWorks has indicated that it plans to support networks in the future. And although NextStep is not X-based, it is heavily dependent on networks and servers, and all Next applications have network capability built in.

Getting Help

GUIs are so easy to use that you don't need manuals or support, right? Right. But just in case, you'd better have a manual handy, and on-line help *would* be nice. It makes sense to be able to ask the interface for help, rather than having to look up what you need to know in a book.

Unfortunately, on-line help seems to be the exception, rather than the rule, for GUIs. Only OS/2 PM, Windows 3.0, and NextStep provide such help. All of them are good, fairly extensive on-line help systems. The Windows help facility is a hypertext system that includes graphics. Vendors can add help information on their own software for the system. The Next computer's help system is a separate, launchable documentation application.

Although the Macintosh doesn't currently provide on-line help, System 7.0 includes a help facility called Balloon Help. When you activate this feature, passing the cursor over any item on the screen will bring up a cartoon balloon-like graphic con-

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taining a brief description of the item. (For more on System 7.0, see "Seven's a Success" on page 42.)

Whether or not you can get on-line support, you can sometimes get telephone support for GUIs. Microsoft has a 900 number (i.e., you're charged for the call) for its phone support. Commodore provides phone support, but, again, you pay for the call. GeoWorks provides support for Ensemble via America Online, an electronic conferencing service, and a help phone line (not toll-free). Sun provides support for Open Look—also for a fee.

Bottom Line

What does it cost to add a GUI to your system? Some—like those that come with the Macintosh, Amiga, and Next computers—are bundled with the system and don't require you to add additional hardware. Looked at one way, those GUIs are free; conversely, they cost as much as the whole system.

GUIs for PC-compatible systems tend to be sold separately. OS/2 costs $340, and Windows 3.0 lists for $149, although that price doesn't take into account the cost of any additional hardware you may need. (You can run Windows 3.0 on a 286 machine, but you won't be able to multitask DOS programs. If you only need to switch tasks easily, though, it should suffice. If you need true multitasking, you'll need a 386 system.)

In contrast, Ensemble—at $199.95—will run on any PC-compatible machine (even an XT) that has 512K bytes of RAM, a hard disk drive, and a CGA display. Ensemble also comes with several applications.

Motif and Open Look are usually included when you purchase a workstation. You can buy them separately, but most people don't. As with DOS-compatible GUIs, you may need to buy additional hardware; the minimum configuration is a 386 system with a VGA display, 8 MB of RAM, and the X Window System server software (although monochrome workstations and X terminals will also work). Then there's the cost of the GUI—an insignificant $10 for Motif, but $295 for Open Look.

Who Needs 'Em?

You'll probably never know if you need a GUI until you try one out. It's usually a matter of personal taste; your level of computer expertise isn't necessarily a criterion. At BYTE, some of the most technically knowledgeable staff members swear by GUIs; others just swear *at* them.

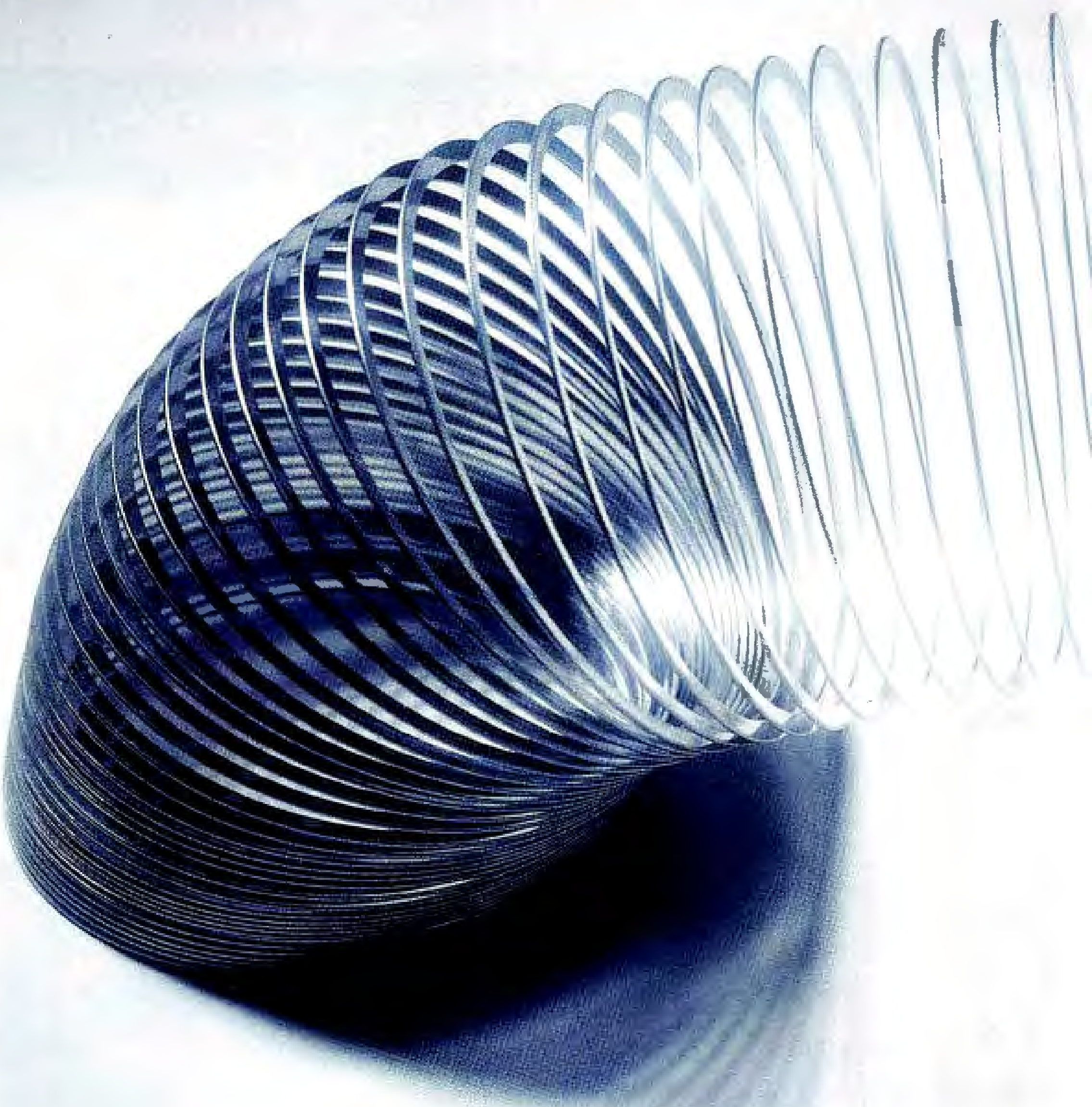
If you already own a computer and you want to add a GUI, your choice is essentially a trade-off between performance and applications—and cost. If you have an older system, and you can live without the latest and greatest applications, Ensemble may be the GUI for you. If you want to run more programs and you need more features, check out Windows or OS/2. You'll probably be interested in Motif or Open Look only if you're already a Unix user.

If you don't own a system and ease of use is a priority, the Macintosh, Amiga, or Next systems with a built-in GUI may be a good choice. The Macintosh has more programs available, but the Amiga has some more advanced features that might make it attractive for certain applications. The Next interface is powerful and seamless and has great features, but there aren't many application programs available for it yet. ■

Kenneth M. Sheldon is a senior editor and Janet J. Barron and Ben Smith are technical editors for BYTE. They can be reached on BIX as "ksheldon," "neural," and "bensmith," respectively.

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

There are still some t



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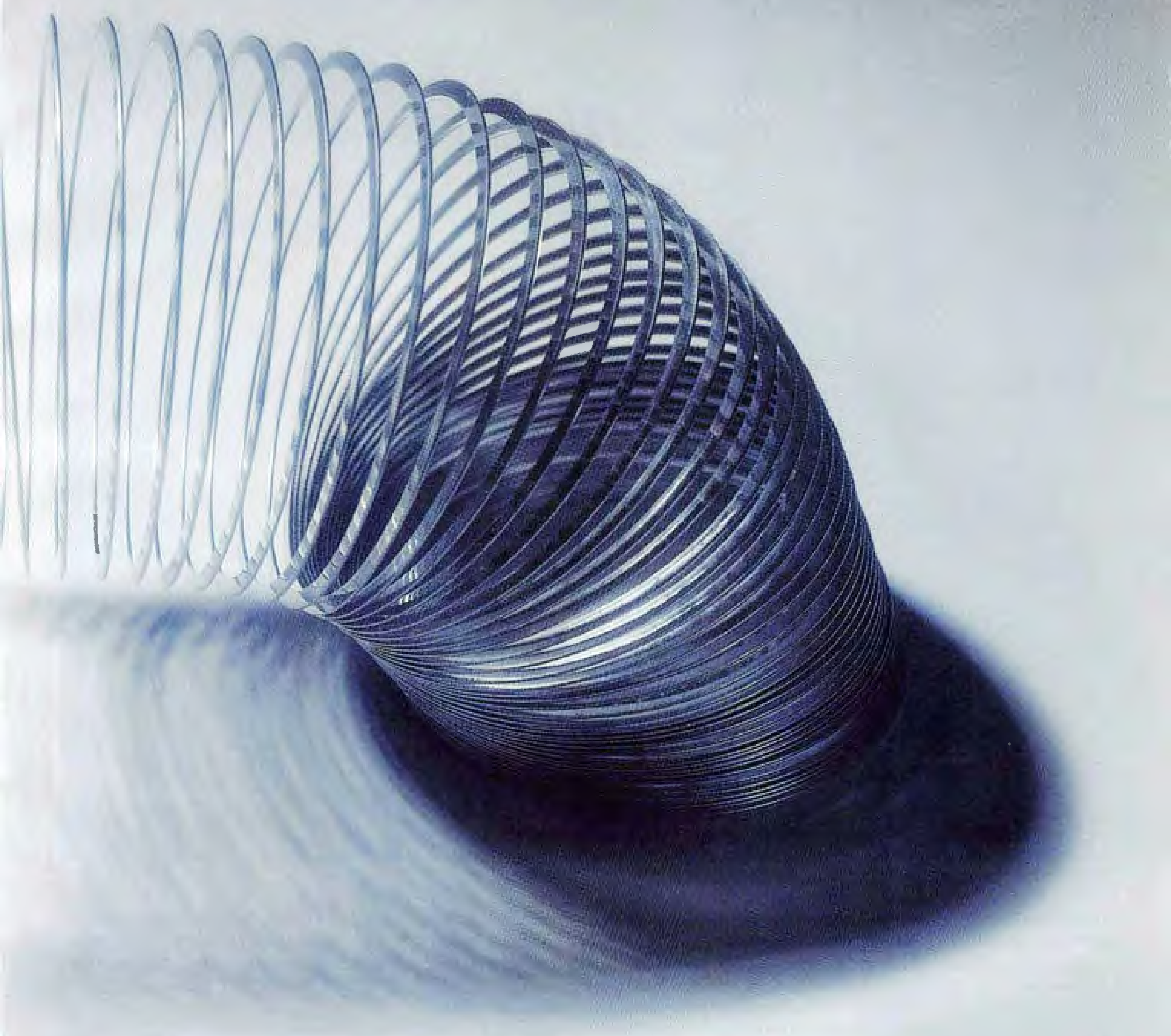

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Tools for Window Workers

Without appropriate programming tools, building window applications is difficult. Now there are development systems to help generate the popular graphical user interfaces.

MARTIN HELLER, PETER WAYNER, AND BEN SMITH

Making applications more appealing and easier to use means adding complex structures and functions: windows, menus, buttons, scroll bars, icons, colors, and so forth. What might be five lines of programming code as a text-based program becomes 105 lines as a window program.

At first, developers had to build their own windows and menus from scratch. Libraries and toolkits for PC compatibles became available, but each was different. Only Macintosh applications showed consistency, largely because the interface was built into the operating system.

Since then, however, some popular and powerful standard window systems for MS-DOS, OS/2, and Unix have appeared. None of these window systems is simple. Most of the designs use concepts from object-oriented programming (OOP), such as object classes and inheritance. Building your first application in any of the major window systems takes a substantial amount of study and many lines of code. It has become clear that the acceptance of any window system takes more than the demands of users; it requires good tools that shorten the learning curve and slim down an expanding development schedule.

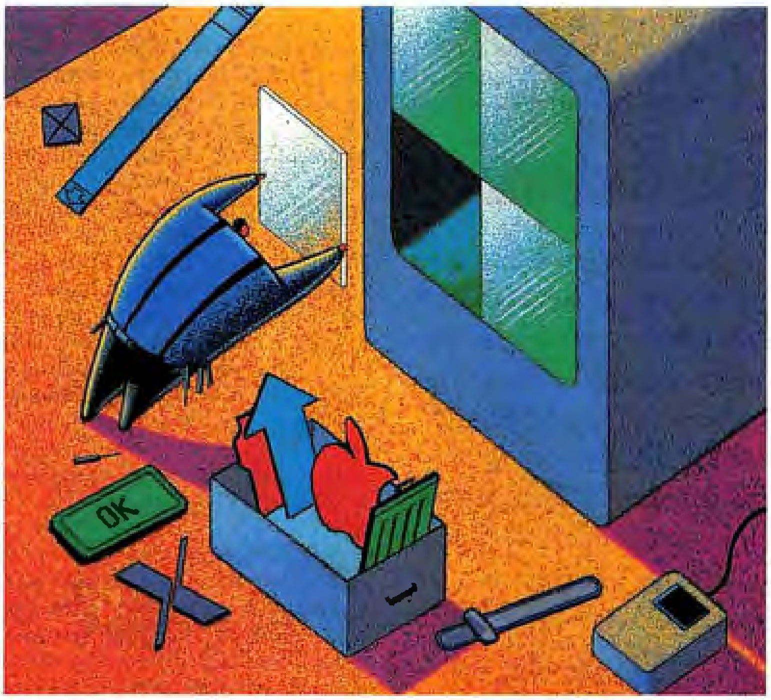
Today there are tools, toolkits, libraries, graphical user interface- (GUI-) based development systems, and you-name-it for programmers developing in any of the now-standard window systems. There are even tools for developing in all window systems at once. (See the text box "A GUI for All Systems" on page 144.)

PRESENTATION MANAGER AND WINDOWS

Martin Heller

One hallmark of a mature technology is that there are lots of third-party add-on products. At least, there are lots of these products for Windows and OS/2 Presentation Manager, but are they mature? Maybe not—but they're growing up. If you want to develop software for Windows or PM, now you actually can pick and choose your tools. Microsoft and IBM development kits and compilers are still good choices, but there are lots of competing products.

Veteran Windows programmers still use Microsoft C and the Microsoft Software Development Kit, because that's what they've been doing for the last eight years. You really do not need to do the same thing. One alternative to Microsoft C that supports Windows (but still requires you to have the Windows SDK) is Zortech C++. The major advantage



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of ZTC over Microsoft C is... well, that it is C++, so you can make your code object-oriented. ZTC comes with a few relatively simple examples of classes for Windows: The hierarchy descends from a root class "WBase" to classes for list boxes, menus, buttons, and file-selection list boxes (descended from the list box class). Because Windows is highly object-oriented, it makes sense to program it in an object-oriented language. Once the class hierarchies are developed, building applications becomes much simpler.

If you want to build a full-blown class hierarchy for Windows 3.0 starting with the Zortech examples, you may still be working on it when Windows 3.1 ships. Fortunately, several vendors have already done the work for you. Glockenspiel of Dublin, Ireland, has developed CommonView (distributed in the U.S. by ImageSoft). CommonView now works with ZTC as well as Glockenspiel's own implementation of CFRONT.

For those who are unfamiliar with C++, CFRONT is the AT&T front end that generates C code from the C++ source. The C code must then be run through a compiler, such as Microsoft C. ZTC combines the steps and produces object code directly from the C++ source.

Another set of class libraries for Windows comes from CNS. Its C-Talk/Views has its proprietary C-Talk language preprocessor along with its Views class library and requires a C compiler; C++/Views implements Views for ZTC.

For those who prefer the Turbo approach to languages, Borland will shortly be shipping versions of Turbo Pascal and Turbo C++ that support Windows. My understanding is that Borland will ship a resource compiler and `#include` files that will enable you to build Windows programs without owning the Microsoft Windows SDK. You may, however, want to buy the Microsoft Windows SDK manuals; they're available at most computer-oriented bookstores and software stores.

Modula-2 enthusiasts will soon be able to write Windows programs, too: Jensen & Partners International (JPI) currently has a version of its TopSpeed Modula-2 program that works with Windows in beta test. Rumors from the beta testers have been encouraging.

On to Presentation Manager

Strangely, there are actually more language choices for OS/2 PM than there are for Windows. You need the IBM Programming Tools and Information (PTI), the Microsoft Programming Tool Kit, or the Microsoft SoftSet. The SoftSet is inexpensive but lacks manuals and examples. You can buy the manuals at bookstores, but you might miss having examples to copy.

As you'd expect, the IBM and Microsoft C compilers are compatible with the tools. So are the OS/2 version of ZTC and JPI's TopSpeed C.

FORTRAN fans can find OS/2-compatible compilers from Microsoft and Ryan McFarland; Modula-2 devotees will find offerings from Logitech, Stony Brook, and JPI. Last but not least, Ryan McFarland offers a COBOL compiler with PM support.

BYTE ACTION SUMMARY

When it comes to writing programs with graphical interfaces, there's more than one way to open a window. The methods range from traditional programming languages with special libraries of graphical functions to development systems that let you use a GUI to create a GUI.

For the Faint of Heart

Not everyone needs to write programs from scratch. Not everyone wants to. Not everyone can: The learning curve for Windows and PM programmers is pretty steep. One shortcut for beginners is to use an application generator. Many of these programs call themselves computer-aided software engineering (CASE) tools or even expert systems, but I don't think most of them qualify in either category.

The limitation of application generators is usually that they get you only 80 percent to 90 percent of the way toward having a usable program. You still have to write code to make an application work properly. In addition, some of the tools will not preserve your additional code, so be careful and keep lots of backups. Nevertheless, you may get substantial benefit from using one of these tools, compared with learning to write Windows or PM programs from scratch.

The list of GUI application generators, which seems to grow more every week, currently includes WindowsMaker and WindowsMaker Professional from Candlelight Software, Instant Windows from WinSoft, CASE:W and CASE:PM from CaseWorks, ProtoView and ProtoGen from ProtoView Development, GUI 3-in-1 Prototyper, and GPF from Microformatic. Application generators can sometimes let you generate code for several different GUIs from a single design. CASE:W and CASE:PM claim to do this, and many other vendors have this capability or are working on it. Generators claim to produce efficient code, too. Caveat emptor: There is more than enough hype in the Windows market to go around.

Development Systems

You may not need the speed of a compiled language: If you are building a prototype or an interface to a "workhorse" program, you might prefer an interpreted system. Of course, ToolBook (from Asymetrix) has received plenty of media coverage. It's a nice HyperCard-like system with some definite advantages over C code in terms of ease of development but marked disadvantages in terms of execution speed.

ToolBook isn't the only object-oriented environment in town. WindowCraft by Echelon Development is another HyperCard-like "multimedia toolkit." Spinnaker Plus boasts the ability to develop and run custom information management systems on Windows 3.0, PM, and Macintosh platforms.

Then there are the object-oriented language systems. The granddaddy of them all, of course, is Smalltalk, and Digitalk has versions of Smalltalk V for both PM and Windows. Or, you can go for Actor (from Whitewater Systems), recently enhanced with Actor Object Graphics.

If you are more comfortable with C++ syntax than with Smalltalk, you might prefer Object/1 from database vendor MDBS, also for Windows and PM. Object/1 has the distinction of coming with a full relational database system (derived from Knowledgeman) built in; it also has built-in interfaces to SQL Server and to the vendor's own high-performance transaction-processing database, MDBS IV.

Databases Galore

On the PM side, three more development systems boast database interfaces: Easel (from Easel Corp.), Application Manager (from Bower's Development), and Mozart (from Mozart Systems). These systems tend to know a lot about IBM's OS/2 Extended Edition database module and about DB2, HLLAPI, EE Communications Manager, and all that Blue stuff. Mozart

has the distinction of running under DOS (in character mode) as well as under PM.

Of course, if you're working with a database, you may not need to look further than your database vendor. Omnis 5 applications can be ported transparently between Macintosh and Windows and are relatively easy to design. Superbase 4 offers its own programming environment, and dBFast/Windows is for dBASE users wanting to move to Windows. dBFast claims also to offer complete portability to the Macintosh.

If you speak Structured Query Language, you might like Gupta's SQL/Windows front end. For performance, db_Vista (from Raima) and MDBS IV run under Windows and can give you excellent results as long as you understand Codasyl and Network database models. I've built applications with both databases, but I write my code in C and use the bare Microsoft toolkits, too.

AI

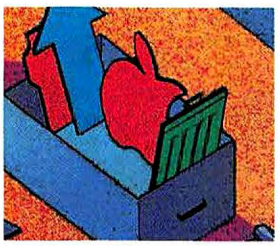
One of the more striking things about last fall's American Association for AI meeting was how many of the exhibitors had products for Windows, both in the expert-system and neural-network areas. Kappa PC from IntelliCorp combines OOP with a frame-based expert system; this is a major-league product, but it also has a major-league price: $3500. For that, you can buy about five copies of Knowledge Garden's KnowledgePro, which combines hypertext with an expert system. And I can't even list all the neural networks that run under Windows.

Bridging Applications

If you want to build a workstation from several Windows applications, you might want to look into the Bridge Tool Kit or Bridge Batch, both from Softbridge. Or you can use the macro languages built into Word for Windows, Word for PM, Ami Pro, or Excel as your starting point and spin a web between applications with Dynamic Data Exchange.

BUILDING FOR THE MACINTOSH USER INTERFACE

Peter Wayner



When Apple introduced the Macintosh, it didn't announce just a computer but an entirely new way of programming. The machine not only had a CPU and memory, but it also had a ROM chip filled with routines that would do much more than access the disk files. Every Macintosh program interacted with you through these standard Toolbox routines for creating windows, menus, radio buttons, and sliders. Apple wrote guidelines for the user interface that specified the right way for all Macintosh software to look and operate.

Unfortunately, all the easy life of the user mandated plenty of work by the programmer. The Toolbox routines for manipulating the user interface were well designed and extremely modular; but at the beginning, programmers found it almost impossible to start writing software for the Macintosh without having first learned a large fraction of the Toolbox. That has changed. There are now several different approaches to programming with the Macintosh toolkit that blend different amounts of OOP, graphical programming, and compiler and interpreter techniques. Each of them makes it easy to build simple Macintosh applications in a day. Doing more complex work, though, still requires a certain amount of diligence.

Closet Secret

The skeleton application was the first solution developed by programmers to handle the complexity of the Macintosh. Many standard applications contained the same basic code for dispatching the mouse and keyboard events to the proper procedures. Programmers quickly realized that these common routines could be abstracted and stored as a code skeleton. Writing a Macintosh program was accomplished by making a copy of the skeleton code and adding the new code for handling the different parts.

There may be as many skeletons as there are dedicated Macintosh programmers, but some of the most popular ones are in the public domain and distributed freely. Transkel is one popular skeleton, and it comes in two versions: for picture and text. It can be found in archives and user-group libraries around the country. (It is also available on BIX.) Many power programmers still swear by skeletons, because they can generate the cleanest code. Of course, only power users can achieve this nirvana.

Objectify Me

Apple also realized that programming the Macintosh often involved many repetitive processes that could be abstracted. They distilled these standard fragments of code into a set of objects called MacApp, which run in the MPW. This system is substantially more sophisticated than a skeleton, because the entire structure is designed in an object-oriented way. Thinking of the Toolbox and the user interface with the object-oriented metaphor makes programming much simpler. In this view, the controls—like radio buttons, menus, or slide bars—and the windows are enchanted objects that accept orders from one another. MacApp passes these messages around in the background, and the programmer, in theory, needs to worry only about hooking up the correct button to the correct procedure for handling it. MacApp does the rest.

Before, a programmer who wanted to add a window would need to duplicate the code for opening the window, updating it, and controlling the buttons and gadgets on it. A programmer using MacApp would just issue the command to create a new window object and add the objects for the buttons and controls. The standard code for manipulating a window's drag bar, its scrollers, and its other features would be automatically bundled in by the compiler. MacApp would also bundle the code for handling all the different buttons and controls. The programmer does not need to even know about skeletons or worry about doing most of the work.

Symantec has also added a set of objects, called the Think Class Library, to its popular C and Pascal compilers. These are quite similar to MacApp, and they provide much of the same support in the same object-oriented style. Some nuances are different, but the basic theme and usage are the same. These libraries are included with the latest versions of the company's compilers (4.0 for C and 3.0 for Pascal) in a reasonably priced package.

To programmers, the one great advantage of these object-oriented systems is that it is easy to add to them and share each other's code. One company, Lexington Software Design, is selling by subscription a product called Prepare( ) for extending the Think C Class Libraries. You get six issues as they emerge from the shop, and each contains a number of different useful objects. The first issue, for instance, contains a sophisticated list-manager object and a directory browser that is modeled after ResEdit's structure. Those who subscribe to Prepare( ) will find it easy to build these into their own code. At the present time, three issues have been published, and the

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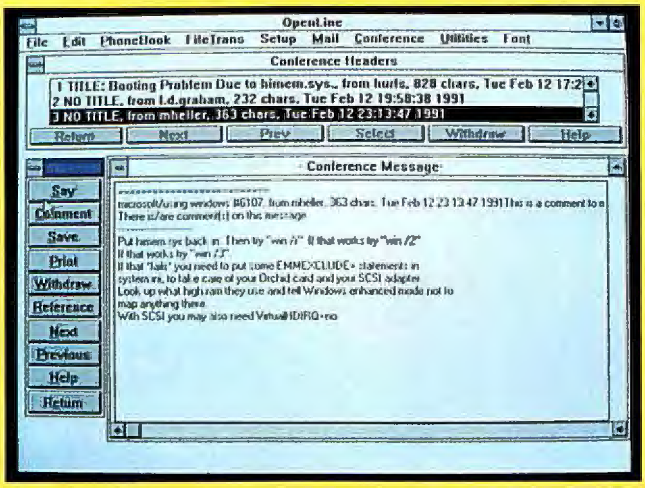
A GUI for All Systems

Steve Carpenter

Imagine writing one interactive, graphical application and having it run without and source code changes—not even conditional compilation—on all the major graphical user interface/window systems: Open Look, Motif, Presentation Manager, and the Mac. Sound unlikely? This is exactly what Extensible Virtual Toolkit (XVT) by XVT Software of Boulder, Colorado, offers: a programming interface featuring source code portability between all these window systems. (See "A Virtual Toolkit for Windows and the Mac," March 1989 BYTE, and "Bridging Troubled Waters," April 1990 BYTE.)



BIX needed a friendlier, more graphical face that would look and feel the same on a variety of computers. The company it contracted used XVT to develop this look, which will be available for Windows, Macintosh, Amiga, and other systems.

You could say XVT is a generic window system. Therefore, any developer in an organization that's concerned with protecting software investment should become familiar with XVT. Not surprisingly, one such concerned organization is the U.S. government. XVT is on the government's list of recommended application portability technology.

Another such organization is BIX, which recently contracted Softwords to develop a user-friendly graphical front end to its on-line conference system (see the photo) using XVT. BIX director Stephen Laliberte says, "BIX subscribers embrace every imaginable type of computer, and we wanted to have the same functionality across a variety of platforms." According to Laliberte, the new interface will be available for PC compatibles, Macs, Amigas, and other systems. It will let users point and click to join conferences, read mail, edit messages, and perform other previously command-oriented functions.

XVT implements a single, layered interface with a set of libraries (one per target GUI) and a common C language header file. Each library and header file combination, with accompanying utilities, tutorials, and documentation, forms one XVT product. Together, the library and header file present you with C functions that transparently invoke the native functions of the target GUI.

This approach might suggest that XVT supports only those functions common to all the target GUI/window systems. This is not so. If a function does not exactly map into all the target GUI systems, XVT makes the layer "thicker" to support a higher level of function abstraction. For example, since type fonts are often different between systems, XVT handles user font changes internally for each target GUI system. Your program does not have to handle the particulars of the font you select, but just an abstract change of font.

Does this mean XVT applications work slower than native GUI applications? I compared a native drawing application with a drawing application that used the XVT interface XVT-Draw. After a painless XVT installation on a Mac Plus and compilation with Symantec's Think C, I noticed no difference in performance between XVT-Draw and the native MacDraw.

There are other issues to consider: Some GUI/window systems have functions not provided on other systems. If you need those functions to do your job, then XVT is not for you. XVT also requires particular versions of tools on target platforms. On the positive side, XVT looks easier to program than Microsoft Windows does. Comparing an XVT Hello World program and the Hello, Windows program in Charles Petzold's *Programming Windows, 2nd Edition*, shows that similar functions can be programmed with fewer XVT statements. Whatever makes notoriously complex GUI programming easier is a boon to programmers!

Steve Carpenter is an independent consultant specializing in event-driven software and open systems technology. He can be reached on BIX as "scarpenter."

other three should come out during this year. After that, all six will be available as one package.

Draw Me

Even though OOP is an easy way to think about the Macintosh, it is still very textual. The GUI is created in MacApp with words, not pictures. Many people asked, "Why not write a graphical program that lets a programmer draw an interface on the screen and create Macintosh interfaces the Macintosh way?" Several companies have done just that. Smethers Barnes markets Prototyper, and Bowers Associates sells AppMaker.

Both let you build menus, windows, and control objects and

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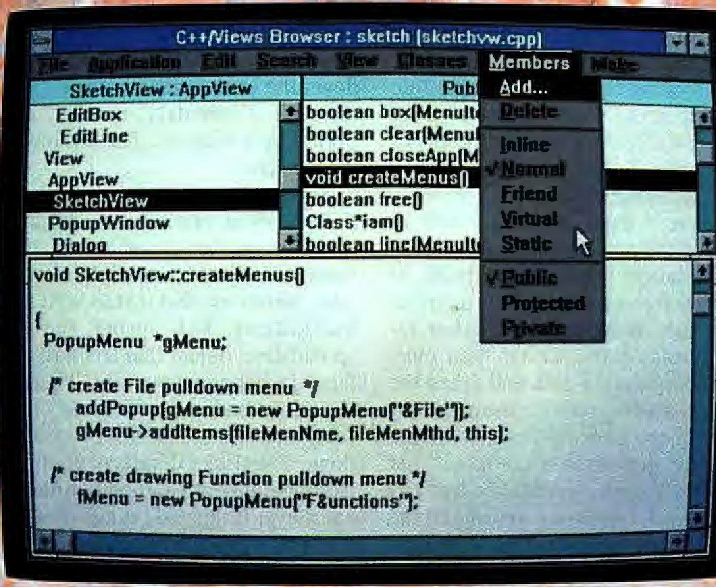

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MICROSOFT WINDOWS

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then move, shrink, and grow everything on the screen with the mouse until it looks just right. Prototyper lets you simulate how the buttons interact, but this is limited to simple operations like opening or closing a window. AppMaker and Prototyper can "compile" these descriptions of the application into either C or Pascal. The C or Pascal compiler converts these languages into the basic machine code and Toolbox calls to build the user interface on the screen. AppMaker's code generator produces code for the Think Class Libraries. Smethers Barnes says it will have a Think Class version available soon.

AppMaker and Prototyper have a basic skeleton inside as well as little skeletons for each of the possible window, menu, or control objects. When compilation begins, Prototyper or AppMaker customizes the various skeletons and glues them together in the right way. The result, however, is a hollow facade—it can only move the controls on the screen. You must create all the interior code for manipulating data and doing the actual work. In many cases, you must also provide the additional functionality for making an object work. When I created a list with Prototyper, the software generated a comment that sent me poring through *Inside Macintosh*. AppMaker lets you solve these problems once and for all, because you can edit the skeleton fragments it uses. The software is useful for an expert programmer who wants to save time, or an experienced programmer who doesn't know anything about the Macintosh Toolbox. The absolute beginner, though, will quickly get lost when trying to modify the intermediate C or Pascal code.

Apple's version of Allegro Common Lisp also comes with graphical software for creating GUIs. This development environment is a hybrid of object-oriented approaches like MacApp and graphical techniques. The software has a nice graphical editor for creating windows and controls, but it spits out objects, not skeleton code. People who use Lisp should find this perfectly acceptable and expected. These objects are customized for your particular windows. When you attach the rest of the program for handling the internal logic, you can do it within the object-oriented metaphor of message passing. The windows are just additional objects in the structure.

Interpret My Lips

Everything described so far could properly be called *compilers*. The GUI is created by drawing or writing specifications, and the software converts these specifications into machine code directly or via an intermediate compiled language like C or Pascal. Another class of software tools includes what are essentially interpreters. These programs, which include the famous HyperCard (now distributed by Claris), the newer Serius (from Serius), and Prograph (from The Gunakara Sun Systems) have their own intermediate languages for describing the user interface. These descriptions are interpreted when the software is run by another program. The latest version of Prograph, 2.0, includes a compiler for creating object code.

HyperCard and the similar Supercard (from Silicon Beach Software) are software programs that interpret "stacks" of cards. Each card can contain a number of controls, edit boxes, and picture windows. The software interprets mouse-clicks by looking at the instructions for the controls and then calls the right routines. For some reason, it doesn't seem natural to include HyperCard with the rest of these tools, but this may be because the system is aimed at every Macintosh user, not just the programming aficionado. These programs are, though, two of the fastest ways to get an interface working on the Mac. The downside is that you need to be running the same program.

Serius and Prograph are two of the more ambitious approaches to Macintosh programming. Everything, from the creation and location of the controls to the instructions that describe them, is described graphically. Everything is a picture. You don't type out lists of instructions, but you create icons for operations like addition and subtraction and string these icons like pearls. The data flows out of the windows and controls and down the lines between these operational icons, which change the data. Ultimately, it reappears at the other end to be displayed by a window. These pathways act like variables containing the data.

Serius, however, stresses that its program should not be thought of as just a graphical language. The software comes with a wide variety of objects that handle the standard functions as well as some of the newer ones. There are objects for files, numbers, and text as well as CD-audio and network communications. This spring, the company plans to introduce a spreadsheet object that lets naive users put a spreadsheet interface to whatever they want. There is also a complete set of functions for handling a database of objects and files. The sample functions contain a mail program with a few simple specifications. The tricky details of communicating with AppleTalk and passing data are handled behind the simple facade of icons and pathways. If the wide range of standard functions and objects is not sophisticated enough, you can create your own in Pascal if you follow the proper interface specifications. To do this, you need the special developer's version of Serius.

When the program performs as you want, Serius creates a stand-alone application containing an interpreter and the instructions distilled from your icons. This production adds an additional overhead so that even simple applications will require over 100K bytes of disk space. If you use this software, you trade clean and efficient code for the ability to develop an application quickly.

Prograph is another visual programming language with a sophisticated concept. It is not so much a set of objects to be strung together as a completely new OOP language for handling all problems. Serius could probably be described as a sophisticated interface-building system. If you want to do anything original or different, you need to build your own objects in a traditional language like Pascal. Prograph, on the other hand, is a pictorial data-flow language that contains icons for handling base operations like strings, lists, arithmetic, and practically anything else you could want. There is no need ever to fire up the Pascal compiler again. If you want to create something special, there are special icons you can use to call any Macintosh Toolbox routine. If these still aren't enough, you can attach C code resources as Prograph primitive icons.

Prograph contains the standard number of tools for creating good user interfaces. These are interpreted by the system, which contains nice facilities for debugging a program. The compiler will also generate fast code. Dataflow languages like Prograph are popular with researchers examining parallel processing, because they make it easy to split jobs into bits that can be done at the same time. This feature really doesn't mean anything to Macintosh users, but it is conceivable that it may come to be valuable when the Macintosh starts running several processors together.

XVT is a toolkit built for programmers who need or want to run their software on the Macintosh, Microsoft Windows, PM, and Motif. (See the text box "A GUI for All Systems.")

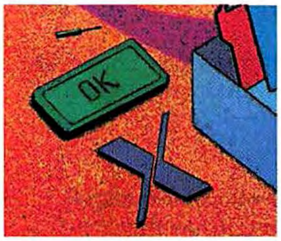
A Wide Range

There's no question that a wide range of products exists for creating GUIs for the Macintosh. The object-oriented extensions like the Think Class libraries and MacApp and the simple visual editors like AppMaker and Prototyper are probably the best items for accomplished programmers. They are quite useful tools, but they often require a bit of tweaking to get things perfect. The reward for this, though, is efficient code. The complete systems like Serius and HyperCard are much more accessible for the beginner. These systems often find more use in custom programming environments like corporate computer shops. The systems make it easy to get something running quickly, and the trade-off may be in the efficiency and size of the code.

These systems will not, though, absolve you from the need to think logically. They might be better described as new, more powerful computer languages. The hype for these products might imply that someone who can't program a VCR will magically be able to create Macintosh applications, but this is simply not true. The systems make life easier for programmers, but they will not do everything.

THE NEW UNIX LOOK

Ben Smith



Although later than Macintosh, DOS Windows, and PM in establishing some serious standardization on window environments, the Unix community has pretty much decided that the X Window System is the basis of its GUI. The exact appearance and behavior of that interface, however, are still open to question: Will it be Open Look (from AT&T and Sun Microsystems), or will it be Motif (from the Open Software Foundation)?

Writing applications that use X Window is notoriously difficult for programmers coming from the text-based Unix world. Before you can do anything specific to your user interface, you must, at least, do the following:

- establish interprocess communications to the X server
- define a window
- communicate the window properties to the window manager
- create the resources (user-definable application properties)
- map the window to the screen
- set up the event-handling
- start the event loop
- generate graphical output in response to events
- shut down the application properly when done

Although each of these steps can be as simple as a few lines of source code (with higher-level library functions, some are reduced to a single line), there are nearly 200 X-specific functions and variables to work with.

Working with X Window at this level gives developers tremendous freedom to create applications with any style they want. But they must define that style. The potential danger is the same anarchy and dissimilarity that exist in the user interfaces of MS-DOS applications. True, companies such as DEC and Hewlett-Packard have strongly enforced style guides for X applications, but each is different. Most applications are being developed outside of these mega-companies.

At the same time that X Window was starting to gain acceptance as the possible common user interface, Sun was becoming a popular graphics workstation. Yet Sun's GUI—SunView—didn't use X Window. It is based on a completely different protocol and graphics model—a proprietary one. So when Sun and AT&T became partners, much of the rest of the Unix community reacted by forming the Open Software Foundation, and Motif was conceived as OSF's first product. (See "OSF/Motif," page 230, May 1989 BYTE.)

Motif is a standard for X applications; it has a well-defined appearance and behavior for applications. Not only that, but it follows much of the style of PM, and it was accepted by a majority of the major Unix companies, including IBM, DEC, and HP. (Motif won an award of excellence from BYTE for its political achievements as much as for its good looks.)

The AT&T and Sun relationship spawned a competing GUI: Open Look. This one also runs on X Window but has much the same style as SunView. (See "Face to Face with Open Look," December 1988 BYTE.)

Open Look and Motif offer the developer the tools to follow their appearance and behavior guidelines. Both provide OOP utility, and both involve a level of programming with greater complexity than simple X Window (an oxymoron if there ever was one).

Motif offers the User Interface Language (UIL) for describing the use of the widgets and gadgets that make up a Motif application. AT&T (actually, Unix System Laboratories) has XView—really just a set of tools designed to facilitate porting from SunView to Open Look, but also used to build any new applications that are compliant with Open Look. No matter which might be the better user interface (see "Window Wars" on page 124), neither was going to gain dominance (let alone acceptance) until there was an easier way to build applications than hand-coding the user interface.

Solutions

Companies such as IXI of London, U.K., were eager to develop Motif applications. They realized that the quickest way to make programmers productive in this rich and complex environment was to first develop a Motif program for developing Motif programs. IXI's Motif development system is for its own in-house use, but the final result of its effort is X-desktop, the Motif application most commonly bundled with Motif.

Integrated Computer Solutions of Cambridge, Massachusetts (its offices are just a few blocks from OSF central), has produced the Builder Xcessory, a GUI-based user interface builder and testing system for Motif applications. It can read in and generate Motif's UIL as well as generate C code. You drag and drop icons of Motif widgets and stretch and move them on your parent window, change the attributes and resources, and view the class relationships of your elements. You then create program stubs for the C code that will perform callback actions that widgets will use. Development, testing, and management of these underlying routines must be done outside of the Builder Xcessory. (ICS also provides libraries for X Window System 11, Motif, and Open Look.)

On the Open Look side of WYSIWYG user-interface builders, Sun has produced the OpenWindows Developer's Guide (DevGuide—Guide is an acronym for Graphical User Interface Design Editor). You use DevGuide in a similar way to ICS's Builder Xcessory: dragging widget icons onto a window and defining their attributes and actions. As with Builder Xcessory, DevGuide only goes as far as the user interface.

Visual Edge of St. Laurent, Quebec, Canada, is the developer of UIM/X, one of the first of the Motif Style Guide–compliant application builders to provide WYSIWYG application-building tools for X Window. With UIM/X, every facet of the Motif toolkits is available to the developer. The design is consistent with the normal process of creating a GUI application. The complexity of developing an X Window–based application is greatly simplified by this design and development system.

The first step is the layout of an application's windows. You select the widgets and gadgets from menus and drop them on the windows. The action of selection, placement, and resizing of widgets is consistent, since UIM/X is, in itself, fully compliant with the Motif guidelines. As you create the look of an application, you can change the properties of each widget individually or as a group, because the organization of all the elements follows the philosophy of OOP: child widgets inherit the properties of the parent.

The second step in creating an application with UIM/X is attaching behavior and action to the widgets. Not only can you specify Motif toolkit (Xm) actions and behavior, but you can also reference any X intrinsics (Xt) and X function calls, or even write your own.

The third phase is testing. Because UIM/X has a built-in C interpreter, you can test any C routines that you may use as callbacks.

Unlike the Next Interface Builder, with UIM/X, you must drop into a standard shell to create and run the project management utilities such as `make` and `sccs`. UIM/X does not use Motif's UIL but instead has its own tables and runs and generates C source code.

If you plan on developing for Motif and Open Look with UIM/X, you're in luck. Visual Edge has an Open Look version for developing Open Look applications.

What's Next?

Running counter to the X trend is the NextStep user interface, which doesn't support X Window (as yet), let alone run under it. Also, it is available only on the Next system and the IBM RISC System/6000.

However, NextStep shouldn't be discounted; developers who have a free choice will often pick NextStep because of Next's Application Kit and Interface Builder. For example, despite the lack of Next dominance in the Unix environment, Lotus programmers began with Next when they developed their state-of-the-art spreadsheet, Improv. (See "What's NeXT After 1-2-3?," October 1990 BYTE.)

The Interface Builder is more than the name implies; more appropriately, it should be called the Builders Interface, because it is the front end to all the steps of developing an application for NextStep: designing, coding, and debugging, as well as managing the collection of source and object files that are part of a complex project.

The most visual of all the elements of Interface Builder are the tools for designing the user interface and associated icons. The Next libraries contain all the classes, methods, and functions of the Application Kit. You link in the tools for sound and music. And you can create your application using Objective-C as well as C.

The developer's interface is a fine example of NextStep programming: a combination of a GUI, a graphics application (the interface builder), and some pretty standard utilities that are hidden from view. ■

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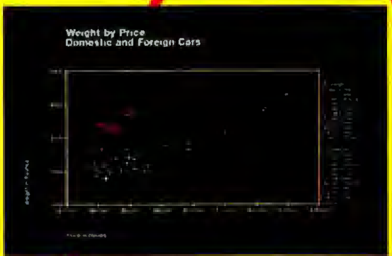

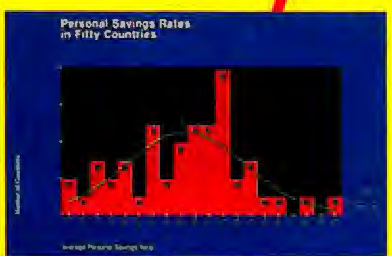

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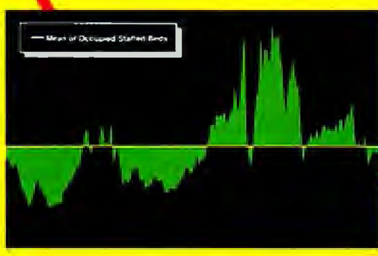

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Symantec Corp.
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Unix System Laboratories
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fax: (514) 332-5914
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Embedded Systems in Control

Chips that once powered PCs are now in airplanes, automobiles, and appliances—and are changing the nature of embedded control

Rick Cook

From disk drives and laser printers to home appliances, embedded computer systems are part of our lives. In fact, the average computer *non*user probably uses a dozen or more computers regularly but does not recognize them as computers, because the devices are dedicated to running things like cordless telephones and automobiles (see the text box "Chips in the Old Block" on page 156).

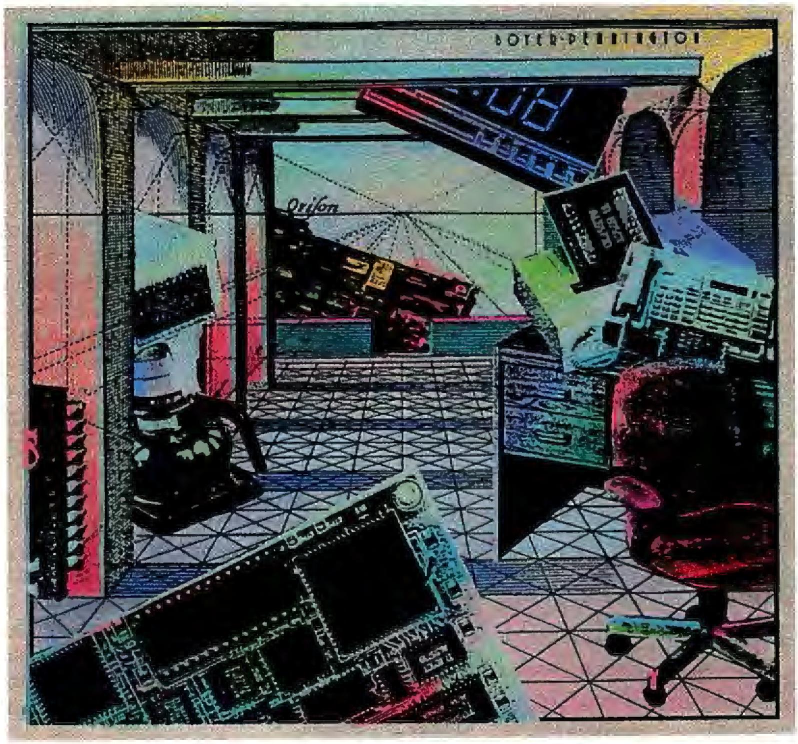
The use of embedded systems is spreading rapidly for two main reasons. One is convenience. Putting a computer in an appliance, a car, or a turret lathe makes the equipment more flexible and better able to meet our needs. In a computer system, too, it makes more sense to have dedicated processors in keyboards and disk drives than to use the system processor to handle mundane repetitive chores.

The other reason for more widespread use of embedded systems is cost. Traditionally, control functions have been handled by mechanisms such as timers, cams, and relays. Today, an embedded computer-control system is not only more reliable than the older technologies but usually cheaper as well.

Another contributing factor to the proliferation of embedded processors is the tendency to use more of them to do a job. Hard disk drive controllers, keyboards, printers, and high-resolution video cards are all likely to have their own processors today. The processors are inexpensive enough that it makes sense to boost overall system performance by dedicating them to specialized jobs. Fifteen years ago, an industrial robot arm might have been controlled by a single computer; a modern arm might have five or six microprocessors, each controlling a specific function (e.g., the elbow or the gripper) and backed up by an embedded computer system to handle overall control and communications.

At bottom, embedded systems are like any other computer systems, but they have their own special characteristics and present their own peculiar problems. Broadly speaking, embedded systems fall into two major varieties: *Event controllers* are directly concerned with managing interaction with the real world, and *embedded microprocessors* do higher-level calculations and control functions.

Embedded microprocessors usually supervise groups of event controllers, or they handle more elaborate calculations, such as constructing bit maps in a laser printer. Because of the jobs they do, embedded microprocessors tend to be more like the computer systems you would normally work with, although with significant differences. The



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68030 or Intel i960 in a laser printer is an example of an embedded microprocessor.

Although the real-time, real-world orientation of embedded systems applies most strongly to event controllers, embedded systems of all kinds are usually concerned with events happening in the outside world, whether it is the timing of a spin cycle on a washing machine or the handling of aircraft flight controls. In many cases, the system has to accept and respond to inputs within a predictable amount of time. A late answer is a wrong answer and may cause serious problems. As a result, operating systems, programming languages, and computer-aided software engineering (CASE) tools written for embedded systems are extremely time-conscious. For example, most embedded-system languages—whether assembly or high-level—specify the maximum and minimum number of clock cycles an instruction will take to execute.

For a programmer, an embedded system has some problems and some compensating advantages. It is expected to perform only over a range of known behaviors, unlike a personal computer, which is expected to handle any "compatible" hardware or software you throw at it. If the embedded system does what's expected under the specified conditions and doesn't do anything too seriously wrong with the undefined conditions, the implementation is a success. The problem with an embedded system is that the consequences of a failure can range from expensive to disastrous. A compact disc player that won't access one of the tracks on a disc is going to cost the CD manufacturer a lot of money and good will. A faulty antilock braking system on an automobile will cost the owner a lot more than that. Because the consequences of buggy embedded-system software can be so heavy, systems developers tend to be very careful and to test their products thoroughly.

Testing is easier to do with event controllers than with the larger, more complicated systems that rely on embedded microprocessors. An event controller usually has a fairly small program (less than 64K bytes of code), and the system behaviors are simpler and can be more closely specified. An embedded microprocessor, on the other hand, is likely to run much larger programs and have to deal with the behavior of larger and more complex systems.

An aircraft autopilot for a commercial airliner, for instance, may use three completely different processors (say, a Zilog Z80000, a Motorola 68030, and a proprietary processor) running software written by three different teams using three different approaches. Even the libraries of standard functions will be different. In operation, the autopilot compares the results of the three systems, and if they disagree, it takes the majority decision.

BYTE ACTION SUMMARY

Think "computer," and you generally think "desktop system." However, as more powerful microprocessors migrate into application-specific environments, the lines between personal computers and embedded systems may become blurred.

The Hardware

The type of hardware used for embedded systems covers a broader range than that used for computer systems. A significant fraction of the embedded-system market is still served by 4-bit processors, for example; at the other end, the latest RISC chips and 32-bit processors are used in some applications.

The most common kind of event controller is a *microcontroller*, which is a microprocessor with auxiliary circuits such as A/D converters (ADCs), timers, and RAM and EPROM built right onto the chip. Microcontrollers are intended to be as self-contained as possible, because that reduces the cost of the system.

One of the most striking features of the microcontroller market is the number of controllers that are using the same basic architecture. For instance, a company may offer two dozen or more versions of the same chip but all differing in speed, bus width, and auxiliary features such as the amount of ROM and the number of timers or ADCs on the part. The reason for this kind of flexibility is that cost is all-important for high-volume applications such as consumer electronics and automobiles. Choosing a microcontroller with only 256 bytes of RAM and two timers may save 50 cents a part over a controller with 1K byte of RAM and four timers. In a million-unit application, that is a significant difference.

The importance of cost also explains why, until very recently, 4-bit controllers outsold the 8-bit models. Often, microcontroller applications are very simple—perhaps as simple as replacing a mechanical timer. Four-bit controllers were adequate and less expensive, so they were preferred. The decline of the 4-bit controller isn't because manufacturers want more power in these systems (although that is a trend, too) but because the cost difference between 4- and 8-bit controllers has essentially disappeared.

From the 4-bit and simple 8-bit controllers, applications shade upward in complexity and required power. Nearly every successful microprocessor has spawned a microcontroller variation. You can still find 1802s, 6502s, 6809s, Z80s, and other popular chips of 15 years ago powering everything from dishwashers to industrial robots. A number of chips that never achieved commercial success in computers are popular in control applications. For example, National Semiconductor's 16- and 32-bit processors are widely used. Today, there is also a new microcontroller called the Echelon Neuron (see the text box "Echelon: A $10 Device Controller" on page 158).

Generally, the decision to use a microprocessor rather than a microcontroller depends on the task at hand. Microcontrollers are better suited to doing "dirty work"—interfacing and direct control, for example. Microprocessors are typically used to control groups of microcontrollers in applications where the microcontrollers' more generalized architectures and flexibility pay off.

There are other reasons for using microprocessors, however. One of them is the need for sheer power. Although microcontrollers can be powerful, they are usually not at the cutting edge of CPU design. The need to add memory and auxiliary functions means that a microcontroller takes more real estate than the equivalent microprocessor. Sometimes, embedded systems need all the power they can get, even at the expense and complication of using a microprocessor.

The high end of jobs in industrial automation, real-time video control, and other such applications stretches even the latest chips to the limit. For example, high-power 32-bit RISC chips like the Motorola 88000 and Sparc International's SPARC are used in some control applications.

Unlike microcontrollers, which concentrate on auxiliary circuits and low cost, microprocessors specifically designed for embedded-system applications tend to be state of the art. Intel's i960 is a superscalar 32-bit processor available in versions of up to 40 MHz and 30 VAX million instructions per second.

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Chips in the Old Block

Vinny Minchillo

In 1966, the Oldsmobile Toronado was the first American car to have front-wheel drive. In 1977, it was the first car to be outfitted with a computer. The system was called the MISAR—Microprocessed Sensing and Automatic Regulation. Its job was to compare input describing engine vacuum, engine speed, coolant temperature, and crankshaft position with values stored in ROM and then calculate the optimal moment for the distributor to fire a spark.

The MISAR's brain was a two-chip set from Rockwell International: a 10-bit microprocessor with I/O and A/D-conversion circuits, and a ROM chip with a little over 10K bytes of data. This simple system boosted the Toronado's fuel mileage from 13.8 to 15 miles per gallon. Still stinging from the OPEC nightmare, Detroit deemed the project a success. The computerized car was born.

Today's engine-control unit is much more complex. In as little as 2.5 milliseconds, the ECU must take in information about the amount of air coming into the engine, air temperature, fuel pressure, throttle position, manifold vacuum, engine speed, and more. From this data, it determines optimal levels for spark firing, ignition timing, and fuel-injection time (i.e., how long the fuel injector nozzle should spray gasoline into the cylinder).

In most cases, the ECU microprocessor is a specially designed 8- or 16-bit chip based on an existent processor. At one time or another, just about every major chip manufacturer has had its product in a car on the road.

Although Rockwell International made the first engine-control microprocessor, Motorola has become the biggest player. You'll find derivatives of its 68000 (the original Macintosh CPU) in Chrysler and General Motors cars. Ford has used chips from Toshiba, Motorola, and Intel. Chrysler originally used an RCA processor for engine management, as well as some Texas Instruments chips in its technologically advanced—but universally hated—voice synthesis systems (the ones that reminded you over and over again, "Your door is ajar.").

Not long after the introduction of the MISAR, Ford introduced its first ECU, based on a Toshiba microprocessor. In 1980, the company switched to a customized version of the Motorola 6800 (a predecessor of the 68000). Then in 1984, Ford made a major advance in automotive computers with the introduction of the electronic engine-control module—the EEC-IV.

The EEC-IV featured a custom-designed Intel 16-bit chip. With capabilities beyond those of traditional 8-bit systems, the EEC-IV was able to deliver fuel to each cylinder independently and accurately. The unit brought new efficiencies to Ford's aging 302-cubic-inch engine, which became the heart of one of today's most potent and popular sports cars, the 5.0-liter-engine Mustang GT.

For 1994, Ford's EEC-IV will be getting a new lease on life. The original Intel 16-bit 8065 controller chip will be joined by a second 8065 chip. The two will operate in a coprocessor arrangement, with the second chip controlling the transmission.

Although it was the first to bring computers to cars, GM was not able to maintain its lead—but that could change. GM currently uses an 8-bit Motorola 68HC11 processor. But a joint development agreement between GM's Delco division and Motorola has created the 68332, the first 32-bit processor designed for automotive use. Planned for introduction in GM cars around 1995, this chip is based on the 68020, found in the Mac II. While some claim a 32-bit processor is overkill, GM maintains that the next generation of cars will have to pack at least that much computing power. In fact, one experimental GM system is so complex that it needs two 32-bit 68332 processors.

The Japanese have also embraced automotive computer technology. Nippon Denso, the Japanese electronics giant, manufactures the Toyota Computer Controlled Systems. Toyota's flagship luxury car, the Lexus LS400, uses TCCS computers in innovative ways to control the drive train, including shifting the automatic transmission electronically.

Not to be outdone, Nissan's flagship, the Infiniti Q45 sedan, carries 14 separate computer modules that control the engine, transmission, speed-sensitive power steering (e.g., the slower you drive, the more power assist you get), security system, adjustable suspension, and more. Every module on the Infiniti Q45 is connected to an on-board communications system called the Diagnostic Data Link; technicians can download information about all modules through a single communications connection.

Like many luxury cars, the Infiniti and the Lexus come with antilock braking systems. While ABS is one of the most noticeable and beneficial features that computers have brought to cars, monitoring and controlling the brake system is actually one of an on-board computer's easiest jobs.

Another feature, electronic traction control, relies on the same sensors and technology as does ABS. Electronic traction control minimizes wheel-spin by automatically reducing engine power—particularly on low-traction surfaces, such as ice or gravel.

LANs on Wheels

The basic automobile wiring system has not changed fundamentally over the years. Every switch is more or less directly wired to the device it operates. Open the door of almost any luxury car, and look at the cable running from the door to the body; it looks more like a phone company trunk line than car wiring. It's not uncommon for that cable to carry up to 50 pairs of wire.

Now, imagine that same trunk replaced by a single LAN-style twisted-pair cable. The concept is called *multiplexing*, a technology that's crucial if cars are to take full advantage of computers. Rather than having a traditional wiring harness, the car would have its own digital bus, with electric windows, electronic fuel-injection system, antilock brakes, and transmission hooked to it—just as a computer has disk drives, monitor, keyboard, and other devices connected to its bus.

Consider a light switch. Instead of sending electric current directly to the lights, the switching action would trigger an input signal module activating a body control module that would send a signal down the bus. The appropriate output signal module would pick up the instruction and activate the proper relay to send current to the lights. That's how it happens on the $55,000 Cadillac Allante sports car—one of the first cars to incorporate some multiplexing.

Running a true digital bus through the car will allow computers to share sensors and trade information. The bus will provide a foundation for future centralized computing systems and make it easier to add more and more high-tech options. In short, multiplexing will do for the automobile what the hard disk drive did for the PC.

Coming Attractions

For the last few years, Buick has been displaying a concept vehicle (an engineering dream car) with all its accessories completely controlled by voice command. There's also electronically controlled four-wheel drive, a satellite navigation system, and drive-by-wire.

A drive-by-wire system is similar to the fly-by-wire systems used in fighter jets. Instead of mechanical links running from the steering wheel, pedals, and shift controls, these devices merely send electronic signals along the data bus to the controllers for the front wheels, accelerator, or transmission. Thus, unencumbered by the need to have the controls physically connected to the vehicle, designers will have the flexibility to locate the positions of the driver, passengers, and their respective controls anywhere in the car.

Another development with far-reaching possibilities is the electronic clutch, which will provide all the advantages, efficiencies, and fun of a standard-shift car along with the ease of an automatic. The current Ferrari Formula 1 racer features buttons on the steering wheel to select the next higher or lower gear. You use the clutch only to start the car from a dead stop.

Other innovations on the drawing board include a computerized muffler that generates sounds to cancel out exhaust noise, a "tattletale" feature that will inform your dealer of your car's all-time top speed, roof panels that change from clear to black at the touch of a button (based on LCD technology), and active suspensions that adjust individual shock-absorber pressure for turns and potholes.

Not Quite State of the Art

For all the technical innovations built into today's automobiles, the current state of computers in cars is something less than state of the art. It's true that the chips and computers are excellent examples of high technology, but they are still only stand-alone devices that have been taken to their extreme technical limits. Making them all work together is the key. And for the average $14,000 car, that kind of integration is still a long way off.

Less than 15 years ago, the automotive computer was regarded as a nuisance—an invasion—a mysterious device to be tolerated or, if possible, removed. But the addition of computers has made today's cars much more efficient. By using computers, we're achieving the fuel mileage and emissions control demanded of us by the economical and environmental condition of the 1990s, while enjoying the performance of 1960s muscle cars. Automotive computers have helped bring new meaning to the term "power user."

Vinny Minchillo is a copywriter for the firm of Larkin, Meeder & Schweidel in Dallas, Texas. He has been writing about technical automotive subjects for four years and has worked with on-board automotive computers and aftermarket fuel-injection systems. He can be reached on BIX c/o "editors."

sors are used. One of the keys to laser-printer performance is how fast a printer can assemble a bit map of the image to be printed. Obviously, the more powerful the processor, the faster a bit map can be built. The Intel i960 RISC chip and the Motorola 68030 are both used to control laser printers. The i960, for instance, is used in Star Micronics' Laserprinter 4, among others. Hewlett-Packard uses the Motorola 68000 family in some of its laser printers.

Another popular chip for high-end control applications is a digital signal processor. DSPs are specialized microprocessors designed to do certain operations very quickly. Their speed and interrupt structure make them valuable for control applications, while the nature of the applications minimizes the disadvantages they suffer as general-purpose computers.

Programming Embedded Systems

Embedded-system programmers have a variety of specialized tools at their disposal. A number of operating systems are designed for real-time control applications. They also have emulators to allow programmers to develop applications on common systems like the PC and the Mac. Other specialized tools include cross compilers and CASE tools.

Another powerful tool is the in-circuit emulator, an emulator that plugs into the processor socket on an embedded system. With an emulator, designers can set hardware and software breakpoints, keep track of register contents, and watch the all-important timing windows of critical events.

A major difference between writing software for embedded systems and writing conventional applications software is that in application development, the development system is usually the target system; that is, if you want to write software for a Macintosh, you work on a Macintosh. In an embedded system, the development system is almost never the target system. This means that cross compilers and simulators are especially important because the hardware and software is usually developed in parallel. For example, the circuit boards may not be available until almost the time the software has to be ready.

Embedded-system programming is getting a lot more attention today, because embedded-system software is becoming a larger part of the cost and development time of new products. A typical programming project for event controllers can take as long as 18 months to develop from scratch. It can take several years to get the software ready for more complex, 32-bit embedded microprocessors.

The cost of developing embedded-system software can be very high, because each application is essentially custom built, and software has to be extensively tested before it is released. A software update usually means recalling the product and plugging in a new chip. Unless the cost can be spread over many thousands of units, software development can be a major item in a product's budget.

Ideally, an embedded-system project starts with a well-defined list of inputs and outputs. With microcontrollers, this can be organized as a matrix with the expected output shown for every input, including the no-op combinations that will be explicitly programmed to do nothing. The timing windows for critical events will be carefully laid out. In a well-run project of any size, the software specifications are tight and exact. On a large project, it could take months just to develop specifications that cover all contingencies.

The actual programming can be done at any language level from C or Ada to assembly language. The choice depends, in part, on what is available for the particular chip and, in part, on the amount of memory available. Some microcontrollers have only a few hundred bytes of ROM, so everything has to be

Echelon: A $10 Device Controller

Rich Malloy

It's a small, low-cost device, but it may have a big impact on the computer industry, as well as on our personal lives. Introduced by Echelon (a new company started by A. C. "Mike" Markkula, a cofounder of Apple Computer), this networkable device—the Echelon Neuron—should be able to control a number of devices, not only in homes, but also in offices and factories.

The technology is based on a new chip called the *Neuron*. Like biological neurons, Echelon Neurons have built-in abilities to communicate with one another. They will be able to control many functions, including office lighting systems, alarms, factory machines, automobile components, and home appliances.

For example, a network of Neurons in your office connected to a motion detector and an ambient-light sensor can ensure that the lights in your office are on only when you are there and it's dark outside. In another example, Neurons connected to an array of smoke detectors, temperature sensors, and exit lights might determine where in an office building a fire has occurred, signal an alarm, and light only those exit signs that would direct people safely away from the fire.

Controllers based on the Neuron chip are expected to sell in volume quantities by late this year. They may eventually cost as little as $10 each, including network connection costs.

The Neuron is a single chip that contains a number of different components (see the figure). These include three 8-bit processors connected in pipeline fashion, 10K bytes of ROM, 1K byte of RAM, and 512 bytes of EEPROM. The 10K-byte ROM area contains the code for a complete seven-layer communications network protocol. Echelon has licensed the technology for the Neuron chip to Motorola and Toshiba; both say they will ship the chip around the middle of this year.

The Neuron is designed to be used in a network that Echelon calls a Local Operating Network. For physically connecting the Neuron chips, Echelon has proposed three "communications transceivers"—one for twisted-pair cable (1.25 megabits per second), one for communicating via AC power lines (9600 bps), and one for wireless radio communications (5000 bps). Any one of these transceivers can be connected to a Neuron, and LONs can be made up of any or all of these media.

Developers can use LONs with a LON Starter Kit. The kit consists of software for an IBM AT-class system plus an external box that allows developers to simulate a LON. Developers can program the individual Neurons using an enhanced version of C called *Neuron C*. Echelon officials say that the 512-byte EEPROM area of the Neuron can accommodate a three-page C program. For larger programs, another version of the Neuron chip will be available that can access up to 42K bytes of external memory. The Starter Kit costs approximately $15,000.

Echelon officials say that the most important component of the LON technology is its peer-to-peer LONTalk network protocol. According to the company, the design constraints for this network were much stricter than those of typical LANs designed for connecting microcomputers. Not only must the network be able to handle three or more different types of physical connections, but it also must be 100 percent reliable even at peak loads, easy to install, secure, and able to fit into just 10K bytes of ROM. The only deficiency of the network protocol is that it is optimized for use with only very small amounts of data.

Although Neurons and LONs have immediate applications in mundane tasks (such as turning on lights), they could also be used for a wide number of other, more challenging duties. For example, they could be used to control an airplane, eliminating miles of conventional cable and possibly lessening the need for a large central computer.

FOR MORE INFO

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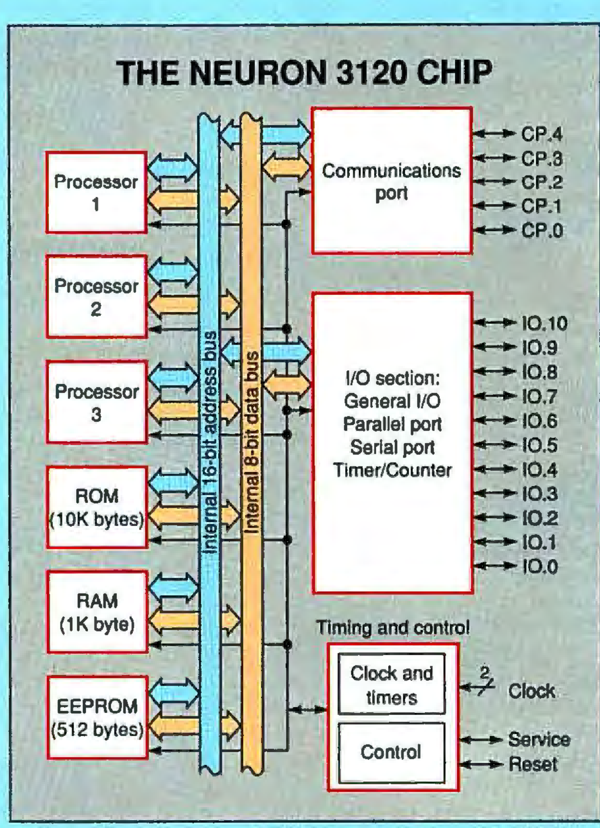

The first member of the Neuron chip family is the 3120 chip. The 3120 contains three processors: two dedicated to LONTalk (the network protocol used by Neurons) and one designed to be used by the chip's application program.

Rich Malloy is the New York-based managing editor of the BYTE news department and editor in chief of BYTEWEEK, a newsletter covering the personal computer industry. He can be reached on BIX as "rmalloy."

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tightly coded; readability, maintainability, and everything else is sacrificed to get the program as compact as possible. These practices went out of general programming practice decades ago. Now, using such methods in embedded-system programming is fading, too, because microcontrollers with more memory are readily available; companies can now cut overall costs by facilitating software development and maintenance. The tendency is to program in higher-level languages and to use operating systems or, at least, libraries of reusable code to handle the routine parts.

Because of the critical nature of embedded systems, a lot of attention is paid to testing and debugging. The software should be exercised against all possible I/O combinations—a huge task even on applications with a definable set of possibilities. In the early stages, testing may be complicated by the fact that testing can't be done on the target system but must be tested on simulators. As a compensation to testing on simulators, the test can be set up to monitor the internal workings of the program closely, including the register contents and hardware details. In some embedded systems, physical environment testing is important, as well.

Trends in Embedded Systems

The trend today is toward more powerful systems. Four-bit controllers are beginning to fade, being replaced by fast 8-bit and even 32-bit controllers. The cost difference between the limited 4-bit controllers and the more powerful 8- or 16-bit controllers is steadily narrowing. With the headroom of these new processors, it is less expensive and easier to add new features to an embedded system.

With more space, it follows that the trend is away from replacement designs and toward feature enhancements to existing products, usually through software. There is also a growing focus on software productivity. This is an especially important issue, because embedded-system designs are essentially one of a kind, and the new processors require more programming.

One way to make programmers more productive is to give them a familiar environment to work in. Modern operating systems that combine a microkernel with message passing can do just that. Chorus, an operating system from Chorus International, can exist in as little as 24K bytes of memory, making it suitable for embedded-system applications. The larger version of Chorus is function-call-compatible with Unix System V release 4, meaning that programmers can develop software for embedded-system applications running Chorus under Chorus. Other, modularized operating systems are also becoming desirable software bases for embedded systems.

There is a tendency to give products better user interfaces to get around the dreaded "VCR Syndrome," but the bottleneck is the cost of the I/O devices. A cryptic user interface with many states can use a very simple display and keyboard. A better user interface usually means a better, and hence more expensive, display and keyboard, but even these costs are dropping.

Historically, we have tended to think of embedded systems as being the smaller, weaker relatives of the hardware and software we use for general-purpose computing. That isn't true anymore, and it is likely to become less and less true in the future. Some manufacturers are exploring advanced methods, such as parallel processing, AI, and neural networks. In another 10 years, the most powerful, capable applications we have may be in embedded systems. ■

Rick Cook is a freelance writer who specializes in high technology and writes science fiction and fantasy for fun. He lives in Phoenix, Arizona, and can be reached on BIX as "rcook."

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*PC Magazine, September 25, 1990

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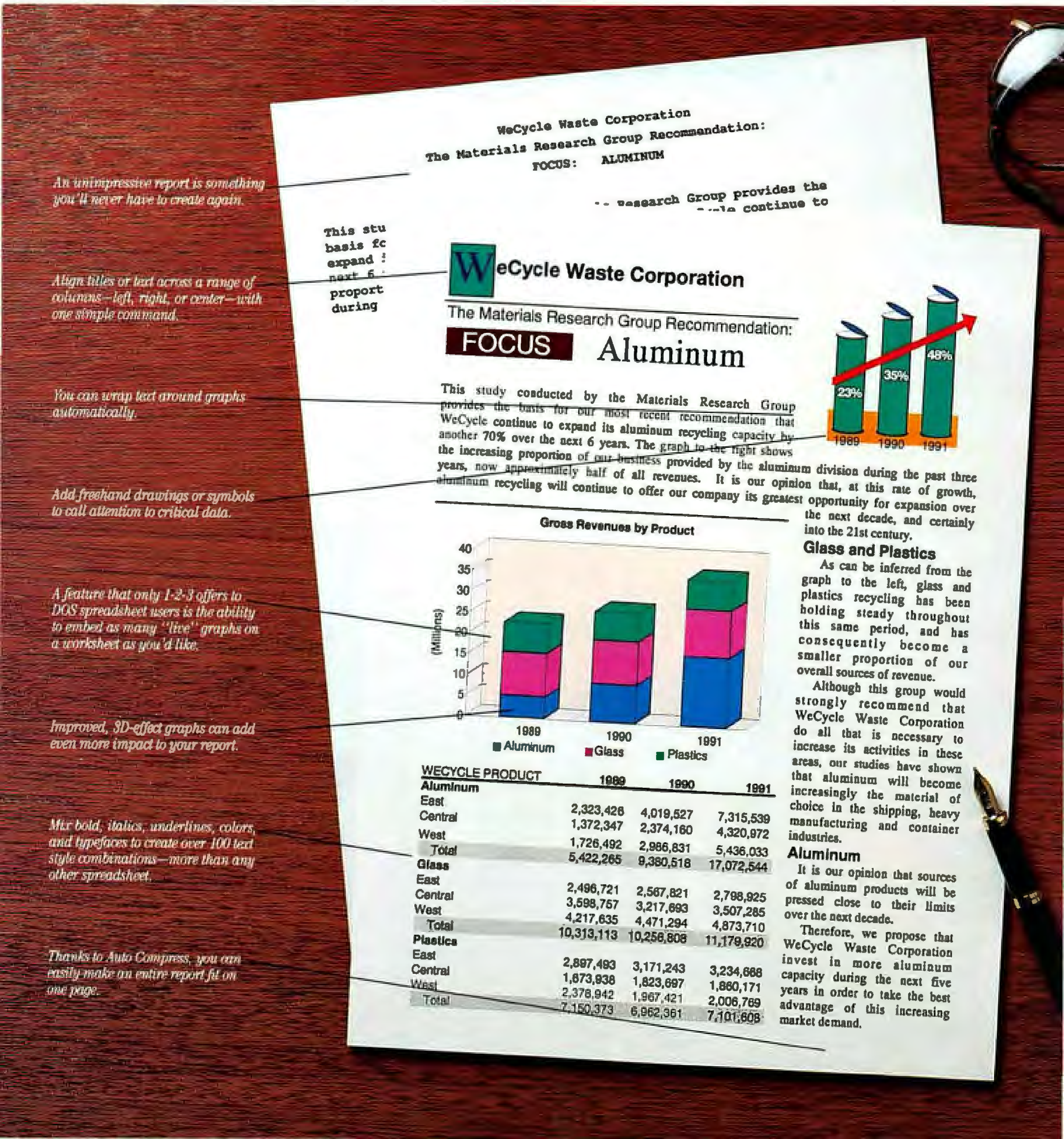
Circle 221 on Inquiry Card.

National Software Testing Laboratories Supplement:

Advanced Spreadsheets

Now you can upgra
without upgradi



de your spreadsheet ng your hardware.

There's a lot to like about the new Lotus® 1-2-3® Release 2.3.

For starters, it's not just a graphical spreadsheet. It's a fast, graphical spreadsheet for DOS. It's easy to use. And it works as well on an older XT with just 512K of memory as it does on the newest 486 machine.

It also shares many features in common with our powerful 3D spreadsheet, Release 3.1. Including its superb spreadsheet formatting and publishing capabilities and full mouse support. Along with its popular Auto Compress feature that gives you a trouble-free way of making larger worksheets print on a single page.

We've also added new features you won't find in other spreadsheets. Like the

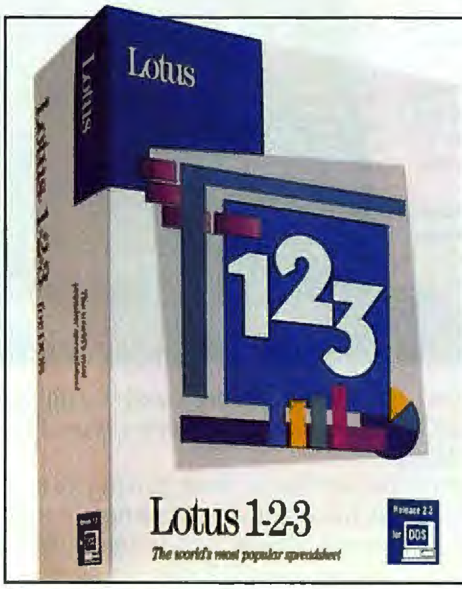
With its WYSIWYG graphical environment, you can do all your formatting "live" on screen.

Viewer (based on Lotus Magellan® technology) which helps you find the file you want before retrieving it. And a very helpful Auditor that simplifies the job of documenting and analyzing complex worksheet logic.

Of course, you won't just like what Release 2.3 does. You'll like how it feels. It's quick and smooth. With a WYSIWYG (what-you-see-is-what-you-get) graphical environment that lets you format text, data, and graphics "live" on screen. Plus, what you see on screen is what you'll get when you print. With the mouse, you can execute commands, highlight cells or ranges, open dialog boxes, place and size graphs, change type styles, fonts and point sizes. All with unparalleled speed and ease.

Lotus 1-2-3 Release 2.3 runs smoothly and quickly no matter what hardware you're running it on.

What's more, Release 2.3 gives you a wide range of printing and reporting capabilities. Including the capacity to place as many live graphs on a worksheet as you'd like.



What's New In Lotus 1-2-3 Release 2.3.

- A WYSIWYG graphical environment with live on-screen formatting
- Lotus Magellan viewer technology for fast file previewing, retrieving and linking...all without leaving your active worksheet
- More graph types, including 3D-effect graphs and graph annotation capabilities
- Auto Compress, for a trouble-free way of making larger worksheets print on single page
- Dialog Boxes for an easier, more interactive way of working
- Text-editing for easy on-sheet word processing, including automatic word wrap, even around graphs
- The Auditor for documenting or highlighting your spreadsheet logic
- Improved memory management for building larger worksheets up to 12 MB in size
- New printer drivers that support all leading laser and dot-matrix printers
- Context-sensitive Help and an interactive tutorial

Along with 96 type style combinations, new 3D-effect graphs, drawing and annotation tools, and the most font support, choices of colors and shading available.

Compatibility? As with any 1-2-3 product, it's no problem. Because Release 2.3 will read all of the files you've created on previous versions of 1-2-3, including files you've formatted using Allways™ and Impress.™ So you'll preserve all your work, as well as your training.

For more information about the new Release 2.3 or for upgrade details, call us today at **1-800-TRADE-UP, ext. 1116.**

The new Lotus 1-2-3 for DOS

Lotus

Before You Blow $500 On Lotus 1-2-3, Excel Or Quattro Pro, Read This.

CA Shocks Spreadsheet World With 70% Price Cut: Highly-Rated SuperCalc5 Now Only $149.00

CAMBRIDGE, Mass — Early today Computer Associates announced a dramatic price reduction on one of the industry's most popular and best-selling spreadsheet programs, SuperCalc5.

Effective immediately, the suggested retail list price for SuperCalc5 has been slashed from $495.00 to $149.00. This means that the new street price for SuperCalc5 — which is Lotus 1-2-3 compatible — will very likely be under $100.00.

This bold, new pricing strategy is great news for spreadsheet users. It means now everyone can afford to trade up to the most advanced spreadsheet technology in the industry. And unlike Lotus 1-2-3 3.0 or Excel f... Windows, which ...

"We've always listened closely to what users want and they've been concerned with high spreadsheet prices and the expensive hardware upgrades which are often required," said a CA spokesperson. "Users told us that they wanted the latest spreadsheet technology, but they needed it at a price they could afford and in one application that would run on all of their PCs. That is exactly what we're giving them. SuperCalc5 at this new low price is by far the best value in the spreadsheet industry."

Initial reaction amongst spreadsheet users and software dealers has been overwhelmingly positive. "This is terrific," said one user, "It's about ..."

It's the beginning of a revolution.

The affordable spreadsheet revolution. Now every user in America can afford the most advanced spreadsheet technology. The latest breakthroughs. Newest features. Hottest 3-D graphics.

CA90s

CA's Computing Architecture For The 90s protects and enhances the value of every CA software solution.

It's all there inside SuperCalc5. With Lotus 1-2-3 compatibility, presentation quality graphics and spreadsheet linking, SuperCalc5 has become one of the most popular, best-selling spreadsheets in the industry.

More than 3,000,000 copies have been sold and unlike some others, SuperCalc5 runs on virtually every type of PC that exists.

If you've been thinking about moving up to a more powerful, full-featured spreadsheet, now's the time. Move up to SuperCalc5 and get everything you've always wanted for hundreds of dollars less than Lotus 1-2-3, Excel or Quattro Pro. For the name of your nearest SuperCalc5 dealer call 1-800-CALC-149.

Do it right now. After all, at this price, why wait?

COMPUTER ASSOCIATES
Software superior by design.

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NSTL Review Supplement: Advanced Spreadsheets

Each month, BYTE evaluates dozens of products in a broad range of categories. We cover a lot of ground, but we are always trying to do more. To that end, BYTE is proud to bring you the NSTL Review Supplement series. As reports become available, BYTE will present the results of product comparisons from the National Software Testing Laboratories, a division of Datapro Research Group and a BYTE sister company. NSTL is one of the world's premier independent hardware and software testing facilities. Its services and advice are sought by many businesses from the Fortune 500 on down.

These pages are supplemental; nothing has been cut from the regular issue of BYTE to make room for them. And the BYTE Lab will continue its long-standing tradition of producing comprehensive, hard-hitting product comparisons.

NSTL publishes ratings reports on Macintosh and PC hardware and software, as well as on networking products. BYTE will select topics based on timeliness and appropriateness to our readership. We will also avoid duplicating product coverage found elsewhere in BYTE.

Many of the tests devised by NSTL are similar to BYTE's—the basic performance benchmarks, for example. Unlike BYTE, NSTL provides a scoring system based on numerical weightings assigned to key attributes such as performance, ease of use, versatility, and overall quality. While some of these ratings are by nature arbitrary, the criteria within the evaluation are consistent for each package and do provide a legitimate means of comparison. Though we've examined NSTL's methodology and found it satisfactory, BYTE has not tried to duplicate NSTL's tests. NSTL retains full ownership of the results published here.

Due to space limitations, we could not publish all the data that NSTL provided in its 75-page report. Instead, we boiled down the information to its essential core. The full report is available for sale from NSTL (see the text box "About NSTL").

We bring you these supplements as a service. The additional pages allow us to provide you with more product comparisons in a wider range of categories. NSTL's format and methodology might differ from what BYTE provides, but they offer a reasonable, alternative means of comparison that complements BYTE's own extensive product reviews. We welcome NSTL to BYTE, and we welcome your comments on the NSTL supplements.

About NSTL

National Software Testing Laboratories (NSTL) is an independent organization that tests personal computer and LAN hardware and software. It provides unbiased performance, compatibility, comparison, and usability testing for personal computer users and vendors. Founded in 1983, NSTL pioneered this use of objective, real-world-based, and comparative methodologies to gain its position as the leading independent testing and evaluation facility in the microcomputer industry.

NSTL publishes test results in *Software Digest Ratings Report, Software Digest Macintosh Ratings Report, PC Digest Ratings Report, and LAN Reporter Ratings Report*. The publications carry no advertising.

NSTL's Commercial Testing Division offers test services on a confidential, contract basis to vendors.

