BYTE

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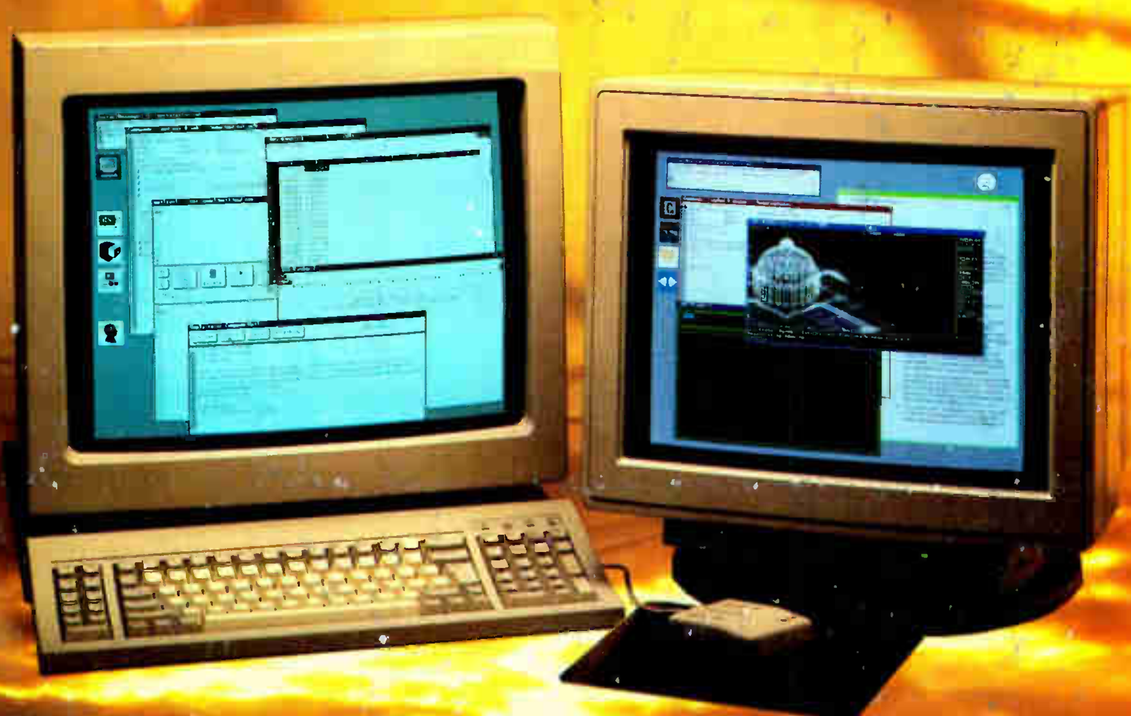

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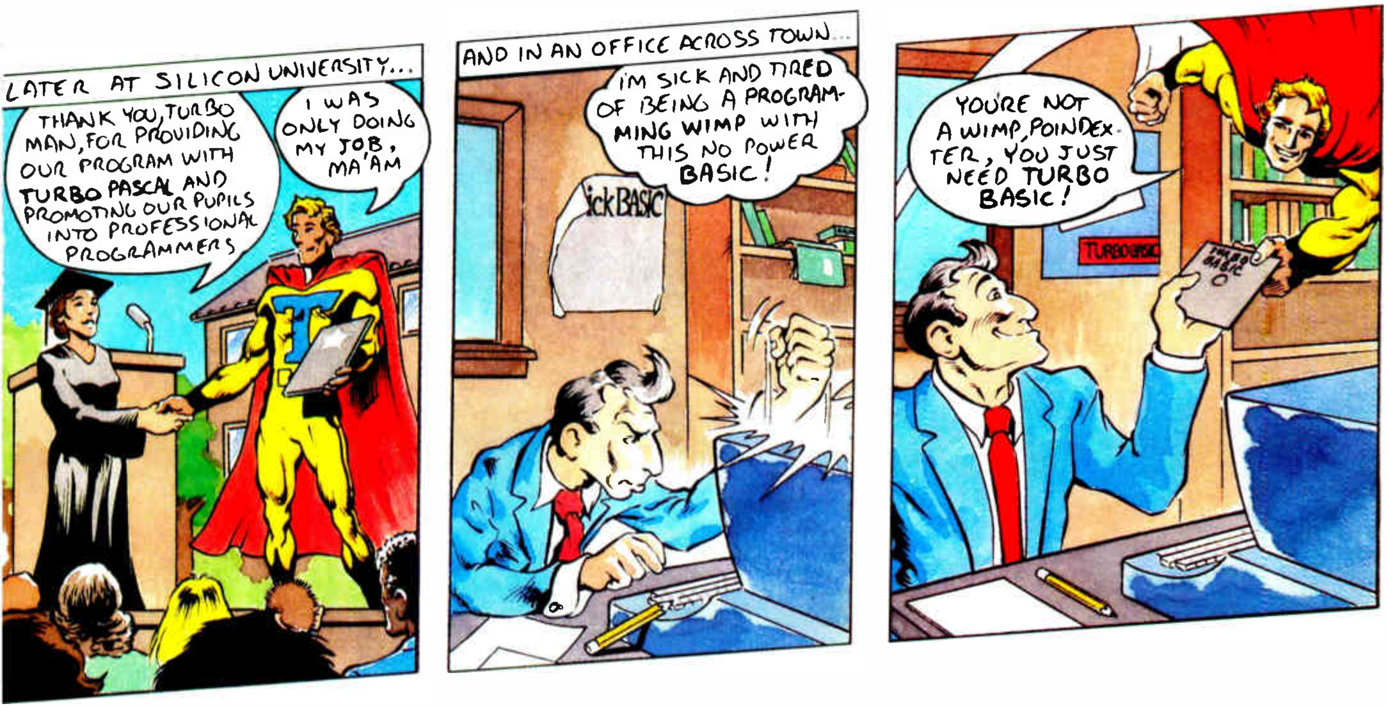

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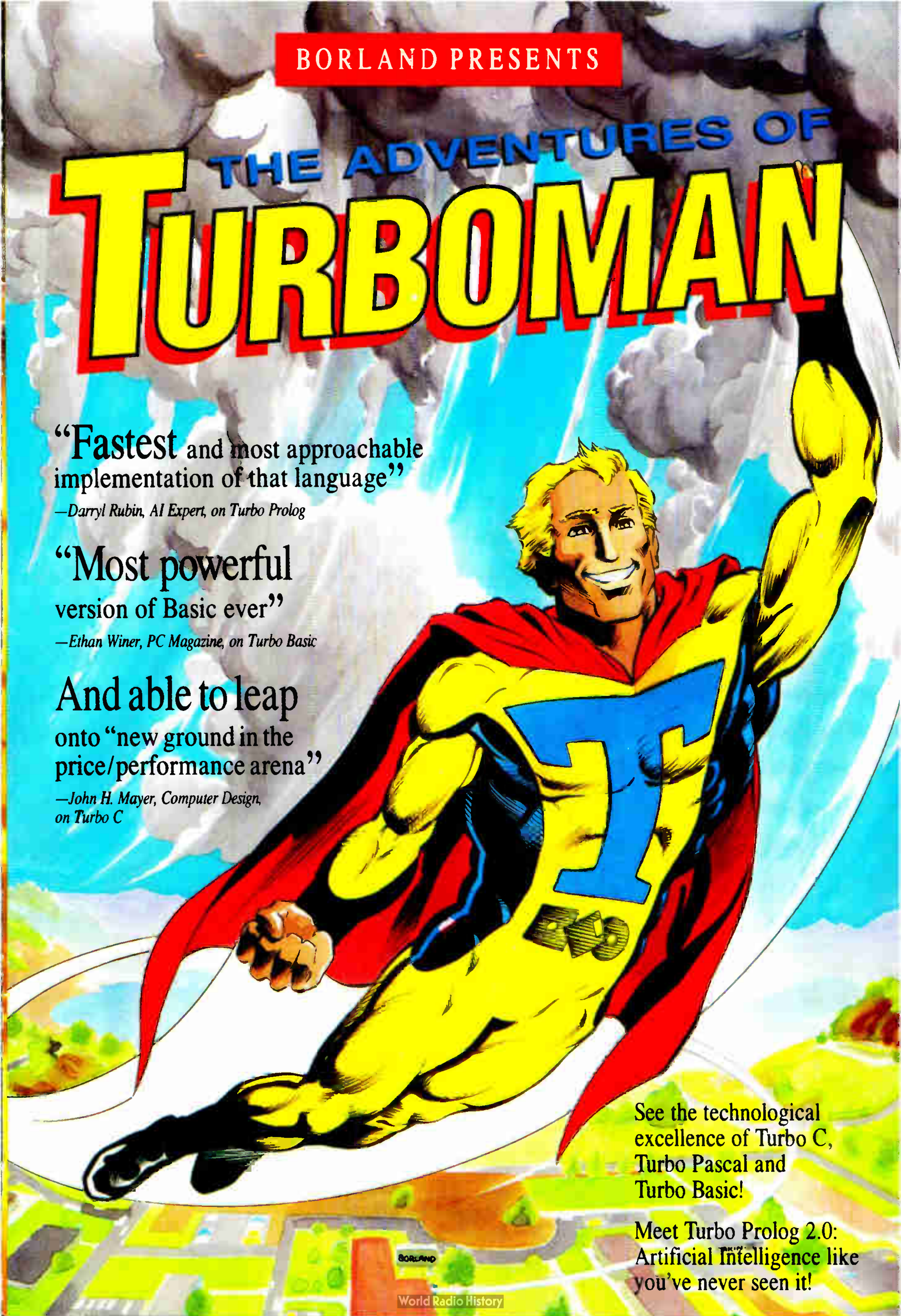
	Turbo Basic 1.1	QuickBASIC 4.0 Compiler	QuickBASIC 4.0 Interpreter
Compile & Link to stand-alone EXE	*3 sec.*	7 sec.	——
Size of .EXE	*28387*	25980	——
Execution time w/80287	*0.16 sec.*	16.5 sec.	21.5 sec.
Execution time w/o 80287	*0.16 sec.*	286.3 sec.	292.3 sec.

The Elkins Optimization Benchmark program from March 1988 issue of Computer Language was used. The Program was run on an IBM PS/2 Model 60 with 80287. The benchmark tests compiler's ability to optimize loop-invariant code, unused code, expression and conditional evaluation.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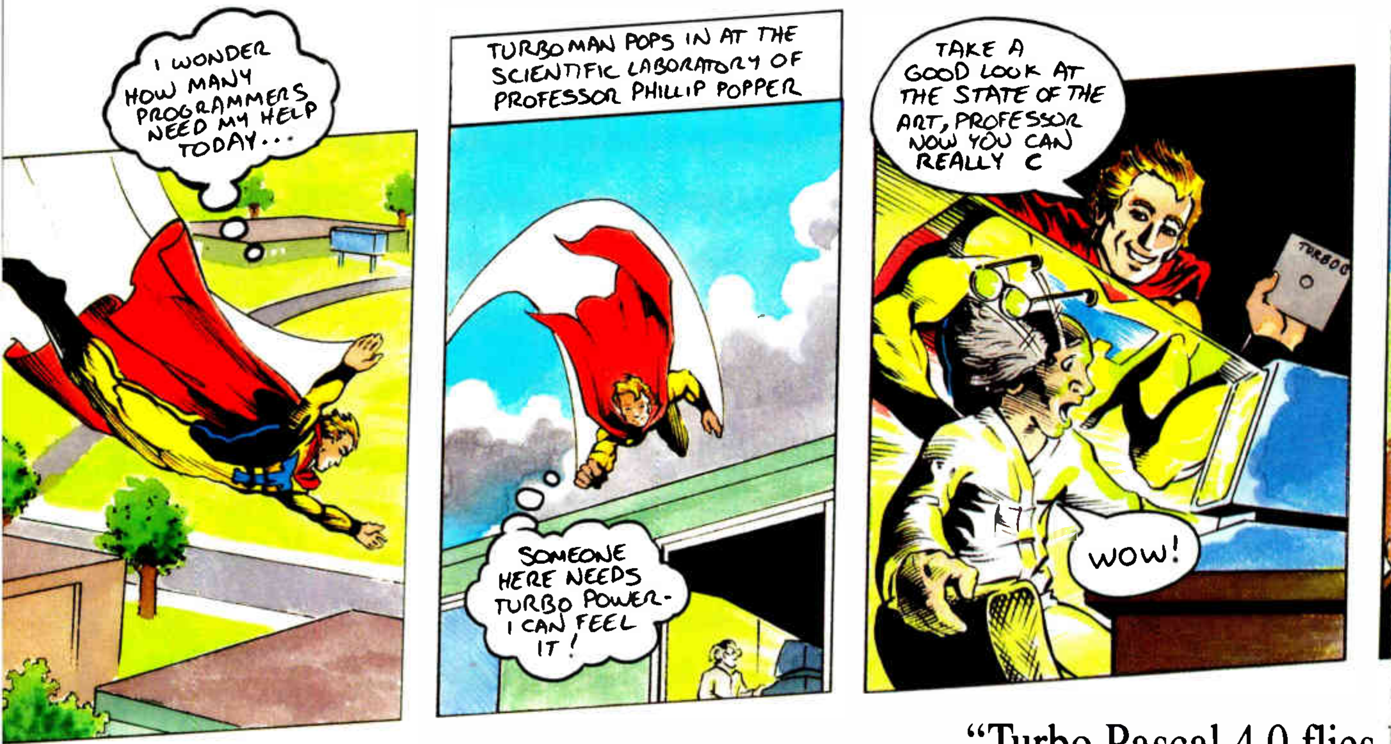

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Heap Sort

	Turbo C 1.5	Microsoft C 5.0
Compile time	4.7 sec.	16.3 sec.
Compile & link time	7.4 sec.	19.5 sec.
Execute time	10.5 sec.	15.5 sec.
Object code size	1119	1313
Execution size	6392	7891

Sort benchmark run on an 8 MHz IBM AT using Turbo C version 1.5 and the Turbo Linker version 1.1; Microsoft C version 5.0 and the MS overlay linker version 3.61.