Additional information on NSTL's Commercial Test Division is available from NSTL, Plymouth Corporate Center, Plymouth Meeting, PA 19462, (215) 941-9600.

Advanced Spreadsheet Programs

In the MS-DOS world, spreadsheets cover a lot of territory—from simple computerized balance sheets to computational wizards with sophisticated viewing and printing options. For this comparative review, NSTL focuses on the high end of the features and performance spectrum.

Although the capabilities of advanced spreadsheets are constantly expanding, the most important components of this software category continue to be worksheet characteristics and data manipulation functions. The past year has brought a number of significant improvements, however. The availability of moderately priced high-performance computer systems has encouraged the development of highly graphical programs, and widespread use of laser printers and color printers means that many advanced packages now include full-featured charting modules. In addition, these programs' list of file handling powers has grown to include networking capabilities, spreadsheet linking, and three-dimensional worksheets. Some offer free-form modules, as well. (For advice on what to look for in an advanced spreadsheet, see the text box "Advanced Spreadsheets: Adding Up Your Options.")

In this roundup, NSTL evaluates seven programs that qualify as advanced spreadsheets: Lotus Development's 1-2-3, Microsoft Excel for Windows, WordPerfect Corp.'s PlanPerfect, FormalSoft's ProQube 3D, Borland International's Quattro Pro, Computer Associates International's SuperCalc5, and Informix Software's Wingz for Windows. With the exception of a prerelease version of Microsoft Excel for Windows (the final version was not available at the time of testing), all were production copies of the companies' latest releases. (Borland has since released version 3.0 of Quattro Pro.) In the case of 1-2-3, for which two versions were available, NSTL evaluated the more powerful release 3.1 instead of the more widely distributed release 2.2. (Lotus's high-end 1-2-3/G was omitted because it does not run under MS-DOS. See the table on page 191 for a list of additional spreadsheet vendors.)

Advanced Spreadsheet Programs

Product & Supplier	NSTL Rating	Overall Evaluation	Overall Power	Overall Usability	Performance	Quality	Versatility	Ease of Use	Ease of Learning	Price	Memory Requirement	Hard Disk Space Needed	Operating System
Microsoft Excel for Windows Prerelease 3.0 Microsoft Corp. 1 Microsoft Way Redmond, WA 98052 (206) 882-8080	★★★★	8.9	8.1	9.6	🔵	🔵	🔵	🔵	🔵	$495	1 MB; 2 MB recommended	5.2 MB	MS-DOS 3.0 or higher; Windows 3.0
Quattro Pro 2.0 Borland International 1800 Green Hills Road Scotts Valley, CA 95067 (408) 438-8400	★★★★	8.4	7.7	9.1	🔵	🔵	🔵	🔵	🔵	$495	512K; 640K recommended	4 MB	MS-DOS 2.0
1-2-3 Release 3.1 Lotus Development Corp. 55 Cambridge Pkwy. Cambridge, MA 02142 (617) 577-8500	★★★	7.2	6.8	7.7	🔴	🔴	🔵	🔵	🔵	$595 ♦ $795 ♣ $495 ◊	1 MB	5 MB	MS-DOS 3.0; compatible with Windows 3.0
Wingz for Windows 1.1 Informix Software Inc. 16011 College Blvd. Lenexa, KS 66219 (913) 599-7100	★★	6.2	7.7	4.7	🔵	🔵	🔵	⚫	⚫	$499	2 MB; 3 MB recommended	2 MB	MS-DOS 3.1 or higher; Windows 3.0
SuperCalc5 5D Computer Associates International 711 Stewart Ave. Garden City, NY 11530 (408) 432-1727	★	5.5	5.4	5.6	⚫	🔴	🔴	🔴	🔴	$495	512K; 640K recommended	5 MB	MS-DOS 2.0 or higher
PlanPerfect 5.1 WordPerfect Corp. 155 North Technology Way Orem, UT 84057 (801) 225-5000	Less than 5.0	4.8	4.7	4.8	⚫	⚫	🔴	🔴	⚫	$495	384K; 512K recommended	3 MB	MS-DOS 2.0 or higher
ProQube 3D FormalSoft P. O. Box 1913 Sandy, UT 84091 (801) 565-0971	Less than 5.0	3.8	4.3	3.4	⚫	⚫	🔴	⚫	⚫	$99	512K; 640K recommended	1 MB	MS-DOS 2.0 or higher

RATINGS KEY (On a scale of 0 to 10)

Overall Evaluation
- ★★★★★ 9.0 or higher
- ★★★★ 8.0 – 8.9
- ★★★ 7.0 – 7.9
- ★★ 6.0 – 6.9
- ★ 5.0 – 5.9

All Other Ratings
- 🔵 7.0 – 10.0
- 🔴 5.0 – 6.9
- ⚫ Under 5.0

- ♦ Standard Edition
- ♣ Network Server
- ◊ Network Mode

Advanced Spreadsheet Programs

Computer Systems	*Mouse*	*Supplier Support*	*Volume-Purchase Agreements*	*Site Licenses*	*Strengths*	*Limitations*
286, 386	Supported; not required	Telephone support; bulletin board; newsletter; support plans available; discounted or free upgrades	No	No	Background recalculation; outlining; fast calculation speed; font preview; 3-D graphing; linear and nonlinear problem solving; backsolver; ability to place graphs on spreadsheets; linking to database tables; charting and free-form graphics; graphical page preview; array of data functions; background printing capability; quality of worksheets and charts	Inability to disable undo feature; lack of free-form lines in free-form graphics module
8086, 8088, 286, 386	Supported; not required	Telephone support; bulletin board; newsletter; forum on CompuServe; discounted upgrades	Yes	Yes	Background recalculation; fast calculation speed; fast overall performance; 3-D graphing; linear problem solving; backsolver; ability to place graphs on spreadsheets; graphical page preview; mapping feature; quality of worksheets; free-form drawing; linking to database tables	Slow speed when printing enhanced spreadsheets; lack of user-defined functions; lack of autosave feature; lack of background printing feature
286, 386	Supported; not required	Telephone support; newsletter; CompuServe forum; Lotus Prompt and Prompt CD; training centers; courseware	Yes	Yes	Seamless background calculation; 3-D spreadsheets; ability to place graphs on spreadsheets; linking to database tables; free-form graphics capabilities; graphical page preview; background printing; quality of worksheets; mapping feature	Lack of 3-D graphing; lack of user-defined functions; lack of autosave feature; inability to justify numbers
286, 386	Required	Telephone support; upgrade information	Yes	Yes	Interruptible recalculation; 3-D graphing; ability to place graphs on spreadsheets; charting capabilities; graphical page preview; background printing capability; quality of charts; free-form drawing	Inability to disable undo feature; poor manuals; difficult to learn; poor page preview; lack of free-form lines in free-form graphics module
8086, 8088, 286, 386	Supported; not required	Telephone support; newsletter; forum on CompuServe; *CA-Insight* magazine, support packages available; discounted upgrades	Yes	Yes	Interruptible recalculation; 3-D graphing; 3-D spreadsheets; good auditing features; strong financial functions; mapping feature	Lack of free-form drawing; lack of graphical page preview; lack of user-defined functions; lack of background printing; lack of support for virtual memory
8088, 286, 386	Supported; not required	Telephone support; bulletin board; *WordPerfect* magazine	Yes	Yes	3-D graphing; factorial overview; graphical page preview; background printing capability	Lack of background or interruptible calculation; poor enhancement features; lack of free-form drawing; lack of undo feature; slow calculation; slow execution speed
8086, 8088, 286, 386	Supported; not required	Telephone support; bulletin board	Yes	Yes	3-D graphing; 3-D spreadsheets; backsolver; mapping feature	Lack of background or interruptible calculation; lack of free-form drawing module; 512-row limitation; lack of undo feature; lack of graphical page preview; inability to support PostScript devices; lack of user-defined functions; poor manuals; lack of autosave feature; lack of background printing feature; inability to justify numbers; lack of support for virtual memory; poor enhancement features

Testing Procedures

To ensure the accuracy of its results, NSTL used the same equipment throughout its testing: a Hewlett-Packard Vectra QS/16s equipped with 5 megabytes of RAM, a 40-MB hard disk drive, a VGA monitor, and a Microsoft serial mouse. The hard disk was partitioned into two drives, designated as C and D; before each program was tested, it was installed on a newly reformatted drive D. Tests were conducted using Compaq DOS 3.31D and Microsoft Windows 3.0 (HIMEM.SYS and SMARTDRV.SYS were included when operating in Windows). BUFFERS and FILES statements in the system's CONFIG.SYS file were set to 30, and extended memory was accessed through Quarterdeck Software's QEMM.

In evaluating the print quality of each program's enhanced worksheet features, NSTL relied on three printers: a QMS-PS 810 turbo PostScript printer, an HP LaserJet III, and an HP PaintJet (for evaluating color printing).

Most performance tests used a complex business worksheet that included a three-year cashflow model, balance statement, inventory, one-year amortization schedule, data table, and personnel file consisting of sales, commissions, and projections. All parts of the model were linked with interdependent formulas. Formulas consisted primarily of arithmetic operations such as addition, subtraction, averaging, and combinations of these functions; others included minimum and maximum functions, vertical lookups, IF...THEN...ELSE statements, financial functions, and a table comparing double-declining, straight-line, and sum-of-the-years' digits depreciation. Raw recalculation tests used a 50- by 200-cell matrix. Unless otherwise specified, tests were timed from the moment the command was entered until program control was restored and the cursor could be moved to another cell.

The default program settings of the spreadsheets were modified only to optimize performance, and features that might slow the programs (automatic backup and save, for instance) were disabled. Tutorial files and sample worksheets were not installed unless required by a program's setup procedure, and each package's program window and worksheet were designed so that they encompassed the entire screen. 1-2-3 was tested using extended rather than expanded memory, and tests were run using its standard and its WYSIWYG interface. Quattro Pro also was tested under both its default character-based interface and its WYSIWYG interface.

Because it has a 512-row limitation, ProQube 3D could not load the entire model as one worksheet. To ensure ProQube was tested using memory requirements equivalent to those used for testing other programs, the inventory portion of the benchmark spreadsheet was loaded as the second sheet of a 3-D spreadsheet.

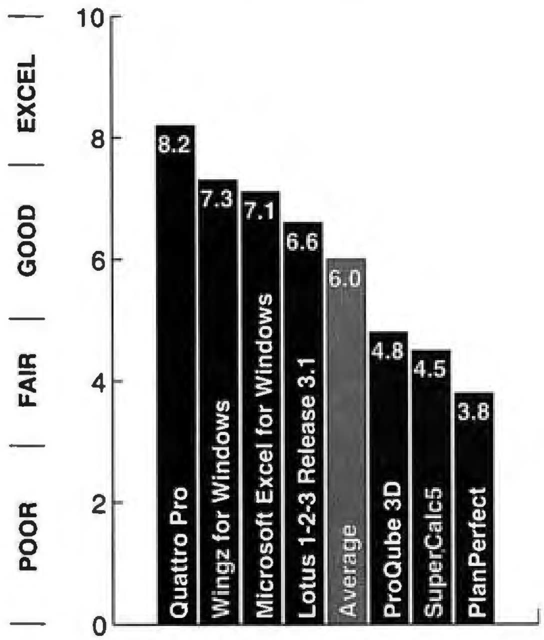
Ratings Analysis

To rank the effectiveness of the seven spreadsheets, the NSTL staff conducted an exhaustive array of evaluations on each product in turn. Spreadsheet capabilities were first broken down into five categories: performance, quality of printed spreadsheets and charts, versatility of a program's features, ease of learning, and ease of use. The various component ratings of each category were weighted according to their importance within the category. The component parts of the ease-of-use category, for instance, are the program interface (assigned a weight of 1), worksheet creation and editing capabilities (3), formatting tools (2), graphing capabilities (2), linking/3-D capability (1), database functions (1), file management (1), quality of manuals (1), and overall ease of learning (4).

Performance

Methodology

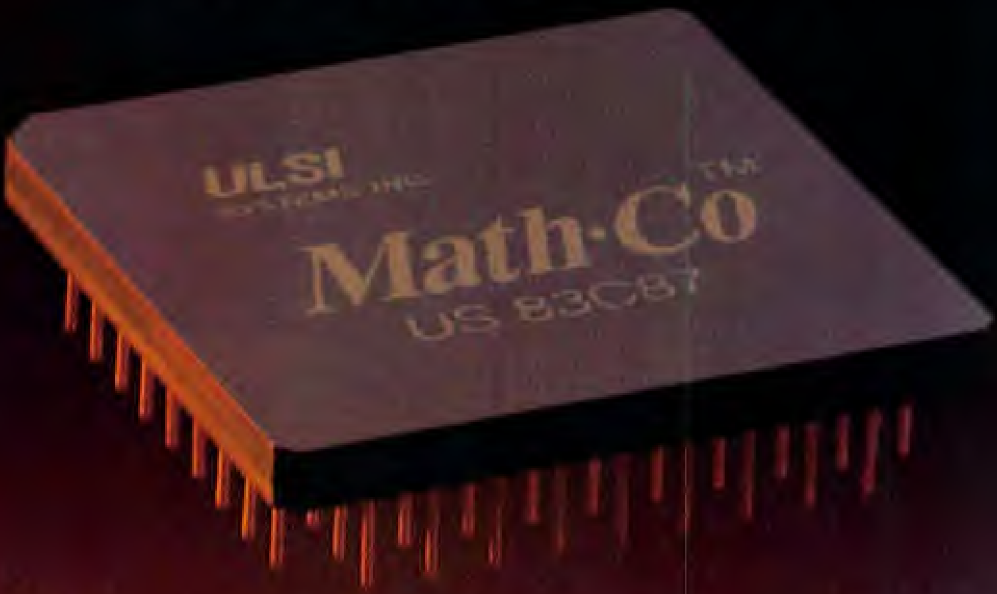
NSTL's benchmark tests for performance measure the speed of common spreadsheet operations and calculations. Tests are devised to rate raw calculation speed, the minimal recalculation speed, and the length of time required to return control to the user from a background or interruptible calculation. Performance is a weighted average of scores for the rated benchmarks. Individual test scores are computed using the following formula: (Program Time - Average Time) / (Best Time - Average Time). The result is then rescaled so that the results for all seven spreadsheets fall within a 1-to-10 scale.



Weight	*Criteria*
1	Import .WK1 file
3	Save a File
2	Load a File
2	Insert a Row, Manual Recalc
1	Insert a Row, Auto Recalc
2	Delete a Row, Manual Recalc
1	Delete a Row, Auto Recalc
2	Insert a Column, Manual Recalc
1	Insert a Column, Auto Recalc
2	Move a Block, Manual Recalc
1	Move a Block, Auto Recalc
2	One-Key Sort, Manual Recalc
1	One-Key Sort, Auto Recalc
2	Multikey Sort, Manual Recalc
1	Multikey Sort, Auto Recalc
3	Background Recalculation
1	Data Table Manipulation
1	Data Table Manipulation, Inputs Switched
2	Print Quality, LaserJet III
2	Print Quality, PostScript
4	Calculation

The New Generation

MATH COPROCESSOR



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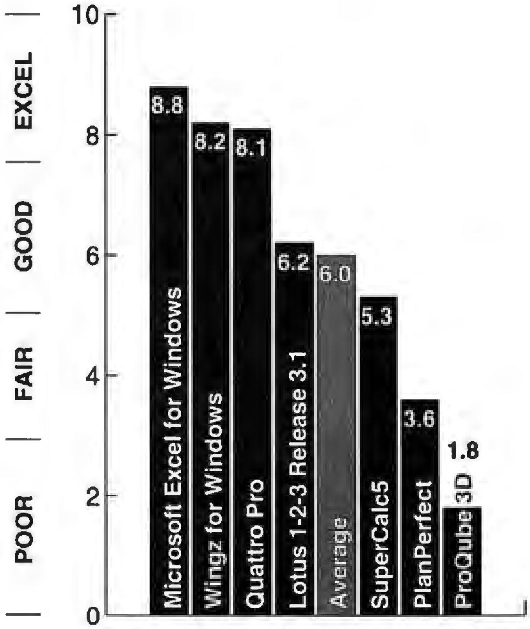
Print Quality

A program's print-quality score is the average of its scores for charting quality and spreadsheet quality. Procedures involve creating the available reports and charts, then enhancing them using shading, outlining, and so on. Quality scores for a program's charts average its evaluations for bar, pie, and line charts. Programs are scored on the basis of available options and on their overall effectiveness at producing the required output.



Quality of Printed Spreadsheets

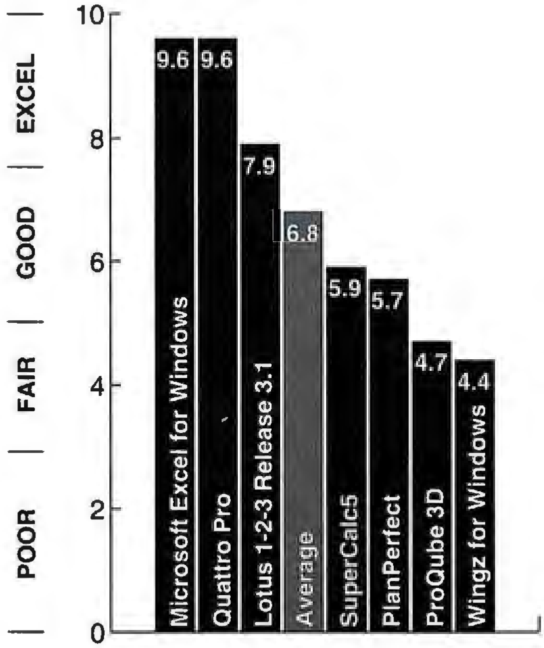
Weight	*Criteria*
1	Options
1	Print Quality with the HP LaserJet III
1	Print Quality with the QMS-PS 810 turbo

Quality of Printed Charts

Weight	*Criteria*
1	When Long X-Axis Labels Used
2	Print Quality with the HP LaserJet III
2	Print Quality with the QMS-PS 810 turbo
2	Print Quality with the HP PaintJet

Ease of Learning

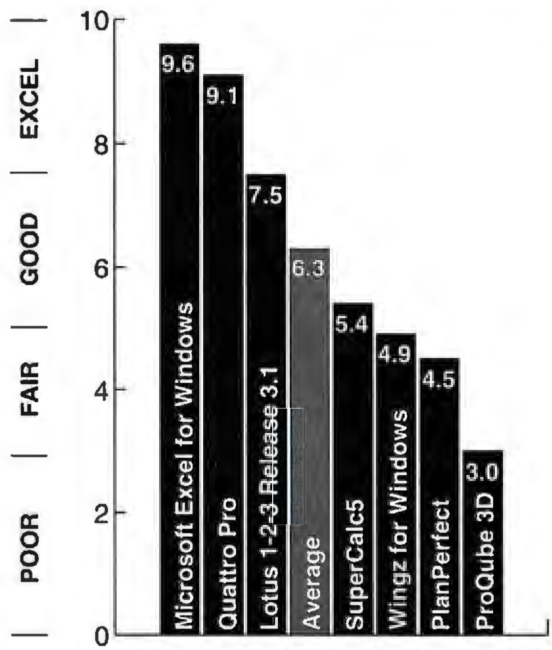
To evaluate ease of learning, NSTL employed groups of novice spreadsheet users and testers with varying levels of experience with Microsoft Windows, 1-2-3, and WordPerfect. Testers were provided with a test model and were given free reign to create a workable spreadsheet solution using a package's manuals, help screens, and program logic. A proctor reviewed each tester's solution and suggested changes to ensure that specific features were included in all the models. A program's ease-of-learning rating is a weighted average of individual scores within the category.

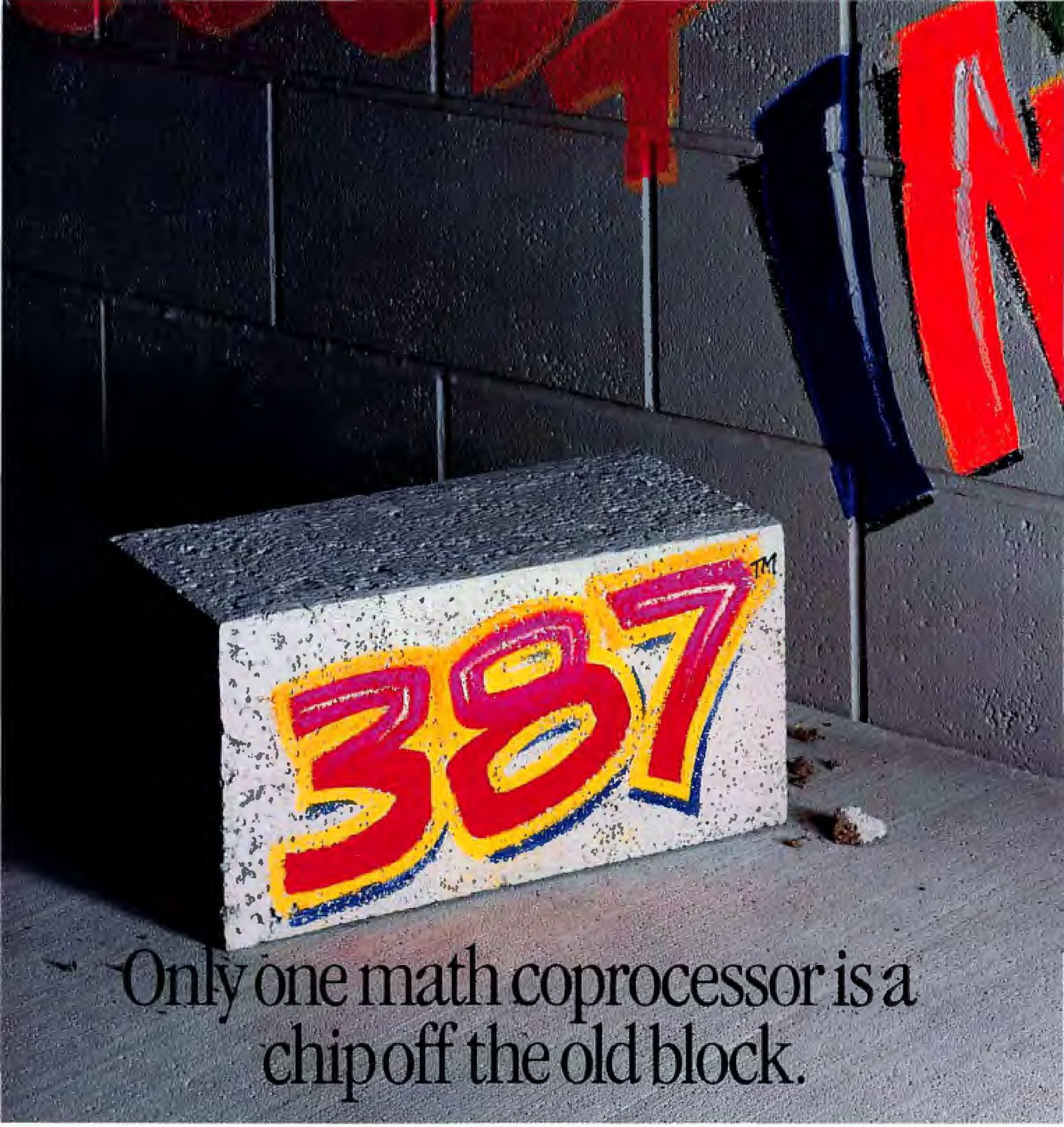


Weight	*Criteria*
1	Program Interface
3	Creating/Editing Spreadsheets
2	Formatting Tools
2	Graphing
1	Linking/3-D Capability
1	Database Functions
1	File Management
1	Quality of Manuals
4	Overall Ease of Learning

Ease of Use

After learning a program, testers evaluated its usability, including the number of keystrokes required for particular procedures, intuitiveness of the menu structure, time needed to perform operations, and quality of reference manuals.





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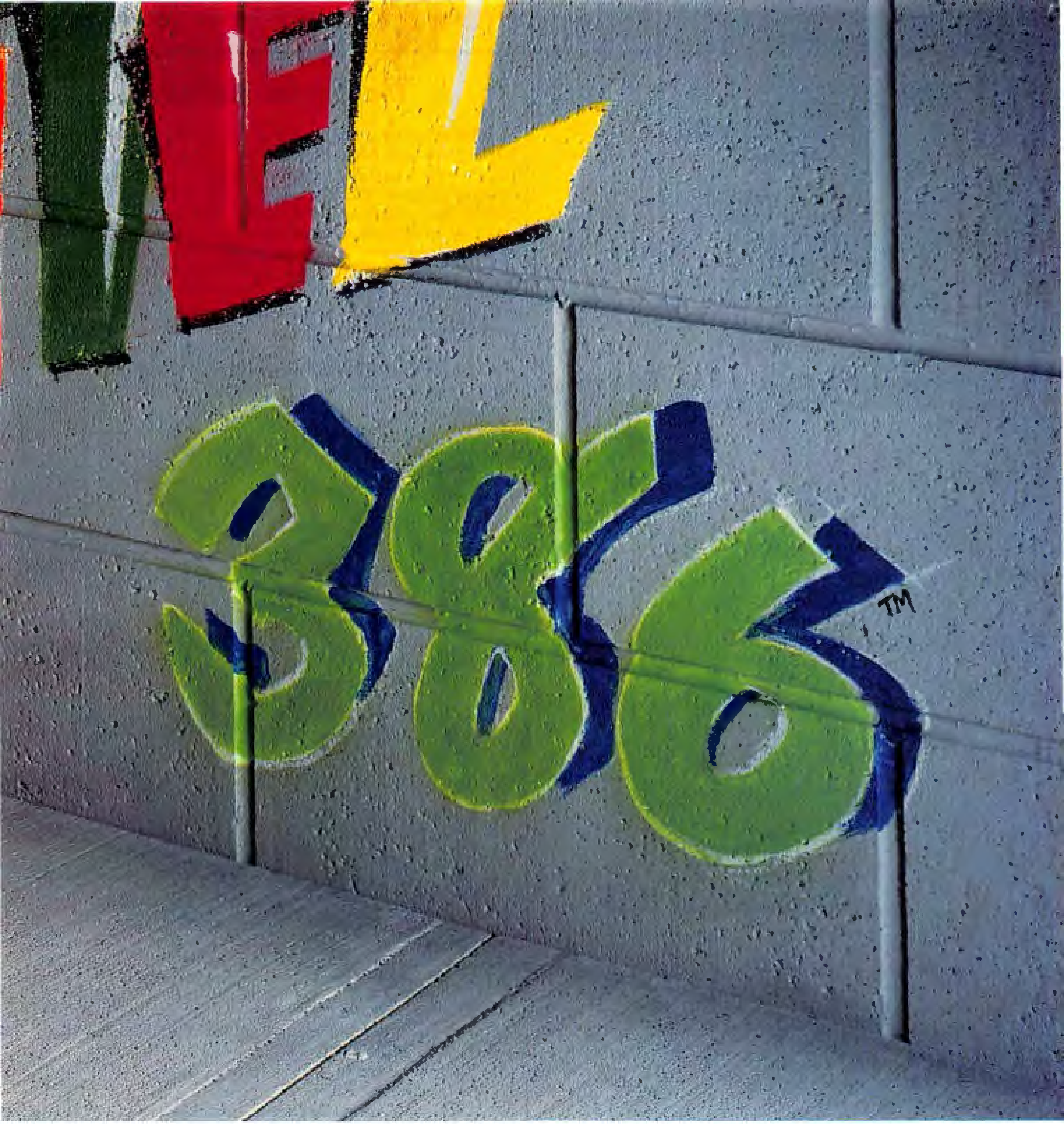

facility, and then tested and retested against an exacting set of criteria.

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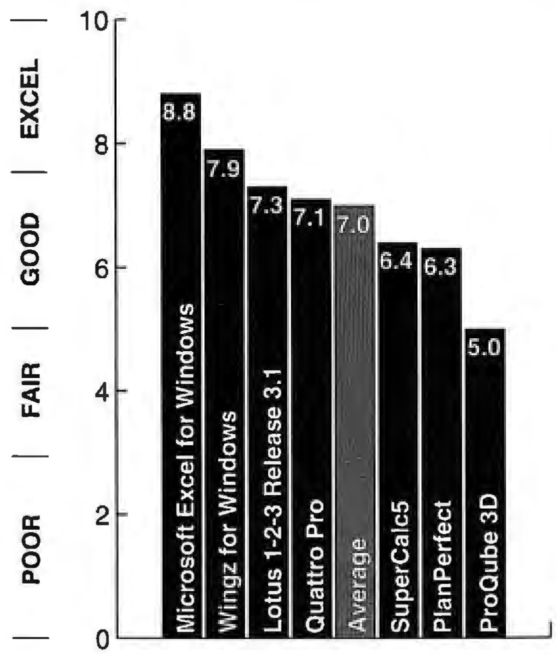
Weight	*Criteria*
1	Program Interface
3	Creating/Editing Spreadsheets
2	Formatting Tools
2	Graphing
1	Linking/3-D Capability
1	Database Functions
1	File Management
1	Quality of Manuals
4	Overall Ease of Learning

Versatility

Versatility ratings are based on a checklist of program features that are assigned weighted scores and grouped by category.

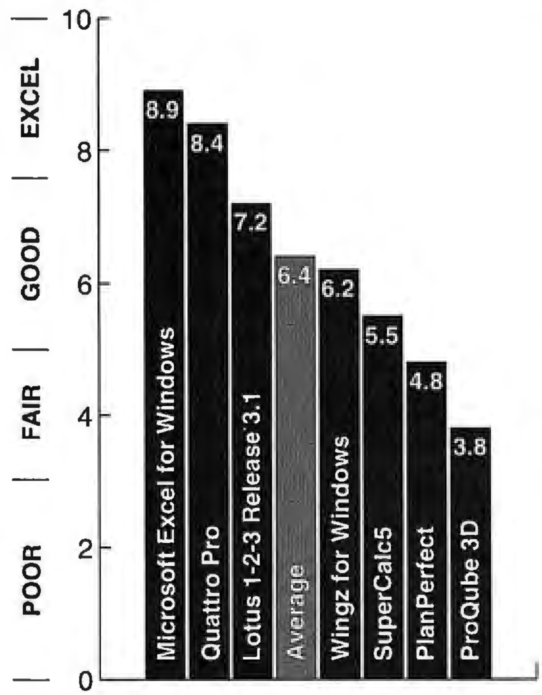


Weight	*Criteria*
5	Worksheets
5	Data Manipulation
2	Presentations
1	File Manipulation
1	Macro/Programming
2	Charting
1	Free-Form Graphics

The Overall Ratings

After evaluating each spreadsheet in the five categories, NSTL computed two overall ratings. The first establishes a power-versus-usability index by weighting the characteristics relating to power (performance, quality of printed spreadsheets and charts, and versatility) and those relating to usability (ease of learning and ease of use) and plotting the scores for each program on a grid. (See "Power vs. Usability" on page 192.) The second overall rating establishes the top spreadsheet among the seven advanced programs tested. NSTL recommends as good buys the programs designated with a checkmark (✓).

The overall evaluation is a weighted average of scores in six categories: the five main evaluation categories plus the testers' general evaluation.



Weight	*Criteria*
4	Performance
2	Quality of Printed Spreadsheets and Charts
4	Versatility
3	Ease of Learning
6	Ease of Use
1	Testers' General Evaluation

MICROSOFT EXCEL FOR WINDOWS PRERELEASE 3.0 ✓

With Microsoft Excel for Windows, Microsoft adds many features to an already powerful program. New features—such as an improved page preview, font preview, and double-clicking with a mouse to invoke dialog boxes—enhance the program's usability. Double-clicking column guides make it simple to adjust column width to accommodate the longest entry.

Excellent flexibility in charting and spreadsheet quality are the consequence of a wide array of enhancements and charting features, including the addition of extensive 3-D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charting options. Excel now places graphs on spreadsheets and includes free-form graphics capability, 3-D graphics, a tool bar, outlining, a goal seeker, a solver, a font preview, style guides, automatic summing, and a format for fractions. Font preview, page preview, WYSIWYG display, shortcut icons, mouse control, and keyboard shortcuts combine with an intuitive interface and excellent on-line tutorial to make Excel easy to learn and use. Microsoft also has improved the program's already speedy recalculation scheme.

QUATTRO PRO 2.0 ✓

While Quattro Pro does not provide the range of features that Excel offers, it outperforms Excel in all but the calculation benchmarks. The program features an intuitive menu structure that you can customize: Existing menus can be changed and rearranged, new commands added and renamed, and new descriptions applied to commands. The program's blazing execution speed enhances productivity, enabling the user to experiment with options rather than wait for the program to finish executing an operation. Although the program runs in less than 640K bytes of RAM, it takes advantage of expanded memory and offers 3-D graphics, a backsolver, linear optimization (in its solver feature), 3-D linking, a graphics mode, free-form capability, a wealth of data functions, and an annotator. On-screen enhancements include outlines and shading. Although the program does not have a graphical interface, it does have programmable buttons that you can use to automate tasks and thus speed operations. Using these buttons to conduct a slide show is a specialty of the program.

Quattro Pro's excellent usability, quality, above-average versatility, fast execution speed, and low memory requirement make it a good choice for any 286 or 386 system—and the only choice for an 8086 or 8088 computer.

1-2-3 RELEASE 3.1 ✓

1-2-3 Release 3.1 comes with the standard 1-2-3 interface (filled out with a few more menu choices) and a WYSIWYG interface that keeps the program competitive with Excel and Quattro Pro. But this dual menu structure can be cumbersome when you're hunting for a certain option. Further, 1-2-3's execution is slow compared with that of the top two spreadsheets, and its charting module lacks the same wealth of features and level of flexibility.

On the other hand, 1-2-3 Release 3.1's WYSIWYG environment provides the most free-form features of the advanced spreadsheets tested here. Background calculation is seamless, and network capability goes beyond simple file locking and read-only access. The capability of its 3-D worksheet is excellent, but 3-D graphics, a solver, and a backsolver are available only in Lotus's very high-end spreadsheet, 1-2-3/G.

WINGZ FOR WINDOWS 1.1

Wingz for Windows is fast and versatile but crashes unpredictably, displaying messages regarding unrecoverable termination errors. And while the program's charting capability is second to none, mastering charting techniques is difficult and the program's overreliance on a mouse is frustrating. Wingz does let you create charts and free-form objects directly on the spreadsheet, but its page preview is not truly WYSIWYG.

SUPERCALC5 5D

SuperCalc5 lacks a page preview of any sort, which adversely affects its usability rating, and its main menu presents an overwhelming number of options. Still, the program offers the best auditing features and financial functions, making it one of the best spreadsheets for heavy-duty financial use. SuperCalc5 manipulates 3-D spreadsheets in the same manner as 1-2-3, but provides no free-form graphics capability.

PLANPERFECT 5.1

Slow and cumbersome, PlanPerfect requires many steps to complete even simple operations. The program also suffers from a lack of free-form graphics, spreadsheet enhancements, 3-D spreadsheets, and a background calculation feature. Charting and auditing features are limited. On the positive side, however, PlanPerfect offers a factorial operator, and its page preview and background printing control are among the best.

PROQUBE 3D 2.00

ProQube 3D—at $99, priced far below the cost of the other products evaluated here—does not provide an equivalent range of advanced spreadsheet features. Missing are spreadsheet enhancements, background calculation, page preview, database functions, font control, an Undo command, matrix inversion, free-form graphics capability, and support for PostScript printers.

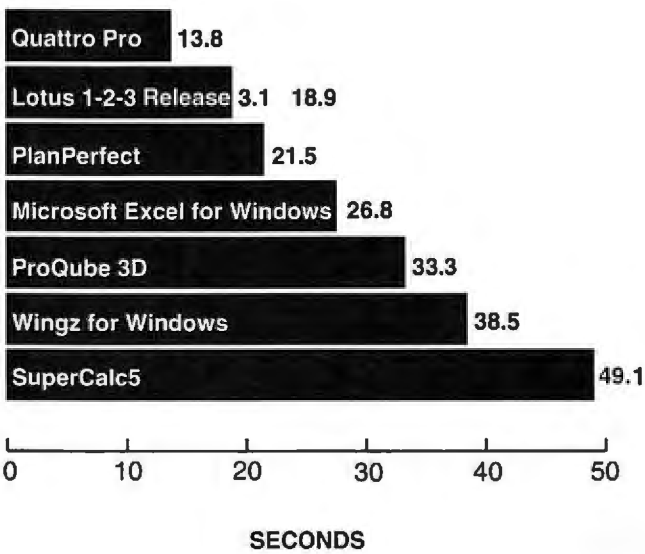
ProQube does offer 3-D spreadsheets and 3-D bar charts. Although no database functions are available, the program includes a backsolving feature, hyperbolic trigonometric functions, and a wealth of mathematical and statistical functions.

Performance Results

To measure spreadsheet performance, NSTL ran each of the seven programs through a battery of tests, weighting benchmark results to obtain an overall performance rating.

Load Lotus .WK1 File

Each program retrieves a 237K-byte file created in 1-2-3 release 2.01.



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Installation is a snap.

The AMD 80C287 plugs easily into a socket that's already inside your 80286-based PC. In fact, you can be up and running in just five minutes. Simply plug the chip into the socket and watch the dazzling improvement in performance! The AMD 80C287 comes with easy-to-follow installation instructions, a free utilities disk (which includes diagnostics and test software), and free color computer games.

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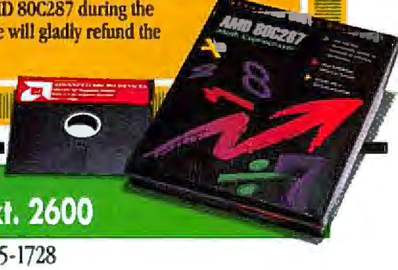

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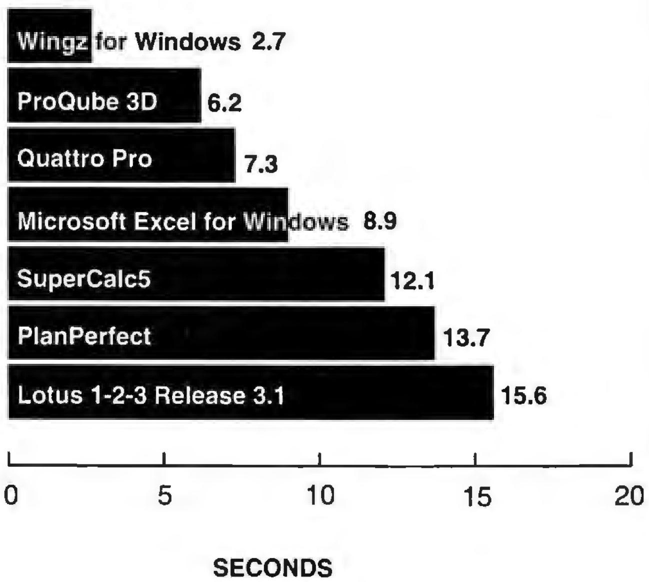
ADDRESS ______________________
____
CITY/STATE/ZIP ______________________
Visa/MC# ______________________
Type of PC ______________________

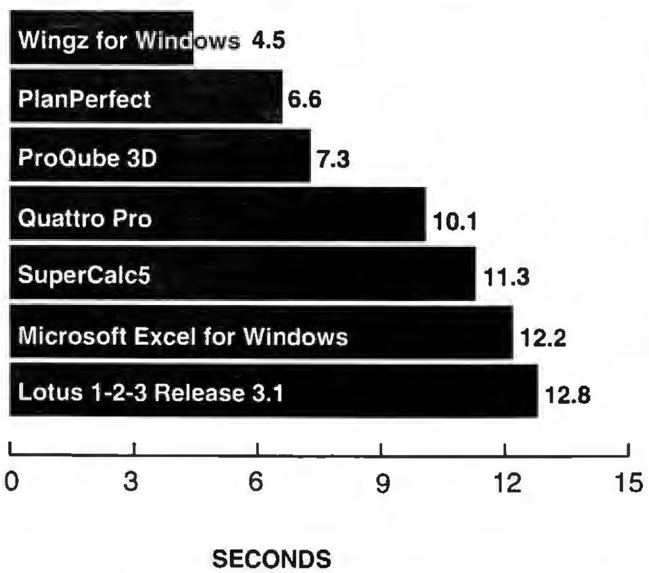
Save a File

Each program saves a file in its proprietary format. The worksheet is completely recalculated to ensure accurate times, and changes are made to the file to provide a means of checking that the file actually is saved. File backup features are disabled.



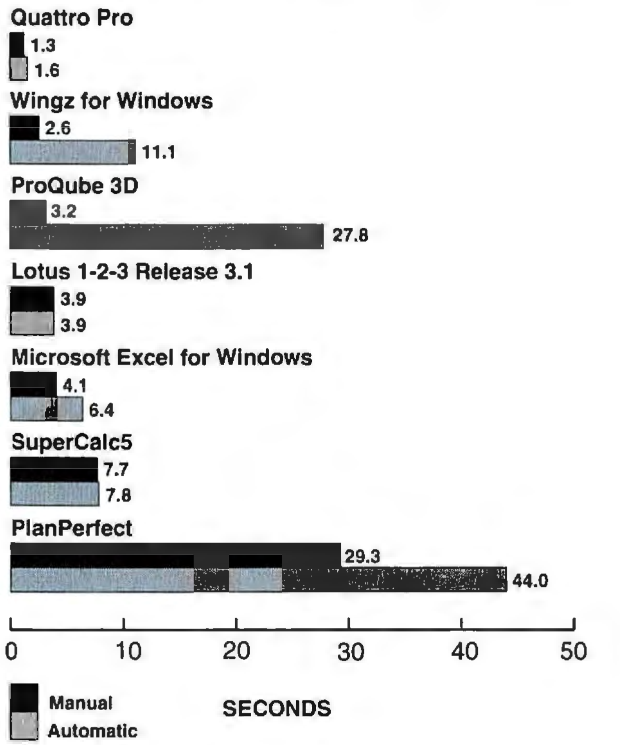
Load a File

Each program loads a file saved in its proprietary format. The test is timed from a clear screen; all worksheets, including blank ones, are closed.



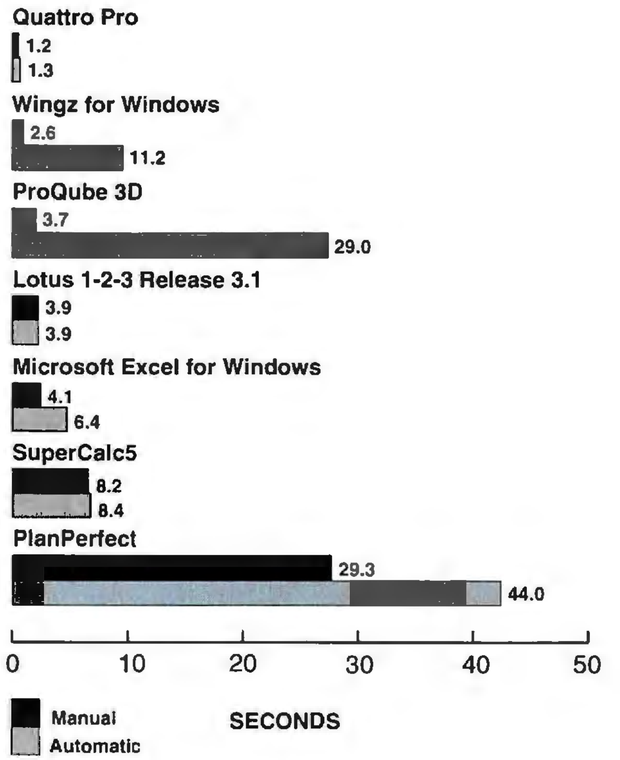
Insert a Row

Each program inserts a blank row at row 33, a procedure that simulates the addition of a cash disbursement. Using manual recalculation, the programs are timed to obtain the actual spreadsheet manipulation time. The test is repeated with automatic recalculation to assess the effects of the background and minimal recalculation.



Delete a Row

Each program deletes the row inserted in the previous test. Using manual recalculation to assess actual spreadsheet manipulation and automatic recalculation to assess the effects of the background and/or minimal recalculation, the programs are timed.



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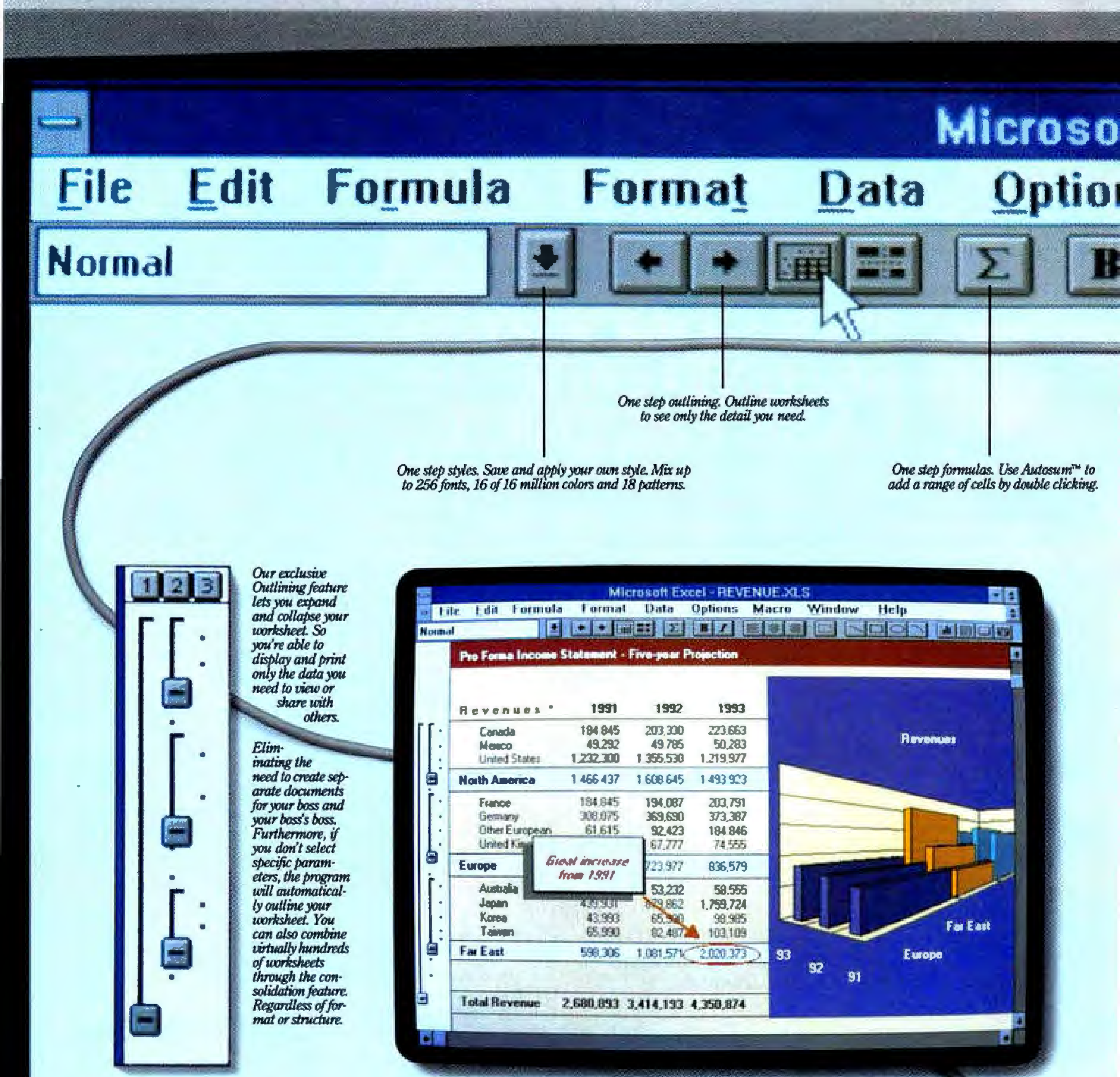

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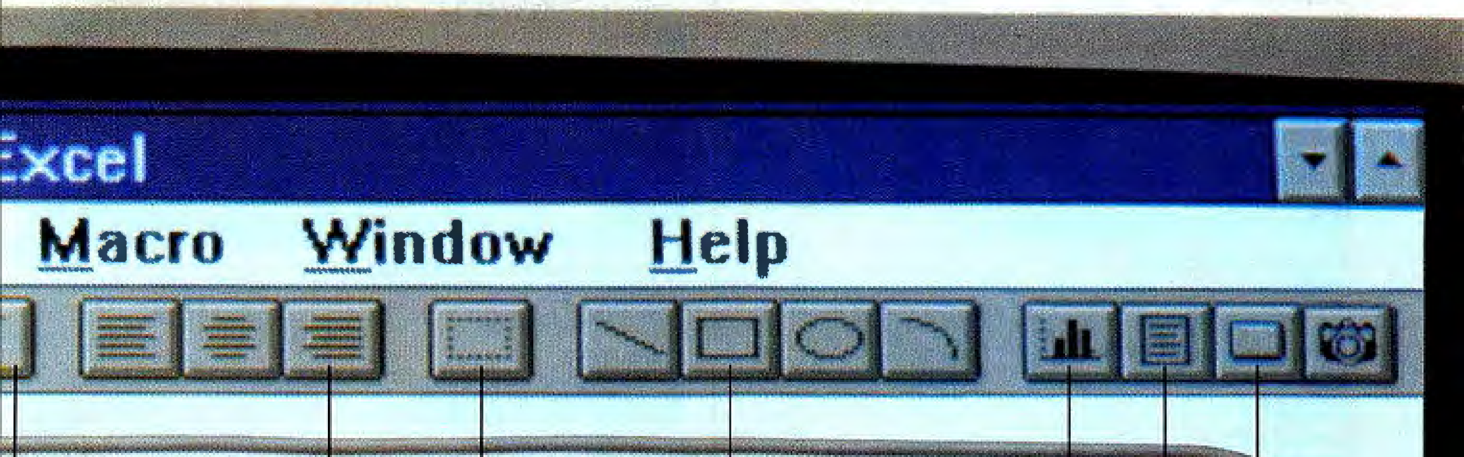
to make this spreadsheet do
tely it'll only take you one.



One step bold and italic. Select a cell and click here. Then see it there.

One step selection. Group objects together. Then move, size or format.

One step alignment. Align data to the left. To the right. Or the center.

One step drawing. Highlight key data with lines, boxes, circles and arcs.

One step charting. Select a range, click and drag. And that's it.

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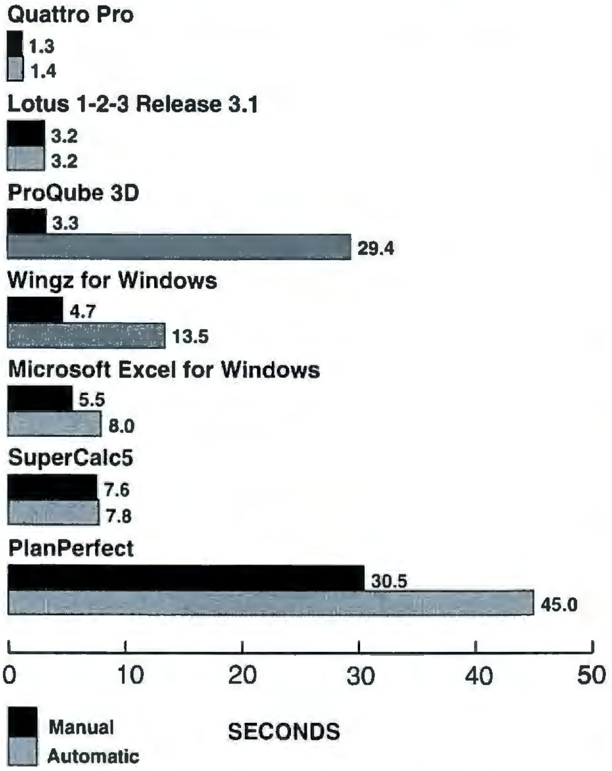
Insert a Column

Each program inserts a column at the second column position. The programs are timed, first using manual recalculation to obtain the actual spreadsheet manipulation times and then using automatic recalculation to assess the effects of the background and minimal recalculation.



Calculation

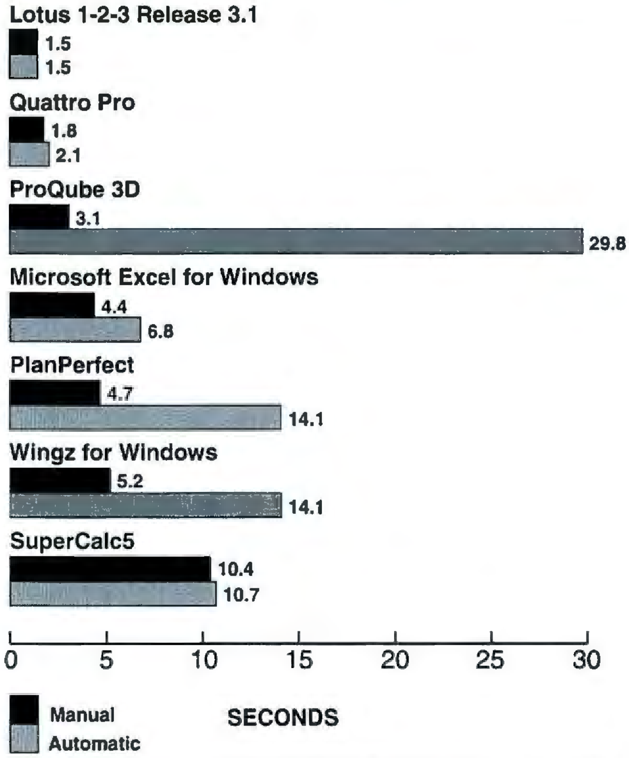
Each program calculates a 50- by 200-cell block; the test ends when the last cell is recalculated. Each cell contains an identical formula that is dependent on the preceding cell so that 10,000 formulas are calculated. The test is first performed with each formula executing a simple addition operation; the test is repeated with formulas for subtraction, multiplication, division, and exponentiation.

Calculation

	Lotus 1-2-3	Excel	Plan-Perfect	Pro-Qube	Quattro Pro	Super-Calc5	Wingz
Addition	6.7	3.0	22.3	16.8	5.7	9.8	3.8
Subtraction	6.6	3.0	22.6	16.8	5.8	9.8	3.8
Multiplication	7.5	3.0	25.6	17.7	6.4	10.1	4.0
Division	7.7	3.2	26.6	18.2	6.4	10.6	5.8
Exponentiation	62.0	29.6	51.8	38.0	36.1	58.7	32.7

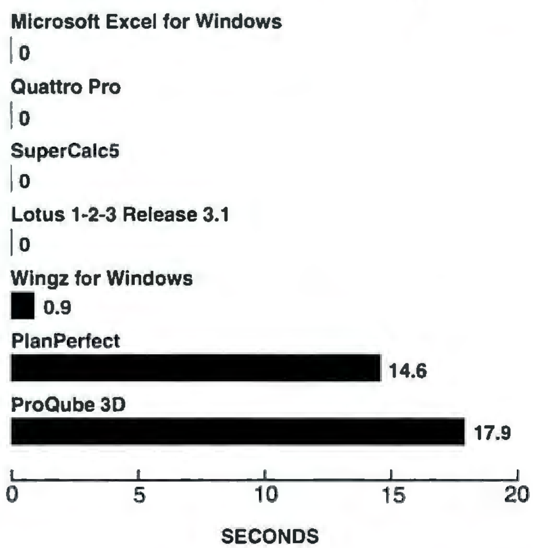
Move a Block

Each program moves one column to the left a block of cells that encompasses C1 through AR93. The programs are timed in two ways: while executing a Block Move command and while deleting the range B1 to B93, which accomplishes the same task. Scoring is based on the faster time.



Background Recalculation

This test measures the time required to return program control to the user when background recalculation is in effect and a value is entered into the worksheet. The test does not measure the recalculation time. Return of control times will vary considerably depending on the cell in which the value is entered and the number of formulas that reference the cell either directly or indirectly.



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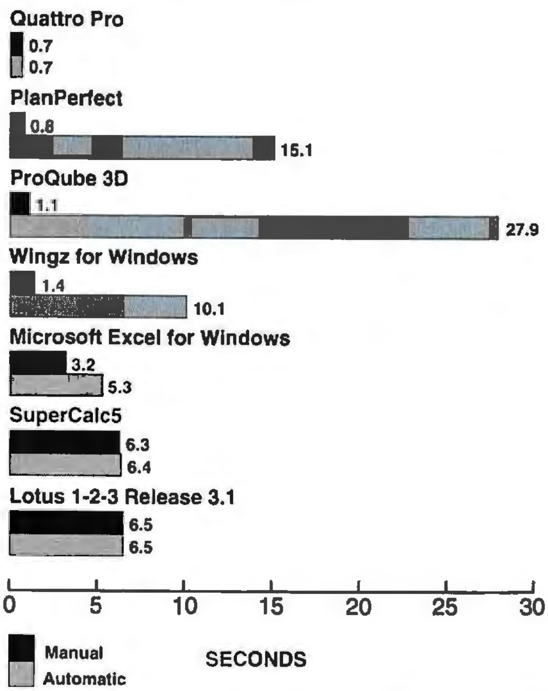
Sorting

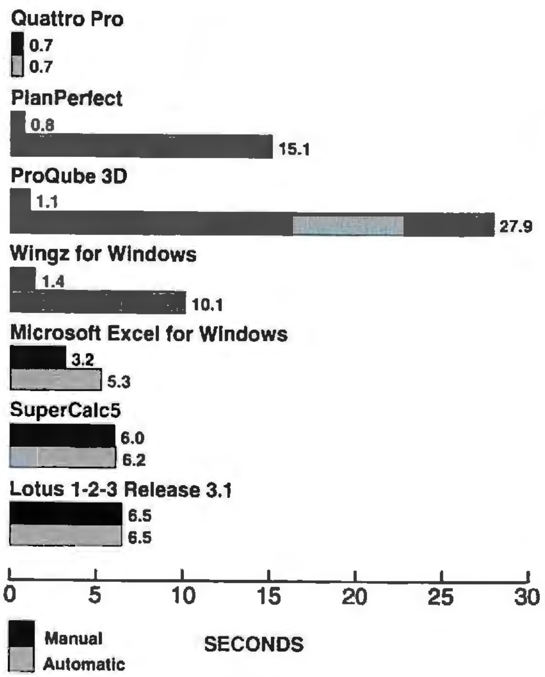
Each program sorts a 19- by 86-cell block, using one key in ascending order (sorting by name in alphabetical order). The test is initiated with the top of the key column positioned at the upper-left corner of the screen.

Each program also sorts the block using the third and first column as keys, thus creating a list of names and associated data sorted in two ways: in descending order by commission rate (expressed as a percentage with one decimal place) and in alphabetical order by name for each rate.

SINGLE-KEY SORT

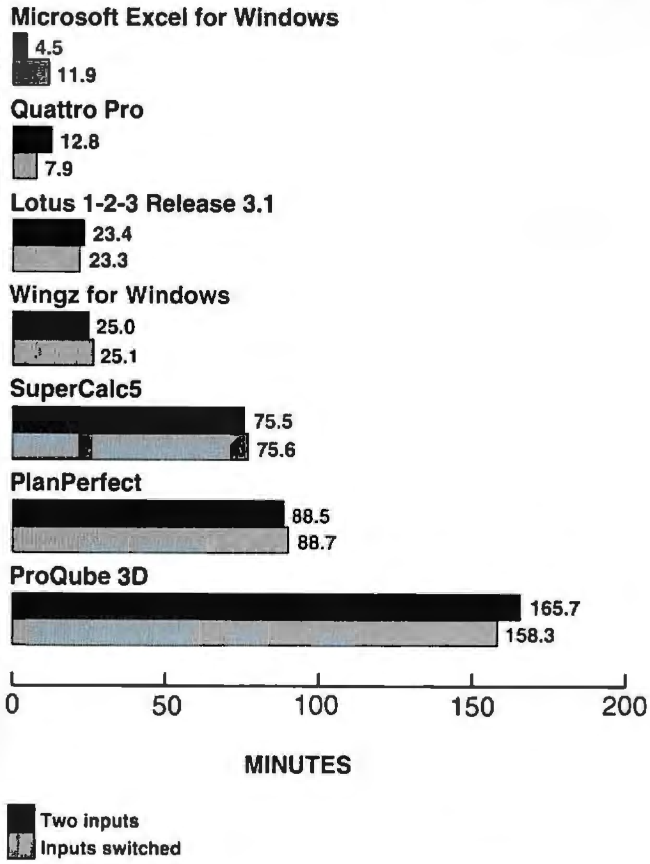


MULTIKEY SORT



Data Table

Each program uses a complex two-input data table to perform a what-if analysis on the working capital available for the spreadsheet model. A 12-month cashflow model determines the amount of working capital available after one year of operation and uses formulas that hinge on percentages based on actual and projected sales. Values for sales increases vary from 1 percent to 13 percent in 0.4-percent increments, and values for operating expenses vary from 16.0 percent to 18.2 percent in increments of 0.2 percent. The data table provides a maximized peak based on the two inputs. All times are measured in minutes. The benchmark is repeated with the two input cells switched.

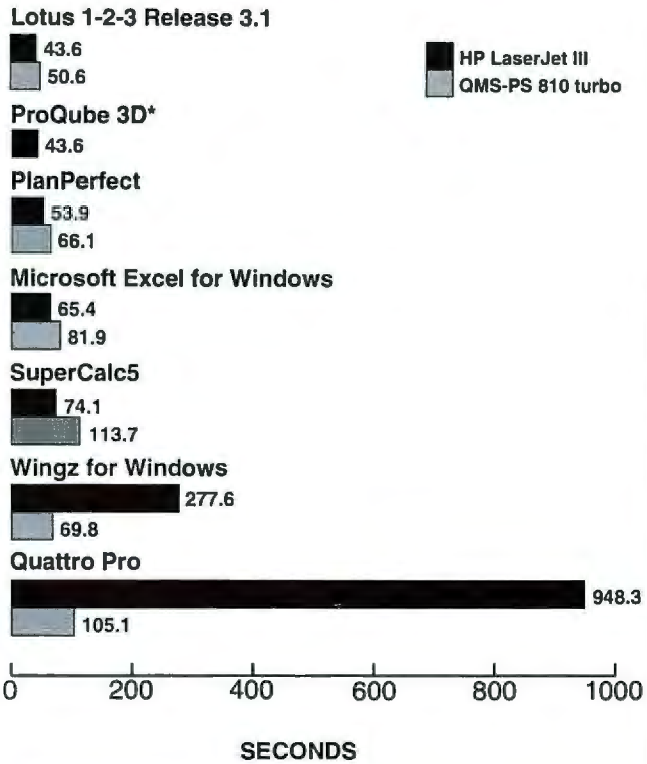


Print Speed

Each program prints a four-page, cashflow report in quality-print mode on a QMS-PS 810 turbo PostScript printer and an HP LaserJet III. The first row of the worksheet functions as a border on all subsequent pages. The range is printed in landscape orientation with half-inch margins. Headers and footers include the date and page number. Output includes borders, shading, and different fonts and type sizes. The programs use the same enhancement options in each location wherever possible.

Graph on following page ➡

Print Speed, continued



* Does not support PostScript

Additional Spreadsheet Vendors

These vendors also sell PC-based spreadsheet software.

Access Technology, Inc.
2 Natick Executive Park
Natick, MA 01760
(508) 655-9191
fax: (508) 651-3788

DacEasy, Inc.
17950 Preston Road, Suite 800
Dallas, TX 75252
(800) 877-8088
(214) 248-0205
fax: (214) 250-3752

Information Resources, Inc.
Javelin Products Group
200 Fifth Ave.
Waltham, MA 02154
(617) 890-1100
(800) 528-3546
fax: (617) 890-1020

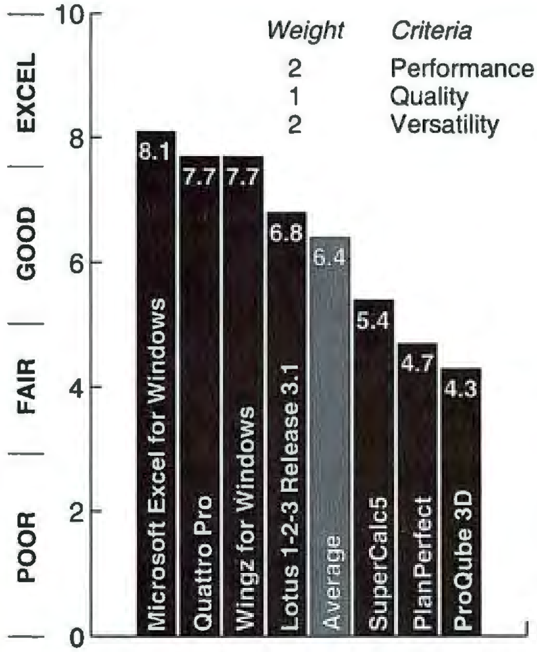
Sinper Corp.
31 Mountain Blvd., Bldg. N
Warren, NJ 07059
(800) 822-1596
(908) 755-9880
fax: (908) 755-9230

Power vs. Usability

One way to judge the effectiveness of advanced spreadsheets is to analyze how well they balance power and usability. NSTL first rated the programs in each category and then plotted the programs' scores to produce an index of power versus usability.

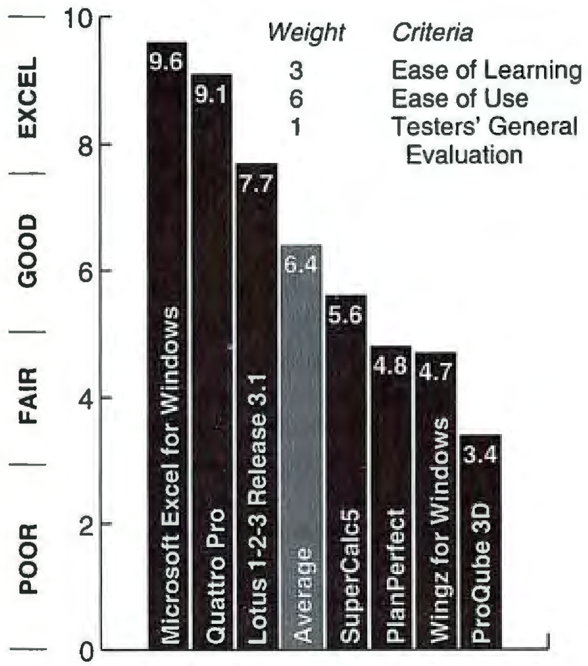
Overall Power

Overall power is a weighted average of scores for the various criteria.



Overall Usability

Overall usability is a weighted average of scores for the various criteria.



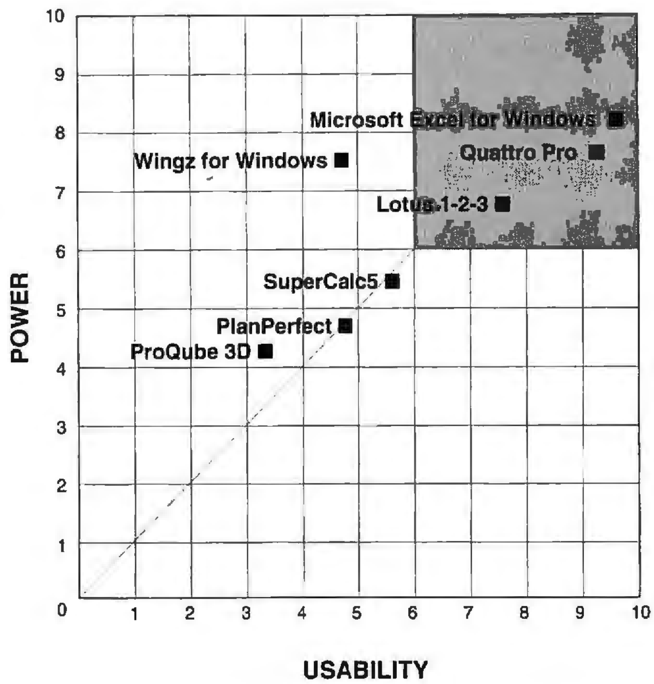
Index of Power vs. Usability

Programs plotted in or near the shaded portion of the chart come closest to having the ideal combination of power and usability. Programs plotted in the center of the chart are equally powerful and useful. Those that fall near the diagonal in the upper-right corner exhibit a balance of power and usability that becomes less acceptable toward the lower-left corner. Difficult, yet powerful, programs gravitate to the upper left, and very accessible programs with little power gravitate to the lower right.

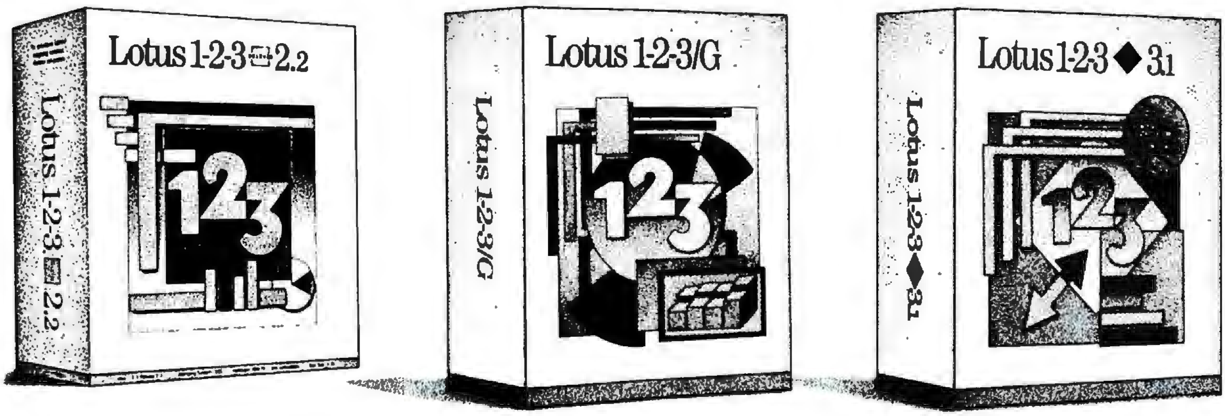
To compute the coordinates for each program, NSTL uses the following weighted formulas:

Overall Power = ((2 x Performance Score) + (2 x Versatility Score) + Quality Score) / 5

Overall Usability = ((3 x Ease of Learning Score) + (6 x Ease of Use Score) + Testers' General Evaluation) / 10



NO ASSEMBLY REQUIRED.



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Advanced Spreadsheets: Adding Up Your Options

Today's high-end spreadsheets reach far beyond the bounds of simple number-crunching. Printing and presentation features approach desktop-published quality. Impressive charting and graphing modules rival dedicated graphics packages. And sophisticated modeling features make designing complicated what-if scenarios a breeze. The best packages blend these capabilities with an intuitive interface.

Spreadsheets come in a wide variety of prices and capabilities. Before you buy, first carefully consider the kind of work you need your spreadsheet program to accomplish. That's the key to determining which features are most important.

You should first look for an efficient means of linking data sheets together. You can expect any high-end spreadsheet to support some type of linking facility. The most powerful mechanism for linking sheets together is a true three-dimensional design. Three-dimensional spreadsheets form a "cube" of data. While a conventional spreadsheet mimics a single ledger sheet, a 3-D sheet resembles a stack of sheets. You can specify ranges of data vertically and horizontally, as with a conventional spreadsheet, but you can also specify ranges across pages. You could, for instance, put a day's worth of sales totals on the first page of your spreadsheet and the next day's total on the second page until you have a full month's worth of data within a single structure. If each page has a daily sales total at cell D11, you can add all the D11 cells on each page by summing a range that spans from D11 of page 1 to D11 of page 30.

Linked spreadsheets do the same thing, but it takes a little more effort. In the daily sales model, you would have 30 separate spreadsheet files, one for each day's sales totals. Another spreadsheet would contain the totals. Instead of simply summing a range, you would have to include a file reference for each sheet (e.g., PAGEONE:D11+PAGETWO:D11... and so forth, where PAGEONE is the name of a single spreadsheet file and D11 is the cell containing the daily total).

If your spreadsheets contain fewer complex links, you won't need a true 3-D structure. However, if you have many related spreadsheets that follow a similar structure and require extensive summary data (such as the example given), a 3-D spreadsheet will be a big win. It not only saves time, it also keeps your data organized by putting related sheets in a single file. If you decide that linking by external reference is sufficient, check to see if you can link to a file on disk. Some linking spreadsheets insist that all file references be open. This can eat up a lot of memory if you have numerous external references in a single sheet. You must have all your referenced sheets loaded in memory to do any recalculations.

Flexible recalculation schemes can boost performance considerably. If your spreadsheet work can take advantage of minimal recalculation, definitely look for a product that supports this feature. With minimal recalculation enabled, a recalculation operation will affect only the cells directly changed. Without this feature, a recalculation command will recalculate every formula in your spreadsheet, even those that will remain unchanged. If you work with large spreadsheets and perform operations on small sections of them, you'll appreciate the efficiency of minimal recalculation.

With background calculation, you can continue working on your spreadsheets while recalculation proceeds in the background. This will usually degrade responsiveness, but it is still faster than waiting for a long recalculation to complete before resuming your work.

The latest spreadsheet programs include sophisticated solver capabilities. With a conventional spreadsheet, you plug in different data values to perform what-if scenarios. A solver feature takes this a step further. You can specify adjustable cells (such as the price you charge for an item) as well as cells that you cannot change (such as the number of items in your inventory). You can then designate a cell to maximize (such as profits), and the solver utility will deliver all the available solutions for the defined problem. A solver utility can save lots of time and effort if your applications require revenue projection, budget management, or extensive what-if modeling.—Stanford Diehl

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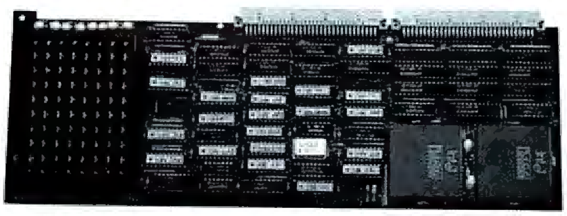

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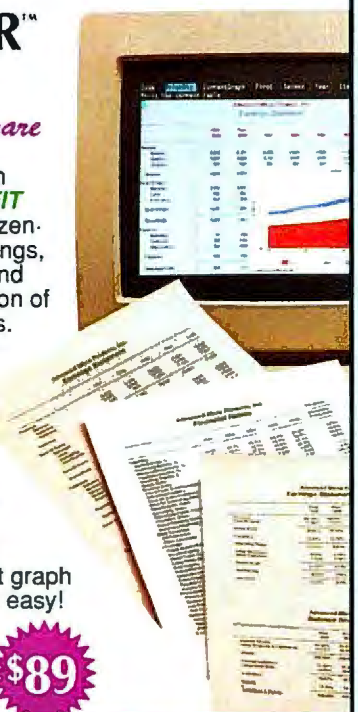

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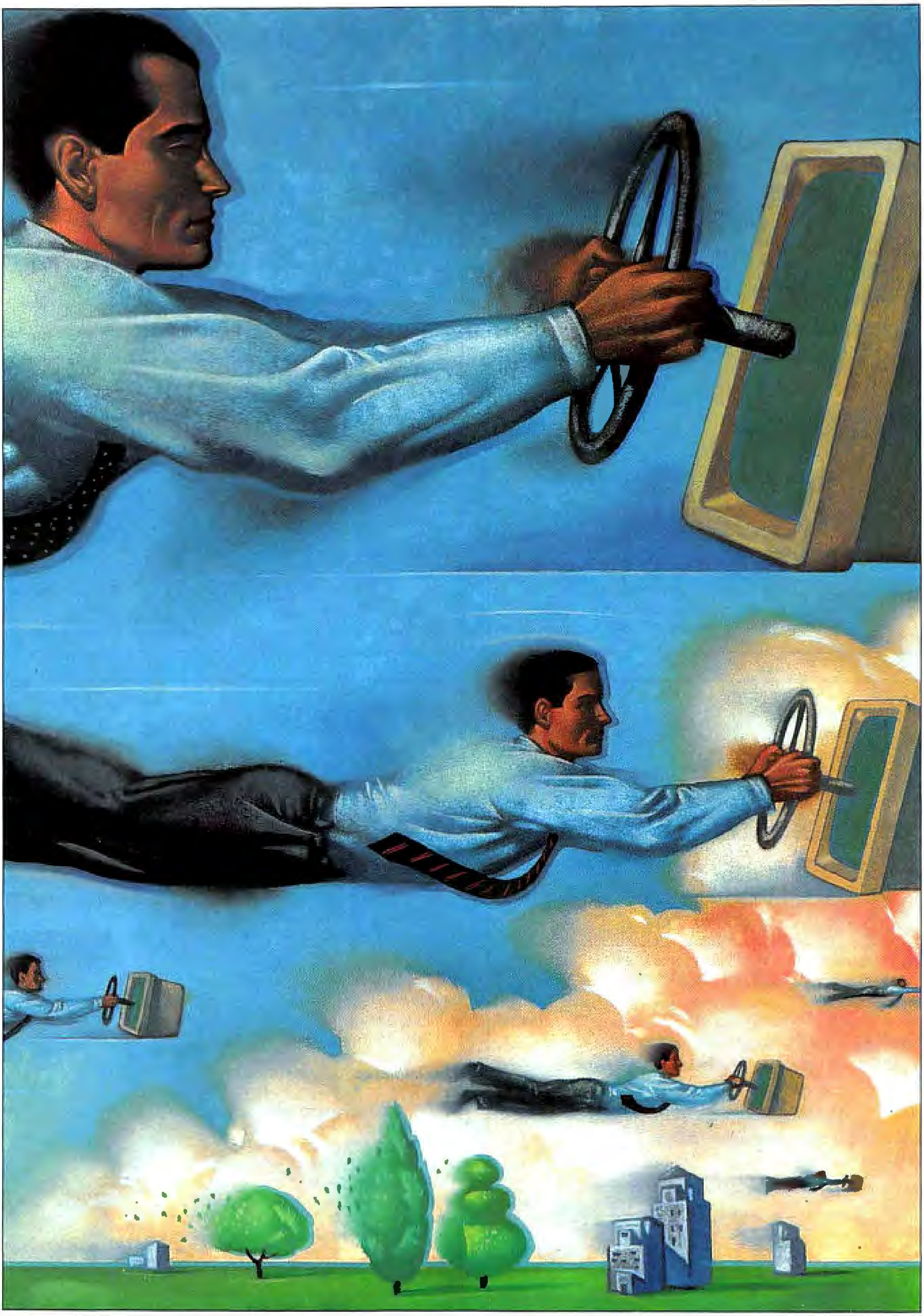

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MULTIPROCESSING

A lot of things in this world are relative—beauty, comfort, ease, productivity—but speed is not one of them. Speed can be measured with terms like *miles per hour, megabytes per second, nanoseconds per instruction*, and so on—faster and faster until, eventually, physical limitations come into play.

For example, a microprocessor can operate at what seems to be an ever-increasing speed, from 12 MHz to 25 MHz to 33 MHz—onward and upward. But the fact is, the single electronic microprocessor has a limit in terms of speed and performance, and we are fast approaching it.

As users, we have insatiable appetites for speed and performance from our computers. Where will further speed improvements come from? Optics is one answer, bound only by the speed of light. But completely optical systems are expensive, and they are still largely on the drawing board.

A more affordable and more available solution lies in multiprocessing. If one processor isn't fast enough, then use more than one. It sounds too simple, but using multiple processors can significantly increase throughput speed and, thus, performance. In "Multiprocessor Surf's Up," Bob Ryan discusses a variety of multiprocessing options.

However, multiprocessing isn't as simple as it sounds. As you multiply the number of processors, you don't just equally expand the number of potential problems—you also add new ones. Among them are connecting the processors, coordinating the processes, and maintaining consistency among the caches. In "Catch as Cache Can," Steven J. Vaughan-Nichols looks at different methods of dealing with this critical issue in shared-memory multiprocessors.

Shared-memory multiprocessors are more popular than message-passing multiprocessors because they can use current sequential programming. However, the shared-memory aspect of their architecture also creates a performance bottleneck. In "Popular and Parallel," Mike Robinson examines some of the research under way at various universities to create alternative shared-memory architectures.

Message-passing multiprocessors have no such bottleneck. They can achieve linear speed increases that are directly proportional to the number of processors used. So, why aren't they more popular? Because you must program for parallel processing to realize such linear improvements. In "Scaling Up: Get the Message?" Richard Marlon Stein explores both the good news and the bad news of the message-passing alternative.

Alternatives seems to be the name of the game in operating systems as well. In fact, until recently, there were almost as many varieties of multiprocessing operating systems as there were multiprocessors. To combat the myriad problems caused by the proliferation of nonstandard operating systems, the Intel Multiprocessor Consortium has come out with a standard Unix for symmetric multiprocessing systems. In "Symmetry, Thy Name Is Unix," Mark Nudelman describes Unix SVR4/MP and how it fits into the open-systems picture.

The trend toward speed and performance in computing mirrors the trend in our lives: Do it faster and faster, and do more of it—whatever *it* happens to be. We're reaching the limit of the single microprocessor's capability, but what about the human's? Do similar limits apply?

The quantity-versus-quality dilemma has been largely ignored—or temporarily forgotten—in today's competitive atmosphere. Balance and reason need a louder voice in corporate decisions. The bottom line isn't always the most important consideration.

How fast is fast enough? Have *you* smelled any flowers lately?

—Jane Morrill Tazelaar
Senior Editor,
State of the Art

MULTIPROCESSOR SURF'S UP

Parallel computing is making a splash in commercial systems, and multiprocessors are leading the wave

BOB RYAN

If Ben Franklin were alive today, he might sing a different tune, especially if he were producing *Poor Richard's Almanac* on a desktop machine. "Everything in moderation—except MIPS" would be more in keeping with the never-ending mania for more computing power.

In theory, there is nothing your current personal computer or workstation can do that couldn't be done on a 1981-era IBM PC or a circa-1977 Apple II. People wrote graphical user interfaces for the 8088, and I'm sure someone, somewhere, tried to do ray tracing with a 6502. The sticking point is practicality.

As applications become more complex, you need more horsepower to make them practical. As you gain more horsepower, you discover more applications for your computer. The driving force behind the quest for ever-faster personal computers is, thus, twofold: making practical applications faster and making complex applications practical.

For the past two decades, making faster personal computers has meant using faster and more powerful microprocessors. As the millennium approaches, however, limitations on how far you can push semiconductor technology will require us to rely more on architectural advances than on material advances to create more powerful computer systems.

From a commercial standpoint, multiprocessing architectures hold the most promise for delivering the most power at a reasonable price. They provide increased computing power by tying together current-generation microprocessors into systems that can harness their combined capabilities.

continued

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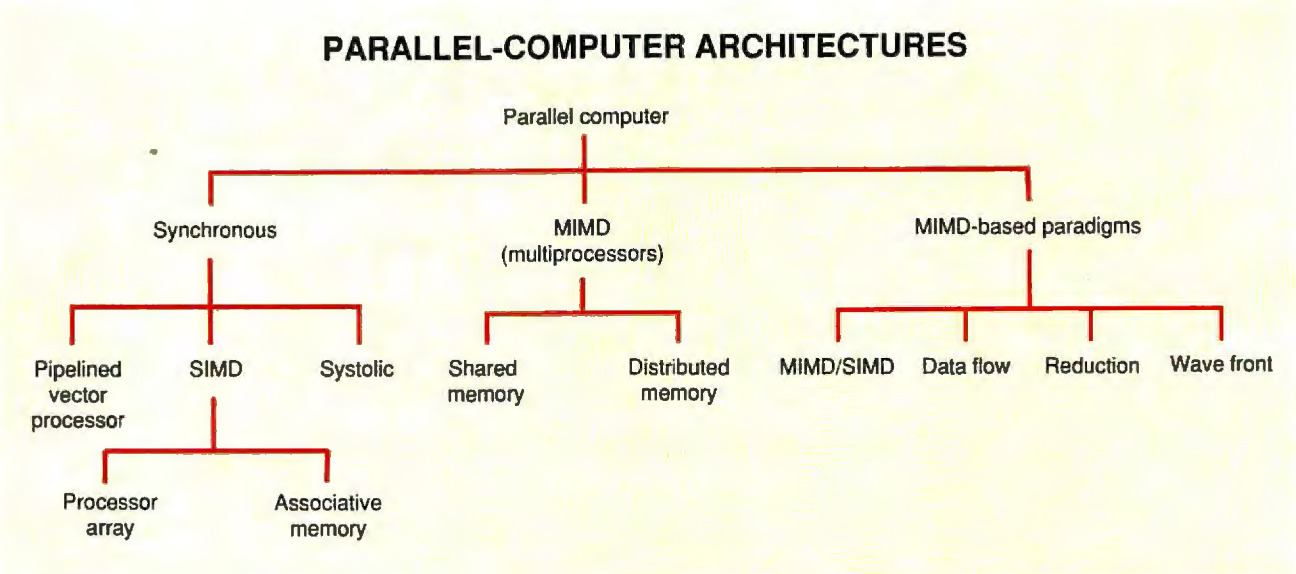

Figure 1: *Ralph Duncan's classification of parallel architectures provides a common vocabulary for discussing parallel computing. Multiprocessors are synonymous with Duncan's MIMD classification.*

Computer Taxonomies

Ask a dozen people to define *multiprocessing*, and you'll probably get a dozen different answers. Part of the confusion comes from the fact that while the term *parallel architecture* is commonly used to refer to any machine that employs multiple identical processing units connected in some fashion, *parallel processing* is often used quite specifically to describe situations where a process is split among multiple processors. Thus, multiprocessing can be a subset of parallel architectures and a superset of parallel processing!

BYTE ACTION SUMMARY

Individual microprocessors are hitting the wall in speed and power; in fact, they've just about reached their limits. To continue the upward climb, we will have to combine multiple microprocessors into multiprocessing systems. At least, of the options available, that's the one that appears to deliver the most bang for the buck.

To convey more precisely what the terms used to describe computer architectures mean, many researchers have come up with classification systems for computers. The most widespread classification scheme is Michael J. Flynn's stream classification, developed in the mid-1960s (see reference 1). Flynn classifies computer architectures on the basis of how many instruction streams and how many data streams they can handle at the same time. His scheme divides computers into four classes:

- *Single-instruction, single-data* (SISD) architectures handle one instruction stream and one data stream at a time. This describes the classic von Neumann architecture.
- *Single-instruction, multiple-data* (SIMD) computers, such as array processors, can have a single instruction stream act upon many data streams at the same time. Because many processes don't lend themselves to having many pieces of data that require simultaneous, identical processing, array processors are useful for specialized processing only.
- *Multiple-instruction, single-data* (MISD) architectures theoretically have many instruction streams operating on one data stream at the same time. No one has yet implemented such an architecture, mainly because no one can see a practical use for it.
- *Multiple-instruction, multiple-data* (MIMD) computers have multiple instruction streams acting upon multiple data streams. There can be various types of interaction between the different instruction and data streams.

Although Flynn's classification remains in use, it has proven ineffective in differentiating among many of the new architectures developed in the past 25 years. Numerous alternatives have been proposed.

In 1988, David B. Skillicorn, of Queen's University at Kingston, Ontario, came up with a classification system based on the number of instruction and data processors in a system, the relationships among them, the memory model for both instructions and data, and the way multiple data processors interacted (see reference 2). He derived 28 computer architectures that can handle everything from computers without instruction processors (data-flow architectures) to those with multiple instruction and data processors. Skillicorn based his classifications on abstract architectures, making them more useful to researchers than to laypersons.

In 1990, Ralph Duncan, of Control Data, introduced a hierarchical taxonomy for parallel architectures to help show the relationships among them (see reference 3). He kept some of Flynn's system while also addressing those architectures that didn't fit into it.

Duncan also shed some light on the intrinsic characteristics of parallel computers. He excluded low-level parallel mechanisms (e.g., instruction pipelining, multiple functional units in CPUs, and separate CPU and I/O processors) because these items have become so commonplace that they negate the usefulness of the term *parallel architecture*.

Duncan's taxonomy (see figure 1) employs three primary classifications: synchronous, MIMD, and MIMD-based paradigms. Synchronous parallel architectures, as the name implies, perform parallel functions in lockstep. MIMD computers employ multiple asynchronous processors. That's not to say that the processors don't work together, but that any cooperation among them is the result of software. MIMD-based paradigms share the multiple, asynchronous aspects of MIMD architectures, but each adds a unique organizing principle.

Most commercial parallel machines come from the MIMD group. This is the group commonly referred to as multiprocessors.

Characteristics of Multiprocessors

Multiprocessors are computers with multiple processors that can each operate on its own data. The processors operate independently of one another, normally on autonomous tasks or significant portions of large tasks. Therefore, they are usually described as providing coarse-grained or medium-grained parallelism.

Unlike the exotic processors used in some parallel machines (e.g., 1-bit processors in the Connection Machine), the processors in multiprocessing systems are usually off-the-shelf components, such as 386s, 68030s, i860s, or Inmos transputers.

Multiprocessing systems come in two flavors: shared-memory systems and distributed-memory systems. The mechanisms used to synchronize the functions of their component processors distinguish one system from the other.

Shared-Memory Systems

The processors in a shared-memory system communicate by reading from and writing to memory locations in a common-address space. Shared memory also usually implies a shared bus. This isn't necessarily the case, however. You can also connect processors to shared memory using crossbar interconnections and multistage interconnection networks (see figure 2). Some other options are being explored in research labs (see "Popular and Parallel" on page 219). But a shared bus is the simplest and, therefore, the most widespread solution.

The problems of having many processors share a single bus are twofold. The first is the problem of bus saturation. With many processors using the same bus, there is always the chance that one

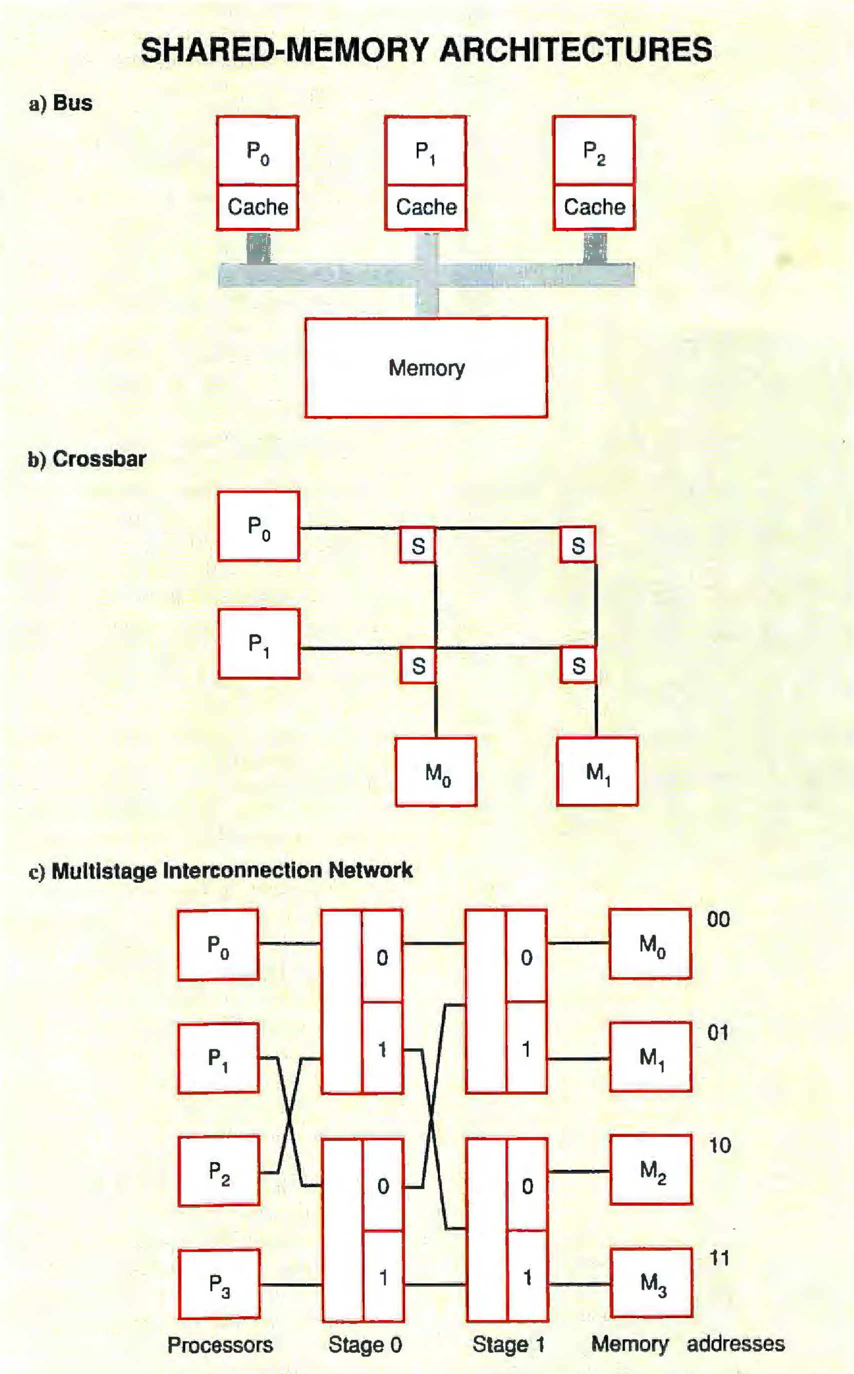

Figure 2: *The simplest way to connect shared-memory processors is with a bus* **(a)**. *These systems usually require a complex caching scheme to reduce bus contention. A crossbar arrangement uses switches to let multiple processors access multiple memory segments* **(b)**, *thus allowing more than one processor to access memory in different segments without contention. Having two processors accessing memory in the same segment still causes contention. A multistage interconnection network (MIN) connects multiple processors to multiple memory segments using different levels of switches. In* **(c)**, *processor P2 accesses memory segment M3 using address 11. The first stage switches using the most significant bit of the address; the second stage uses the least significant bit. MINs scale more easily than crossbars; connecting N processors (where N is a power of 2) to N memory segments requires log2N stages, each of which contains N/2 switches.*

processor will have control of the bus when another one needs to access memory. This problem is usually addressed by giving each processor a sizable local memory cache that it can access in place of the shared memory. Caches do not eliminate contention for the bus, but they do make it possible for two or three dozen processors to share memory.

The second major problem with shared-memory systems is data consistency. With many processors having access to the same data, you can wind up with different values for the same variable in every cache in the system (see "Catch as Cache Can" on page 209). There are many schemes available to ensure the consistency of data—bus snooping, different caching systems, and so on—but all of these add to the cost and complexity of the system.

Because issues like bus contention and cache coherency are normally invisible to programmers, shared-memory multiprocessors are the easiest parallel computers to program. In fact, with coarse-grained systems, where the simplest executing unit is a complete process, you can often run programs written for a uniprocessor system on a multiprocessor. (The granularity of a system describes the relative time that a processor spends communicating as opposed to computing. Processors in fine-grained systems spend much more time communicating than do those in coarse-grained systems, which spend more time computing.)

For example, the MPX extensions for SCO Unix let you run unaltered Unix processes on a multiprocessing system (see "A Fearful Symmetry," May 1990 BYTE). The additional structures needed to schedule the multiple processors and handle external devices are contained in the MPX-modified kernel. Instead of running multiple processes on a single processor, MPX lets you run multiple processes on multiple processors.

Other Unix variants also support coarse-grained multiprocessing. For example, the Mach operating system and Open Software Foundation's OSF/1 have built-in support for multiprocessing, and many vendors are offering multiprocessing extensions to Unix System V release 4, called SVR4. (See "Symmetry, Thy Name Is Unix" on page 243.)

Distributed-Memory Systems

Distributed-memory multiprocessors have many advantages over shared-memory systems. Because they don't share a common-address space, they don't have consistency or contention problems. They are also far more easily scalable than shared-memory machines.

Scalability describes how additional processors affect overall system performance. A linear scalable system is the ideal: Add 25 percent more processors, and you get 25 percent more performance.

Shared-memory systems are scalable when you add small numbers of processors. Go much beyond 10 or 20 processors, however, and you begin to see the performance/processor ratio drop off as the bus becomes saturated.

With no bus to worry about, distributed-memory systems can theoretically be scaled to include hundreds, and even thousands, of processors. Software that can take advantage of the extra processors will also see a linear increase in performance (see "Scaling Up: Get the Message?" on page 231).

Because they don't access the same address space, the processors in a distributed-memory system use messages to coordinate their activities. Each processor has its own memory space and interconnects with one or more of the other processors in the system.

A processor, its memory, and its interconnects are normally referred to as a *node* on the system. Because of the use of messages to synchronize the activity of the processors, distributed-memory systems are sometimes referred to as message-passing multiprocessors. And because each node is a complete computer in its own right (that is, it has a processor and memory), these systems are also called *multicomputers*.

Distributed-Memory Interconnects

How you connect processors in a distributed-memory system has an enormous effect on its performance. The interconnection strategy is paramount because it determines the average latency of any message transmitted on the system.

The ideal interconnection strategy would be to connect every processor in the system to every other processor. No message would ever have to pass through an intermediate node before reaching its destination. Although optical interconnects may one day make this practical, the difficulty of engineering and scaling such a system precludes universal interconnections for all but the smallest distributed-memory systems.

Many interconnection strategies exist for the processors in distributed-memory systems. These include rings; binary trees; and two-dimensional arrays of processors, where every processor is connected to all its neighbors. The problem with many of these strategies is that the

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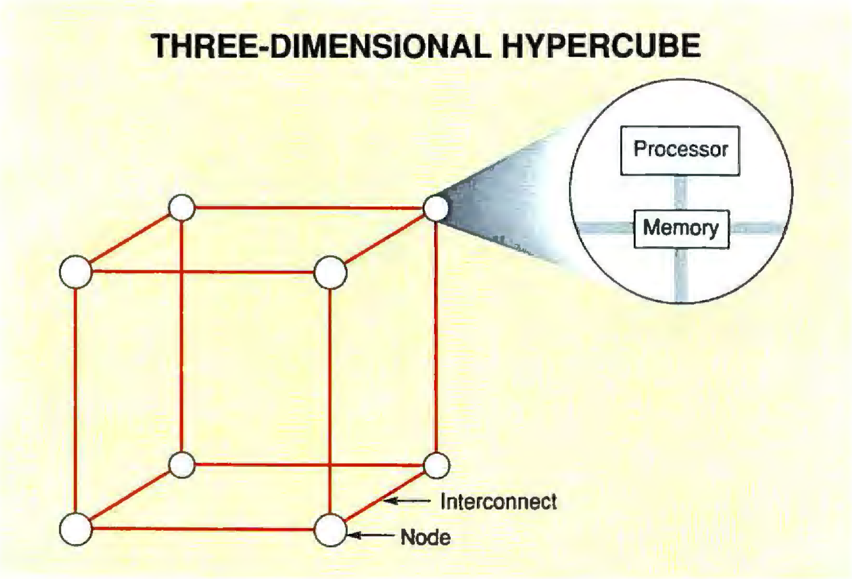

Figure 3: *A three-dimensional hypercube has the logical structure of a cube, with each node containing a processor, local memory, and connections to three other nodes (see inset). The edges of the cube represent the interconnections. The longest transmission path between any two processors—the communications diameter—need involve only three processors (excluding the sender but including the receiver).*

number of nodes a message must travel through on average before reaching its destination increases dramatically as you add processors.

The hypercube is currently the best answer to the problem of scaling up the number of processors in a distributed-memory system without unduly increasing the average message latency. Hypercube topology was first demonstrated in the California Institute of Technology's Cosmic Cube. In a hypercube topology, N processors are arranged in an n-dimensional cube, where $N = 2^n$. Each processor is connected to n other processors, and the maximum number of nodes a message must traverse is n.

For example, a three-dimensional hypercube consists of eight processors (2^3). The topology resembles a cube, with the nodes being its corners and the interconnects its edges (see figure 3). A 4-D hypercube consists of 16 processors (2^4), with each processor connected to four others. The longest path between two processors (the communications diameter) comprises four processors (see figure 4).

The great advantage of a hypercube can be seen when you scale a system to hundreds and thousands of processors. For example, an 8-D hypercube consists of 256 processors, yet no message has to pass through more than eight nodes. A system with 1024 processors has a communications diameter of only 10. The most successful distributed-memory systems—Ncube's Ncube and Intel Scientific's iPSC—are hypercube systems.

Commercial Multiprocessors

Developing software for multiprocessing systems is the main obstacle to their general acceptance. Today, with more and more businesses demanding *open systems*, the only new architectures that can succeed are those that can run portable software, and only certain shared-memory machines using one of the Unix multiprocessor extensions fit this bill.

For example, Corollary (Irvine, CA), the developer of MPX for SCO Unix, has also developed a bus and cache architecture for linking multiple 386 and i486 processors. Known as the C-bus, this architecture forms the basis of multiprocessing Unix machines for companies such as DEC and ALR.

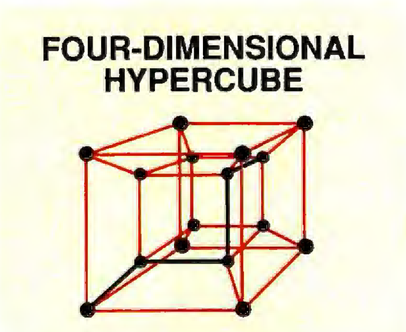

Figure 4: *A four-dimensional hypercube has the logical structure of a tesseract. It has 42 processors, each with connections to four other processors. The communications diameter is 4.*

Such systems provide the coarsest granularity. The unit of parallelism in such systems is the process. With each process being essentially autonomous, the only significant shared data in a coarse-grained system is in the operating-system kernel, particularly in the process-scheduling mechanism. Thus, only the kernel must be modified to have the system run multiple processes.

System-speed increases come not from decreasing the time it takes to execute individual processes but from decreasing the time it takes to execute all the processes. This is a significant improvement, but not as significant as the speed increases you can achieve if you split a process into multiple, independently executable parts.

The reason current commercial multiprocessors don't go this extra step is that there is not a significant commercial software market to support such systems. So, while shared-memory systems are viable today, distributed-memory systems, which are best-suited to medium- and fine-grained parallelism, remain confined primarily to research labs and college campuses.

Where's the Software?

Why is developing parallel programs so hard? John Allen and Ken Kennedy of Rice University may have put their collective finger on the problem when they wrote in 1985 (see reference 4): "Because humans tend to think sequentially rather than concurrently, program development is most naturally done in a sequential language such as FORTRAN. While the resulting programs are usually very efficient on a scalar machine, they are often incapable of directly making effective use of parallel processors."

Developing commercial-quality software for nonparallel computers is a difficult intellectual enterprise. Developing parallel software engenders all the problems of traditional programming and adds quite a few more, all without the benefit of the variety of aids and tools available to traditional programmers. Parallel programmers must handle synchronization among parts of a program, map processing units to processors, and do other architectural details that are transparent to traditional programmers.

The most efficient way to do this is with parallel programming languages

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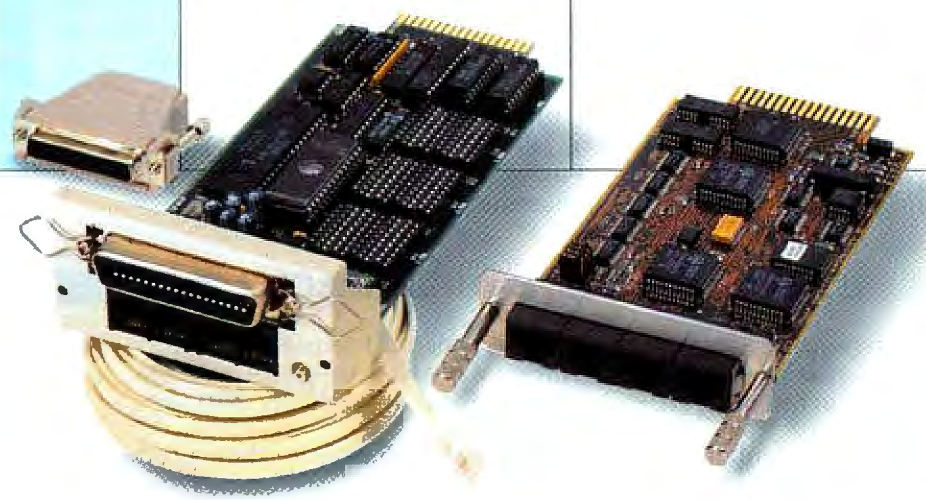

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that resemble assembly languages in their degree of architecture dependence (e.g., Occam). Architecture-independent solutions, such as Strand88 and Linda, are far easier to program, but you pay a price—sometimes a significant one—in performance because of the control you give up.

Unlike von Neumann architectures, parallel architectures differ so radically that it is difficult to come up with one programming paradigm that works well with all of them. So, while Strand88 and Linda make parallel programming far more accessible to traditional programmers, it is not yet clear whether either can provide the basis for a commercial market in portable, parallel software.

Parallel Markets

What is the future of multiprocessing systems for business users? Ted Lewis is director of the Oregon Advanced Computing Institute, a consortium of schools and companies dedicated to advancing parallel-processing technologies. Lewis sees the commercial market for parallel computers developing in three stages.

In the first stage, from the present to 1995, Lewis believes shared-memory multiprocessing systems will be the first parallel architecture to gain general acceptance in the commercial arena. Such systems excel at transaction processing, and Lewis expects to see them used in applications like automated-teller machines and database servers. He also notes that successful systems will use multiprocessor versions of Unix and run standard Unix applications.

According to Lewis, successful designs won't necessarily be the most powerful. "Interoperability, not MIPS, is the issue," he says. Systems that can't run standard software and provide a platform where DOS, OS/2, and Macintosh computers can work together won't make the grade.

By about 1998, Lewis expects another parallel technology to have a significant commercial impact. Compilers for data-parallel technologies will enable a commercial software market for machines like those being offered by MASPAR and Thinking Machines.

In about 10 years, Lewis thinks that a viable commercial software market will ultimately exist for what he calls "true parallel processing"; that is, running a single application across multiple processors in a multiprocessing system.

Parallel technologies have long been touted as the future of computing. With Unix-based, shared-memory multiprocessors, the technology will finally start to deliver solutions outside of universities and research labs. And if Ted Lewis is right, it is only the first wave in the flood tide of parallel processing. ■

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Bob Ryan is technical editor of BYTE's State of the Art section. You can contact him on BIX as "b.ryan."

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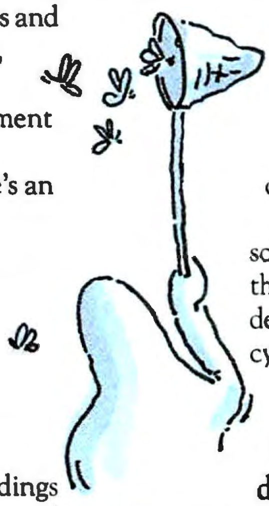

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CATCH AS CACHE CAN

Cache coherency is a critical problem in microprocessor-based multiprocessing systems. Is anyone even close to a solution?

STEVEN J. VAUGHAN-NICHOLS

Single-CPU microcomputers are approaching their limits. So far, they have grown from circuit-board toys to desktop workhorses to network nodes. In doing so, microcomputers have retraced the steps of minicomputers and mainframes.

The next step in this evolution is to move to multiple-CPU microcomputers, or multiprocessor systems. The makers of such new systems as the Compaq Systempro and the NetFrame NF-400 must contend with difficulties unlike any encountered before in microcomputers.

Chief among these problems is cache coherency in multiprocessor systems. In particular, the bottleneck created by using shared-memory caches in multiprocessor architectures has yet to be cleared to everyone's satisfaction on any platform.

Why Use Caching?

If all parts of a computer system operated at the same speed, caching wouldn't be necessary. However, processors, as they zoom past 25 MHz, demand data faster than even the speediest disk I/O, bus, or memory can provide. The slowest parts of a system shackle its performance.

Caches grant freedom from the shackles of slow I/O. In the simplest terms, a cache is memory that is dedicated to storing the data and instructions that the CPU may require at a moment's notice.

You can place caches at several different locations within a system's architecture. Software implementations such as Microsoft's Smartdrive typically reserve a section of main memory. While this memory normally isn't fast enough for optimal CPU use, it is much quicker than

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directly accessing mass-storage devices like floppy and hard disk drives. Even the least efficient caching software can improve effective disk-access rates by an order of magnitude.

Hardware schemes typically call for dedicated high-speed cache memory banks. This type of cache is normally made up of expensive static RAM chips. The memory banks can be located on the motherboard, the disk drive controller (hence, caching controllers like Western Digital's WD1007A), or the CPU itself. The i486 and 68040 microprocessors, for instance, both have tiny on-board caches.

No matter where the cache is located, the principles behind it are the same. The nature of most programs and data manipulation is that the same information or code will be needed again and again. Once you load this information into a cache from a slower storage or transmission medium, you can access it far more efficiently. In addition, it's often a good idea to load related information into the cache, called *read-ahead caching*, to anticipate process requirements.

Uniprocessor Caching

In a uniprocessor system, the cache is relatively easy to implement. Years of mainframe and minicomputer experience have blazed the trails that microcomputers now tread. However, due to certain problems, building the perfect cache becomes a Herculean task.

The first of these problems is that every cache eventually fills with data. When this occurs, you must kick some data out of the cache. It's not easy to decide what information to throw out. The most common solution is to use a *least recently used* algorithm to decide which data to exile. However, this is far from a perfect method.

More polished caching software and firmware use a *least frequently used* algorithm. At the price of memory and processing overhead, these schemes ensure that frequently accessed data will stay in the cache even if it hasn't been called on recently.

Another issue that every cache must contend with is how to handle data writing. Cache designers do not agree on the best way to perform this task. Most caches will check, using a variety of algorithms, to see if the write request will force the cache to overwrite identical data that has already been written to disk. Other caching plans try to optimize the data-writing process. This minimizes the mechanical—and therefore most time-consuming—element of writing data to disk.

Write-through designs have the advantage of ensuring that the cache writes data to disk as soon as possible. This reduces the probability of data corruption in the event of a power outage. Unfortunately, write-through caches are not the most processor-efficient means of handling data writes. By preempting clock cycles and occupying bus bandwidth at times when they're needed for ongoing processes, write-through caches slow down the system.

The alternative *deferred writes* delay disk writes until the system is free from other activities. While a favorite method in mainframe and minicomputer environments, where uninterruptible power supplies are de rigueur, data-integrity concerns limit the appeal of this approach in microcomputer environments.

Another problem is how to determine the optimal cache size for a system. No master key or algorithm exists to solve this one. Contrary to popular belief, bigger is not always better. As cache size increases, at first cache misses decrease, but not in a linear fashion. And eventually, cache misses increase. The ratio of misses to hits shrinks until it reaches the data-pollution point. When this occurs—determined by the size of the cache and its component memory blocks—misses begin to increase.

Using smaller memory blocks delays the arrival of data pollution in larger memory caches. Memory costs become the limiting factor long before you reach the data-pollution point.

BYTE ACTION SUMMARY

Cache coherency is critical in shared-memory multiprocessor systems. Without it, if two or more people are working in the same area at the same time, changes made by one person can be overwritten by others and lost. A variety of options is possible to handle this potential problem—none of them perfect. But finding a solution you can live with is essential to the success of such a system.

Multiprocessor Caching

Now, take all the caching problems for a uniprocessor system and transplant them into a multiprocessor environment. They multiply dramatically. Multiprocessor systems must cope with the woes of caching in general and with three other issues as well: memory, communications, and bandwidth contention.

The nature of most programs and data manipulation is that the same information or code will be needed again and again.

Multiple processor requests to the shared-memory cache cause memory contention. These data requests create communications contention and can interfere with each other's access to data even if the requests are not aimed at the same area of memory.

Bandwidth contention occurs whether the processors are located on a network or on a common bus. The larger a multiprocessor system becomes, the more time it requires to carry out data communications. Together, these three factors can interfere with effective multiprocessing.

This troublesome trio would exist even without caching, but with it, the problem becomes how to implement caching to maximize processor I/O efficiency and minimize contention. One popular method of attacking this problem is to furnish every system processor with its own cache. Private caches avoid most memory-contention problems. However, they increase communications and bandwidth contention.

Another way to use caching in a multiprocessor environment is to let the processors share common caches. The advantage of this approach is that applications that can make good use of shared data and code will need less memory and will execute more efficiently.

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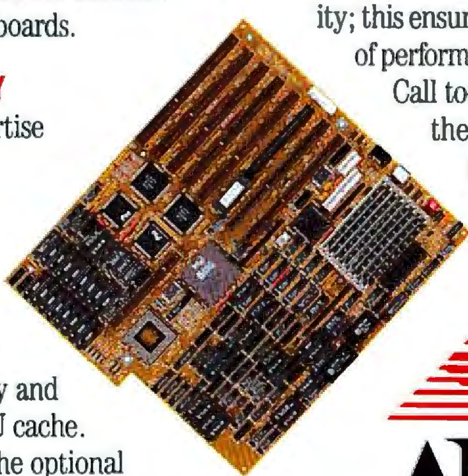

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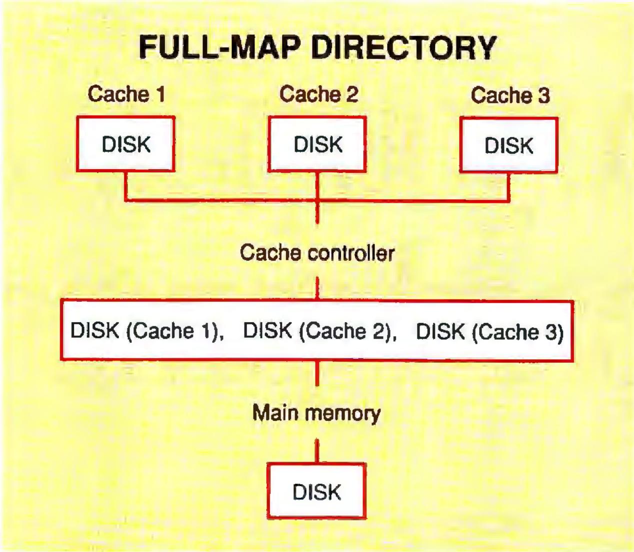

Figure 1: *In a full-map directory, every cached block has a record and a pointer in the cache controller. The record includes status flags that indicate whether you can write to the block and whether it is a valid block. The costs for a centralized cache directory are primarily memory overhead, more controller processing demands, and communications bottlenecking.*

Cache Coherency

Unfortunately, even shared caches contain multiple local copies of memory locations and, possibly, of the data in those locations. Any time that the system modifies the local location of data—which it will do constantly with data flow—it must update the system view of the cache data.

If you don't have a consistent global view of cached data, data corruption and a system crash are not far away. The crux of the cache-coherency problem lies in trying to maintain a single, coherent version of cached information without imposing unnecessary system overhead.

The cache-coherency problem doesn't apply to some uses of cached information. For example, read-only data causes no problem. However, public read/write structures (e.g., the disk directory) must be maintained properly. Even private writable structures aren't safe from cache-coherency woes if the system allows applications to move from one processor to another.

Both private caches and shared-memory caches must contend with cache-coherency issues. The difference is that in shared-memory caches, process communications can address cache coherency within memory, while the private caches must ensure coherency over a network or bus. Thus, private caching actually incurs a greater overhead because of bandwidth and communications contention.

Cache-coherency problems have no easy answers. Despite a long history of dealing with these issues in parallel-processing and multiprocessor systems, no panacea has been discovered. The roads now taken by microcomputer vendors are rocky and ill-mapped.

Bus Cache Coherency

The most popular real-world solution to the problem is to use the bus as the basis for cache-coherency maintenance plans. Buses lend themselves to this use because all the system processors can be attached to a single bus. You can then instruct the processors or dedicated cache controllers to look at all memory-bus transactions.

When a change that affects an element in the local data image is recorded over the bus, the system can either invalidate or update the image. This is the general theory behind *snoopy* protocols, which constantly monitor bus transactions (hence the name).

More precisely, each cache looks for cache-consistency commands in the data stream. When it finds them, the cache controller must process the command to decide if it applies to its own cache.

The disadvantage to the bus approach is that any bus has a limited bandwidth. The more often cache programs "snoop" on the bus, the less room the bus has left for its main job of ferrying information back and forth from main memory to the processors. In addition, the broadcast nature of cache-consistency commands requires valuable bandwidth.

Why use snoopy protocols, then? Because they are easier to implement than others, and they can be realized directly in hardware. Under normal conditions, a snoopy protocol monitors every block of data that is transmitted between a cache and memory. Duplicate blocks can exist.

For example, I can have a document in a cache, whether private or shared, and I can also have my own copy of it in cache. When I change a data element in my copy (if I change the word *disk* to *tape* in the string "I prefer disk storage"), two actions can take place to maintain cache coherence. The first is write-update, and the second is write-invalidate.

The write-update protocols use brute force to maintain cache consistency. When any copy of a data block changes, the system updates every cached copy. The memory copy may or may not be updated, depending on the implementation.

While this approach keeps the bus hopping as it shuttles data hither and yon, it cuts down on data misses. Another concern is that the cache processor can waste time updating copies of data blocks that it won't need again.

A write-invalidate system (when I change *disk* to *tape*) invalidates any other existing copies of the data block, including the one in main memory. As I'm the user who made the latest change to this block, my copy has now become the "real" document.

If I make another change (if I decide that I like *holographic* storage better), my copy of the document is still the real one as far as the system is concerned. If Frank, down the hall, opens the document and starts to edit it, the protocol validates and updates his copy from my cached version of the document.

While elementary to put into practice, this approach is fraught with problems. For instance, if Frank and I are both working on a document at the same time, my changes invalidate his copy, and his changes invalidate mine. Both caches start registering misses because neither copy can be updated until it has been revalidated from the other. These validation misses put a heavier load on the bus.

Whoever made the latest change to the document has the one true copy, but determining who this is puts a large load on bandwidth and communications. As acknowledgments of missed reads and validations begin to clog up the free flow of data communications, the shuttling back and forth of data blocks between caches eats up bandwidth. This shuttling process, which can cause a traffic jam on the bus or network, is called the *ping-pong effect*.

Fixing the Bus

Increasing the size of the cache or memory block won't tame the ping-pong effect. Simulations have demonstrated that neither measure works satisfactorily in a multiprocessor system.

One way of cutting down on the ping-pong effect is to expand the bus's bandwidth. By adding lanes, in effect, to the data highway, traffic jams are less likely to take place. This amounts to the traditional solution of bulldozing a problem with more capacity. However, some bus designs inherently help cache coherency by providing dedicated bus lines to support cache-consistency commands.

The most noteworthy of the dedicated-bus designs is the venerable Futurebus, the IEEE-proposed standard-896 32-bit bus. This bus has built-in cache-coherency support for multiprocessor write-back caches. Unfortunately, Futurebus and its successor, Futurebus Plus, are more theoretical models than working realities.

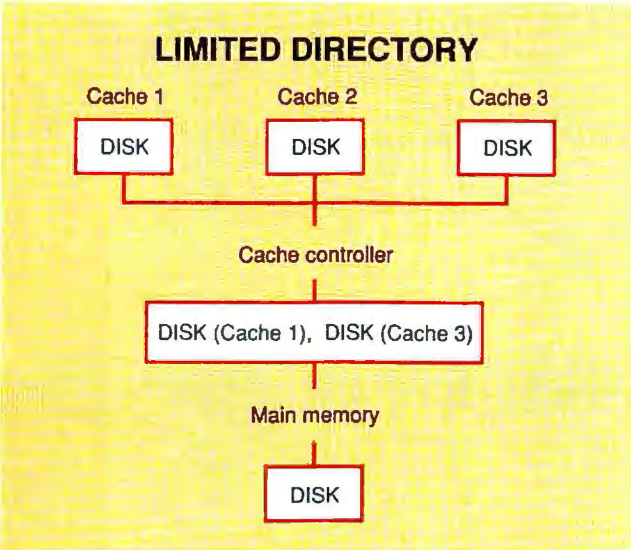

Figure 2: *In a limited directory, the structure can be similar to a full map's, but there are a limited number of pointers. When the pointers are exhausted, the next cached-record pointer in evicts an older pointer and its record. In this case, the same cache block is present in all three caches, but lack of room in the directory has evicted the pointer and record for the copy of the memory block in cache 2. This memory block must now be kept up-to-date by a write-invalidate broadcast protocol.*

In Theory

Despite the growing numbers of multiprocessor systems, surprisingly little experimental work has been done on testing new answers to cache-coherency questions. For all the troubles that are attached to snoopy caching, considerable effort is still being devoted to improving these protocols.

There have been attempts to give the write-invalidation model new life with a protocol named *read-broadcast*. In this protocol, the system updates all appropriate copies of a record when the first read-miss occurs. This avoids multiple read-miss traffic while (mostly) avoiding the write-update bandwidth problem.

Beyond the Bus

Broader answers exist as well that can be used on a bus and in other architectures. Such solutions can handle situations that bus-based methods can't. For example, scalable multiprocessor systems, while possessing greater potential bandwidth than bus-based systems, can't easily support snooping methods.

One area that has been studied a lot lately is the use of cache directories. While only useful in bus-based systems, directories are essential to maintaining cache coherency in other architectures.

A cache directory, which may be either centralized or distributed, maps every cached data block's location. Each directory record holds a flag bit and pointers to the location of every copy of a data block.

The flag bit, usually called the *dirty* bit, indicates whether a particular cache can write to the data block that the directory entry points to. Other informational flags may also be set, depending on the directory design.

Many different directory plans exist. From a structural point of view, you can divide them into three types: full map, limited, and linked list. These three types have one element in common. Usually, control structures are in place to ensure that only a single cache can write to a data block at one time. In this case, the writing cache is said to have ownership of the data block. Each directory type provides a way of transmitting a data-change notification through main memory and the caches. Other than this, the different directory plans go their own separate ways.

Full-Map Directory

Full-map directories have the singular advantage of being able to store information on every block in memory. This style of directory has pointers equal in number to the number of processors on the system (see figure 1) plus two status bits and the dirty bit.

The bits that correspond to a processor indicate whether a particular block is present in that processor's cache. The status bits, which are duplicated in the cache, show whether the block can be written to and whether it is a valid block. The dirty bit indicates whether a particular cache can write to the block.

Full-map directories have several problems. Because the directory is centralized, it is prone to conflict between competing processors and could become a performance bottleneck. Another concern is that searching and updating the directory could put an undue burden on caching performance. Although optimizing mechanisms could address both problems, they would also add complexity. In addition, full-map directories impose considerable memory overhead.

Limited Directory

Limited directories avoid the memory troubles of full-map protocols. By requiring that only a limited number of pointers be maintained, they keep memory overhead within bounds. Otherwise, the structure resembles that of a full-map directory. When the number of copies of a particular memory block exceeds the number of pointers assigned to track them, the newest pointer replaces an earlier one in a process called *eviction* (see figure 2).

How can a limited directory preserve cache coherency? Its defenders have a twofold answer that is not completely satisfactory.

The first part of the answer says that, statistically, a limited directory is sufficient because rarely will more processors need a particular data block at once than it can handle. This part of the answer ignores data blocks containing primary storage-directory information. They may very well be simultaneously in use on multiple caches.

You wonder what would happen, for example, on a multiprocessor Unix system using a limited directory if, on the approach of a thunderstorm, all the users ran sync at once. The sync command flushes all previously unwritten buffers to disk, including the latest copy of the data block containing the system's master directory. Hopefully, the multiprocessing extensions to the operating system would handle the resulting mess.

In addition to this worst-case scenario, there are other concerns. Thrashing seems to be a distinct possibility if the number of pointers is smaller than the number of processors referencing a limited set of data blocks.

The second part of the answer says that limited directories can fall back to a write-invalidate broadcast protocol. That is fine as far as bus-based systems are concerned, but what about systems that are built around scalable point-to-point interconnection networks? In these systems, it is almost impossible to ensure that the broadcast will reach every applicable cache.

In short, while limited directories may serve a role in certain special-purpose architectures, it seems unlikely that they will gain widespread use. Their only real advantage is that the rate of memory overhead grows linearly with the number of system processors. This reason is insufficient to outweigh either the disadvantages of a centralized system or the directory's limited usefulness in non-bus-based systems.

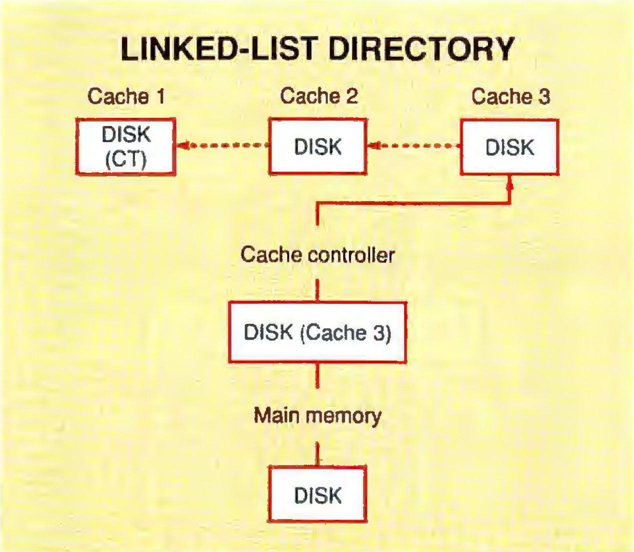

Figure 3: *In a linked-list directory, the directory is decentralized. Pointers themselves are used in the cache to maintain cache coherency. In this example, a single-list directory, cache 1 was the first to hold the memory block. Thus, cache 1's block has the chain-termination pointer (CT). Cache 2's block points to cache 1, and cache 3 points to cache 2. Each cache's copy is made from the block in main memory. Cache 3, containing the most recent edition, is the one that the cache controller's directory points to. If a change is made in cache 2, for instance, the controller relays instructions for the other copies to be invalidated along the pointer chain. Many variations on this theme are possible.*

Linked-List Directory

The promise of linked lists shines more brightly than that of any other method. Thus, several research groups are pursuing this route. Among them are DEC, in conjunction with Stanford University, and the IEEE Scalable Coherent Interface (SCI) standard project.

There are two approaches to implementing linked-list, or *chained*, directories: single-linked and doubled-linked. In these methods, the directory comprises linked lists of pointers to shared-memory blocks.

In a single-linked chain, whenever the system places a copy of a data block in a cache, it sets a pointer to the new block in a directory in main memory or the cache controller. The system also sets a flag, called the *chain-termination pointer* (CT), in the first data-block copy.

When the system needs another copy of the block, it makes the copy from main memory with a pointer to the prior copy made. For instance, with three cached copies of one memory location, the first copy would include the CT, the second copy would have a pointer to copy 1, the third copy would have a pointer to copy 2, and the directory would have a pointer to copy 3 (see figure 3).

There are variations on this theme. In the SCI coherence protocol (a double-linked system), when a processor calls for a data block, it doesn't receive a copy from main memory. Instead, it receives a pointer to the most recently changed or most recently added cache copy. The requesting cache then asks for the data block from the cache owning the freshest version of the data. This cache replies by setting a pointer to the requesting cache and transmitting the data block. When multiple data-block requests are received, they are handled in first-in/first-out order.

In the single-linked model, when a change is to be made to a data block, the system sends a data-invalidation message down the list until the CT is reset. This indicator informs the system that a particular memory block has been changed and invalidates all previously cached versions of the block. During this process, the system locks every block in the chain to prevent competing changes.

The double-linked version adds another pointer to the directory and each cached-memory location. The additional pointer lets the system send invalidation messages up and down the chain. The result is faster, more flexible adjustments to changes in the caches.

Nothing is free, of course. In the linked-list directory, the block size is larger, and maintaining cache coherency is more complicated. Preliminary theoretical studies show that a double-linked system is only marginally better than a single-linked system.

The efficiency of the linked-list method comes close to that of a well-implemented full-map directory without the headaches. At this early stage in its development, no firm disadvantages to this method have surfaced. However, this scheme is more complex to put into place than other methods. Further work is needed before linked-list implementations live up to their potential.

Return of the Bus

It's true that methods using a bus as the foundation for a shared-memory cache-coherency scheme eventually run into difficulties with bandwidth and communications contention. There is, after all, only so much room on a bus. However, this doesn't mean that you have to abandon the simplicity of bus designs.

Perhaps the most interesting exploration of this area is the proposed Wisconsin Multicube multiprocessor. In this computer, every processor would sit at the intersection of a two-dimensional array of vertical and horizontal buses. Every vertical bus would have a memory module attached to it. Each processor would come equipped with a snoopy cache controller and a large cache. Fully ramped up, this computer would have 1024 processors. (For more information on the Wisconsin Multicube, see "Popular and Parallel" on page 219.)

Software Solutions?

Up until now, every answer to multiprocessor cache coherency has appeared in hardware. However, that does not mean that you cannot deal with the issues in software. It's just a great deal more difficult.

Some researchers have suggested designing compilers or preprocessors that can mark variables or data structures as cacheable or noncacheable. Other designs would attach counters to data structures to determine when they should be updated from main memory.

continued

While they may be very promising, software solutions to cache-coherency problems are still in their infancy. The most exciting research in this area is actually being conducted on the Cedar system at the University of Illinois at Urbana-Champaign, where researchers are exploring a variety of possible software answers.

Software solutions to cache coherency are still in their infancy.

A Critical Element

People outside the computer field—when they do not think computers are black magic—presume that computer design is a hard-and-fast science. Nowhere is that assumption more absurd than in shared-memory multiprocessor cache coherency.

The puzzling question of cache coherency is a critical element in designing multiprocessor systems, but no one has even come close to a satisfactory solution. Additional research and a great deal more hands-on experimental work are required to solve the problem. The arrival of microprocessor-based multiprocessing systems on the scene only increases the need for cache coherency. ■

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POPULAR AND PARALLEL

But are truly scalable shared-memory architectures possible, probable, and practical?

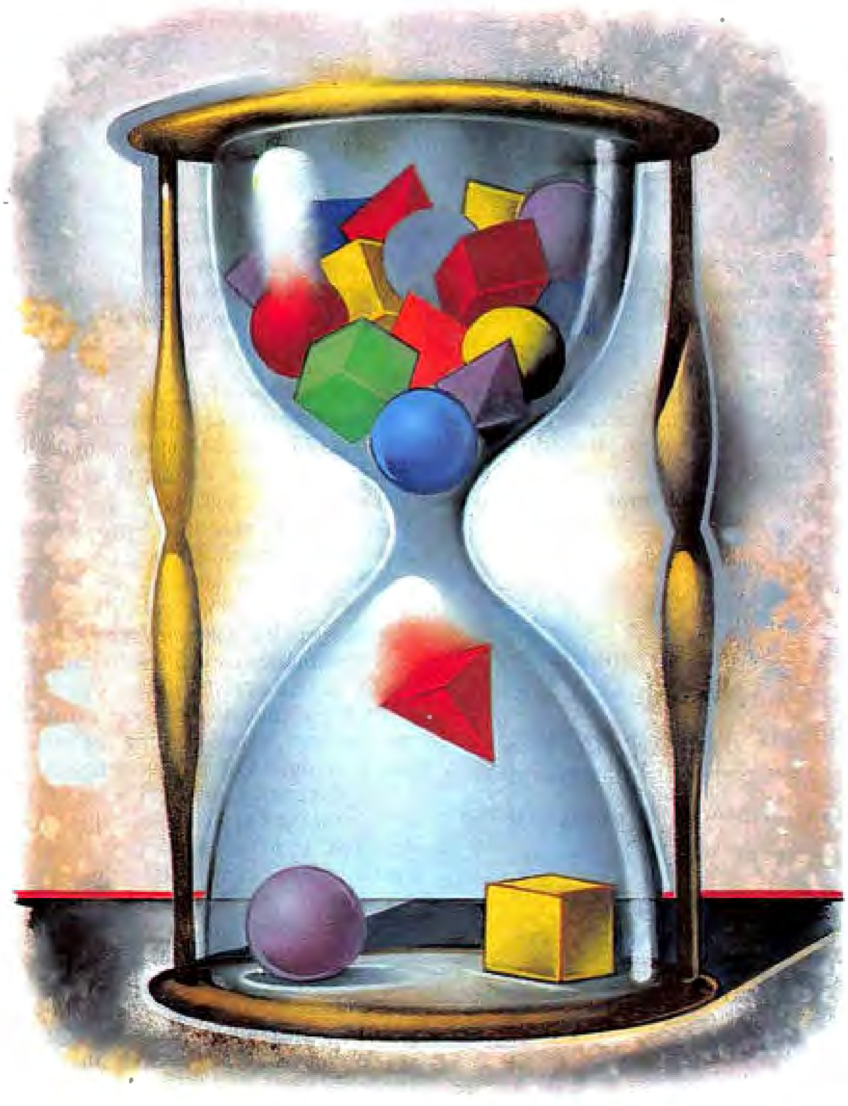
MIKE ROBINSON

In the world of multiprocessing, shared-memory systems have proven extremely popular. They are easy to program, because you don't have to confront the issue of data partitioning. They are also compatible with standard programming languages and can run sequential programs without any changes.

Shared-bus, or bus-based, shared-memory systems are particularly attractive for several reasons. For one, their implementation is relatively straightforward, because they are extensions of bus-based uniprocessor systems. For another, they offer a simple way to give the processors access to the shared memory. And since each processor (or cache) needs only to observe the memory transactions on the bus, a shared bus also provides a simple mechanism to maintain the consistency, or coherence, of multiple caches. In addition, the globally shared memory and consistency mechanisms yield a programming model that is very similar to systems of cooperating processes on a uniprocessor.

For these reasons, shared-memory machines are more popular for parallel programming than are distributed-memory, or message-passing, multiprocessors (also known as multicomputers). However, distributed-memory multiprocessors are highly scalable, whereas current shared-bus, shared-memory architectures generally allow scaling only to a few tens of processors.

Shared-memory systems are limited by memory-access issues: access times, communications contention (i.e., several processors contend for the same link in the interconnection network), and memory contention (i.e., several processors



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WISCONSIN MULTICUBE ARCHITECTURE

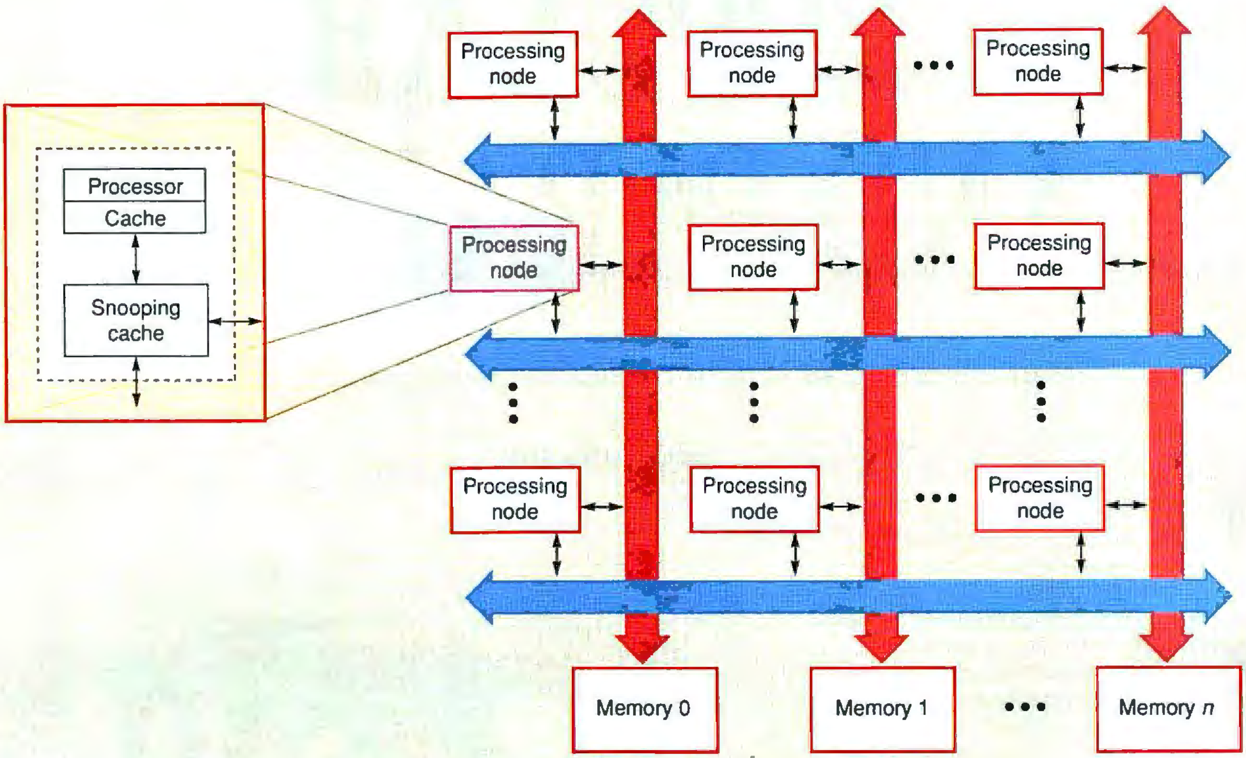

Figure 1: *The Wisconsin multicube is a special case of a multicube architecture in which a grid of buses interconnects a highly scalable number of processors. A node (see inset) consists of a high-performance microprocessor (which would probably have its own cache); a separate, conventional cache; and a snooping cache connected to the node's row and column buses.*

attempt to access the same memory module). Shared-bus versions are particularly affected by bus-bandwidth limitations: Since a bus has a fixed bandwidth, it is unable to accommodate more than some 30 or 40 processors.

The two main keys to increasing the scalability of shared-memory multiprocessors, therefore, are the design of the memory system and the processors' interconnection scheme. Uniprocessors have demonstrated the benefit of using cache memory to increase, in effect, the memory bandwidth. Most, if not all, shared-memory machines have adopted cache memories as well, with each processor having a private cache.

Multiple caches, however, introduce the problem of maintaining the consistency of data stored in them, and the cache-coherence protocol adds to the traffic on the bus. Therefore, the protocol (and, in more complex systems, the cache organization itself) must be designed to reduce bus traffic as well as hardware complexity.

The attractiveness of using bus-based shared-memory multiprocessors has led researchers to explore various approaches to creating truly scalable shared-memory architectures that use multiple interconnection paths, at least one of which is a bus. One major focus is the cache-coherence protocol. To improve processor performance and reduce traffic on the interconnection, researchers are devising directory-based schemes that are generally applicable to both bus-based and network-based systems.

Researchers are also attacking the single-bus interconnection scheme. Since the speed of the bus is limited by the technology available, and the bus's fixed bandwidth severely limits scalability, an obvious approach is to increase the number of buses. This increase can be in one, two, or three dimensions. The buses can also be organized hierarchically.

Hierarchical interconnection schemes often use an interconnection network at the highest level possible, because networks do not present the disadvantages that buses do. (They do, however, have drawbacks—primarily cost, complexity, and network latency.) In addition, some schemes have adopted features that resemble those of distributed multiprocessors. All the major projects aimed at developing scalable bus-based or hierar-

BYTE ACTION SUMMARY

Shared-memory multiprocessing systems are extremely popular because they are easy to program and compatible with standard programming languages. Various research facilities are working on ways to solve the shared-bus bottleneck that limits these systems.

chical shared-memory multiprocessors, however, are intended to yield general-purpose machines capable of handling a wide range of applications and parallel-processing granularity.

The Wisconsin Multicube

Perhaps the simplest experimental architecture is the *Wisconsin multicube*, being developed by researchers at the University of Wisconsin–Madison. The multicube consists of a symmetric grid of buses with a processing node located at each intersection. In addition, a memory module is connected to each column bus. A snooping (frequently called *snoopy*) scheme is used to ensure cache consistency (see figure 1).

A processing node comprises a processor, a conventional cache memory (called the *processor cache*) to reduce memory latency, and a snooping cache that is connected to both its row and column buses. The processor would probably have an on-chip cache as well. The large snooping cache (built with DRAM chips) is designed to reduce bus traffic as well as to implement the snooping protocol.

This architecture is a member of a new class of symmetric-interconnection topology that the researchers have proposed. Called simply the *multicube*, it consists of n^k processors, where each bus is connected to n processors and each processor is connected to k buses (k also can be considered the number of system dimensions). The hypercube is a special case of the multicube in which $n = 2$. The Wisconsin multicube is a two-dimensional version ($k = 2$) in which n scales to 32, yielding a proposed system of 1024 processors.

The researchers were attracted to the hypercube topology because of its extreme scalability. However, they were reluctant to adopt the architecture's liabilities: the explicit mapping of processes and data onto the processors and memory that a distributed system requires and, for a large-scale machine, the large number of intermediate nodes a message must often traverse.

By adopting a grid of buses and shared memory, the Wisconsin multicube eliminates those drawbacks. Furthermore, because it uses a snooping cache-coherence protocol, the view of shared memory resembles that of existing single-bus, shared-memory multiprocessors.

The symmetry of the multicube's organization distributes bus traffic uniformly among the buses, reducing the chance of bottlenecks. Because of its grid organization and snooping scheme, a memory request that produces a cache miss requires, at most, twice the number of bus operations as that of a single-bus multiprocessor.

The researchers note that the architecture can be considered a collection of conventional bus-based multiprocessors connected by orthogonal sets of buses that transparently extend the snooping cache protocol to higher dimensions. Indeed, a conventional shared-bus multiprocessor can be viewed as a multicube with $k = 1$.

The multicube uses a snooping cache-coherence protocol.

In a k-dimensional system, the total number of buses is kn^{k-1}. Therefore, the bandwidth per processor equals kn^{k-1}/n^k, or k/n. Thus, the bandwidth available to each processor scales directly with the number of dimensions.

Although the architecture specifies that main memory must be spread across the column bus, it could be distributed among the processors. The snooping protocol requires only that each memory block have a home column, or home bus, on which it resides.

The Aquarius Multi-Multi

Researchers at the University of California at Berkeley investigated a variety of hierarchical architectures and were led to develop a design based on the multicube. Although the research effort is called the *Aquarius project*, the researchers call the architecture a "multi-multi." (Like the developers of the multicube, they use Gordon Bell's term *multi* for today's multiprocessors.)

Like the multicube, the multi-multi uses a grid of buses with a moderate number of processors per bus and accommodates several dimensions. However, the shared memory is divided among the nodes (from a suggestion made by the developers of the Wisconsin multicube that it could be), resulting in a "semiprivate" address space for each processor. Memory is shared using the high bits of the memory address.

This arrangement is efficient for private data and serves as a natural division of directory information. Thus, each node can run independently of the rest of the system as well as share memory to any extent. Sharing, of course, is most efficient for processors on the same bus.

The cache-coherence protocol combines aspects of snooping and directory schemes. The snooping component maintains the consistency of caches on individual buses, and the directory com-

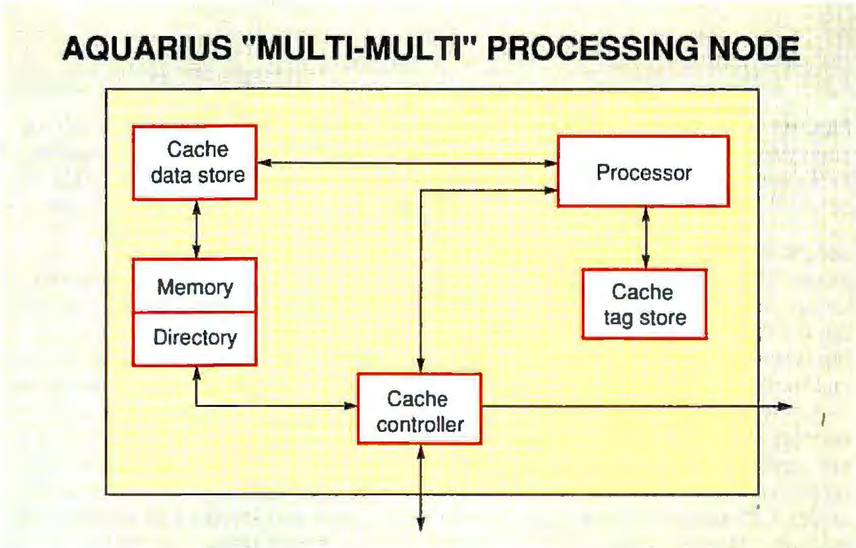

Figure 2: *The Aquarius project's "multi-multi" divides up the main memory among the processing nodes and adds a directory scheme to a snooping scheme to ensure cache consistency.*

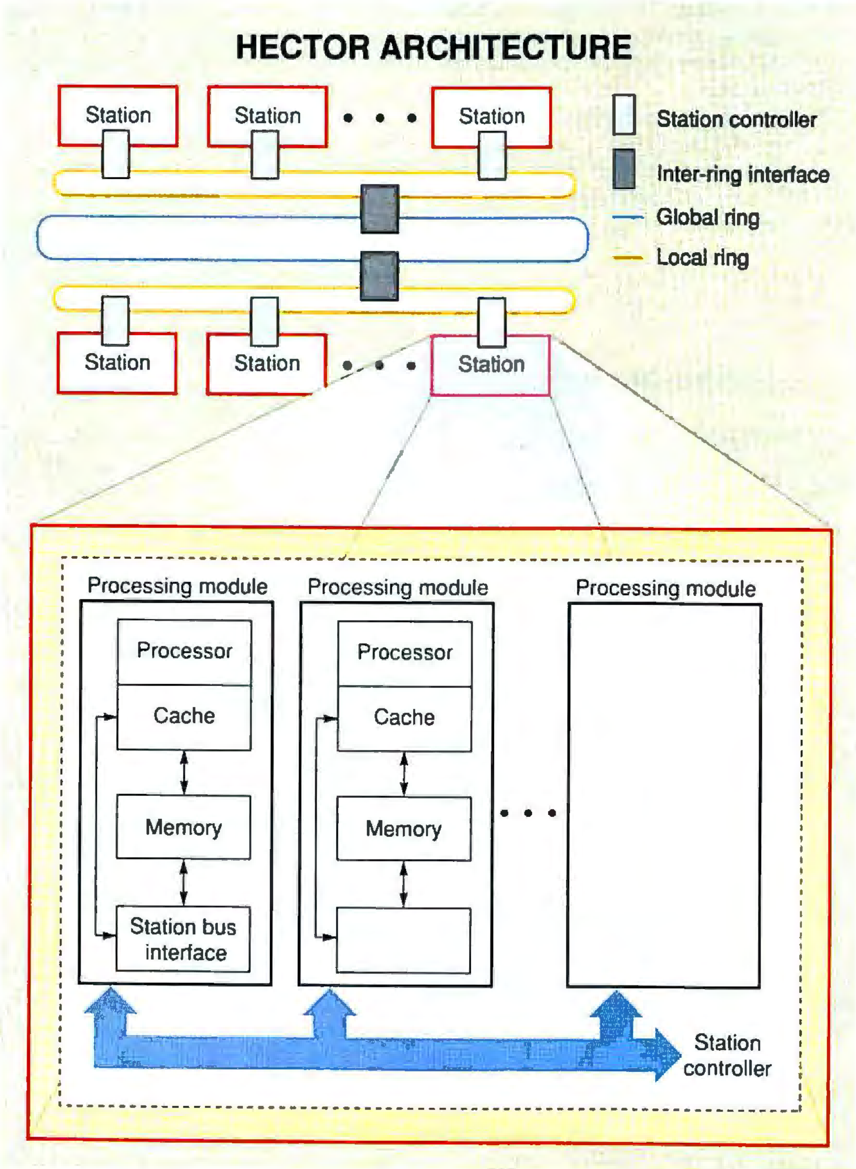

Figure 3: *Hector opts for a hierarchical arrangement in which the top two levels use rings for the interconnections. The processing node (see inset) includes an interface to the station bus and, typically, a processor, cache, and local memory as well.*

ponent handles consistency among the buses. The overall protocol takes advantage of local sharing (i.e., blocks shared among the nodes of one bus) by observing when a block is shared only locally and limiting transactions to just that bus.

A node contains a high-performance microprocessor, a cache, and local memory (see figure 2). The local memory is large—at least 4 megabytes—and includes a directory that holds tags for the memory blocks. The cache is fairly large—128K bytes each for data and instructions—and includes a multiported cache controller, which connects to the node's row and column buses.

The Hector Architecture

In some ways, the simplest conceptually of these proposed hierarchical architectures is Hector, being developed at the University of Toronto. One of the project's aims is to produce a scalable design with a good cost/performance trade-off; another is to ensure that the cost of a system is directly proportional to its size.

To achieve those aims, the architecture uses two levels of bit-parallel rings to link small buses (see figure 3). Because the buses and rings can transfer data independently, the total bandwidth increases proportionally with the number of interconnection units.

More important, the interconnection scheme is simple, inexpensive, and scalable to higher speeds. It contributes to increased reliability and flexibility. In addition, the cost of accessing remote memory increases incrementally with distance; in contrast, most systems with nonuniform memory access have only two time costs: local and remote.

Hector's simplicity derives from the fact that it merely links processing nodes by a bus and bus interfaces and then uses two simple, higher-level links and associated controllers to configure the system. Part of that simplicity, however, is due to the lack of cache consistency across all the nodes.

At the lowest level, a bus connects a group of processing nodes. The researchers call the nodes *modules* and the groups *stations*. Although a processing module typically consists of a microprocessor, cache memory, local memory, and a station-bus interface, the researchers use the term *processing module* to indicate memory and I/O modules as well.

A local ring links several stations, and a global ring connects the local rings. Because they can be built with short point-to-point links, rings provide faster signaling than buses. More important, the total bandwidth increases proportionally with the number of segments. (The optimal number of segments, however, is a trade-off, since network latency likewise grows proportionally.)

Information is transferred in packets. The transfers are handled hierarchically by three types of interface circuits. At the lowest level, the station-bus interface manages a processing module's communications. Next, a station controller handles the traffic within a station plus the traffic to and from the local ring. At the highest level, an inter-ring interface links the local ring and the global ring.

The DASH Architecture

Stanford University's DASH multiprocessor is another conceptually simple architecture. It uses a simple hierarchical structure with a distributed-directory cache-coherence protocol. A scalable interconnection network and the directory protocol are the key elements in making the system scalable.

The general architecture consists of clusters of processors linked by a high-bandwidth, low-latency interconnection network (see figure 4). A cluster, which the developers call a *node*, contains a small number of high-performance processors, each with its own cache, local memory, common cache for remote accesses, and directory that connects the cluster to the network. A bus links the elements within the cluster, and a snooping scheme maintains the consistency of the cluster's caches. Across nodes, the directory scheme ensures consistency.

The directory protocol is independent of the type of interconnection network. DASH can use any of the low-latency networks that were originally developed for message-passing parallel processors, such as a mesh or a hypercube.

The Paradigm Architecture

As with Hector, the developers of the Paradigm architecture sought to show that a shared-memory multiprocessor can scale from a few processors to hundreds and provide cost-effective performance across the entire range. Believing that a switching network is required for scalability but recognizing the high latency of such networks and the high cost of specialized types like shuffle-exchange networks, the developers turned to clusters of high-performance microprocessors that use an optimized hierarchy of shared buses and caches.

Unlike the other architectures, Paradigm—also being developed at Stanford University—is a software and hardware architecture. More specifically, it combines the operating system, hardware, and firmware-like components such as cache management software modules. (An earlier version of Paradigm had the name VMP-MC, for V multiprocessor multicomputer, and was an extension of the original VMP work.)

Paradigm's use of distributed-operating-system techniques for very large-scale, widely distributed operation and parallel application-structuring tech-

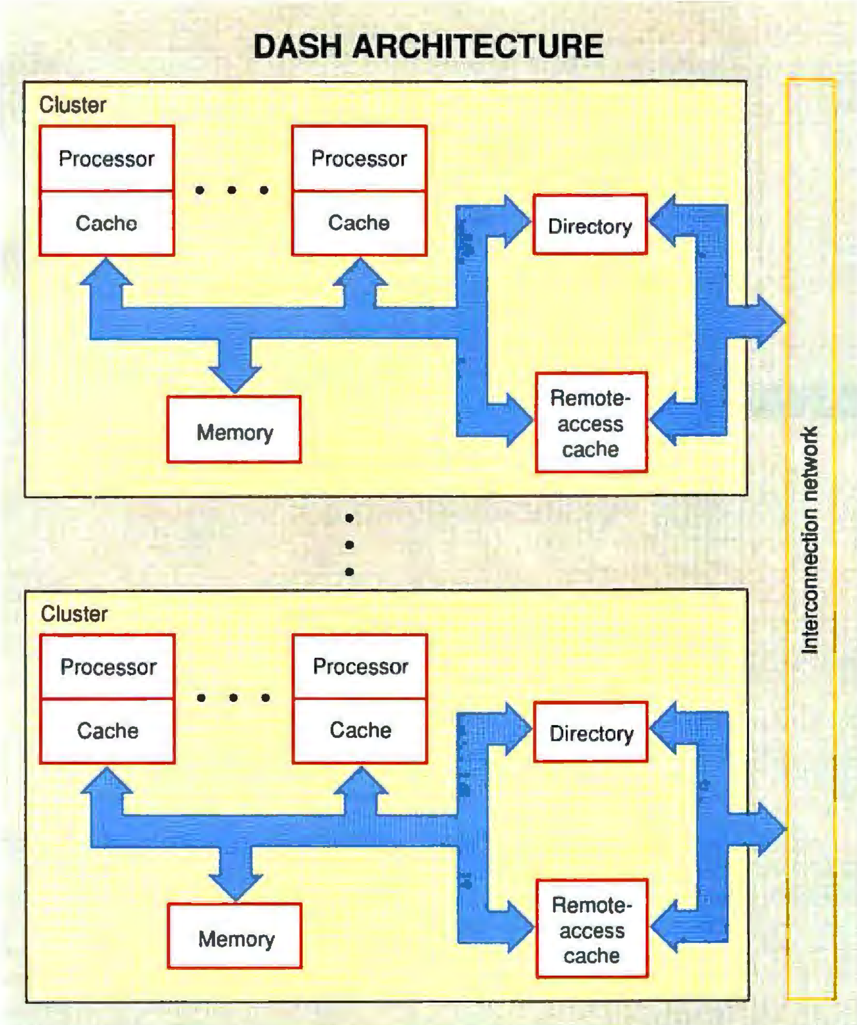

Figure 4: *DASH uses a simple two-level hierarchy, with a bus connecting processors and their caches with each other, local memory, and a second-level cache and directory.*

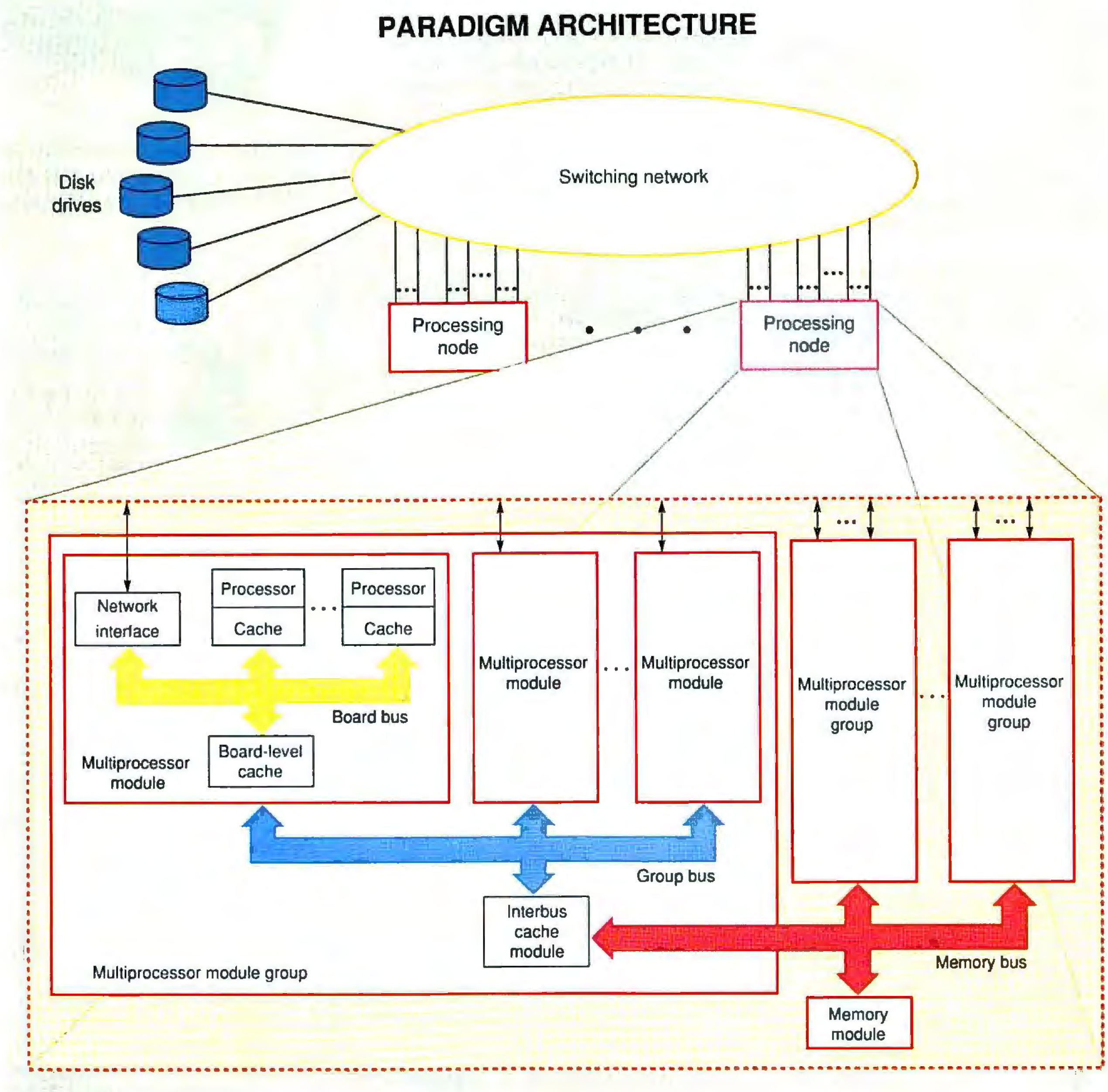

Figure 5: *In Paradigm, high-level groups of processors, called nodes (see inset), are linked to a switching network. The links, however, are not central nodal links; instead, they connect multiprocessor module groups—the second level down in the hierarchy—to the network, eliminating some bus traffic.*

niques that maximize locality and minimize contention helps it to realize high-performance scalability. The general hardware architecture consists of processing "configurations" connected by the switching network (see figure 5). The configurations, confusingly called *nodes*, consist of clusters of processors linked hierarchically to memory modules.

Each processor is a microprocessor with an on-chip cache. Two to eight microprocessors, connected by a bus and sharing a higher-level cache, form a multiprocessor module. The MPM also contains an interface that connects it to a high-speed network. Similarly, a number of MPMs are linked by a higher-level bus to a higher-level cache, called an *interbus cache module*. This collection is called an *MPM group*. Finally, a number of MPM groups, linked by a memory bus to a memory module, form a node.

Each MPM is connected through the switching network to all the other MPMs and through the module bus (called a *board bus*, since the module is implemented as a single board) to the other MPMs in its node. The shared bus and cache interconnection of this setup provide low-latency communications among the clusters of processors within a node.

Although the described structure contains three levels of buses and caches, it can be extended recursively to additional levels. A key task in the Paradigm project

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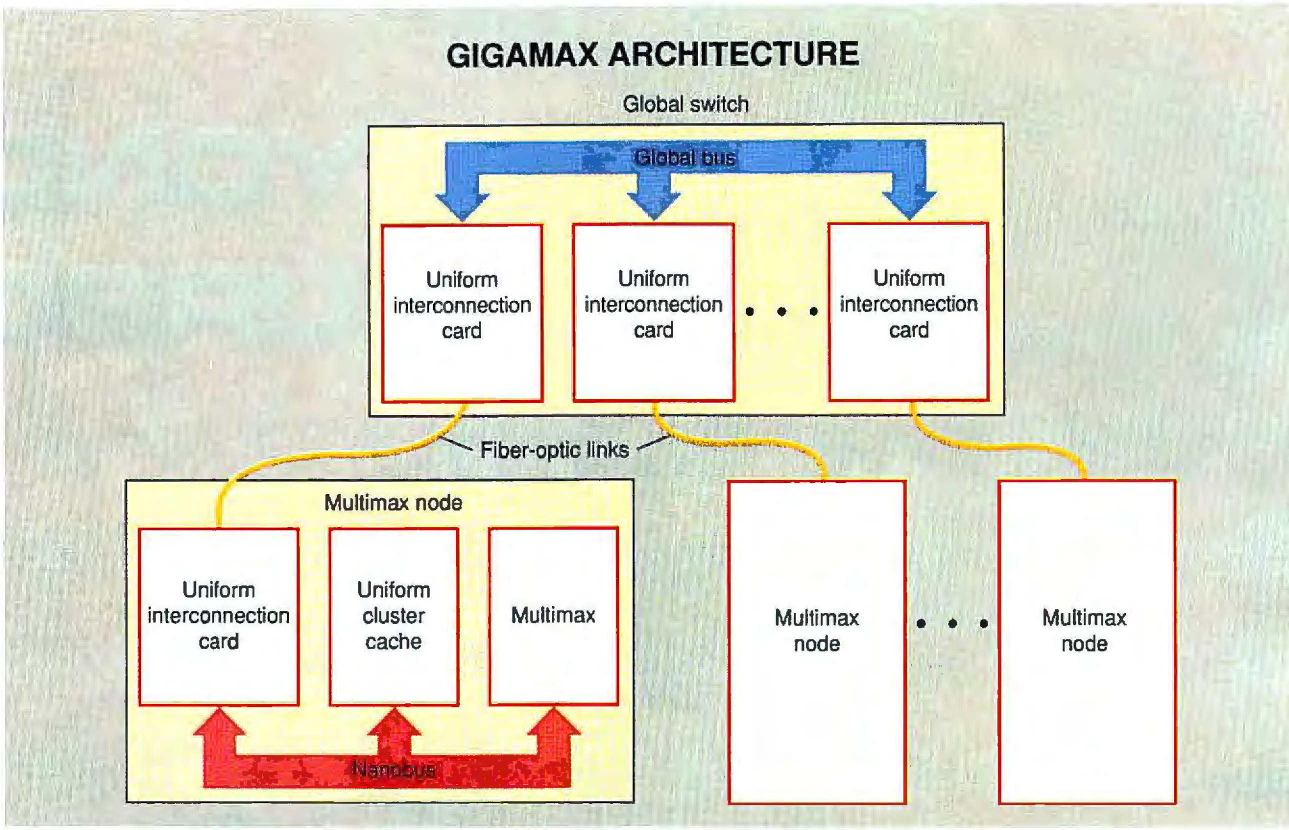

Figure 6: *The only commercial R&D project to develop a bus-based shared-memory multiprocessor, Encore's GigaMax links a number of the company's shared-bus Multimaxes.*

is to determine the appropriate number of levels, or height, of the hierarchy.

The memory module includes a directory that keeps the state of each block that's in memory, thus supporting cache coherence. It also supports a memory-based multicast message facility.

The GigaMax Architecture

The GigaMax project, carried out by Encore Computer (Fort Lauderdale, FL), was the one serious commercial effort to develop a scalable shared-memory multiprocessor that uses at least one bus. But whether it is truly scalable (by which computer architects mean "highly scalable") depends partly on how you define the term.

Simulations of GigaMax indicated that a 128-processor system is practical, and analytic modeling suggested that a 160-processor version might be possible. The initial discussion of the proposed architecture was one of the first to describe a hierarchical bus and cache arrangement; Paradigm resembles it in its board-level cache and its directory scheme, and another system, the Data Diffusion Machine, is similar to it in many ways.

GigaMax is an extension of Encore's Multimax system. In the last version of Multimax, a system can be configured with 2 to 20 processors (1 to 10 processor cards) and up to 160 MB of memory (10 memory cards), plus I/O cards (the bus has 19 slots). Each processor, which is built around a National Semiconductor 32532 microprocessor, has its own write-back cache, which snoops on the bus to maintain consistency.

The version of GigaMax most recently described consists of eight processing clusters connected by fiber-optic links and a high-speed bus serving as a global switch. A cluster comprises a Multimax, a system interface (called a *uniform interconnection card*), and a second-level cache card (called a *uniform cluster cache*). The cards occupy two slots in the Multimax, which uses a high-speed bus, called a *nanobus* because of its 80-nanosecond cycle time. (See figure 6.)

Whether GigaMax is truly scalable depends partly on how you define the term.

The cluster cache stores the location of remote memory blocks that the local (cluster) processors have recently accessed. The interconnection card handles the traffic with the rest of the system and snoops on the bus to maintain cache coherence at the cluster level.

Part of the GigaMax project involved the design of the processor board, contributing to the company's next-generation system, the 93 series. It uses a Motorola 88100 with 32K bytes of write-through cache, with four processors per card and up to eight cards per system. An important part of the system is a 1-MB write-deferred board-level cache.