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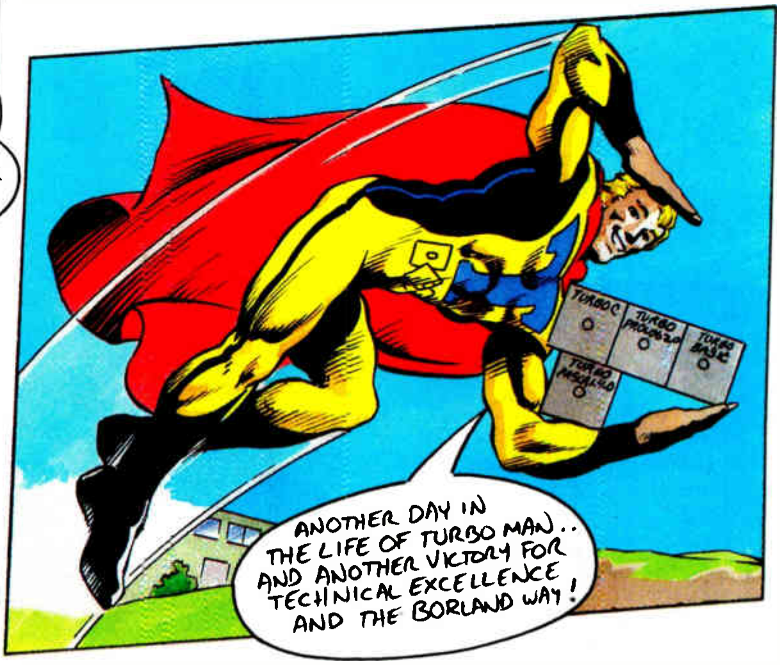

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JULY 1988 VOLUME 13 NUMBER 7

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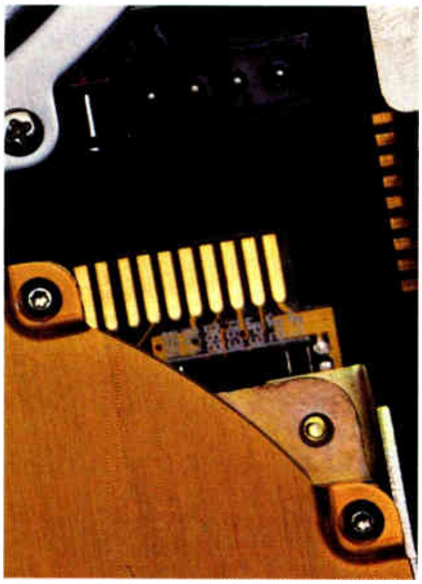

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DRIBBLEWARE

BYTE polls COMDEX attendees on which operating systems will become dominant

While we were at the Spring COMDEX in Atlanta, we asked attendees, "Which operating system will be dominant 5 years from now?" The answer we received was surprising—so surprising, in fact, that newspapers all over the country picked up the story. (You may have seen a brief summary in your local newspaper.) Here's the full story.

The poll was carefully worded to avoid stacking the deck one way or the other. For example, the ballot specifically named several prominent operating systems: the Macintosh's, DOS, OS/2, and two different flavors of Unix (traditional command-line Unixes and the new graphical-interface Unixes like "Open Look"). We also included an "other" category, so that respondents could name a less popular operating system.

We collected over 5000 ballots: OS/2 and DOS each garnered about 1600 votes, the Unixes captured roughly 1300, the Mac got a little over 200, and "other" racked up some 500 votes.

In plain terms, there was no winner. In a random poll such as this, variations of a few hundred votes are meaningless: It's fair to say that DOS, OS/2, and the Unixes finished in a dead heat.

The Mac's poor showing is not significant. Apple didn't exhibit at COMDEX, so I take the Mac's low numbers in the poll to be more indicative of Apple's absence rather than low confidence in the Mac as a viable machine. A poll at a MacWorld Expo would undoubtedly show MultiFinder and A/UX ranking among the contenders.

No Aberration

The poll results were borne out on the show floor, where there was no flood of OS/2 software (a COMDEX joke referred to the few true OS/2 programs as "dribbleware"). All the major software companies are working on OS/2 products, but much of the software being shown was very, very far from finished.

The general feeling at COMDEX was that OS/2 is indeed coming, but that it is likely to be *one of* the dominant operating systems rather than *the* dominant system. Why?

One answer lies in the large number of generally satisfactory alternatives to OS/2. For example, when I asked software developers what they were looking for in OS/2, the almost unanimous answer was "access to big memory," with multitasking a distant second, and Presentation Manager's graphical prowess an even more distant third.

Of course, Unix already offers multitasking and access to major-league memory. Such programs as Phar Lap's 386/DOS-Extender—and even the somewhat clunky Lotus/Intel/Microsoft 4.0 standard—also give you access to large memory; other alternatives like PC-MOS/386, VM/386, and Concurrent DOS 386 (the latter two are reviewed in this issue) let you multitask your current DOS programs. Also, programs like Windows give you a serviceable graphical interface without having to wait for Presentation Manager.

In some cases, you don't even need a DOS alternative, shell, or extender for extraordinary flexibility. As I write this, I'm also simultaneously downloading my morning BIX mail and messages while printing out my daily schedule. Simple multitasking like this is no big deal. All it takes is my word processor, a background telecommunications program, a print spooler, and plain old DOS 3.1.

Even at this point, you probably already can see why there's no clear winner in the operating-system wars. But it gets even more muddled.

For example, there's the next upgrade of DOS waiting in the wings. It probably will overcome some of the fundamental limitations of the current DOS (like the 32-megabyte cap on hard disk size)—but the new DOS's file structure probably will be incompatible not only with current DOS, but with OS/2 as well.

It's a safe bet that Microsoft will also offer an 80386-specific version of OS/2—one not hampered by the 80286's internal limitations (like the inelegant and time-consuming "soft reboot" it uses to switch from protected to real mode).

Who's on First?

All this is confusing for end users and a nightmare for software developers. Instead of one or two or even three major standards, we're facing a future with up to a dozen viable ways to boot and run an Intel-family machine, plus at least three different ways to boot and run a Mac. And that's not even looking at the many excellent smaller operating systems.

That's why our poll shows no clear winners. For better or worse, you and I are going to have to cope with and sort out more choices, more options, and more incompatibilities than ever before.

Of course, a multiplicity of standards increases the need for objective information on competing standards, and that's BYTE's specialty. You can count on our broad, non-machine-specific coverage to help you sort through this morass of choices and to help you match the right hardware and software to the job at hand, regardless of brand.

For your copy of our COMDEX report, or for reports of PC Expo or the upcoming MacWorld, please send $3 to: Show Report, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Be sure to specify which show report you want and to include a return address.

—Fred Langa
Editor in Chief
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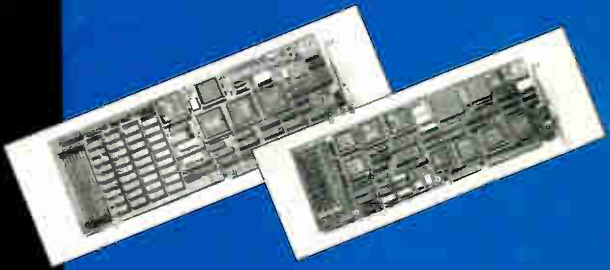

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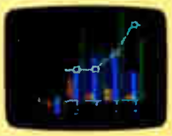

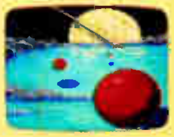

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Circle 251 on Reader Service Card

Staff-written highlights of developments in technology and the microcomputer industry

Look Out, SQL: Here Come Object-Oriented Databases

Although we've been told that the database interface of the future will be based on the Structured Query Language, some experts predict that the relational database model and SQL will be severely challenged within the next 5 years by object-oriented databases. According to professor L.A. Rowe of the University of California at Berkeley, the relational database model is fine for traditional business applications but inadequate for databases used for CAD, scientific, and engineering applications. Relational databases are suitable for applications requiring a small number of data types and a fairly simple set of relations. But they are not well suited for databases involving new data types, such as graphics and other complex objects, and many relations with small numbers of rows, Rowe says.

Rowe and a team of graduate students are working on a different type of database, which they call "Post-Ingres," that lets users add new data types and customize indexing methods depending on the application. The database will also have forward- and backward-chaining rules for expert-system applications.

Post-Ingres can store "objects," such as a graphics image or a forms specification, as a record in the database, based on an "object ID number." Objects can be shared by multiple databases. The approach Rowe and his cohorts are developing will make it possible to compile frequently used queries and also store them by ID number in the database. Thus, an application program could execute "query #47," which could be a compiled binary record in the database, for example. This would greatly improve performance of complex queries.

Post-Ingres will also give users access to historical data stored on optical disks, researchers say. In fact, the system will support a three-level hierarchy of storage—hard disks, tapes, and optical disks—allowing transparent data access on all three types of media. This capability would be extremely useful for accessing historical data, such as archived medical or legal records.

"Next-generation" database systems will appear within 3 to 5 years and will be developed using object-oriented programming and window interfaces on graphics workstations, Rowe predicts. Alphanumeric terminals eventually will be replaced by graphics workstations for most database applications, he added.

continued

Flat-Panel VGA Displays Due Next Year in Portables

By 1989 we'll be seeing portable computers sporting flat-panel VGA displays. One major manufacturer of thin-film electroluminescent displays, Planar Systems (Beaverton, OR), now sells a 640- by 400-pixel electroluminescent screen and plans to introduce a 640- by 480-pixel by 16-gray-scale VGA display in 1989.

Planar's Rolland Von Stroh said the company is working with both domestic and Far East computer manufacturers on a number of new projects involving flat-panel displays. Such screens are not limited to portable applications; some manufacturers plan to use 19-inch flat-panel displays in their engineering workstations.

The next major development in the flat-panel field will be color displays, said Von Stroh. Planar will introduce full-color flat-panel displays in military applications, such as airplane cockpits, in early 1990, and the first industrial applications of full-color flat-panel displays will follow later that year, he said.

Von Stroh predicted that flat-panel displays will eventually capture a large share of the CRT market. By 1995 they could have 50 percent of the current CRT market, he said. Flat-panel displays have some advantages over CRTs. They are, of course, much more compact, have much less glare because of their flat surface, consume much less power (14 watts versus 50 to 100 watts), and are more reliable (according to Von Stroh, 45,000 hours mean time between failure versus 10,000 hours for CRTs). They cost 3 to 5 times as much to make as CRTs. However, Von Stroh claimed that thin-film electroluminescent displays are already displacing backlit LCDs and gas-plasma displays because of things like better contrast and greater range of viewing angle.

Nanobytes

• Despite being recognized as technologically impressive personal computers, **Atari's ST and Commodore's Amiga** haven't had the kind of market success enjoyed by machines from IBM et al. and Apple. So what's the problem? Part of the problem is that "computers are not powerful enough to be used at home for anything productive," says Neil Harris, director of product marketing at Atari. "I think the ST and the Amiga are in the right direction, but we're still not there yet." Harris also blames the industry press for not covering the Atari machines enough. "The computer press is too busy analyzing its readership," he says. He also cites less malevolent forces, such as the RAM shortage. As for Atari's success in Europe, as opposed to the U.S.: "MS-DOS wasn't entrenched overseas, and there's much less disposable income there, so when a lower-cost alternative was introduced, it was embraced" by the Europeans.

• Researchers at the **National Bureau of Standards** (NBS) are working on tools for measuring the performance and efficiency of multiprocessors. The tools differ from software measurement systems in that they don't affect the program that's being measured. The researchers at the NBS Institute for

continued

NANOBYTES

Computer Sciences and Technology hope to examine such factors as information flow and processing loads.

- Marlboro Man goes optical: **Optical data processing** is making its way into the commercial world. **Carnegie-Mellon University** and **Philip Morris** Corp. have built a device for inspecting cigarette packs. The system uses pattern-recognition techniques and is considerably faster than digital systems, a CMU spokesperson said.
- "There is **too much piracy** of intellectual property, including computer software," U.S. trade representative **Clayton Yeutter** told the International Computers and Communications Conference in Washington, D.C., recently. There are standards for patents, trademarks, and copyrights, but no enforcement teeth to make these rules effective, Yeutter said. "I want some clarification and effective delineation of fundamental principles to protect intellectual property rights," he said, and he threatened that the U.S. will take an aggressive approach with other governments in order to achieve enforceable agreements.
- Are you budding? Have you written some software but can't find a publisher? A company called WCE Publishing (Surrey, BC, Canada) says it's looking for "budding **software writers** with publishable software" that could sell for between $50 and $100. The company thinks "the days of the megabuck software product" are over. You can

continued

New Chip Could Mean Lower-Priced 80386 Machines

In an effort to minimize software compatibility problems across its line of processors, Intel (Santa Clara, CA) has developed a new version of its 80386. The new chip is aimed at "midrange personal computers," which don't require the high performance offered by the current versions of the 80386 with the 32-bit data bus. The new 386SX runs at 16 MHz and uses a 16-bit data bus and 24-bit address bus, similar to the 80286. However, the 386SX is supposed to be able to run all 80386 software, although at lower performance levels than its full 32-bit brother. Intel rates the performance of the 80386 at 4 to 6 VAX million instructions per second (depending on if the clock speed is 16, 20, or 24 MHz) and the 386SX at 3 MIPS. Intel is planning to release a similar version of the 80387 numeric coprocessor; the 387SX is fully compatible with the 80387.

The 386SX has the potential to make 80386 software accessible on more affordable machines. With the advent of powerful programs such as Windows/386, which runs exclusively on the 80386, the chip has become attractive to a wide range of users. However, current 80386 machines are too expensive for many individuals. The 386SX could be the ticket to 80386-based software for those users.