The original goal of GigaMax was to develop a machine that was capable of 1000 million instructions per second (MIPS). By using the 88100, Encore can achieve this target by linking just two 93-

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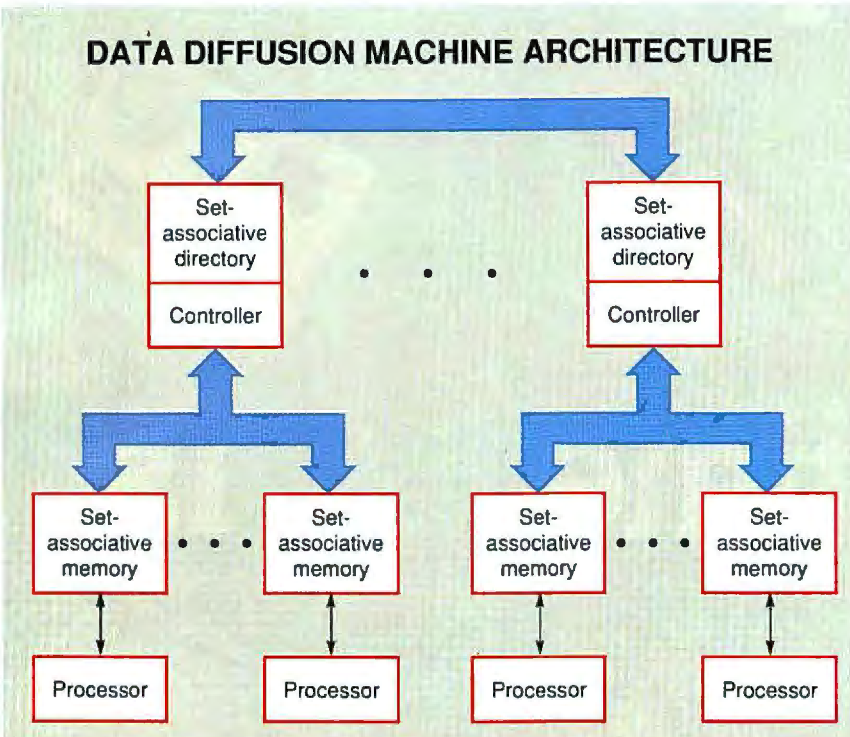

Figure 7: *The Data Diffusion Machine uses the original GigaMax tree architecture but divides the shared memory among the processors. More important, it turns to virtually, rather than physically, addressed memory, using set-associative memory and directories.*

series machines. Due to the greater power of current-generation microprocessor units, Encore no longer sees GigaMax as commercially viable.

The Data Diffusion Machine

Although it is based on the GigaMax architecture, the Data Diffusion Machine (DDM) represents, in some ways, the greatest departure in conception for a scalable shared-memory multiprocessor. Part of the European ESPRIT project, it uses a tree structure (as did the original GigaMax proposal).

What most distinguishes the DDM from the other architectures is that the shared memory is a virtual one. In other words, the location of a piece of data in the machine is completely decoupled from its virtual address. Furthermore, there is no set location where a data item must reside; instead, it migrates to where it is needed. This arrangement reduces access times and traffic.

Thanks to its virtual memory scheme and the extensibility of the hierarchy, the machine is scalable to an arbitrary number of processors. The hardware organization comprises a hierarchy of buses and data (i.e., directory) controllers linking the processors. Each processor has a large set-associative memory, and each data controller has a set-associative directory containing status bits for the data under its control (see figure 7).

The design of the DDM is based on the following ideas: Software does not really need to know where a piece of data resides; all it needs is a way to identify each data item—the virtual address. The physical placement of the data should be done automatically by the hardware in a dynamic, totally flexible manner that enables most of a processor's memory accesses to be satisfied locally.

The machine's design was oriented to executing logic programs, but it is very general because it is independent of the choice of processor, language, or application. It will, therefore, run software written for conventional shared-memory machines without change.

At the bottom of its tree structure are the processors (each likely to have its own cache) and their local, set-associative memories. This memory, which is the sole form of main memory, is large and is organized like a very large cache, but it contains an image of part of the global virtual memory.

The memory is connected by a memory controller to a local bus; a group of processors and memory forms a cluster. The cluster (i.e., local bus) is connected to a higher-level bus through a directory controller, and so on up the tree.

The directory controller's set-associative directory has space for the status bits for all the data blocks in the memories below it. The controller also observes the activity on the buses it is attached to (i.e., the one immediately above it and the one below it), acting like a snooping cache.

But Will They Fly?

All but one of these projects are academic, and the one commercial project (GigaMax) has ended its efforts to build a highly scalable system. The other commercial makers of shared-memory multiprocessors—primarily Sequent Computer Systems and Alliant Computer Systems (which uses a crossbar switch rather than a bus)—see no value in pursuing such a goal. Sequent says it does not see a demand for more than 30 processors—its maximum in the current Balance series—and that the average customer uses only 8 to 10 processors.

As Bob Hessinger, manager of large-systems marketing at Encore, put it, the explosion of individual CPU capability calls into question the whole notion of a highly scalable shared-memory machine that uses one or more buses. For one thing, you no longer need to link hundreds of processors to achieve what was once considered supercomputer performance. More important, the need for bus bandwidth grows with the processor's performance, and a large-scale multiprocessor using today's microprocessors would need lightning-fast buses, which are not technically feasible.

Furthermore, shared-memory systems, especially bus-based ones, are general-purpose machines, and other types of machines are more competitive. Vector processors are well suited to certain applications and are simple to program because of their optimizing compilers. And distributed-memory multiprocessors are more economical for the kind of applications they serve.

Still, economies of scale and the fact that they are binarily compatible over a wide range of configurations—2 to 32 processors—make shared-memory multiprocessors at the large end competitive with mainframe computers. Research aside, their future seems to be confined to that level of parallelism. ■

Mike Robinson is a freelance writer and editor in Lexington, Massachusetts, specializing in electronics technologies. You can reach him on BIX c/o "editors."

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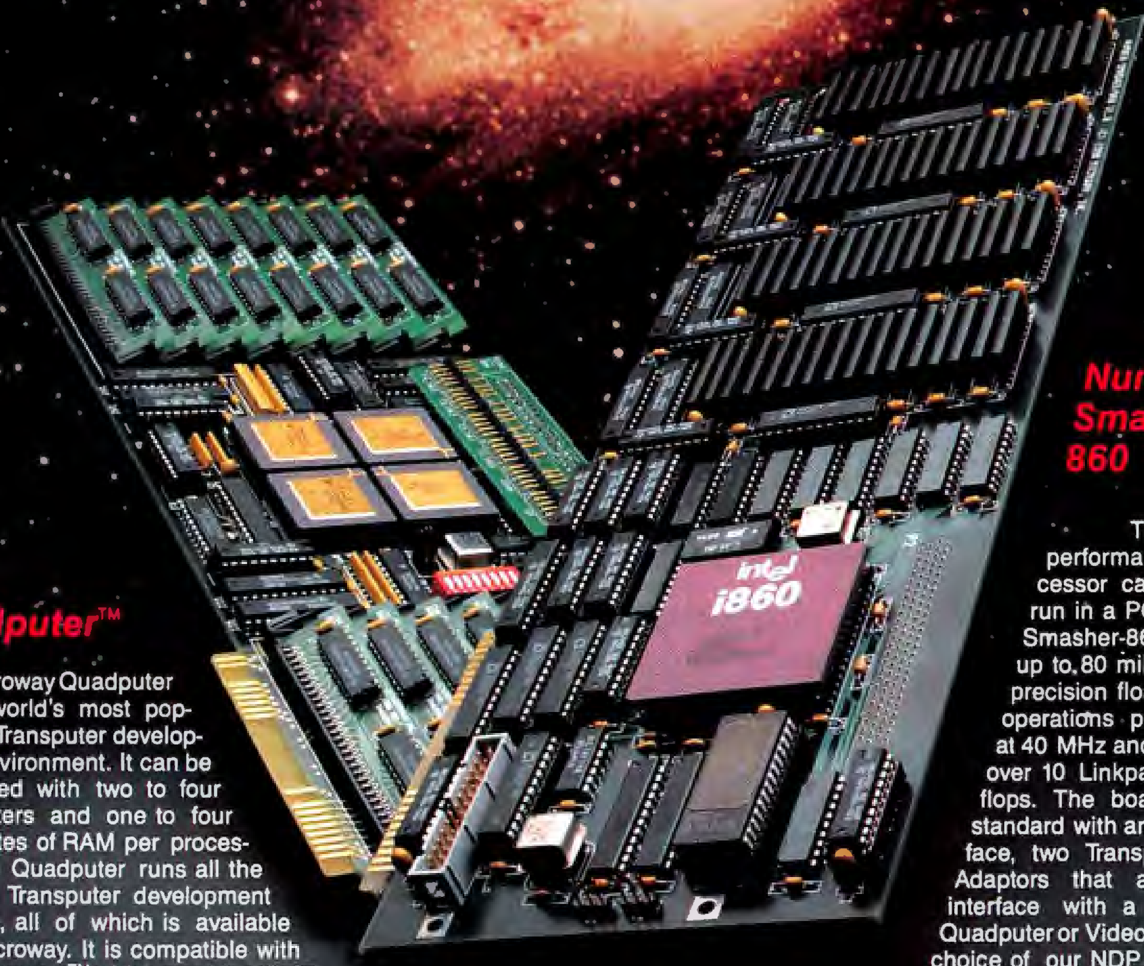

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SCALING UP: GET THE MESSAGE?

Message-passing multicomputers can produce linear improvements in performance; current shared-memory multiprocessor systems can't

RICHARD MARLON STEIN

While currently each new generation of multiprocessor systems delivers faster and faster results, soon the computing bandwidth of shared-memory multiprocessors will reach its limit. The laws of physics weigh against substantial speed improvements that preserve the existing cost-effectiveness of multiprocessor systems.

Message-passing parallel computers circumvent the architectural limits of current shared-memory multiprocessor systems. Also called *multicomputers*, these systems can achieve speeds that continue to increase linearly with the number of processors used.

Multicomputing vs. Multiprocessing
Multicomputers are scalable computation systems; they share no resources and, architecturally, exhibit no areas of contention—a giant killer. The shared-memory architectures found in current multiprocessor systems are limited in the number of CPUs that they can connect to a common memory pool. This limitation constrains the performance on real work to a less-than-linear improvement (see figure 1).

A generally accepted bound for multiprocessor systems is eight processors, but some workstations can only accommodate four. Each CPU must arbitrate with its bus partners to gain access to the common memory—a source of significant contention. Thus, bus bandwidth becomes more costly and less efficient.

Some manufacturers, such as Alliant Computer (Waltham, MA), permit over 20 CPUs to share a common memory. To achieve this architecture, multiple buses

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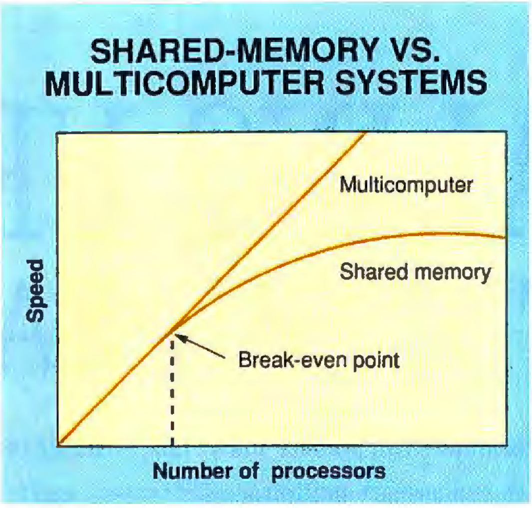

Figure 1: *Speed versus number of processors for shared-memory and multicomputer systems. Contention limits the speed increase attainable in shared-memory systems to a nonlinear measurement. (Note that the* x *and* y *axis elements are not labeled because specific numbers are not being shown.)*

combine several CPUs (four to eight) into a cluster. When one CPU requires data that resides in a different cluster's address space, a message is passed through a high-speed channel.

To exploit this architecture, the software engineer must partition the problem across many clusters and organize message passing between them. Distributed-memory multicomputers require this mechanism.

Message passing in shared-memory systems is simpler than this. When a message is sent, the synchronization between process peers is conducted according to a common clock. Each peer "knows"—in a temporal sense—when a message was sent or requested.

A distributed-memory multicomputer has no such luxury. Many hundreds or thousands of processors execute asynchronously. The improper coordination and synchronization of these processors can lessen performance gains or even halt processing.

To build multicomputer software, you need to learn to think in a concurrent context to comprehend the complexity of this articulated multiprocess situation. If you understand the concurrency issues, you can apply standard structured software-engineering principles to the multicomputer domain.

You can also construct a system that exhibits linear increases in speed. Problems will be solved in times that are directly proportional to the number of nodes in your multicomputer.

Active, Dynamic—and Staggering

Multicomputers are not burdened by contention; they offer linear increases in speed and are typically $1/10$ to $1/100$ the cost of equivalent multiprocessor systems (in terms of million instructions per second and million floating-point operations per second). Why, then, are they substantially less prevalent? Because there is little or no software for them.

While multiprocessor systems enjoy a vast resource of "dusty decks" (i.e., old computer programs full of intrinsically sequential code), few multicomputer programs have been written.

A multicomputer's distributed-memory architecture deters the wholesale port of existing sequential software; it is much harder to write effective multicomputer software than it is to write sequential shared-memory implementations.

Part of the difficulty is algorithmic. *Gaussian elimination* (see reference 1), a familiar technique for solving simultaneous systems of linear equations, can be implemented in a multicomputer. However, the performance results, in a per-processor comparison, don't match those obtained by a vectorized multiprocessor solution.

Some algorithms just don't map well into multicomputer architectures. Since most of the existing programs are based on "tried and true" algorithms, it is hard to invent new techniques that are distributed and work with multicomputers.

The other stumbling block is conceptual. A multicomputer is constructed from many individual processors, each possessing a small portion of local memory, perhaps 4 megabytes each. These computation elements, or *nodes*, are connected to each other with high-speed links. Processes send and receive messages through these links to other processes resident on different multicomputer nodes.

The conceptual difficulty with this architecture is that you must now consider not one processor and one process, as in the sequential machines, but n processors and m processes, each exchanging messages with the others. This ensemble is an active, dynamic system with n times m degrees of articulation. The configuration can be quite staggering.

Thinking Concurrently

Good software depends on a solid, thoroughly organized design, and for multicomputers, this is the rule, rather than the exception. Software engineering depends on abstraction to transform a physical system or environment into a superposition of operators and data types that a computer can process. Therefore, you need to describe the system requirements and find a method to extract the parallel elements of the problem and abstract them into a software design.

A computer performs work by executing a *process*. A process is literally a superposition of inputs, outputs, and assignments. A multicomputer process accepts input from other processes by way of message passing, performs some computations (e.g., $x = y * \sin(2 * z)$), and outputs results to another process, also through message passing.

This abstraction leads to the *process-structure graph*, an illustration that details the *granularity* of the system (see figure 2). The process-structure graph quantifies the number of processes and their interfaces. With several simple processes, such as those that perform simple arithmetic operations (e.g., +, −, and

BYTE ACTION SUMMARY

Message-passing multicomputers can achieve speeds that continue to increase linearly with the number of processors used. How fast would you like your system to go? Just add more and more processors—well, maybe not "just." Multicomputer software is more complex and not as easily available as multiprocessor software. But once you have it, you can indeed increase your speed just by adding processors.

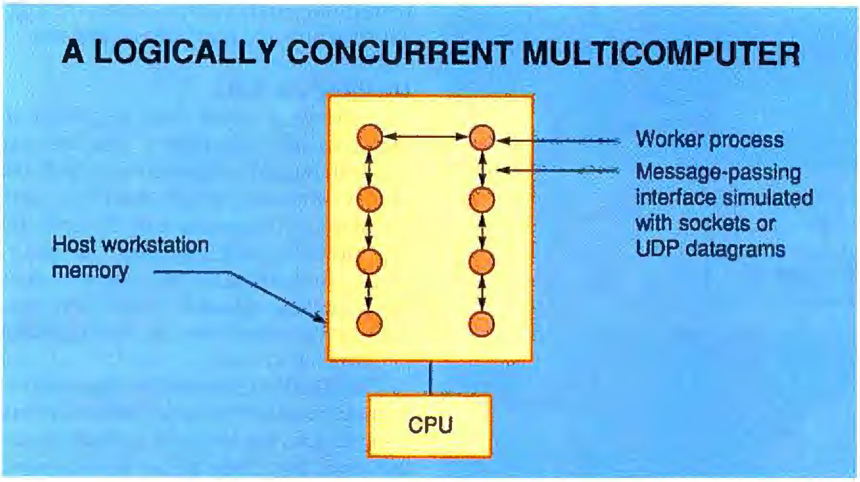

Figure 2: *Developing a multicomputer system that runs on* n *processors requires that you first create a logically concurrent description and cast it into a process-structure graph. Here, an eight-process system is organized as a line of processes. The processes are debugged in a single address space using message passing. This verifies that the system will not deadlock when ported to the multicomputer.*

*), a "fine-grained" process-structure is said to exist. It takes a good many simple arithmetic processes to perform a fast Fourier transform or matrix inversion that may be implemented without using a separate process to do all arithmetic operations.

You may decide to create a separate process, called `proc_add(a,b)`, that performs all the additions for your system. Or you may decide to create a single process called `proc_sstraj(position, attitude, velocity, mass,..., etc.)` that determines the space shuttle's reentry trajectory. Clearly, `proc_add` is superfluous and quite expensive to use in a run-time environment. However, you only need to use `proc_sstraj` once, because it is a complex set of assignments and functions.

You can create the process-structure graph at any level of detail you wish. The graph becomes more fine-grained as additional *process bubbles*, or circles, are added. Similarly, the fewer the number of process bubbles, the more coarse-grained the graph is. Each process is entirely isolated with the interface arrows, which point out the direction of message-passing flow between processes and enumerate the packet structure of the messages.

A single-interface arrow may carry more than one message type, or packet structure. The precise organization and process dependency (who gets what message from whom) of these interfaces must be known; otherwise, a *nondeterministic* system, one that does not produce the same results for a fixed set of initial conditions, may arise.

Bubbles and Nodes

Specifying the process structure of a multicomputer system sets the stage for evaluating the *logical concurrency* of the graph (see "T800 and Counting," November 1988 BYTE). Logical concurrency is a measure of the simultaneous actions, events, and processes that occur during the course of execution. The process structure expresses the logical concurrency of the system through the relationship of each process bubble to its companions.

Process bubbles placed within other bubbles imply that these embedded processes are composites of the larger ones, much like a collection of subroutines that modularize a large program. No restriction is placed on the context of the embedded processes: There may be several within a larger process, and they can execute simultaneously or sequentially, just like a series of function invocations in FORTRAN or C.

Processes on equal footing (i.e., those appearing in the graph at the same level of granularity) are logically concurrent peers of the same rank. Processes of equal concurrency rank should exchange messages. This is a "rule of thumb" that aids multicomputer software specification and design development. Message passing between multiple concurrency ranks is permissible as long as you can clearly document and illustrate the message path.

By imposing this restriction on the process-structure graph, the logical concurrency within the process hierarchies, their interfaces, and their functions is easier to maintain and transform into a multicomputer system. It's a way to eliminate "spaghetti code" in multicomputer software.

To transform a process-structure graph into a multicomputer system, you must convert the logically concurrent specification into the physical concurrency of the multicomputer. That is, if you have a process-structure graph that describes a system of eight processes and each is organized as an element along a straight line where messages are passed point-to-point through "nearest neighbors" along the line, then somehow you must place each process onto a multicomputer node such that the interface arrows preserve this topological configuration (see figure 3).

The message-passing portion of a multicomputer system is critical. Each message that is sent must have a receiver, and vice versa, or the system will *deadlock*. The transaction between sender and receiver must complete, or the sender will *block* (cease execution). Deadlock is the scourge of multicomputer software. Fortunately, a design technique helps minimize the probability of deadlock.

The process-structure graph that is constructed from the software design should execute in a single address space. By spawning separate processes corresponding to the process-structure graph, the message passing occurs in the single address space of a workstation. You can create the message-passing primitives from sockets or User Datagram Protocol datagrams under Unix.

By exercising and validating the logically concurrent specification in a single address space, the system's message-passing communications requirements can work correctly without deadlock. If the message passing works, then the internals of each process in the process-structure graph will also cycle correctly.

This design technique actually realizes physical concurrency. The physical concurrency's multiprocess emulation is enough to guarantee execution in the multicomputer, provided the topology is wired correctly.

One multicomputer operating system, Genesys from Transtech Parallel Systems (Ithaca, NY), incorporates a "stand-

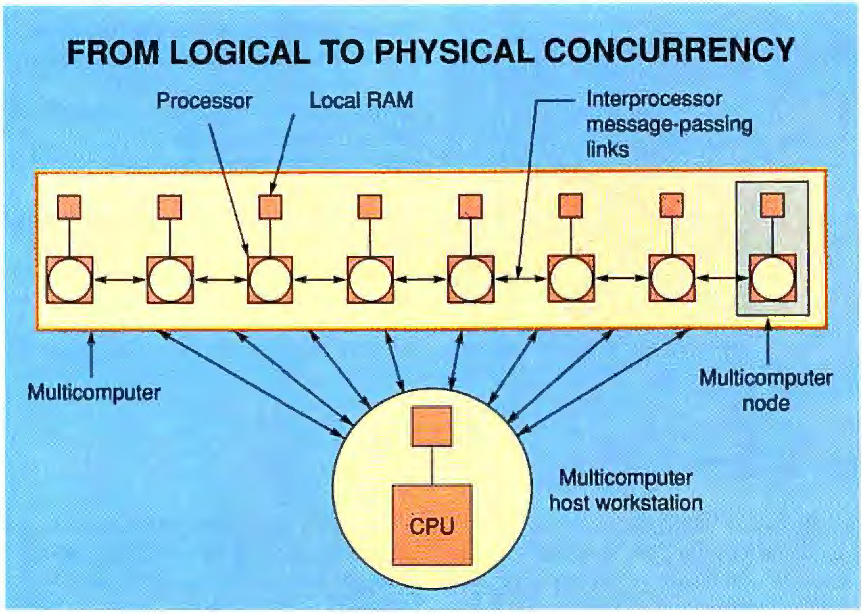

Figure 3: *After checking out its logical concurrency in a single address space, you can translate a process-structure graph to physical concurrency by porting the system to a multicomputer.*

alone router" library that possesses the identical message-passing functionality of the point-to-point processor communications library used in the multicomputer. To switch from physical-concurrency emulation in a single address space to the full-blown multicomputer, you merely recompile the code with a different library.

Achieving message passing in a single address space has another advantage: It is far easier to debug the process internals of a complicated computation in a single address space. Can you imagine poking around hundreds of multicomputer nodes, trying to find out which one has the erroneous information? While the system's temporal structure is not preserved in a single address space, the logical structure and message passing are.

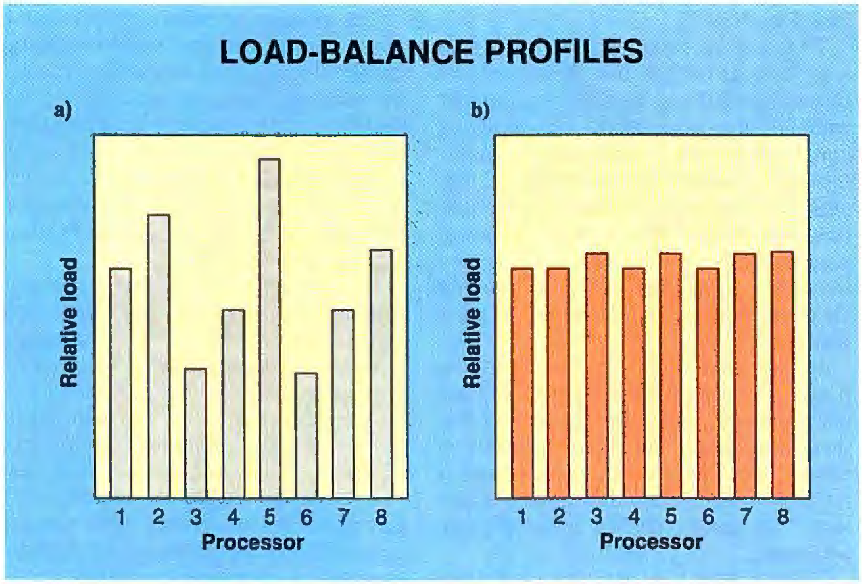

Figure 4: **(a)** *A strong load imbalance will produce a poor increase in performance when performed on a multicomputer.* **(b)** *By contrast, a near-perfect load balance will produce linear improvements in performance. (Note that the y axis elements are not labeled because specific numbers are not being shown.)*

Dividing the Data

To achieve proportional increases in speed in multicomputers, you have to map the logical concurrency, which the process-structure graph describes, onto the physical concurrency of the underlying multicomputer platform. However, placing and arranging the processes does not guarantee effective speed increases; each process must have an equal amount of data to work on.

The distributed-memory organization of multicomputers implies that the entire data set does not reside in a shared-memory pool but, instead, is disseminated among the *n* processes of the process-structure graph. You must perform this data decomposition to make the best use possible of the processors. All the processors in the multicomputer must simultaneously operate on nearly identical portions of the distributed data set so that they can execute in the shortest time possible.

The term *data decomposition* describes the data set's proportional distribution to each multicomputer node. Highly symmetrical computation domains, such as grids, parallelepipeds, and cylinders, all possess degrees of symmetry. You can exploit this symmetry to yield congruent data decompositions. A data decomposition is called *congruent* when the same quantity of data has been placed on each multicomputer node (see figure 4).

An irregularly shaped domain, such as a protein molecule or the airframe of the proposed National Aerospace Plane, requires a data decomposition that is not easily "eyeballed" into a congruent decomposition. Obtaining a congruent data decomposition for irregular domains requires a more sophisticated technique.

Sharing the Load

When all processors have equal quantities of data to work on, then a *load balance* occurs. A load balance must exist for a multicomputer to obtain linear increases in execution speed.

To understand why a load balance must exist, imagine, for example, two processes that communicate via message passing. Suppose that one process, process A, has a data set twice the size of the data set for its companion, process B. During their respective computations, process B requires a piece of data (e.g., a message) from process A. But process A requires twice as long to complete its computation as process B needs. So

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process B must wait, or *block*, for a message from process A.

When a process blocks, it does no work, and the portion of the program that process B performs does not proceed. A load imbalance produces this unwanted interruption, and it diminishes a multicomputer's efficiency; the maximum increase in speed possible is proportional to the execution time for the work on the most heavily loaded computation node.

A few load-balancing techniques are known. The one you use depends on your problem domain. Highly symmetrical data-parallel computations can usually be "eyeballed" to obtain a data decomposition that produces a load balance.

Irregular domains (e.g., those found in the solution to large, sparse linear systems) require a more sophisticated technique. *Simulated annealing* is a successful and popular method for equalizing multicomputer load imbalances. This method is used in the Transpiler (see "Configuring Parallel Programs," December 1989 BYTE), a multicomputer software compilation suite that performs load-balancing functions on transputers.

To achieve a load balance, simulated annealing evaluates a near-optimal value for an objective function that expresses the cost of computing some portion of the data set while accounting for the message-passing effects. The equation

$$S = \sum_{\substack{\text{processors } i \\ i=1}}^{N} (W_i)^2 + \frac{t_{\text{comm}}}{t_{\text{calc}}} \sum_{\substack{\text{alls } p,q \\ \text{where } p<q}} C_{p,q}$$

where W_i = workload of processor i, $C_{p,q}$ = communications overhead between data elements p and q, N = number of processors, t_{comm} = typical communications time per element, and t_{calc} = typical time for floating-point operations per data element (see reference 2), is typical of the kind used in simulated-annealing load balancing.

The simulated-annealing algorithm optimizes this equation. It forces the relocation of data elements to different nodes, based on an initial *scattered decomposition* of the data. By supplying an initial data decomposition that may be randomly scattered throughout the multicomputer, the simulated-annealing algorithm, when applied to an objective function, directs the placement of the data elements so that the computation and message passing are near optimal.

The multicomputer performance measurement is physically dependent on individual processor speeds and on the rate at which messages can be communicated

between nodes. This differs from the situation found on typical shared-memory multiprocessors, where memory bandwidth and processor speed are the critical factors influencing performance.

Choosing a Topology

The logical-concurrency, data-decomposition, and load-balancing issues are central to a multicomputer's software design. Deciding how to abstract the work into a logically concurrent description and then transform it into the physical concurrency of the multicomputer are key elements. But you must arrange the computation to execute so that message passing proceeds expeditiously between processes, taking the most direct route and avoiding bottlenecks and circuitous paths.

Often, the topology of the multicomputer is closely linked to the geometry of the problem at hand. Two-dimensional meshes are useful for the finite-difference problems found in weather forecasting; hypercube configurations are useful for sorting; and *toroids*, which are interconnections of nodes arranged in a circular fashion, are used for *n*-body problems in molecular dynamics. (In this class of problem, you must compute the interaction between each particle and every other one in the system; hence the name "*n*-body.")

The connection scheme that you select fixes the topology of the multicomputer. Inmos transputers serve as a cost-effective computation element and are easily configured into almost any topology. Commercially available multicomputers, such as the Touchstone Delta from Intel Scientific Computers (Beaverton, OR) or the Ncube II from Ncube (Beaverton, OR), let you configure a specific interconnect pattern by extracting topologies from a *processor farm*.

A processor farm is a collection of processor resources (nodes) from which you reserve an arbitrary subset and configure it into a topology for a problem solution. Processor farms permit several users simultaneous access to a multicomputer resource.

The notion that you can design a scalable piece of software, acquire the precise number of computation nodes to implement it, wire the nodes up, load them with the software, and start your computation demonstrates the potential and opportunity presented by multicomputer technology. Whether you construct your own multicomputer from transputers—virtually anyone can do it—or purchase a multicomputer system, you still must write the software.

You now have the freedom to engineer custom multicomputer solutions from off-the-shelf parts. These scalable computation systems, based on the so-called "killer micros" (microprocessors), have emerged as important alternatives to mainframes and supercomputers.

The Cost Factor

Software development costs, even for modest-size projects (10,000 to 50,000 lines of code), are enormous. The Department of Defense spends billions of dollars each year for software to support defense-related acquisitions. The DoD, through the Defense Advanced Research Projects Agency, has funded much of the basic R&D manifest in today's shared-memory multiprocessor and multicomputer systems.

Now, with the availability of massively parallel multicomputer systems such as the Connection Machine from Thinking Machines (Cambridge, MA), it is only a matter of time before these machines find their way into defense-system acquisition. This leads to an important question: How do you estimate software-engineering costs for a multicomputer system?

In data-parallel situations, where a single process is replicated n times, once for each multicomputer node, you only need to write a single piece of software. Therefore, data-parallel software-engineering costs are comparable to those for sequential systems. The logic needed to implement the message-passing scheme, which depends on the topology, is insignificant compared to the body of the code, which requires the majority of the specification, design, code, integration, and testing efforts.

Data-parallel computations use the same piece of software to operate on small portions of a large data set that is data decomposed over all multicomputer nodes. A data-parallel computation would be similar to evaluating a spreadsheet over 100 personal computers simultaneously: Each personal computer would update one spreadsheet cell.

Alternatively, if you need to compute 100 spreadsheets, you would save time by calculating them in parallel, each one on a separate personal computer via Lotus 1-2-3 or Microsoft Excel, rather than waiting for 100 serial computations to complete on a single personal computer.

The logical concurrency of data-parallel computations is usually minimal, and the process-structure graph is comparatively sparse; one process is replicated n times. The solitary process does need communications interfaces to exchange data with its peers, but this is a simple edifice to construct.

However, contrast a simple data-parallel situation with the complexity of an articulated system, such as the avionics control system for the space shuttle. The articulated system requires an extraordinary number of unique processes to implement. The process structure's logical concurrency grows enormously as more granularity is added to the process-structure graph. Process-structure refinement adds successively greater levels of complexity to the system, and this balloons into even more software to write.

For the space shuttle's avionics control system, you must be able to create m unique processes, but their interactions, the message-passing interfaces, are more numerous and varied. The software-engineering costs rise in proportion to m, the number of processes.

You can reduce this cost factor if you can substitute or coerce your process structure into a data-parallel context. Data-parallel computations are easier to design and less costly to implement than articulated systems in multicomputers.

How Fast Will It Go?

Estimating performance for multicomputers is another challenge. From the logical concurrency expressed in the process-structure graph, you can evaluate approximately the amount of computation and I/O resources needed to complete a single iteration of the design.

If the system contains many unique, replicated processes on each processor, you may be concerned about the CPU context-switch time. If you use the Inmos transputer, a process context-switch requires 2 microseconds. So, even if you have 100 processes per transputer, it will take just 200μs for each iteration through the process queue. This is a small price to pay for executing 100 processes simultaneously.

The transputer's greatest asset as a multicomputer computation element comes from its multiprocess support for concurrently executing contexts. You can easily execute a logically concurrent process structure on a single transputer.

You can simply and painlessly transform that process structure to an n-processor, physically concurrent multicomputer. The transputer is a scalable computation element, and as long as your system's process structure possesses scalable concurrency characteristics, an n-processor multicomputer will supply an equivalent increase in performance.

A utility that evaluates a process-structure graph and returns a scalability factor (i.e., the slope of the expected speed-increase curve) for a given process structure would be most useful. It is hard to say if such a computer-aided software engineering tool can be created for multicomputer software engineering, but it would be of tremendous value.

Clearing the Final Hurdle

Linearly scalable software is a special breed of system. Multicomputers are best used on problems that possess a high degree of symmetry in their data. Not all problem domains are sufficiently symmetrical to produce a linearly scalable system. Increases in speed, which grow according to the square root of the number of processors (n) or the logarithm or some other power of n, are also possible.

Parallel processing is a rising star, but it will flame out unless more engineers and scientists are trained to organize logically concurrent systems. A scalable system is a reusable system.

You can always refine the data decomposition to accommodate more physical concurrency; for example, you can rerun an eight-processor system on 8192 processors, provided the problem domain is explicitly parallel.

Multicomputer software requires a blend of discipline, intellect, creativity, and desire to build. Applying these skills and your software-engineering know-how to create linearly scalable software is a challenge, but a highly rewarding one when it is successfully met.

The hardware issue has already been solved, thanks to the Inmos transputer. Software remains the final hurdle to clear if parallel processing via multicomputers is to emerge as a popular alternative to sequential processing. ■

ACKNOWLEDGMENT

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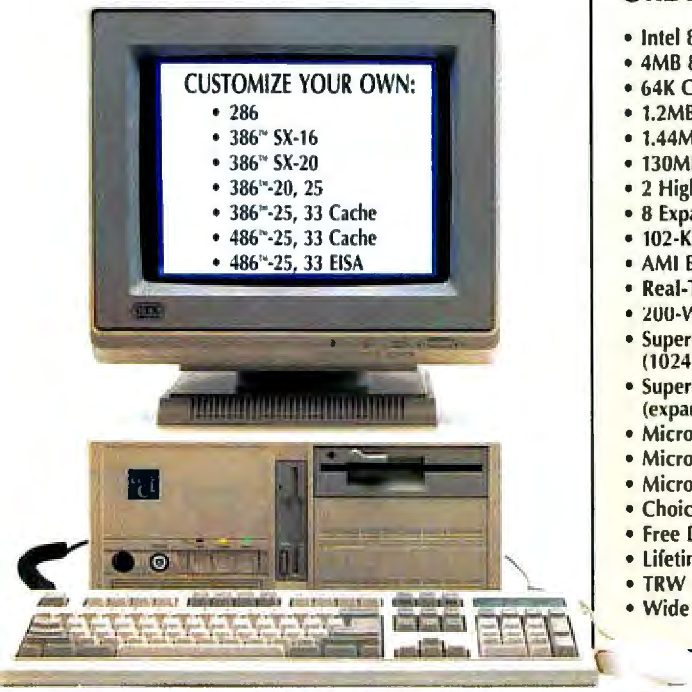

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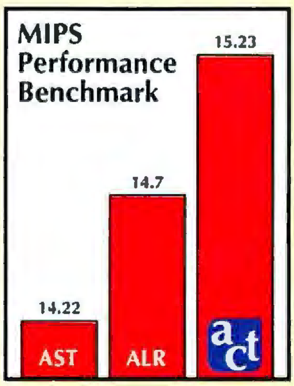

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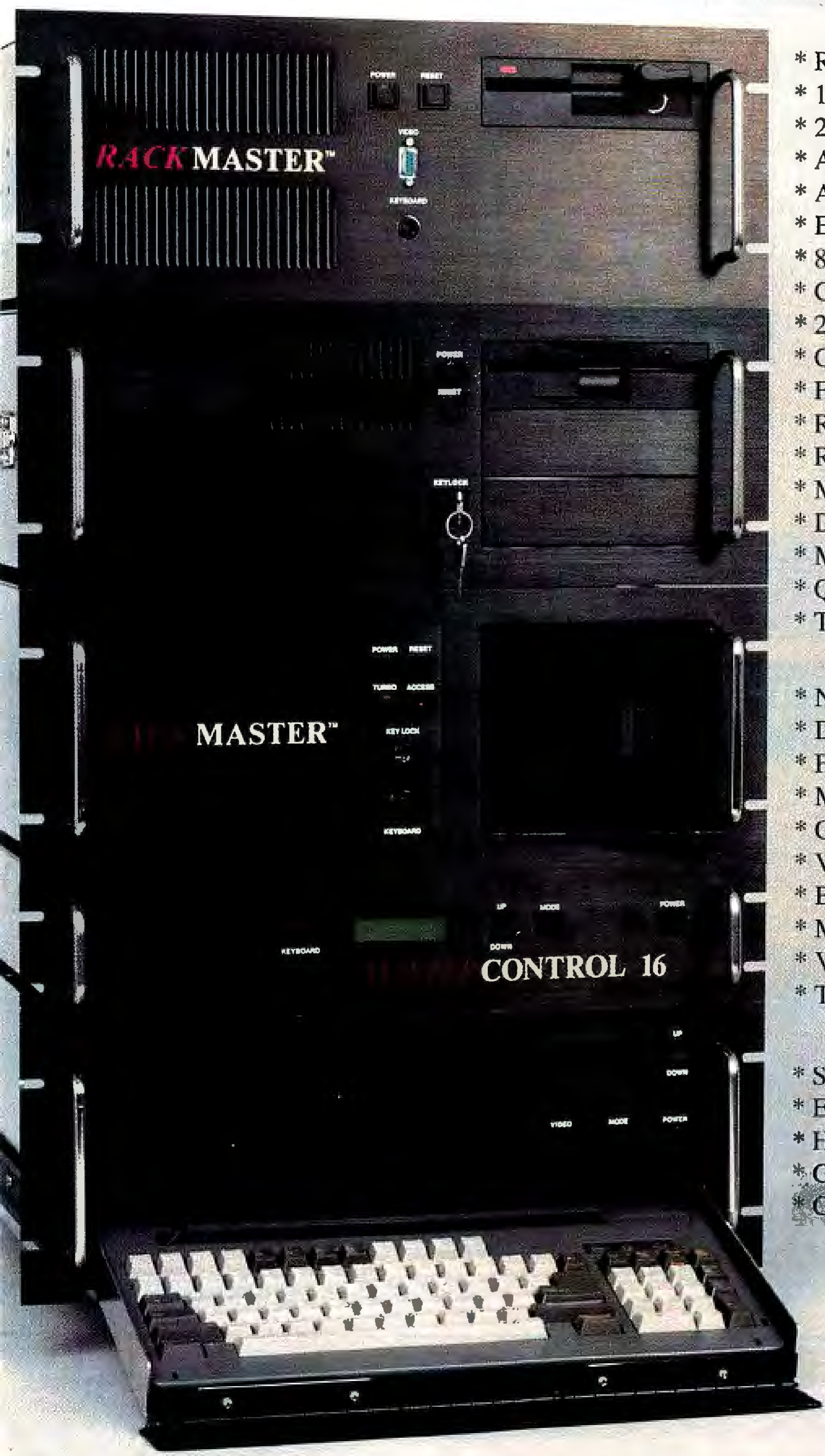

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SYMMETRY, THY NAME IS UNIX

Unix SVR4/MP: A new standard for multiprocessing with Unix. How does it fit into the open-systems picture?

MARK NUDELMAN

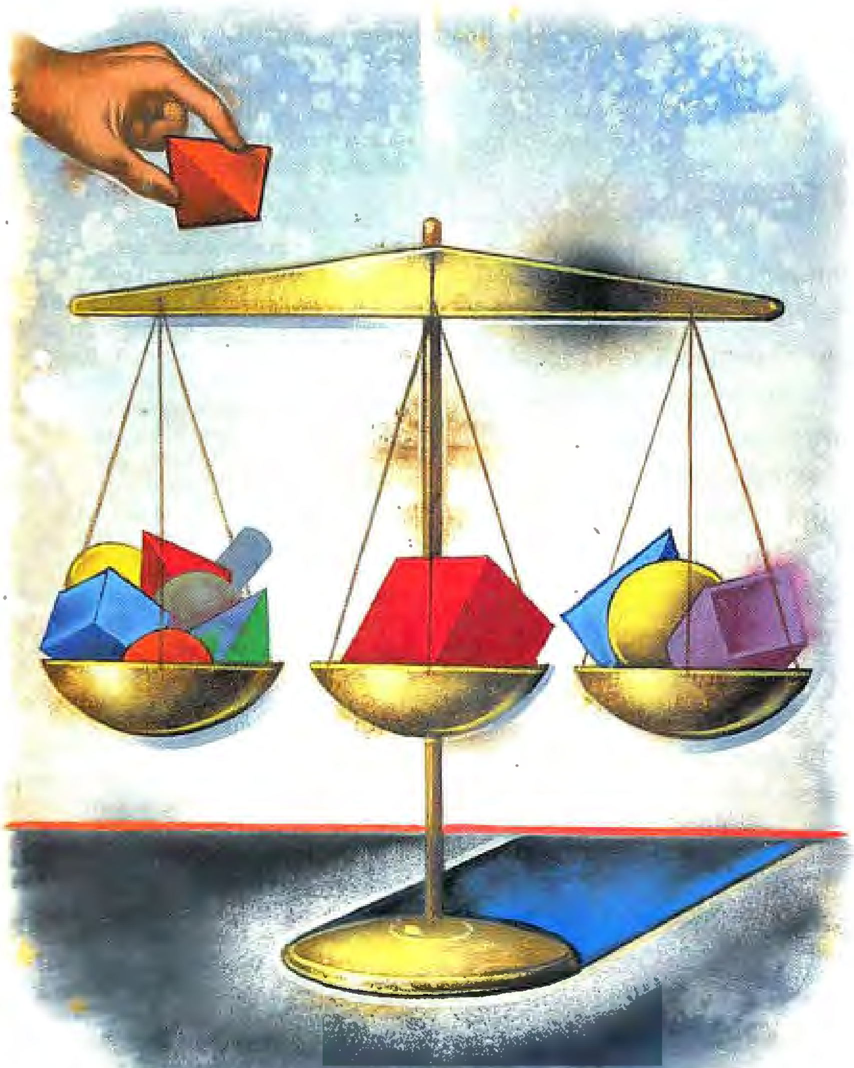
Symmetric multiprocessing (SMP) yields dramatic improvements in Unix server power, throughput, and upgradability by uniting multiple processors into a single system. However, to date, implementations of Unix/SMP have not conformed to open industry standards—arguably the single most significant feature of Unix. Without a widely endorsed standard for Unix running across multiprocessors, implementations will lack the broad applications portability, enterprise-networking capabilities, and other open-systems hallmarks that have made Unix a success.

In the fall of 1989, in an attempt to fill this void, Intel gathered together several companies focused on Unix. At the time, each of the companies was working independently on Unix/SMP variants. To avoid a proliferation of incompatible interfaces, NCR, Okidata, Olivetti, and Unisys joined the Intel Multiprocessor Consortium to produce a single Unix version for SMP systems based on AT&T Unix System V release 4.0 (SVR4).

Over the last year, engineers from the participating companies have spent their workdays at Intel as members of a single engineering team. The result of their efforts is due for delivery in mid-1991 to AT&T's Unix Systems Laboratories (USL), which will package and sell it as Unix System V release 4, Multiprocessor version 1 (SVR4/MP): the new standard for open multiprocessor systems.

What does this standard multiprocessor Unix include? I'll look at SVR4/MP with an eye for the challenges met and the technologies used to design an open multiprocessing system.

continued



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Living in a Uniprocessor World

How do you fit multiprocessing into an open-systems model when many of the open standards have grown—and will continue to grow—out of uniprocessor architectures? Three major design principles drove SVR4/MP's architectural decisions:

- *Complete compatibility with uniprocessor SVR4 application-binary-interface definitions.* To fulfill the open-systems promise of shrink-wrapped portable applications, SVR4/MP will run any SVR4 ABI-compliant software and most other SVR4 software without any change—without even recompiling. It will pass all conformance tests (e.g., X/Open Portability Guide, IEEE Posix, and Unix International's SVID) to the same level that SVR4 does.
- *Minimal changes to SVR4 source code.* It's easy to imagine producing an SVR4/MP standard that follows the first principle but violates the second, starting from scratch to produce cleaner multiprocessing code. However, changes to the SVR4 kernel are minimal in SVR4/MP—just enough to ensure efficient multiprocessor operation. Minimizing changes helps to ensure that the system meets its compatibility goals and eases future implementation of the same multiprocessing enhancements to new releases of standard uniprocessor Unix.
- *Easy hardware porting.* SVR4/MP supports Intel 386 and i486 microprocessors. However, any operating system requires some porting to move it to a different machine architecture. SVR4/MP is designed for fast and easy ports. In development, porting to a new machine has required only three to four days for a single programmer familiar with the code.

BYTE ACTION SUMMARY

Without a widely endorsed standard, Unix multiprocessor implementations would lack the broad applications portability, enterprise-networking capabilities, and other open-systems hallmarks that have made Unix such a success. Thus, the Intel Multiprocessor Consortium has formed and produced a single standard Unix for symmetric multiprocessing systems based on AT&T Unix System V release 4.0. Unix SVR4/MP is compatible with uniprocessor SVR4 as well as being portable across a variety of hardware platforms.

SMP systems have high-speed caches for each processor.

The code is also as portable as possible to new microprocessor architectures. The code specific to a given microprocessor is isolated, easing efforts currently in progress to port the system to the Intel i860 and other microprocessors.

The Intel Consortium developed a separate but closely related (and standard) enhanced specification for the Device-Driver Interface/Driver Kernel Interface that supports multiprocessor and uniprocessor systems. While standards such as Posix 1003.1 and SVID define source code portability for applications, and while the ABI and BCS focus on binary portability for applications, the DDI/DKI specification defines a standard set of services for system device drivers. It removes all the operating-system-dependent information from device drivers, streams modules, and streams drivers to ensure that drivers are portable both in source and binary form among DDI/DKI-compliant systems.

Reaching Its Goals

The SVR4/MP system adheres to specifications in the *Unix System V Roadmap* (Unix International, January 1990), which specifies the essential components of an open-systems Unix/SMP solution.

The best attainable scalability for a multiprocessor system is 100 percent of the first processor; that is, an *n*-processor configuration with 100 percent scalability will perform *n* times better than a uniprocessor configuration. However, both the hardware and the application mix being run strongly affect scalability. It is rare to see 100 percent.

The goal for SVR4/MP is to achieve 85 percent scalability (i.e., each processor adds at least 85 percent of uniprocessor throughput) for up to six processors across a wide range of applications—a target appropriate for entry-level and midrange multiprocessing machines.

Performance is also measured by how much the SMP enhancements degrade a uniprocessor. Under SVR4/MP, application performance on a uniprocessor system degrades no more than 5 percent from performance on the same system under SVR4. System performance is established using a variety of industry-standard benchmarks, including AIM, Neal Nelson, and AT&T's GAEDE.

Setting Up the Target

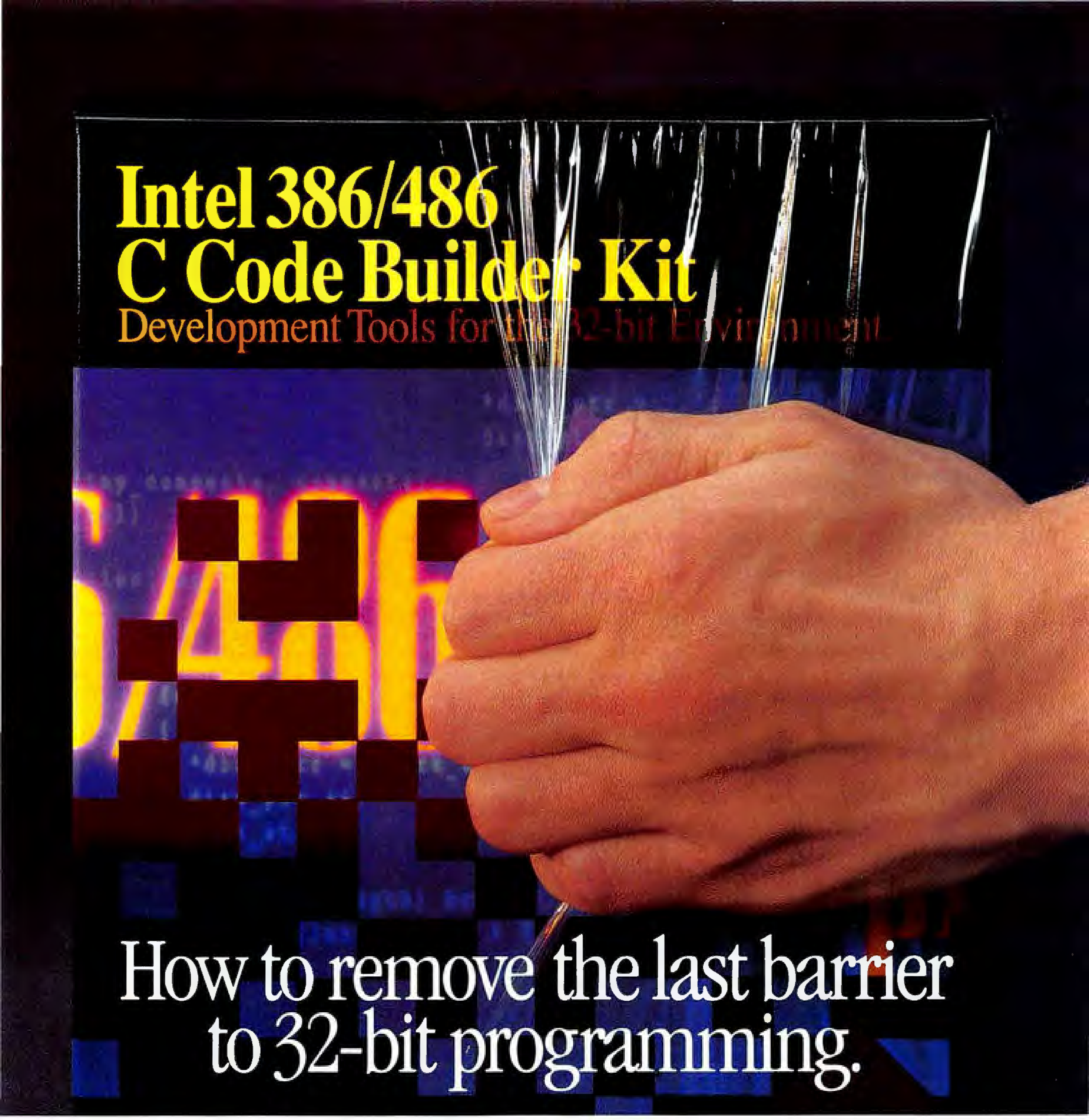
SVR4/MP supports multiprocessor architectures that are symmetric with respect to memory; that is, each processor has access to all system memory. This includes most multiprocessor architectures, except for high-end massively parallel systems (e.g., the Connection Machine from Thinking Machines in Cambridge, MA) with large numbers of processors, each with its own memory.

The target hardware has to support automatic coherency among all memory caches within the system. Typically, SMP systems have high-speed caches for each processor to eliminate some of the overhead required for continual memory access. The most recently used data goes into the cache, where it can be reaccessed more readily than from system memory.

In a multiprocessor system, however, processors execute common kernel code and operate on common data structures. If one processor modifies the data in its cache, then the corresponding items in other processors' caches become obsolete, unless all are updated to reflect the new value. Most multiprocessor systems use hardware to ensure consistent values for data in these memory caches. SVR4/MP assumes that this control is present.

Typically, however, multiprocessor hardware does not provide the capability to ensure coherency in translation look-aside buffers, which cache virtual-memory translation information. SVR4/MP provides its own TLB synchronization method (see the text box "Lazy TLB Flushing" on page 248).

I/O access can be symmetric or asymmetric; that is, all I/O devices can—but



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Lazy TLB Flushing

A particularly interesting feature of Unix SVR4/MP is how it makes translation look-aside buffers coherent under software control. TLBs are common to the many Unix multiprocessors that have virtual memory. A translation is needed between virtual addresses (which the program uses) and physical addresses (which the memory system and the bus use). Typically, some type of hardware translates the virtual addresses in the program to the physical addresses used outside the processor.

To speed these translations, chip designers often create a cache of address translations—much like normal data caches. If a processor translates an address, it places the virtual and physical addresses in the cache for the next translation, if required.

This cache is called a TLB, and it presents the same problem within multiprocessor architectures as data caches do. If one processor changes an address translation, then the same translation already in another processor's TLB will be outdated; that processor could use it to translate a virtual address to an obsolete physical address.

The most obvious solution would be to broadcast every changed translation via an interprocessor interrupt, but that costs too much in overhead: A uniprocessor SVR4 system running a fairly moderate load changes translations about 200 times per second. Instead, SVR4/MP uses the "lazy TLB-flushing algorithm." In the uniprocessor code, whenever a processor changes a translation, it updates the uniprocessor's own TLB. The algorithm piggybacks on that local flushing. No broadcast is necessary as long as no other processor tries to use that address.

If another processor does try to use the address, there's no problem if the second processor flushes its own TLB between the time the first processor changes the translation and the time the second processor tries to use it. It's not necessary to do an expensive broadcast operation in these cases. The tricky part is determining when a broadcast *is* necessary.

SVR4/MP's solution is to create a systemwide generation number that is incremented every time any processor flushes its TLB. Each processor keeps a local copy of what the generation number's value was the last time that processor flushed its TLB. Every time that a processor changes the translation for a virtual address, the current systemwide generation number is associated with that address.

If the generation number associated with the address a processor is going to use is greater than any processor's local number, an old translation of the address may exist and the requesting processor's TLB may need to be flushed. If it does, the system executes a broadcast and global flush. If the generation number associated with the address is less than all other local generation numbers, then all other processors have already flushed their TLBs since the last time that address translation was changed.

SVR4/MP still performs 200 or so local flushes a second, as does the uniprocessor. However, this method almost never requires a broadcast and global flush.

---

don't have to—be accessible to all processors. The I/O architecture can also have symmetric or asymmetric device-interrupt distribution. That is, interrupts can always go to one processor (asymmetric); different interrupts can go to different processors (partially symmetric); or any interrupt can go to any processor (completely symmetric or distributed). As in SVR4, SVR4/MP supports the ISA/EISA I/O buses.

The hardware must also support interprocessor interrupt capability: There has to be a way to send an interrupt from one processor to another. This capability is required, for example, for TLB synchronization. Also, the microprocessor has to support a "test and set" operation to enable multiprocessor locking (the xchg instruction on 386/i486 processors).

Balancing the Load

Various mechanisms make it easier to fully use the parallelism inherent in multiprocessor systems; the most notable are threads. To date, however, the industry has not agreed on the proper interface for parallel programming. At least four separate standards organizations are currently working on interface definitions, including the Unix International Workgroup on Multiprocessors and the Posix P1003.4 Real-Time Committee.

So far, commercial computing markets have shown little demand for applications parallelism. Until recently, scientific users, whose applications (e.g., modeling windflow over a wing) show significant benefits from parallelism, have dominated the multiprocessing market. These users typically run single, monolithic applications, and they are willing to invest the substantial programming efforts required to obtain the highest possible performance.

Corporate installations usually have many users running a variety of applications. It's more critical that the system balance the load evenly across all available processors than that it run a single application very fast. For this reason, as well as the lack of standards, few commercial applications support threads.

Thus, SVR4/MP won't include extensive parallel-programming enhancements until the industry reaches a consensus. This means that a uniprocess application running by itself will not benefit from additional processors. But SVR4/MP does provide automatic load balancing—an easy task based on the standard SVR4 uniprocessor process-scheduling method.

On a uniprocessor system, one of the kernel's main tasks is to arbitrate competition among processes (i.e., programs that are executing) for the single processor. The kernel selects a process that is ready to run from among those with the highest priority and allocates the processor to it. The process then executes until the kernel performs a *context switch* (i.e., it stops the current process and allocates the processor to another one).

In SVR4/MP, the kernel operates essentially the same way. At any particular time, if you have *n* processors, you have *n* active processes. Each processor schedules processes, switches contexts, and reschedules independently. Because each processor always runs when processes are waiting, and because the self-scheduling processors always pick the highest-priority process that is available, the load spreads out automatically and evenly.

Keeping the Door Locked

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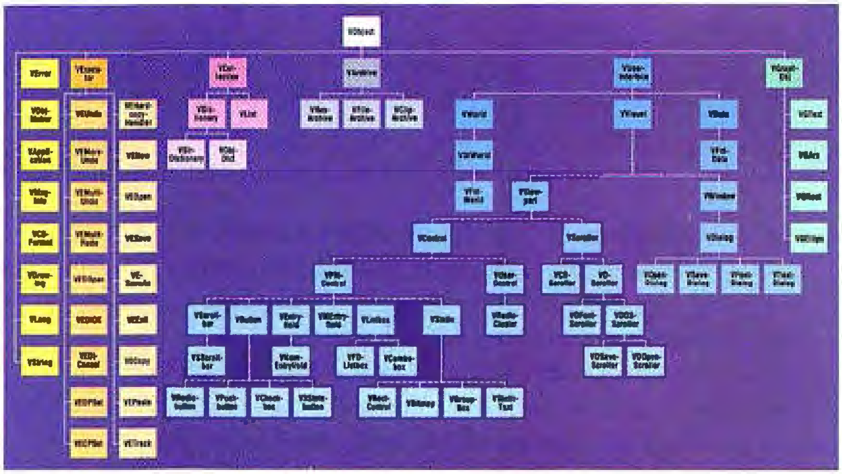

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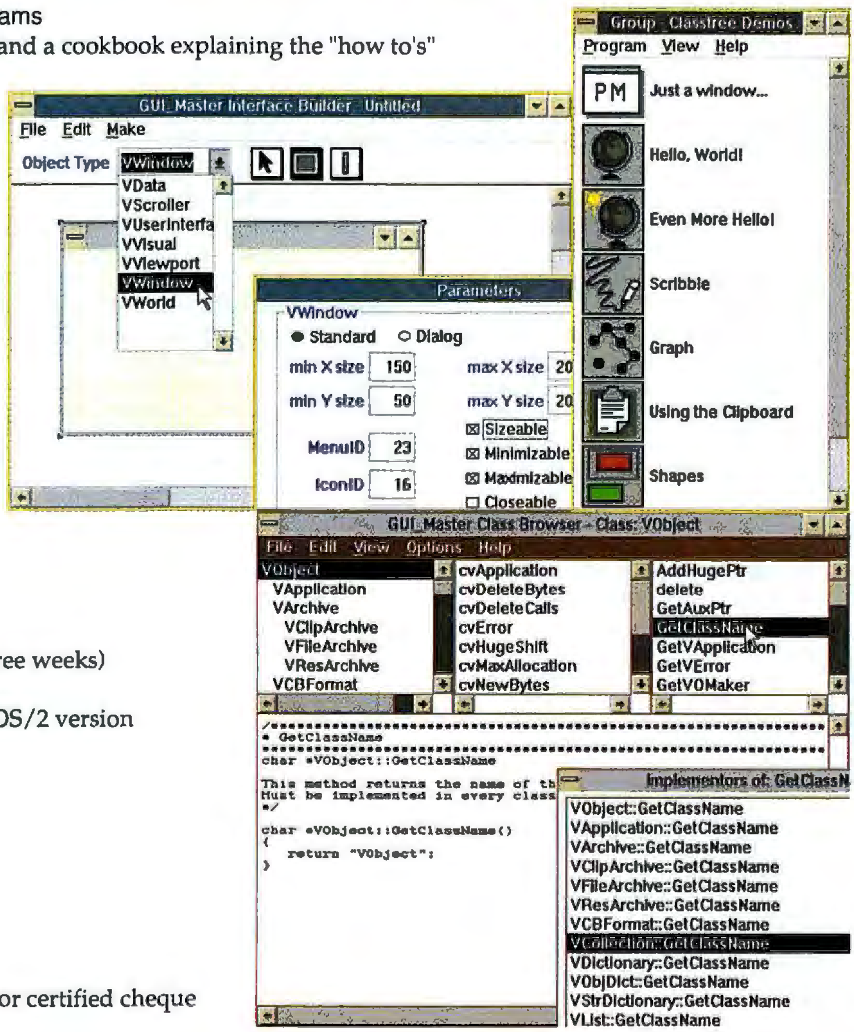

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starting from a uniprocessor porting base. One major assumption pervades the entire SVR4 kernel: The code runs on one processor. Whenever a process runs in the kernel, it knows it has complete control of the machine (except for device interrupts) until it explicitly gives up control.

This "single-minded" control ensures the integrity of all the kernel's data structures (which contain data accessed for system calls or kernel functions). Examples of these structures are the Process Table, which keeps track of all processes in the system, and the File Table, which tracks all open files. If any of the structures become corrupted, the system will either crash or develop a bad limp.

Multiprocessing breeds anarchy, however, and dramatically violates the assumption of a single thread of control. Multiple processors run processes independently. It's easy to imagine a situation where multiple processes simultaneously access and even modify the same data structures.

For example, consider a data structure called *count*, an integer that is continually incremented; the process reads the integer, adds 1 to it, and writes it back to memory. If two processes are performing this same operation, they could both read the value 5 simultaneously, increment it, and write it back as 6. The system would miss one increment; the count should actually be 7.

The only type of protection that even remotely addresses this problem in SVR4 is the system-priority-level mechanism for blocking selected device interrupts to the processor. These are interrupts that could themselves modify or look at the data structures the interrupted process is using. But SPLs don't stop those same device interrupts from occurring on another processor; nor do they keep other processes from simultaneous access.

The major effort in multithreading SVR4 was to implement a type of lock, called a *mutual-exclusion* (*mutex*) lock, associated with every data structure in the kernel. Before accessing any data structure, a process must acquire the lock associated with it. When the process is finished with the data, it releases the lock. This mechanism ensures that only one process at a time is manipulating the data associated with the lock.

Some Unix/SMP variants have implemented locks only on those portions of the kernel that the majority of applications use most often. In those systems, atypical applications that use less popular system calls will not benefit from multiprocessing. To ensure that all applications scale properly, the SVR4/MP kernel has implemented locks throughout and is entirely multithreaded.

The Size of the Grain

The overhead required in acquiring and releasing locks was the key concern in attaining system performance goals. To minimize overhead, an optimum balance of lock granularity had to be determined. At one end of the spectrum are *coarse-grained locks*—those that cover a large number of data structures. Implementing coarse-grained locks can create substantial contention for every lock. Processes must wait for a lock to access data that may be totally unrelated to what the process holding the lock is operating on.

At the other end of the spectrum are *fine-grained locks*—zillions of locks covering little bits of data. A process performing a single operation may have to acquire many different locks to access the appropriate data structures. The overhead of just acquiring and releasing locks that are too fine-grained can become larger than that of the processor's actual operation on the data.

SVR4/MP obtained an optimum balance in lock granularity with a set of lock-debug tools that helped to find the "hot spots." The lock-debug tools have various additional uses. For example, device-driver writers can use them to look for bottlenecks in their own use of locks.

Standard types of consistency checking were another use for the lock-debug tools. For instance, the code checked for invalid operations, such as a process trying to release a lock it hadn't acquired, or for processes that *spin* (i.e., wait for a lock to be released without switching contexts) for more than 10 seconds (locks are typically acquired and released in a matter of microseconds).

The lock-debug tools were also used to check the lock hierarchy—the order in which processes must acquire locks. Departing from the established hierarchy is the most common cause of *deadlock*.

Suppose two different locks protect data structures *A* and *B*. Process 1 acquires lock *A*, and process 2 acquires lock *B*. Then suppose that process 1 needs data structure *B* and must wait for lock *B*. Meanwhile, process 2 needs data structure *A* and must wait for lock *A*. Neither process can proceed.

The processes deadlock because they try to acquire the locks in different orders (*A*,*B* and *B*,*A*). The simplest way to fix this is to determine a static ordering for acquiring all locks—a *lock hierarchy*. The lock-debug tools ensured consistency throughout SVR4/MP's code.

The Flexibility Stretch

The mutex locks were designed to minimize modification of SVR4 source code and to allow flexibility for code optimizations. For instance, many multiprocessing lock models distinguish between locks that spin and locks that sleep. *Spinning*, or waiting for the lock rather than switching contexts, is usually used for locks that a process holds for a short period of time; conversely, if a given lock is typically held for a long time, the process goes to *sleep* by switching contexts.

The mutex locks can either spin or sleep, and their mode of operation is determined under software control during initialization. That means that a given lock can be switched between spin and sleep simply by changing the one place in the code where it's initialized, rather than by replacing the lock throughout the kernel. Or, if you wish, the spin/sleep parameter can also be changed only at specific locations.

Another parameter that a lot of systems typically lock in is the exclusive or shared option. An *exclusive lock* is a normal kind of lock that requires other processes to wait while it is held. When *shared locks* are acquired, the calling process can choose to acquire them in either shared or exclusive mode. If the choice is "shared," new rules apply. Other processes can also acquire the lock, but only in shared mode. Thus, multiple processes can hold a shared lock, but only one process can ever hold an exclusive lock.

Shared locks decrease contention on a given lock when a process needs to protect a data structure that it will be looking at for a while but not modifying. Shared locks are also known as reader/writer locks: Readers acquire shared locks in shared mode, and writers obtain them in exclusive mode.

Innovative and Recursive

A couple of other features in the mutex locks are worth a brief discussion as well, because they are not commonly used in other multiprocessing systems. The first is *recursion*; the second is *automatic release on sleep*.

In the basic model, if a process tries to acquire a lock that is already held, it must wait. But what if the process that already has the lock tries to acquire it again? The holding process will find that the lock is held and will wait for it forever because it is the one holding the lock—a classic case of single-processor deadlock.

Other multiprocessing systems don't allow this: The code always knows what locks the process already holds. SVR4/MP's second design principle—minimal changes to the SVR4 source code—made it difficult to use that model.

SVR4's design permits various kernel subsystems to make calls to each other without concern for whether the subsystem is being reentered. For example, many common operations cause the file system to call the virtual memory system, which again calls the file system. Although not a bad design, this feature makes it hard for any one subsystem to know what locks are being held when it is called. Even locks that belong exclusively to the subsystem may already be held as a result of an earlier nested call into it.

SVR4/MP's solution to deadlock is recursion. If the process already has the lock and tries to acquire it again, a counter is incremented to indicate how many times the process has acquired the lock so it knows how many times to release it. In this way, functions are more isolated and don't have to be concerned with what locks the process that is calling the function has already acquired.

Recursive locks are a bit more expensive in terms of overhead, so locks that don't require recursion are declared to be nonrecursive at initialization. The only other disadvantage to the recursion model is aesthetic: Elegant code would be more "lock-aware."

Automatic Release

What happens to all the locks that a process holds when it goes to sleep? Keeping all the locks would severely degrade system performance. A process that goes to sleep waiting for a disk I/O operation may sleep for many milliseconds while holding onto valuable data resources. All the other processes that need the locks have to wait as well, even though the process is not actually changing anything while it sleeps.

Many multiprocessing systems are designed so that processes won't go to sleep holding locks that other processes require. However, such a model would require rewriting substantial portions of the SVR4 source code to make explicit which locks a process holds when it goes to sleep and which ones it should or should not release. There are hundreds of places in the kernel where processes go to sleep, and it is not at all obvious at these points which locks they hold.

In fact, a multiprocessing port of Unix SVR3 using such a model was written. It involved changing all the sleeps in the kernel to know which locks are held. This was enormously difficult, and it took nearly three years to come up with a properly debugged system; one lock or another was always missed. SVR4/MP's unorthodox solution was to automatically release all locks upon sleep and rely on built-in uniprocessor mechanisms to maintain data consistency.

In the uniprocessor model, the data

structures can be in any indeterminate state while the processor executes a process. If the process is going to switch contexts (i.e., go to sleep), the built-in uniprocessor mechanism ensures that the data structures are in a consistent state such that other processes can look at them and retrieve meaningful information. Thus, points where a process goes to sleep are significant in the uniprocessor model; that's where the data structures are consistent.

In the strict multiprocessor model, however, data structures either must be consistent or, if they aren't, must be locked so that no other processes can access them. But eliminating the uniprocessor model would require major changes to the SVR4 source code.

So, SVR4/MP reconciles the two models, using both multiprocessor locking mechanisms and standard uniprocessor mechanisms to ensure data consistency. Whenever a process goes to sleep, all the locks it holds are automatically released, without the process's knowledge. When the process wakes up again, it automatically reacquires all the locks. This solution works because the existing uniprocessor code already ensures that everything is consistent when a process goes to sleep. Thus, the mutex locks really only protect data structures between sleep points.

Enhancements built into the context-switch mechanism ensure that a process reacquires all its locks by keeping a list of all acquired locks in a *lock stack*. Before a newly reawakened process recommences executing code, the mechanism looks at the lock stack and reacquires all the locks the process held when it went to sleep.

The solution maintains the Unix uniprocessor model, but, again, because locks are released without a formal release procedure, multiprocessing purists may consider it aesthetically—although clearly not functionally—impaired.

In case the need arises to replace existing uniprocessor mechanisms that protect data structures during sleep with a more general multiprocessor mechanism, SVR4/MP also implements another type of lock, called a *resource lock*. Resource locks do not release upon sleep and are used rarely, so changes to existing uniprocessor code are minimized.

Block and Tackle

Another uniprocessor mechanism that SVR4/MP maintains is the SPL mechanism, which blocks device interrupts to the processor. Generally, if a processor is executing a process and a hardware device interrupts it, the processor will save the state of process and immediately start executing code in the interrupt handler.

A problem occurs, however, if the interrupt routine needs to access a data structure that the process was working with when the interrupt occurred. The interrupt will spin, waiting to acquire the associated lock. However, the lock will never be released, because the interrupted process holds it. Deadlock will occur.

In fact, deadlock threatens any data structure accessed at interrupt level, so SVR4/MP contains an SPL level built into the locking primitives. Whenever a process acquires a lock, an SPL level is one of the function parameters.

Bound and Gagged

Multiprocessing locks are not just for the kernel. Multithreaded device drivers, streams modules, and streams drivers that conform to the new DDI/DKI specification also use lock interfaces. Just like kernel code, device-driver code may also run on more than one processor at a time, making it necessary to lock data structures internal to the driver.

But DDI/DKI uses different types of locks, developed through long-term negotiations among the Consortium, USL, and other industry vendors to ensure an industry commitment to standardization. The new DDI/DKI specification also cleans up some of the ambiguities in the original specification.

SVR4/MP also provides support for single-threaded device drivers that conform to the original DDI/DKI specification. It permits them and their interrupts to be "bound" to a specified processor, thereby eliminating the need for locks.

Support for device-driver binding solves yet another problem: supporting hardware with asymmetric I/O. If the hardware only lets a specific processor access a certain device, the device driver is effectively bound to that processor.

SVR4/MP automatically releases all locks upon sleep.

Private Access

In uniprocessor SVR4, there are several processor-specific data structures that must be available for every processor in a multiprocessor. Examples of such variables are *fpkind*, which indicates what kind of FPU is on the processor; *ipl*, which indicates the set of interrupts the processor is currently masking; and *curproc*, which is a pointer to the process currently running on the processor.

There are two ways to replicate these variables on a per-processor basis. Each variable could be changed into an array of variables, but this would require many changes throughout the code. Instead, SVR4/MP provides *processor-private* variables, which use the virtual memory system to map the same virtual address to a different physical address and memory location for each processor. This solution required changing only the mapping of the processor-specific variables; the numerous usages of these variables (e.g., *fpkind*, *curproc*) were not changed at all.

An Easy Migration

Unix SVR4/MP and the enhanced DDI/DKI specifications provide an easy migration path to Open Unix/SMP. Broad compliance with SVR4/MP's three main principles—complete compatibility with uniprocessor SVR4 ABI definitions, minimal changes to SVR4 source code, and easy hardware porting—will be key to the success of this new standard Unix for open multiprocessor systems. ■

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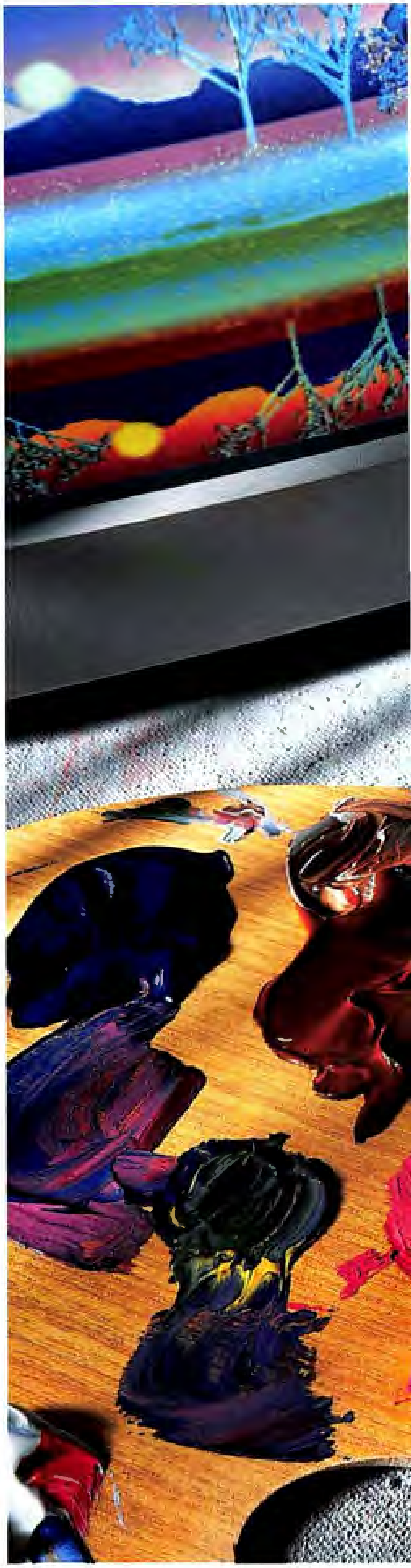

Professional-level paint programs combine the artistic range of traditional media with the advantages of computers

TOM THOMPSON AND RICK GREHAN

Until recently, many graphics professionals refused to consider the personal computer as a tool for serious color work. The reason was simple: 8- and 16-bit color systems were not able to display the range of hues available from paint and other traditional media. But now that's changed. Macintoshes were the first to provide 24-bit display capabilities out of the box, which meant Macs could process 16.8 million colors for true-to-life coloration—hence the term *true color* for 24-bit colors. This is more than enough hues to satisfy the needs of many artists, illustrators, and desktop publishers. More recently, Intel-based PCs heightened their true-color presence, thanks in part to new or lower-priced color boards from Hercules, Truevision, and RasterOps.

While the price of even a minimum true-color painting system isn't cheap on either platform, the rewards are significant. The main advantage is that you can readily print or transmit electronic artwork. For example, an artist in Duluth might produce thumbnails for a magazine cover and send the sketches via modem to a New York art director for immediate feedback. The finished, full-color image can subsequently travel cross-country just as efficiently. Similarly, a desktop publisher might exploit the full range of colors in these paint packages to retouch and enhance electronic images for an advertising insert. In addition, these programs provide graphics professionals with a wide range of special-effects tools, such as gradient fills, embossing, and drop shadows.

You will need sophisticated software with a boatload of features to electronically duplicate canvas and paint (see the features table). This is where the BYTE Lab stepped in. We judged five Mac-based and three PC-based 24-bit-color paint applications that were shipping at press time to see how well they met the requirements of professional artists. (A sixth Mac product, MicroIllusions' Photon Paint 1.1, didn't arrive in time for testing.) The Amiga platform also has its share of

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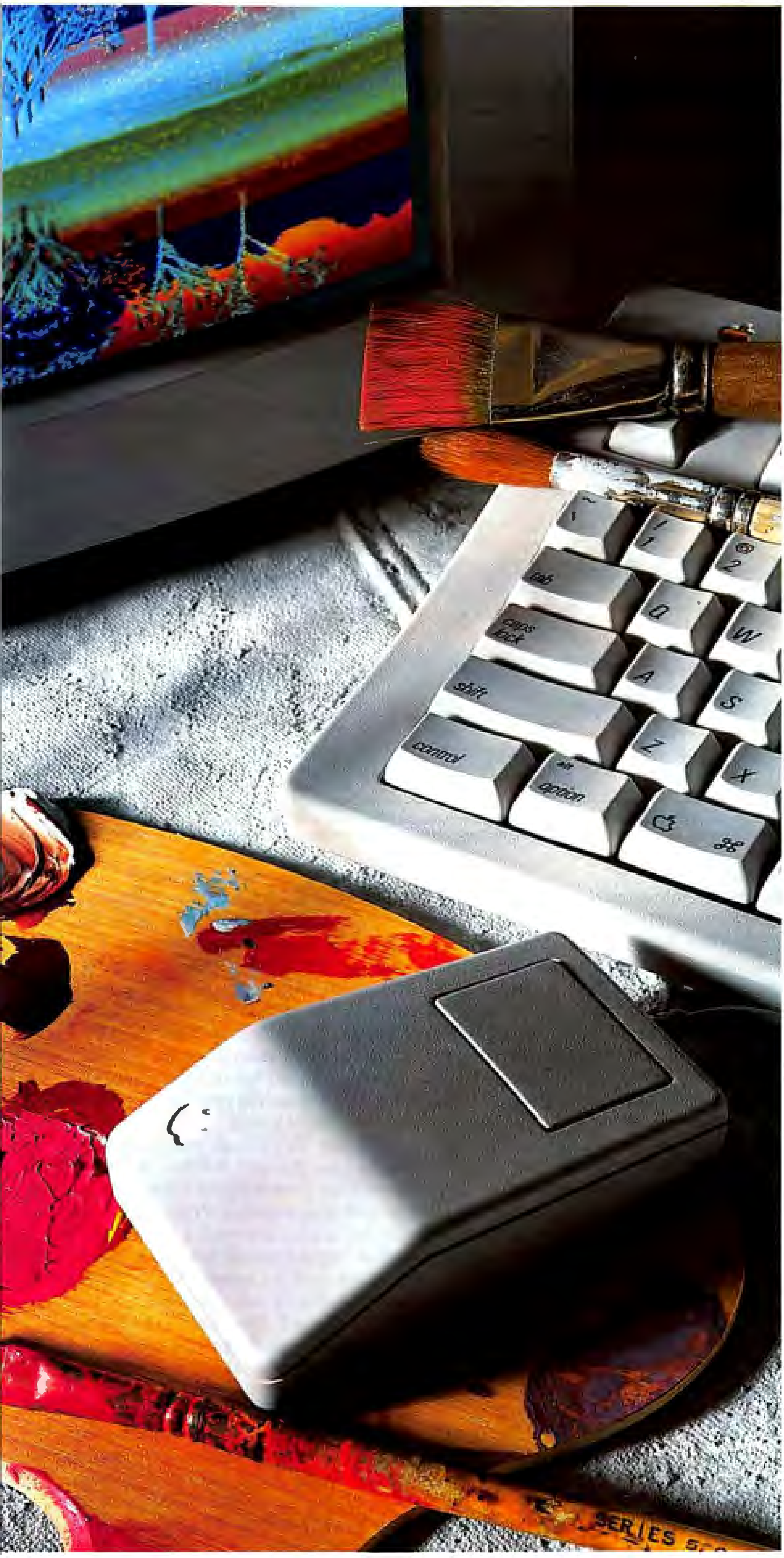


BYTE ACTION SUMMARY

- **WHAT 24-BIT PAINTING DOES**
  Provides color palettes of 16.8 million colors and a range of painting, drawing, and special-effects tools.

- **LIKES**
  Using an almost unlimited range of colors, you can create or enhance artwork for publications, presentations, or exhibitions and readily print or transmit the images electronically.

- **DISLIKES**
  Hardware and software costs can be staggering. For a complete Mac or PC system, plan to spend at least $7500—much more if you have special needs, such as a 19-inch display for full-page artwork.

- **RECOMMENDATIONS**
  On the Mac high end, choose Studio/32 for its efficient color and printing control, plus its support for Pantone color matching (however, beware of the program's large appetite for RAM). If you need a paint program that produces color separations, PixelPaint Professional is your only current option. Zedcor's DeskPaint is the best buy on the Mac low end. Tempra gets our nod for PC-based programs. It's the least expensive of the lot and handles a variety of image formats.

- **REQUIREMENTS**
  For the Mac, you'll need a 20-MHz IIsi or better with an 80-MB hard disk drive, no less than 4 MB of RAM (you'll want 8 MB of RAM for full-page images), a 24-bit graphics board, and a monitor. PC systems must consist of at least a 386SX machine with a minimum of 80 MB of hard disk space and 640K bytes of base memory, enough EMS memory to support your choice of software, a 24-bit display board, and a multi-scanning monitor.

COMPARING 24-BIT PAINT FEATURES

How can you tell paint programs apart? Here's a summary of price and capability choices for Mac and PC packages.

Product name / Features	Mac programs: Color MacCheese 2.07	DeskPaint 3.03	Oasis 1.0	PixelPaint Professional 1.0	Studio/32 version 1.1
Minimum RAM	1 MB	2 MB	5 MB	2 MB	5 MB
Customizable brushes	Yes	Yes	Yes	Yes	Yes
Antialiasing	Yes	Yes	Yes	Yes	Yes
Zoom or magnify	100%-900%	6.25%-1600%	No	100%-400%	12.5%-800%
Number of open documents	Limited only by memory	Limited only by memory	Limited only by memory	1	Limited only by memory
Mask support	No	Only to remove colors	Yes	Yes	Yes
Color models	RGB, HSV	RGB	RGB, HSV, CMY, HSL	RGB, HSV, CMYK	RGB, HSV, CMY, HSL
Pixel depths (bits)	1, 2, 4, 8, 16, 24, 32	1, 2, 4, 8, 16, 24, 32	1, 2, 4, 8, 16, 24, 32	8, 16, 24, 32	8, 16, 24, 32
Import format	MacPaint, PICT, TIFF, EPSF[2]	MacPaint, PICT, TIFF	PICT, TIFF, TGA	MacPaint, PICT, TIFF, EPSF[2]	MacPaint, PICT, TIFF, EPSF[2]
Export format	PICT, MacPaint, TIFF	MacPaint, PICT, TIFF	PICT, TIFF, TGA	MacPaint, PICT, TIFF, EPSF[2]	PICT, TIFF, JPEG, EPSF[2]
PMS support	No	No	No	Yes	Yes
Color separations	No	No	No	Yes	No
Price	$99	$199.95	$795	$695	$695

[1] Magnification depends on a combination of the screen and a detail window's magnification.
[2] Only the preview bit map is read and edited; the PostScript code is not altered.
[3] Can read raw data if user supplies header length and pixel size.
[4] Hercules Art Dept. price includes display board with 2 MB of VRAM and additional software.