With the introduction of the 386SX, Intel will discontinue production of the 16-MHz 80386. The chip maker will focus on high performance with the 80386 and on lower-cost computers with the 386SX, said product manager Bruce Schechter. The 80386 will continue to be aimed at high-end personal computers, while the 386SX will become the main processor for midrange machines like today's AT class or PS/2 Models 50 and 60. Meanwhile, the "80286 will move downstream to the lower end of the market," said Schechter. Intel expects the 80286 to become the entry-level processor in its product line; the 8088/8086 processors will gradually disappear, Schechter said.

Intel emphasized that the 386SX is not pin-compatible with the 80286. In fact, the 386SX is considerably smaller than its predecessors. With the less complex circuitry required in building a 16-bit bus, the 386SX could be ideal for portable computers and add-in boards.

Several manufacturers already have production units; although Intel won't name names, the most likely candidate is IBM, which plans to introduce 80386-based versions of the Model 50 and Model 60 next year. The chip will be shipped in volume in the fourth quarter. Initially, the 386SX will cost $212 in quantities of 100 (the 80386 is $299). But Schechter said that price differential between the 80386 and the 386SX will increase with volume production.

Will Neural Nets Put Patton in a Box?

Depending on the results of the first part of a multiphase contract awarded by the U.S. Department of Defense (DoD), the next generation of battlefield commanders could have pearl-handled Tempest-rated cases around their silicon brains—sort of a cloned Patton on casters. Computer experts don't agree on the potential of neural networks, but the DoD is investing heavily in the new technology and has just awarded a contract to Hecht-Neilsen Neurocomputers (San Diego, CA), one of the first companies to develop commercial neural network products. So far, nearly all the research funding for neural network projects is DoD-related.

The Electronics Technology and Devices Laboratory of the U.S. Army Laboratory Command awarded Hecht-Nielsen this contract to "identify Army battlefield problems and develop a design for a battlefield neurocomputer to satisfy the processing requirement." Jacqueline Townsend, a spokesperson for Hecht-Nielsen, said this first $50,000 phase is for "proof of concept." Assuming that the concept is accepted by the Army, phase two might begin to define the actual system, which, she said, "we probably won't be able to talk about."

Asked if a battlefield computer might consist of one of Hecht-Nielsen's Anza neural network plug-in boards for an IBM PC AT in a Tempest box, Townsend replied that it is too early to say what, if any, future configurations might be.

While the idea of a swaggering robotic commander is a bit farfetched, the inherent capabilities of neural networks, such as learning, pattern recognition, and associative memory, would lend themselves to defense applications. Performing dangerous and repetitive tasks, radar, sonar, image processing, data manipulation, delivery of defense systems with "humanlike discrimination" capabilities, "opposing force modeling (wargaming), and weapons aiming and steering" are some of the areas where neural networks might be used, according to Hecht-Nielsen.

continued

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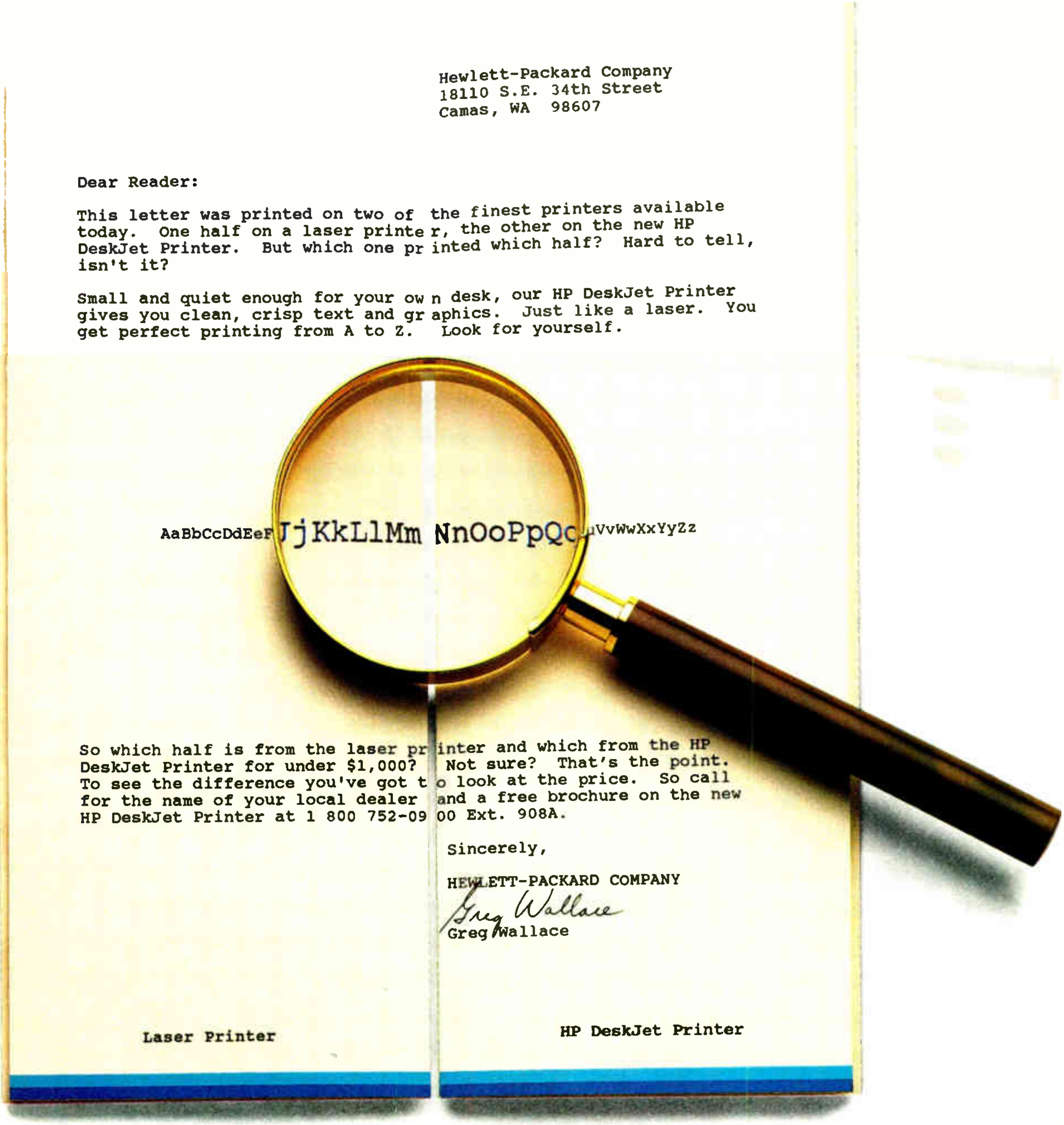

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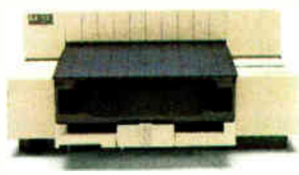

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• IBM hopes to push the "standardization" of its **Micro Channel architecture** by licensing its patents to companies that want to build PS/2-like computers, says **Gordon Campbell**, chief executive of Chips & Technologies (San Jose, CA). "IBM said it will license the patent portfolio. That's very different from licensing the technology. We in the industry have missed what IBM has been saying all along; we've heard only what we wanted to hear." Campbell said that by licensing the IBM patent portfolio, "a company is free to build Micro Channel products, but they have to do all the work." IBM said that licensees will have to pay "a maximum of 1 percent of sales revenue" on a product that uses an IBM patent; the maximum is 5 percent, depending on the number of patents involved.

• Some of the **well-to-do are computing**. Thirty-eight percent of "affluent households" in the U.S. have personal computers, says a study by International Research Associates (Mamaroneck, NY). And what's the machine of choice among the upper crust? This study says 13 percent of the respondents have an IBM PC, 10 percent have Apples, and 7 percent have Commodores.

• **Versacad** (Huntington Beach, CA) has come out with three **HyperCard stacks** for users of its VersaCAD/Macintosh Edition. The hyperware—Bill of Materials, Door & Window Scheduling,

continued

Compromise Brings Hope of High-Speed Modem Standard

There's no standard yet—but it's coming. That's the word from two U.S. companies spearheading the work for a standard modem system that will work faster than 9600 bits per second over regular dial-up phone lines. USRobotics (Skokie, IL) and Telebit (Mountain View, CA) have reached a compromise and asked CCITT, the European standards agency, to give them more time to develop a complete standard.

USRobotics (USR) is proposing a system with one high-speed channel, similar to current lower-speed modems. According to Dale Walsh, USR's vice president of engineering, the main channel would send data at a top speed of 14,400 bps, while a 450-bps back channel would perform error correction and other protocol functions. USR's proposal is supported by Rockwell, Racal-Vadic, and Paradyne.

Telebit's proposed system uses more than 500 channels, each operating at relatively low speed. According to Ted Brown, manager of systems engineering at Telebit, the system normally sends data at up to 18,000 bps, though lab results show speeds of up to 28,000 bps.

Under the compromise, the USR single-channel system would be mandatory, with Telebit's multichannel system as an option, and a system for selecting between the two. Walsh said USR was pleased that work toward a standard would continue. "We've made significant progress, and this way we can work as a team to make more progress," he said. Dwight Decker, Telebit's director of modem engineering, agreed: "The critical thing is that the compromise means there really will be a standard."

Decker said the compromise was supported by eight modem manufacturers and the national standards agencies of Germany, France, Spain, Sweden, and Switzerland. Both he and Walsh said a draft standard should be ready for examination by the full study group early in the next CCITT plenary session, perhaps as soon as next February.

USR favors a traditional approach, using a single main channel running at up to 14,400 bps. Telebit wants multiple channels running up to 28,000 bps. USR's Walsh said that a multichannel system can't really run that fast. "To achieve the high speeds claimed [by Telebit], they're operating beyond the available bandwidth on a voice line," he said. "As soon as they get interference on a real phone line, it falls back to slower speeds."

Telebit's Ted Brown countered that the slower speeds are still faster than a single-channel system—up to 18,000 bps. In addition, multichannel modems can drop back by as little as 100 bps at a time; traditional modems, on the other hand, must drop by 2400 bps at a time, he said.

Video Could Be the Key to Good Color Printers

Forget that serial or parallel port connection for your printer. To get the state of the art in color printer technology, you may soon be hooking up your computer's video output directly to the printer.

Sony has developed a thermal-transfer color printer that, while designed primarily for broadcasters who want still photos from videos, offers a tantalizing glimpse of where color printer technology is going.

The UP-5000 does have an RS-232C port, but it's used for picture editing and control, not for carrying the actual print data. The printer accepts a wide variety of video inputs, including standard National Television System Committee (NTSC) video and analog RGB, and other standards like differential R-Y, B-Y and S-video. The interface digitizes 8 bits of video and can print 256 variations of each of the three primary colors (magenta, yellow, and cyan). That amounts to something like 10 million possible colors per pixel.

The printer captures images in an internal buffer and stores up to two frames. You can view the image on a color monitor and adjust the color and tones under computer control. A full-size print from the UP-5000 is 6 by 4½ inches, and the unit will also do overhead transparencies. It takes 67 seconds for it to do its work on each print using special color thermal paper, and you can print multiple copies from the frame buffer.

Print quality is stunning—virtually indistinguishable from a commercial color print, not at all like the muted colors from most of today's color computer printers. As you might expect, though, it's not cheap. The UP-5000, which will be shipped in July, has a retail price of $7000. But a Sony spokesperson said he expects the cost of the technology will fall dramatically in the next couple of years, bringing this type of color printer within the price range of individuals and small companies.

continued

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and CAD Text Processor—is packaged with version 1.1 of VersaCAD for the Mac.

- It seemed an unlikely fit when **Autodesk** (Los Gatos, CA) bought into Ted Nelson's **Xanadu**. But the maker of AutoCAD sees the possibility of using hypertext as a means of managing and sharing CAD drawings generated by AutoCAD. John Forbes, project manager for AutoCAD, said he envisions a distributed drawing management system in which users can connect architectural and engineering drawings to text comments. (For example, a user could point to a location on the drawing and

continued

No More Golden Vaporware: Xanadu Products Next Year, Nelson Says

The first products based on the Xanadu hypertext concept will ship sometime next year, say Ted Nelson and his Xanadu team. Nelson said the time has come to "get this mother out of the closet and onto peoples' desks and into their minds. We're a member of the Golden Vaporware Club, along with Alan Kay's Dynabook."

The Xanadu Hypertext System, said Nelson, would create "a new unification of applications. We're going to create a uniform data structure that developers of all types of applications can use." A preliminary system will be delivered to developers late this year, according to Xanadu's Roger Gregory. "We're looking at Suns, Macintoshes, and IBM PCs as platforms," he said.

"We have something that's real," Gregory said. "You can see that it's real because it crashes."

Big Changes to the Chip Not Likely, Inventor Kilby Says

Nearly 30 years after he invented the computer chip, Jack St. Clair Kilby says improvements in the memory, performance, and cost of his invention are getting harder to come by. "Nothing goes on forever," he told the new Austin, Texas, chapter of the American Electronics Association recently. "There may not be another 5 orders of magnitude of improvements to be made. Certainly not with the techniques we now use," he said.

The industry needs to focus on improving chip packaging, according to Kilby.

Kilby said he's not pessimistic about the future of the IC, which he invented in 1958. He said he's simply mindful that "30 years is an incredibly long time in the history of electronics for the domination of a single device."

continued

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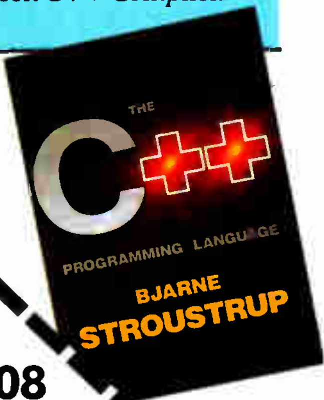

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retrieve a related description or report on the design characteristics of that piece of the drawing.) "We see hypertext as a means to manage information in a more intelligent way," said Chris Record, Autodesk vice president of business development and now president of Xanadu.