24-bit paint packages; however, the integration of processing and display hardware isn't as straightforward on the Amiga as it is on Macs and PCs (see the text box "Amigas Grapple with 24 Bits" at right).

In addition to the hands-on evaluations that were done in the BYTE Lab, we asked two professional artists, Roger Goode and Cal Vornberger, to use these applications to create original illustrations and rate each program for its facility and power. Their personal perspectives appear in the text boxes "A Painter's Brush with Mac Color" and "State-of-the-Art PC Art" on pages 262 and 270, respectively.

Those diving into the world of 24-bit color painting need a grounding in some special terminology, much of it borrowed from the lexicons of traditional painting and printing. In the text box "How to Choose the Right Color Application" on page 275, we define paint programs and discuss two related graphics applications. "Tools and Terms: A True-Color Glossary" on page 273 presents definitions and illustrations of many other important terms you'll need to know.

Real Systems

Graphics professionals may have a coronary when confronted with the price tag for 24-bit systems. For the Mac, nothing less than a 20-MHz IIsi will do unless your creativity can take a backseat to lengthy screen redraws. You'll need a hard disk with a minimum capacity of 80 megabytes to store images and no less than 4 MB of RAM. You'll want 8 MB of RAM if you create large images. Then there's the matter of a 24-bit display, which can raise the bill steeply, depending on your needs. If a 13-inch monitor will do, both Apple and RasterOps offer display boards for well under $1000. If you need a 19-inch behemoth to display full-page or larger images, plan to spend over $7000 for the monitor and board.

Mac prices have been falling, so some fine Mac systems are within the financial reach of professional studios. A complete system consisting of a Mac IIsi with 9 MB of RAM and a 13-inch 24-bit display will cost about $7500, list. You can get some better deals if you use third-party vendors for RAM and display hardware. You can also trim the bill if you opt for a 16-MHz 68030-based Mac.

PC-based artists will need at least a 386SX machine with a minimum of 80 MB of hard disk space and 640K bytes of base memory (your software choice will determine the minimum amount of EMS memory you'll need; the more the better). Also, you'll need a display board such as the Hercules Graphics Station Card ($1024) or Truevision's TARGA (Truevision Advanced Raster Graphics Adapter) ($2500 for the TARGA+ 64), plus a multiscanning monitor. Total cost: approximately $5000.

For our BYTE Lab evaluations, we used a Mac IIci with 8 MB of RAM and SuperMac Technology's 19-inch monitor and Spectrum/24 PDQ board. We also ran a Mac IIfx with 8 MB of RAM and an Apple 8•24GC board. On the PC side, we used a Gateway 386SX with 4 MB of RAM, a Hercules Graphics Station Card, and Truevision's TARGA+ 64 display board. We printed images on a Tektronix Phaser II PX thermal-wax color printer with 10 MB of RAM.

The mouse's lack of precision and control made us feel like cavemen daubing lard on the walls with a stick. Digitizing tablets with a stylus solve this problem. We used Wacom's SD-510C tablet on the Mac and a Numonics GridMaster on the

PC programs		
Lumena	Tempra	TIPS
640K-byte base, 2-MB EMS 3.2	640K bytes; additional EMS memory recommended	640K-byte base, 2-MB EMS
Yes	Yes	Yes
Yes	Yes	Yes
Variable[1]	100%-800%	100%-800%
1	1	1
Yes	Yes	Yes
RGB, CMY, HSV	RGB, CMY, HSL, HSV	RGB, HSL
24	1, 8, 16, 24	24, 32
TGA, PIX, BPX, foreign[3]	AVC, PCX, PIC, TGA, TIFF	TGA, EPS
PIX, BPX, TIFF, EPS, TGA	AVC, PCX, PIC, TGA, TIFF	TGA
No	No	No
No	No	No
$3995[4]	$495	$795

PC. The Wacom tablet uses a serial driver, so it's also available for the PC. These gadgets operate remarkably like a pad and pencil. The Wacom tablet ($695 for a 6- by 9-inch model) uses a stylus that can measure the pressure you exert on it. The GridMaster ($449 for a 12- by 12-inch pad) connects via a serial port and emulates Summagraphics tablets.

At some point, you will want your artwork in printed form, but a number of technical challenges may impede you. Many color PostScript printers make color output as easy as choosing Print from a menu. However, these printers can produce only 300-dot-per-inch output, and their wallet-warming prices start at $5000. For the best results, you'll want to print color separations on typesetters, which have resolutions ranging from 600 to 2450 dpi. Commercial printshops use typesetter-produced color separations to lay down the appropriate color ink on paper to reconstitute an image. Packages that let you specify industry-standard Pantone colors (see "PMS" in the glossary) have an advantage here.

The following descriptions detail the strengths and weaknesses of each package, starting with the Mac products.

continued

Amigas Grapple with 24 Bits

Bob Ryan

At comparable resolutions and depths, you won't find a faster personal computer for graphics than the Amiga. Its speed is a function of the tight integration of the CPU and the video display system, which includes a blitter and a video coprocessor.

While delivering speed, this integration is also a curse, making it extremely difficult to upgrade the resolution and depth of native Amiga graphics while maintaining compatibility with current software. In fact, except for the addition of some minor (but not very useful) display modes, native Amiga graphics have remained unchanged since the Amiga 1000 was introduced in 1985.

This situation has retarded the development of paint and all other 24-bit applications for the Amiga. Amiga users and software developers have waited for years—thus far in vain—for Commodore to either upgrade the Amiga custom chip set or decouple the Amiga graphics library from the current chip set. Recently, hardware developers have stepped in to fill the void by creating alternate displays that are—to greater or lesser degrees—incompatible with current Amiga software. As a result, these display systems have little software support; the paint programs that work with them are bundles.

Composite Solutions

Amiga true-color display systems fall into two categories: composite systems and RGB systems. The composite systems manipulate 24-bit images, but due to the limitations of the composite video color space, they can directly display only 20 or 21 bits of information. (This isn't as great a limitation as it seems, given that the human eye can't discern 24 bits of color information, either.) The two major composite display devices for the Amiga are Digital Creations' DCTV and Newtek's Video Toaster (see "Newtek's Video Toaster Makes Professional Video Affordable," March BYTE).

The Video Toaster comes with a 24-bit paint program that allows you to manipulate 24-bit images, although not directly. What you see and work on are indirect 12-bit approximations of the image displayed by the native Amiga graphics. When you want to see the actual image, you have to download it to the Toaster.

Unlike the Toaster's paint program, DCTV Paint (which is bundled with Digital Creations' DCTV) lets you manipulate 24-bit images as they are displayed by DCTV—no indirection here. Like the Toaster, DCTV Paint provides features you normally find in high-end video paintboxes, such as the Quantel Paintbox. It is also an ideal tool for video work.

RGB Color

While it is not a 24-bit display device, HAM-E from Black Belt Systems outputs an effective 18 bits of color and requires only minor modifications to existing Amiga software. It comes with a paint program that lets you modify 24-bit images, though you see only an aproximation of the image.

Direct 24-bit RGB paint programs are not yet available for the Amiga, but that will change as more 24-bit display devices appear. For example, a paint program for Firecracker 24, a 24-bit display currently available from Impulse, is in beta test. Another program will be bundled with an as-yet-unnamed 24-bit display due this summer from Great Valley Products.

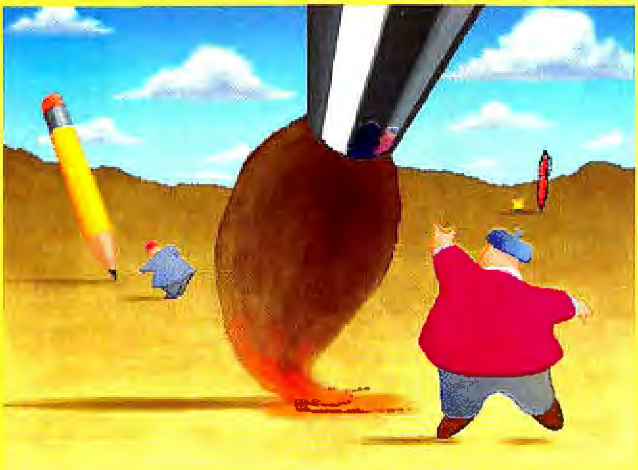
Until Commodore announces how it intends to pursue 24-bit graphics, true-color applications for the Amiga will probably be limited to what third-party display manufacturers bundle with their hardware. This will necessarily limit the choices of Amiga users for the foreseeable future.

Bob Ryan is a BYTE technical editor and author of Amiga DOS II Companion *(IDG Books, 1990). You can reach him on BIX as "b.ryan."*

A Painter's Brush with Mac Color

Roger Goode

As a professional artist and magazine art director I've worked with a number of paint programs, mostly on the Amiga. The features I appreciate most are a good gradient fill, a blend or transparency tool, a magnifying glass for close-up work, and a handy means of choosing and matching colors. Also of considerable importance to me are brush, edge-softening, and dithering or antialiasing tools. However, my most important criterion for a paint package is ease of use. Accordingly, I spent little time studying manuals and referred to them only when I met problems.



This PixelPaint Professional image began as a scanned drawing. The easy-to-use transparency tool and the program's speed helped make it the author's top choice.

PixelPaint's a Pro

PixelPaint Professional is my favorite among these paint programs. PixelPaint is not quite as easy to learn as Color MacCheese is, but its operation is straightforward and elegant, and the program offers the little extras that make it a powerful tool. One feature I particularly like is PixelPaint's transparency control. At the bottom of the picture window is a small slider control that allows you to set the level of transparency for any tool and any color quickly and accurately. This is the feature I use most. Because it is so near at hand and easy to use, it sped up my work tremendously.

However, I don't care for PixelPaint's zoom option, because it limits the size of the zoom window. This makes having a 16-inch screen seem like a waste.

Color MacCheese is an awfully close second choice. The deciding factor is the fewer number of options it offers, although, to be honest, I'm not sure how important it is to have a lot of little extras like perspective and 3-D tools. Sure they can be nice to have on hand, but they're certainly not necessary.

I like MacCheese because it's so incredibly easy to use. All the tools are clear and obvious in their application, and all the important options are kept handy in open windows. There's even a Help window that can remain open.

MacCheese doesn't fall short in power or results. I was gratified by the simplicity and excellent results of the gradient fill tool. I also liked the color-selection windows: One palette lays out standard preset colors in rows by value; a second palette has a rainbow-style color wheel that lets you pick a general color that you can then quickly modify with a value slide. This arrangement makes color selection about as fast and intuitive as it can be.

MacCheese let me whip through the creation of my graphic in record time. I don't want to make speed a virtue in the creation of art, but that facility let me focus more on my internal creative forces. I appreciated spending less time on the technical side and more on the creative side of painting.

Mixed Results

Studio/32 was easy for me to learn due to my familiarity with Electronic Arts' Deluxe Paint, my favorite Amiga paint program. The two programs are different, but their basic feel gave me a reference point.

Studio/32 is intuitive, and there was not much need to dicipher the tools and menu items. However, some tools worked in unpredictable ways. I was particularly distressed by the gradient fill. For the purposes of my picture, I was looking for a clean, linear gradation of color in the fill areas. I was troubled by the way that irregular shapes within the filled area and irregularities in the bounding shape created castoffs of the gradated fill. This is most evident in the jacket of the foreground figure (see the screen at right). The irregular gradation under the figure's right sleeve was an unplanned artifact of the program. For the sky fill, I was forced to remove all the drawing elements down to the horizon, fill the sky, and then replace the elements.

On the plus side, with Studio/32's gradient fill you can define gradients of more than two colors. For example, the sky goes from a deep violet-blue to a lighter blue-green, and then to light blue. All this in one fill and with complete control over the speed of the transitions. All the other programs use a more common gradation of one color to another without intermediates. I also liked opening multiple windows for a variety of control elements (e.g., the extended palette and a color-mixing window).

DeskPaint is among my least favorite programs because it is cumbersome and painfully slow in operation. When I'm in the process of creating artwork, I don't want to have to wait for the program. Although DeskPaint has all the tools to get the job done, it doesn't lend itself to a very fluid style of work. For example, to apply gradient fills, I had to enter a setup window cluttered with a set of preset options for fill direction, density, and so on. Going through all those options takes time, and the results were not always what I expected. So I had to go back into the setup procedure and try again. In other programs, I simply clicked on an area to be filled and dragged out a line to indicate the direction of the gradation. Simple and elegant: That's how it should be.

Studio/32's gradient fill created unwanted "castoffs," as seen in the foreground figure's jacket.

Oasis was not to my liking at all. First, there is no magnifying glass, so I did all my work in one size. Although this is not a disaster, it's nowhere near as easy as being able to zoom into an area and work up-close on details. The program is also extremely slow. I found myself spending a lot of time waiting while Oasis struggled with some surprisingly simple tasks.

I found the gradient fill the most difficult to use. For this and other functions, you must define an area by tracing it with a lasso or a marquee before the program applies the effect. I can't imagine anything more cumbersome. To create the gradation in the sky, I had to wipe out the entire upper portion of the picture, including the horizon, then create a filled rectangle, and finally redraw everything back over it.

But Oasis's methods for controlling transparency levels and brush sizes are very nice. Both methods use a small window in a lower corner that you simply click on and enter a number. It would have been nicer still to have a slider, like the one in PixelPaint, but this was still a nice feature.

The tools worked well, but it sure felt like more work than it was worth. If I really wanted to put in that kind of labor, I'd drag out my oils and canvas; at least I'd be able to smell the paint.

Roger Goode studied painting at the Art Students League of New York and has been an art director for two computer magazines. He now is the principal of the Proper Pup Studio, a graphic arts, desktop publishing, and illustration studio in Hillsborough, New Hampshire. You can reach him on BIX c/o "editors."

Color MacCheese

Color MacCheese shows off its handy palette window just above the the color wheel window (lower right). The sunset sky was done using a gradient fill.

The documentation of this package is like *Zen in the Art of Archery*: At first glance, both look too brief to cover their subjects adequately. In the case of Color MacCheese, though, the software's interface is so intuitive you'll be able to navigate through the program with only a few retreats to the manual.

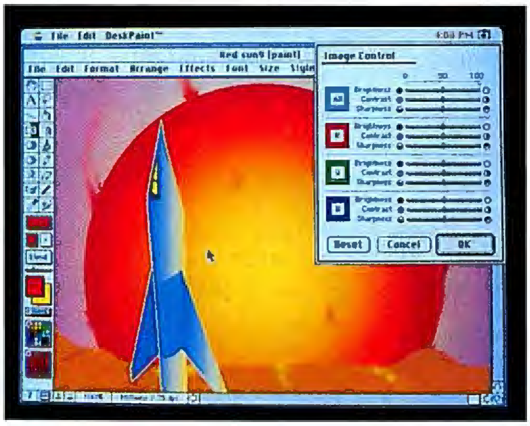
Color MacCheese capitalizes on the windowing system built right into the Mac. Thus, you can resize the canvas window and move tool windows anywhere on the screen. Color MacCheese offers a "handy palette" in a small window that provides a scrollable view into a subset of all available colors and patterns. You can add to the palette by selecting a region with either the lasso or the marquee selection tools and activating an entry on the selection menu. Similarly, you can remove anything new you add to the palette and easily customize it to hold colors and patterns for a specific drawing.

Color MacCheese's color wheel is perhaps its best feature. In a single 2-inch-square window, the entire color spectrum is available to you. You control a roving cross hair within the color wheel. On the circle's right is a graduated scale ranging from light to dark, its hue set by whatever color you've chosen.

The ability to perform blending and smoothing seems less developed in Color MacCheese than in the other packages. The blending tools you'll reach for most are the rake, which "stirs" pixels beneath the tool, and the water drop, which runs adjacent colors together. When you create graded fills, you can specify a direction for the flow of the fill as it blends one color into another. We found it difficult to lend a three-dimensional aspect to items using a graded fill because the blending is done in a linear fashion.

There's also a special highlighted fill. Its effects are pleasing to look at, but the process consumes time and memory. It's handy if you want to create rendering effects, such as a bright spot on a 3-D solid. For simple shapes like a circle, the algorithm does a good job of yielding an object that looks like a sphere.

All in all, the creators of Color MacCheese deserve high marks for clever design tools and for their efforts to create a powerful application with a simple interface. And best of all, the package comes at a price that's affordable: $99.



DeskPaint

Although it's a DA, DeskPaint offers some professional features, such as color control, shown here. The slider at the lower left controls the transparency of the "ink" used in a blend operation, and the palette at the bottom lets you choose colors nearest the last color used.

Here's a Mac 24-bit painting package with a unique twist: It's a desk accessory (DA). While some painting applications weigh in at hundreds of kilobytes or more, DeskPaint is a svelte 99K bytes of tight 68000 code. Despite its trim size, DeskPaint easily matches the capabilities of the bigger painting applications. It can produce both black-and-white and color artwork in different pixel sizes, it can read and save files in several formats (including TIFF), and it offers excellent printing controls. One drawback is that DeskPaint supports only the RGB color model.

DeskPaint is also fast: It whipped open a 1.6-MB TIFF file in 12 seconds flat, while other painting applications took 43 seconds or more. The package achieves this speed by jamming everything into memory, so you'll need lots of RAM to work with large documents. However, when we zoomed in and began editing a 24-bit image using DeskPaint's split-window mode, we found that the pixel updates occasionally got sluggish.

The DA can perform good blends, although you're limited to two colors. A dialog box lets you set the blend direction and preview the results. You can control the transparency or opacity of colors (including blends) as they are applied to the artwork. There are also tools for skewing or distorting portions of the artwork. Interestingly, DeskPaint sports an Image Control dialog box, where you can adjust the artwork's contrast or colors in much the same way that you can with retouching software.

The page layout function lets you adjust the document's dpi setting (including values for typesetters, not just color PostScript printers), scale, and pixel size. Other printing functions include previewing the output and cropping the artwork. But we encountered errors when attempting to print artwork that was deeper than 8 bits to a PostScript printer. Zedcor's technical-support staff was helpful as we discussed the problem and tracked it down to a bug in the program's printing code. Now aware of the problem, Zedcor promises a fix.

Currently, DeskPaint doesn't support the Wacom tablet's pressure feature, although this is planned in a future release. While it doesn't have zillions of special effects, DeskPaint is quite versatile. As a DA, it's always there at a moment's notice. And there's nothing wrong with the price: $199.95 buys you both DeskPaint and DeskDraw, a drawing DA.

continued

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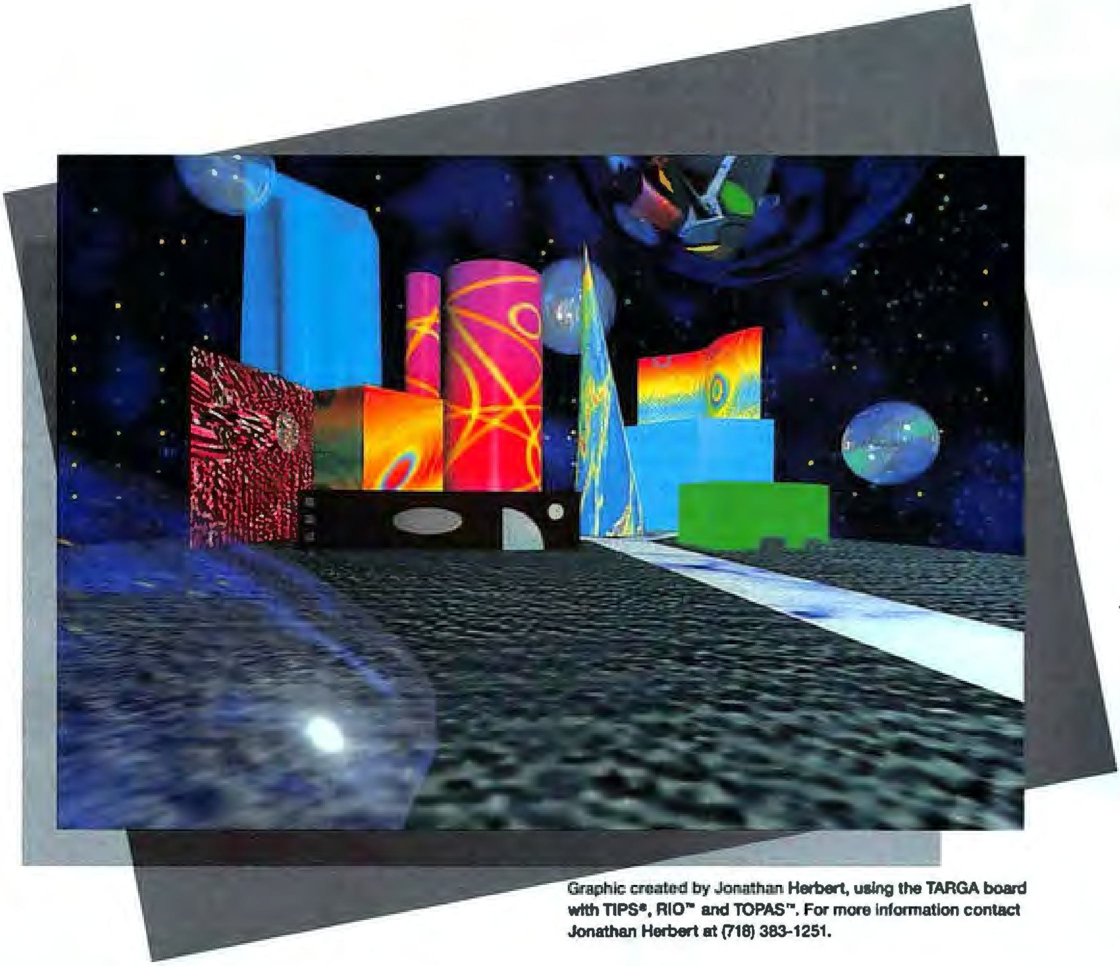
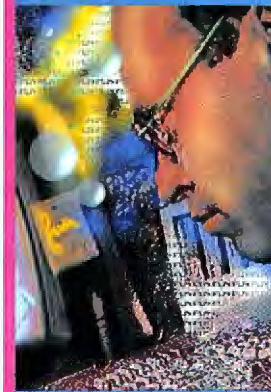


Graphic created by Jonathan Herbert, using the TARGA board with TIPS®, RIO™ and TOPAS™. For more information contact Jonathan Herbert at (718) 383-1251.



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Oasis

Oasis can handle a variety of special effects, such as a gradient fill inside the text, as shown here. The tools can be configured for a wide range of effects, but, unfortunately, there's no magnify or fatbits capability for detailed work.

Oasis ($795) is a latecomer to the Mac, introduced last March, but a number of significant features make it a powerful contender in this crowded market. You can tear off tool palettes and some menus to arrange the layout of the screen to your taste. Similarly, using a matrix of attributes, you can adjust the size and density of the painting tools. This feature lets you modify the tools' behavior so that you can paint with the electronic equivalent of pastels, inks, pencils, oils, or watercolors. With a Wacom tablet, you can further configure the tools so that ink flow and smears vary for realistic effects. For example, we set up the eraser tool so that it stripped off varying levels of color. The final results looked just like a pastel sketch on which we had used a rubber eraser. We achieved the most realistic color-pencil effects using this package.

Oasis also has a slew of special effects. For example, you can flow a gradient fill within text characters to produce a logo. A "lightbox" function lets a background scanned image show through dimly so that you can trace over the image or copy portions of it using a reveal function. An emboss effect lets you give a stamped appearance to an image, and you can control the lighting direction to vary the results. Oasis works with Truevision's NuVista and NuVista+ video boards and with RasterOps's 364 video boards to capture live NTSC video. It also can use software modules to operate color scanners.

Oasis's features would have made it an easy winner except for two problems. First, printing support is limited: You can't adjust the document beyond 72 dpi, which makes scaling for printing difficult. Even worse, there's no zoom function. There's simply no way to tweak the artwork at the pixel-by-pixel level. If you cannot adjust the artwork as it stands on the screen, you're stuck. Time Arts promises that version 1.1 (due this summer) will have a magnifying function. We hope so, because this fatal flaw cripples what stands to be a fine painting application.

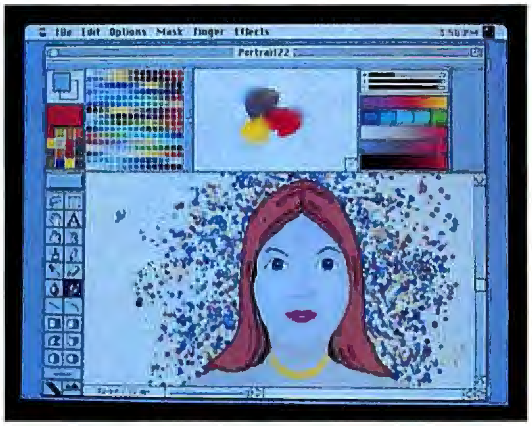
Compared to the other painting applications, the $695 PixelPaint Professional is an old-timer: It started shipping in 1989. While it's starting to show signs of age, PixelPaint Professional still has some features, such as the ability to print separations, that are unmatched by even the latest entries in the 24-bit paint competition.

If you first mastered Mac graphics using MacPaint, you'll find PixelPaint Professional's tools and behavior similar. It has good fill controls and an army of special effects, such as emboss, neon, and fractal. You can toggle these effects off or on individually for each tool. Drop shadows, whose position and color you can set, can be applied to many graphics operations.

You can zoom in on an image to work on fine details. A "split screen" mode lets you view your changes to the artwork at normal size while you work on a magnified section of the image. You adjust the dpi setting of the document by clicking on a setting at the window's bottom. Clicking on a bar at the top of the painting window opens a palette, where you choose colors or mix custom blends. Another button controls masking. You create masks by painting into a window or by copying a section of artwork from the Clipboard.

PixelPaint Pro

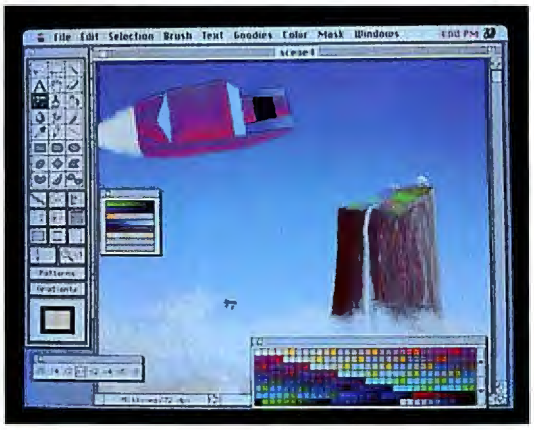
Despite its age, PixelPaint Professional has many features that rival those of later painting applications. You can use different color models, mix colors, or choose neighboring colors while painting. It also can produce color separations.



PixelPaint Professional is not without a few annoying quirks and limitations. It lets you work on only one document at a time, and its response to screen updates and tool action can sometimes be sluggish. TIFF files are limited to gray scales.

Despite these quirks, PixelPaint Professional is the only package we looked at that can print color separations—a must for some applications. It also provides support for the Pantone color-matching system (PMS). Based on our look at a beta version of PixelPaint Professional 2.0, which should be shipping by the time you read this, the new version promises many improvements, including the ability to handle 24-bit TIFF files and support for the Wacom tablet's pressure feature.

continued



Studio/32

Studio/32 lets you tear off certain tools, such as the Palette, Magnify/Reduction, and Gradient tools. You can set the document's dpi easily for exact printing control.

This $695 painting application has a voracious appetite for RAM: In 24-bit mode, Studio/32 requires 5 MB of RAM right out of the gate. Along with this huge initial memory demand, Studio/32 also creates a disk-swap file for virtual memory management when you're working with large pieces of artwork. As a result, performance slows to a crawl.

Tear-off palettes provide you with ready access to such tools as the magnification and color selectors. This means that you won't have to constantly be moving the mouse to the left side of the screen.

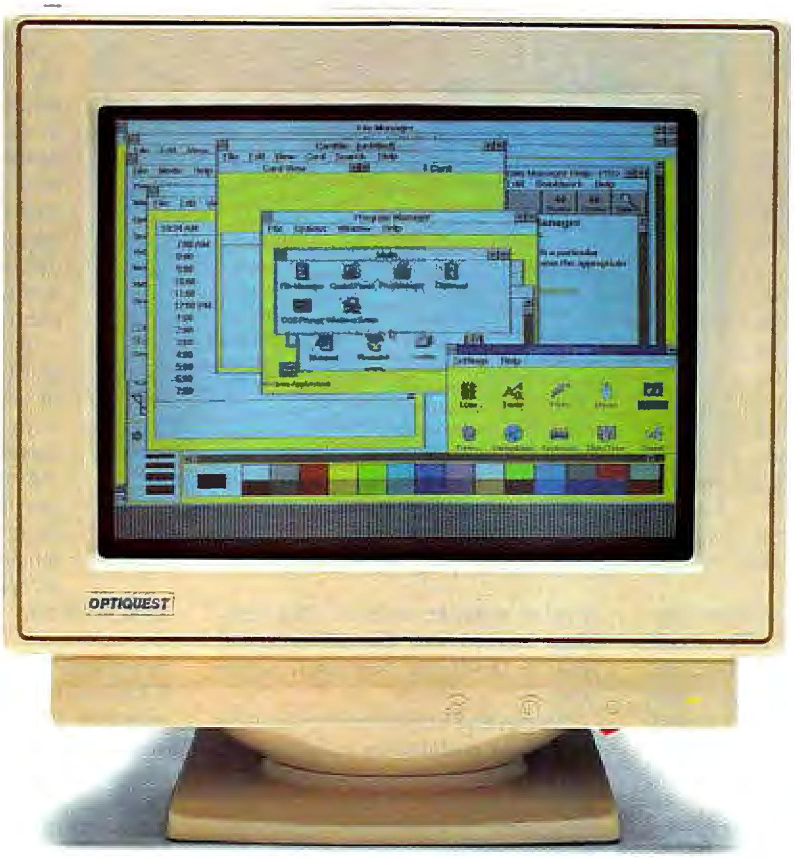
You can configure the magnification selector to work in an expanded view of the artwork or in a split-screen view that shows both the magnified area and the artwork at normal size. At first we found the gradients selector confusing to work with, but then we discovered that dragging the slider onto the gradient bar sets up the color blends. Gradient blends can have several different color blends, so you can easily create imitations of the gleam of metal pipes or mirrors, for example. In addition, the Blend, Sharpen, Smudge, Antialias Brush, and Airbrush tools all support the Wacom digitizing tablet's pressure feature.

Studio/32 also offers you a variety of special-effects capabilities, including embossed text, shear and skew operations, shadow effects, and a unique "define perspective" function that fills a plane with a user-defined pattern. Masking operations can make use of a selection of colors (e.g., all the colors in a painting of a red Trans-Am) and a tolerance level (i.e., how closely a color in an image matches the color that you have selected).

Studio/32's support for printing is good. You get the advantage of PMS, and changing the document's dpi setting is just a menu selection away. You simply preview the print page and choose PostScript, color PostScript, or QuickDraw printing mode. You can even use binary PostScript, which requires less data sent over the network and makes for faster printing.

continued

Non-interlaced



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State-of-the-Art PC Art

Cal Vornberger

Having beta-tested my fair share of graphics programs, I am well acquainted with the idea of a "bug report." I sometimes wonder whether there really might be some insects that thrive on the silicon in computers. This idea inspired my work "Bug Reports" (see the screen).

In giving these 24-bit paint programs a thorough workout, I tried to create the type of image that might be found in a production environment and to use tools and techniques that I incorporate in my work. From within TIPS, I used a video camera to capture the image of a circuit board with a chip pulled from its socket. I saved it as a TIPS "window." The illustrations also make use of freehand drawing tools, masks, gradations, and other digital drawing techniques. I sent the three "Bug Reports" images for output to 35mm slides (at 4000 lines of resolution) to Graf Werk in New York City, which used an Agfa Forte system.

Because it is vector based and infinitely scalable, Lumina's font-creation ability excelled compared to the bit-mapped fonts in the other two PC programs.

While the version of Lumena I tested came bundled with the Hercules Graphics Station card and is called Hercules Art Dept., it is virtually identical to the stand-alone version from Time Arts that I have been using for the last four years in my commercial work. I also teach computer illustration at the Pratt Institute in Manhattan, where Lumena and TIPS are the mainstays of our computer illustration curriculum. When I began writing this review, I was not at all familiar with Tempra. The version that I tested was designed to run only on the Hercules board. Its similarity to TIPS made it easy to learn.

Type Control

Smooth gradations from one color to another are a basic function of all three programs. Tempra, however, gives the designer greater control over the type, direction, strength, and amount of dithering used in creating gradations. You can vary the amount of dithering between colors to create smooth transitions or stonelike textures. This technique worked well for the simulated stone in the border (see small screen shot).

Tempra also lets you employ this type of dithered gradation as a tint or wash with varying degrees of transparency. I used this technique to texture the main background in the Tempra illustration by laying down a nondithered gradation and then going over the original gradation with one that used the same colors, in the opposite direction. I set dithering to "full" and used a very slight tint level. This ability to transparently layer effects on top of each other lets designers create many interesting textures and add depth to an illustration.

Another feature I like about Tempra is its ability to open other file formats, notably TARGA, PCX, TIF, and PC Storyboard. It can also save in all those formats except PC Storyboard. I opened my image of the chip coming out of its socket (saved in TIPS window format) directly from within Tempra. I had to resave the window as a TARGA file, however, to open it in Lumena.

Lumena is in a class by itself. The program has an overwhelming number of tools, modes, and other image-processing effects. I spend the better part of a semester teaching Lumena at Pratt.

The program has no Undo function per se. Lumina does let you make buffers that serve as temporary holding places for your work. You must remember to continually save to the buffer as your work progresses. If you make a mistake, you can retrieve from the point at which you last saved to the buffer. You can also have multiple buffers and cut and paste from one to the other.

The real power in Lumena comes from its ability to combine drawing tools with different modes to create hundreds of interesting effects. Lumena also can import various alien file formats but saves in its unique PIX format. There is an option to save in TGA or TARGA format.

Venerable TIPS

If Lumena is king of the high-end paint programs, then TIPS is its grandfather. Venerable and stable, TIPS has been around since the TARGA board's beginnings. It still acquits itself well. While it is nowhere near as complex as Lumena, all tools and functions are logically laid out in the menus.

TIPS gives you all the standard drawing tools plus gradations, blends, tints, and a range of other effects. The masking tool is very effective. I liked TIPS's masking feature the best out of all the programs. You can turn on the masking function and draw a mask with any of the drawing tools (e.g., filled rectangles, hollow circles, and brushes). TIPS also lets you turn on dithering for gradations, although its dithering is not as coarse as Tempra's. TIPS has a handy Undo function.

Of these three programs, Lumena is best when it comes to font manipulation. Its fonts are vector based and infinitely scalable, and can even be saved in a vector file for cleaner output. Both Tempra and TIPS use bit-mapped fonts, but Tempra doesn't do a very good job of font scaling. There isn't a great range of font sizes in Tempra, and when I scaled down my choice to the size I wanted,

Tempra offered the best control of gradations among the three PC packages. It also did an excellent job of creating textures like this simulated stone.

text became ragged. TIPS has a greater choice of fonts and seems to antialias scaled fonts better. The programs let you do gradations easily within fonts, and all support font antialiasing.

I sorely missed in the Hercules version of Lumena the ability to zoom in and out using the keyboard. I find it much easier to press a function key to zoom in on a particular area of my drawing to do small touch-ups than to select a menu item and drag a bounding box around the area to be magnified. Lumena is best used with a graphics tablet. You can get by with a mouse in both TIPS and Tempra, although both work well with a tablet.

One pet peeve I have about TIPS and Tempra is their modality. Often I have to click through too many menu layers to get to the tool or effect I want. One reason I like Lumena so much is that its menu system has an immediacy. I can "flick" off my drawing screen and onto the menu screen, change my tool, and be back at work in a lot less time than it takes to click through several layers of menus in Tempra and TIPS.

My dream 24-bit paint program would combine the best of these three. Is such a thing possible? I don't know. Do spiders eat silicon?

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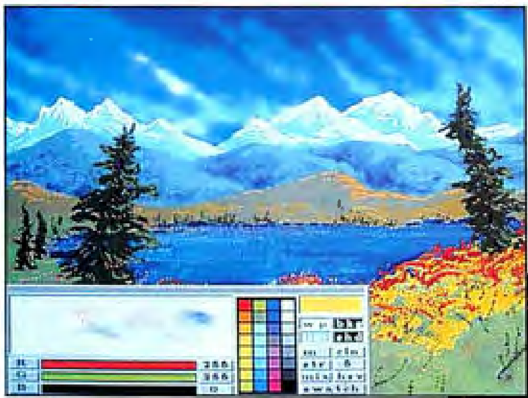
Lumena



Lumena's toolbox appears on a monochrome display. (You need both color display and monochrome display to run Lumena.)

Lumena's canvas window is separate from its tools window. Here, the palette and mixing window is on-screen.

Lumena, a PC program, needs the "right stuff" to run effectively, including at least 2 MB of EMS 3.2 memory. The version we tested required the Hercules Graphics Station Card ($3995 for the bundle, as tested; $2495 for the software only), as well as a monochrome adapter.

Why two displays? Lumena doesn't offer pop-up menus. The display connected to the Graphics Station becomes your canvas, while the monochrome display is your command control console—sort of a toolbox.

During operation, the cursor is active on either the canvas display or the control display. You toggle between the two by pressing the space bar or by moving the pen off the digitizing pad. (The second technique of switching screens uncovered an annoying feature of Lumena. Whenever we let the stylus wander or even tilted it in the hand, the system would flip the cursor to the alternate display and emit an irritating beep.) We used the space bar because we occasionally lost the cursor in digital limbo whenever we moved the stylus off the bitpad.

We're not convinced that Lumena's dual-display arrangement is better than a single-display system. You might argue that the Lumena system allows you to view an entire uncluttered canvas screen. However, other packages work quite well with one display.

Although you can use a mouse, the documentation strongly discourages it in favor of using a digitizing pad. Actually, we found the software wouldn't respond to a Microsoft Mouse clone; we had to switch to a true Microsoft Mouse. Then we noticed "blind spots" on the canvas display. These were pixel-wide horizontal stripes that the mouse pointer refused to land on. We gave up on a mouse and switched to the GridMaster pad.

Lumena's copy-protection technique is too protective. Included in the package is an EPROM chip. You have to open your machine, pull out the Graphics Station card, locate its BIOS EPROM, and replace it with the new chip. Apparently, that chip has been programmed with a serial number that corresponds to a serial number hidden in your copy of the Lumena software. When you execute Lumena, the software checks its serial number against the one in the EPROM. Beyond being a pain in the neck, this procedure is one more thing to go wrong.

In operation, we found that Lumena suffered two great flaws. First, while its fatbits appear in a kind of pop-up window, changes you make in the magnified view do not appear on the canvas until you close the pop-up window. (Canceling the pop-up window causes Lumena to "forget" any changes you have made.)

Worse is Lumena's lack of a true undo function. You've got to train yourself to regularly save images to disk. Fixing your picture after a slipup is then a matter of reloading the image file. Heaven help you if you've got a slow disk drive. This also discourages experimentation, which is critical in using paint packages.

One advantage of Lumena is that the palette window can remain on-screen while you're working, so you can dip into the palette to pull up a new color. This is in contrast with the other PC paint packages that keep the palette attached to the tools menu, which forces you to close the pop-up tools and palette menu while you are painting.

Tempra

Tempra's zoom window magnifies the top of a tree. The smaller rectangle off to the right picks the area to be magnified. Notice that Tempra's color palette bar is available across the bottom of the display.

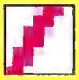
Tempra ($495) is a one-screen package for the PC with its own windowing system. We tested it with a two-button mouse (Tempra also accepts Summagraphics-compatible tablets, including the GridMaster) and the Hercules Graphics Station card. Pressing the right mouse button calls up the Tempra menu, which is composed of the tools menu and the palette bar. From there, menu buttons call up individual functions and their associated parameters. For example, one menu button accesses draw functions, such as freehand drawing and geometric shapes.

The color map lies below the pop-up menu. It's a rectangular bar of 256 colors. Clicking on any selection makes that color the current painting color. While you're working, Lumena's pop-up menu disappears, taking the color palette with it. Some users could be distracted by switching between the canvas and the menu to get colors; we were not bothered by it.

You alter the current color by clicking on the color icon. This activates the color menu, from which you select one of four color models to "mix" a custom color. Through the color menu, you can build a

Tools and Terms: A True-Color Glossary

airbrush A fine-mist paint tool used to create halos, fog, clouds, and similar effects. Most paint programs let you control the size and shape of the application area. Some packages provide a transparency adjustment that determines the density of the applied color.



antialiasing A blending effect that smooths sharp contrasts between two regions of different colors. Properly done, this eliminates the jagged edges of text or colored objects.

blend The smooth transition from one color to another. Blending tools give a realistic look to a drawing, especially if you want to create a smooth shadow.

brush A paint package's most basic image-creation tool. Most packages let you select a variety of sizes and shapes. Many let you customize shapes.

CMY A color model used by the printing industry that is based on mixing cyan, magenta, and yellow. It's also referred to as CMYK, with the *K* denoting black. The *K* was added after printers discovered they could obtain a darker black using special black colorants rather than by combining cyan, magenta, and yellow alone.

color model A technique for describing a color (see *CMY, HSL, HSV*, and *RGB*).

curves and arcs Paint packages handle curves and arcs in a variety of ways. Examples include spline curves, wherein you specify a series of points and the package draws a curve that smoothly approaches those points, and "three-point" curves, in which the first two points anchor the ends of the curve and the third selects the apex.

drawing tools The means of creating freehand lines or basic geometric shapes. Paint packages often provide an ellipse-drawing function as a variation of the circle (or vice versa) and a square-drawing function as a variation of the rectangle. Virtually all packages offer filled geometric figures, the fill item being either a solid color or a pattern.

fatbits Extreme magnification of individual pixels to allow easy pixel-by-pixel editing of images.

fills Designated areas that are flooded with a particular color. Most paint packages let you create geometric shapes in filled form. All packages also let you fill irregular closed regions. Two types of such fills exist: A *seed fill* floods all connected regions with the color specified by the mouse or stylus pointer; a *boundary fill* floods a color until the algorithm encounters a specified boundary color.

gradient fill A fill composed of a smooth blend from a starting color to an ending color. There are many variations on this theme. Most programs let you fill with patterns, some packages let you apply textures, and others have "smart" gradient fill routines that lend a three-dimensional appearance.

HSL A color model based on hue, saturation, and luminance. *Hue* is the attribute that gives a color its name (e.g., red, blue, yellow, or green). In this model, *saturation* refers to the strength, or purity, of the color. If you were mixing watercolors, saturation would specify how much pigment you added to a given amount of water. *Luminance* identifies the brightness of a color. For example, full luminance yields white, while no luminance yields black.

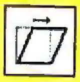
HSV A color model based on hue, saturation, and value. *Hue* specifies the color, as in the HSL model. In this model, *saturation* specifies the amount of black pigment added to or subtracted from the hue. *Value* identifies the addition or subtraction of white pigment from the hue.

lines The line tool draws straight lines, typically from point to point. Most paint packages let you continue lines in a fashion that permits rapid creation of polygons.

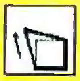
mask The electronic equivalent of placing transparent tape over selected regions of an image, a mask marks pixels that remain unchanged by subsequent painting operations. For example, you might mask out a mountain range and add background clouds to the sky. In the final image, the clouds will appear between the peaks.

PMS The Pantone Matching System, a universal language for solid-color specification and reproduction. Colors defined by PMS receive a unique number and mixing formula. Consequently, when artists specify a PMS number, they can be sure that the final printed product will match the chosen color.

RGB A color model based on the mixing of red, green, and blue.



shear A tool for distorting a selected area vertically or horizontally.

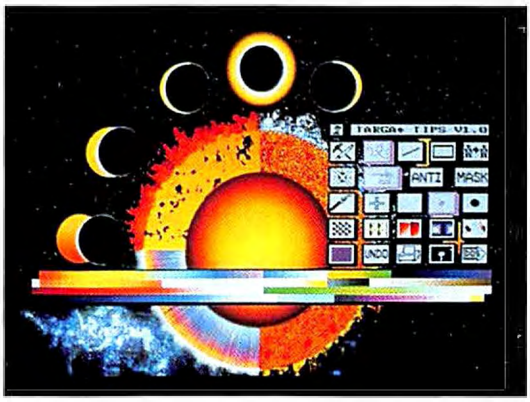


skew A tool that slants a selected area in any direction.

zoom (see *fatbits*).

color spread by specifying two "endpoints" in the color map. Tempra automatically alters the color-map entries between the two endpoints so they evenly blend from one to the other.

The zoom function activates a movable rectangle whose contents are magnified and projected in the zoom window. You can change the size of the rectangle in discrete steps, thus increasing or decreasing the magnification. Although you can alter only single pixels in the zoom window, some effects (e.g., tint) are active. Furthermore, four tools associated with the zoom window—the most notable being "local undo"—allow you to undo any mess you've made in the zoom window. While you're working in zoom mode, you can observe the changes you make on the canvas.



TIPS

A supernova illustration shows off some of TIPS's blending and gradient-fill capabilities. Notice that the menu and color palette must share screen space with the drawing.

Truevision's TIPS (for Truevision Image Processing Software) supports the TARGA+ video board, which makes it a more expensive alternative to the Hercules-compatible products.

At a casual glance, you could easily mistake TIPS for Tempra. Both share the same general pop-up menu layout. The menu is a rectangle of square icons arranged in a grid. The leftmost row of icons changes the remainder of the main menu into icons that represent lines, rectangles, circles, and other function settings. Clicking on the rectangle icon leads you to a text submenu, where you can select attributes (e.g., whether or not the rectangle is filled). The menuing system is easy to learn; once you understand its underlying logic, you can navigate without problems.

You select drawing colors from the TIPS palette bar, which stretches below the menu and gives you instant access to 256 colors. TIPS logically groups the colors by hues. However, if you prefer, you can click on the current drawing color to call up a color-mixing menu and then fabricate a custom palette. Furthermore, you can click on an on-screen pixel to make its color the current drawing color.

TIPS's magnification capability is the easiest to work with of all the PC packages. By pressing the F10 key, you increase magnification by a factor of 2. For image editing, TIPS can magnify the picture eight times—enough to enlarge individual pixels to discernible rectangles. The F7 key returns you to normal magnification.

In other PC paint packages, working with a magnified image is sometimes restrictive. But in TIPS you can smoothly scroll about the full canvas even in magnified mode. Because scrolling is hardware-assisted, working with fatbits is a joy rather than a pain. (You can also activate the magnification while the menu is on-screen. This capability is especially useful if you want to home in on a specific pixel to use its color as the current drawing color.)

TIPS's most unique drawing implement is the fractal tool, which allows you to select a triangular region that acts as a frame within which TIPS generates hordes of fractal-guided triangles. The net effect simulates mountains or hilly terrain. Although we explored the fractal tool only peripherally, applying the proper fill routines could yield rapidly constructed landscapes.

TIPS comes with printer drivers for a variety of color printers. The documentation also points out that Truevision makes available a public domain printer-driver design specification. Knowledgeable programmers can use this to create custom printer drivers.

Finally, although we didn't test it for this review, TIPS can work with the TARGA+ video board to accept live video and overlay the video with graphics images on-screen.

continued

How to Choose the Right Color Application

There's a plethora of color applications on the market, so it's easy to assume that you'll find one that suits all your needs. Unfortunately, this is not the case.

The variety of applications speaks to the fact that color manipulation requires different tools for different jobs. We divided these jobs into three categories: painting, drawing, and retouching.

Painting with Pixels

Painting applications, the group we chose to evaluate in this review, handle artwork as a collection of pixels, or a *pixel map*. These applications operate much like the artist's traditional canvas and palette, with electronic tools functioning like their studio counterparts. You can select a hue from a color palette, mix it with other hues, and then freely apply it to the screen by painting, smearing, or spraying. Many artists will find themselves on familiar ground when using painting applications. The great flexibility that this software provides for laying down colors on the screen lets artists produce work with a distinctive style.

The difficulty comes when you want to modify an image. For example, if you misplace a colored oval, it becomes part of the image and you cannot remove it easily. That's because everything in the image—including text—is simply pixels. If you erase the misplaced oval in a complicated illustration, the eraser tool removes all pixels, whether they belong to the oval or to the background. Text suffers as well, because it's reduced to pixel patterns on the artwork.

Furthermore, pixel maps undergo serious distortion when they're scaled down, either for printing or inclusion in a document. This occurs because information—pixels—must be discarded to reduce the artwork's size. You can reduce printing distortion by printing the image at multiples of the output device's resolution—say 150 or 300 dots per inch. At such resolutions it's possible for the printer to reduce the size of the pixels themselves, rather than throwing them away.

Drawing Programs

Drawing, or object-based, applications treat artwork as geometric objects (hence the term *object-based*). These applications operate much like drafting tables, T-squares, and templates, in that specialized tools make circles, rectangles, and curves on the screen. You make color blends by selecting a starting and an ending color for an object and requesting a fill operation.

The drawing application's advantage is that it provides you with precision and control over the artwork. As an object, an oval can be placed into position using electronic rulers and guides. Also, you can pick up and move a misplaced oval.

Drawing programs create text as characters of a certain typeface and point size, so you can use outline fonts to display the text on-screen or download it to a printer for clean output. Since these programs describe artwork using geometric formulas, you can easily resize the work with no loss of information. This also lets the artwork take advantage of high-resolution output devices such as typesetters.

The disadvantage of these applications is that drawing a picture requires that you define it as sets of objects, which can be a very rigid and confining way to draw.

Image Retouching

Finally, there are instances where you might want to work with an existing pixel-mapped image, typically from a scanner. You might want to crop the telephone lines out of a forest image or enhance the contrast in a catalog's product photo. Retouching applications handle these tasks. Like paint applications, retouching software works with pixel maps. It typically has few painting tools. However, the programs can modify the color balance in a image, change its contrast, or apply filtering operations to remove visual artifacts from a poor image. Since scanners supply the data that retouching software works with, many of these applications have special menus or software modules to operate them.

Because we're evaluating painting packages here, we obviously won't be looking at drawing applications such as Corel Systems' Corel Draw (see Reviewer's Notebok, April), Adobe Illustrator (see "An Artist's Old Tool Learns New Tricks," February), or Aldus FreeHand (see Short Takes, May). We qualified Adobe's Photoshop (see Short Takes, April 1990) and Letraset's ColorStudio as retouching packages.

Because painting and retouching software works with pixel maps, determining which category some of the software fell into was a challenge. For example, ColorStudio has as many painting tools as any paint application, but its real strengths lie in image manipulation. The same can be said for PC-based packages such as Desktop Computing's Desktop Artist and Micrografx's Picture Publisher Plus (see "High-Quality Image Editing Develops on the PC," May), which will support 24-bit color display by mid-year.

On the other hand, paint packages sometimes blur definitions, too. For example, DeskPaint has color-correction control, and Oasis can capture images from several NTSC video boards and perform some clever scanned-image manipulations.

The point is, before you buy any color software, you should first determine what jobs it must handle. If your work requires a lot of text or fine precision, you should seriously consider a drawing package. Artwork demanding a unique style or look requires a painting package. Fixing scanned photos is the domain of retouching software. Once you have determined what category your job fits into, shop around for the software that fits your budget.

What to Buy: BYTE Lab Picks

Choosing the right paint program is a subjective matter based as much on individual tastes as on specific tools and features. The following selections represent the BYTE Lab's favorite true-color paint programs. (Also see the text boxes "A Painter's Brush with Mac Color" and "State-of-the-Art PC Art" to find out which packages our professional artists rated highest.)

At the high end, we chose Studio/32 as the overall best Mac painting package because of its good color and printing control, plus support for PMS. We wish, though, that Electronic Arts could put an end to its RAM binges. If you absolutely have to produce color separations in-house, PixelPaint Professional is your only option, despite its age and lack of tablet support. As we mentioned earlier, PixelPaint Professional 2.0 should be shipping by the time you read this, and it will be worth a look.

For low-end Mac software, Zedcor's DeskPaint is a good buy. It's fast, handles a variety of image formats, and has just enough professional features to make it invaluable for those who need to open a graphic, tinker with it, and then drop it into a document. As a DA, DeskPaint is available from within any application for the System 6.0.x crowd. The company says that Wacom tablet support will be added sometime this summer. Delta Tao Software receives an honorable mention for Color MacCheese's incredibly low price, which comes (as the vendor freely admits) at the expense of variety in file-input format and document resolution.

On the PC side, Tempra gets our nod. It's the least expensive of the lot and handles a variety of image formats. Another plus is that Tempra doesn't require additional hardware beyond the single 24-bit monitor and adapter.

On the question of which is the better paint platform, the Macintosh is our machine of choice. Its operating system, 32-Bit QuickDraw graphics software, and printer drivers are mature and have been field-tested for several years. Even many of the tool icons (e.g., the paintbrush and the lasso) have become standardized among the different applications. Furthermore, the Mac's integrated application environment means that you can easily place artwork created in any of the Mac painting packages into other documents.

Now that 24-bit graphics has arrived on PCs, the Mac is getting some competition. But the Mac isn't standing still, as planned upgrades to much of the Mac painting software indicate. The 24-bit paint competition will continue to be an interesting race—one in which, for once, the user—the artist—will come out the winner. ■

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COMPANY INFORMATION

Delta Tao Software, Inc.
(Color MacCheese 2.07)
760 Harvard Ave.
Sunnyvale, CA 94087
(408) 730-9351
fax: (408) 730-9337
Circle 1401 on Inquiry Card.

Electronic Arts
(Studio/32 version 1.1)
1820 Gateway Dr.
San Mateo, CA 94404
(800) 245-4525
(415) 571-7171
fax: (415) 570-5137
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Hercules Computer Technology, Inc.
(Lumina/Hercules Art Dept.)
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Berkeley, CA 94710
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fax: (415) 540-6621
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Mathematica, Inc.
(Tempra)
402 South Kentucky Ave.
Lakeland, FL 33801
(813) 682-1128
fax: (813) 686-5969
Circle 1404 on Inquiry Card.

SuperMac Technology
(PixelPaint Professional 1.0)
485 Potrero Ave.
Sunnyvale, CA 94086
(800) 345-2888
(408) 245-2202
fax: (408) 735-7250
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Time Arts
(Oasis 1.0)
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Santa Rosa, CA 95407
(707) 576-7722
fax: (707) 576-7731
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Truevision, Inc.
(TIPS)
7340 Shadeland Station
Indianapolis, IN 46256
(317) 841-0332
fax: (317) 576-7700
Circle 1407 on Inquiry Card.

Zedcor
(DeskPaint 3.03)
4500 East Speedway, Suite 22
Tucson, AZ 85712
(800) 482-4567
(602) 881-8101
fax: (602) 881-1841
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These companies provided equipment used for testing:

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(GridMaster)
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fax: (215) 361-0167
Circle 1409 on Inquiry Card.

RasterOps
(RasterOps 24L)
2500 Walsh Ave.
Santa Clara, CA 95051
(408) 562-4200
fax: (408) 562-4065
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Tektronix, Inc.
(Phaser IIPX)
Graphics Printing and Imaging Division
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fax: (503) 682-3408
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(SD-510C)
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Paramus, NJ 07652
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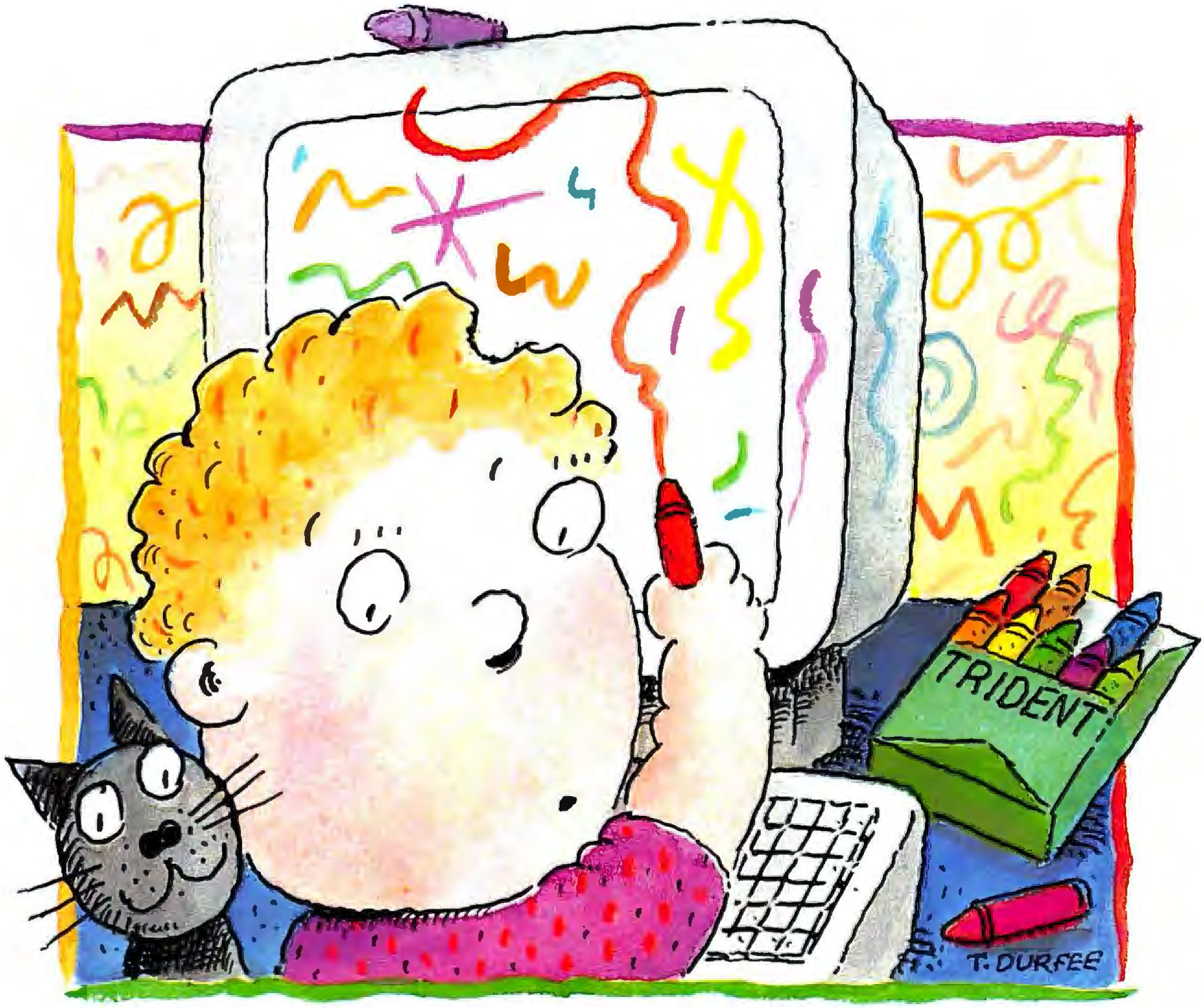

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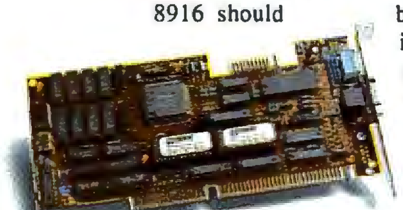

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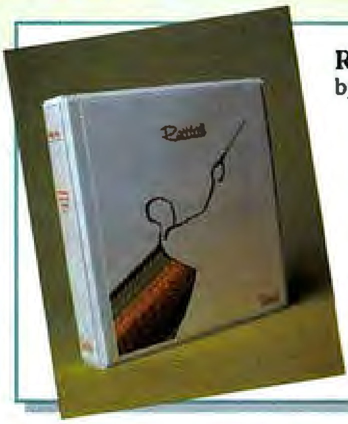

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BYTE REVIEWS

HARDWARE

No-Compromise Notebooks with 386SX Power

STEVEN J. VAUGHAN-NICHOLS

Once upon a time, if you wanted to take a computer on the road, you had a choice: You could have a full-powered computer, or you could take a laptop. Portability wasn't a problem—just give up your hard disk drive, possibly your floppy disk drive, a decent screen, and any pretenses of power. Times have changed.

First came the spate of notebook-size 286 machines, followed by Compaq's LTE 386s/20—the first notebook-size SX machine (see "Perfectly Portable," February BYTE). Now, a flood of notebook-size 386SX computers has hit the streets. These no-compromise systems have more power than many desktop computers and can accommodate an external monitor and keyboard. BYTE has rounded up the first of this new breed: Advanced Logic Research's (ALR) Venture/16, the AST Premium Exec 386SX/20, the Dataworld NB320SX, the Everex Tempo LX, the Grid 1450SX, the Samsung NoteMaster 386S/16, the Texas Instruments (TI) TravelMate 3000, and the Toshiba T2000SX. Serious computing power is ready to hit the road.

Powerful Selection

Computing road warriors have never had more of a selection. BYTE asked vendors to supply systems configured with 1 megabyte of system memory, a 20-MB hard disk drive, and one high-density 3½-inch floppy disk drive. With these configurations, prices range from $2650 to $5499—quite a spread. I tested both 16- and 20-MHz SX machines. A rundown of the system configurations and options appears in the features table.

Having this kind of power in a laptop is nothing new, but until now such machines were always tied to the nearest power outlet. These notebook computers are much smaller and lighter than their AC-powered counterparts. Any of them will fit into your briefcase. And except for the Grid 1450SX, these are under-8-pound wonders that won't tire your arm during the daily commute. But to shed weight, these systems have made the AC power supply an external component. With their maximum battery life just over 2 hours on average and just under 4 hours at best, you'll have to make room in your briefcase for the brick-size power supplies that come with them.

The BYTE Lab ran each of the machines through its notebook computer test suite, a scaled-down version of the standard BYTE benchmarks that includes low-level and application benchmarks and a battery-life test that simulates a word processing session. (For more on these benchmarks, see the text box "From the Testing Notebook," February BYTE, page 152.) The results are shown in the graph; I've included Compaq's LTE 386s/20, a 20-MHz SX notebook computer, for comparison.

Key Subsystems

Notebook computers have many vices, one of which is cramped keyboards. The keyboards on all the reviewed machines except the Toshiba T2000SX are barely adequate for extended typing, although most are tolerable for brief periods. Even the models that use extensive overlays to fit all the keys into limited space are tolerable only for short work sessions. Only the Everex and Grid keyboards have full-size function keys, and none of the systems has a detachable keyboard like that on the Compaq LTE 386s/20.

Short key travel makes working on these keyboards like running on concrete: It doesn't hurt at first, but the pounding wears on you the longer you work. Notebook-computer keyboards are fine for small jobs, such as writing a memo, but their charm quickly evaporates when they're used for bigger tasks.

The supertwist LCDs in these systems have come a long way. Characters are sharp and clear, although you will see some smudging when the screen images change quickly. Despite this, text-based applications like WordStar 5.5, Procomm 1.1B, and Quattro Pro 2.0 are as usable here as on any desktop PC. But only the most fanatic Windows users should attempt running that environment on a notebook computer. The CPUs have the horsepower for the assignment, but you'll quickly lose track of the cursor.

Improvements in backlighting, sidelighting, and LCD technology have made these systems usable in conditions

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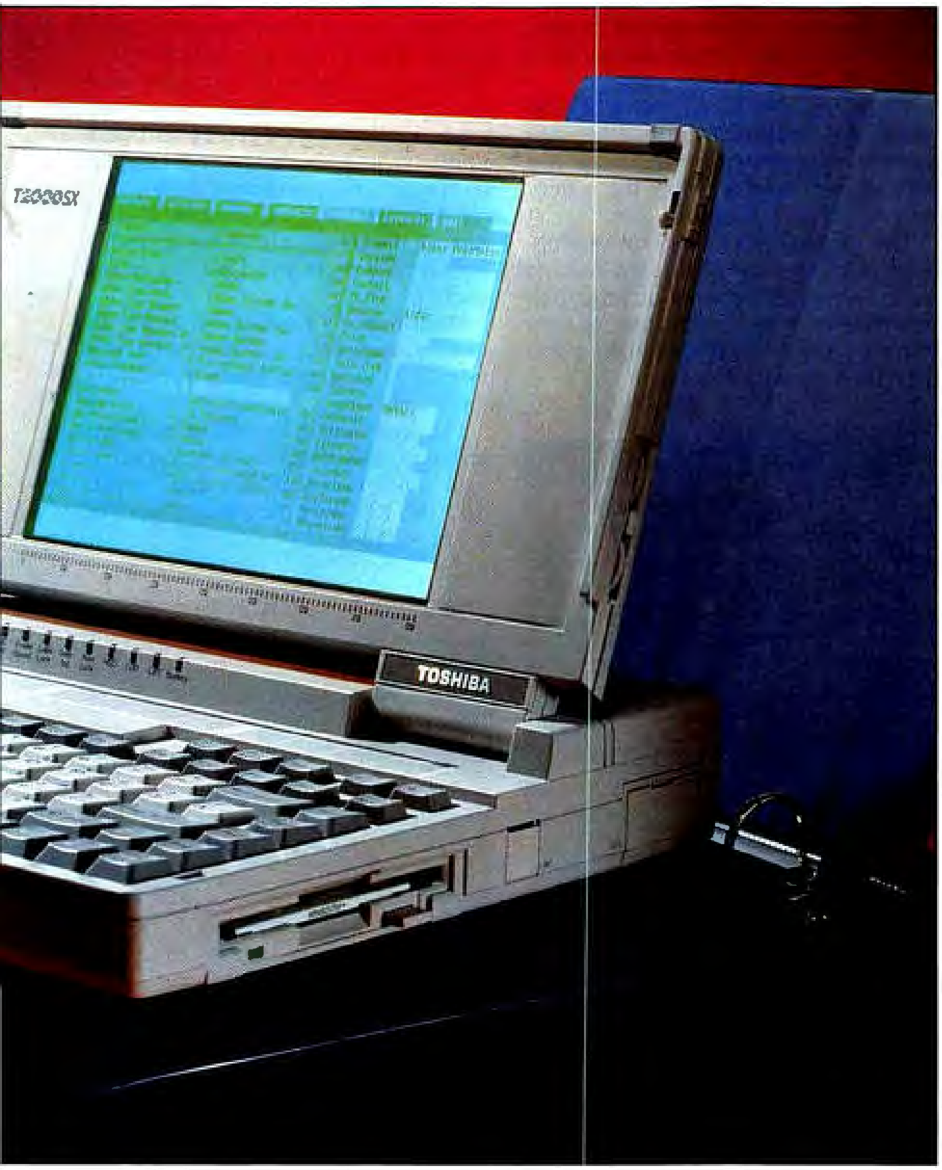

BYTE ACTION SUMMARY

- **386SX NOTEBOOKS**
- **LIKES**
  Display quality that's better than ever and performance that rivals most SX desktop machines. All accept an external keyboard and monitor when you're in the office.
- **DISLIKES**
  Ergonomically abysmal keyboards, except for the Toshiba T2000SX's. Most units run for just over 2 hours between battery charges.
- **RECOMMENDATIONS**
  Buy the Toshiba T2000SX. Display quality, performance, and battery life are all excellent. And the outstanding keyboard makes all the difference between wanting to use a notebook computer on the road and leaving it in your suitcase.

from near dusk to bright noon light. These machines even work under the glare of office lighting. If there's light enough to work, there's light enough to use these computers.

Processors have grown more powerful, disk storage has increased, and screens have become sharper, but batteries have lagged behind. Battery life has increased, but through better battery management rather than better batteries. Dataworld's Phoenix BIOS, for instance, lets you set time-outs that shut down each subsystem after a period of inactivity. Other systems use similar schemes either in software or in ROM. Despite these efforts, battery life is still a major headache for notebook users.

The exception to this rule is the Toshiba T2000SX—the first laptop to use nickel-hydride batteries. BYTE's battery-life tests show that these batteries deliver power for longer periods than do the nickel-cadmium batteries used by Toshiba's competitors (see the bar chart). Nickel-hydride batteries aren't prone to nickel-cadmium batteries' charge memory woes. (Unless a nickel-cadmium battery is discharged completely before you recharge it, the battery capacity is reduced.) The T2000SX delivered 3-plus hours of battery-powered work time, and its power management software is as good as it gets.

All these notebook computers include ample hard disk storage. Every system comes with at least a 3½-inch 20-MB hard disk drive, with 40-, 60-, and even 120-MB drives available as options. While none of these drives is a speed demon, all have average access times of under 25 milliseconds, and all turned in good performance times.

In the last generation of notebook computers, some laptop makers gambled that users wouldn't miss a floppy disk drive if they had a file transfer program like Traveling Software's LapLink in ROM. Users didn't buy it. Even with a hard disk drive installed, users still want floppy disk drives. Vendors have responded: In this latest generation, notebook computers include a high-density 3½-inch floppy disk drive. Some continue to bundle LapLink or similar file transfer utilities, but they provide them on standard floppy disks rather than in ROM.

Field Tested

I carted these systems with me on several business trips. None broke down, but a few of them seemed better suited for life on the road than others. The TI TravelMate 3000 felt too flimsy to be bouncing around in a briefcase. Nothing ever went wrong with it, but in the back of my mind I was always a little worried about its durability. At the other extreme, the Grid 1450SX felt sturdy enough to cart to Kuwait and back.

On a more minor point, the I/O port covers often didn't work well. Specifically, the TravelMate 3000 and Tempo

LX port covers don't fasten tightly. I almost had to pry open the port covers on the ALR Venture/16. And the Grid 1450SX doesn't even have port covers; its design relies on sturdy ports to withstand travel wear and tear. A short review of each machine follows.

ALR Venture/16

The Venture/16 base system includes a 16-MHz 386SX CPU, 1 MB of RAM, and a 20-MB hard disk drive for $2795. The unit is slightly bigger than an 8½- by 11-inch notebook. A special connector accepts an external hard disk drive.

The backlit supertwist LCD supports standard 640- by 480-pixel VGA graphics with 32 gray scales and is easy on the eyes. The contrast and brightness controls, which sit flush with the display panel surface, are hard to adjust.

BYTE's benchmarks put the Venture/16 in the upper performance bracket, but the presence of an 80387SX skewed the results. The other systems would have fared better relative to the Venture/16 had they been comparably equipped.

ALR is unique in bundling Digital Research's DR DOS 5.0 with the Venture/16 instead of MS-DOS 3.30 or 4.01. Best of all, the Venture is one of the least expensive 386SX notebooks around.

That's what you'll like. Here is the rest of the story. The keyboard layout is good, but tiring to use. The function keys (10 dedicated keys, with F11 and F12 overlaid on F1 and F2) are half the size of other frequently used keys.

The keyboard by itself isn't that big a deal, but there's more. The general system assembly leaves much to be desired. The Venture/16 has a toylike feel to it. The floppy disk drive worked intermittently until I opened the unit and reseated the disk drive cables. But I couldn't do anything about the slightly loose hinges connecting the display panel to the rest of the computer. I was also annoyed with the port panel, which pushed slightly into the system every time I exerted pressure on it when attaching cables.

While the Venture/16 had a healthy battery life compared to the other systems, its early warning system gave just a 30-second warning before the battery gave out. That's not enough time.

The Venture/16's fit-and-finish problems gave me pause. Still, it's hard to argue with ALR's pricing. A few small improvements in construction quality would go a long way toward making this machine a top contender.

AST Premium Exec 386SX/20

The Premium Exec is another inexpensive system from a well-known company. The standard configuration includes a 20-MHz 386SX processor, 2 MB of system memory, and a 20-MB hard disk drive for $2995. AST also offers this machine with a 12-MHz 286 processor, and your dealer can upgrade the CPU as 386SL processor modules become available. You can also expand the memory to 8 MB—more than all but the Toshiba and Dataworld systems.

The VGA screen supports 32 gray scales and is about on a par with its competition. The slide-bar brightness and contrast controls are a cinch to use. This 6½-pound machine is lighter than all but TI's TravelMate 3000. It's not the equal of its lighter cousin in performance, but the Premium Exec has more than enough processing muscle to take care of any computing chores that you are likely to run into while you're on the road. The important numbers here, though, aren't measured in pounds and milliseconds, but in dollars and cents. The Premium Exec is almost as good as the TravelMate, for $2500 less.

As with most of these systems, the keyboard is the Premium Exec's Achilles' heel. The 2-millimeter key travel, typical of most machines that I tested, is 1.5 mm less than that of a standard desktop keyboard. That doesn't sound like much, but an hour of typing will definitely convince you that you want another keyboard. The pint-size Control, Alt, and function keys all sit next to each other in the bottom row of the keyboard; WordPerfect users will have fits on this machine.

More minor fit-and-finish issues include inadequate display latches and port covers. A moderate bump can spring either open.

The Premium Exec has a mediocre keyboard, but it earned my respect in most other areas. If you don't touch-type, this relatively inexpensive machine is a good choice.

Dataworld NB320SX

Dataworld is well known in the direct-sales world, but its name hasn't spread far from there yet. The NB320SX may change that. At $2650, this is the least expensive SX notebook I tested. And the NB320SX isn't a stripped-down system. It comes with a 20-MB hard disk drive and 2 MB of RAM. Memory upgrades require a trip to your dealer, but the machine can accept up to 16 MB of RAM using 4-MB single in-line memory modules.

The NB320SX's application performance lags behind that of the 20-MHz AST Premium Exec, the TI TravelMate, and the ALR Venture/16. While its raw processing power is impressive on the low-level tests, this system isn't as well integrated as the others. Still, the differences are small, and the backlit VGA display is almost as good as those in the TI and AST units.

The keyboard is nothing special, but it worked better than other shrunk-down

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386SX NOTEBOOK COMPUTERS

The most noticeable difference between notebook computers is price; nearly $3000 separates the low-cost Dataworld NB320SX from the high-end TI TravelMate 3000. You'll want to think twice, however, about picking a machine by price alone. All machines include a high-density 3½-inch floppy disk drive, an 80387SX math coprocessor socket, and ports for an external keyboard and monitor. All also carry a one-year warranty and an FCC Class B rating.

Computer	ALR Venture/16	AST Premium Exec 386SX/20	Dataworld NB320SX	Everex Tempo LX	Grid 1450SX	Samsung NoteMaster 386S/16	TI TravelMate 3000	Toshiba T2000SX
Processor/speed (MHz)	386SX/16	386SX/20	386SX/20	386SX/16	386SX/16	386SX/16	386SX/20	386SX/16
Memory (min./max.; MB)	1/5	2/8	2/16	1/5	1/5	1/5	2/6	1/9
Memory upgrades user-installable?	Yes	Yes	No	No	No	Yes	Yes	Yes
System Unit								
Dimensions (inches; W×D×H)	12.2×8.6×2.1	11.4×9×2.25	11×8.5×2.2	10×12×2	12.5×11.5×2.6	11×8.5×2.1	11×8.5×1.8	12.2×10×1.9
Weight (pounds)	7.5	6.5	7.0	6.9	11.2*	7.0	5.7	6.9
External power supply								
Dimensions (inches; W×D×H)	3×6.5×2	3.1×6.4×2.2	3×6.4×2	3.1×8×2.1	3.25×5.5×1.9	3.5×5.9×2	3.25×6.25×2	3×6.1×1.75
Weight (pounds)	1.5	1.3	1.5	1.5	1.0	1.2	1.5	1.5
Keyboard								
Number of keys	82	82	80	82	82	80	79	86
Key travel (mm)	2	2	2	3.5	2	2.5	2	2
Display								
LCD type	Backlit	Backlit	Backlit	Backlit	Backlit	Sidelit	Sidelit	Sidelit
Graphics resolution (maximum) in pixels	640×480 VGA	640×480 VGA	640×480 VGA	640×480 VGA	640×480 VGA	640×480 VGA	640×480 VGA	640×480 VGA
Gray scales	32	32	32	16	16	32	32	16
Viewable screen area (inches; W×H)	5.2×7	5.2×6.9	5.2×6.8	5.8×7.6	6×8	5.2×6.9	5.9×7.8	5.1×6.8
Internal hard disk drive	20-MB	40-MB	20-MB	20-MB	20-MB	20-MB	20-MB	20-MB
Battery type	Nickel-cadmium	Nickel-cadmium	Nickel-cadmium	Nickel-cadmium	Nickel-cadmium	Nickel-cadmium	Nickel-cadmium	Nickel-hydride
Claimed battery life (hours)	3	3-4	2.5	2-3	2 or 4	3	3	3
Battery recharge time (hours)	2	3	4	1	2	4-5	3	1.5
Device ports								
Serial	2	1	2	1	2	2	1	1
Parallel	1	1	1	1	1	1	1	1
Expansion options								
Internal modem?	No	2400/9600 bps data/fax	2400 bps	2400 bps	2400 bps	2400/9600 bps data/fax	2400/4800 bps data/fax	2400 bps
Expansion chassis?	No	No	Yes	No	No	No	Yes	Yes
Bundled software	DR DOS 5.0 and ALR utilities	DOS 3.3, LapLink III, Battery Watch, other utilities	DOS 4.0, FastLynx, other utilities	DOS 4.01 and utilities	DOS 3.3 and utilities	DOS 4.01, LapLink III, Windows 3.0, GWBASIC, and utilities	DOS 4.01, LapLink, Battery Watch, and utilities	DOS 4.01 and utilities
Price	$2795	$2995 (with 20-MB hard disk drive)	$2650	$2999	$4795	$3999	$5499	$4999

*7.9 pounds without detachable external battery pack.

layouts. I was especially pleased by the full-size Control key next to the *A* key. The good spacing between the 12 small function keys on the keyboard's top row makes them easy to use.

The NB320SX's one weakness is the battery. The test machine ran out of juice in just 1 hour, 40 minutes during BYTE's battery-life test. That put it in last place, along with the Grid 1450SX. (You might do better in actual use—BYTE runs the battery test with the power conservation functions disabled.) The battery also takes 4 hours to recharge—longer than that of any other machine tested except the Samsung NoteMaster.

You get what you pay for, so the saying goes. Dataworld's model isn't the smallest, lightest, or fastest system I tested, but it's definitely the least expensive. This system is the loss leader—but don't forget to bring the power supply along.

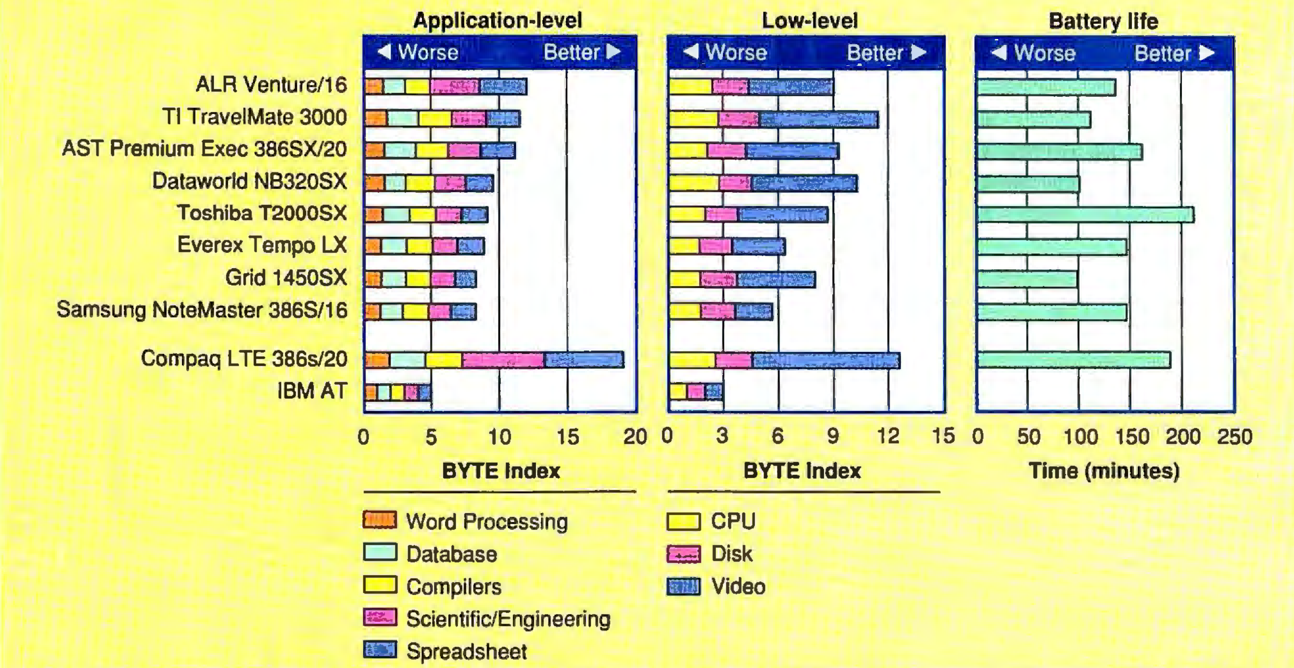
Everex Tempo LX

The Tempo LX is Everex's first attempt at a laptop. This 16-MHz system comes with 1 MB of RAM and a 20-MB Conner Peripherals Intelligent Drive Electronics hard disk drive for $2999. The machine accepts up to 5 MB of system RAM, but your dealer has to install it.

Everex fans will be disappointed to learn that the Tempo is not a performance leader. It posted relatively slow video benchmark scores, and its application benchmark scores were about on a par with the other 16-MHz SX machines. The Tempo's nickel-cadmium battery held out for 2½ hours during the battery test, matching the results for Samsung's NoteMaster. Only the AST and Toshiba computers did better here.

continued

NOTEBOOK COMPUTER BENCHMARKS



Notebook benchmark results aren't directly comparable with the standard system benchmarks. The battery-life test results are in minutes. For all other benchmarks, the results are indexed and show relative performance; for each index, an 8-MHz IBM AT running MS-DOS 3.30 = 1.

The BYTE low-level benchmark suite identifies performance differences at the hardware level; the application benchmarks evaluate real-world performance by running a standard test suite using commercially available applications. Application indexes include tests using the following programs: Word processing: XyWrite 3.55; Database: Borland Paradox 3.0 and Ashton-Tate dBASE IV; Compilers: Microsoft C 5.1 and Turbo Pascal 5.5; Scientific/Engineering: Stata 2, MathCAD 2.5, and PC-Matlab 3.5f; and Spreadsheets: Lotus 1-2-3 release 2.2 and Quattro Pro 1.0.

The BYTE Lab introduced the notebook benchmarks in the February issue (see "Perfectly Portable"). To obtain a copy of the benchmarks, join the listing area of the byte.bmarks conference on BIX or contact BYTE directly.

The Compaq LTE 386s/20, AST Premium Exec 386SX/20, and Toshiba T2000SX offer the longest battery life. The Premium Exec, TI TravelMate 3000, and LTE 386s/20 outperformed the rest of the group. The ALR Venture/16 also did well, due in part to its math coprocessor—no other machine had an 80387SX installed.

The Tempo has a good-quality backlit LCD. It could have been a little bit brighter, but that's all I would ask. The Tempo's default character font is also more attractive than those on the other systems. Graphics adjustments are simple thanks to the sprocket controls that Everex mounted on the side of the keyboard. That's good, because it's easy to hit them by accident.