• The Association of Personal Computer Consultants has formed with the intent of "certifying true professionals" in the field. The group plans to issue credentials and a statement of ethics "to acceptable professionals." If you think you might be acceptable, write to the APCC at P.O. Box 14430, Philadelphia, PA 19115.

Apple Wants Developers to Push Mac into 32-bit World

Apple Computer (Cupertino, CA) and outside developers are working to move the Macintosh into the world of 32-bit computing. And since most current Mac programs operate primarily in the 16-bit realm, this direction is the one that has the most implicit fallout for developers. Some third parties have widened their programs for 24-bit-deep color monitors and cards, but those are the exceptions.

Apple is encouraging developers to think in 32-bit terms. For its part, the computer maker has suggested revising the system software to accompany the use of a 68030 processor in its machines (Apple officials have hinted at a Mac SE with an 030 in it). Some people at Apple's Spring Developers' Conference said Apple is considering a "fat slot" (one that addresses more than 24 bits in the slot) and "fat pixels" (up to 32 bits deep).

The move to 32 bits falls in neatly with the closer ties between Apple and DEC; if Apple software runs at the 32-bit level, DEC compatibility is easier. It will mean a total rewrite of Apple printer drivers, for example, to achieve this. It's not clear what that would mean for a company that has existing special drivers to convert QuickDraw into direct printer output, but a complete rewrite of these kinds of drivers is implied by any change in QuickDraw. "Apple is asking a lot in moving to 32 bits. I think they realize they are going to need better error-catching tools if applications are going to get written in a decent time frame," said one developer.

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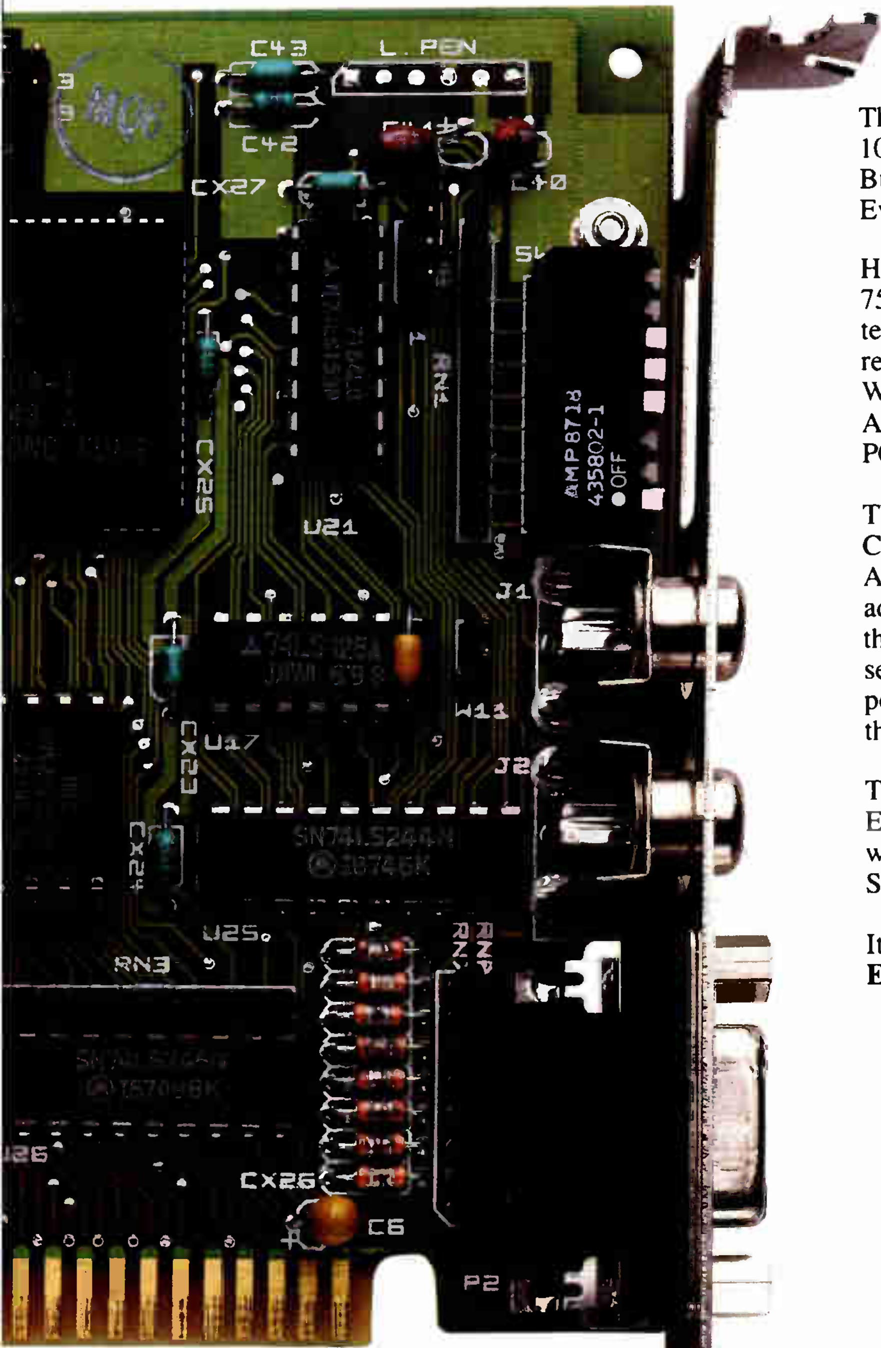

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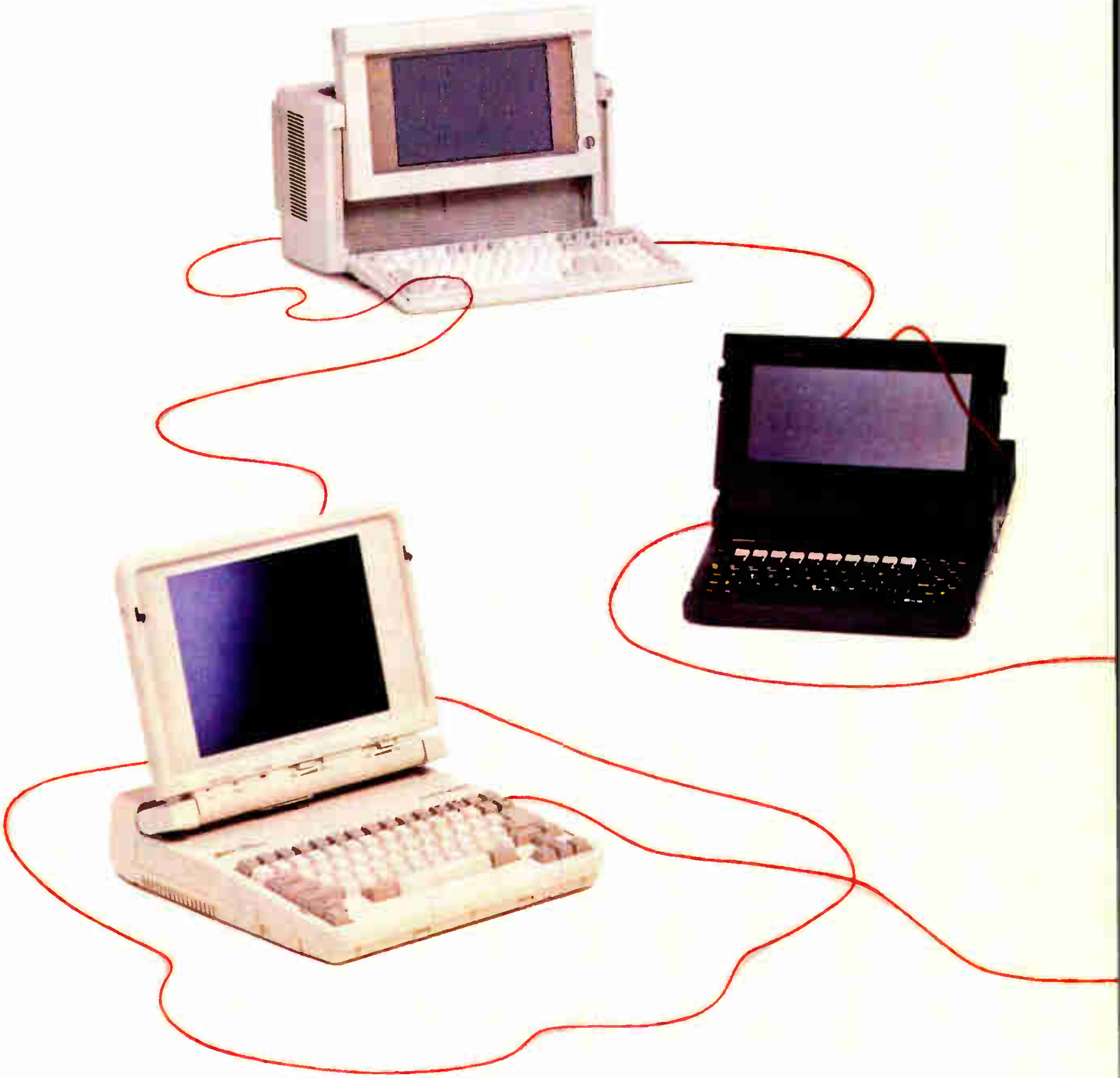

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```
    {should have put n > 1 here}
    Hanoi(n-1,a,c,b) &
    Inform(a,b) &
     {Lane called
      Hanoi(1,a,b,c) here}
    Hanoi(n-1,c,b,a)
```

I've modified both programs slightly here so they can be directly compared without affecting their substance. Now Trilogy executes 10 and 11 rings but overflows on 12. Turbo Prolog doesn't overflow.

Unfortunately, Lane did not realize that the programs were not equivalent. Note the cut operator (!) in the Turbo Prolog version. Whenever the recursion comes down to 1 (and it comes there 2048 times for 12 rings), the cut removes the so-called choice point from the stack. Lane's Trilogy program leaves all the choice points on the stack. In other words, Lane has explicitly commanded Trilogy to overflow. If he wanted an equivalent comparison, he should have removed the cut (!) from the Turbo Prolog program—then he would have overflown its stack/heap with 12 rings as well.

Cuts are features that violate the logic of Prologs. They were introduced as quick hacks in order to improve the execution times. Prologs are sorely missing the IF...THEN...ELSE constructs required here. Trilogy does not contain cuts, and Lane should have used an IF...THEN...ELSE:

```
procHanoi(n:<I,a:<S,b:<S,c:<S)
    iff
 if n = 1 then
   Inform(a,b)
 else
   Hanoi(n-1,a,c,b) &
   Inform(a,b)
   Hanoi(n-1,c,b,a)
  end
```

The execution times for the Tower of Hanoi benchmark as given in the review are irrelevant because they just measure the speed of writing to the screen. I compared this last version with the Turbo Prolog version on 18 rings with the prints turned off. Trilogy executed in 39 seconds (on a 4.7-MHz IBM PC), whereas Turbo Prolog required 77 seconds (this ratio remained the same for any number of rings). By using the IF...THEN...ELSE construct, the stack overflow has disappeared and the program has become more readable to anyone fluent in the procedural style.

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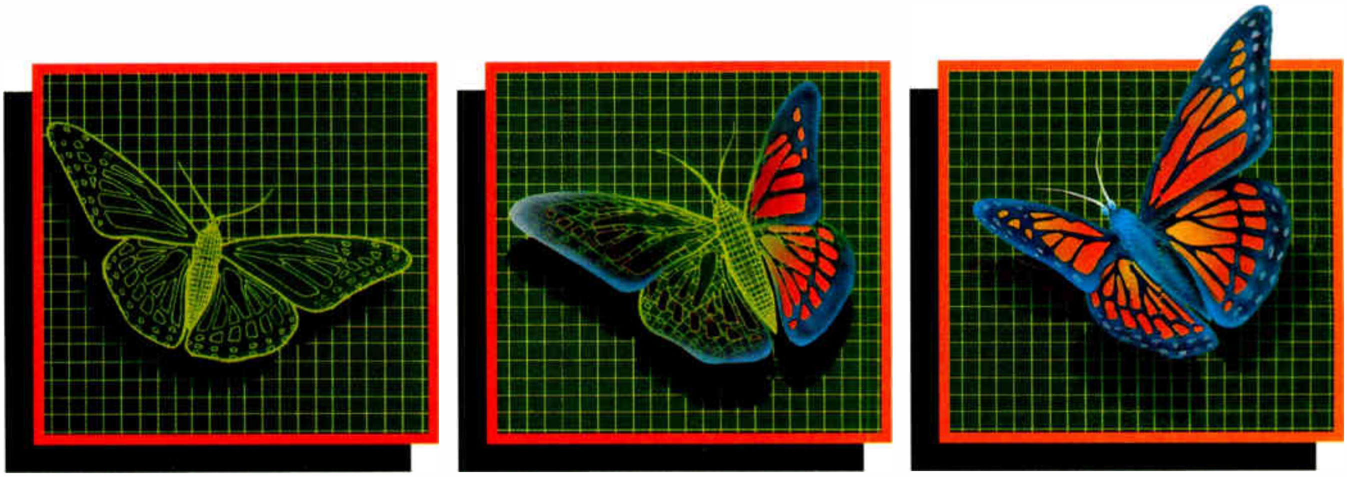

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lease in the fall. This update will include incremental garbage collection, a debugger, and the large data model (Trilogy 1.20 already uses the large code model). The price of the update will be $33.

Although Trilogy 1.20 has a sophisticated relational file system, it cannot yet be characterized as a full database system. We are preparing the B-tree indexes, query optimizer, and form and report generators for release early next year.

Dr. Paul J. Voda
President
Complete Logic Systems
North Vancouver, B.C., Canada

Dr. Voda's letter underscores the difficulty of benchmarking any new language, and, particularly, of attempting to compare benchmark results with those from other languages.

My mention of stack/heap overflow was primarily related to discussions of the list-reversal and disk-read benchmarks in Trilogy. Although I did have a problem with stack/heap overflow while attempting the Tower of Hanoi, my major observation for that benchmark noted that a substantial part of run time was spent writing to the screen. Although the rate of output to the console may be deemed irrelevant since it is not the central focus of the Hanoi test, I thought it did rate a line in the review.

As regards use of Prolog's cut (!) operator, I thought that the benchmarks should reflect the performance capabilities of each language, using all the tools available. Quick hack though it may be, the cut is part of Prolog, so I used it.

I am grateful for Dr. Voda's other comments, and I'm pleased to see that the IF...THEN...ELSE *construct allows the Hanoi benchmark to run. However, it would appear that a potential Trilogy programmer must have quite a good understanding of logic programming principles to use the language to best effect. I would have liked to see such information in the user documentation.*—Alex Lane

Multiplying Integers

In his letter ("A Tale of Two Integers," April), Peter Crosby asks how to get the QuickBASIC compilers to correctly multiply two integers to get a floating-point result. The problem is a common one when using compiled BASIC for the first time. The answer lies in the conventions used in compiling: Any expression will take on the precision of the highest-precision element. That is, in the program