The Tempo keyboard has a tinny feeling that I didn't care for. I approve highly of the key arrangement, however, which features oversize Control, Alt, and Enter keys. The price for the roomy keyboard is a large case, but the Tempo still weighs in at a hair under 7 pounds.

The Tempo's slow video won't help with graphics-intensive applications, and the keyboard is mediocre. Still, the machine has relatively good battery life, quality construction, and the Everex name to recommend it.

Grid 1450SX

Grid Systems' 1450SX is bigger, heavier, and a little older than the other systems. The 1450SX, with 1 MB of RAM, a 20-MB hard disk drive, a floppy disk drive, and a 16-MHz microprocessor matches up feature-for-feature with other systems and performs about as well as its peers. The $4795 asking price is high, but its impeccable construction quality should please field-service technicians and others who need a sturdy machine for the road.

The 1450SX reminds me of an expensive European touring car. It may not get to your destination any faster than other systems, but you'll enjoy the ride more. It's the Rolls-Royce of laptops, with a keyboard, display, and casing that are handsome and a pleasure to use.

Ergonomic and psychological factors aside, there's little to recommend the 1450SX. One minor annoyance is that memory upgrades require a trip to the dealer. A more serious problem is the oversize battery (11½ by 12½ inches), which covers the bottom of the computer and brings the total system weight to 11.2

pounds. What's worse, it barely keeps up with those of the other systems: It quit after 1 hour, 40 minutes. Strong low-level video and disk benchmark scores didn't distinguish the 1450SX in the application benchmark suite. If Grid would improve the battery life, shrink the bulky battery down a bit, and lower the price, this would be the notebook for everyone.

Samsung NoteMaster 386S/16

The NoteMaster looks like the other SX computers. It has the same essentials: a 16-MHz 386SX CPU, 1 MB of RAM, a 20-MB hard disk drive, and a high-density floppy disk drive for importing and exporting data. Its $3999 price puts it in the same ballpark as the Everex Tempo.

This machine falls short in many respects, however. It ran slightly behind its competition in most performance categories. The screen is harder to adjust than those of the other systems. But by far the most annoying feature is the keyboard. In a word, it's lousy. The keyboard has small, inappropriately located special-purpose keys, and the key travel and feedback are poor. I tried to write part of this review on each machine, but the NoteMaster was just too frustrating for even that simple task.

Now for the good points. The NoteMaster did well on the battery-life tests. It went 2½ hours before shutting down and gave plenty of advance warning when the battery went low. Samsung also paid attention to preserving battery life. The computer beeps if you try to close the case while the machine is running and lets you set time-outs that shut down the CPU, display, and other subsystems after a period of inactivity. This is not enough to redeem the machine, but it is enough to make me regret that the rest of the system didn't live up to this area.

continued

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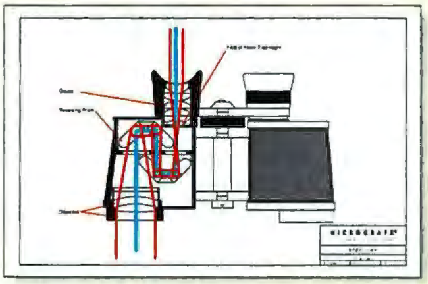

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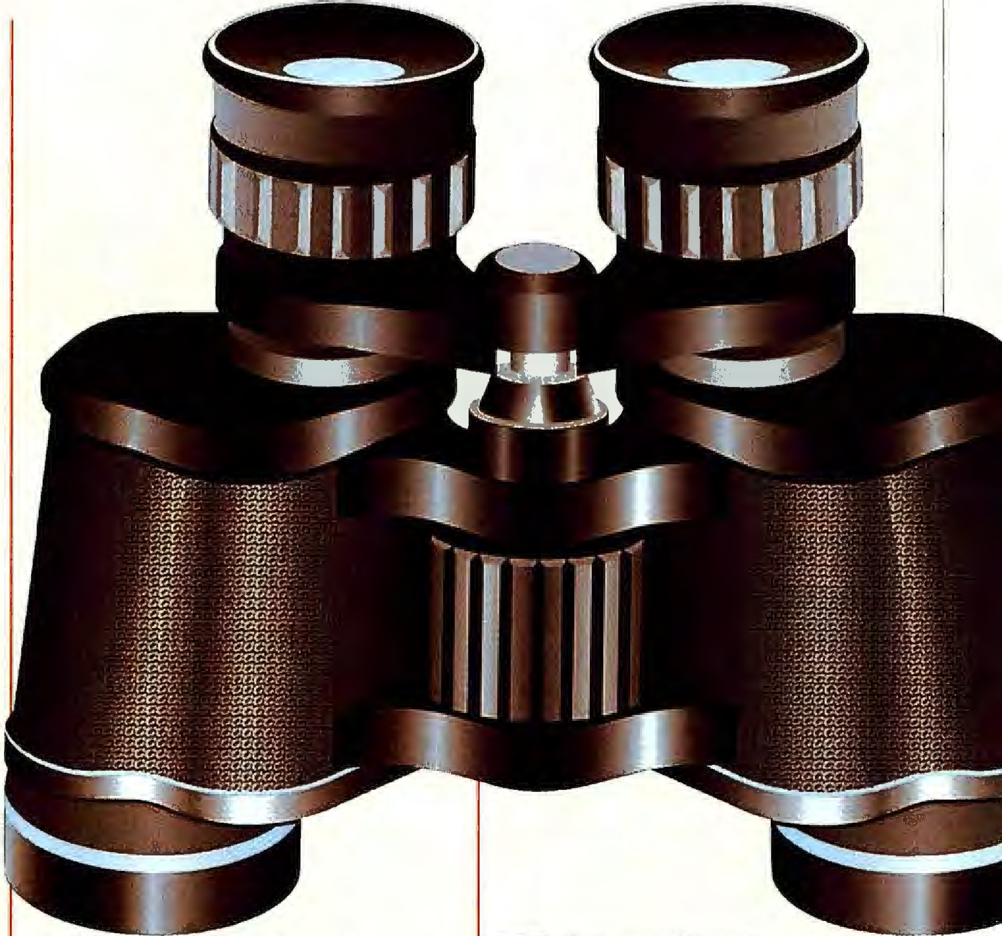

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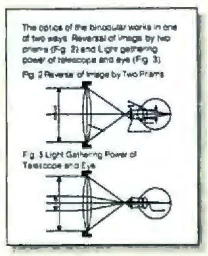

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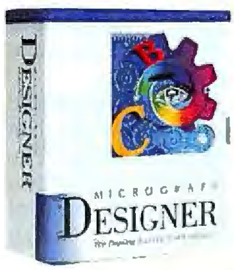

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COMPANY INFORMATION

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fax: (714) 581-9240
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AST Research, Inc.
(AST Premium Exec 386SX/20)
16215 Alton Pkwy.
P.O. Box 19658
Irvine, CA 92713
(714) 727-4141
fax: (714) 727-9355
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Dataworld, Inc.
(NB320SX)
3733 San Gabriel River Pkwy.
Pico Rivera, CA 90660
(800) 736-3282
(213) 695-3777
fax: (213) 695-7016
Circle 1077 on Inquiry Card.

Everex Systems, Inc.
(Tempo LX)
48431 Milmont Dr.
Fremont, CA 94538
(800) 821-0806
(415) 498-1111
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Grid Systems Corp.
(1450SX)
47211 Lakeview Blvd.
P.O. Box 5003
Fremont, CA 94537
(800) 222-4743
(415) 656-4700
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Samsung Information Systems America
(NoteMaster 386S/16)
3655 North First St.
San Jose, CA 95134
(800) 446-0262
(408) 434-5400
fax: (408) 434-5653
Circle 1080 on Inquiry Card.

Texas Instruments, Inc.
(TravelMate 3000)
P.O. Box 202230
Austin, TX 78720
(800) 527-3500
Circle 1081 on Inquiry Card.

Toshiba America Information Systems, Inc.
(T2000SX)
Computer Systems Division
9740 Irvine Blvd.
Irvine, CA 92718
(800) 334-3445
Circle 1082 on Inquiry Card.

TI TravelMate 3000

TI is back, and this time it means business. The 5¾-pound TravelMate 3000, with its 20-MHz CPU, is the fastest and lightest system in this roundup. Its good all-around performance placed it in the company of the AST Premium Exec and the ALR Venture/16.

The TravelMate has a few drawbacks. The bare-bones configuration of a 20-MB Conner Peripherals hard disk drive, floppy disk drive, and 2 MB of RAM lists for $5499—more than any other notebook computer except the Compaq LTE 386s/20 ($6499). It also has a relatively short battery life.

The keyboard console is not suitable for long sessions, but it's no worse than that of any other notebook machine. The sidelit screen, one of the better displays, features VGA graphics with 32 levels of gray. The monitor controls, although flush on the display panel, are easy to manipulate. The case seems a bit flimsy, but it held up fine during testing.

Unquestionably, the TravelMate 3000 is a technological showpiece and a performance leader. Given its price, I question how many business travelers will be throwing a TravelMate into their briefcase; it does, however, make an ideal traveling companion.

Toshiba T2000SX

Toshiba has once again come through with a winner. The T2000SX outperformed most of the other 16-MHz machines in this review, and its unique nickel-hydride battery outlasted those of every SX notebook machine BYTE has tested, including that of Compaq's LTE 386s/20. The system went 3½ hours between charges in my tests. With Toshiba's power management features enabled, you should get well over 4 hours of battery life.

The base machine isn't cheap, however. Configured with 1 MB of RAM and a 20-MB hard disk drive, it lists for $4999. The T2000SX also holds up to 9 MB of RAM.

Better battery technology is just one reason to go with the T2000SX. The machine's power management software is top-notch, and Toshiba's unique Resume feature lets you turn the machine off while running an application. When you power the machine up again, your application begins running where it left off. Even if the battery runs out while you're working, you don't have to worry about losing data.

The keyboard is also first rate. The nearly full-size (86-key) layout features good key placements, and using it is almost like typing on a full-size keyboard. I also preferred the system's fluorescent sidelit display, which stands out even against those of the TI and Everex systems.

Like any other computer, the Toshiba T2000SX has its share of troubles. Some of the port covers detach completely from the system. They are difficult to fasten securely, and they seem almost custom-made to get lost. But these are minor points. If I were going to go out and buy a 386SX laptop computer, I would spend the extra money and get the T2000SX. It's not perfect, but it's close enough. ■

Steven J. Vaughan-Nichols is a freelance writer based in Lanham, Maryland. You can reach him on BIX as "sjvn."

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HARDWARE

WaveLAN: A Network with No Strings Attached

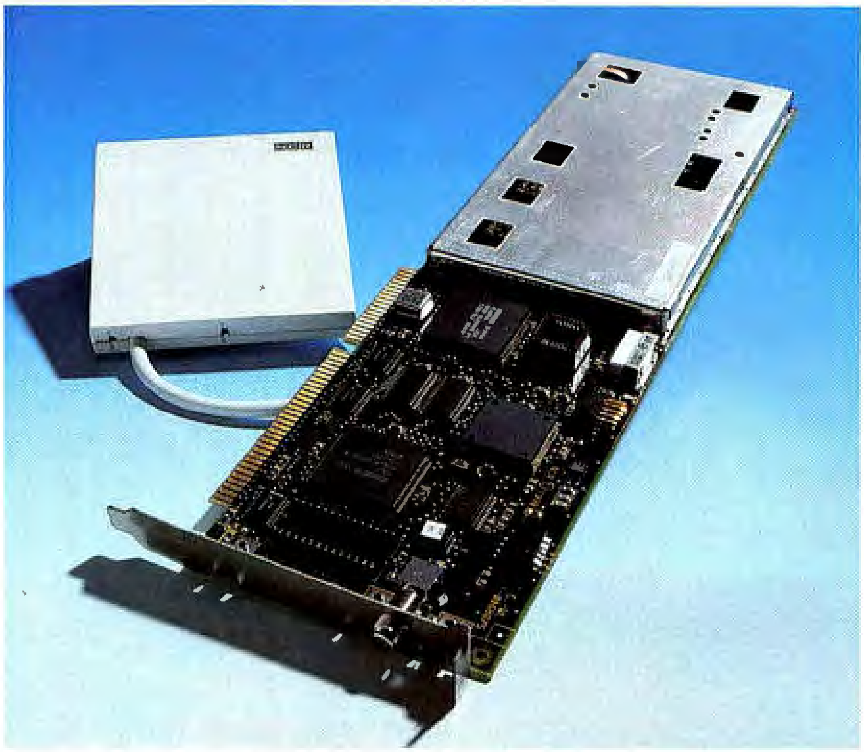
WAYNE RASH JR.

NCR's WaveLAN seems like the perfect solution to many of the problems associated with installing a LAN. You get fast, reliable connectivity without the wires. And unlike some other systems that include their own network operating system, WaveLAN supports NetWare. There are, however, a few problems in paradise.

WaveLAN replaces network cabling with high-frequency radio signals and uses spread-spectrum techniques to reduce interference. Nodes can transmit at up to 2 megabits per second over distances of 800 feet (unobstructed). Like a standard Ethernet LAN, WaveLAN uses CSMA protocols. But where Ethernet adds collision detection, WaveLAN uses collision avoidance techniques.

Because WaveLAN uses radio signals instead of transmitting data through a cable, collision detection would be difficult to arrange. Instead, WaveLAN listens before transmitting in an attempt to avoid collisions. When simultaneous transmissions do occur, WaveLAN depends on NetWare to detect garbled packets and request a retransmission.

WaveLAN currently works only with versions of NetWare 286 between 2.1 and 2.15C. NCR claims that WaveLAN will support NetWare 386 by the time you read this review, and it's working on drivers for Banyan's Vines and Microsoft's LAN Manager.



WaveLAN includes a 2-Mbps network adapter, NetWare drivers, and an external antenna (upper left).

The Basic Package

NCR includes everything you need to set up a WaveLAN workstation or server with each network interface card. The package includes a full-length 16-bit AT-bus or 32-bit MCA-bus NIC, an antenna that's slightly larger than a 3½-inch disk, mounting hardware, two installation and setup disks, and an installation guide for $1390. A metal enclosure that houses the RF circuitry takes up approximately half the space on the network card. The back of the card holds a bank of four DIP switches and an F connector for the antenna. (The F connector looks like the threaded jack that your cable TV company installs in your house.)

You select from four available I/O addresses by setting two of the DIP switches (the other two control the boot ROM address for diskless workstations). Next, you insert the card into your computer and attach the antenna. Threading the cable onto the F connector is difficult; the connector sits so close to the top of the card that the computer case blocks access. This is such a problem that NCR now bundles a special tool with WaveLAN to attach the cable. Replacing the F connector with a standard BNC connector is an even better idea.

Configuration Hassle

WaveLAN's software installation procedure suffers from enough problems that some installers may want to quit before they've met success. Once you interpret the documentation, installation is fairly easy. Unfortunately, the documentation is poorly organized, the procedure is nonintuitive, and the messages from the software are obscure.

To be fair, part of the problem involves NetWare 286's unfriendly installation process. Nevertheless, NCR could have done a better job. The WaveLAN manual discusses the installation but leaves all discussion of configuring the software to the Novell documentation. The WaveLAN documentation should lead you step-by-step through the entire process, or at least give you a high-level overview of the procedure so you don't miss important steps.

If you don't configure the WaveLAN card properly during the installation, you get a cryptic error message that seems to come from NetWare. Unfortunately, no amount of study in the NetWare manuals will solve the problem, because WaveLAN is the culprit. You can't even boot your file server until you've configured WaveLAN correctly.

The installation process requires that you run Novell's NETGEN utility to regenerate your network operating system, a task that you must do for any such change in a NetWare 286 file server. In the process, you must have read the README file, which lists several drivers that work with the different versions of NetWare 286.

Once I divined the software require-

BYTE ACTION SUMMARY

- **WAVELAN**
- **LIKES**
  No cabling needed; NetWare-compatible; high reliability; performance acceptable for most applications.
- **DISLIKES**
  Poor documentation makes installation irritating; noticeably slower than Ethernet for large file transfers, particularly with competing network traffic.
- **RECOMMENDATIONS**
  Worth consideration in offices with frequent moves and changes, or where running cable is difficult.
- **REQUIREMENTS**
  An AT- or MCA-bus PC and NetWare 2.1x
- **COST**
  $1390 per workstation or server; $90 for Data Encryption Standard chip
- **FOR MORE INFORMATION**
  NCR Corp.
  1700 South Patterson Blvd.
  Dayton, OH 45479
  (800) 225-5627
  (513) 445-5000
  fax: (513) 445-3842

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ments, server installation went routinely. Setting up the workstation cards was easier, although I was never able to get the drivers to work with version 3 of the NetWare workstation shell. NCR claimed that it had added support for the version 3 shell as this review went to press.

WaveLAN vs. Ethernet

Once you get through the installation, WaveLAN workstations work just like any other NetWare 286 workstations. WaveLAN's 2-Mbps speed rating is only 20 percent of Ethernet's theoretical 10-Mbps potential, but the difference isn't noticeable for most applications. There is an obvious difference if you have to perform transfers of large files, however.

In an effort to measure WaveLAN's

ability to deal with large files, I transferred a 1.2-megabyte file 10 times (5 times in each direction) between my Samsung/Novell 386AE file server and a Unisys PW2 486/25 client. I compared this with the same operation over conventional thin-wire Ethernet using a 3Com 3C503 card in the Unisys client and a Novell NE2000 in the Samsung/Novell file server. The 1.2-MB transfer averaged 1 minute, 36 seconds over standard thin-wire Ethernet versus 2 minutes, 41 seconds over WaveLAN. (Note that these numbers reflect relative performance; they do not reflect the speed of the network medium. Other factors affecting throughput include the speed of the hard disk drives, available memory, and the size of any disk cache on the workstation and client machines.)

Since WaveLAN depends on NetWare to catch transmission errors, I tried the same test while generating traffic from another workstation (a Zenith Z-248 in another room) to create interference. The effect was clear: The transfer still occurred without errors, but the average file transfer time increased to 3 minutes, 38 seconds—almost a minute longer.

WaveLAN uses spread-spectrum transmission in the 902- to 928-MHz range, so it's unlikely that it will interfere with anything you're likely to have around your office, although NCR warns that any machinery that generates radio noise, such as microwave ovens and copiers, could meet with interference that affects performance. One unexpected office appliance that WaveLAN interfered with was my multifrequency monitor. If you set the antenna next to a VGA color monitor as I did, your screen will look like it's under water. Moving it away from the machine solved the problem.

Do You Want One?

Compared with the cost of standard Ethernet NICs, the WaveLAN's $1390 list price sounds high, but you don't have to pay for workstation cable drops with WaveLAN. A typical Ethernet installation that includes new cabling and adapter cards typically costs between $500 and $1000 per node, depending on the cable used. WaveLAN makes sense in areas where moves and changes happen frequently, or in open areas where it's difficult to run cabling.

WaveLAN will never completely eliminate the need for cabling. While it can transmit up to 800 feet under ideal conditions, realistically you'll be confined to a single floor of a high-rise building. You will still have to connect multiple servers with a backbone cable, and you may find that cable is required in some locations with high levels of electrical noise.

WaveLAN is clearly not going to keep up with Ethernet for CAD users wanting to transfer large files—particularly when many nodes are contending for transmission time. But for most typical LAN applications, WaveLAN is plenty fast. ■

Wayne Rash Jr. is a contributing editor for BYTE and a principal and technical director of the Network Integration Group of American Management Systems, Inc. (Arlington, VA). He consults with federal and private sector clients on microcomputers and communications, and he is coauthor of two books for business network users: The Executive Guide to Local Area Networks *and* The Novell Connection. *You can contact him on BIX as "waynerash," or in the to.wayne conference.*

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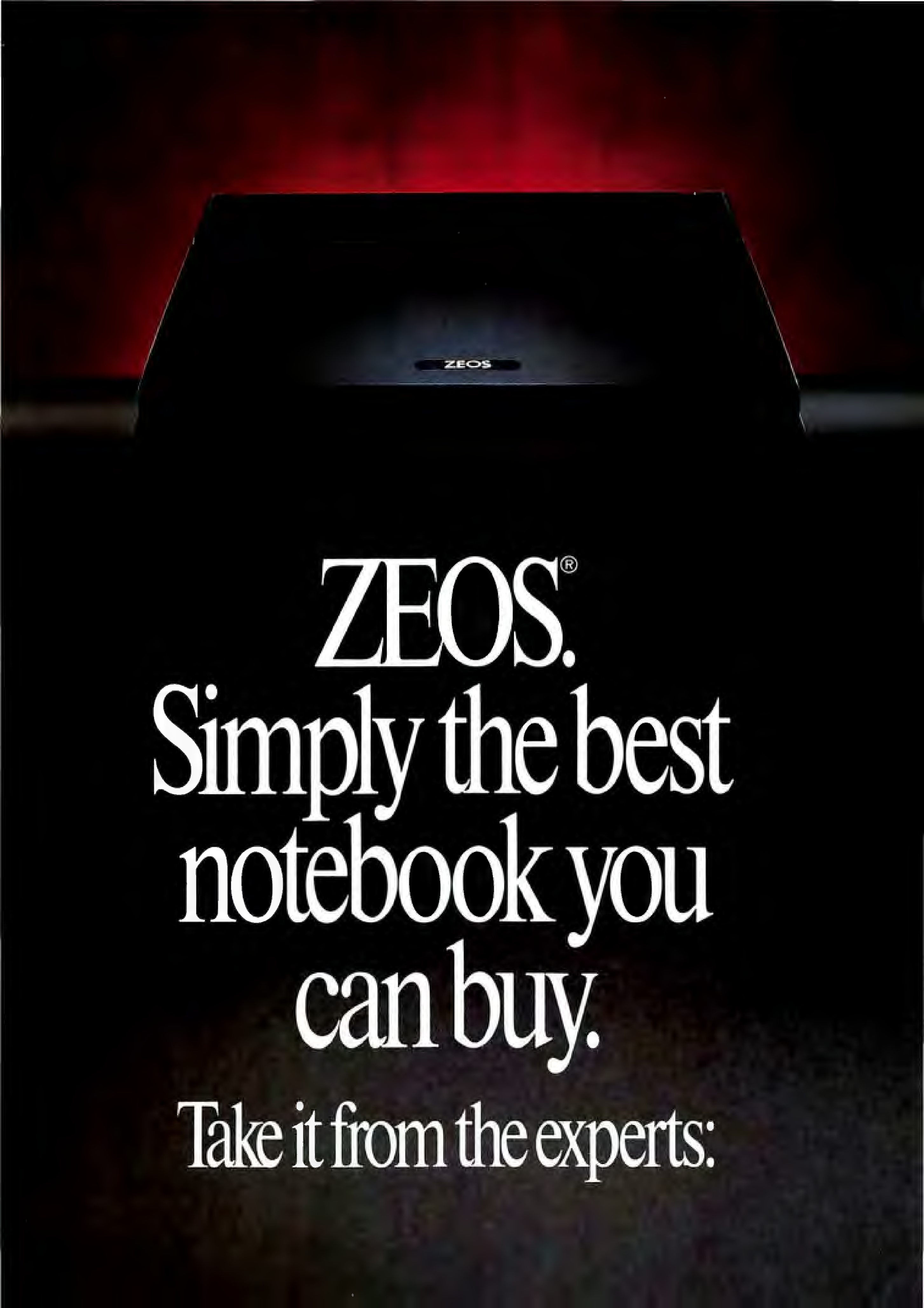
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ZEOS NOTEBOOK 286

The ZEOS Guide to the Perfect Notebook:

PROCESSOR: PC Magazine recommends a '286 or '386SX processor pointing out that "8086- and 8088-based portables have only half to a third of the computing power of a 286." That's why ZEOS offers you your choice, '286 or 386SX! More power for you. After all it's just like a 6.5 pound desktop!

DRIVES: *Two drives, built in!* A whisper quiet high speed 20 Megabyte hard disk *plus* a 1.44 Megabyte 3.5 inch floppy. Remember, with a built in floppy drive you don't need to fool around with strange interfaces to load and transfer files.

VIDEO: ZEOS raises the ante to VGA! We're talking about bright and crisp VGA displayed on one of the largest notebook screens in the industry. The display also features advanced fluorescent backlighting, 32 grey scales and 640 x 480 resolution. Plus, it can be adjusted to any position over a 135° angle and features easily adjustable brightness and contrast controls. Easy viewing under virtually any lighting conditions. You can connect to an external VGA color monitor too!

GREAT BATTERY FEATURES: Every battery feature you want. You can plug your notebook in and "quick charge" the battery in less than one hour or you can "trickle charge" while in use. Plus, your battery easily snaps out allowing the quick installation of an optional replacement battery. It's great to be able to carry a light weight spare for those especially long trips. An optional battery charger stand is available as well.

INTELLIGENT POWER MANAGEMENT: Your new ZEOS notebook features an intelligent programmable power management system if you wish to use it. Based on the length of time since your last keystroke, you may reduce CPU speed, display screen backlighting etc. Full power is immediately restored at the stroke of any key. The system even knows *not* to use the power management system when you are operating on AC power!

CHECK IT OUT!

Now, you can take desktop computing power anywhere! Your ZEOS notebook has many features of obvious importance. Also, there are a number of features that are subtle yet critical to your ultimate satisfaction. We'll go over them here one by one. We think you'll agree your new ZEOS Notebook is the one for you!

SYSTEMS STATUS AT A GLANCE: Yes, monitor eight key system components at a glance! We've equipped your new notebook with eight LED indicators which monitor disk access, keyboard functions and power status. There is even an audible alarm which may be programmed to inform you of a low battery condition and to let you know if the cover is closed with the power on. Now that's one smart notebook!

DESKTOP KEYBOARD FEATURES: We're talking 82 full size keys with full 101-key emulation. And the keyboard isn't squeezed either. The distance between the "Q" key and the "[" (left bracket) key measures 7.5 inches, just as PC Magazine suggests. The keys are of standard size, plus touch typists will love our full 3.5mm keystroke. Type for hours and love it!

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ZEOS NOTEBOOK

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HARDWARE

The Nextstation: A High-Performance Graphical Workstation with a PC Price Tag

STEVE CARPENTER

The Nextstation is more practical in case design, performance, and price.

There's no question that Next makes an avant-garde machine. The original Nextcube had a unique set of features that made it "one of the most eagerly anticipated machines in recent memory." (See "The NeXT Computer," November 1988 BYTE.)

But there were some serious problems with the original Nextcube. First, the $10,000-plus price tag put the first Next system beyond the reach of many budgets. Then, the features that made the original Nextcube so attractive slowed down the 25-MHz 68030 and optical drive combination to the point that some people were disappointed with its performance. Finally, although the Nextcube had some fantastic native applications, there weren't enough third-party applications available to justify many end-user purchases. (See "Sizing Up the Cube," January 1990 BYTE.)

But that was then. Now, the new Nextstation leaves the original Nextcube's problems in the dust. And if Next overcomes its marketing and distribution problems before Apple, PC vendors, or workstation vendors field a competitive model, the competition could be in for a big surprise.

The Reality Zone

The lessons Next learned about the impact of pricing have certainly come home to roost. An entry-level Nextstation with 8 megabytes of memory, a 2.88-MB floppy disk drive, and a 105-MB hard disk drive (the interesting but pricey optical drive is gone) lists for an affordable $4995. This configuration is competitive with other vendors' entry-level *diskless* machines. But although this configuration is usable, for the kind of work this machine was meant to do, more is better. I reviewed a system with 16 MB of RAM and a 406-MB hard disk drive. The cost of that configuration is still very aggressive at $7275.

The 17-inch, 1120- by 832-pixel MegaPixel display is almost the same as the one shipped with the old Nextcube, but the Nextstation's CPU housing has shrunk from a 1-foot square to a 2½-inch-high pizza-box shape. This has the effect of reducing the awe-inspiring black cube to a (more functional) monitor stand. Despite this diminished profile, Next promises at least three times the performance of the Nextcube, thanks to a powerful combination of 68040 CPU, cache, integrated channel processor, 56001 digital signal processor, and a fast hard disk drive instead of the optical drive. I figured I was in for a treat.

The other issue for Next was stimulating application development. Next has been aggressive here, too. All the workstation vendors advertise thousands of applications, but only a fraction of the applications actually take full advantage of a graphical environment.

Next takes a different approach to applications, one that reflects its avant-garde focus. First, it developed NextStep, its acclaimed visual object-oriented programming environment (see "The Next Step," March 1989 BYTE). Second, *all* applications in Next's catalog use NextStep. As of March, according to Next, 43 third-party NextStep applications, including Lotus's revolutionary Improv speadsheet, are shipping (see "What's NeXT After 1-2-3," October 1990 BYTE, for details on Improv).

Also, Next bundles another eight major integrated applications packages, including the multimedia Nextmail, and at least a dozen more useful demonstration (unsupported) packages that you have to see to believe. With all this taken together, the Nextstation is probably a more useful machine out of the box than any other workstation on the market, and quite possibly any system in its price range, including PCs and Macs.

Close Encounters

I dove right in to get some first impressions. My first excursion involved logging on as the supervisory user "root." This brought up the familiar Next workspace screen: a menu bar to the left, a file browser in the center, and, to the right, a set of applications icons "docked" along the side of the display. But no terminal window was visible; as a longtime Unix user, I felt a little out of place.

A quick tour through the documentation was helpful, but it seemed to consist mostly of guide rather than reference materials. This is documentation that you must read completely to find the information you might need, not something to breeze through. It's not a chore, though, because the documentation is well organized. For avid bookhaters, Next has an on-line librarian that helps you find what you need, and includes a nice multimedia tour conducted by the pleasant-voiced Ms. Cathy.

I got my terminal window running and started poking around. A quick tour told me that this was indeed a Berkeley Unix system. I became a little distressed when I couldn't find the vertical bar (pipe symbol) key. I finally found it on top of the right key cluster—not a good place if you want to use the Unix system interface. Surprisingly, Next moved the key from the more reasonable position on the original Nextcube's keyboard.

I then set up the original Nextcube beside the Nextstation. Whereas the Nextcube takes several seconds to build the workspace, the Nextstation, with 16 MB of RAM and a fast 406-MB hard disk drive, starts up almost immediately. Opening an application window was a slow process on the Nextcube, but windows pop up quickly on the Nextstation. Running in this environment with several open applications seemed to have no noticeable effect on graphics performance. In contrast, just moving one window on the Nextcube completely stopped a file scrolling in another window. Checking the BYTE benchmark results at right confirms that feeling.

From this user's perspective, the Nextstation lives up to the workstation performance I've come to expect. So it's safe to say that Next kept its promise of exceptional system throughput and performance and laid to rest the performance problems of the original Nextcube. Expanding on this good news, Next recently announced a family of Next systems, as well as a 68040 upgrade board for the original Nextcube (see "Fast New Systems from NeXT," November 1990 BYTE).

Stacking It Up

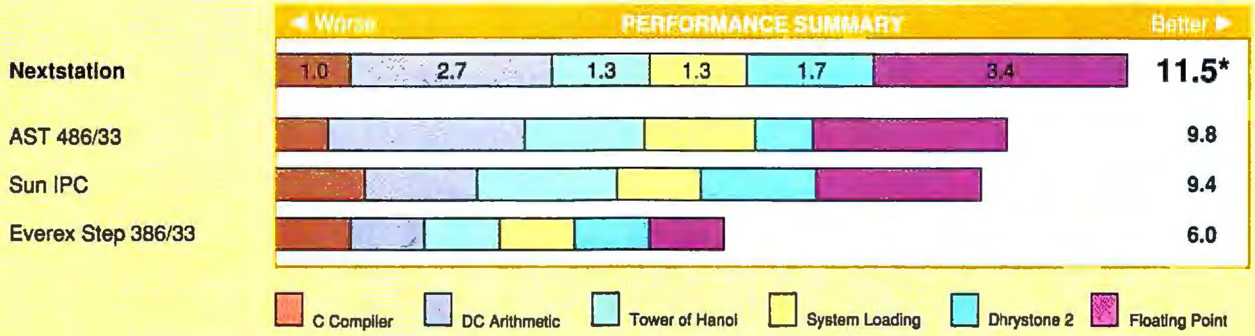
In doing a review, it's ideal to compare the reviewed system with like systems from other vendors, but it's hard to come up with competing systems that have much in common with the Nextstation. The Nextstation has the competition beat right now in price and standard features. However, that set of features will become commonplace in the coming years, and you can configure competing systems now with third-party products that offer similar capabilities. So to get a rough idea whether the Nextstation is indeed a price/performance bargain in its class, I compared a Nextstation with systems that

BYTE ACTION SUMMARY

- **WHAT THE NEXTSTATION IS**
  A fast, inexpensive monochrome Unix workstation.
- **LIKES**
  Excellent graphical interface; usable "out of the box" with bundled applications.
- **DISLIKES**
  Its nonstandard Unix, network administration, and windowing system might create some headaches for those with existing Unix systems.
- **RECOMMENDATIONS**
  Possibly the best workstation value on the market, and a good choice for first-time Unix users.
- **PRICE**
  $7275 (as reviewed)
- **FOR MORE INFORMATION**
  Next, Inc.
  900 Chesapeake Dr.
  Redwood City, CA 94063
  (800) 848-6398
  fax: (415) 780-3950

  Circle 1207 on Inquiry Card.

UNIX BENCHMARKS



HIGH-LEVEL PERFORMANCE

	Time	Index
• **C Compiler**	2.15	0.97
• **DC Arithmetic**	0.23	2.74
• **Tower of Hanoi** (17-disk problem)	0.42	1.33
System Loading[1]		
1 background process	3.53	1.15
2 concurrent background processes	4.80	1.21
4 concurrent background processes	7.57	1.27
• 8 concurrent background processes	13.23	1.31

LOW-LEVEL PERFORMANCE

	Time	Index
• **Dhrystone 2** (without registers; Dhry./sec.)	23850	1.72
Arithmetic (10,000 iterations)		
Arithmetic overhead	0.21	3.43
Register	3.22	0.91
Short	2.90	1.21
Integer	3.20	0.98
Long	3.20	0.98
• Floating Point	3.52	3.39
Double	3.52	3.76

	Time	Index
Throughput		
System call overhead (5 x 4000 calls)	0.50	2.20
Pipe throughput (read and write 2048- × 512-byte blocks)	0.72	1.28
Pipe-based context switching (2 × 500 switches)	0.42	1.50
Process creation (100 forks)	2.20	0.56
Execl throughput (100 execs)	3.15	1.09
Filesystem throughput (10-second test in Kbytes/sec.)		
Read	833	N/A
Write	576	N/A
Copy	460	N/A

* Cumulative index is formed by summing the indexed performance results for C Compiler, DC Arithmetic, Tower of Hanoi, System Loading (with 8 concurrent processes), Dhrystone 2, and Floating Point tests.

[1] System loading was performed using Bourne shell scripts and Unix utilities.

Note: All times are in seconds unless otherwise specified. Figures were generated using the BYTE Unix benchmarks version 2.6. Indexes show relative performance; for all indexes, an Everex Step 386/33 running Xenix 2.3.1 = 1. N/A = Not applicable. For a description of the benchmarks, see "The BYTE Unix Benchmarks," March 1990 BYTE.

I thought would have most of the performance and a similar configuration and be in the under-$10,000 price class. On that basis, a high-end Macintosh, a high-end i486-based system, and a low-end workstation should all be candidates. I was in for some more surprises.

The Mac IIfx running A/UX version 2.0, although beating the original Nextcube soundly in the BYTE benchmarks, clocked in at 50 percent to 60 percent of the Nextstation's performance. One IIfx configuration with 8 MB of RAM, a keyboard, a 210-MB Quantum drive, and a 19-inch display lists for $12,125. Of course, some dealers have packages offering significant discounts. After adding high-quality audio, Unix, and Ethernet, the best current Apple system costs more than twice as much as a base Nextstation and offers less performance.

Then I turned to PCs. A 486/33 beats the Nextstation in some of the BYTE benchmarks, but it still lists at close to $10,000 without the add-ons needed to match the Nextstation's best features. There was no need to carry this configuration exercise any further.

Next identifies Sun Microsystems as its main competitor in the commercial workstation market. In that comparison, Sun's low-end systems (including the $9995 color IPC with a 207-MB hard disk drive) fare relatively well, performing only slightly worse than the Nextstation. But Sun systems lack the bundled applications and general ease of use of the Nextstation. It will be interesting to see if Next's 68040-based systems can take any steam out of SPARC's commanding lead.

The Next to the Last

Despite my obvious affection for the Nextstation, it isn't perfect. Steve Jobs' vision of the needs of the commercial workstation user didn't have room for either the X Window System or System V Unix, both of which are becoming increasingly important. Users expect to be able to connect their various workstations, and the Nextstation, with its unique Mach/Berkeley Unix and proprietary windowing system, has a little trouble fitting in with non-Next hardware. Next, along with its third-party software vendors, has plans to address this (including a commercial version of X Window that runs under NextStep).

Next excels in providing excellent value for the money. A first-time computer buyer would be well advised to consider the Nextstation, because even a fast PC can't equal the Nextstation's bundled applications and point-and-click simplicity. Insignia's SoftPC product adds DOS application compatibility. Mac users will feel very much at home in NextStep, and the crisp gray-scale monitor is perfect for technical publishing. Those who have already invested in Unix workstations should perhaps tread a little more carefully, but with X Window added, the Nextstation could be a cost-effective and valuable addition to an existing network.

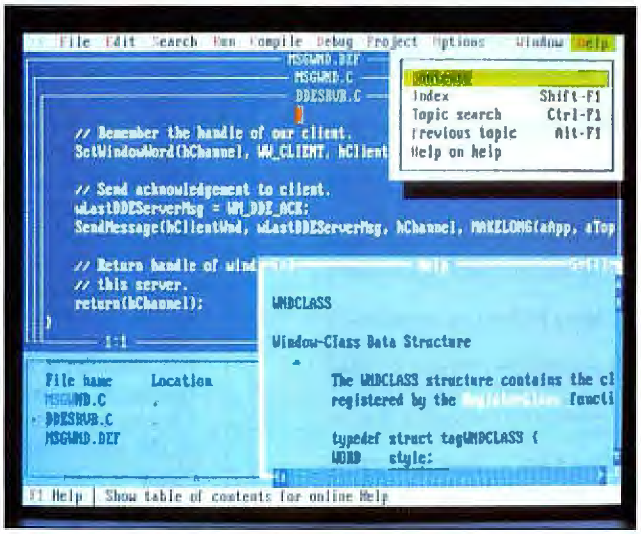
In many ways, Next has redeemed itself by finally releasing a system equal to the task of running its demanding operating-system and graphical-environment software. The Nextstation, along with its array of standard software, is wholly impressive. ■

Steve Carpenter is an independent consultant specializing in event-driven software and open systems technology. He can be reached on BIX as "scarpenter."

SOFTWARE

Borland C++ 2.0 Moves into Windows Territory

STEVEN KEARNS



Borland C++ 2.0 maintains the text-based integrated environment of its predecessor while extending support for Windows application development.

Borland C++ 2.0 is a major upgrade of Borland's integrated environment for C++ programming. I found the previous version (called Turbo C++ 1.0) to be disappointing, because it could compile only small, non-Windows applications, and it had some code-generation bugs. The new version solves these problems and introduces important new features.

One major feature of 2.0 is the use of extended memory. There are now versions of each tool (compiler, linker, and so on) that use extended memory. You no longer have to worry about running out of memory during a compile or link.

The other major feature of version 2.0 is support for Windows programming. When you buy other C++ development systems, you also have to purchase the Microsoft Windows Software Development Kit (SDK). Borland C++ eliminates this hassle and expense, providing everything you need to create a Windows application in one package. And a large package it is: Borland C++ weighs in at nine manuals and 15 megabytes of program and code.

Getting to the Window

Borland C++ can generate Windows applications and dynamic link libraries (DLLs) in addition to DOS applications. Also, the project manager part of the integrated environment can now handle the .DEF and .RES files that are part of a Windows application.

You can also run Borland C++ from Windows 3.0, but the extended-memory version runs only in standard mode (not in 386 enhanced mode), and it is still a DOS application with a text-mode interface.

The disadvantages of Windows' standard mode include the lack of virtual memory and longer pauses when switching between programs. Also, any extended memory you allocate to Borland C++ reduces the memory available to Windows. My machine has 4 MB of memory, which is barely sufficient for Windows development.

An important element in the creation of a Windows application is creating resources, which describe the appearance and behavior of dialog boxes and other graphical objects. Borland C++ includes a resource compiler, which generates resources from a textual description. However, writing down the coordinates and options of every object in a dialog box is cumbersome. Fortunately, Borland C++ also includes the Whitewater Resource Toolkit. This is a Windows program for graphically designing most types of resources, including dialog boxes, controls, menus, icons, and cursors.

Resources can be contained in special files or DLLs, or bound into .EXE files. The Resource Toolkit lets you modify resources wherever they're found, and even copy them from one type of file to another. While the program feels clumsy, it has some nice features, such as displaying resource IDs using symbolic names taken from a header file. The Resource Toolkit is easier to use than the analogous set of tools in the Microsoft Windows SDK, but the latter includes a font editor that the former does not.

Standard Extras

Most DOS debuggers cannot be used to debug Windows programs, but Borland C++ includes a version of Turbo Debugger especially for this purpose. It runs as a text application while Windows is active, and it automatically switches to the graphical Windows screen when necessary.

Some excellent additions to Turbo Debugger simplify Windows debugging. You can stop execution when your program receives a specific message or class of messages, and you can log the important communications between your program and Windows. These features are welcome, because Windows' event-driven control structure horribly complicates debugging.

An extensive hypertext help facility is part of Borland C++ 2.0. It documents everything from options of the integrated environment to details of the Windows application programming interface. Although not as pretty as the help file that comes with the Microsoft SDK (which uses the Windows 3.0 help system), it is just as functional.

There is one component missing from Borland C++ that would make it much easier to create Windows applications: an object-oriented user-interface toolkit. Without such a library, Windows programming can be tedious, error-prone, and time-consuming. I used C++/Views from CNS in conjunction with Borland C++ to create, in record time, a Windows application complete with menus and dialog boxes. Other third-party Windows-interface toolkits have been announced for Borland C++.

The Proving Ground

In order to test Borland C++, I ran the extended version of the integrated environment from within Windows 3.0 (in standard mode) to compile and link a program; from there, I transferred to Epsilon for major editing, to Turbo

Debugger for debugging, and to Windows to test my application and to use the Resource Toolkit and the C++/Views class browser. The combination was very productive.

An exciting new feature of Borland C++ is "precompiled headers." It has been observed that C++ compilers spend most of their time processing include files, which rarely change. Borland C++ automatically notices if it is parsing a sequence of headers it has seen before and, if so, loads precompiled versions. This can dramatically boost compilation speed.

Unfortunately, this feature requires some refining. If a header file contains in-line functions that the compiler refuses to generate in-line, or if a header file contains a definition of a variable, Borland C++ refuses to precompile that file and any following. For example, one of the most common header files to include is `iostream.h`, which defines some variables and thus inhibits precompilation. The most common header file in Windows programming is `windows.h`. Fortunately, it can be precompiled.

Other random features include an integrated assembler and faster huge arithmetic. In addition, compilation speed has been boosted back to the responsive level you've come to expect from Turbo products. Turbo C++ 1.0 was surprisingly slow. Apparently, the Turbo C++ version will now be aimed at educational markets, while Borland C++ will be for professional programmers. Fortunately, dropping the "Turbo" moniker caused no decrease in program speed!

Borland C++ 2.0 is too finicky about in-line functions. For instance, it refuses to generate in-line functions that call a destructor on a local or temporary variable. This can slow your program down and interacts badly with the precompiled header feature, although in most programs it should have little effect.

I found only four bugs during a week's worth of extensive testing. When I converted a mass of code to Borland C++, the only major stumbling block involved bit fields: Borland supports a maximum bit-field size of 16, unlike other compilers, which support sizes up to 32. Overall, I judge the robustness of the compiler and environment to be the best of any C++ programming system I have used. Still, it typically takes a month or two before all the major bugs are evident. Technical support was reasonably knowledgeable and friendly, but I waited on hold for 15 minutes before a representative answered.

Borland C++ provides almost everything you need to create a Windows application in C++. Of course, there are always improvements to look forward to, such as a Windows interface for the integrated environment that can run in 386 enhanced mode, improved generation of in-line functions, smarter header precompilation, and a built-in object-oriented toolkit for Windows applications. With Borland's aggressive pricing, commitment to improvement, and outstanding range of features, Borland C++ represents an exceptional value that I can recommend without hesitation. ■

BYTE ACTION SUMMARY

■ **WHAT BORLAND C++ 2.0 IS**
A native-code C++ compiler for producing DOS and Windows programs. Windows applications can be created without the Microsoft Windows SDK.

■ **LIKES**
The aggressive price, compilation speed, and debugger enhancements for testing Windows applications.

■ **DISLIKES**
The integrated environment is still a DOS text application; developers must switch between Windows and DOS during development.

■ **RECOMMENDATIONS**
The Borland C++ compiler is one of the least expensive ways to get started with Windows applications development.

■ **COST**
$495; owners of existing Turbo C and Turbo C++ can upgrade for either $99.95 or $149.95

■ **FOR MORE INFORMATION**
Borland International, Inc.
1800 Green Hills Rd.
Scotts Valley, CA 95066
(408) 438-8400
fax: (408) 438-8696

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Steven Kearns received a Ph.D. in computer science from Columbia University. He is president of Software Truth, developing the next generation of programming environments. He can be reached on BIX c/o "editors."

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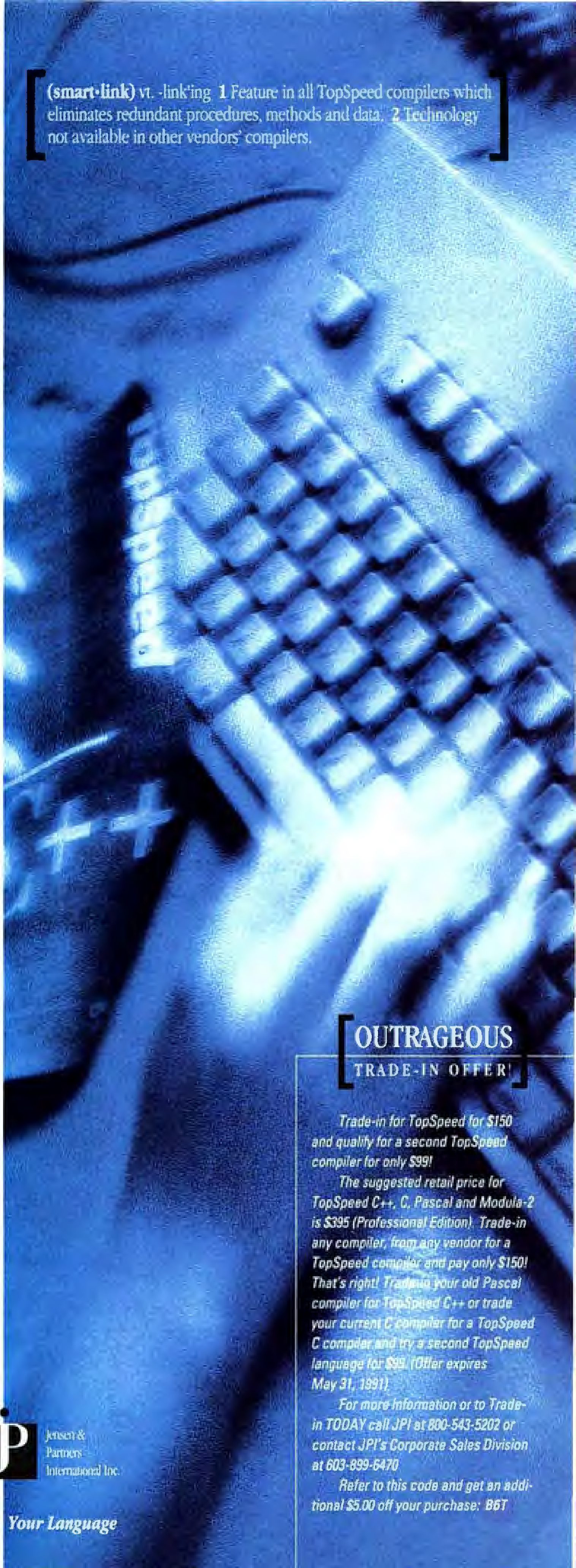
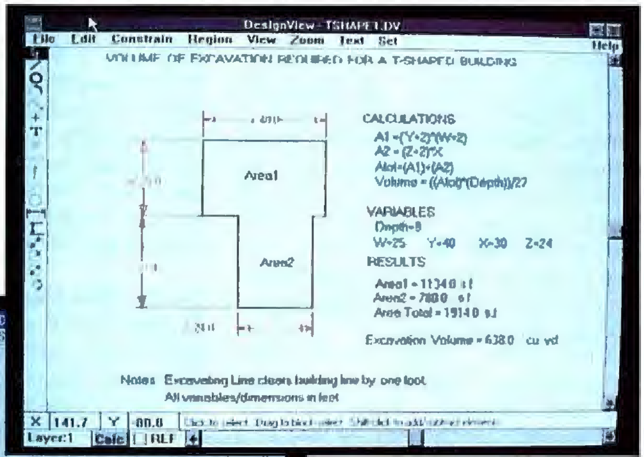


We Speak Your Language

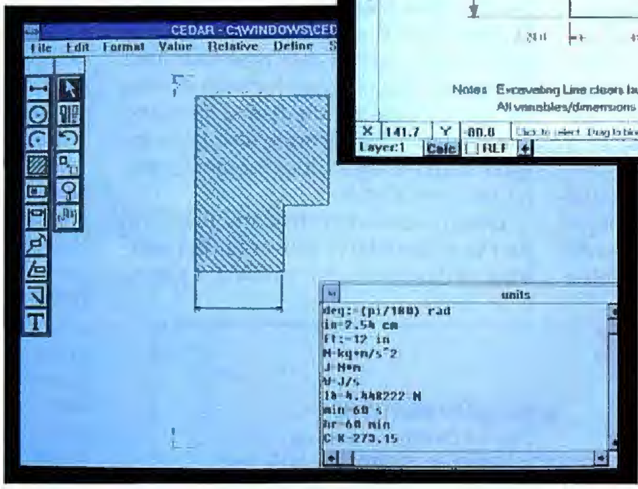
HARDWARE

What-If CAD: Parametric Math Migrates to Windows

DON BISSELL



Screen 1: *DesignView offers sophisticated polyline creation. In addition, it dynamically links and presents engineering calculations.*



Screen 2: *Although some of Cedar's drawing capabilities surpass DesignView's, a confusing interface and other problems make even the simplest drawing a challenge.*

At first glance, Computervision's DesignView 2.0 and MCAE Technologies' Cedar 1.07 look like noteworthy additions to the arsenals of PC-based mechanical engineers and CAD designers. The packages are among the first CAD products to support and capitalize on Microsoft Windows 3.0. Also, their dimension-driven drawing approach may well convince designers to abandon the hand-held calculator, thanks to the variational geometry that lets engineers explore and resolve design alternatives while bypassing some customary recalculations.

But don't confuse these packages with production-drafting software like AutoCAD: DesignView and Cedar (for conceptional engineering design and reporting) are primarily design, analysis, and presentation tools. And while the two packages promise similar results, DesignView ranks as the far superior implementation of Windows-based parametric mathematics.

What-If for Designers

As an analysis tool, parametric CAD has much to offer. Because equations and formulas control key elements within the drawing, what-if scenarios play out in the same way as spreadsheet analyses, except that they are graphically visible in the CAD packages. And the underlying engineering calculations don't fade into the background; instead, they appear alongside and link dynamically to the geometry. Vividly displayed are the usual functions of piece-part design, clearance checking, geometric analysis, moments of inertia, and kinematics (by flipping between equations, you can produce animations).

With this dimension-driven, variational geometry, the drawing environment itself is an unambiguous and dynamic parametric file. Each drawing entity becomes one parameter or constraint, inextricably linked to the whole file. The application of constraints, such as unalterable dimensions, controls the drawing's behavior.

As the model acquires intelligence, it automatically adds logical limitations to preserve its defining mathematical relationships. You can modify these constraints by selective manipulation, such as changing a single dimension's value. Or you can enter a mathematical equation via the equation command. In either case, the model dynamically adjusts to the new parameters.

Why Windows?

Thanks to Windows 3.0, a CAD designer can multitask several designs at once. I opened numerous windows—four in DesignView and four in Cedar—and maintained an acceptable performance level. The number of windows, or data segments sharing code with the main application programs, appears limited only by your system's computing power and the 16 megabytes that Windows addresses.

DesignView and Cedar use Windows 3.0 to cut and paste text and graphical information effortlessly to various windows operating within the drawing environment. However, the packages can access only textual information from other programs via the Windows Clipboard. DesignView makers promise that the next release will ingest a bit map and let you draw on top of it. But for now, if you want to transfer graphics information between applications, you must choose the tedious DXF or Initial Graphics Exchange Specification (IGES) translation route.

The report on translations, however, is mixed. Using DesignView's DXF Translator and Cedar's Smart 2-Way DXF Translator (a $100 option), I decoded moderate-size AutoCAD, DesignView, and Cedar drawings and successfully ported them into and out of all three packages. Since Cedar doesn't support polylines or layering, the program would not convert drawings containing these entities. Large 600K-byte to 1-MB AutoCAD drawings did not cross over into Cedar or DesignView despite the amount of hard disk space I freed up.

Another Windows-related feature, Dynamic Data Exchange links, allows mathematical links to remote Windows applications like Excel; for example, you can start DesignView from within Excel and load values back and forth. (Cedar's current version does not support DDE.)

As a CAD designer and AutoCAD user, I initially questioned the value of Windows-based CAD. Why hand over to Windows computing power that my RAM-hungry application requires? But working engineers who deal with medium-size drawings and who spend more time analyzing than drafting can benefit from the environment. Windows exploits DOS and gives engineers time-saving access to a variety of applications besides CAD drafting. Engineers can always pass their completed designs into production CAD applications by way of a DXF or IGES translation.

I tested DesignView and Cedar under Windows 3.0 on a Compaq Deskpro 386/20e Model 40 with 6 MB of RAM and Intel's 386 cache-memory controller and 80387 coprocessor. Compaq's Advanced Graphics board and 16-inch monitor provided a 1024- by 768-pixel resolution and 16 colors. I freed up 10 MB of hard disk space and operated Windows 3.0 in 386 enhanced mode, which let those 10 MB act as RAM. This feature, of course, is one of the main reasons to choose Windows. I also tested the two packages on my NEC PowerMate 1 Plus with 2 MB of RAM on an Intel AboveBoard Plus, an Intel 80287 coprocessor, a Paradise 16-bit video card, and an Imtek 800- by 600-pixel color monitor. Perhaps because I only worked with the modest sample drawings on this system, the results compared favorably with those of the 386 machine.

DesignView Run-Through

DesignView's setup routine quickly loads about 3 MB of data onto your hard disk drive. The program includes drivers for most monitors, digitizers, printers, and plotters. The software also provides spooler and setup utilities for most popular memory boards.

DesignView is easy to learn, thanks in part to a tutorial that delivers a fine overview of dimension-driven CAD. I passed a pleasant Saturday working the three-tiered tutorial and absorbing the well-written manual. By evening, I felt comfortable merely referring to a quick-start reference card.

DesignView taught me the practicality of dimension-driven CAD, and I was delighted to have discovered a new analysis tool. When I did encounter problems, I found Computervision's technical-support staff to be informed and willing to provide detailed explanations.

I had little difficulty in creating an original drawing with DesignView (see screen 1). The software makes masterful use of construction lines set in the ortho mode. Although orthographic projection is not supported, you can link a side view to the plan view. Polyline creation and editing is quite sophisticated, and there is a noteworthy dynamic control of dimensioning. Via menus and keyboard macros, you can access the usual CAD commands, which both DesignView and Cedar call *tools*.

But DesignView's limitations are apparent when compared to a feature-laden production CAD package; for example, DesignView's undo facility only allows one step back, and you can't add user-defined macros to the menu. Text will not resize, and it blocks automatically whenever you rescale the drawing to a smaller-than-normal size. Mostly, I missed a built-in text editor, an omission that severely limits any attempt at productive CAD drafting. Working in the reverse of typical CAD packages, DesignView and Cedar require you to select an entity before you can act on it. This, and the requirement to adjust constraints, makes any drafting process laborious.

Sorting Out Cedar

Cedar's installation instructions direct you to copy its 600K bytes' worth of data into the Windows directory. Cedar uses the drivers supplied with Windows 3.0. But because I prefer to keep my hard disk organized, I moved the Cedar files into Cedar's own subdirectory, where the program behaved without problems.

Some of Cedar's drawing commands, such as Pan, Zoom Window, and Delete, surpass DesignView's. Undo will retreat 25 steps, and there's a Redo facility. However, Cedar's spline or polyline requires concatenation of miscellaneous arc and line segments, which cannot be constrained and will not respond as variational geometry. As with DesignView, you must select each entity before acting on it. Although the reference manual provides 11 pages of instruction, the arc command remains confusing.

continued

BYTE ACTION SUMMARY

- **WHAT DESIGNVIEW AND CEDAR DO**
  They operate under Windows 3.0 and let mechanical engineers explore designs through what-if scenarios that bypass many engineering recalculations.

- **LIKES**
  Equations and formulas control key elements within a drawing. In DesignView, Dynamic Data Exchange allows mathematical links to remote Windows applications like Excel.

- **DISLIKES**
  Although the packages provide basic CAD functionality, they lack the sophistication of CAD packages. Also, the respective DXF translators work successfully only with moderate-size drawings.

- **RECOMMENDATIONS**
  Choose DesignView as an engineering design, analysis, and presentation tool that can augment your production CAD application.

- **PRICE**
  DesignView 2.0: $895, as tested;
  Cedar 1.07: $995 (as tested; includes $100 Smart 2-Way DXF Translator software)

- **FOR MORE INFORMATION**
  Computervision
  55 Wheeler St.
  Cambridge, MA 02138
  (617) 868-4556
  fax: (617) 868-4658
  Circle 976 on Inquiry Card.

  MCAE Technologies, Inc.
  3160 De La Cruz Blvd.,
  Suite 201
  Santa Clara, CA 95054
  (800) 258-6223
  (408) 748-0334
  fax: (408) 748-1915
  Circle 977 on Inquiry Card.

The ultimate notebook PC and its place in your life.

You've just finished The Big Meeting and you head out of the building, a dozen ideas filling your mind. Budgets, forecasts, letters and directives to members of your team all appear on your mental list of things to do.

You hop a cab for the airport, wishing you could get your hands on a PC. Unfortunately, yours is holding down a corner of your desk back at the office.

Wish no more.

Next trip you can tuck away all the computer power you need in the bottom section of your briefcase. Right now, take a few minutes to imagine how it's going to be when you're out there with that list of tasks, several sheets full of notes and your Texas Instruments TravelMate™ 2000 in hand.

The first thing you like about the TM 2000 is its scant 4.4 lbs. – a six pack of soft drinks weighs a lot more. With many of the common notebook computers tipping the scales at around 7 lbs., you might think we left something out. Not much. Your bantam-weight includes a built-in 20MB hard drive, 286™ processor, 10" diagonal VGA screen, AT®-style keyboard, up to two-hour rechargeable battery and standard 1MB RAM. Yes, all that.

At 8.5" x 11", your TM 2000 could almost be lost under a sheet of letterhead. Most three-ring binders are thicker than its 1.4", so you might wonder why it's called a "notebook."

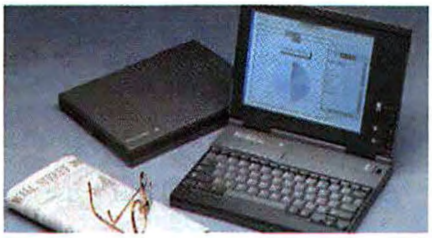
You switch on your new TM 2000 to see what you can do with 286 power. You find it already supplied with an array of free extra-value software – standard, not optional: MS-DOS® 4.01, Battery Watch®, LapLink™, Laptop File Manager and a set of special utilities that do things like extend battery charge life and customize the TM 2000 display. What's more, your TM 2000 swallows up huge chunks of software quicker than you can say "twelve megahertz clock speed."

Once on board, you'll like how fast your programs run. They seem to go quicker than your fingers on the keys, and easily as fast as a desk-bound 286. As for take-it-with-you capacity, you have all you need with the 20MB hard disk drive.

Small outside, enormous inside.

You can boot up popular software with room to spare on 1MB RAM, or take on the latest colossus with optional expansion up to 3MB RAM.

Small, yes, but this is no scaled-down compact, robbed of the features you're used to in the office. Take the keyboard, for example. You recognize its AT-enhanced configuration with a full 79-key inventory of the alpha-numerics you know and need. What the skeptics don't



The Texas Instruments TravelMate™ 2000.
4.4 lbs., 286 CPU, 12MHz.

expect, however, is the full size and solid feel of the keys. They're all arranged in less than 11 inches, side to side. Put a ruler to the AT keyboard in your office and you'll wonder how it's possible!

Well, here's part of the secret. You can get an optional outboard numeric keypad. You plug it in when you do heavy number crunching. The rest of the time you don't need it, so it's not there just taking up space. Makes sense.

Easy on the eyes.

As for the display, you're looking at serious high-resolution technology: a 640 x 480 VGA 10" diagonal, sidelit, reversible black-on-white, picture-perfect, triple-supertwist LCD screen that makes complex graphics and windowing applications show up like ink on paper. With 16 gray scales, visibility is magnificent under just about any lighting condition. Check it out!

Major league interface.

The TM 2000 wasn't built to be a minor player, so it can support all the interface capability you need. Its serial (RS-232-C) nine-pin interface is standard. There's also a parallel (Centronics) port for your printer. You can drive your VGA color monitor with a CRT interface option. Or you can plug in an optional 2400 bps modem with send/fax capability. An optional multislot expansion station for one full- and one half-size IBM PC/XT/AT®-compatible cards rounds out your flexible interface array.

That's not to say you won't have to sacrifice.

To keep you light on your feet, something had to give. So we took the 3.5" floppy disk drive out and made it optional. Now you only carry it with you when you need it. Besides, you can transfer files between your TM 2000 and a desktop PC fast and easy with LapLink.

Awards winner.

When you add it all up, you'll understand why *BYTE* magazine said, "The TravelMate is as close as you can get to the ultimate portable."* In fact, *BYTE* gave the TM 2000 its 1990 Award of Excellence, acclaiming its exceptional value for the money and smart design. Not only that, *PC World* named it their 1990 Best Buy for its premium power and portability. And *PC Magazine* was so impressed that its editors gave the TM 2000 their most prestigious awards: the Editor's Choice Award – for two consecutive years – and the 1990 Award for Technical Excellence.

Yes, awards are great. But what we really aim to win is *your* vote. So we built this new look of power to be one you can count on. After all, Texas Instruments has more than two decades of experience in portable computing under its belt. That's why we're able to support the TM 2000 with a worldwide network of authorized service representatives.

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Dial our toll-free number. We'll tell you where you can see the TravelMate 2000 for yourself. And see how light, thin and powerful it really is. Then see yourself finding a place for this ultimate notebook PC in your life. It'll cost less than you think!

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	TM 2000	TM 3000
Size:	4.4 pounds, 11" x 8.5" x 1.4"	5.7 pounds, 11" x 8.5" x 1.8"
Performance:	12 MHz 286 processor, 1MB RAM (expandable to 3MB)	20 MHz 386SX processor, 2MB RAM (expandable to 6MB)
Display:	Reversible 10" black-on-white sidelit LCD with 640 x 480 VGA resolution in 16 shades of gray	Reversible 10" black-on-white sidelit LCD with 640 x 480 VGA resolution in 32 shades of gray
Storage:	20MB hard drive, optional external 1.44MB 3.5" floppy drive module	20-30-40-60MB hard drive, internal 1.44MB 3.5" floppy drive

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TEXAS INSTRUMENTS

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I proceeded to work through Cedar's tutorials, but I discovered that even basic commands, such as Text and Cell, which allow display of dimensional values and calculation results, did not work consistently. I created a rudimentary drawing (see screen 2) and found that although I could constrain horizontal lines, I could specify only one of two contiguous vertical dimensions. My attempts at an area computation were unsuccessful.

When I called MCAE Technologies' technical-support staff, they identified my problem immediately: an Epson 24-pin dot-matrix printer configured in Windows 3.0. They suggested that I reconfigure Windows for a Hewlett-Packard LaserJet Series II printer, even though I didn't have one. This would possibly solve my text, cell, and dimension-display problems, but it would also leave me without a printer or plotter.

I also learned that unlike horizontal lines, vertical lines needed their lengths specified by the program before I could constrain them. And an area calculation, like all equations in Cedar, requires careful preparation, especially if you prefer inches and feet to metric units, the default. Although you can select feet from the units file, you have to define square feet (ft2:$=$ft^2) as a new unit. My test volume calculation also required a new ft3:$=$ft^3 unit.

MCAE recommended that I use the software primarily for analysis and that I turn to my regular high-end drafting program for general drawing. But the software's problems, coupled with documentation that lacks information and a lengthy learning curve, make me question the product's usefulness as an analysis or even as a basic drafting tool.

DesignView 2.0: a dynamic analysis and presentation tool.

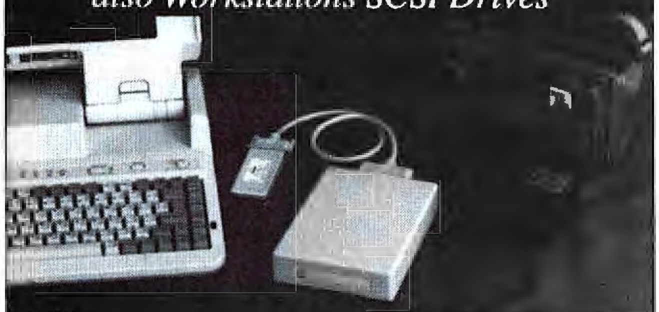
The company promises that Cedar's next version, which was slated for release after press time, will offer an enhanced user interface, better documentation, and expanded graphics, equation, and spreadsheet functions.

CAD Pick

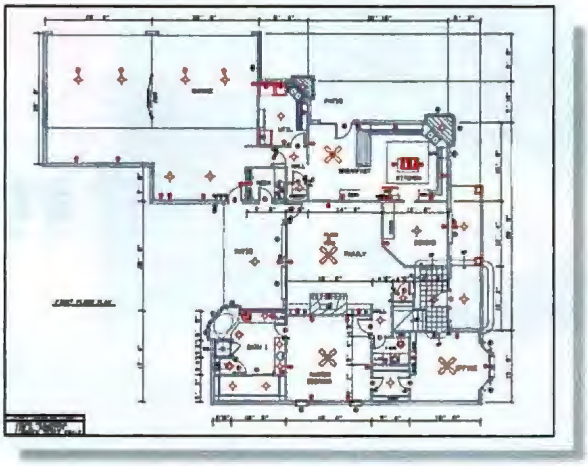
By contrast, DesignView 2.0 performed as advertised as a dynamic analysis tool for moderate-size databases. If you attempt to constrain a large database containing thousands of construction elements, be prepared to summon Herculean computing power. DesignView also delivers the look and feel I've come to expect from quality CAD software. But at $895, it's priced substantially below high-end production CAD software.

Because of its ease of use, short learning curve, well-written documentation, enthusiastic technical support, and relative sophistication, I can recommend DesignView as an engineering design, analysis, and presentation tool. ■

Don Bissell is a CAD designer and technical writer based in Wells, Maine. You can contact him on BIX c/o "editors."



WHAT MAKES A BEST SELLER A BEST SELLER?



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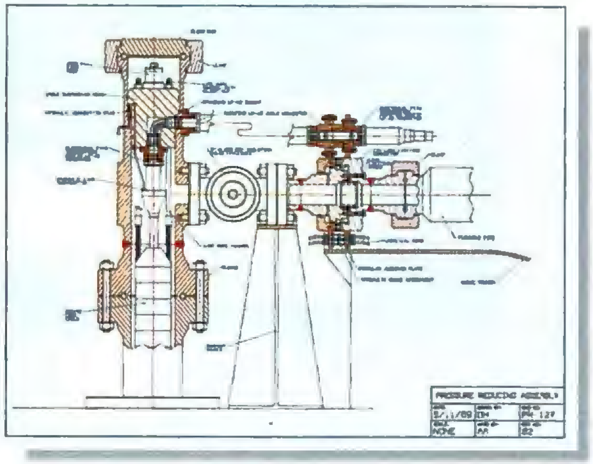

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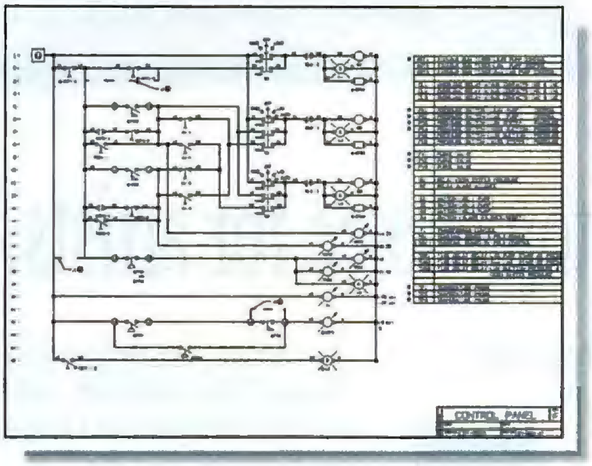

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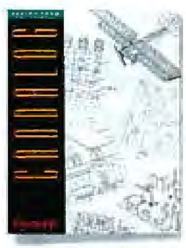

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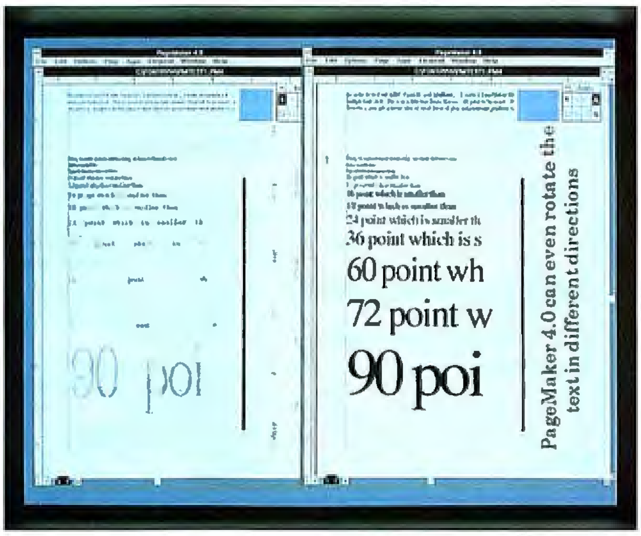
APPLICATION

Windows Display Managers File Rough Edges from Text

HOWARD EGLOWSTEIN



In the standard Windows installation (left), synthesized fonts often take on a craggy appearance. Any font larger than a certain size appears as a thin, almost anorexic outline. With the FaceLift font manager installed (right), typefaces are clear and readable at any size.

When you switch to a Microsoft Windows environment, you gain both multitasking ability and the promise of true WYSIWYG on-screen. Unfortunately, the standard Windows font management fails to deliver on that promise.

Adobe Type Manager (ATM), Bitstream's FaceLift, and Hewlett-Packard's Intellifont-for-Windows font managers bypass the standard Windows font display and replace it with true WYSIWYG. In a stock Windows installation, you decide which fonts you'll need on-screen and pregenerate bit maps for all the sizes you expect to use. When your application calls for a screen font, Windows first looks for an exact match for size and typeface. If it finds one, great. If not, Windows tries to scale one of the existing sizes to fill your request.

Windows font managers don't pregenerate any fonts. Rather, they place a mathematical representation of the typeface on your hard disk drive. The font management software patches itself directly into Windows and begins to perpetrate a lie—it agrees to any font request your application makes. When it comes time to display the font on-screen, the font manager takes control, calculates the correct bit map from the description, and renders it at your display's best resolution. The same principle applies to your printer. Even though you may not have a printer with a page-description language, a font manager can use your printer's graphics printing capability to print any installed font in any size at full printer resolution.

These three font managers have much in common. The Windows SYSTEM.INI file determines which device drivers control the environment. ATM replaces the standard SYSTEM.DRV file with its own, and then it points back to SYSTEM.DRV with an extra entry in the file. By making this one patch, ATM takes control of all display and printing functions. FaceLift and Intellifont both patch out the DISPLAY.DRV entry to gain control over the screen. To get control of the printer, FaceLift provides its own generic print driver, SHELLPRT .DRV, which then chains to the original printer-specific driver. It's all rather confusing, but take heart: The installation routines handle everything for you.

These products make a standard Windows installation look positively lame. I tested all three with a variety of software, including PageMaker 4.0, Ami Pro, and WingZ. Any installed font, at any size, looks clear and sharp. Without a font manager, large characters display with distinct jaggies or get converted to

BYTE ACTION SUMMARY

WHAT WINDOWS FONT MANAGERS DO
These products bring true WYSIWYG to Windows applications.

LIKES
All three products make fonts readable at all sizes.

DISLIKES
For best performance, you'll need a large memory cache.

RECOMMENDATIONS
Adobe Type Manager for PostScript users; Intellifont for HP scalable-font users; FaceLift for Bitstream font users or for any Windows user who wants finer control of dot-matrix printers.

FOR MORE INFORMATION

Adobe Systems, Inc.
1585 Charleston Rd.
P.O. Box 7900
Mountain View, CA 94039
(800) 344-8335
Circle 1208 on Inquiry Card.

Bitstream, Inc.
215 First St.
Cambridge, MA 02142
(800) 522-3668
(617) 497-6222
fax: (617) 868-0784
Circle 1209 on Inquiry Card.

Hewlett-Packard Co. Inquiries
19310 Pruneridge Ave.
Cupertino, CA 95014
(800) 752-0900
(303) 353-7650
Circle 1210 on Inquiry Card.

FONT MANAGER FEATURES

All three type managers share the same system requirements but support different font formats. If you've already invested in a font library, stick with a package that supports it. Likewise, Intellifont should satisfy LaserJet Series III owners. It's bundled with the LaserJet III.

	Adobe Type Manager	Bitstream FaceLift 1.2	HP Intellifont-for-Windows
System requirements	Windows 3.0 or higher, MS-DOS 3.1 or higher, 286 or 386 PC with 1 MB of RAM, Windows-compatible display	Windows 2.03 or higher, MS-DOS 3.1 or higher, 286 or 386 PC with 640K bytes of RAM and EMS or extended memory, Windows-compatible display[1]	Windows 3.0 or higher, MS-DOS 3.1 or higher, 286 or 386 PC with 1 MB of RAM, Windows-compatible display
Printers supported	Most laser and impact graphics printers with Windows drivers	Most laser and impact graphics printers with Windows drivers	HP LaserJet III
Font format	Adobe Type 1	Bitstream Speedo[2]	Agfa Compugraphic FAIS scalable format
Included fonts	Times Roman, Helvetica, Courier	Dutch (like Times Roman), Swiss (like Helvetica), Park Avenue, Cooper Black, Brush Script, Formal Script, Monospace	CG Times and Univers
Optional fonts	Adobe Plus Pack (adds remaining 35 PostScript fonts): $198 Adobe Typeset 1 and 2: $99 each Other fonts available	FaceLift Companion Pack for PostScript (adds remaining 35 typefaces): $179 FaceLift Companion Pack for the HP LaserJet III (12 resident typefaces): $99 Other fonts available	Included with font cartridges
Price	$99	$99	Bundled with printer

[1] Product did not work with Radius TPD/PC display in high-resolution mode.
[2] Upgrade available for existing Fontware fonts.

an anemic vector representation. Font managers also give you a performance improvement. After a short delay to build the font in memory, they update the screen faster than Windows can normally display its scruffy fonts.

Adobe Type Manager

ATM uses Adobe's Type 1 PostScript fonts as its font representation. While it supports any standard Windows printer, the PostScript base makes ATM ideally suited to installations that have a PostScript printer and a selection of PostScript fonts.

In addition, folks who prepare documents for final printing on PostScript typesetting equipment should consider that ATM will assure compatibility between the screen and their final output.

FaceLift

Bitstream's FaceLift is a serious competitor to ATM and offers you more control over nonlaser printing devices. Selectable print resolution and density control let you adjust its output for the best appearance. FaceLift's font source is the Bitstream Speedo format, a proprietary format that is sadly incompatible with the existing Fontware format. Folks with a collection of Fontware can upgrade their fonts to Speedo format.

My only problem with FaceLift during testing was a driver incompatibility with the Radius TPD/PC dual-page monitor. Using FaceLift 1.2, I connected an HP LaserJet Plus to a 386 machine running Windows on the Radius in 1280- by 960-pixel mode. While the display looked perfect, the printed page came out scrambled. Switching the display to standard VGA mode corrected the printout. Bitstream was still looking into the problem as we went to press.

HP Intellifont-for-Windows

HP's Intellifont is more of a special-purpose font manager than ATM or FaceLift. It uses HP's scalable-font format for the Series III printers as its base and renders only to the screen. Printing from an Intellifont installation requires an HP Series III printer into which to download the font outline.

The big advantage for Series III owners is that Intellifont is free. To get screen fonts, you simply buy an HP font cartridge or disk for your Series III printer. If you're looking at third-party fonts, be sure to ask if the package includes the Intellifont font outlines.

Putting Your Best Face Forward

If you have a Series III printer and work with the HP scalable fonts, Intellifont is your obvious choice. It's free, and it supports all of HP's scalable fonts.

Some people accumulate PostScript fonts like dust bunnies under a sofa. For them, ATM seems the natural choice. It handles the Type 1 format directly and guarantees that your screen will look exactly like PostScript output. On non-PostScript devices, it does a superb job as well, although it provides just the fonts and not the PostScript emulation.

Many people don't have PostScript printers and don't prepare work for typesetters. For them, FaceLift is ATM's equal. Its adjustable density control is particularly handy for printing on dot-matrix printers.

Your final call should be based on the font technology you already own. Fonts are expensive, and switching formats can be costly. If you've already invested in fonts, stick with the offerings from that vendor. If not, and you don't have a Series III printer, it's almost a coin flip. I prefer ATM because of its clean installation and the better guarantee of WYSIWYG when working on PostScript devices. Either way, a font manager is a must-have item when you're buying or upgrading a Windows machine. ■

Howard Eglowstein is a testing editor in the BYTE Lab. He has a B.S. in architecture and design from MIT and is a desktop publishing systems consultant. You can reach him on BIX as "heglowstein."

An Out-of-Towner's Introduction to the BIX Community

BIX is for people who use microcomputers for business, finance, research, and career and personal development. There's always something interesting happening here. No matter what you're into. The latest industry news. Top-notch software libraries. Private electronic mail. Real-time chatting. And every month, the complete text of *BYTE* magazine. (Read more about BIX, and how to join, on adjacent page.)

From Artificial Intelligence to Zenith Laptops...

Whatever your interest, BIX has a conference for you. Here's our latest list. (In each Exchange, Conference name appears on left, description on right.)

BIX COMMUNITY CALENDAR JUNE 1991

■ Amiga Exchange

Joanne Dow, Exchange Editor

amiga.user	Exchange ideas, solve problems, compare notes
amiga.sw	Amiga programming and developer issues
amiga.hw	Amiga hardware design, use, and hookup
amiga.arts	Artistry using the Amiga
amiga.int	Developing for the international Amiga
amiga.special	Special guests and events
amiga.dev	Commodore's conference for developers

■ IBM Exchange

Barry Nance, Exchange Editor

ibm.pc	The venerable PC
ibm.at	The AT series and workalikes
ibm.ps	The PS/2 series
ibm.os2	OS/2 operating system
ibm.dos	PC/DOS & MS/DOS operating systems
ibm.os.386	Alternative 386 operating systems
ibm.utils	Utility software for IBM computers
ibm.repairshop	Garage and Tune-up Shop
ibm.new.prods	New products for IBM computers
ibm.exchange	IBM Exchange clearinghouse
ibm.listings	Index to program files in the Exchange
ibm.other	Apps, printers, modems, etc.
microsoft	Products from Microsoft

■ Writers' Exchange

Wayne Rash, Jr., Exchange Editor

desktop.pub	Using microcomputers for publishing
elfquest	Find out about things elven with Richard Pini
journalism	Reporting and writing news
journalism.pro*	Interaction for working press only
lexicon	About words
marketing	Promos, sales, public relations and high tech
new.writers	Getting started in the writing business
poetry.prose	Writing both types of English
sf	Science Fiction, Star Trek, and fantasy fans
sfwa*	Science Fiction Writers of America
tech.news	Discuss Microbytes, product reports, items
word.processor	Word-processing programs
writers	The original writers conference
write.fiction	How to write fiction
writers.pros*	Interaction for professional writers only
writers.talk	Conversations with professional writers

■ Macintosh Exchange

Dr. Larry Loeb, Exchange Editor

mac.apple	The word from Cupertino
mac.business	Macs in the office
mac.desktop	Publishing with a Mac
mac.external	Information from all over
mac.hack	Technical information about the Mac
mac.hypercard	Using the HyperCard programming environment
mac.news	Up-to-the-minute information
mac.novice	For beginners
mac.products	Listings of new hardware and software
mac.sandbox	For off-hours fun

■ Tojerry Exchange

Jerry Pournelle, Exchange Editor

tojerry	Messages for and from Jerry Pournelle
chaos.manor	Computing at Chaos Manor
astronomy	A star party for amateur astronomers
contact	Science fiction meets science
disasters	Natural and man-made disasters
education	Computers in American classrooms
mathematics	Talk about high-level mathematics
sciences	Scientific programs
space	Space exploration and development
technology	New technologies and their impact

*Please Note: Membership in this conference is limited to pre-screened specialists only.

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Things tend to disappear from my Macintosh hard disk. The disk isn't defective—the files just seem to get lost in the clutter of hundreds of other files in hundreds of subdirectories. When I try to look for the files that I need, the names provide only a clue to their contents; this means that if I'm looking for a particular passage, I must endlessly open and close files until I find the keywords. Some programs automate this search, but they still take too long, because the disk is too big.

The best of all possible disks would have an index that knew where to find every word. In the discussion that follows, I'll consider the details of how to create a program that automatically maintains such an index to all the files on a disk. Once the program has constructed the database, you can find the files you want instantaneously.

Design for Size and Speed

A good index is nothing more than a set of pointers between keywords and the file blocks that contain those words. A set of pointers takes space, though. The trick is to design a network of pointers large enough for quick searches but small enough to avoid overwhelming the disk. An index must also be easy to update when files are added, deleted, or modified.

A null index is one extreme of the trade-off between space and search time. It doesn't take up any space, but searching every file for keywords is slow. Luckily, the other extreme is a complete index of all the data, which usually consumes no more than 5 percent of the entire disk, because an amazing amount of data is redundant.