```
10 B% = 30
20 A = B% * B%
```

what actually happens is that `B% * B%` is calculated as an integer, since both terms in the expression are integers. The result is stored in an integer temporarily, and then the assignment (with accompanying conversion) is made to `A`, the single-precision variable.

The problem is one that has never affected interpreted BASIC, because it always calculates in single-precision floating-point; however, it is a problem that is addressed in nearly every "changes from the interpreter" section of the manual that I've read. Unfortunately, this section is usually pretty well buried in the back of the manual. I can't seem to find it at all in the QuickBASIC 4.0 documentation. As common as this error is, it seems odd that Microsoft would not mention it prominently in the manual.

In any event, the easy fix for the above program is to change line 20 to read

```
20 A = 1.0 * B% * B%
```

Now, since the expression involves a real (single-precision) constant, the calculation must be done in single-precision math so that the result doesn't suffer from integer overflow when `B% * B%` exceeds the maximum representable integer.

Dan Mick
Newbury Park, CA

Is Hartley Really Faster?

Mark A. O'Neill did a fine job of explaining Hartley transforms ("Faster Than Fast Fourier," April), and BYTE proved itself once again to be a premier forum for the intelligent discussion of technique.

The article is wrong, however, in asserting that the fast Hartley transform is faster than the fast Fourier transform (FFT). This conclusion follows only when the Hartley transform is compared with an entirely naive implementation of its Fourier counterpart. There are two essential and well-known tricks used in modern FFT algorithms that, when combined, actually serve to make the Fourier procedure the faster of the two.

The first trick was published by J.W. Cooley et al. not long after his famous paper that introduced the basic FFT method. It adapts the computation to the important circumstance of real-valued data by transforming a pseudosequence of half length. The even-numbered points in the original sequence of length N are taken to be the real parts, and the odd-numbered points the imaginary parts of the pseudosequence, so that no rear-

continued

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rangement of the input array is required.

The transformation of this shortened sequence can be carried out by performing $N/4$ "butterflies" on each of $\log_2(N/2)$ levels. This transform is followed by an additional level of $N/4$ butterflies to turn its results into the first half of the Fourier coefficients for the original sequence. The second half is neither calculated nor stored, since the coefficients are known a priori to be the complex conjugates: $X(N-k) = X \times (k)$. This last level of butterflies involves the same necessity for retrograde addressing that marks all levels of the Hartley transform and reflects the deep relationship between the two approaches.

This trick alone evens the race between the Hartley and the Fourier transforms. Both require $\log^2 N$ levels of computation. On each level, the Hartley procedure requires $N/2$ butterflies, each involving two real multiplications, for a total of $N \times \log_2 N$. The Fourier procedure has only $N/4$ butterflies on each level (because the transform is of half length), but each requires a complex multiplication. If these were done in the usual way, as Mr. O'Neill suggests, using four real multiplications apiece, then the contest would be a draw.

A second trick, however, can be used to make Fourier transforms the more economical computation on most computers of the present era. Because multiplication instructions typically require much longer to execute than those for addition or subtraction, this trick succeeds by reducing the number of real multiplications at the cost of an increased number of the quicker operations. I learned the technique from a friend who called it "Golub's method," but I am unable to cite a reference duly crediting its originator.

The idea is to compute a complex product $(A + iB) \times (X + iY)$ with only three real multiplications:

$$(A + B) \times (X - Y) + A \times Y - B \times X + i(B \times X + A \times Y).$$

When the products required for Cooley's real-valued FFT algorithm are taken in this way, the number of time-consuming real multiplications is reduced to three-fourths of those needed for the fast Hartley transform. A well-crafted Fourier routine is therefore faster.

Commercial Fourier transform packages also employ other tricks to achieve increased speed and accuracy. Many of these are equally applicable to Hartley and other related transformations. Probably the most important additional notion is to abandon the level-by-level sequence of calculations implicit in the foregoing discussion in favor of an ordering that groups operations involving common multipliers. This allows computations corresponding to angles of 0, 90, 45 degrees, and so on, to be handled by specialized loops that are much faster than the general case.

J.W. Hartwell
Hillsborough, NC

Symmetric Summation

I was pleased to see fuzzy logic featured in "When Facts Get Fuzzy" by Bradley L. Richards (April). Unfortunately, the operations usually used in fuzzy-set theory lead to logical inconsistencies that make it difficult to apply to real situations. To use one of Richards' examples, suppose that a medical diagnostician observes that symptom A indicates a 70 per-

continued

cent chance of disease and symptom B indicates a 40 percent chance—then if both symptoms are present, the combined chance is

$$0.7 \text{ p-OR } 0.4 = 0.7 + 0.4 - (0.7 \times 0.4) = 0.82.$$

An optimistic patient might conclude that symptom A means a 30 percent chance of health and symptom B a 60 percent chance, and

$$0.3 \text{ p-OR } 0.6 = 0.3 + 0.6 - (0.3 \times 0.6) = 0.72,$$

or a 72 percent combined chance of health. The numbers do not add up to 100 percent, as they should.

Several years ago, I investigated a class of operations on fuzzy sets

$$(a @ b) + ((1-a) @ (1-b)) = 1,$$

where @ is called the "symmetric sum." An example of such a symmetric sum is the operation defined by

$$a @ b = ab / (1 - a - b + 2ab).$$

Applied to Richards' medical example, the chance of disease is

$$0.7 @ 0.4 = 0.7 \times 0.4 / (1.0 - 0.7 - 0.4 + 2 \times 0.7 \times 0.4)$$

or 61 percent, while the chance that the patient is healthy is

$$0.3 @ 0.6 = 0.3 \times 0.6 / (1.0 - 0.3 - 0.6 + 2 \times 0.3 \times 0.6)$$

or 39 percent—the two values add up to 100 percent, so both the pessimist and the optimist can agree.

Fuzzy-set definitions are always arbitrary, since for every set there is a complement, and meaningful results should not depend on which one of them we work with. Symmetric summation is the only type of operation that combines fuzzy sets in a way that leads to conclusions that are the same whether we deal with a particular choice of sets (e.g., young @ beautiful) or their complements (old @ ugly).

An interesting feature of symmetric summation is that it applies only to fuzzy sets, and indeed it is the only operation on fuzzy sets that I know of that does not correspond to an operation on normal sets. This is because of the easily proved requirement that $a @ (1 - a) = \frac{1}{2}$.

William Silvert
Dartmouth, Nova Scotia
Canada

Drawing Lines

There is a problem with the attempt to draw a horizontal line in "A C Interface" by Don F. Ridgway (November 1987). Listing 1 on page 363 of that article is an interesting `ANSISYS.H` header file (not an `ANSISYS.C` header file, as the caption states). Also, in the `#define WINDOW` definition, the horizontal and vertical lines should not be filled.

Harold LeRoy Ling
Jackson, MN

FIXES

In the article "POP Goes the Macintosh" by Dick Pountain (May), the first line of code included in the text on page 290 should have read as follows:

```
pr('That took '><count><'
seconds');.
```

■

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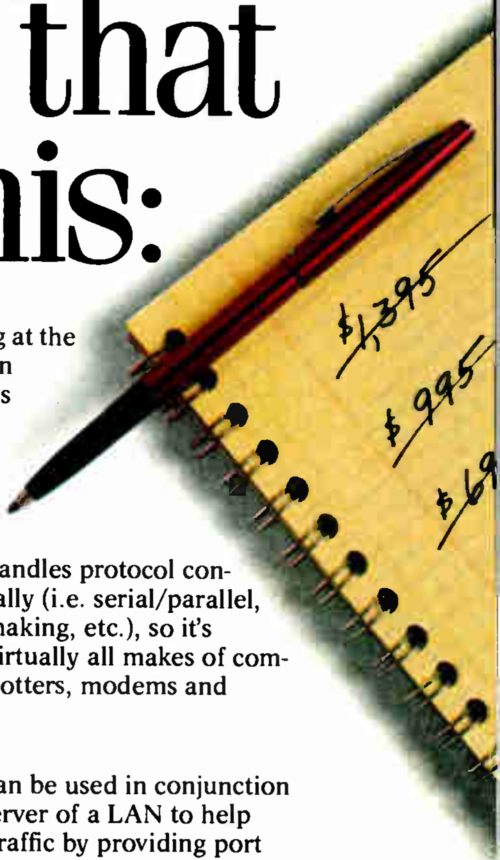

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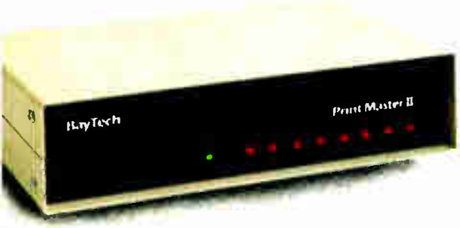

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Circle 32 on Reader Service Card

Chaos Manor Mail

Jerry Pournelle answers questions about his column and related computer topics

Kind Words for Multitasking

Dear Jerry,

I've been an avid reader of your column since its beginning. I have generally agreed with your comments—until you blasted multitasking operating systems in the November 1987 issue.

OS/2 is the first glimmer of hope for serious computing at the personal level. Most attempts at multitasking under MS-DOS are serious kludges (e.g., terminate-and-stay-resident programs like SideKick or massive polling loops like Microsoft Windows). These programs make extra efforts to bypass the operating system.

A big problem with IBM PC software is compatibility. Every developer has a different method of bypassing the operating system. Real operating systems (e.g., VMS, Unix, and OS/2) provide standard interfaces and services to support multitasking; therefore, different vendors' software can coexist.

Regarding your comment that "...what everyone wants is not multitasking, with its inevitable slowing of what you're doing in the foreground...": The new generation of 80386 machines has more than 2 million instructions per second of computing power. With this amount of power available and a multitasking operating system, you won't even notice several background processes.

"Real" networking (e.g., electronic mail, transparent file access, and remote procedure calls) cannot be done without true multitasking. Attempts to perform these operations with polling-loop implementations under MS-DOS produce mediocre results.

You say that what we really want is multiprocessing. That's nice in theory, but more processors cost more money. If the operation can be performed with a decent processor and operating system, why throw more hardware at it? Even with multiprocessing, we need multitasking to effectively coordinate the actions of several processors in a system.

I believe your blasting of multitasking is similar to the comment you made several years ago regarding type-ahead buffers for keyboards. You didn't think they were necessary until you used a system that incorporated one.

Please don't bad-mouth true multitasking until you've tried it.

Kert H. Jans
Encinitas, CA

I don't recall saying anything about type-ahead buffers; indeed, I do recall insisting on n-key rollover on my early CP/M systems; isn't that what a type-ahead buffer does? Gee.

As to OS/2 on an 80386, I agree: It looks like it ought to be plenty fast and very useful. I'm not so certain about the 80286.

Multitasking is fine, but I'd settle for a really good way to do multiple applications. With luck we'll get both.

As to not knocking something I haven't tried, it's precisely because of the bad memories I have from trying multitasking that I'll remain skeptical until I see for myself that I can type and have my words appear on-screen instantly. Some people stare at the keyboard when they type; me, I watch the screen, and even the tiniest delay is noticeable.

We'll see, and I sure hope you're right.—Jerry

Microsoft Word Macro Delays

Dear Jerry,

I am happy that Microsoft Word 4.0 "is certainly the next program to try," as you said in your column in BYTE. I have used it for 3 years, and think it's the most elegant and versatile writing tool there is.

But you should be warned about its macros. They can emulate Electric Pencil commands just fine. But as your book chapters get bigger, Word's macros get slower. The delay is not noticeable with

continued

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. He can be reached c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

small files, but it increases with file size and the cursor's location toward the end of a file (where most writers spend much of their time). On a standard IBM PC, 25 seconds may elapse between the time you hit the macro key(s) and the time the macro starts to execute, if you are at the end of a 35K-byte file. The more you need speed, the less you will get. "Intolerable," as you remarked about Q&A Write.

The only solution is to load ProKey 4.0 along with Word; its macros have no perceptible delay.

Since macros were just introduced in Word 4.0, perhaps it will take another major version for them to be implemented correctly, as is the case with many of Microsoft's other product enhancements.

Allan Fries
Seattle, WA

Gee, thanks for the tip. I expect SuperKey (or, for that matter, DESQview) macros would work the same way. I'll try it.—Jerry

Calling All PX-8 Orphans

Dear Jerry,

Do you have room for a "minority" public service spot?

On a couple of occasions, you've mentioned one of my favorite dinosaurs in your column. It's a small-in-size but big-in-bells-and-whistles CP/M machine called the Epson PX-8 (Geneva). Admittedly, between the advent of MS-DOS and all the reviews that kept saying the Geneva was only for "active computer users" (what does that mean, anyway?), it died out there in consumerland pretty quickly. Nevertheless, there are a lot of PX-8ers around still, and since Epson is out of the PX-8 business, I thought I'd pass on an address or two that might be of some value to other orphans.

SynderScope International (1594 Hilltop Dr., El Cajon, CA 92020) still provides support, peripherals, and reams of software. The company also runs a bulletin board at (619) 442-3789. DAK Industries (8200 Remmet Ave., Canoga Park, CA 91304) also handles some hardware and software. (It seems prices these days for a PX-8 or peripherals are just a fraction of Epson's original suggested retail. Beware, it's enough to make an early Epson buyer weep!)

Another source of Geneva information is the bulletin board system at (313) 538-6968. By the way, Canadian users might still get some limited support through their local Epson dealers (at least they do in Winnipeg).

Thanks for mentioning CP/M occasionally. There's plenty of life in the old gal yet.

Christopher Lars Arney
Winnipeg, Manitoba, Canada

There sure is a dance in the old girl yet. Toujours gai!—Jerry

Hail the Paper Clip

Dear Jerry,

In Computing at Chaos Manor (October 1987), you mentioned that "Apple should have put a control lever on the Mac so you can eject floppies without begging permission."

Jerry, Apple did; the company just hasn't publicized it for fear of making things too easy for Mac users. There are three ways to eject disks from the Mac:

1. Pull down the window and use the "eject" feature, which you found frustrating.
2. Use the double-infinity Command key near the space bar, simultaneously pressing the Control key and lowercase number 4 at the top to electronically force a disk out (this won't hurt anything, I promise).
3. Bend the long end of a thick paper clip to a 90-degree angle from the body of the clip and insert into the little ubiquitous hole near the disk slot, located about ½ inch from the right-hand corner of the slot, keeping the wire totally at a 0-degree angle to the Mac; insert until you hit the mechanical frog (disk grabber) and press forward ¼ inch; that will release the tension on the frog, and—bingo—your disk will pop out.

I have done this hundreds of times on all models of Macs and never damaged one in the least, and most of my colleagues forced to suffer Macs all keep a similar paper clip with them at all times and have done this procedure thousands of times with no damage whatsoever.

H. Kent Craig
Raleigh, NC

Well, I guess the solution is to issue a box of paper clips with each Mac!—Jerry

Stamp Out "Turbo"

Dear Jerry,

I am writing to solicit your help in promoting the enactment of federal legislation that would make it a capital offense to use the prefix "turbo" in the name of any product or service not directly and intimately associated with the power-plant industry.

I know I can count on your moral, if not your financial, support in this most worthy of endeavors.

(Embedded command: Remove tongue from cheek in order to lick stamp.)

David Fisher
Scottsville, NY

Hey, I'll join that campaign!—Jerry ■

Circle 181 on Reader Service Card

ASK BYTE

Circuit Cellar's Steve Ciarcia answers your questions on microcomputing

Digitizing Live Video

Dear Steve,

Could you point out the proper combination of hardware and software that would permit an IBM PC user to display a full-motion video signal on the PC screen?

There seem to be a number of expensive video capture boards/software around (AT&T's TARGA, for example), but they are overly complex for this simple application. I'd like to be able to call up and view a video signal from a PC menu using my keyboard and return to a menu when done.

In reality, I'd like to go one step further and be able to select one video signal from a menu list of several video sources, using the PC communications port to drive a video switch. My ultimate goal is to be able to window the video into positions on the screen, such positions being controlled by a program.

Ron Van Note
New York, NY

The reason those TARGA boards are so expensive is that they're doing something quite complicated. Let me walk you through the problem.

A standard PC display (everything except the new VGA hardware) uses digital signals to represent the colors for each pixel. EGA displays can handle 64 colors, but the EGA boards can generate only 16 different colors at one time. No matter where your picture comes from, it will have only 64 colors when the EGA is done with it, and that's not enough for what you want to do.

The VGA displays use analog video signals, and the boards can produce 256 colors from a selection of about 250,000 (with 320- by 200-pixel resolution), which is closer to live video. Unfortunately, the screen scanning rates are so different that the monitor can't overlap a video signal on a digital image at the same time.

The TARGA boards sidestep the problem by digitizing the video image and using software to position the pixels in memory. That process just doesn't happen in real time, if only because the PC isn't fast enough to update the picture that quickly.

Some manufacturers do make a genlock accessory for the EGA display that will superimpose the EGA (in CGA mode) signal on a background of live video. I'm not sure of all the details, but I suspect you need an analog monitor that can handle both standard video and RGB inputs at the same time. The ads showed up in BYTE and PC Magazine *a while ago, but I can't track them down again.*

In any event, I think it'll be a lot more expensive than you'd like. Maybe having two monitors isn't that awful.—Steve

IN ASK BYTE, Steve Ciarcia, a computer consultant and electronics engineer, answers questions on any area of microcomputing and his Circuit Cellar projects. The most representative questions will be answered and published. Send your inquiry to
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Due to the high volume of inquiries, we cannot guarantee a personal reply. All letters and photographs become the property of Steve Ciarcia and cannot be returned.

The Ask BYTE staff includes manager Harv Weiner and researchers Eric Albert, Tom Cantrell, Bill Curlew, Ken Davidson, Jeannette Dojan, Jon Elson, Frank Kuechmann, Tim McDonough, Edward Nisley, Dick Sawyer, Robert Stek, and Mark Voorhees.

ROM Disk

Dear Steve,

I use a laptop computer quite a bit. I chose the NEC MultiSpeed because it is fast, powerful, inexpensive, and can run on batteries alone for those times when AC is unavailable.

The two built-in 720K-byte floppy disk drives are sufficient for many purposes. Of course, you can never have too much disk storage space. I can usually fit each major application program onto one or two 720K-byte disks, leaving the B drive open to hold the working files. So I have a disk for Word and a disk full of documents, two disks for Lotus 1-2-3 and a third with spreadsheets and graphs, another pair of disks for Reflex and one for each major database, two for Microsoft C, and one for each major program I'm developing. Get the picture?

While this system is adequate, it tends to involve a lot of disk swapping. Worse yet, the heavy use of the floppy disk drives runs down the battery quickly. While the battery is rated at about 6 hours' use with "minimal" disk access, the NEC service representative told me that it was "normal" for the battery to last only about 2 hours with heavy disk use. And for certain operations (most notably programming), those disk drives are running almost constantly.

An internal hard disk drive, which some of the other laptops have, solves the problem of disk swapping but aggravates the problem of battery life. Besides, it doesn't look as if NEC will offer its hard disk drive as an upgrade option for the existing MultiSpeed machines. The new MultiSpeed HD looks quite a bit different than its predecessor.

I have a solution that I think is actually superior: Why not design and build an external ROM disk for the MultiSpeed? In fact, if I'm not mistaken, you could make the IBM-compatible parallel printer port operate bidirectionally. So you could adapt a ROM disk designed to run from the parallel printer port to all current (and, presumably, future) laptop machines. It would be a silent, low-power, expandable "disk drive" that you could carry easily wherever you went, and it could substitute for a fistful of disks.

I envision a system consisting of multiple circuit boards connected by a bus of ordinary flat ribbon cable. Board #1 would be a simple microprocessor controller board. A low-power Z80, an 82C55 parallel interface chip, a 27C128 EPROM, one or two 6264LP static RAM (SRAM) chips, and some "glue" would probably do the job. Board #2 (one or more copies in parallel on the ribbon-

continued

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Uniware Z-80 C Cross Compiler *by SDS*	995	899
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Microsoft Windows 386	195	129
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Norton Commander	75	55
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For OS/2	150	109
Norton Utilities	100	59

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muLISP-87 Interpreter & Compiler	400	299
muMATH-83	300	219

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DATABACK ... *New*	70	67
MACK DOS ... *New*	60	58
Turbo G GRAPHICS Development Library ... *New*	80	75
with Source Code ... *New*	150	135

other products

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APL*PLUS PC *by STSC*	695	529
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Dan Bricklin's Demo II *by Software Garden*	195	179
Desqview *from Quarterdeck*	130	115
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EXTEND *FORT 77 Extens by Design Decisions* ... *New*	149	129
Flow Charting II+ *by Patton & Patton*	229	189
GRASP *by Paul Mace Software*	99	85
HALO 88 *by Media Cybernetics* ... *New Version*	325	CALL
Instant Replay III *by Nostradamus*	150	129
Mace Utilities *by Paul Mace Software*	99	85
MathCAD *by MathSoft*	349	319
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MICROSTAT-II *Statistics Pack by Ecosoft* ... *New*	395	359
Opt-Tech Sort *by Opt-Tech Data Proc*	149	99
Peabody *by Copia Intl, Specify Language*	100	89
PMI Products *All Varieties*	CALL	CALL
Quinn-Curtis Products *All Varieties*	CALL	CALL
STATGRAPHICS *by STSC*	895	699
TLIB Version Control *by Burton Systems Software*	100	89
Turbo Analyst 4.0 *by TurboPower*	75	69
TurboGeometry Library *by Disk Software*	100	89
Turbo Professional 4.0 *by TurboPower*	99	89
XENIX System V *All Varieties by SCO*	CALL	CALL

cable bus) would be filled with 27C512 EPROM chips. Each ROM board could hold up to 32 EPROMS, or 2 megabytes, of "disk" space.

With very little additional effort, you could design the system so that it also accepted a third type of board containing 43256LP CMOS SRAM chips instead of EPROMs. Then you could have an external RAM disk that did not reduce the MultiSpeed's working RAM capacity, or a mixture of RAM disk and ROM disk for maximum flexibility.

Loading software and data files into the ROM disk would be the only complicated part of the whole project. A labor-intensive approach would be to use software on a host PC with a hard disk drive to build an image of the ROM disk drive, convert the changed data to an Intel hex file, figure out which EPROM chips need to be removed from the ROM disk board(s), and then dump the hex files to an EPROM programmer one chip at a time.

A hardware approach would be cleaner. You could design a fourth board that would contain EPROM programming circuitry. It could burn the EPROMs in the ROM disk boards; you wouldn't even have to remove them from their sockets. With this programmer board in place, the host PC could simply COPY or XCOPY one or more files to the ROM disk as if it were writing to a real disk.

What do you think about this idea?

John P. Toscano
Apple Valley, MN

Every now and again the subject of an external ROM (or RAM) disk comes up. You've done a good analysis of the project, but you've overlooked one absolutely essential specification: the economics of the project.

The ROM disk you describe uses 32 27C512 EPROMs, which cost about $10 apiece in moderate quantities. Sockets, bypass capacitors, buffers, and the like add about $1 to the cost of each EPROM. I think that the support circuitry could be a little simpler than you describe, but let's figure about $50 in parts for the CPU and other ICs. Just the EPROMs require about 50 square inches of PC board space, so we'll stack two 6- by 8-inch boards in a box; figure $30, including the board connectors. The board needs a connector to the PC, so add another $15 or so. Figure that there will be some costs for assembly, test, and rework, and you're up to about $500 for each unit.

But we haven't allowed for design time, software development, advertising, shipping, or the profit motivator. You can assign any markup you'd like to cover the cost of running the business that makes the ROM disk possible; I'll use a factor of 2 (which may not be enough).

The bottom-line price to the consumer would be about $1000, which seems awfully steep for a box that replaces 2.84 floppy disks—and needs a power supply and cable.

Don't feel too bad, though. I've built quite a few projects that didn't make any economic sense; they were just fun to do. If I can figure out any way to make a general-purpose ROM disk workable, I'll be sure to do it.—Steve

Improving Iris after Cataracts

Dear Steve,

My father-in-law was operated on for cataracts a few months ago. Unfortunately, complications resulted in the loss of proper function of the iris of one eye. This makes it difficult for him to cope with wide variations in light intensity and detracts from his enjoyment of his favorite outdoor activities.

I would like to build or procure a simple, lightweight, artificial iris for him. My idea is to overlay one lens of his eyeglasses with some material that can be rendered more or less transparent by a varying electrical field controlled by a light-level sensor mounted on the glasses frame. I know that somewhere, in a discussion of NASA research or similar activity, I read of a material with such properties. In fact, Edmund Scientific markets a liquid-crystal material that might be adapted to the purpose. Unfortunately, it requires a high voltage, and I'm not sure that its clear state is sufficiently transparent.

Are you or is anyone on your staff aware of any material that might be suitable for the purpose?

Robert D. Williams
Mathews, VA

A low-tech solution to your father-in-law's problem may produce better results than a state-of-the-art optoelectronic project. The trouble with the latter is that it's going to be absurdly expensive and probably ugly.

How about a simple polarizer added to a pair of Polaroid sunglasses? If you picked the lenses carefully, they'd have a nearly spherical section so you could mount a polarizer disk against the inside surface. By rotating the polarizer, you could vary the transmission from about 50 percent (more or less) to almost nothing.

You could also use neutral-density fil-

continued

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	MODEL	DESCRIPTION	ANALOG INPUTS Channels	ANALOG INPUTS Resolution (bits)	ANALOG INPUTS Throughput (kHz)	ANALOG OUTPUTS Channels	ANALOG OUTPUTS Resolution (bits)	ANALOG OUTPUTS Throughput (kHz)	I/O Lines
LOW COST	DT2811-PGH	Low Cost A/D, D/A, Interrupt	16SE/8DI	12	20	2	12	50	8 In, 8 Out
	DT2811-PGL	Low Cost, Low-Level A/D, D/A; Interrupt	16SE/8DI	12	20	2	12	50	8 In, 8 Out
	DT2814	Low Cost A/D, Int.	16SE	12	25	–	–	–	–
	DT2815	Low Cost D/A	–	–	–	8	12	3.3	–
	DT2817	Low Cost DIO	–	–	–	–	–	–	32
GENERAL PURPOSE	DT2808	Low Cost, DMA	16SE	10	3.3	2	8	10	16
	DT2801	General Purpose, DMA	16SE/8DI	12	13.7	2	12	14.8	16
	DT2801-A	Higher Throughput, DMA	16SE/8DI	12	27.5	2	12	29.5	16
	DT2801/5716A	High Resolution, DMA	8DI	16	20	2	12	14.8	16
	DT2805	Low Level, DMA	8DI	12	13.7	2	12	14.8	16
	DT2805/5716A	Low Level, DMA	8DI	16	20	2	12	14.8	16
	DT2818	Simultaneous Sample & Hold, DMA	4SE, SS&H	12	27.5	2	12	29.5	16
HIGH SPEED	DT2821	High Throughput, DMA, Interrupts	16SE/8DI	12	40	2, Deglitched	12	130	16
	DT2821-F-16SE, DT2821-F-8DI	Very High Throughput, DMA, Interrupts	16SE or 8DI	12	150	2, Deglitched	12	130	16
	DT2821-G-16SE, DT2821-G-8DI	Ultra High Throughput, DMA, Interrupts	16SE or 8DI	12	250	2, Deglitched	12	130	16
	DT2823	High Throughput, High Res., DMA, Ints.	4DI	16	100	2, Deglitched	16	100	16
	DT2825	High Throughput, Low Level, DMA, Ints.	16SE/8DI	12	40	2, Deglitched	12	130	16
	DT2827	High Resolution, High Throughput, DMA, Int.	4DI	16	100	2, Deglitched	12	130	16
	DT2828	High Throughput, SS&H, DMA, Interrupts	4SE, SS&H	12	100	2, Deglitched	12	130	16
DT-Connect™	DT2841	High Throughput, DT-Connect™ Transfer	16SE/8DI	12	40	2, Deglitched	12	130	16
	DT2841-F-16SE	Very High Throughput, DT-Connect™ Transfer	16SE	12	150	2, Deglitched	12	130	16
	DT2841-F-8DI	Very High Throughput, DT-Connect™ Transfer	8DI	12	150	2, Deglitched	12	130	16
	DT2841-G-16SE	Very High Throughput, DT-Connect™ Transfer	16SE	12	250	2, Deglitched	12	130	16
	DT2841-G-8DI	Very High Throughput, DT-Connect™ Transfer	8DI	12	250	2, Deglitched	12	130	16
	DT2841-L	750kHz Throughput, DT-Connect™ Transfer	4DI	12	750	2, Deglitched	12	130	16
	DT2847	16-bit Resolution, DT-Connect™ Transfer	4DI	16	100	2, Deglitched	12	130	16
	DT2848	High Throughput, SS&H, DT-Connect™ Transfer	4SE	12	100	2, Deglitched	12	130	16
FLEXIBLE I/O	DT2806	ISBX A/D	Up to 80	12	20	Up to 24	12	5	Up to 72

Subroutine libraries and/or application–specific software packages are available with all boards.

—Fred "Atlas" Molinari, President

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DIGITAL FUNCTIONS		SCREW TERMINAL PANELS		PRICE
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–	√	DT707	DT709-Y, DT756-Y, DT760(-T), DT707-T	$ 845
–	√	DT757	DT709-Y, DT756-Y, DT760	$ 395
–	–	(2)DT757	–	$ 499
–	–	DT758-C	–	$ 199
–	√	DT707	DT709-Y, DT756-Y, DT760	$ 495
–	√	DT707	DT709-Y, DT756-Y, DT760	$ 995
–	√	DT707	DT709-Y, DT756-Y, DT760	$1,095
–	√	DT707	–	$1,970
–	√	DT707	DT707-T	$1,095
–	√	DT707	DT707-T	$2,070
–	√	DT707	–	$1,695
–	√	DT707	DT709-Y, DT756-Y, DT760	$1,345
–	√	DT707	DT709-Y, DT756-Y, DT760 (SE)	$1,995
–	√	DT707	DT709-Y, DT756-Y, DT760 (SE)	$2,995
–	√	DT707	–	$2,795
–	√	DT707	DT707-T, DT760	$1,445
–	√	DT707	–	$2,495
–	√	DT707	–	$1,995
–	2	DT707	DT709-Y, DT756-Y, DT760 (SE)	$1,450
–	2	DT707	DT709-Y, DT756-Y, DT760	$2,095
–	2	DT707	–	$2,095
–	2	DT707	DT709-Y, DT756-Y, DT760	$2,695
–	2	DT707	–	$2,695
–	2	DT707	–	$2,995
–	2	DT707	–	$2,495
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Circle 78 on Reader Service Card

ters; perhaps you could use two or three levels in various combinations. They might be easier to mount than a polarizer because they wouldn't need to rotate.

Drop into a good camera store and see what they have in the way of filters. You could cannibalize a second pair of sunglasses for a polarizer; that would give you good optical quality for a very low cost.

You might have to drill a few holes in the lens for the filter mount, but that's a mechanical problem and doesn't involve delicate surfaces, high voltages, or complex electronics. While it often seems as though I like high-tech gadgetry for its own sake, you'll notice that many real-world interfaces are brutally simple and reliable—otherwise, they don't work for long. —Steve

Too Much Space

Dear Steve,

I am using an IBM PC with DOS 2.0 and a Brother HR-35 printer with a sheet feeder. A problem shows up when I print from the word processor of MultiMate Advantage II. Specifically: Occasionally, for no apparent reason, extraneous spaces appear in lines of print. In succeeding lines, the left margin is offset the same number of spaces. If I switch the printer off and back on (which clears its buffer), the left margin goes back to its proper setting.

Ashton-Tate's only suggestion was to use `TTYCRLF.PAT`, but this gave me other troubles with justification and 4-line-per-inch spacing.

Also, the sheet feeder of the printer moves the paper 0.6 inch to the right of its normal position. When I use sophisticated software (e.g., MultiMate, dBASE III Plus, and Norton Utilities), I can adjust for this in the margin specification. But I cannot use the `shift-printscreen` function. Brother says I cannot do anything with the printer to overcome this. Is there some way I can modify DOS or BIOS to correct this problem?

Russell G. Hill
Princeton, NJ

There are a couple of possibilities, but to figure out what's going on you'll need to do a little experimenting. I'll run through the choices and suggest how to test for them.

Because the offset is consistent from line to line, the Brother HR-35 may be getting a command to set the left margin. I don't know if getting a margin command in the middle of a line would cause additional spacing in that line, but it's worth checking.

The first step is to capture your printer's output so you can see exactly what's going on. The most practical way is to install a resident program that redirects the printer output to a file so you can look at it. PC Magazine *(December 22, 1987) presented a utility called* `PRN2FILE` *(print to file) that does the deed.*

`PRN2FILE` *will create a disk file containing all the characters going to your printer. You can then use* `DEBUG` *or some file dump utility to examine the file in detail. You can also reprint the same file over and over to see if you get different results from the same data; because you use the* `DOS COPY` *command to do this, there's less chance for timing problems.*

There are two possibilities: (1) either the data file will contain some extra or garbled data, or (2) it won't. If it does, the fault lies in the printer driver software. If it doesn't, then there's a problem in your printer. If you can reprint the same data file with different results, the printer is almost certainly kaput.

Check your cables, connectors, and so forth, even though you're sure they can't possibly make any difference. Often, a 2-day debugging session starts with a flaky connector.

As far as adjusting the margins for `printscreen`*—tinkering with the BIOS code isn't worthwhile. By and large, you'd need to write a replacement routine; this isn't terribly difficult, but it shouldn't be your first whack at assembly language. What may be more practical is to set up a batch file that moves the left margin over 6 or 10 spaces, then do normal* `printscreens` *and let the printer handle the margins. Admittedly, that's not too elegant, but it ought to work.*
—Steve

Hard Disk Mysteries

Dear Steve,

I have two problems that I've spent considerable time trying to resolve without success, despite reading everything I could find and writing letters to the manufacturers involved.

I built my IBM PC XT clone from components, and to date I have had no problems with hardware failures or software incompatibilities. The following list of my equipment may help you assist me, if you think my problems can be traced to hardware.