Many keywords occur numerous times in a file, but the index needs only one entry. The worst case would be a disk that was filled with a spelling dictionary of unique words; the index would carry one entry for each of those words and a pointer to that one file. In this case, the index would actually be larger than the data it was mapping. But on the other extreme, if the disk contained text from simple children's books, the index would contain only its limited vocabulary—maybe a hundred items.

My hard disk contains plenty of programming code filled with funny variable names like `PQIncrement` and `PMIncrement`. The index is somewhere between the extremes, but because the words go beyond the English language, it is actually a little larger than simple text.

The system I describe can convert a normal array of data into a decent-size index. My almost-full 40-megabyte hard disk drive generates an index that is about 1800K bytes. This index system includes the ability to make a few simple trade-offs between completeness and index size by providing some indexing options, but the default should be efficient enough that you won't need to use these options except in pathological cases of very low disk redundancy. On the other hand, I haven't cut every bit of fat from the system. The structure of the index is rich with pointers that are not explicitly necessary but that make the system run much faster. The index files are not as small as they could be, but they are manageable on a system with a 40-MB hard disk drive. Even though the examples and code have been implemented using Pascal on a Mac, the concepts are easily transportable to other languages and operating systems. The listings are written in pseudocode. Listing 1 is composed of global definitions for the examples.

The Structural Outline

This indexing scheme uses three main structures: a list of the filenames on the disk, a list of the keywords in the files, and a set of pointers between the keywords and the filenames. The list of filenames has one entry for each filename on the disk. The list of keywords has one entry for each unique word on the disk. The glue between these two lists is the set of pointers between each word and the file (or files) that contains an instance of that word. Each of these structures is stored in memory in a unique format, tuned to balance access speed, modification ease, and small size.

As an example of how this design works, let's say that your disk contains three letters of complaint to Getta Lottagrief, the director of customer service at a company. The names of the three files, `MadLet`, `Really Mad Let`, and `Extremely Mad Let`, are included in the list of filenames. Her last name, the word `Lottagrief`, would have a list of pointers joining it (as a keyword) to the entries for the three filenames. The keyword `upset` would have pointers to the latter two letter files as well as other files on the disk that contain that word.

Listing 1: *The global definitions for the pseudocode.*

```
Globals:
   FileStructureRoot: file node holding root directory.
   WordStructureRoots[a..z]: contains 26 roots, one for each letter of the
      alphabet.
   UnallocatedFileNumberList: a list of file numbers set up initially to
      contain the number 1..8192. Two functions, PushUnique# and
      PopUnique#, add and remove elements to this list.
   AllocatedFileNumberList: a list of unique numbers already assigned and
      pointers to the leaves of the tree containing it.
```

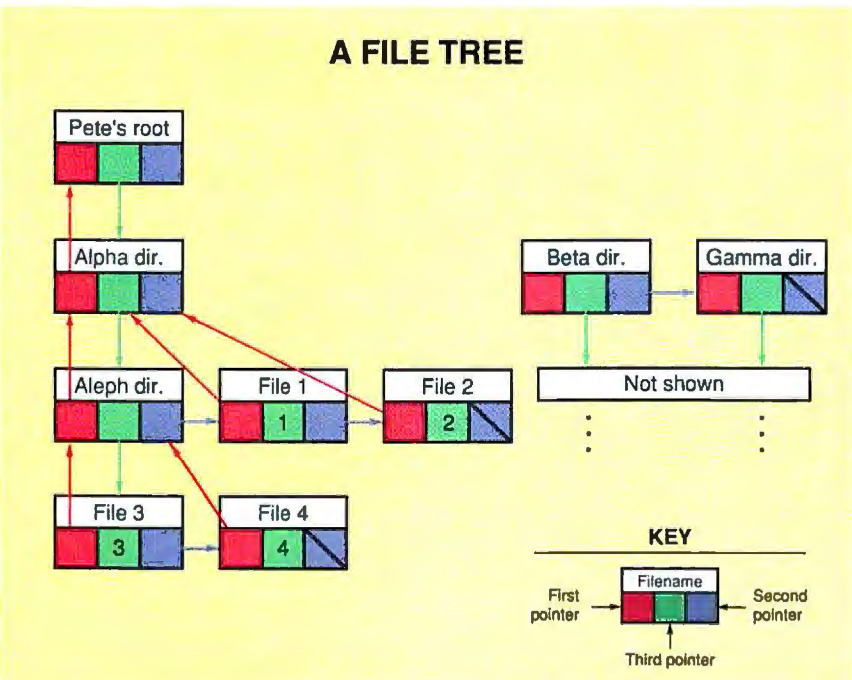

Figure 1: *Each file tree node contains the name of a directory or a file and three pointers to other nodes. The first pointer points up to the parent directory. The second pointer is directed to the next entry in the same directory. If the node is for a directory, the third pointer points down to the list of names of files and subdirectories contained within the directory. If the node represents a file, though, the third pointer contains the unique number assigned to that filename. (A slash means* empty.*)*

The Filename Tree

In the filename structure, each file has a unique ID number. The structure that matches the number with the file has two parts, which saves space and allows safe modification. The first part of the structure holds the filenames in a tree-like network that mimics their positions on the disk, and the second part holds a list of file numbers and their position in the tree. By shaping the first structure like a tree, you use far less space than you would if you used the complete path name for each file, because each directory name appears only once in the tree. The second list allows you to manage file numbers.

Each file tree node contains the name of a directory or a file and three pointers to other nodes (see figure 1). The first pointer points up to the directory that contains the name of a particular node. For example, if the file `Lambada` is in the directory Waltzes, the first pointer for the node Lambada will point to the node Waltzes. The second pointer of the Lambada node will point to the next entry in the same directory—say, a file called `Bartman`. The third pointer does one of two things: If the node represents a directory, the third pointer points down to the list of filenames and subdirectories contained within it (e.g., the third pointer of Waltzes points to `Lambada`). If the node represents a file, though, the third pointer contains a unique number assigned to that filename.

The complete file path can be constructed by tracing the first pointers of each node from the leaf entry to the root. In connecting a keyword and a file that contains it, the indexing program converts the unique file number into the full path; the first pointers make this easy to do. Adding new nodes in the correct place and moving pointers makes it easy to add and delete filenames. The function `AddFileName` in the pseudocode of listing 2 describes the basic recursive structure of a function that adds a filename to a tree. The indexing program uses a function similar to `AddFileName`

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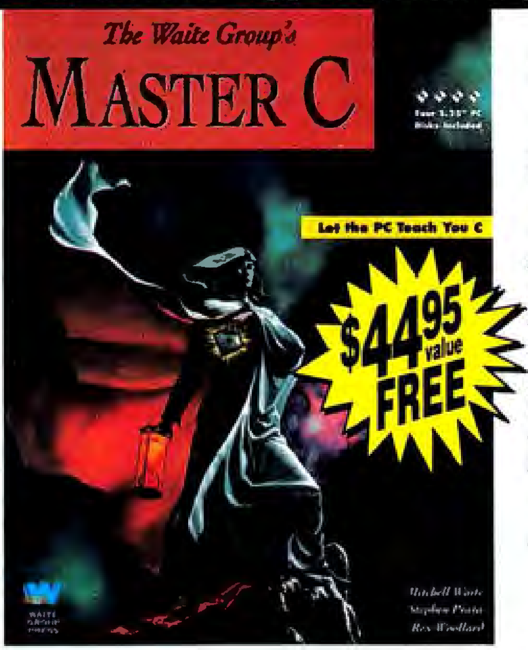

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Listing 2: *The basic recursive design for adding a filename to the filename/number tree.*

```
Function AddFileName(p:array[1..n] of file or directory names)
:FileNodePointer;
   {This function adds a path of n-1 directory names and one filename to
   the file structure.}
var
   CurrentNode:FileNodePointer;
   CurrentLevel:integer;
begin
   Set CurrentNode to FileStructureRoot. {This assumes one root directory.}
   CurrentLevel:=2;
   StillSearching:=true;
      {We are now at a list of the branches at CurrentLevel.}
   while p[CurrentLevel] is not past the end of the path do begin
      Scan along this list started by CurrentNode until the name
         corresponding to p[CurrentLevel] is found.
      If the file / directory name is found, then set CurrentNode to the
         down pointer here. Increment CurrentLevel.
      Otherwise, add the new name and the rest of the path. Do this by
         creating a node. Set the first pointer to point to previous
         directory. Set the second one to point to the next file / directory
         at this level, and fill the third with the pointer to the next
         level.
   end;
   when the loop exits because it finds (or adds) the node of the last
      filename, return this leaf. Set the number stored at this leaf (in
      the third pointer) to the value of PopUnique#.
end;
```

to search a directory for new files added since the last time the index was updated.

The filename section must also keep track of the numbers that have been allocated as unique file numbers. It is not enough to simply increment a counter to get a unique number for the next file added to the index because the continual updating of the index will soon exhaust the list. The system recycles file numbers by maintaining a list of unallocated numbers. When a new number is needed, it is taken from the front of this list; when a number is retired, it too is added to the front.

For reasons that will become clear, this index program (in its current form) is limited to 8192 files (i.e., 13 bits of information). The list of unallocated numbers is set up as an array of 8192 pointers, with each array element pointing to the next. When a file number is needed, the program pops it off the top of the list, and the pointer to the next element is replaced by a pointer to the leaf of the tree in the first part of the structure. This makes it easy to convert a unique file number into a position in the filename tree and, consequently, into a complete file access path.

When a file number, say *i*, is retired, it is recycled by setting its pointer to the current first value in the list and setting *i* to be the first value in the list. Before the list has been used, it looks like the following: 1,2,3,4,. . .,8192. After three files have been indexed and three numbers have been popped off the top of the list, it becomes 4,5,6,7,. . .,8192. If file number 2 is erased from the disk, its number is recycled by placing it at the front of the list, which would then appear as 2,4,5,6,. . .,8192. The next new file will have the number 2 assigned to it.

The structure is an alphabetically sorted tree, referred to as a trie.

The Alphabet Tree

When I scanned my disk, I found about 35,000 words on it. This is probably a higher number than an average disk would contain because of the non-English variable names in the large amount of program source code and the 25,000-word English spelling dictionary. In all, my index is probably larger than one containing just word processing files. I've tried the program on disks that have up to 50,000 words.

The index needs to link each keyword with a list of the file numbers for every file that contains that word. The list of file numbers is stored in a separate structure (for the purposes of conceptual clarity and space). For now, assume that each keyword comes with a pointer that leads to this list. The problem is finding an easy way to store these keywords and their single pointer. The structure should be as small as possible, easily accessible, and mutable when files are added or deleted from the index. It should also be a structure that makes adding and deleting words fast. There are several possibilities. Some are compact but slow, and others are large but faster. I use the faster, larger version in this index, but I'll look at two other designs first.

The first scheme is a simple list of words. Each word and its pointer would be placed in one long list. Assuming that the average word length is six characters, it follows that at 1 byte per character, 3 bytes per pointer, and one extra stop byte, each word would take 10 bytes to store. That means it would take 350,000 bytes to hold my list of 35,000 words. (Data compression could make it somewhat smaller.)

With this scheme, adding new words to the list looks deceptively simple—they could simply be plunked on the end. The problem is that this method does not check for duplicate entries, an obvious requirement. Checking for words that are already in the list would take a scan of the whole list—a list that would eventually grow to 35,000 words. This just isn't efficient.

The second scheme is to build a hashing table. The big list could be split into a set of *n* lists using a function that parcels out words evenly to each of the *n* lists. If the function did a good job distributing the words to the *n* lists, the average list would be 1/*n*th the size, and the algorithm would run *n* times faster. But getting hashing functions that distribute words equally can be difficult.

The structure used in this program is an alphabetically sorted tree, sometimes referred to as a *trie*. In this structure, there are 26 roots that correspond to the first letters of the words. At each node, there is a letter, and the letters in the nodes along paths from the roots to the leaves are guaranteed to form words. This saves a great deal of space, because

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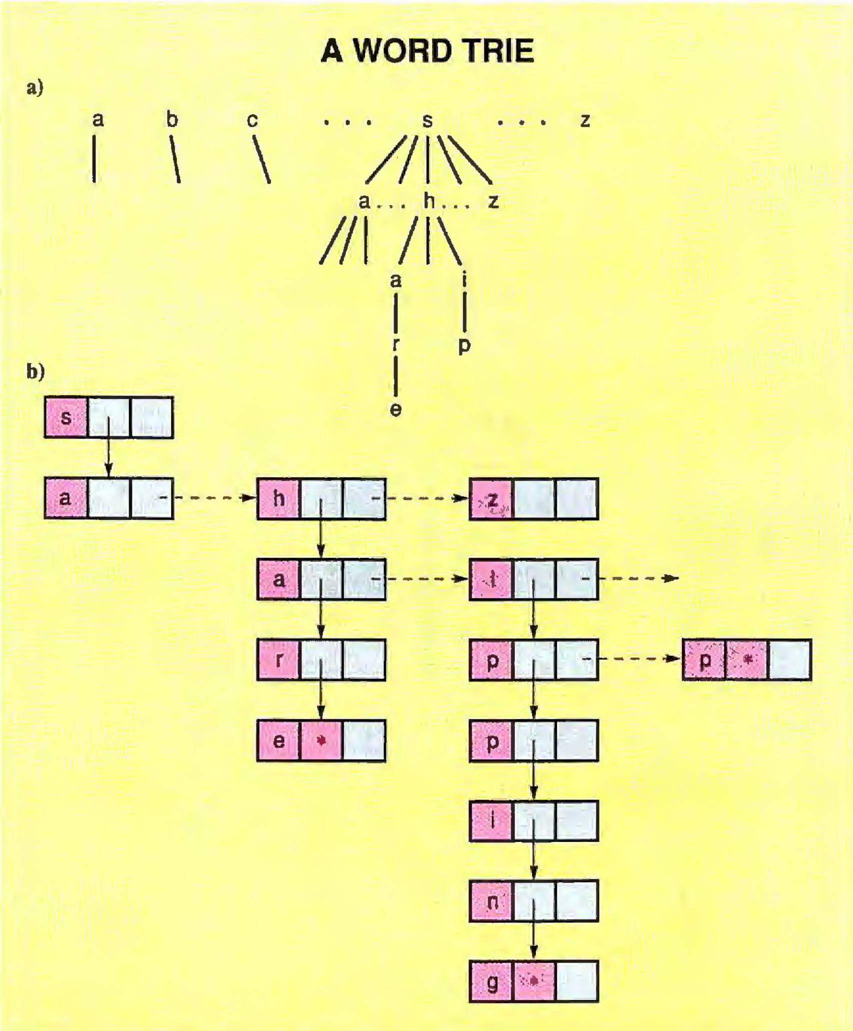

Figure 2: (a) *A trie—26 trees, one for each letter of the alphabet, and each node containing a single letter. The path from the root defines a word. Each node that represents an indexed word contains a pointer to a list of file numbers.*
(b) *The pointer structure of the trie. (The asterisks stand for pointers to a list of file numbers; the empty boxes could be pointers to other nodes; the dashed lines indicate the omission of a few nodes for clarity.)*

many words share the same beginnings. Figure 2 illustrates a simple trie. Words like *share* and *ship* have the same first two letters, so there is a fork after *sh*. One path leads to *a*, *r*, and *e*, and the other path leads to *i* and *p*. The first two letters are not duplicated, thereby saving space. The function `AddWord` in listing 3 shows how a word is added to the structure using recursion.

You build a trie out of nodes that contain a letter, two pointers, and a bit flag that is set to TRUE if the node is a leaf. One pointer leads to the next node at the same level, and the other pointer leads to the first node on the next level down. This structure is similar to the one used to hold the filenames, but the pointer to the parent node is unnecessary here, because the program will only be searching down the tree. The nodes on the same level are kept in an alphabetical list. The down pointer from each of these nodes points to the next level down. Figure 3 shows the node structure built from the tree in figure 2. When a node is a leaf (the path down the tree is one of the keywords), the down pointer becomes the pointer to the list of numbers for the files that include this word.

To conserve space, the nodes need to be packed as tightly as possible; in this tree, you need only 8 bytes for a node. The two pointers are each reduced to 3 bytes and are packed with the one letter and the bit into 8 bytes. The 3-byte pointers are not direct pointers to memory but are just relative offsets from the beginning of the memory chunk. Figure 3 shows how to do this. Packing the data into 8 bytes makes it the size of two 4-byte integers, a great advantage on some processors. For example, the 68030 fetches 4-byte integers at locations evenly divisible by 4 much faster than it fetches integers at other locations. Some RISC processors don't allow access at locations that aren't evenly divisible by 4.

The Web of Connections

The objective of this index system is to connect keywords to the files that contain them. Three parts make up this system. So far, I have discussed only two: the file list and the keyword list. The third part is the connection between these two. The connection begins with the second (down) pointer in the leaf nodes of the word list tree, and for leaf nodes, this points to the beginning of the word list.

There must be a separate list for each unique word—some 25,000 to 100,000 (or more) separate lists. When there are so many lists, a structure needs to be simple to conserve space, so I chose to use a simple linked-list structure and pack each node into 4 bytes of data. In this tree, every node contains a number corresponding to a filename and a pointer to the next node in the list. The lists are kept in sorted order so that finding duplicates will, on the average, take half as much time. (The function `AddValue` in listing 4 shows how to add a value to a sorted linked list.)

Thirteen bits are allocated to the file number, which means there are $2^{13}=8192$ file numbers allowed (remember the limitation I stated earlier?). The other 19 bits are allocated to the pointers. This means that a block of lists can contain 512K-byte nodes. The bits can be split differently between the file numbers and pointers, but this division should be adequate for now. In the future, when files contain terabytes of information, these 4 bytes will be inadequate.

It is tempting to pack these lists even tighter. With the pointers taking up 19 bits per node, this takes up plenty of space when the list looks like this example:

```
value₁ pointer value₂ pointer
...valueₙ null-pointer
```

It is possible to just place the numbers end on end and designate a stop value, similar to a null-terminated character string. In this case, the list becomes like this example:

continued on page 412

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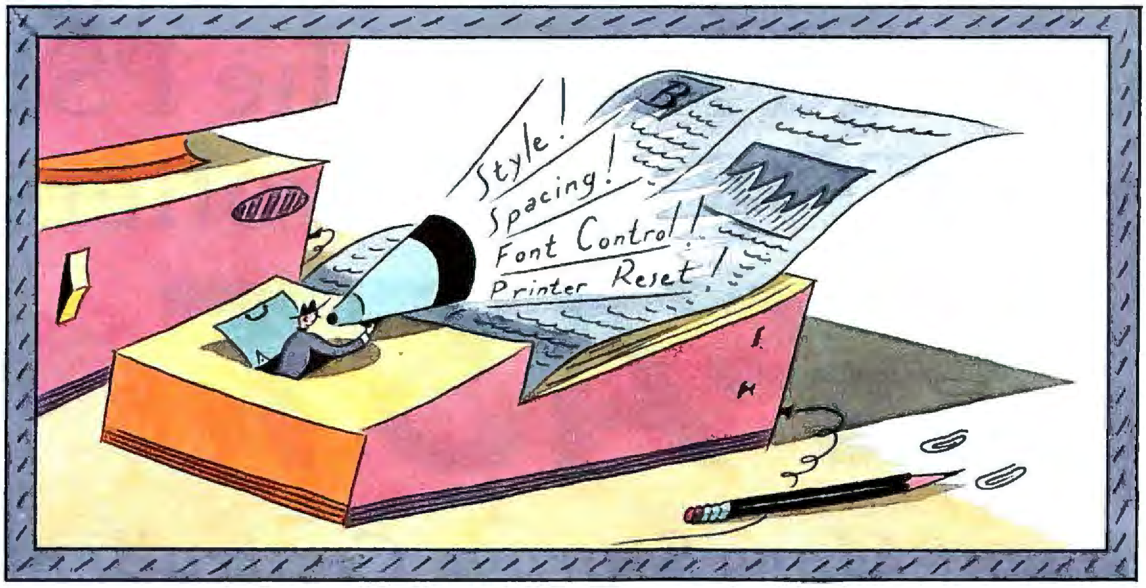

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Laser printers have become the office workhorse because they can produce fast, high-quality graphics output at a reasonable price. Among their most important features has been support for multiple character-font types and sizes, useful in desktop publishing and other document preparation applications. Printer-resident page-description languages define the command set used to tell the laser printer what to do, in much the same way that a BASIC interpreter or Pascal compiler determines the instructions that can be used to tell a computer what to do. And just as BASIC programs and Pascal programs use different instructions to accomplish the same task (e.g., drawing a line on your video screen), different PDLs require different commands to accomplish the same print function (e.g., printing a line on the paper).

As its name implies, a PDL is page oriented; all the commands that describe the format of the printed page go to the printer before it actually prints the page. This contrasts with conventional dot-matrix "pin-head" printers, which print each text or graphics line as the computer receives it. Two PDLs in particular have become standard in personal computer laser printers: Adobe Systems' PostScript and Hewlett-Packard's Printer Command Language. A lot has been written about the powerful PostScript PDL and its many features. Its support for scalable fonts and vector graphics has made it overwhelmingly the PDL of choice in desktop publishing applications. In this article, I'll take a look at the evolution of HP's popular PCL, concentrating on the latest version, PCL 5, and how it is encroaching on PostScript's turf.

A note on terminology: HP makes a point to clarify that a typeface is a set of characters and symbols with a unique look, whereas a font is a typeface of a specific size. Thus, it would be appropriate to refer to scalable typefaces, not scalable fonts. Nevertheless, the term *scalable fonts* seems to have become the vernacular, and I'll use it here. Nonscalable fonts are commonly referred to as bit-mapped fonts, since they are simply made up of fixed, prearranged dot (bit) patterns.

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PCL in its line printers. In 1982, realizing the need for improved definition and varying levels of functionality, HP's Vancouver, BC, division formed a PCL committee to develop a PCL for the company's ThinkJet (ink-jet) and LaserJet printers. The ThinkJet, which was introduced in 1984, incorporated the company's basic-level PCL 1. This language had only "print and space" functionality for basic printer operation, including basic control codes (e.g., carriage return, linefeed, and page eject), printer reset, character-set selection, and basic raster-graphics support.

Today, HP's PCL committee consists of representatives from many of the company's divisions, to ensure that each progressive enhancement to the language fits within the scope of overall product goals and integrates properly with other company products. HP's stated goal with PCL is to meet the functional requirements of its broad customer base in a way that offers an acceptable trade-off between cost and performance.

Aside from the basic printer control codes, all the PCL commands consist of an escape character (ASCII 27) followed by a sequence of characters that specifies the operation to take place; thus, the commands are often referred to as *escape sequences*. From the outset, PCL was designed to be expandable, enabling future versions to add additional commands and capabilities; each successive version becomes a functional superset of the previous version. If a PCL printer receives an escape sequence it does not recognize, it simply ignores it, assuming that it is targeted for a higher version of PCL.

Each new version represents a new, substantially enhanced level of functionality. Within a given version, however, there can be variations in the commands that different printer models support. The LaserJet IIP, for example, incorporates PCL 4 like its LaserJet II big brother, but the IIP includes a few enhancements not found in the LaserJet II, such as the ability to rotate fonts 90 degrees.

PCL 2 and PCL 3 were also introduced in 1984. PCL 2 was used on some HP line printers, and it achieved what HP refers to as "electronic data and transaction processing" functionality. Cursor, margin, and line-spacing control functions were added to the PCL command set.

PCL 3 made its debut with the original HP LaserJet—the printer that solidly established laser-printer technology in the personal computer marketplace. PCL 3 attained a level of functionality referred to as "office word processing," which included support for plug-in font cartridges.

The next generation, PCL 4, was introduced with the HP LaserJet Plus in 1986, although it was popularized by the now-ubiquitous LaserJet II, introduced in 1987. PCL 4, with its page-formatting level of functionality, added support for downloadable soft fonts, macros, and improved graphics capabilities. The LaserJet II's implementation of PCL 4—with several enhancements over the LaserJet Plus implementation—has become the de facto industry-standard PDL. A majority of competing laser-printer manufacturers have cloned this version of PCL.

While the LaserJet II was successful, it lacked some of the features that the ever-expanding number of desktop publishing and high-end word processing users increasingly demanded. The limited number of built-in character fonts, combined with the lack of scalable-font support and vector-graphics capabilities, kept the LaserJet II from performing optimally in desktop publishing applications. Adobe Systems was a primary beneficiary of these limitations, as sales of its PostScript PDL increased steadily—in the LaserJet II and in other printers—to fill the void. In a short time, PostScript became well known as the PDL of choice for desktop publishing and other applications.

The Debut of PCL 5

Not being a company to rest on its laurels, even in the midst of the LaserJet II's enviable market success, HP became acutely aware of the LaserJet II's limitations and worked to alleviate them. The culmination of this effort was last year's introduction of the greatly enhanced LaserJet III.

PCL 5 offers a quantum leap in capability over the previous generation.

The HP LaserJet III's PCL 5 lives up to the company's office-publishing functionality designation, offering scalable-font capability, a full-featured vector-graphics command set (HPGL/2), and the ability to change the printing direction (to any angle); it can perform reverse (white on black) printing, and gray-shade and pattern fills. In addition, the LaserJet III includes eight scalable fonts (two sets each of normal, bold, italic, and bold italic) and 11 bit-mapped fonts built in, as well as HP's proprietary Resolution Enhancement Technology for smoother curves. Note that RET is a feature of the LaserJet III printer, not a PCL 5 feature. In short, PCL 5 offers a quantum leap in capability over the previous generation.

For its scalable-font capability, HP enlisted the help of Agfa Compugraphic. That company's Intellifont scaling technology lets you scale HP's typefaces from 0.25 to 999.75 points without distortion; since there are 72 points per inch, that means characters can range from microscopic to nearly 14 inches tall. An algorithm known as *hinting* is

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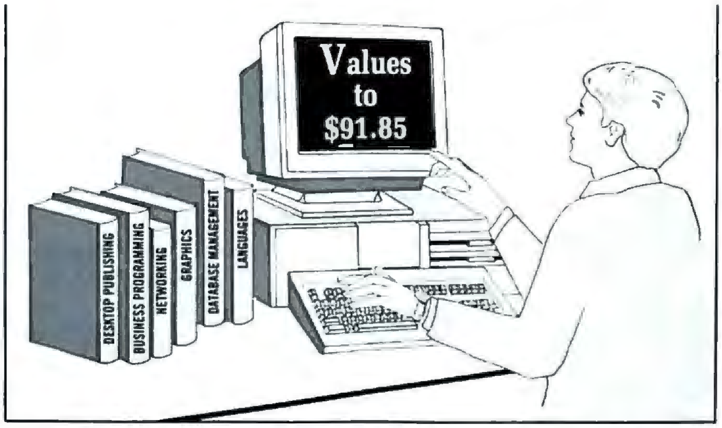

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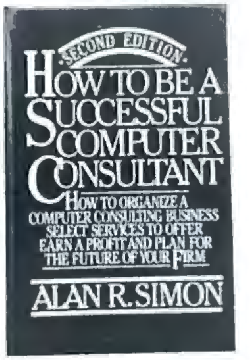

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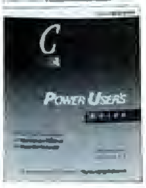

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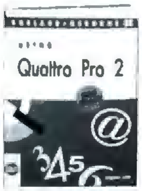

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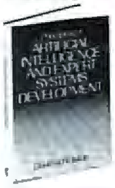

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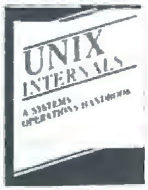

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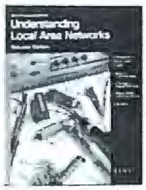

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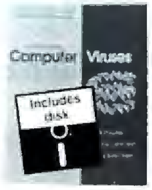

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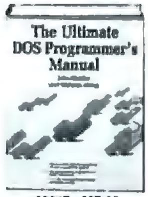

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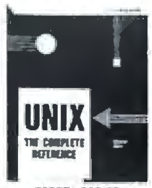

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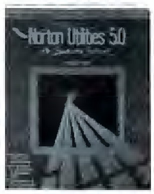

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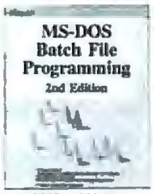

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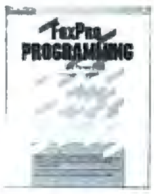

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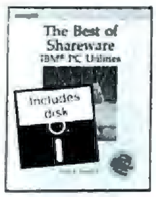

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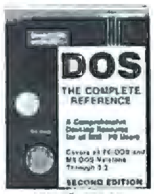

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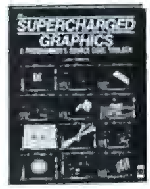

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used to ensure proper character formation regardless of size. Of course, scalable-font cartridges (and downloadable soft fonts) available from HP and other vendors let you add additional scalable fonts to the printer; scalable-font developers can obtain technical details from Agfa Compugraphic on how to engineer the scalable fonts to take advantage of hinting and the Intellifont technology.

Printing Pictures

With the font-scaling problem resolved, HP's next major obstacle was vector-graphics capability. HP has been an industry leader in vector-oriented pen plotters for years, so it was only natural to port the company's industry-standard Hewlett-Packard Graphics Language vector-graphics language used on its plotters to the PCL 5 for use on its laser printers. In addition to providing vector-graphics capability to PCL 5, the powerful, full-featured HPGL also provides compatibility with the myriad software packages that are already capable of generating HPGL output. The HPGL/2 implementation in PCL 5 includes some additional commands that are required for residing happily inside a laser printer (e.g., "Select Primary Font ID" and "Enter PCL Mode").

PCL 5's vector-graphics support has numerous benefits. Most notably, system software can be simplified, and substantially faster print operations can now take place by using vector-graphics commands instead of generating the traditional raster graphics. For example, a single HPGL/2 command consisting of a few characters can tell the laser printer to draw a diagonal line across the paper; it would take many lines of PCL raster-graphics data to accomplish the same task. As you'll see shortly, HPGL/2 is also capable of many more complex operations (e.g., drawing circles, arcs, polygons, wedges, and other complex images), all from a few simple commands.

While PCL 5 has filled the major voids that until now have separated PCL 4 and PostScript so noticeably in desktop publishing applications, HP claims that its goal is not to incorporate all of PostScript's capabilities into PCL. Indeed, HP sells an Adobe PostScript cartridge for its LaserJet III series of printers, and the new IIIsi offers an optional integrated PostScript.

HP recognizes that PostScript offers powerful features and functions that are not implemented even in PCL 5, such as support for multiple colors, and drawing support for Béziers and conic lines. Moreover, for professional publishing

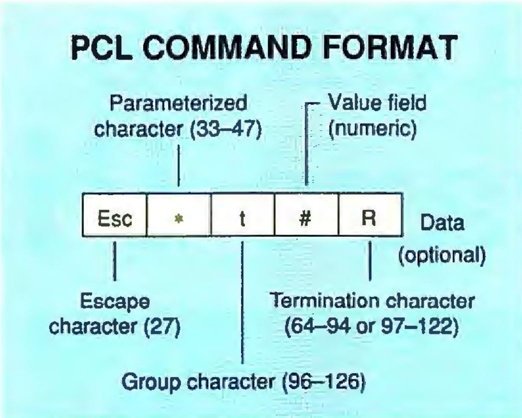

Figure 1: *Commands begin with an escape character and conform to a five-part format.*

tasks, with PostScript's hardware-independent design, PostScript-formatted documents are more easily transferred to other, higher-density printing devices, such as Linotronic printers. Nevertheless, PCL 5 has addressed many of the deficiencies that hindered many PCL 4 users, narrowing the gap between PCL and PostScript.

Command-Language Basics

The primary reference for PCL 5 is HP's PCL 5 Printer Language Technical Reference Manual. I'll provide an overview of the language to give you a taste of its features and power. I'll also introduce some of the concepts and terminology associated with PCL 5.

In describing the PCL command escape sequences, I'll use `Esc` to represent an escape character (ASCII 27); this character could be sent to the printer from, for example, a BASIC program using the statement

```
PRINT CHR$(27);
```

Some PCL commands are two-character escape sequences, while most are multiple-character parameterized escape sequences. Two-character commands include Printer Reset (`EscE`), Clear Horizontal Margins (`Esc9`), and Half-Line Feed (`Esc=`). Notice how the character following the escape character is printable. All the PCL escape sequences use printable characters, making it easier to generate and debug PCL commands.

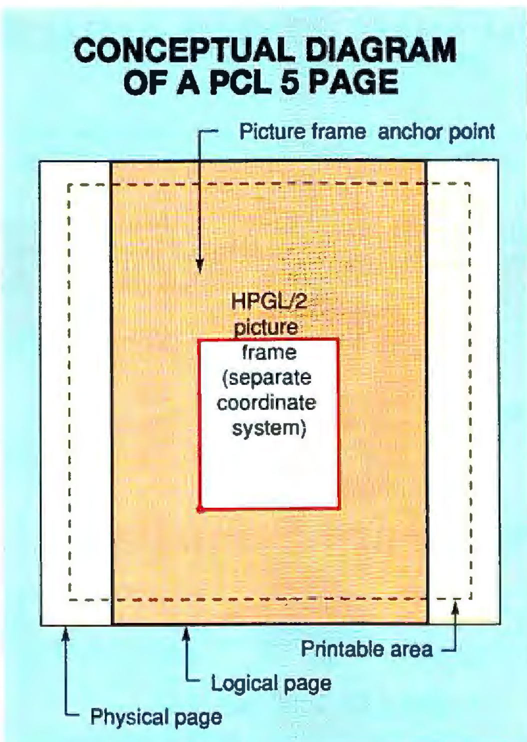

Figure 2: *How PCL and HPGL/2 view the page. PCL addresses a logical page that differs slightly from the region of the physical page on which the printer can place dots. HPGL/2 vector-graphics commands operate in a rectangular frame within the logical page and obey HPGL/2 coordinates within that frame.*

Figure 1 illustrates the general, five-part format for parameterized PCL commands. An escape character is always the first character of the sequence, informing the printer that the characters to follow are part of a PCL command. It's followed first by a parameterized character with a value between 33 and 47 (ASCII ! to /), which tells the printer this is a parameterized command (as opposed to a two-character command).

The next character, the *group character*, has a value between 96 and 126 (ASCII ` to ~). This, in conjunction with the parameterized character, determines the function group or type of function to be performed.

The value field consists of one or more numeric digits, specifying a value required by the command. Depending on the command, the value may be one of a few specific choices available for the command, or it may be a variable. It may even be a signed value—possibly floating-point. If a value is not specified, it is assumed to be zero.

The last character, the *termination character*, is a value between 64 and 94 or between 97 and 122 (ASCII @ to ^ or *a* to *z*). It identifies the command parameter to which the value applies, and it signals the end of the escape sequence. Note that some commands, such as the Transfer Raster Data command (for generating raster graphics), require data after the command escape sequence.

Some of the font-selection commands differ from the general command format outlined above in that they lack a group character. For example, the Symbol Set (primary) command format is

```
Esc(ID
```

where ID is the symbol set identification number. The command to select the HP Roman-8 symbol set (ID = 8U) would be

```
Esc(8U
```

In some cases, you can combine PCL commands, eliminating certain character redundancies. Basically, if the parameterized and group characters of multiple commands are identical, the commands can be combined. In that case, only the first command in the sequence requires the escape, parameterized, and group characters. In addition, only the termination character of the last command in the sequence is in uppercase; all other termination characters in the sequence must be in lowercase.

For example, to rotate the printing direction 90 degrees, the escape sequence

PCL COMMANDS BY CATEGORY

Table 1: *With these commands, programs (and users) control print jobs, define page characteristics, select and manage fonts, define macros, and—of course—produce images.*

Job control commands
Printer Reset
Number of Copies
Simplex/Duplex Print
Left Offset Registration
Top Offset Registration
Duplex Page Side Selection
Job Separation

Page control commands
Page Size
Page Length
Paper Source
Logical Page Orientation
Print Direction
Left Margin
Right Margin
Clear Horizontal Margins
Top Margin
Text Length
Perforation Skip
Horizontal Motion Index
Vertical Motion Index
Line Spacing

Cursor positioning commands
Horizontal Cursor Positioning (columns, decipoints, dots)
Vertical Cursor Positioning (rows, decipoints, dots)
Half-Line Feed
Line Termination
Push/Pop Cursor Position

Font selection commands
Symbol Set
Spacing
Pitch
Height
Style
Stroke Weight
Typeface Family
Orientation
Font Selection by ID
Select Default Font
Transparent Print Data
Underline

Font management commands
Font ID
Font Control

Font creation commands
Font Descriptor
Character Code
Character Descriptor and Data

Macros
Macro ID
Macro Control

Print model commands
Source Transparency Mode
Pattern Transparency Mode
Area Fill ID
Select Current Pattern

Rectangular area fill graphics commands
Horizontal Rectangle Size (decipoints, dots)
Vertical Rectangle Size (decipoints, dots)
Area Fill ID
Fill Rectangular Area

Raster graphics commands
Raster Graphics Resolution
Raster Graphics Presentation Mode
Raster Height
Raster Width
Start Raster Graphics
Raster Y Offset
Set Compression Mode
Transfer Raster Data
End Raster Graphics

Troubleshooting commands
End-of-Line Wrap
Display Functions Mode

```
Esc&a90P
```

is sent to the printer. To set the left margin to the eighth column, you would send the escape sequence

```
Esc&a8L
```

Similarly, to set the right margin to the seventy-second column, you would send the escape sequence

```
Esc&a72M
```

Since the parameterized and group characters (&a) are the same for these three commands, the commands can be combined as

```
Esc&a90p8L72M
```

PCL Concepts and Terminology

To use the PCL 5 command set effectively, you need to understand how the printer views the page (see figure 2). The physical page is the actual piece of paper or other medium the image is to be printed on. The logical page (or the PCL addressable area) is the area in which the PCL "cursor" can be positioned. The PCL cursor position is simply the position on the logical page where the next character is to be placed. The PCL cursor cannot move outside the bounds of the logical page.

The printable area is the area of the physical page in which the printer can print a dot. Notice that the printable area extends beyond the logical page on the sides, and the logical page extends beyond the printable area at the top and bottom.

With the introduction of HPGL/2 vector-graphics support to PCL, the concept of the picture frame is also important. The picture frame is an area within the bounds of the logical page where HPGL/2 vector graphics can be placed. The size and location of the picture frame within the boundaries of the logical page depend on the location of the anchor point of the picture frame. HPGL/2 employs its own coordinate system within the picture frame.

The PCL coordinate system is defined using Cartesian coordinates. The (0,0) point is at the intersection of the left logical page boundary and the current top margin. The positive *x* direction is then to the right, and the positive *y* direction is down.

Depending on what you are doing, units can be rows, columns, dots, or decipoints. Since the printer prints at 300 dots per inch, a dot equals 1/300 inch. Following the standard in the typesetting/printing industry, a PCL point is 1/72 inch; a decipoint, then, is 1/10 point, or 1/720 inch. The column width is determined by the current horizontal motion index. Similarly, the distance between rows is defined by the current vertical motion index or the current lines-per-inch setting. In all cases, the units are internally converted to *internal units*; one of these equals 1/7200 inch (which, of course, is divisible by both 1/300 inch and 1/720 inch).

A Sampler of PCL 5 Commands

PCL 5 has a robust command set, accounting for its high level of functionality and versatility. The PCL commands are broken down into several functional categories, shown in table 1. Table 2 lists the many HPGL/2 commands available for vector-graphics operations. I'll present examples of how some of the commands are used.

The job control commands include Printer Reset and other functions that are used for selecting the number of copies to print, controlling duplex (two-sided)

HPGL/2 COMMANDS BY CATEGORY

Table 2: *With powerful vector graphics now built in, PCL 5's pictorial prowess far surpasses that of its predecessors.*

Configuration/Status group
Default Values
Initialize
Input P1 and P2
Input Relative P1 and P2
Input Window
Advance Page
Rotate Coordinate System
Replot
Scale

Vector group
Arc Absolute
Arc Relative
Absolute Arc (three-point)
Circle
Plot Absolute
Pen Down
Polyline Encoded
Plot Relative
Pen Up
Relative Arc (three-point)

Polygon group
Edge Rectangle Absolute
Edge Polygon
Edge Rectangle Relative
Edge Wedge
Fill Polygon
Polygon Mode
Fill Rectangle Absolute
Fill Rectangle Relative
Fill Wedge

Character group
Alternate Font Definition
Character Fill Mode
Character Plot
Absolute Direction
Relative Direction
Define Label Terminator
Define Variable Text Path
Extra Space
Select Primary Font
Select Secondary Font
Label
Label Origin
Select Alternate Font
Scalable or Bitmap Fonts
Standard Font Definition
Absolute Character Size
Character Slant
Relative Character Size
Select Standard Font
Transparent Data

Line and fill attributes group
Anchor Corner
Fill Type
Line Attributes
Line Type
Pen Width
Raster Fill Definition
Symbol Mode
Select Pen
Screened Vectors
Transparency Mode
User Defined Line Type
Pen Width Unit Selection

operation, and performing job separation. Only certain printer models can handle duplex printing (e.g., the LaserJet IIID) and job separation (e.g., the LaserJet IIIsi). Job separation involves displacing one printed document slightly from the previous one in the output tray to simplify the separation of multiple documents in the tray. HP recommends sending the Printer Reset command (EscE) to the printer at the beginning and end of each print job, to ensure that the printer settings are at a known (default) state at the start of each print job.

The page control commands permit the setting of parameters related to positioning characters and symbols on the page. These commands select the page size, orientation, margins, print direction, text spacing, and paper source (for printers with multiple input trays, such as the LaserJet IIIsi). The Print Direction command is particularly interesting; it allows printing to occur at any 90-degree angle. PCL 5 printers can print text at any angle using HPGL/2 commands.

The cursor positioning commands, as the name implies, are responsible for positioning the printer's logical cursor where the next character is to be printed. The cursor can be positioned at any absolute location on the page (with the coordinate units specified in dots, decipoints, or rows/columns), or it can be moved relative to its current position. You accomplish relative moves with the Half-Line Feed command or common printer control codes: carriage return, space, backspace, linefeed, formfeed, and horizontal tab. This command group includes a special command, Push/Pop Cursor Position, which permits some powerful operations. It allows the current cursor position to be saved and then restored later (with up to 20 nested levels). The BASIC program in listing 1 uses this command to anchor angled text.

The font-selection commands permit the selection of the symbol set, typeface, character pitch, height, style, weight, orientation, and other characteristics of the next font the printer is to use. The program in listing 1 uses the Typeface Selection, Spacing, Stroke Weight, and Height commands to specify a bold scalable font with a large (18-point) size.

The font management commands are useful for deleting, saving, copying, and assigning ID numbers to soft (downloadable) fonts. The font creation commands

Listing 1: *A PCL 5 sample program.*

```
1 ' PCL 5 Sample Program
5 WIDTH "lpt1:", 255
10 ESC$=CHR$(27)
20 LPRINT ESC$;"E";              :' Reset Printer
25 LPRINT ESC$;"&a30c30R";       :' position cursor near page center
30 LPRINT ESC$;"(s4101T";        :' Typeface Selection (Times Roman)
35 LPRINT ESC$;"(s1P";           :' Spacing (proportional)
40 LPRINT ESC$;"(s3B";           :' Stroke Weight (Bold)
50 LPRINT ESC$;"(s18V";          :' Height (18 Point)
60 LPRINT ESC$;"&a0P";           :' Print Direction (0 Degrees)
70 GOSUB 1000                    :' print text line
80 LPRINT ESC$;"&a270P";         :' Print Direction (270 Degrees)
90 GOSUB 1000                    :' print text line
100 LPRINT ESC$;"&a180P";        :' Print Direction (180 Degrees)
110 GOSUB 1000                   :' print text line
120 LPRINT ESC$;"&a90P";         :' Print Direction (90 Degrees)
130 GOSUB 1000                   :' print text line
140 LPRINT ESC$;"E";             :' Reset Printer
150 GOTO 2000                    :' exit
1000 LPRINT ESC$;"&f0S";         :' Push Cursor Position (save cursor position)
1010 LPRINT "I Like BYTE!";
1020 LPRINT ESC$;"&f1S";         :' Pop Cursor Position (restore cursor position)
1030 RETURN
2000 END
```

create soft fonts in the printer.

PCL 5 supports user macros; that is, you can assign a series of PCL commands to a single macro ID and store it in the printer. By merely telling the printer to execute the macro, you execute the entire series of commands. Macro definition and execution are handled by the macro commands.

The print model commands provide another method for doing complex image generation on the LaserJet. You can select a shade of gray (including black or white) or one of six patterns for printing subsequent text and raster images. For even greater flexibility, the pattern can be projected onto a destination image after being masked by a source image; special transparency modes provide an even wider variety of printed outputs.

The rectangular-area-fill graphics commands, as you might guess, let you define rectangles and fill them in with a gray shade or a pattern. Similarly, the raster-graphics commands are responsible for the generation of raster graphics on the printer. With these commands, several controlling parameters can be set for the raster-graphics operation, including the raster print area, orientation, resolution, and compression mode. There is also provision for downloading raster-graphics pixel images. The resolution setting determines the size of the raster pixel or "dot," and it can be set to 75, 100, 150, or 300 dpi. Each dot for the lower resolutions consists of an array of the printer's standard 1/300-inch dot.

PCL 5 supports three data compression formats: run-length encoding, TIFF revision 4.0, and delta row compression. Using compressed data can noticeably reduce the download time for graphics images, but HP points out that it doesn't reduce printer memory use. TIFF is a popular graphics file format that Aldus and its PageMaker software have made famous. It is also now used by many scanners and paint programs. The other formats are described in HP's PCL documentation.

Realizing that not all programmers write perfect code the first time through (I must be the rare exception), HP has included some troubleshooting commands in PCL 5 to help debug printing problems. The End-of-Line Wrap command can tell the printer to wrap characters around to the beginning of the next line if they go past the right margin (where they would otherwise normally be clipped, or cut off). The Display Functions Mode command forces all escape sequences and control codes to be printed instead of executed, letting you verify what PCL commands are getting to the printer, and in what order. There are two exceptions: A carriage-return control code causes the printer to generate a carriage return and linefeed, and the Printer Reset command (EscE) is still executed (exiting the display functions mode).

A whole book could be written on the HPGL/2 functions alone. This vector-graphics command set has many advanced functions, and using the HPGL/2 commands in a LaserJet can dramatically reduce the graphics-image download time over comparable PCL raster-image downloading.

HPGL/2 commands let you generate a wide variety of shapes, such as circles, arcs, rectangles, wedges, and other polygons. HPGL/2 also allows versatile line drawing, with varying angles and line widths, and it even lets you print text at any angle. It's a powerful command language in its own right—the predominant vector-graphics language of choice in the plotter world—and its adoption into the PCL 5 definition makes an already-capable PDL all the more powerful.

The commands in HPGL/2 don't have the same escape-sequence format as the standard PCL commands. Once HPGL/2 mode is entered, the printer interprets incoming commands as HPGL/2 commands and cannot interpret PCL commands (except Printer Reset). After you return to PCL mode, the incoming commands are again interpreted as standard PCL escape sequences.

Beefing Up the Standard Office Printer

HP's PCL has come a long way since its formal debut in 1984. With the addition of scalable, rotatable font technology, the ability to change print direction, and the incorporation of the robust HPGL/2 vector-graphics command set, PCL 5 has seen vast improvements over industry-standard PCL 4, established by the LaserJet II. Now that it contains much of the functionality primarily sought after in PostScript, PCL 5 has become a powerful contender for use in desktop publishing applications. When combined with HP's RET, PCL 5's scalable fonts and graphics images print with unprecedented sharpness on a conventional 300-dpi printer.

Since HP is a trendsetter in the laser-printer industry, it shouldn't be long before most applications support the expanded capabilities of this enhanced language. Thanks in part to PCL 5, the workhorse office printer is becoming a much more capable beast. ■

ACKNOWLEDGMENT

I would like to thank Clay Young and Kurt Rockenhaus, both of Hewlett-Packard, for their generous help during the preparation of this article.

Roger C. Alford is president of Programmable Designs, a Michigan-based consulting firm specializing in electronics design. He can be reached on BIX c/o "editors."

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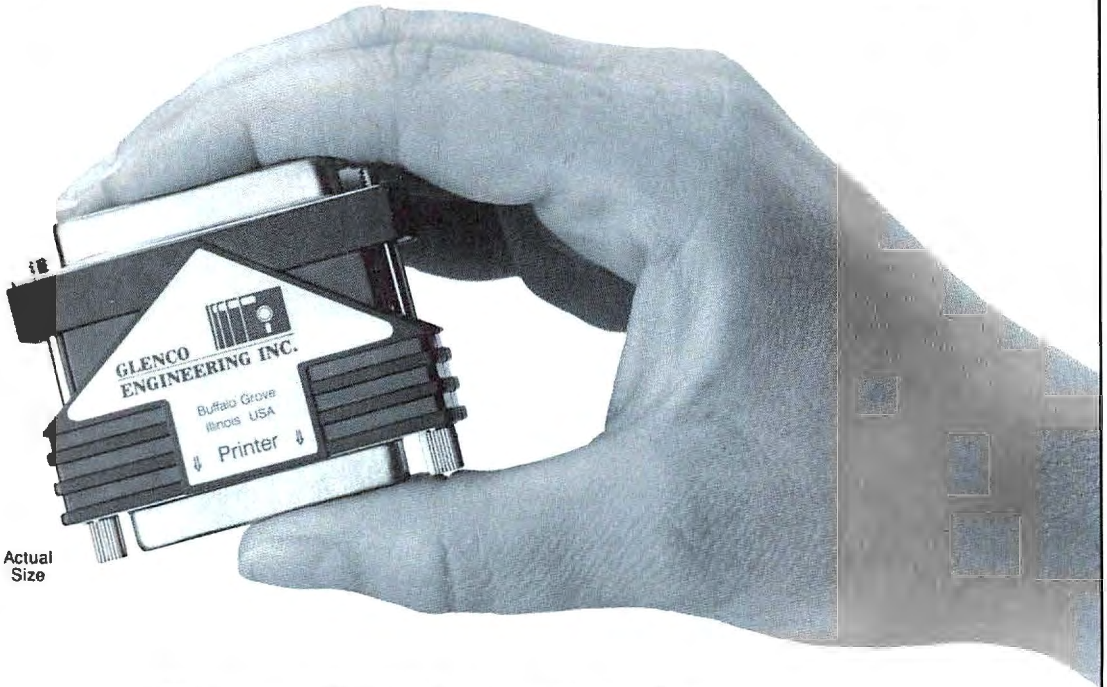

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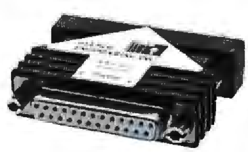

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BARRY NANCE

JUST FOR CHECKING UP

This is the first installment of a new column in which we will present useful programs and utilities at no charge (or as shareware) for PC-compatible, Macintosh, and Unix systems. Source code and executable versions (when offered) of Software Corner programs are available in a variety of formats. See page 5 for details.

If you agree that the Novell _USERLIST_ command is a little dry at times, you'll like NETMAP. NETMAP draws a colorful map of your NetWare LAN. Each user is represented by a push button on your screen. You can use a mouse to click a push button and reveal the user's log-in date and time, along with some simple traffic counts for that user's workstation: "Lost Packets" (the number of times IPX received a packet it didn't know what to do with); "Postponed AES" (the times IPX could not process a rescheduled packet event on time); "Listen ECBs" (the number of event control blocks given to IPX, usually by NET3, for receiving packets); "Packets Sent" and "Inbound Pkts" (the total counts of network message activity); and "Can't Route" (the times IPX couldn't find a route across the network to deliver a packet).

NETMAP requires a PC-compatible computer with EGA or VGA display, and it uses a mouse if you have one. This software shows up to 100 connections (users) on a VGA screen, but it has room for only about 70 on an EGA screen.

If you don't have a NetWare LAN, you can still run NETMAP. If no network is present, the program randomly creates pretend users it can display.

NETMAP polls the network every 2 seconds, looking to see who might have logged on or off. You'll see new push buttons appear for the new users. People who have logged off are represented by bright blue, empty push buttons on the screen. (Ask a friend to temporarily log off the network while you watch the screen.) Users show up as white push buttons; your file servers are cyan and are in the center of the display. If you use the Tab key, the currently highlighted user is bright white and the current server is red.

Three free programs that monitor NetWare LANs, Mac memory, and UUCP connections

Programming Techniques

I used version 2.0 of the Turbo C compiler to develop NETMAP. In the source code, you'll find lots of techniques and coding strategies you can explore. The management of the graphics display is pretty simple; I draw push buttons—using the Borland Graphical Interface—in a pattern that starts near the center of the screen. I reserved the center itself for servers. The *x,y* coordinates of each push button are saved in an array so I can do mouse hit-tests.

The network aspects of NETMAP are a little more complicated. Every 2 seconds, the program gathers data on all the current workstations and servers. It uses the `GetConnectionInformation()` NetWare function call to do this, and it compares the data with what it saved from the previous calls. NETMAP shows the differences as either new users or logged-out users (the blue, empty push buttons). When you click on a push button, the program establishes an SPX connection with the other workstation and issues a series of diagnostic requests. NETMAP asks for only a small amount of the diagnostic data that's available. If you have the NetWare technical references handy, you can turn NETMAP into a full-fledged diagnostic tool. ■

MAC/Tom Thompson

Swatch Watches Your Memory

Swatch 1.1 (short for "system watch") is an INIT/application combo that monitors Macintosh memory usage. Scaled bars represent the amount of memory each application uses; the system heap is also shown. Colors within each bar indicate that memory blocks are either locked, relocatable, purgeable, or free. The display is updated automatically as applications launch, quit, and run. A magnifying glass function lets you zoom in to examine a particular memory block, or zoom out to get the big picture on memory use. Holding down the Option key while clicking on a block gives its memory address.

These capabilities make Swatch a handy developer's tool. If you're tangling your heap because you're forgetting to dispose of memory you allocated, it'll show up on Swatch's display quickly. This little jewel could have spared me a lot of grief with heap management on an earlier Mac development project. Swatch was written by Joe Holt.

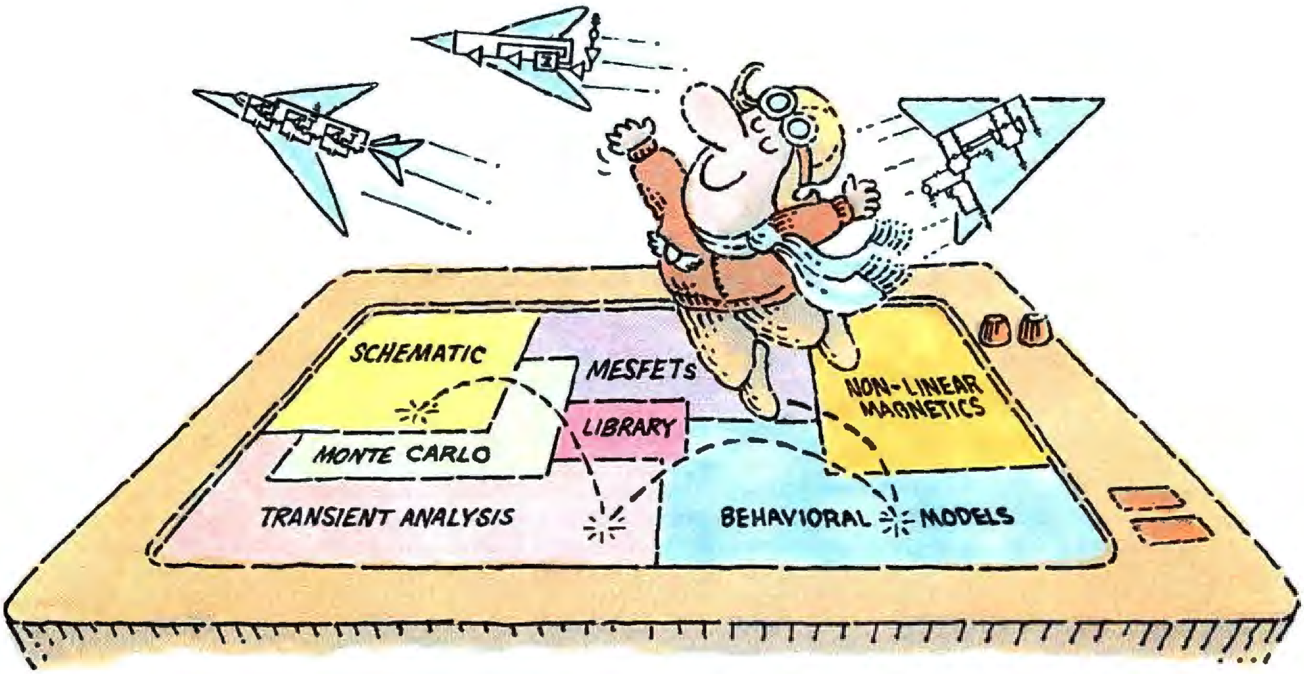
UNIX/ Ben Smith

UUSTATUS Checks Connections

The freely available Unix utility `uustatus` uses the Curses visual library routines to display the current status of active UUCP connections. When a system spools files up for transfer, `uustatus` displays the number of files and number of tries. When a connection becomes active, the display changes to show what state it is in, and the log file for UUCP connections to that site scrolls in at the bottom of the window. Here's a sample screen dump from `uustatus`:

SYSTEM	RETRY	IO	FIL	LAST TRY	NEXT TRY	STATUS 03/01 14:51
uunet		0	1	03/01 05:56	03/01 16:56	SUCCESSFUL
maxx			2	03/01 13:58	03/01 15:58	WRONG TIME TO CALL
infopro		I	3	03/01 14:50	03/01 14:50	TALKING
ronin	2			03/01 13:34	03/01 16:34	CALLER SCRIPT FAILED
idgeast				03/01 12:12	03/01 16:12	SUCCESSFUL
crsfld				03/01 07:31	03/01 20:31	SUCCESSFUL

Editor's note: *We solicit your contributions. If you've written a program or utility that you think others might find useful, let us know. We'll pay $50 for any program we use. Write to Software Corner, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.*



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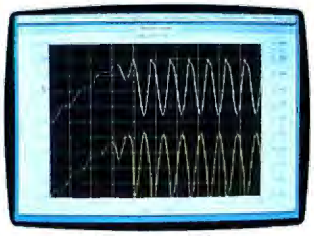

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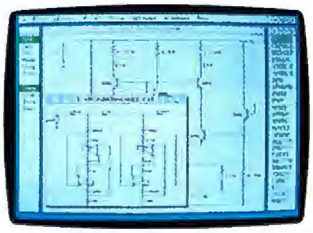

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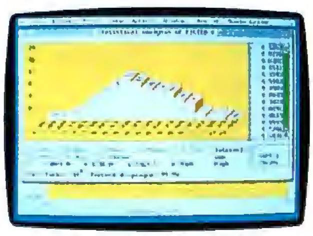

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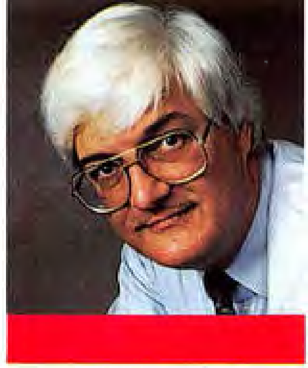

BARRY NANCE

PART 2
THE AIX ALTERNATIVE

Last month, I discussed Wausau Insurance's decision to hire my company to rework our DOS-based insurance-rating application. Wausau wanted it to run as an AIX-based client/server application on IBM RISC System/6000 file servers, with DOS clients and perhaps some Unix clients. I immediately began a search for the right network-support software and narrowed the choice down to two products from IBM: its version of Sun Microsystems' Network File System (NFS) and AIX Access for DOS Users (AADU), which is its version of Locus Computing's PC Interface.

NFS took an early lead in the competition, but I discovered several problems with it, as I detailed last month. Specifically, NFS's extra overhead makes it slow, the IBM version lacks the `lockd` daemon for file and record locking, and there's no mechanism for mapping user names and permissions across the network.

This month, I'll talk about AADU, and I'll let you know which product got the nod and why. I'll also discuss a special Oracle interface we constructed that saves both memory and money.

How AADU Works

AADU, like NFS, runs on top of TCP/IP. On a Token Ring LAN, it consists of two DOS device drivers. One implements TCP/IP; the other establishes a new letter for the network drive. You don't designate the network-drive letter for each workstation as you would with NetWare's Map command, however. DOS and AADU assign the next available letter.

The network drive encompasses the top-level directory structure of the Unix host, including all its file systems: You'll see typical Unix directories such as `\USR`, `\TMP`, and `\LOST'UND`.

The last one is AADU's way of representing the ubiquitous Unix "lost+found" directory in terms of the more restrictive DOS rules for filenames. The `udir` utility in AADU lets you see both the full AIX name and the mapped DOS name.

To accomplish file redirection, AADU uses the Internet Protocol and User Datagram Protocol for LAN communications. IP routes the packets; UDP provides simple process-to-process datagram services on top of IP.

When an application (even COMMAND.COM) issues a DOS request for file or disk services, AADU snatches the request away from DOS and shunts it across the LAN to the Unix host. A background process (daemon) on the host fills the request by issuing the corresponding Unix system call and sends the response back to the workstation.

These AADU packets, like other Token Ring frames, have specific source and destination network addresses. NetWare, LAN Server, and NFS/AADU can coexist on the same physical LAN, but a workstation can see only one type of server at a time. (I boot my own workstation with one of three CONFIG.SYS files that load DOS and NetWare, OS/2 and NetWare, or DOS and AADU.)

Actually, two Unix daemons (`pcimapsvr.ip` and `pciconsvr.ip`) run on the host, and these daemons spawn a third daemon (`pcidossvr.ip`) for each workstation that performs the AADU log-in sequence. The `pcimapsvr.ip` daemon maintains site maps that identify all the AADU servers on the LAN; the AADU log-in program uses the information to list these servers so you can pick one. You identify servers by host name and by Internet address in the `/etc/hosts` AIX file.

The `pciconsvr.ip` daemon periodically broadcasts `<host name> HERE` messages to let all `pcimapsvr.ip` daemons know to include the host name in their site maps. The `pcidossvr.ip` daemon maintains a dialogue with the workstation and executes Unix system calls on behalf of that workstation. The host transmits the results from these system calls back to the AADU workstation, but it appears to the workstation as though DOS has performed the request. As you would expect, AADU supports both printer and file redirection.

This structure of Unix daemons and DOS device drivers works well until a DOS user forgets to use the AADU logout program to end a session. If the DOS machine reboots during a session (or if it suffers a power failure or lockup), `pcidossvr.ip` remains running as a "zombie" Unix process. Only a supervisor-level (`root`) Unix log-in can kill it.

continued

A software developer chooses between NFS and AADU network-support software

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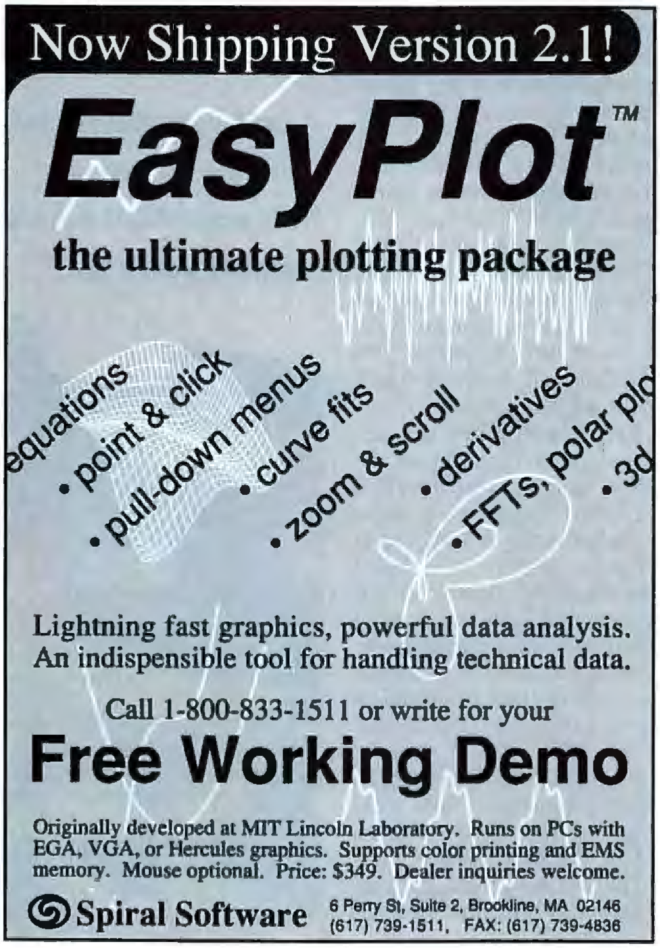

Each Unix file system, like each DOS drive letter, has its own space-available and space-used statistics. Since AADU maps the entire Unix host as a single DOS drive, you can get confusing and conflicting reports from even a simple DOS DIR command. In the `E:\TMP` subdirectory, for example, you might see the following message:

```
8,000,000 bytes free
```

But in the `E:\USR` subdirectory, you'll see a different report. This is disconcerting, but if AADU were to map each Unix file system as a separate network drive, the result might be even more confusing and difficult to follow.

Locks Supported

AADU supports DOS file and record locking—something that's lacking in IBM's NFS. This was a sore point for me when evaluating NFS, and I was prepared to add my own record-locking scheme on top of NFS by writing a custom Unix daemon.

With AADU, I wouldn't have to, although there are administrative headaches associated with record locking. The `pcidossvr.ip` daemon uses Unix shared memory to keep track of record locks, and a DOS workstation that reboots or crashes with outstanding locks leaves those shared-memory entries intact. To free the locks, all AADU users have to log off and the supervisor has to use the AADU `sharectl` utility to clean up shared memory. I would face this

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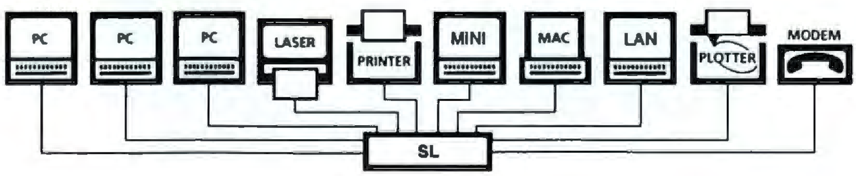

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same situation as a design issue if I decided to write a record-locking daemon for NFS.

To my surprise, I also found that AADU doesn't support Machine Name, a common feature of most networks. Machine Name is supposed to be available through a standard DOS call, function 5E00 hexadecimal. Because our application uses the first two characters of Machine Name to uniquely identify each

Be aware that each AADU DOS device driver contains a serial number and is copy protected.

user, I had to write a small (800-byte) TSR program to add this support to AADU. This was annoying, but certainly not fatal. IBM or Locus should correct this oversight.

For security, AADU relies on standard Unix protections. You use the AADU log-in program, which prompts you for a Unix account ID and password, to gain access to the network drive. (The supervisor must add each AADU user to the Unix system.) The supervisor can deny any user read or write access to files and directories on the Unix host through the standard Unix permission masks.

Speaking of security, be aware that each AADU DOS device driver contains a serial number and is therefore copy protected. Don't take the first disk and make copies for all the users, as I did. You'll have to recall all the disks and make new ones, one at a time, from each individual distribution disk.

AADU Measures Up

Memory usage and performance are always big concerns on a network, and AADU did well in both of these areas. The AADU device drivers use about 60K bytes of RAM, compared to about 90K bytes for NFS. Our application runs as quickly using AADU on a RISC System/6000 PowerServer 320 as it does

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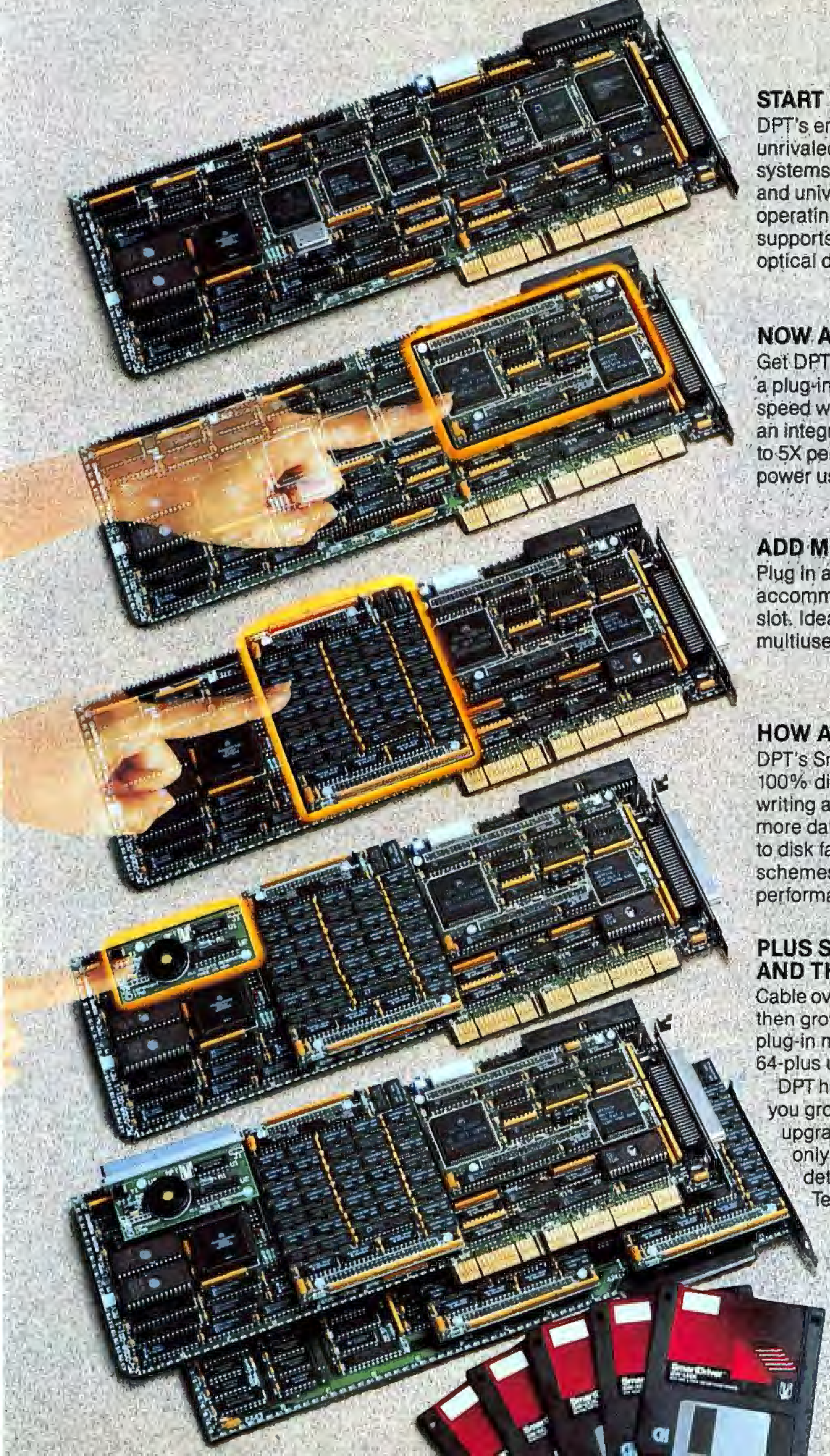

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using NetWare on a 33-MHz 386 server. This tipped the scales between NFS and AADU, and, if you haven't guessed by now, we chose AADU over NFS.

A few other features helped to make AADU the favorite. The software includes a set of utilities for starting and monitoring Unix software from the DOS environment. It even comes with a C programming interface that lets you embed host-control functions in your software. You can manipulate AADU, execute Unix programs, and perform DOS/Unix interprocess communications involving message queues and semaphores.

What if you want users to be able to run Unix software *and* DOS software? No problem; AADU provides two terminal emulators (i.e., VT100 and VT220) that work across the LAN through a virtual serial link. You can easily hop back and forth between a DOS prompt and a Unix prompt. However, you can't hot-key between the two.

Oracle Innovations

We're using Oracle 6.0 on the RISC System/6000 to store much of our data in relational form. The front-end application (a DOS program that resides on each workstation) issues Structured Query Language statements to retrieve the data; a series of DOS programs on the workstation then do the processing and issue SQL statements to store the results.

One way to get the SQL statements and data across the LAN to Oracle on the RISC System/6000 is to use Oracle's SQL*Net software on each workstation. SQL*Net makes it look as if Oracle is running on the workstation by redirecting data to and from the host. Unfortunately, SQL*Net takes up extra memory underneath the application, and Oracle's per-workstation licensing is expensive if you have many workstations.

We passed over SQL*Net and developed a homegrown link (a queue) between the DOS machine and the Unix host. Through this link we pass data records in both directions. We issue the actual SQL statements directly to Oracle with a C program on the RISC System/6000; the C program responds to entries we place in our queue. This approach leaves us with enough memory to run our application, and it saves the cost of about 100 copies of SQL*Net.

Unix and DOS Get Closer and Closer

As this column went to press, IBM announced that it has become a reseller of Novell's NetWare products, Novell has announced that it will soon have a version of NetWare that runs under AIX on the RISC System/6000, and IBM is working on a version of OS/2—as yet unannounced, but I've seen it—for the RISC System/6000. Also, Locus Computing should be shipping PC Interface for the Mac by the time you read this.

We don't think we'll change our minds about using AADU as our network support software, but it is comforting to know that LAN vendors are offering a wider and wider range of solutions for DOS/Unix connectivity. ■

Barry Nance does R&D and technical-support work for Insurance Software Systems, a software development company in Hartford, Connecticut. He is also the author of Network Programming in C *(Que Publishing, 1990) and is the IBM Exchange editor on BIX, where you can reach him as "barryn."*

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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MARTIN HELLER

WINDOWS MEETS AI

Windows 3.0, Microsoft says, is revolutionary. Hype? Yes, of course. It's really an *evolutionary* improvement over Windows 2.0. But still, Windows 3.0 is good enough to move the graphical user interface (GUI) into the mainstream of the many-forked IBM-compatible personal computing river.

One of the striking things that Windows 3.0 has done is to open up the PC to AI applications. There are two good technical reasons why this should happen. First, Windows 3.0's protected-mode operation gives AI applications the memory they require to run efficiently. Equally important, Windows provides the GUI that AI applications need to be usable by mere mortals.

A funny thing happens to AI environments on the way to Windows: They become general-purpose development environments. They still have their expert-system heritage in there somewhere, but it gets bundled with other good stuff like object hierarchies and interprocess communication.

According to a good book on the subject, Edmund Payne and Robert McArthur's *Expert Systems* (John Wiley & Sons, 1990), that trend isn't unique to Windows programs. The expert-system shells of 10 years ago have grown up into hybrid systems. These days, a "real" shell is an integrated set of tools that provides facilities for building a knowledge base as well as support for various AI paradigms.

Payne and McArthur cite editors, interface-building tools, debuggers, and an open architecture as the four necessary facilities. They list rules, frames (or classes), inheritance, graphics, truth maintenance, alternative views, external language calls, and an external program interface as the usual paradigms that need support. They discuss examples using Knowledge Engineering Environment (KEE), Knowledge Base Management System (KBMS), GoldWorks, Nexpert, Level5, and Advanced Debugging System (ADS), along with their own software, Entrypaq.

Kappa PC

KEE is an interesting example. It runs on Lisp machines from Symbolics and Texas Instruments, Hewlett-Packard and Sun workstations, and Macs or 386 PCs with TI Explorer boards. The HP version costs about $30,000.

IntelliCorp, the maker of KEE, also has a line of C-based applications development and deployment environments: Pro-Kappa, which runs on workstations, and Kappa PC, which runs on Windows.

AI applications benefit from the memory and interface features of Windows

Kappa PC costs $3500, and run-time licenses are $450.

Several years ago, I built a prototype expert system for diagnosing the cause of failures in metals and alloys. My work was based on the *Failure Analysis* volume of the *Metals Handbook*, and I used Level5 on a PC. At that time, Level5 was purely a rule-based system; now, I understand, it has frames as well. It was a lot of work implementing my failure-analysis system using unstructured facts. The knowledge base is full of rules that assert obvious things like the following:

RULE ferrous materials 2
IF material IS carbon steel
THEN material is ferrous
AND material type is alloy

When I started to convert my Level5 implementation to Kappa PC, I discovered that more than half the rules could be replaced by an object hierarchy that I simply drew in Kappa PC. Instead of having to assert facts about material classification with rules, I was able to build a classification tree. The rule above was replaced by making carbon steel a child of ferrous materials and setting carbon steel's material type slot to alloy (as opposed to metal).

This technique is a major improvement. IntelliCorp says that the diagram is the program. While that is a gross exaggeration, it has more than a grain of truth.

In addition to rules, frames, and inheritance, Kappa PC supports object methods, procedural programming with the KAL language, Dynamic Data Exchange (DDE), active graphical images, and a C language interface. The level of integration is very, very high. Rules can look at slots, which can reference objects, which can invoke methods, and the music goes round and round. My biggest problem in learning to use this package was that so many paradigms are

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supported: It took me a while (and some telephone support) to get a feel for which piece of the puzzle went where.

In the course of talking to other users, I discovered that Kappa PC was developed as a thesis research project in the MIT civil engineering department. The student who developed it (Fadi Chehayeb) went on to form his own company, MegaKnowledge, and finally sold the product to IntelliCorp, which made substantial improvements.

The MIT civil engineering department continues to use Kappa PC as well as KEE. According to Prof. Robert Logcher, the department gets far more use out of Kappa PC because it is an easier development environment than KEE—and certainly a lot less Lisp-oriented. Currently, Logcher is using Kappa PC to develop a construction manager adviser for Shimizu.

Fascinating stuff, this. Logcher's system picks up where the Program Evaluation and Review Technique and critical-path method scheduling systems leave off. Instead of telling you that delays have slipped your schedule, the system figures out how to recover from the delays and restore the original schedule most efficiently, by shifting resources and allocating overtime. The development of the system was fairly smooth with Kappa PC. Logcher's team had no trouble writing its own C programs to expand the capabilities of Kappa PC and no trouble interfacing to construction data in dBASE.

Across the Charles River, Dr. Chris Cimino at Massachusetts General Hospital has been developing a unified medical-language system—an integrated query workstation for accessing bibliographic data on MEDLINE and drug data on the Physicians' Desk Reference CD-ROM—using Kappa PC as a development environment. When MGH was looking for an environment some 18 months ago, the alternatives weren't anywhere near as flexible as Kappa PC—and Cimino's development group has added lots of C modules, as well as making extensive use of Kappa PC's object hierarchy and user interface paradigms. Interestingly enough, Cimino says he has yet to write a rule in almost two years of working with Kappa PC, although he expects to use rules for parsing natural-language queries.

I can recommend Kappa PC for serious R&D projects, but I'd caution you that there's a steep learning curve—it's right up there with learning to read Chinese or learning to program Windows in C. (By the way, learning to read Chinese isn't impossible—I've done it. It does, however, require you to learn new paradigms and acquire hundreds or thousands of characters.) On the other hand, once you understand Kappa PC, you'll find that it's a solid, high-level tool with more than enough depth for big projects. It is an open architecture. You won't find any real walls.

KnowledgePro for Windows

Of course, not everybody can justify $3500 for a development environment, especially with run-time fees tacked on. IntelliCorp does have a "gateway" program that allows consultants to use Kappa PC for six months before paying for it. But for $695 (with no run-time fees), KnowledgePro Windows (KPWIN) from Knowledge Garden looks like a bargain by comparison.

While KPWIN doesn't support all the

paradigms and facilities of a full hybrid expert-system development environment such as Kappa PC, it is interesting in its own right. KPWIN is a development environment with a programming language that handles lists but has a syntax more like Pascal than Lisp. It includes a backward-chaining inference engine and rules, and it has a number of hypertext features, but it's not a conventional expert system.

KPWIN's building block for objects is the *topic*. A topic can contain procedures and daemons, as well as rules and variables, and you can organize the topics in a hierarchy. KPWIN has no frames as such, but you can get the same effect with topic hierarchies. It has no forward-chaining engine, but you can build one fairly easily with procedures acting on topics.

A lot of the applications for KPWIN seem to be in the training and intelligent assistant areas. For instance, Avis Leasing is testing a KPWIN program to automate sales proposals; Commonwealth Edison is using KPWIN to link scanned maps with geographical information about gas and electric lines. A system called HUGO, sponsored by the National Institute on Drug Abuse, helps minority students apply for grants and provides technical information on NIDA policies. These are smaller-scale applications than people are creating with Kappa PC, but they are still significant.

I came to KPWIN with the same impediment that made it difficult for me to learn Kappa PC: I already knew how to write programs and rules for a conventional expert system. According to Bill Thompson, who with his wife Bev developed KPWIN, the people who do best with the product are not necessarily the hard-core programmers or knowledge engineers. They're more likely people who have written Excel or Lotus 1-2-3 macros.

I eventually got the hang of KPWIN, and I like it as a rapid prototyping tool for Windows. It's quite a rush doing a whole file-selection dialog box (which is about three pages of C code) with the following:

```
selected_file is
file_menu('*.bmp','.').
```

continued

COMPANY INFORMATION

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That merely scratches the surface. KPWIN has several hundred functions in its language, including the ability to call functions in an external dynamic link library, to have DDE conversations, and to execute the contents of a text string (shades of Lisp!).

The Thompsons' goal is to use the computer to communicate knowledge. They have got a great start at that in KPWIN. If you're looking for a fairly easy development tool for small-to-middling Windows applications—especially those that could benefit from an inference engine or hypertext—KPWIN may be just what you need.

Odds and Ends

And now for something completely different. . . .

Most of my time the last month has been spent working on my book, *Advanced Windows Programming*, which is to be published in the fall by John Wiley & Sons. One of my major examples is a simple image-display and processing program. I was really tuned into this project when I came across PhotoStyler, which is a new, full-blown photographic image-processing application from U-Lead Systems.

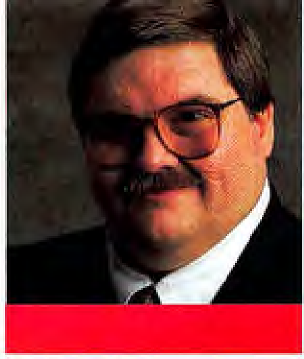
I can't tell you how nice PhotoStyler is—you'll have to see it for yourself, preferably on a 24-bit color display. I have "only" a 256-color Super VGA display; PhotoStyler makes me want better. It does color correction, color conversion, color separation, image editing, retouching, and composition. Also, it can run a scanner. At $795, PhotoStyler is not inexpensive, but it looks to be worth every penny.

I will be producing my own camera-ready pages once I've finished writing the book. The piece of hardware that makes this possible is the LX6 Professional printer enhancement board from LaserMaster Technologies. The LX6 is a PC add-in board with 6 megabytes of memory, several programmable array logic chips, and its own processor. It talks to an HP LaserJet or compatible printer through the printer's video port.

I have it working under both Windows and Presentation Manager with 135 fonts. In low-resolution mode, I get 300 dot-per-inch pages at the full 8 pages per minute that the printer engine can handle; in high-resolution mode, I get 800-dpi pages at about 4 ppm. I didn't deserve this kind of performance until I started the book, but printing graphics from Windows 2.0 (at 20 minutes per page) was making my beard turn gray.

There has been one drawback with the LaserMaster board besides the price (which is about as much as the HP printer it drives): The output is too nice. Not for the book: 800 dpi is at the low end of typeset quality. No, my problem is that my younger daughter is in a cooperative nursery school. And the nursery school has a newsletter, which my wife edits. I made the mistake of producing one page for them, at 800 dpi, in several sizes of Bookman, with ornamental stuff in Zapf Dingbats. I just couldn't leave well enough alone: It showed up the rest of the newsletter. Guess who has to produce the whole newsletter now? ■

Martin Heller, a contributing editor for BYTE, develops software in Andover, Massachusetts, and is writing an advanced Windows programming book. He holds a Ph.D. in physics. You can reach him on BIX as "mheller."



DON CRABB

System 7.0—Apple Defines Its Future

I have been using System 7.0 since the initial developers' beta version was sent out last year after the 1990 developers' conference. By the time you read this, Apple will have released System 7.0 at this year's developers' conference. My comments here are based on System 7.0b4, the final beta version Apple sent to developers.

Let's get one thing straight: System 7.0 is not supposed to be a niche operating system for only the highest-powered Mac iron, like OS/2 is for Intel boxes. It will run on a Mac Classic with 2 megabytes of RAM, as well as on a loaded-to-the-max Mac IIfx. Because it's an evolution of the existing Mac graphical user interface, it has success designed into it right from the start. It's not like Apple tossed out everything and started over. Because of the importance of System 7.0, it's also my software of the month.

Apple has announced that System 7.0 will *not* be available through the usual on-line distribution channels (e.g., CompuServe MAUG, Connect, America Online, and GEnie). You'll buy one of two upgrade kits from your local dealer. The first kit costs about $99, and it comes on 800K-byte floppy disks along with new manuals; the second kit comes on a CD-ROM and is targeted for Mac managers who must upgrade a lot of Macs across a network. Pricing for the CD-ROM kit hadn't been set at press time.

In both cases, Apple will give you 90 days of free telephone support—yes, you read that right. This is the first time Apple has done this for its Mac OS. Considering all the differences between System 7.0 and System 6.0.x, this support will be needed.

The New Finder

On the surface, not a lot seems to have changed with System 7.0's interface. What is new requires a bit of exploration and some getting used to. The first thing you'll notice about System 7.0 is that the Finder has disappeared. Well, not really, but it's gone away in terms of the Finder/MultiFinder dichotomy. Under System 7.0, the Finder *is* MultiFinder. In fact, MultiFinder is now built in, so you can't choose not to use it.

This new Finder has a load of improvements that show Apple listens to its customers and developers. Icons and windows now take on a three-dimensional look, much like those you see under Next and Windows 3.0 (although you'll need at least 16 colors or grays to see these differences).

Finder menus have been enhanced. If you scan the menu bar on the Desktop, you'll see the familiar Apple menu. But when you open it up, you'll see immediate differences. First, you'll see cute little icons next to each menu item. Second, you'll notice something that's likely to knock your socks off: The Apple menu is no longer just for desk accessories (DAs). In fact, you can drag (no more Font/DA Mover!) any application or document into the Apple menu (using the Menu Items Folder in your System Folder), where they are handily grabbed.

These changes are instantaneous: You don't have to restart your Mac to see the new stuff in the Apple menu. That alone makes System 7.0 about a million times more convenient for Mac power users.

Gone also is the ubiquitous (and ugly) Control Panel DA. Instead, a new menu item called Control Panels reflects the Control Panels Folder contents. Like the Menu Items Folder, the Control Panels Folder is located in the System Folder (see the screen shot). That's the metaphor Apple has chosen for all its System modifiers—separate folders within the System Folder to hold the stuff to modify and customize your system. Thus, you'll also see folders labeled Extensions (to hold INITs and cdevs), Scrapbook File, Preferences, Start-up Icons, and Clipboard, among others.

The watchword for the new Finder is customization. One such new feature, the Views Control Panel, works like the current shareware Layout Plus, in that you customize the look of windows and set defaults for information display. Other new Control Panels include Labels (a replacement for the current Color menu), Sharing Setup, User Setup, and File Sharing Monitor (these last three cdevs let you manage the new personal file-sharing capability of System 7.0—

Don takes full measure of Apple's newly announced System software and finds more hits than misses

ILLUSTRATION PAUL SCHULENBERG © 1991

sort of a personal version of AppleShare). System 7.0 makes it much easier to modify the way your Mac works without going to shareware.

Other Goodies

Other Finder enhancements include an honest-to-goodness fast and powerful find command, file aliasing that lets you create filenames on your Desktop that refer to the real files elsewhere, and new memory capabilities. Unlike the current System, which lacks virtual memory and limits you to a physical address space of 8 MB, System 7.0 includes a simple virtual memory implementation that can address up to 1 gigabyte, while also supporting up to 128 MB of real memory on machines with 32-bit clean ROMs, like the Mac IIfx and IIci.

Don't expect miracles with virtual memory, though. In my tests, if you set virtual memory to be anything close to your real single in-line memory module count, you can expect performance to take a serious nosedive.

Keep in mind that while System 7.0's virtual memory can help memory-poor MacFolk a little, it's no panacea. These virtual memory improvements are available only to the 68030-based Macs and 68020-based Macs with the external paged memory management unit.

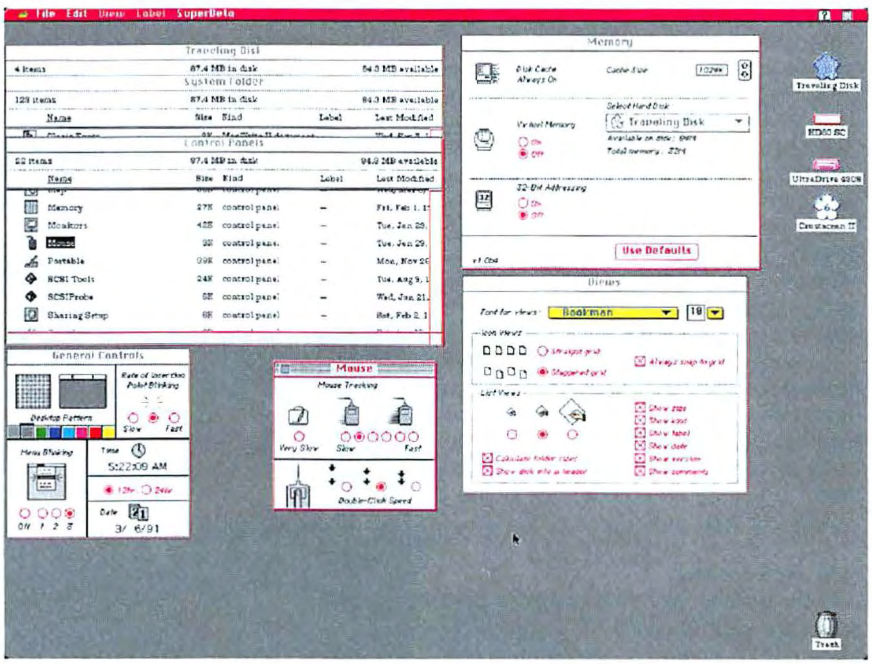
Besides these improvements, Apple has also added a bunch of other new features. Interapplication Communications lets you hot-link different application documents. A Publish and Subscribe mechanism makes any document available to any user on a network. The Data Access Manager will make it easier to wire your Mac to applications sitting on other computers, while TrueType fonts offer sharp outline fonts on any printing device without the need for PostScript.

Taken together, all the improvements in System 7.0 help to make up for the product's overly long gestation period. Now, Apple, it's time to get cranking on System 8.0, so we don't have to wait two years for it, too.

Tip of the Month: The Outbound Portable

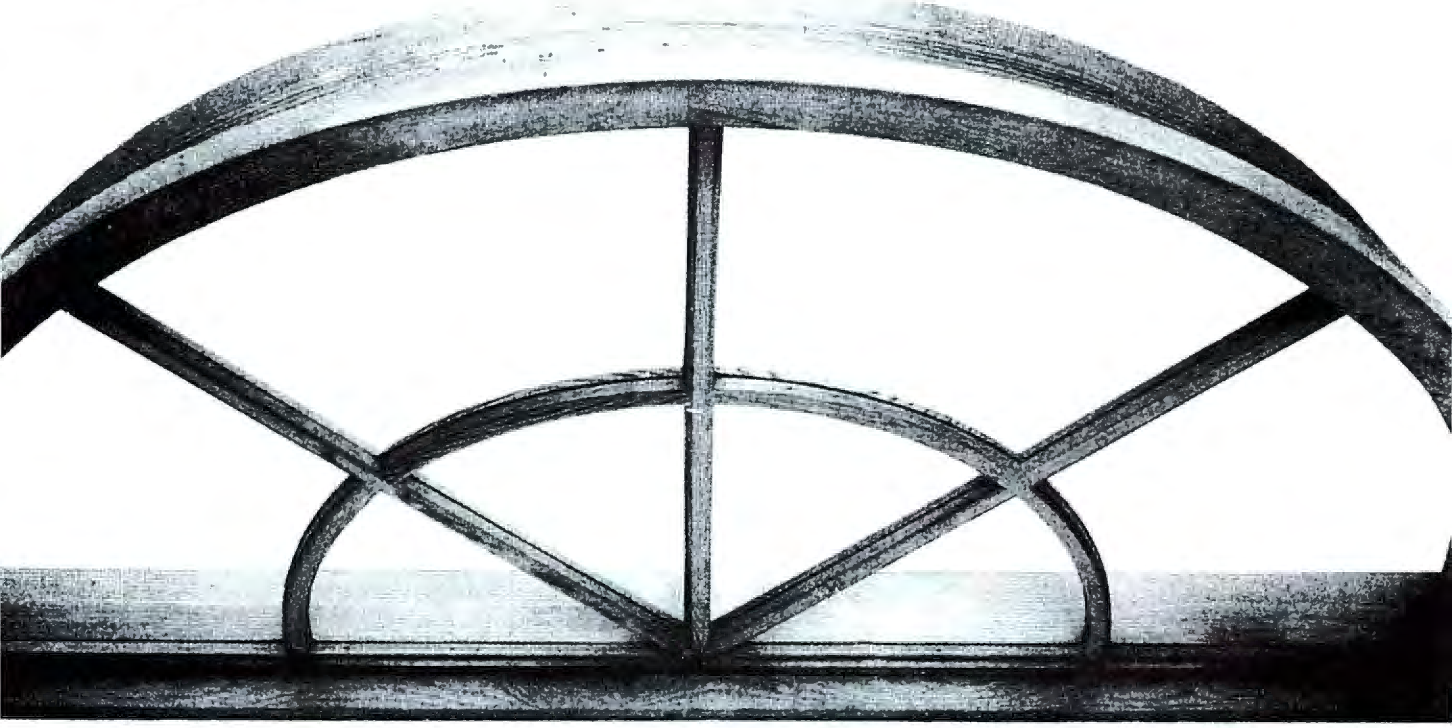
Ever since Apple delivered its Mac Portable, MacFolk everywhere have been waiting for the other shoe to drop. They have been waiting for Apple to get serious about portable Mac computing and produce some machines that can compete with the likes of Toshiba, Zenith, Compaq, and others in the DOS world. Frankly, Apple has been pathetically slow at supplying a notebook-size Macintosh solution for the huge pent-up demand for portable computing—so slow, in fact, that many people have bought DOS machines and use file transfer products like LapLink Mac III to meld their DOS and Mac worlds.

Another by-product of Apple's portable recalcitrance has been the growth of third-party portable vendors. Colby and DynaMac have been around for quite a



The System Folder contains the Control Panels Folder.

Elegant Extensions...



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Between the quality of the code we generate and the richness of our extensions, we thought 1991 might be a good time to examine new platforms or processors. Then along came Windows 3.0 with its 386 enhanced mode. Not happy with being able to multi-task only under UNIX or DESQview, many of our customers now wanted to run their 32-bit applications under Windows. So we visited Microsoft and followed up with ***NDPWIN*** — a Windows Extender used to create and run 32-bit applications on Windows.

One of the features of ***NDPWIN*** is that it makes possible both character and graphics based I/O. You can create a 32-bit character based application that runs in a window or an application which calls the Windows API. Programs with character based I/O will run without changes and can take advantage of Windows multi-tasking, while you're learning to deal with GUIs, APIs and SDKs. Developers who have already ported using the Windows SDK but need access to 32-bit speed or memory can simply recompile with our tools, using the ***NDPWIN-SDK.*** The ***NDPWIN*** versions of our 386 languages, including tools, are $895. The ***NDPWIN-SDK*** which interfaces the Windows SDK is $1495.

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while, making overpriced and overly large portable Macs by cutting up whole Macs bought from Apple.

The only real third-party Mac Portable clone maker is Outbound Systems. Its machine, the Outbound Portable, cleverly extends the Mac Plus or Mac SE bus and stuffs it into a lunchbox-size portable Mac that's less than half the size and weight of Apple's original Mac Portable (the Mac Portable II, with backlighting, is a bit less heavy). Due to a special deal with Apple, even though the Outbound uses Mac Plus or SE ROMs, Outbound can sell these Mac clones at will.

Without mincing words, the Outbound Portable is a pretty darn good machine. I've used one since July 1990, and I've hauled it through the x-ray machines at O'Hare Airport frequently enough to ionize everything in its guts. Despite this abuse, the Outbound Portable has acquitted itself admirably. I really love this little traveling companion, so much that my Mac Portable now stands in for use around the house, on the patio, and out in the backyard.

I have stuffed my Outbound Portable with 4 MB of RAM, 16 MB of RAM disk, and a 40-MB hard disk drive. The machine also includes an antiglare-coated backlit LCD screen capable of resolutions slightly greater than that of the Mac Classic screen (560 by 384 pixels), a tiny outboard 2400-bps modem that's powered by the serial port, a small outboard Superdrive-compatible floppy disk drive, and a SCSI adapter that lets me plug in small external SCSI disks, like the IDS Wips that I'm fond of. The keyboard is detachable (infrared or corded connections) and includes a built-in Isopoint tracking device (a separate two-button Microsoft Mouse also comes standard).

Excluding the small external doodads, this Outbound Portable weighs just 8½ pounds, making it a bit large by 286- and 386SX-based notebook standards, but tiny compared with the Mac, Colby, and DynaMac behemoths.

Apple is reportedly set to announce one to three smaller Mac notebook machines later this year (using either 68020 and 68030 CMOS processors and weighing in at around 5½ to 6½ pounds). But if you need truly portable Mac computing now, the Outbound Portable works well and is reasonably priced (the street prices for a 40-MB hard disk drive model average less than $2600). ■

Don Crabb is the director of laboratories and a senior lecturer for the computer science department at the University of Chicago. He is also a contributing editor for BYTE. He can be contacted on BIX as "decrabb."

ITEMS DISCUSSED

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System 7.0............... $99
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DAVID FIEDLER

NETWORKING UNIX

Ah, networking. In the realm of Unix systems, dealing with LANs can be a bittersweet experience. If you're a system or network administrator, your initial experiences with setting up the network may be a nightmare. Analogous to UUCP, the first connections are the hardest, yet things can get far more interesting when attempting to hook up to the world at large (in this case, the Internet).

Since the desired end result is transparent high-speed access to computers, files, and devices that can be scattered all over your company or even all over the world, it's worth a bit of brain-busting. Users have it a bit easier, since their biggest problem might be keeping track of what machine they're on at any given time. But, as usual, it always helps to define a few terms, trying to make things easier to understand. I'll use references to real life here, so you won't feel as if I'm just talking about dull theory. Future columns will address the nuts and bolts of hooking up and using Unix systems on an Ethernet LAN.

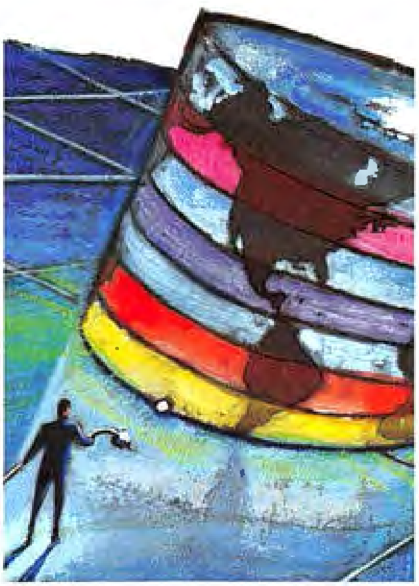
A Multilayer Cake

The basis of networking is the famous seven-layered ISO/Open Systems Interconnection (OSI) reference model (see the figure). It took seven years to fully develop and specify this model, so in the future people may think the number 7 had mystical significance.

The ISO model defines how networks are constructed to keep implementation details hidden from higher levels. In essence, once your application programs have been written to operate with a properly designed network, they won't have to change, even when network topology changes or hardware technology improves. This will be important in the next few years, as hardware moves from Ethernet to Fiber Distributed Data Interface (FDDI) and beyond... but now I'm getting ahead of myself.

The details of which software belongs to which layer are of interest mostly to network designers, yet system programmers often have to get involved at every level below the application layer. Actually, the term "application layer" itself might be confusing. It refers not to the application programs themselves, but rather to the interface between application programs and the network. Thus, application programs have to use and be cognizant of the system calls that make up the application layer if they wish to deal with the network.

When you have 10 megabits per second and a heterogeneous network standard, UUCP and serial connections become outdated



A typical Unix installation uses Network File System (NFS), TCP/IP, and Ethernet as the software and hardware bases for its network. In such a case, the data link layer—the next-to-lowest level of the OSI model—would be represented by the device-driver software that talks to the actual Ethernet transceiver (i.e., the card that the coaxial cable is plugged into). The physical layer is the hardware itself.

The TCP and IP packages reside in the transport and network layers, respectively. Programs on the top three layers deal with higher-level messages, and they can ignore any particular network implementation. Data transmission, reception, routing, errors, and other nasty details are handled in the lower layers.

While the software in each layer interfaces with the next one in a vertical path, it can be written as if it communicates directly with software on the same layer of a different machine (i.e., the transport layer on machine A would be talking to the transport layer on machine B). This is known as *peer-to-peer communications*.

I'll stress that there is more than one way to write a program properly, but a network application must be written to be as general as possible. This will let you use the finished program no matter what the eventual configuration of the network, and no matter where the system files, file systems, and devices such as printers actually reside.

Far Out, LAN

The TCP/IP protocols are common because, like so many other standards, they were developed for the U.S. government. They have been implemented on many operating systems besides Unix and are themselves the basis for a number of other networking innovations (e.g., NFS), which also transcend operating systems. TCP/IP is not bound to Ethernet; it can also be found on Token Ring,

ILLUSTRATION PAUL SCHULENBERG © 1991

ISO/OSI REFERENCE MODEL

Application
Presentation
Session
Transport
Network
Data link
Physical

The seven layers of the OSI model for networks are designed to make the specification endure many changes in technology.

StarLAN, ARCnet, and X.25 networks.

The converse is also true: A physical Ethernet is not limited to supporting TCP/IP protocols (as Novell users know well), and one Ethernet can run several compatible protocols at the same time.

But you don't buy into TCP/IP just because you like the acronym. At the very least, most TCP/IP implementations provide a set of basic applications, including `telnet`, E-mail, and `ftp` (file transfer protocol). `Telnet` lets you connect to another machine on the network as if you were logged on directly. The basic concept is similar to dialing up another computer by way of `cu`, except that there are no modems, dialing delays, or phone charges (past whatever you're already paying to be on the network). You're just there.

The `ftp` program gives you the ability to transfer files between your local machine (the one you're really logged onto) and a remote machine (any other one on the network). And these files transfer at very high speeds: You move megabytes in just a few seconds. With hundreds of thousands of computers on the Internet, it's easy to see why this is a simple, yet powerful, tool. It's even more interesting when you remember that large numbers of these machines aren't running Unix. TCP/IP is surely the common denominator of the network world.

You've probably heard the term "anonymous `ftp`"; it's similar to setting up a number of files in your `/usr/spool/uucppublic` directory and letting anyone log on via UUCP to copy them. Unix systems doing the same on the Internet will put their files in the `/usr/ftp/pub` directory, advertise that fact and their network address, and let anyone log on under the name "anonymous."

Unix systems running TCP/IP generally have many remote utilities, most developed at the University of California at Berkeley, that can be used only between Unix systems. For instance, `rlogin` lets you log onto another Unix machine, `rcp` copies files from one system to another, and `rsh` lets you run programs on another machine. While these are analogous to the BNU utilities `cu`, `uucp`, and `uux`, don't forget: They can execute almost instantaneously on machines thousands of miles away. Naturally, to use any of these programs, you must have the

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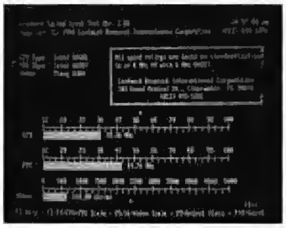

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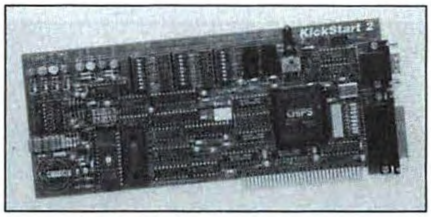

KickStart 2 is ideal for permanent installation. It eliminates the need for an I/O card, provides remote and on-site diagnostic capabilities for quick repair time and offers a solid hardware based solution to unauthorized access with impenetrable password protection.

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My son just turned two, and I'll bet that he'll never know what a modem was.

appropriate permission and, generally, a log-in on the remote machine.

You can even use a standard serial port or modem to dial into many TCP/IP installations via Serial Line Internet Protocol. This gives you access to both `telnet` and `ftp`, without having to carry a coaxial cable wherever you go.

Blazing Packets

At the low end, the ubiquitous Ethernet runs at 10 megabits per second. The high-speed fiber-optic link, FDDI, is rated at up to 100 Mbps. Technology has been moving so fast that it almost doesn't pay to research new methods between these two speeds, since the object is simply to go as fast as possible.

Physically, a LAN running on Ethernet is usually implemented via coaxial cable in one of two thicknesses (the thinner one is often called Cheapernet). Hooking up outside a single building is accomplished by coaxial cable or microwave links, and it can be done by regular radio as well. For longer distances, leased telephone lines are generally used, ranging from the well-known 9600 bps to the T1 line at 1.544 Mbps and the T3 line at 45 Mbps. It's clear that various physical constraints (not the least of which is money) can affect the speed of data transmission.

Broadband ISDN is what the future will hold. It will put everyone's communications on high-speed digital links that will carry voice, video, and data simultaneously (see the text box "On the Threshold of a Dream" on page 234 of the June 1990 BYTE). When will this happen? Not tomorrow, but my son just turned two, and I'll bet he'll never know what a modem was.

How much data can realistically make it through all those layers of software? Using a bare Ethernet, the theoretical maximum for data throughput is about 1.2 megabytes per second. Once you start adding protocol layers and allowing for busy hosts, though, real-world performance can actually range anywhere from 30K bytes per second to 400K bytes per second. It's interesting to note that this compares favorably with many systems' hard disk drives. The inescapable conclusion is that your brand-new superspeed modem is already obsolete: At only 1000 or 2000 bytes per second, your modem is no match for even the most loaded-down LAN. The speed is available; perhaps it's time for you to join the modern world of networks after all. ■

David Fiedler has been a consultant and writer on Unix topics for over a decade and has started several Unix publications. His company, InfoPro Systems, produces corporate image and marketing videos for high-tech firms. You can reach him on BIX as "fiedler."

ASK BYTE

External Floppy Disk Drives

I am presently using a desktop IBM PC compatible with a 5¼-inch 360K-byte floppy disk drive and a standard controller board. Because I am purchasing a Toshiba laptop, I am looking for a portable 5¼-inch floppy disk drive to install in this system. Unfortunately, I have had no success.

My plan is to use the old floppy disk drive as an external and portable drive. I would like to build a drive board to change the old internal floppy disk drive into a portable drive.

The old drive is a Sankyo model with a 34-pin flat cable connector for data and control and a 4-pin connector for a 5- and 12-volt power source. The Toshiba has a DB-25 parallel port.

Carlos Emilio Senna Delgado
Volta Redonda, Brazil

You did not mention the model of your Toshiba laptop, but I can give you information that should be valid for most Toshiba models. The parallel port can be configured as a standard parallel connector or as a floppy disk drive connection, and Toshiba does offer a 5¼-inch 360K-byte floppy disk drive that you simply plug into the reconfigured parallel port. This sounds like the easiest and most convenient solution for you. The suggested list price for the drive is $499, but you should be able to get a better price from a dealer or a mail-order house.

You could also purchase the Backpack from Micro Solutions Computer Products ((815) 756-3411). The Backpack floppy disk drive will plug into any parallel port. If you need more space, you can also get a portable hard disk drive from Liberty Systems (120 Saratoga Ave., Suite 82, Santa Clara, CA 95051, (408) 983-1127). The Liberty drive also plugs into the parallel port, but it delivers 52 megabytes (50QC for $899) or 105 MB (105QC for $1199) of disk space.

If you're a die-hard do-it-yourselfer, Toshiba also sells a cable that maps the floppy disk drive/parallel connector to emulate a standard 34-pin controller-card edge connector. Therefore, you could hook up your existing 5¼-inch floppy disk drive.

However, you would also have to build a power source for the floppy disk drive, because the drive's power is being supplied from your PC. For safety's sake, your power source should also include a fan. If you want to pursue this project, give Toshiba technical support a call at (714) 587-9476.—S. D.

Come On, Be a Good Sport

I bought a Zenith TurbosPort 386e several months ago at a good discount, gambling that there would be graphics support for the double-scan CGA display (640 by 400 pixels compared to the standard 640 by 200 pixels). I'm quite happy with the display for text-mode applications, but the CGA graphics are barely tolerable. My primary graphics applications are MathCAD, Smalltalk/V 286, and Windows 2.0. MathCAD's Toshiba DCGA driver doesn't quite work, but it comes close enough to indicate that DCGA graphics should be good enough for many applications.

I haven't found any drivers yet, and being overseas, I don't have access to the BBSes that appear to be the best source of device drivers. Have I lost my gamble, or can you direct me to a source for TurbosPort 386e DCGA display drivers? I'm especially interested in a Windows 3.0 screen driver.

Steven H. Rogers
APO San Francisco

Zenith is working furiously on a DCGA driver even as we speak. When it's ready, it will be available from local Zenith resellers. Simply walk into your neighborhood Zenith dealer and ask for a copy of VDDCGA.386. If they don't have it, they can get it from the dealer BBS.

Being overseas may present a logistical problem. Perhaps a friend can secure a copy for you.—H. E.

CD Search

I am looking for addresses of manufacturers of CD-ROM players and discs. Could you send me complete information?

Ferrer Fabienne
Paris, France

A good source of information on CD-ROM discs and drives is the Bureau of Electronic Publishing, 141 New Rd., Parsippany, NJ 07054, (201) 808-2700, fax (201) 808-2676. It publishes a large catalog and carries a wide selection of CD-ROMs, drives, and accessories for the PC and the Mac.

You can also contact CD-ROM drive manufacturers. Here is a selection of some companies:

Chinon America, Inc.
Information Equipment Division
660 Maple Ave.
Torrance, CA 90503
(213) 533-0274
fax: (213) 533-1727

Hitachi Sales Corp. of America
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(213) 537-8383

Laser Magnetic Storage International Co.
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1414 Massachusetts Ave.
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(800) 632-4636
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fax: (508) 264-8673

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Sony Corp. of America
Component Peripheral Products Co.
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fax: (408) 943-0740

Toshiba America Information Systems, Inc.
Computer Systems Division
9740 Irvine Blvd.
Irvine, CA 92718
(800) 334-3445
(714) 583-3000

Sony has recently introduced its Data Discman CD-ROM player, but it is not yet available in the U.S.—S. W.

A Turn for the Durst

Although one of my hobbies is computers, I make my living in the field of photography. Computers have also invaded this area, and my company has three Durst 2501 enlargers. This model is fully computerized, and all the programming resides in a 2764-25 EPROM.

I have two questions: Can I duplicate those EPROMs? Can I modify their programs to adapt to our needs? I would much appreciate any advice you can give me about where to start looking into this matter.

Carlos Baranyai
Scarborough, Ontario, Canada

Duplicating the EPROM would be child's play for any EPROM programming device, but why would you need to? Each enlarger already has one, and I don't see any purpose in making duplicates—unless, of course, you want to modify them, but that also seems pointless. As you indicate, the 2501 is heavily computerized, and the EPROM contains all the programming for its many functions. To reprogram it, you would have to know all the ins and outs of the 2501's hardware design.

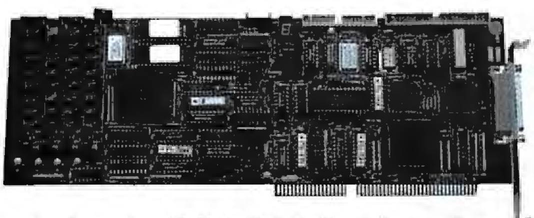
I spoke with Colenta America (Durst's distributor in the U.S.), and it suggested that if you have the HL2501AF model, you should order the HL2501AFN upgrade kit. It's Colenta's guess that your biggest complaint with your 2501 is the paper programming, and the upgrade is a big improvement.

Basically, it gives you simplified paper programming, Refrema roll-paper easel support, expanded paper channels, added light output and on-line capabilities for the densitometer, a bar code reader, and the Durst Optoscan film scanner.

Before you attempt to modify your enlarger, I suggest you contact Colenta America (347 Evelyn St., Paramus, NJ 07652, (201) 265-5670). It's quite possible that there's some neat user tip that will make your enlarger do what you want without modification.—H. E.

I've Got the Jitters

My problem is a strange one. When my computer is on and any "visible" action (e.g., typing, mouse movement, screen updates, or hard disk drive activity)



is taking place, the screen is covered with jittery bands of light and dark areas. The actual computer screen is still there (and highly legible); it is just lighter and darker in those bands. The bands appear only in the parts of the screen that the computer is "using."

When I increase the brightness on the monitor, the portions of the screen that were black do not have the bands—only the portions that were "colored." For example, in a word processor with white letters and a black background, I can't see the bands unless I look very carefully. Only the letters are affected, not the black background. When no input is taking place, the screen has much less activity. But smaller bands still seem to creep up the screen, much like a TV that is not quite tuned.

This just started happening today, and I can't figure it out. It happens in Windows, out of Windows, with everything attached, with only the bare minimum attached, and so forth. I can't remember any significant event that triggered it, either.

Chris Hecker
New York, NY

Based on what you've described, your first step should be to isolate the problem to your video card, monitor, or cable. My guess is that the problem is in your monitor. If you have a friend with a computer whose monitor and adapter card are compatible with yours, see if you can do a quick swap for a few minutes so you can determine the culprit.

If it's your cable, get a replacement. If it's your video card, perhaps reseating any socketed chips and cleaning the edge connector might solve it. If it's your monitor, unless you're qualified to go digging around inside high-voltage electronics, I'd recommend that you take it to your nearest computer store to have it serviced.—R. G.

You're Not Alone

I write in response to Dennis C. Kornbluh's letter in the October 1990 Ask BYTE. I, too, have a Conner drive that occasionally hangs while performing I/O. It happens when reading or writing large files (e.g., loading Windows 3.0). The drive activity light stops flickering and remains solidly lit. The drive will occasionally complete its operation after several seconds, but about 75 percent of the time it remains hung. At this point, toggling the CPU speed rapidly between 12 and 25 MHz will sometimes cause the drive to continue normally.

There is never any indication of an error; either the operation completes, or it hangs longer than 3 minutes (the extent of my patience). I can duplicate this problem whether the computer is warm or cold, shadow RAM is enabled or disabled, or PCTools' Mirror and PC-Cache are loaded or not. All connections are tight.

The above suggests that Mr. Kornbluh is not alone, and that the problem is not one of the ones you suggested. I am also writing to Conner and DTK (the manufacturer of my motherboard) to see if they have any suggestions.

Bjarne Hansen
APO New York

Good luck, and keep us posted.—Staff ■

BYTE

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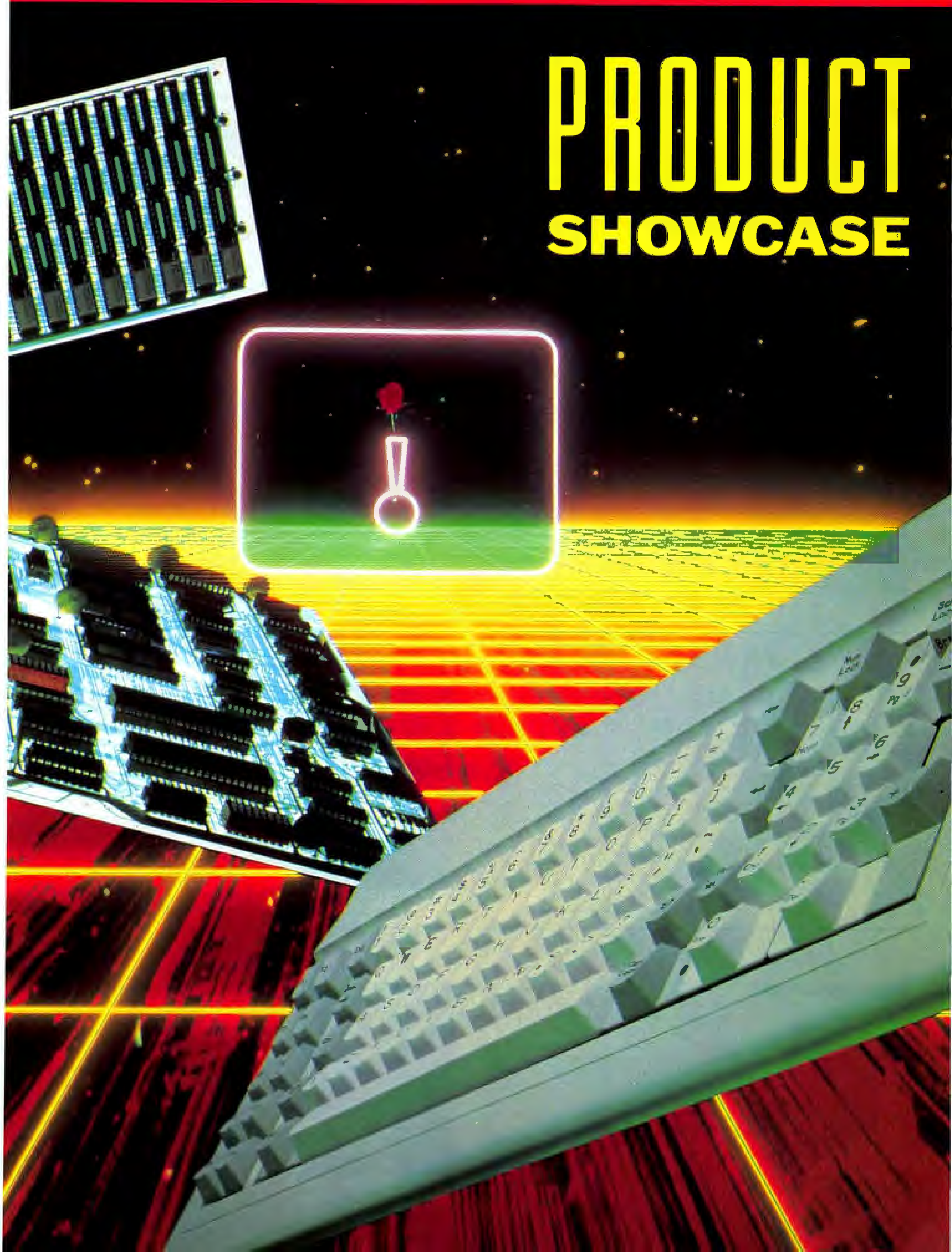

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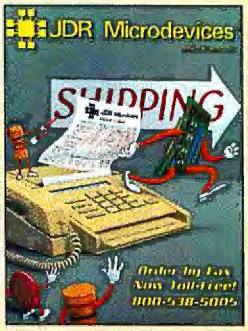

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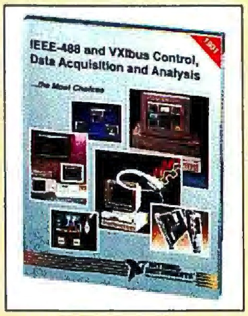

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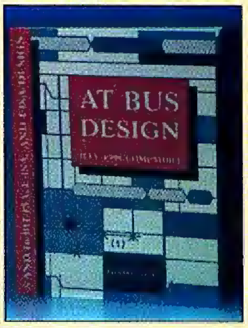

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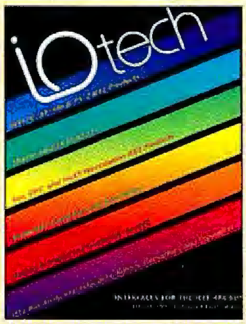

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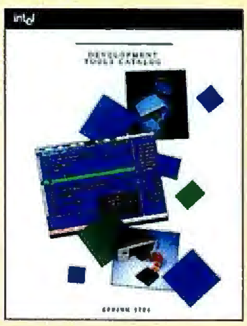

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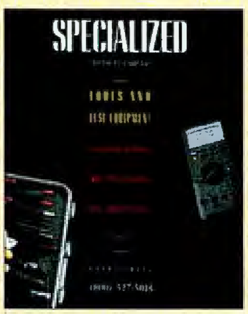

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Effective January 1, 1991.

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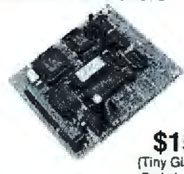

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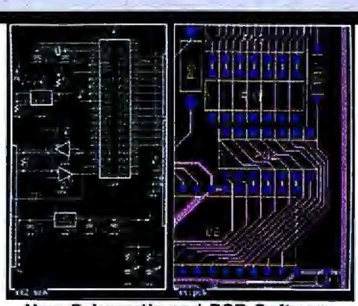

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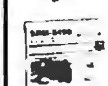

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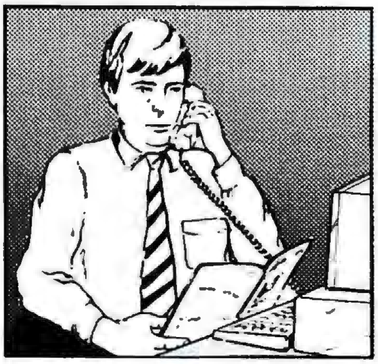

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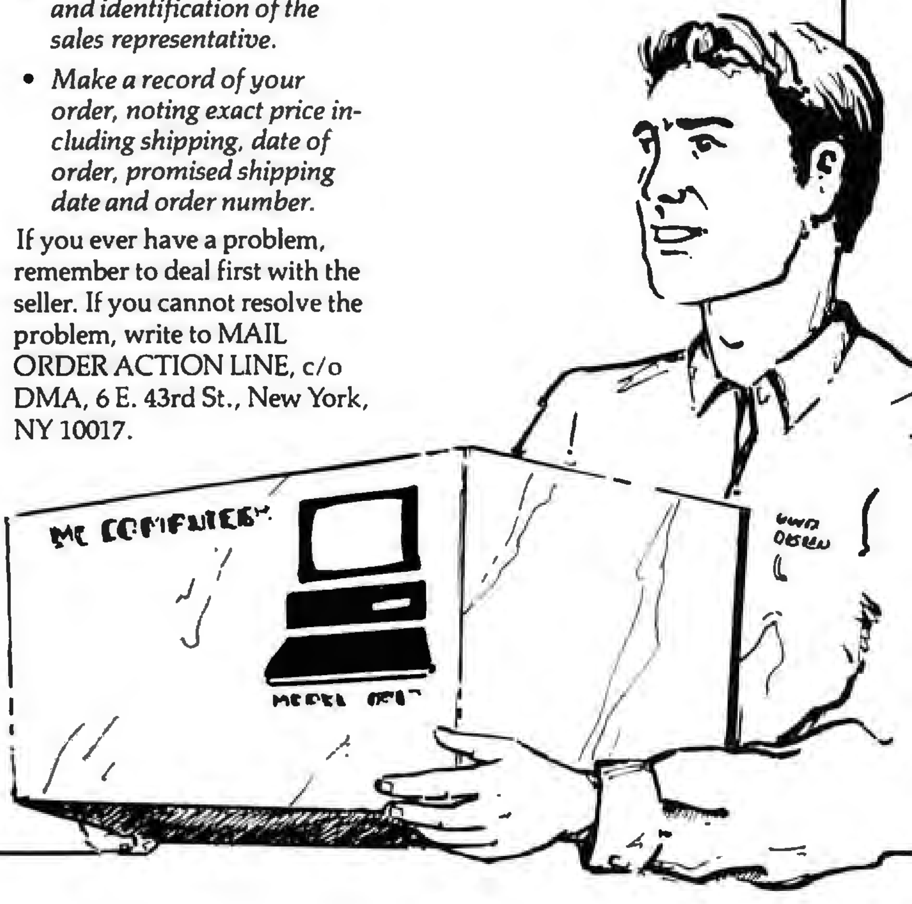

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6450379 (2MB)	80-111, 311	$ 199.00
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6450128 (4MB)	90, 95	$ 499.00
6450605 (2–8MB)	70, 80	$ 399.00
34F3077 (2–16MB)	70, 80	$ 499.00
6450609 (2–16MB)	50, 50Z, 55SX, 60, 65SX	$ 419.00

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Model	Memory Added	Part # EQ	PRICE
DP 386/33, 486/25, 33 & Systempro	2MB MODULE	115144-001	$ 159.00
	8MB MODULE	116561-001	$1,069.00
DP 386/20e, 20, & 25e, 25	1MB BOARD	113644-001	$ 159.00
	4MB BOARD	113645-001	$ 409.00
	1MB MODULE	113131-001	$ 109.00
	4MB MODULE	113132-001	$ 319.00
DP 386s/16	1MB BOARD	113633-001	$ 159.00
	4MB BOARD	113634-001	$ 409.00
	1MB MODULE	113646-001	$ 109.00
	4MB MODULE	112534-001	$ 319.00
DP 286N, 386N & 386SX/20	1MB MODULE	118689-001	$ 99.00
	2MB MODULE	118689-001	$ 149.00
	4MB MODULE	118690-001	$ 459.00
	0K BOARD	118700-001	$ 99.00
DP 386/16	1MB BOARD	108069-001	$ 279.00
	2MB BOARD	108069-W/71	$ 399.00
	4MB BOARD	108070-001	$ 599.00
	8MB BOARD	108070-W/72	$ 899.00

NEC

Model	Memory Added	Part # EQ	PRICE
Powermate SX Plus	1MB BOARD	APC-H850E	$ 279.00
	2MB BOARD	& APC-H851E	$ 479.00
	4MB BOARD	APC-H852E	$ 759.00
	8MB BOARD	& APC-H853E	$1,299.00
Powermate SX/20			Call
Powermate 386/20	2MB BOARD	APC-H655E	$ 499.00
Powermate 386/25	2MB BOARD	APC-H655X	$ 499.00
	8MB BOARD	APC-H656X	$1,399.00
	8MB BASEBOARD	APC-H657X	$1,449.00
Powermate 386/25S	2MB KIT	OP-410-8103	$ 249.00
	8MB KIT	OP-410-5202	$ 699.00
Powermate 386/33E 486/25E	2MB MODULE	OP-410-5101	$ 379.00

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Model	Memory Added	Part # EQ	PRICE
MAC Classic	1–3MB BD	M6361LL/A	$ 119.00
	2MB KIT	M0514LL-A	$ 109.00
MACIIci, IIsi	1MB KIT	M0291LL-A	$ 79.00
MACIIsi	2MB KIT	M0514LL-A	$ 199.00
MACIIci, IIsi	4MB KIT	M0292LL-A	$ 229.00
MACIIsi	8MB KIT	M0513LL-A	$ 799.00
MACIIci, IIsi	16MB KIT	No # Available	$1,099.00
MACIIfx	4MB KIT	M0378LL-A	$ 249.00
	16MB KIT	No # Available	$1,199.00
MAC SE, SE30, Plus, II, IIcx, IIx	4MB KIT	M02707	$ 229.00

AST

Model	Memory Added	Part # EQ	PRICE
BRAVO 486/25	2MB SIMM	500718-004	$ 229.00
PREMIUM 386SX/16, SX20 & 386/25, 33	1MB MODULE	500780-003	$ 89.00
	4MB MODULE	500780-004	$ 499.00
	8MB KIT		
PREMIUM 386C, WKST & BRAVO	1MB KIT	500510-007	$ 89.00
	4MB KIT	500510-008	$ 279.00
PREMIUM 286			
Fastram	512-2MB BD	500394-001	$ 289.00
Fastram Kit	512 UPGRADE	500510-001	$ 55.00
Adv. Fastram	2–8MB BD	500565-001	$ 629.00
Adv. Fastram Kit	2MB UPGRADE	500510-002	$ 139.00
PREMIUM 386	1MB KIT	500510-003	$ 89.00
	4MB KIT	500510-004	$ 299.00

CHIPS

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Part#	PRICE
256 X 8-10	$ 17.00
256 X 9-10	$ 18.00
256 X 9-80	$ 19.00
256 X 9-70	$ 21.00
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1 X 9-10	$ 55.00
1 X 9-80	$ 54.00
1 X 9-70	$ 58.00
4 X 9-80	$ 239.00
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Part#	PRICE
1 X 1-10	$ 5.50
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256-70	$ 2.20
256 X 4-10	$ 5.50
256 X 4-80	$ 6.00
4464-10	$ 2.20
4464-80	$ 2.50
4164-10	$ 2.00

LASER PRINTER MEMORY

Model	Memory Added	Part # EQ	PRICE
H.P. LASERJET IIP, III, IIID	1MB MODULE	H33474B	$ 85.00
	2MB MODULE	H33475B	$ 139.00
	3MB MODULE	H33476B	$ 189.00
	4MB MODULE	H33477B	$ 239.00
H.P. LASERJET II, IID	1MB MODULE	H33443B	$ 85.00
	2MB MODULE	H33444B	$ 139.00
	4MB MODULE	H33445B	$ 239.00
H.P. DESKJET	256K MODULE		
IBM 4019, 4019e	1MB MODULE	1039136	$ 149.00
	2MB MODULE	1039137	$ 169.00
	3.5MB MODULE	1038675	$ 275.00
OKi LASER 400	1MB MODULE	70014701	$ 179.00
	2MB MODULE	70015801	$ 249.00
OKi LASER 800, 820	1MB MODULE	70016501	$ 179.00
	2MB MODULE	No # Available	$ 249.00
	4MB MODULE	No # Available	$ 359.00
PANASONIC 4450	1MB MODULE	KXP440	$ 190.00
PANASONIC 4420, 4450i	1MB MODULE	KX443	$ 169.00
	2MB MODULE	KX441	$ 219.00
	4MB MODULE	No # Available	$ 329.00
CANON LBP-4	1MB MODULE	S63-2240	$ 189.00
	1MB EXP	S63-2230	$ 189.00
CANON LBP-8II	1MB BOARD	S63-1300	$ 99.00
	2MB BOARD	S63-1880	$ 149.00
	4MB BOARD	No # Available	$ 269.00
APPLE LASERWRITER	1MB KIT	M6005	$ 89.00
	4MB KIT	M6006	$ 299.00
EPSON EPL6000	2MB MODULE	IBS401	$ 199.00
	4MB MODULE	IB401/4	$ 329.00
TI MICROLASER	1MB MODULE	2559810-8001	$ 89.00
TOSHIBA PAGELASER 6	2MB MODULE		$ 219.00
	4MB MODULE		$ 349.00
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2C87-12	$ 179.00
2C87-20	$ 229.00
3C87SX-16	$ 249.00
3C87SX-20	$ 269.00
3C87-20	$ 289.00
3C87-25	$ 359.00
3C87-33	$ 449.00

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Model	Memory Added	Part # EQ	PRICE
TOSHIBA			
T1000SE, XE & 2000SX	1MB KIT	PC14-PA8311U	$ 199.00
	2MB KIT	PC14-PA8312U	$ 279.00
	4MB KIT		$ 649.00
	8MB KIT		$1,099.00
T1200XE	2MB KIT	PC-PA8306U	$ 169.00
T1600	2MB KIT	PC8-PA8302U	$ 169.00
T3100SX	2MB KIT	PC15-PA8308U	$ 169.00
	4MB KIT	PC15-PA8310U	$ 449.00
T3100	2MB KIT	PC9-PA8341U	$ 169.00
T3200SX	2MB KIT	PC12-PA8307U	$ 169.00
	4MB KIT	PC12-PA8309U	$ 449.00
T3200	3MB KIT	PC6-PA7137U	$ 279.00
T5100	2MB KIT	PC7-PA8301U	$ 169.00
T5200, 5200C, 8500	2MB KIT	PC10-PA8313U	$ 169.00
	8MB KIT	PC10-PA8313U	$ 999.00
COMPAQ			
Portable III	Modem/Interface	107808-001	$ 89.00
	0-6MB BD	107811-001	$ 169.00
	512 KIT	107331-001	$ 39.00
	2MB KIT	107332-001	$ 129.00
Portable 386/20	Modem/Interface	107707-001	$ 89.00
	1MB KIT	107651-001	$ 239.00
	4MB EXP	107653-001	$ 699.00
Portable LTE286	1MB BOARD	117081-001	$ 129.00
	2MB BOARD	117081-002	$ 179.00
	4MB BOARD	117081-003	$ 699.00
Portable LTE386S/20	1MB BOARD	121125-001	$ 349.00
	4MB BOARD	121125-002	$ 999.00
SLT/286	1MB BOARD	110235-001	$ 159.00
	4MB BOARD	110237-001	$ 699.00
SLT/386	1MB BOARD	118303-001	$ 169.00
	2MB BOARD	118304-001	$ 309.00
	4MB BOARD	118305-001	$ 699.00
NEC			
Prospeed SX/20	1MB BOARD	PC-43-21	$ 289.00
	4MB BOARD	PC-43-22	$ 679.00
Prospeed 286, 386SX/16	1MB BOARD	PC-21-21	$ 289.00
	2MB BOARD	PC-21-26	$ 459.00
	4MB BOARD	PC-21-22	$ 679.00
Prospeed 386	2MB CARD	PC-31-21	$ 459.00
	8MB CARD	PC-31-22	$1,399.00
Zenith			
Supersport Sx	2MB ALPHA	ZA-180-86	$ 279.00
	2MB BETA	ZA-180-87	$ 279.00
	2MB EXP	ZA-180-64	$ 279.00
Slimport, 286e	2MB CARD	ZA-180-64	$ 279.00
	4MB CARD	ZA-180-71	$ 699.00
Turbosport 386e	1MB BOARD	ZA-3034-ME	$ 249.00
	4MB BOARD	ZA-3034-ME/4	$ 599.00
OTHER LAPTOPS			
MAC Portable	1MB BOARD	M0248	$ 239.00
	2MB BOARD	M0248/2	$ 699.00
	3MB BOARD	M0248/3	$ 899.00
	4MB BOARD	M0248/4	$1,199.00
AST Executive Notebook	1MB SIMM	500814-001	$ 109.00
	4MB SIMM	500814-003	$ 599.00
SHARP PC-6220 Notebook	1MB BOARD	CE-621B	$ 189.00
Ti Travelmate 2000	1MB BOARD	2568034-0001	$ 189.00
Everex Tempo Lx	2MB MODULE	PCA-00053-00	$ 399.00
Panasonic CF-170,270	1MB CARD	CF-BA165	$ 249.00

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- 2 ☐ Programmer/Systems Analyst
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- 4 ☐ Sales/Marketing
- 5 ☐ Engineer/Scientist
- 6 ☐ Other

B. What is your level of management responsibility?
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- 8 ☐ Middle-level
- 9 ☐ Professional

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10 ☐ Yes 11 ☐ No

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- 15 ☐ UNIX
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- 19 ☐ 26-50
- 20 ☐ 51-99
- 21 ☐ 100 or more

MAY 1991

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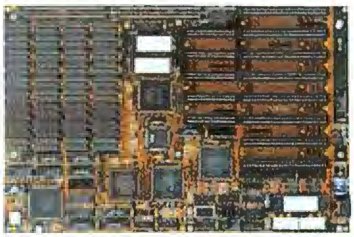

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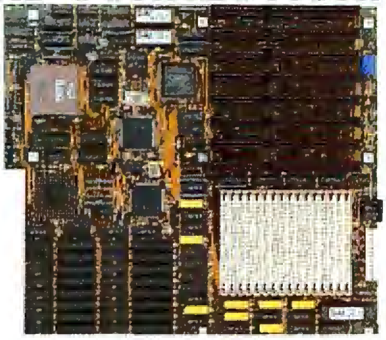

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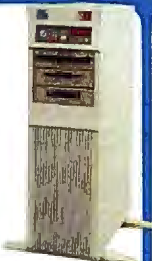

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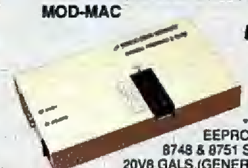

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KEY CODE #1012

Circle 6 on Inquiry Card (RESELLERS: 7).

Listing 3: *The functions for finding and adding words to the trie.*

```
(a) Function FindWord(w:string[1..n] of characters):LetterNodePointer;
      {This function will find the right leaf corresponding to a path from
      the root to the nth character of w.}
   var
      CurrentNode:LetterNodePointer;
      CurrentLevel:integer;
   begin
      Set CurrentNode to the root corresponding to w[1].
      CurrentLevel:=2;
      StillSearching:=true;
         {We are now at a list of the branches at CurrentLevel.}
      while w[CurrentLevel] is not past the end of the word do begin
         Scan along this list started by CurrentNode until the letter
            corresponding to w[CurrentLevel] is found.
         If the letter is found, then set CurrentNode to the down pointer
            here. Increment CurrentLevel.
         Otherwise, exit.
      end;
      if the loop exits because it finds the leaf of the last letter,
         return this leaf.
      else return nil;
   end;

(b) Function AddWord(w:string[1..n] of characters):LetterNodePointer;
      {This function will add a word. It is similar to FindWord, except it
      will insert new nodes.}
   var
      CurrentNode:LetterNodePointer;
      CurrentLevel:integer;
   begin
      Set CurrentNode to the root corresponding to w[1].
      CurrentLevel:=2;
      StillSearching:=true;
         {We are now at a list of the branches at CurrentLevel.}
      while w[CurrentLevel] is not past the end of the word do begin
         Scan along this list started by CurrentNode until the letter
            corresponding to w[CurrentLevel] is found.
         If the letter is found, then set CurrentNode to the down pointer
            here. Increment CurrentLevel.
         Otherwise, add the correct letter and the rest of the word.
      end;
      when the loop exists because it finds (or adds) the leaf of the last
         letter, return this leaf.
   end;
```

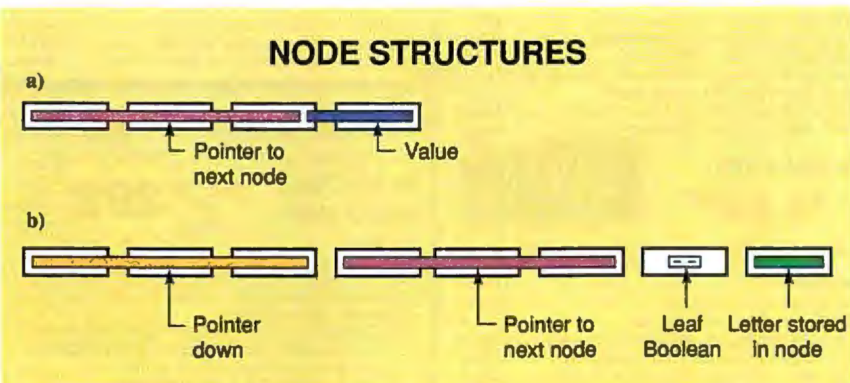


Figure 3: (a) *The packing structure for a list node: 22 bits for the pointer and 10 for the value.* **(b)** *The packing structure for a letter node: 3 bytes for a pointer, a bit for a Boolean, and a byte to hold a character.*

continued from page 322

$\texttt{value}_1$ $\texttt{value}_2$ $\texttt{value}_3\texttt{...value}_n$ stop-value

This can save plenty of space, but it is not easy to add and remove values when the index is being constructed or updated. The lists can also easily grow into each other as new values are added, and the program must be able to repack them—another bit of complexity. In my index, there are over 35,000 of these continually changing lists, and it just doesn't make sense to try and keep track of the beginnings and ends of these lists as they merge into each other. On the other hand, if you are indexing a CD-ROM and the lists will never change, a simple string of values is quite appropriate.

Memory Management

For each of the three major structures of this index application, the program uses data structure nodes that include pointers, and these nodes are allocated as needed. It is possible to use the native `malloc` or `new` functions to create new nodes on the fly, but this is often very slow because these memory allocation routines must maintain many system-wide tables.

This implementation does its own memory management for the sake of speed. At the beginning of the program, a new memory block is built for each of the three sections. Large segments of memory are allocated in one step and broken up into nodes by the implementation. The pointers are not absolute but simply measure the offset from the beginning of the memory chunk. On one hand, this slows down the program, because looking up a value at a pointer cannot happen until the relative location of the pointer can be converted in the real location in memory. On the other hand, it makes node allocation much faster.

The memory chunks are initialized by filling them with a chain of empty nodes of the appropriate size. One of the pointers in each node points to the next empty node in the chain. When a new node is required, the program calls its own internal memory allocation routine, which pulls off one of the nodes from the front of the list. When a node becomes free, it is placed at the front of the list. This primitive form of garbage collection manages and recycles memory by using the actual structures.

Limiting the List

The current implementation of the program stores only the uppercase version of the words (recall that there are only 26 roots in the trie). Lowercase letters are converted into their uppercase equivalents, and punctuation and other non-letter characters are converted into spaces. This substantially reduces the keyword list size by increasing the redundancy in the sources. A function it adds is that the searches do not need to be case specific.

Even with all the efficiencies built in, the index may be too large to be efficient. A smaller index means a less precise index, but if compactness is what you want, it can be done by not including some entries. One good way of thinning the list is to leave out words that appear in most of the files—say, greater than 50 percent of them. When that threshold is reached, the word gets deleted. This leaves out many *glue* words that have grammatical meaning but provide little information (e.g., *the*, *down*, *have*, and *almost*).

Another way to reduce the keyword list is to compress similar entries into one. The disadvantage of this technique is that the ambiguity must be resolved when the word is looked up, and the returning filenames must be searched to see if they really contain the correct word. For an extreme example of this technique, only the first letter of each word would be stored. The words *slow* and *sanguine* would be converted into *s*. The index would be very small—26 entries—but when it came time to look up *slippery*, the index would return a list of files that contained at least one word beginning with the letter *s*. Obviously, an extreme such as this would not be very useful, but a conservative application of this method can produce a useful index.

This index program has several parameters for controlling the size of the index. The parameters set minimum and maximum bounds on the length of the words that are stored. There are many small words like *and*, *or*, *a*, and *the*, which are used repeatedly in almost all files. Setting the minimum word length to four characters removes these.

The maximum word count can also affect the size of the index in different ways depending on how the program deals with larger-than-normal words. The program can be set to truncate long words or to break them into overlapping (or nonoverlapping) chunks. For example, if the maximum word length is set to three characters, the word *Carter* is stored as *CAR* if you choose to truncate. If you choose the overlapping option, it is stored as *CAR*, *ART*, *RTE*, and *TER*. If you choose the nonoverlapping option, it is stored as *CAR* and *TER*. Naturally, when the words are truncated, information is lost. (*FOOTBALL* and *FOOTODOR* index as the same word if the maximum word size is set to four letters.)

Listing 4: (a) *The function for adding a file number to the list of files found with a keyword and* **(b)** *the function that indexes a file.*

```
(a) Procedure AddValue(ListStart:ListNodePointer; value:integer);
        {A file is given a number. This function adds this number to the
        list in the correct, sorted order.}
    begin
        ScanningPointer:=ListStart;
        while Value is less than the value at the node pointed to by
            ScanningPointer do
                ScanningPointer:=ScanningPointer.next;
        If the value is already there, do nothing.
        Otherwise, Allocate a new node and insert it here.
            Move the pointers.
    end;

(b) Procedure DoFile(filename:string);
        {Opens up the file and adds all their words to the structures.}
    var
        w1:string;{The Word.}
        Location:LetterNodePointer;
    begin
        Add the filename to the filename structure by breaking it up into
            the path names and using AddFileName.
        Open up filename;
        Set FileNumber to a new number from the file number structure;
        while the end of the file has not been reached do begin
            Set w1 to the next word;
            Convert it to Uppercase;
            Location:=AddWord(w1);
            Call AddValue with the down pointer at Location and File Number.
                Note that the down pointer here is now pointing in the list
                structure.
        end;
    end;
```

An advantage of using a trie for the word list is that you can easily find words that begin with a specific prefix by finding the roots underneath the prefix. That means you can easily search for all words that begin with *post*. The subtree contains *post*, *postal*, *post office*, and many others. Many hashing schemes lose the information about the structure of the words, because they are tuned to give an even distribution.

Freely Available

A working version of this indexing program is available on BIX or in a variety of formats (see page 5 for details). The source code is about 10,000 lines of Think Pascal for the Macintosh. Anyone who wishes to port the code to another system must pay particular attention to the memory allocation routines. It is substantially easier to deal with large blocks of memory on the Macintosh than on DOS machines. My 5-MB system will build an 1800K-byte index without much problem. This amount of memory is becoming more common, so I did not try to save any more by making the structures more efficient. Implementing the program on a smaller system without virtual memory will require building in some swapping of structures to disk or using tighter structures. Implementing it under another operating system also requires modifying the file access routines.

This index system is nearly complete, but it is by no means finished or perfect. For further reading, see *The Design and Analysis of Computer Algorithms* (Aho, Alfred; Hopcroft, John; and Ullman, Jeffrey. Reading, MA: Addison-Wesley, 1974). It is possible to use other algorithms (e.g., hashing) to build smaller indexes, but they would probably have some degradation in performance. It is also possible to add a third pointer to the alphabet trie to turn the list of letters at the same level into a binary tree. This would certainly speed things up, but at the expense of memory. There are many other possibilities for the optimal tradeoff between speed and space, but this is an exercise left for the ambitious reader. ■

Peter Wayner is working toward a Ph.D. in computer science at Cornell University. You can contact him on BIX as "pwayner."

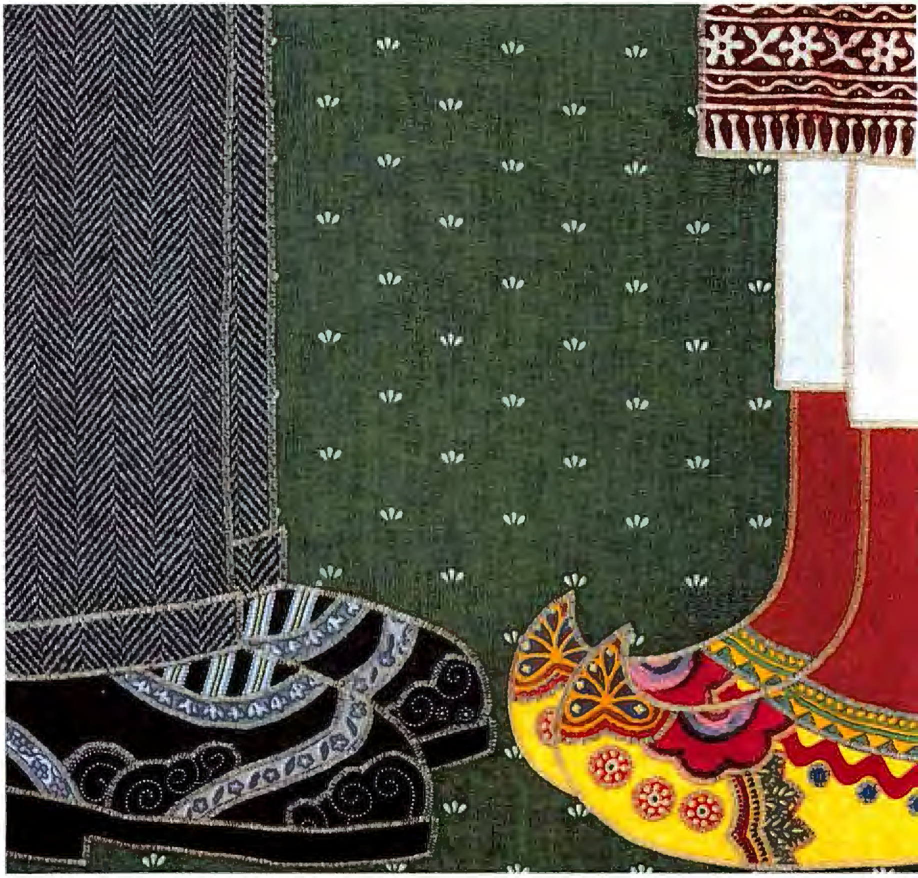
PRINT QUEUE

HUGH KENNER

A Passage from India

East meets West on the level plane of mathematics, as described in the biography of an Indian genius

In *A Mathematician's Apology* (1940), intensely personal though it plainly is, G. H. Hardy discloses next to nothing about himself. So, 20 years after Hardy's death, to orient readers of a fourth printing, his friend C. P. ("Two Cultures") Snow supplied a biographical foreword. And since Hardy once said that discovering Ramanujan was "the one romantic incident in his life," Snow gave eight pages to the Ramanujan story. His 2000-word version is the one most nonmathematicians know. In its mythic simplicity it has proven pretty hard to forget.



Briefly: A 25-year-old clerk in Madras, India, nearly devoid of formal education, mails 10 handwritten pages to G. H. Hardy at Cambridge. The package arrives early in 1913. The covering letter requests Hardy's opinion of some mathematical discoveries. All the rest of the sheets are crammed with theorems, "most of them wild or fantastic-looking, one or two already well-known, laid out as though they were original. There were no proofs of any kind." Hardy, at 36 already world famous, was routinely pestered by cranks. Therefore, he shrugged and resumed his usual routine: check the cricket scores in the *Times*, do 4 hours' work, lunch lightly, play some tennis. But the letter nagged at him, and that evening he thought it worth showing to his colleague and collaborator, Edward Littlewood.

"Before midnight they knew, and knew for certain. The writer of these manuscripts was a man of genius." (Hardy would later class Ramanujan's natural gifts with those of Gauss and Euler; of one group of unproven theorems he remarked, "They must be true because, if they were not true, no one would have the imagination to invent them.") So Ramanujan must be brought to England! And Hardy went into action.

The rest is lamentably brief. Ramanujan arrived in April 1914. Hardy had to teach him math elements English schoolboys learned in the upper forms. But soon they were in collaboration: "Five papers of the highest class." At 30, Ramanujan was a Fellow of the Royal Society, a Fellow of Trinity. Then he came down with tuberculosis. "It was difficult, in war-time, to move him to a kinder climate." So he shriveled in English hospitals till war's end, then took a boat home, to die.

(Hardy would visit his wasting protégé in a Putney hospital. One day he was fumbling for small talk: "The number of my taxi-cab was 1729. It seemed to me rather a dull number." And Ramanujan: "No, Hardy! No, Hardy! It is a very interesting number. It is the smallest number expressible as the sum of two cubes in two different ways!")

You can see why that's held the attention even of readers whom a whiff of algebra can stun. Why Ken Russell never made a film version is unclear. (Perhaps for lack of someone to play Hardy? Leslie Howard was a look-alike, but he's long dead.) More important: Why did no one, in all these years, ever undertake a book-length expansion? Well, Robert Kanigel has; and it's a pleasure to report that *The Man Who Knew Infinity: A Life of the Indian Genius Ramanujan* (Charles Scribner's Sons, 1991, $24.95) is in the "1729" class: the most luminous expression ever of two three-dimensional lives along both personal and professional axes. As a presentation of genius interacting with genius, I've seen nothing to compare with it.

The theme of interaction stimulates Kanigel. His *Apprentice to Genius*, subtitled *The Making of a Scientific Dynasty*, details the web of relationship—sponsor, colleague, apprentice—in a front-rank biology lab. And Hardy did all his best work in collaboration. (Forced to listen to some pompous bore, he would say to himself, "Well, I have done one thing *you* could never have done, and that is to have collaborated with both Littlewood and Ramanujan on something like equal terms.")

Call him "Rah-MAH-na-jun," the stress on that second syllable very light. Situate him a thousand miles south of the Ganges, in Kumbakonam, where they wove silk saris and detailed fine metalwork, and supported a fine English-language high school, to which he was admitted at age 10. His parents eked out meager funds by boarding college students, whom he'd pester for math books from the college library. By 13 he'd mastered a trig text and somehow glimpsed something that it didn't offer: That trig functions are more than line ratios; they emerge from infinite series.

Some of Ramanujan's theorems are still being worked on.

And at 16 Ramanujan came upon a magic book: G. S. Carr's *Synopsis of Elementary Results in Pure and Applied Mathematics*: simply, some 5000 theorems—known results—so arranged that if you understood, say, the first 47, you were ready to tackle number 48. There were no proofs; the thing was meant simply as a cram-book for the notorious Cambridge math exam, the Tripos, one's ranking in which could shape one's career for life. Ramanujan set out to work his way through it, devising methods—and notation—as he went along. By 20, when his refusal to bother with anything but math had flunked him out of two colleges, he'd accumulated much of the famous notebooks from which he'd skimmed what he sent to Hardy: on hypergeometric series, continued fractions, singular moduli.... He was short, and squat, and bulky like a sumo wrestler. And jobless.

As to how we know all this, and much, much more—well, anyone who wants insight into the methodology of a solid job should study Kanigel's source-notes. His narrative is woven from many dozen sources, including much gleaned during five weeks in South India. ("I toured the house in which he grew up, participated in opening exercises at his alma mater, wandered through the grounds of the temple in Namakkal to which he came at a turning point in his life, and saw the room in which he died in Madras.") He even talked with Ramanujan's very aged widow.

And if India is a strange country, so is England; hence, much of the story's tension. So a 50-page minibiography of Hardy locates him in Britain's class and academic structure, where he's in some ways as much of an oddity as his Brahman protégé was in India.

Ramanujan indulged "in mystical disquisitions that few understood, and in mathematics that no one did." And Hardy? Blessed with gorgeous good looks, yet "to his own eyes so repulsively ugly" he couldn't bear a mirror, "Always, he kept the world at bay. The obsession with cricket, the bright conversation, the studied eccentricity, the fierce devotion to mathematics—all of these made for a beguiling public persona, but none encouraged real closeness."

Hardy was proud to claim that not a particle of his math—"real" math, and rigorous—was even remotely "useful." No, it was solely art. And after two eminent Cambridge mathematicians had brushed aside written appeals from Ramanujan, it was Godfrey Harold Hardy who said yes.

Which brings us to another strength of Kanigel's book, that he'll not omit equations from his pages, nor shirk the task of helping his reader understand why such things fired the passion of his two heroes. You'll not learn number theory from the book, but you'll learn, via specific instances, what it's about, and gather how it might consume someone's life. Contrast the strategy of bubbly popularizers like Pamela McCorduck, placing human color in the foreground, hiding technicalities under any handy rug. No, the technicalities were what these persons lived for; there's no evading that, short of settling for melodrama.

A quotable instance: "Proof is no mere icing on the cake. Take the sequence of integers 31, 331, 3331, 33331, 333331, 3333331. Each is a prime number. So is the next in the sequence. Have we hit upon some hidden pattern? No, the pattern self-destructs with the next in line," which is divisible by 17.

"A mathematician with an insufficiently ironclad proof is a little like the police lieutenant in the movies, convinced of the butler's guilt but brought up short by his boss's caution, *Yeah, but that won't convince a jury.*"

And Ramanujan in his notebooks "had proclaimed a thousand versions of *the butler did it.*" Most of the time he was right, and the butler *had* done it. But, so Littlewood remarked, "the clear-cut idea of what is meant by a proof. . .he perhaps did not possess at all." Luckily, Hardy's insistence on rigor "had sent him off almost singlehandedly to reform English mathematics." He had told Bertrand Russell how happy a real proof made him: "If I could prove by logic that you would die in five minutes, I should be sorry you were going to die, but my sorrow would be very much mitigated by pleasure in the proof." So, "Ramanujan, Intuition Incarnate, had run smack into Hardy, the Apostle of Proof."

And, "In what, in some ways, was his greatest achievement, Hardy brought Ramanujan mathematically up to speed without muzzling his creativity or damping the fires of his enthusiasm. It would have been easy to sniff at his shortcomings and dutifully correct them, like a bad editor who crudely blue-pencils his way through a delicate manuscript. But he knew that Ramanujan's insight was rarer by far than even the most formidable technical mastery."

For math is not a deductive art. It *checks* its intuitions by deduction. But you need the intuition. You need a theorem to prove in the first place. Some of Ramanujan's are still being worked on.

His miserable last years are tactfully handled; the epilogue is wise in locating on the map of learning the importance of what we've read. And everywhere, the story C. P. Snow outlined is enhanced by countless new details. For instance, take the "1729" anecdote. In what two different ways can we express that as the sum of two cubes? Snow omits to tell us; Kanigel doesn't. Try 12^3 and 1^3, or else 10^3 and 9^3. A proof that 1729 is the smallest such number may be left (Hardy would have said) as an exercise. ■

Hugh Kenner is a professor of English at Johns Hopkins University. He writes for publications ranging from the New York Times *to* Art & Antiques. *His recent books include* Mazes *and* Historical Fictions. *He can be contacted on BIX as "hkenner."*

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

STOP BIT

JOSEPH J. LAZZARO

WINDOWS OF VULNERABILITY

Over the past five years, the disabled have enjoyed a new electronic independence in the form of the personal computer. We achieved an electronic bill of rights (see "Opening Doors for the Disabled" in the August 1990 BYTE). As a person who is legally blind, I believe that some of this newly obtained and hard-won freedom is in danger of being revoked in the name of the graphical user interface (GUI). To retain this freedom, we need to take some bold steps toward adaptation.

Thousands of blind, deaf, and physically handicapped people now benefit from many forms of adaptive technology, including speech synthesis, large-print processing, braille desktop publishing, TDD modems, voice recognition, and custom switches. The sad fact, however, is that almost none of this exotic hardware and software is GUI-compatible.

Will the graphical user interface deny the blind and learning-disabled access to computers?

According to the World Institute on Disability in Oakland, California, there are over 1.7 million blind or severely visually impaired Americans. Unfortunately, the talking hardware and software products used by the blind to access computers work in a text-only mode and are mute if you use graphics.

The implementation of GUIs and GUI-related applications may actually benefit some groups (e.g., the motor-disabled, who do not usually thrive in a keyboard-intensive environment). However, GUIs may effectively lock the blind out of future personal computing, because currently there is no method to add voice synthesis to graphics.

Speech-synthesis systems allow the blind user full access to every byte on the screen, but they are powerless to describe icons, images, and complex graphics. If the GUI becomes the accepted standard for all computer software, the blind will be confined to using only specially written talking programs, and they will gradually pursue a path away from the mainstream. And they may not be on this road alone.

Hundreds of thousands of learning-disabled people also find graphics confusing, and a picture does not mean the same thing to everybody. Does that cylinder at the bottom of your screen mean a "trash can" or a "coffee cup"? This question may sound ridiculously simplistic, but it is a valid issue for those with learning disabilities. Even if the user is not learning-disabled, every person does not interpret pictures in the same way, and adding speech to GUIs could help learning-disabled users solve this problem.

The use of a mouse for GUI systems also may present a potential stumbling block to those with dyslexia, because dyslexics often have a difficult time with eye-hand coordination. Therefore, does the adoption of GUI systems mean the end of personal computing for the learning-disabled as well?

Just as Scrooge was given a second chance, this state of affairs does not have to spell disaster, and there are many ways to avoid this potentially gloomy future. If we take the time to adapt the GUI for the disabled, the future is undoubtedly one we can all look forward to. It is essential that hardware and software companies do such adaptation, especially if they want to market their products to the federal government. Section 508 of the Federal Rehabilitation Act states that no vendor can market to the government unless its equipment is fully accessible to the disabled community.

It won't take a great deal of effort to implement this all-important adaptation process. For example, the mouse was a lonely creature until it became an accepted standard among software developers. All it took was the writing of some device drivers and the generation of extra code in the application to make the rodent come to life. A speech synthesizer is just another device that, with major vendor support, would rapidly become an industry mainstay.

You can configure a speech synthesizer to emulate a parallel or serial port. For these devices to become widely accepted, software developers need only write code to support them. Programmers could write software with built-in voice labels for icons. The disabled could then enjoy the power and flexibility that voice-accessible GUIs have to offer. This type of environment for the disabled would forever slam this potential window of vulnerability. ■

Joseph J. Lazzaro is the cofounder of Talking Computer Systems in Watertown, Massachusetts. He is currently project director for the adaptive-technology program at the Massachusetts Commission for the Blind in Boston. You can reach him on BIX as "lazzaro."

Stop Bit is a forum for informed opinion on personal computing topics. The opinions expressed are those of the author and not necessarily those of BYTE. Your contributions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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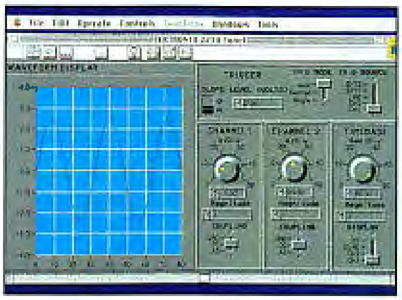

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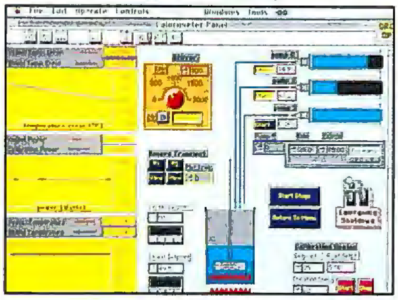

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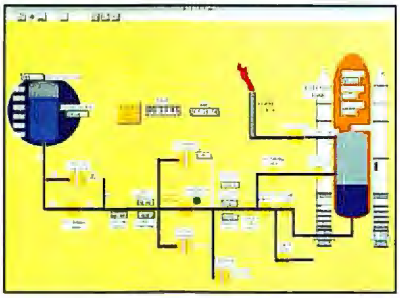

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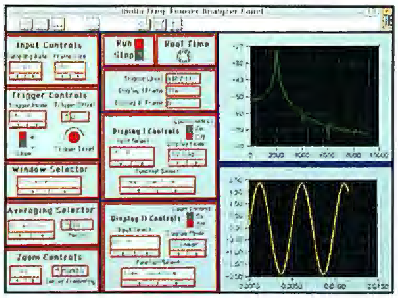

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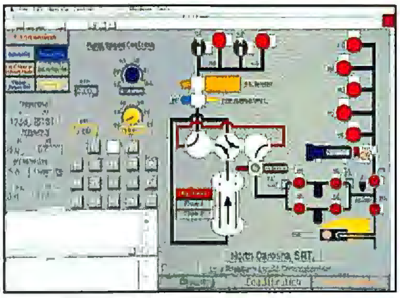

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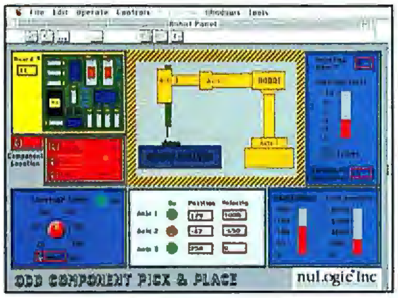

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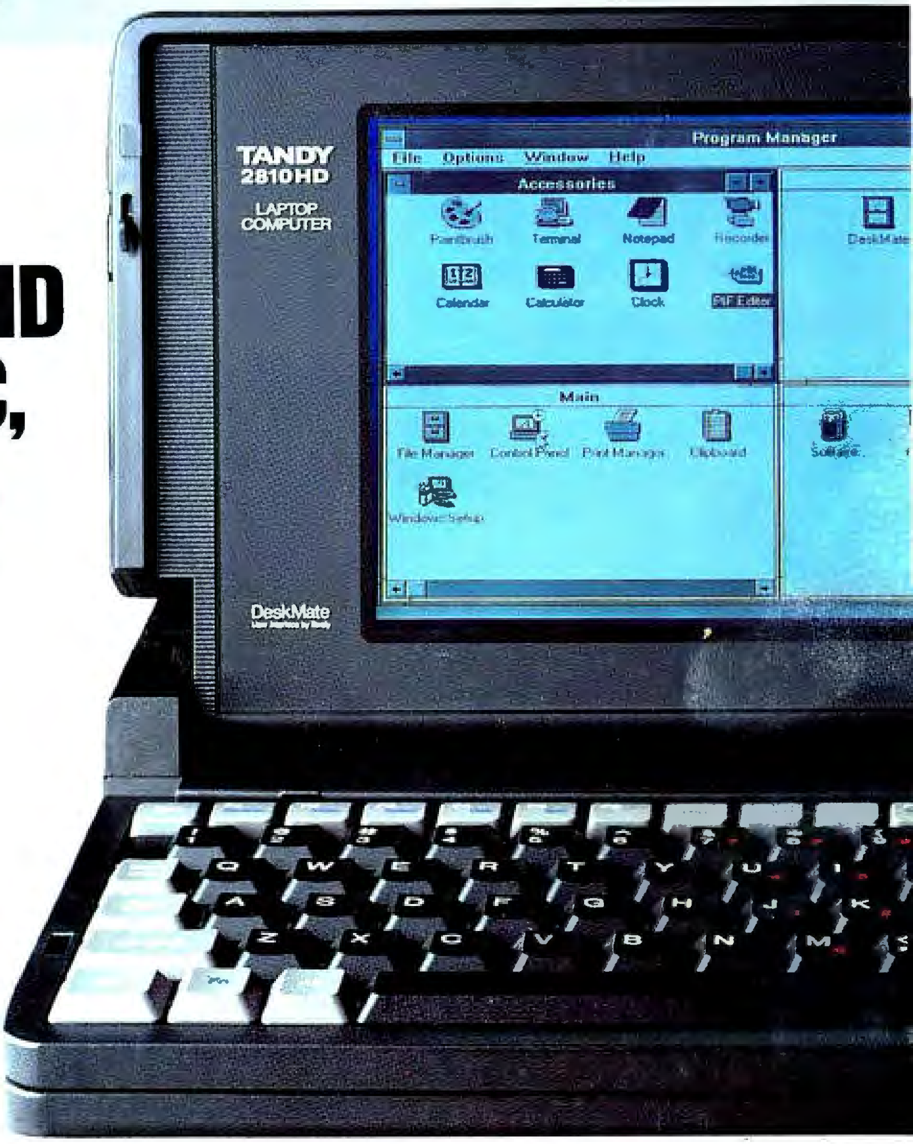

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