I have a DTK 4.77-/8-MHz motherboard with an NEC V20 CPU, Phoenix 2.27 BIOS, and 640K bytes of 150-nanosecond RAM mounted in a steel flip-top case. The display card is the ATI EGA Wonder with 4.02 BIOS. I have a Samsung SM-12SFA7 amber flat-screen monitor and a DTK Multi I/O card with floppy disk drive controller; the card is configured with a game port, a clock, and COM1 enabled (COM2 is disabled). The floppy disk controller is hooked to a Toshiba 360K-byte floppy disk drive (A) and a Toshiba 3½-inch 720K-byte floppy drive (B). My hard disk drive is a Seagate ST251 with a Western Digital WX1 (F300) controller, configured as a 32.6-megabyte hard disk drive (C) and an 8.9-megabyte hard drive (D). A Fujitsu 1.2-megabyte floppy disk drive and a Magitronic PE-510 Super FDC will be installed as drive E after I've resolved the problem. A 150-watt power supply (modified by the internal addition of surge and radio-frequency interference suppression) provides stable outputs. The keyboard is a DataComp DFK-777. Finally, a Zoom 2400-bit-per-second modem operates as COM2.

Now for the problems. Here's the first one. I had two Seagate ST225 21-megabyte hard disk drives with an Everex (which appears to be similar to the Western Digital WX2) controller, formatted with the MS-DOS 3.2 operating system. Wanting to install the 1.2-megabyte floppy disk drive, I installed the Seagate ST251/Western WX1 and formatted everything with MS-DOS 3.30. Now my old `CONFIG.SYS` file no longer works (the system says `unrecognized command`).

Furthermore, while I can run a directory of the C drive's root and copy or edit files there, programs such as PC Tools and Menu consistently tell me there are no files in the root directory and will not read the volume name of the hard disk.

The second problem regards formatting the hard disk: Many of the Seagate ST255s (and now my ST251) ignore my interleave specification (I enter a 3) when controlled by a Western Digital WX2 or WX1 controller.

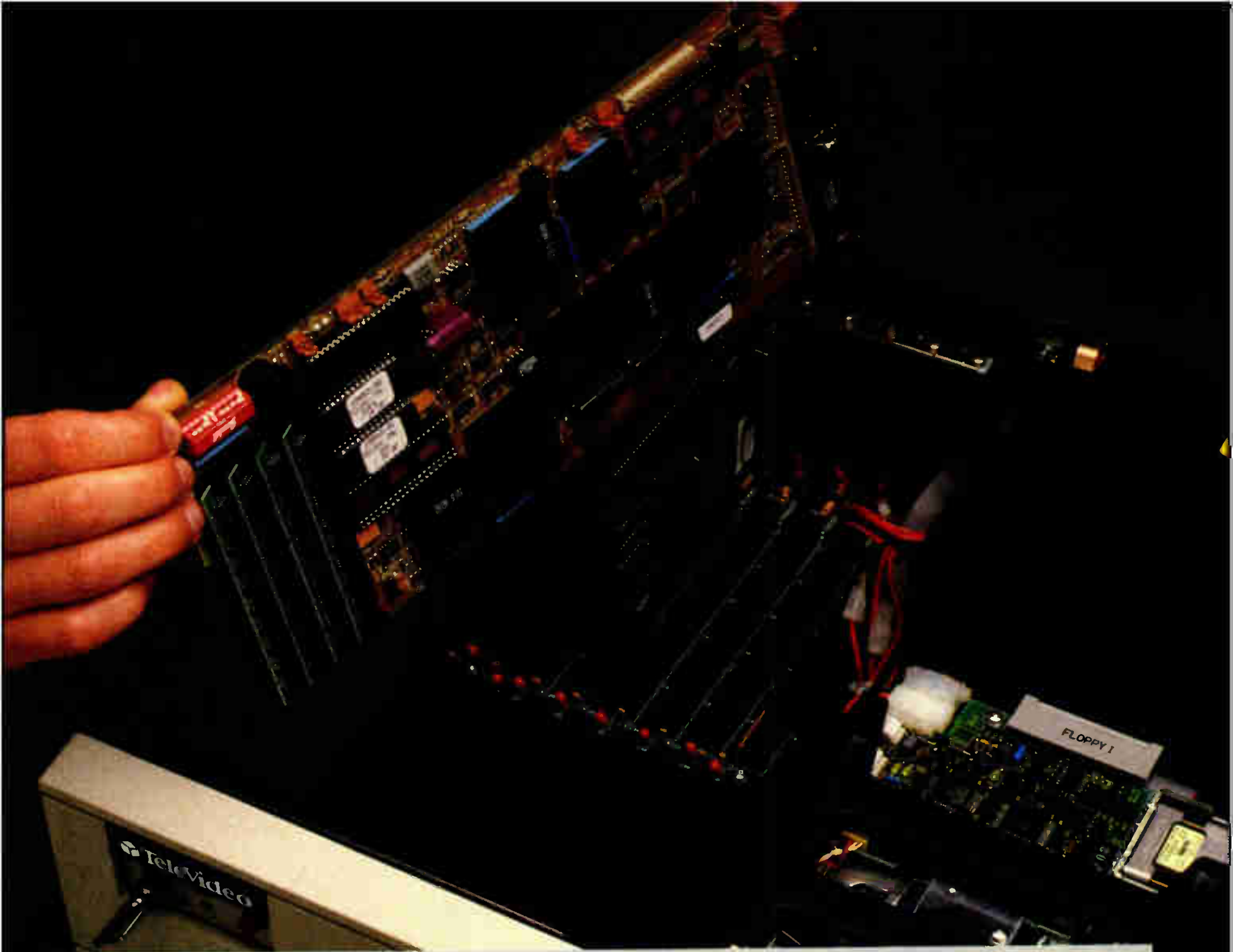
I obtained a program called `SPINTEST` from a local bulletin board, and it gives the result of 3 revolutions to read a track (with a 174,080-byte-per-second transfer rate) when I use an Omti 5520, Microtek, HDC-1000, or DTC 5150. Occasionally I get a Western Digital WX1 to format with an interleave of 3, but, typically, `SPINTEST` indicates 17 revolutions to read the track with a transfer rate of 30,710 bytes per second. Is there a fix for this?

Christopher Koch
Buffalo, NY

I think this is one where you've got to be there to make any headway...

Here's what I'd do. First, back up the

continued



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hard disks so you don't lose anything in the ensuing melee. Stick the appropriate boards into the PC, cable up the appropriate drives, check everything once, and fire it up. Do a low-level format on the drives and then run DOS 3.3's FDISK *and* FORMAT /s *(you should use the original DOS disks to make sure you get the right version).*

If you need device drivers, set up CONFIG.SYS *at this point and load the drivers into the appropriate subdirectories. Keep everything else off the disk until you're sure the machinery plays. Once everything is OK, fill up the disk from the backup you make, taking care not to overwrite the boot files with some leftover trash.*

Unless that Magitronic floppy disk controller is designed to work with a standard floppy card already installed (presumably using entirely different hardware I/O addresses and its own device driver), neither one will work. Right? So you might want to start the process without that card, just to make sure. Once the rest works, then add the new floppy disk controller and see what breaks.

From what you've told me, I think some of your problems come from mixing versions of DOS and controllers. Remember that there's absolutely no standardization of what the controllers actually slap on the disk, so you can confuse things mightily if you interchange drives and controllers without a low-level format to set things right again.

Setting the interleave often has no effect on cards with clever controllers and internal track buffers. They run with whatever interleave the controller needs to handle the data, so you can't twiddle with DOS or BIOS parameters. Your controllers probably fall into that category, but I'm not sure.

Remember, however, that an interleave of 3 may be too low. If the PC isn't ready when the next sector comes around, it will have to wait another revolution to get the data. That's the penalty you pay for trying to speed it up—it goes slower! If SPINDISK *is asking for the sectors in such a way that the controller flushes its buffer, it will take 17 revolutions no matter what the interleave is. Different controllers may react in a different manner.*

In cases of mysterious behavior such as this, it often pays to start from scratch and work very carefully through all the steps. I've found that when you're convinced that a particular process is meaningless, you're ready to learn something new.—Steve ■

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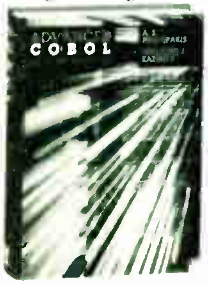

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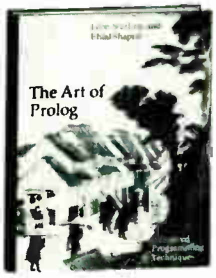

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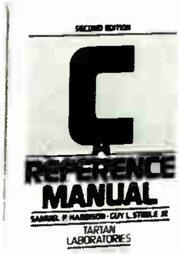

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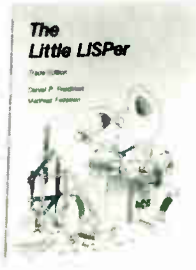

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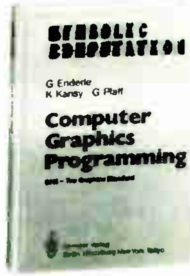

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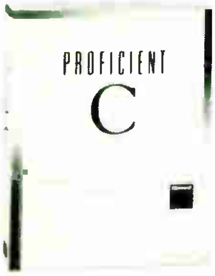

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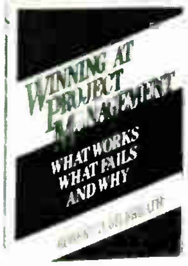

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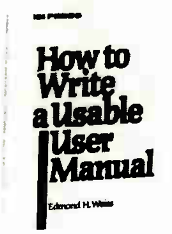

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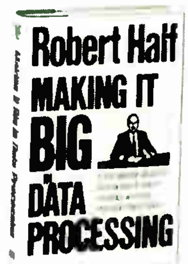

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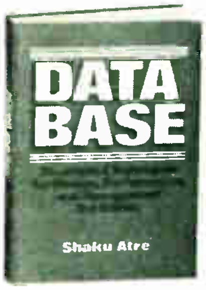

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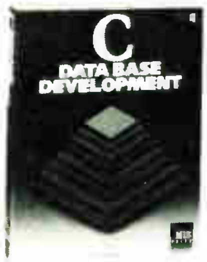

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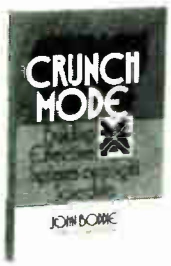

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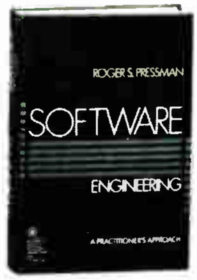

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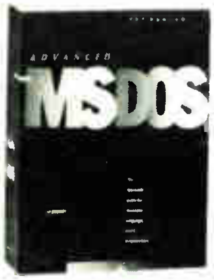

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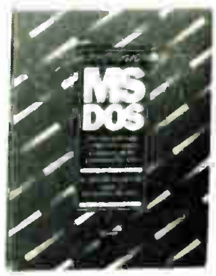

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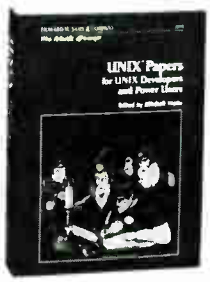

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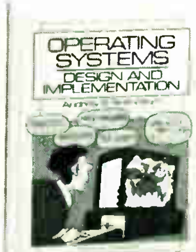

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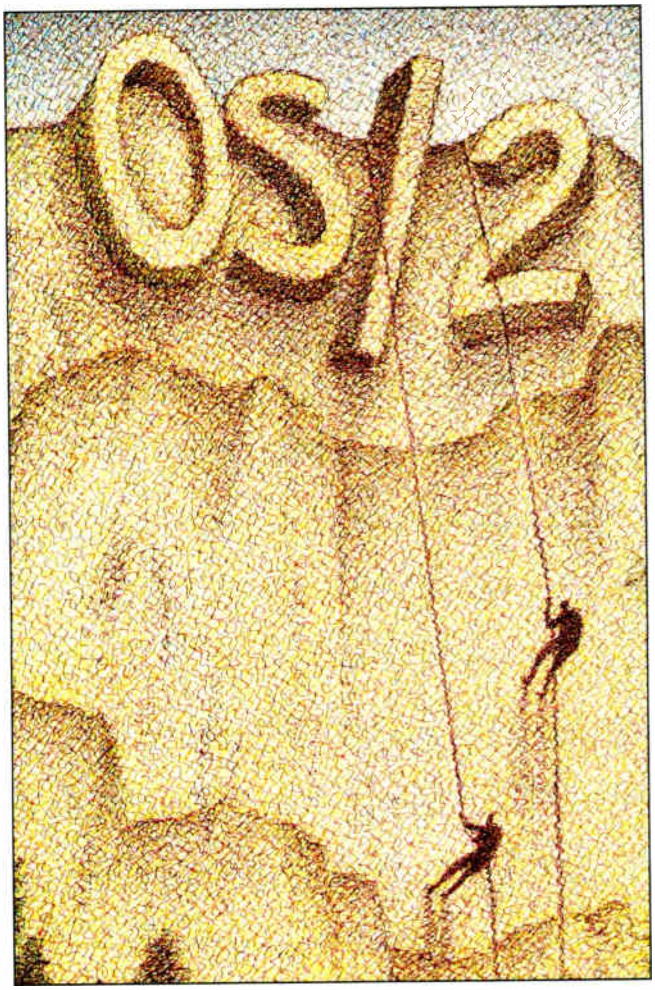
ROUNDUP

Inside OS/2
Gordon Letwin

OS/2 Programmer's Guide
Ed Iacobucci

OS/2 Features, Functions, and Applications
Jeffrey I. Krantz, Ann M. Mizell, and Robert L. Williams

Using OS/2
Kris Jamsa



Reader's Guide to OS/2

G. Michael Vose

The first months of 1988 brought us four books seeking to explain OS/2. One attempts only to show how to use OS/2, two others offer lots of detail about the mechanics and internal workings of OS/2, and the fourth tries to explain OS/2's gestalt.

A good place to start learning about OS/2 is ***Inside OS/2*** (Microsoft Press, Redmond, WA: 1988, 289 pages, $19.95) by Gordon Letwin, chief architect for systems software at Microsoft. With chapters entitled "History of the Project," "The OS/2 Religion," and "The Future," this book should be the place to discover the vision of what OS/2 will become.

Letwin offers many insights concerning what OS/2 provides as a platform for the computing future. He discusses the electronic office, where all computers are linked together via local-area networks (LANs), sharing data and resources. And he makes implicit comparisons between OS/2 and telephones: When telephones were invented, people scoffed and couldn't see what benefits a phone provided as a communication aid. After all, by the time you wrote out your message, had your secretary call the correspondent's secretary to dictate the message, and then had that secretary hand the message to its intended recipient, you could have sent a letter by messenger. A change in mind-set had to occur for telephones to catch on as tools. Letwin anticipates a similar lag before people really grasp the power of the new paradigm offered by OS/2. That paradigm, of course, is multitasking, with communication among the running tasks.

After extolling the advantages of multitasking, Letwin spends the rest of his book explaining why OS/2 works the way it does. This explanation serves as the mental model a programmer should adopt to write OS/2 programs.

By explaining how the pieces fit together, Letwin provides information that should save programmers time and frustration when they begin writing OS/2 programs. His explanations not only provide a conceptual framework for programmers but actually anticipate the kinds of bugs to which OS/2 programmers might fall prey. His warnings should be heeded.

For example, the chapter on multitasking has three full pages of hints and warnings dealing with parent and child processes and their associated file handles. Here, Letwin details the side effects caused by handle inheritance. He also warns readers not to "follow the standard Unix practice of blindly closing file handles 3 through 20 during program initialization," since OS/2's dynamic link libraries may have previously opened one or more of these handles.

But even after reading all the insider thinking that went into the design of OS/2, I still found myself wondering just what an OS/2 application will do that an MS-DOS application cannot. Maybe this results from the perceptual lag Letwin warns about early on: Maybe you have to see an OS/2 application in action to really appreciate the potential of OS/2.

Letwin's book is definitely thin in source code; the sam-

continued

ALSO REVIEWED

Programming Translation Fundamentals

Programming Language Translation

The IBM Programmer's Challenge and *The Apple Programmer's Challenge*

Mind Tools

Elements of Functional Languages

ILLUSTRATION: DAVE RIDLEY © 1988

ples he gives rarely, if ever, run more than five lines.

Ed Iacobucci's book, ***OS/2 Programmer's Guide*** (Osborne/McGraw-Hill, Berkeley, CA: 1988, 1100 pages, $24.95), promises nearly as much as Letwin's: Iacobucci is Letwin's counterpart at IBM, the OS/2 system architect. And his massive volume on OS/2 provides even more detail than Letwin's on the nuts and bolts of OS/2.

Iacobucci justifies OS/2 mostly by talking about what MS-DOS and Intel 8088-/8086-based machines couldn't do. Then he jumps right into detailed technical discussions about how to write OS/2 programs. In fact, 16 percent of this book is programs—29 different OS/2 programs or program fragments that explain how to use OS/2 features. Many of these programs might be useful to programmers as more than just examples: One displays a file in hexadecimal, and two others allow copying data to and from the standard input and output devices and shared memory segments.

The IBM influence shows through strongly in these example programs. All the code is in assembly language. (Common industry scuttlebutt says that all IBM programmers write in assembly language. One of the reasons put forth for OS/2's long gestation was that IBM's design team first had to learn C.) A disk offered separately contains the assembly code and C versions of the programs. But in a bizarre decision, possibly intended to placate Iacobucci's IBM superiors, Osborne/McGraw-Hill elected to print assembly language instead of C code. The availability of a companion disk with C code remedies this potential deficiency.

I've heard several OS/2 programmers claim they've learned more from Iacobucci's book than from the OS/2 documentation for software developers. One programmer bewails the prohibitive cost ($3000) of Microsoft's OS/2 Software Development Kit (SDK) and claims that you can become an OS/2 developer just by buying Iacobucci's book. This programmer learned enough from the book to construct the necessary `doscalls.h` and `subcalls.h` libraries so he could write OS/2 programs. The 159-page appendix A details all of OS/2's function calls.

Iacobucci's book has even helped programmers find bugs in early versions of OS/2. I know of one programmer who was having trouble with a field in the `KbdStatus` structure used by `KbdSetStatus`. The documentation for `KbdSetStatus` in the Microsoft SDK *Programmer's Reference* lists this bit as reserved. This directly contradicts Iacobucci's text. When queried about this discrepancy, Microsoft responded that shift-key reporting, as documented in the Iacobucci book, is part of the OS/2 spec and is safe to use.

OS/2 Features, Functions, and Applications (John Wiley & Sons, New York: 1988, 282 pages, $24.95) is also written by members of the IBM OS/2 design team. Authors Krantz, Mizell, and Williams try to pass on some of the "tremendous amount of knowledge in the depth and breadth of the product" that they have accumulated. Interestingly, they wrote the programming examples in C code, not assembly language.

This book really shines in its discussions of PS/2 programming, offering some previously little known information on the PS/2s' Advanced BIOS. The authors also provide a good discussion of the difference between the edge-triggered hardware interrupt mechanism in the IBM PC AT environment and the level-sensitive triggering of the PS/2s, and how OS/2 device drivers can use this hardware feature.

The book's drawback, however, is its dense presentation. The writing is passive and academic, making the information hard to access.

continued

Kris Jamsa is a recognized authority on MS-DOS; he wrote *DOS: The Complete Reference*, he presides over the DOS User's Group, and he is the editor of that organization's newsletter. Despite these qualifications, his *Using OS/2* (Osborne/McGraw-Hill, Berkeley, CA: 1988, 757 pages, $19.95) is the least useful of this bunch.

The first several chapters explain using OS/2 to a novice user—how to care for disks, how to boot the computer, and how to format and back up disks. Even casual MS-DOS users will find these chapters of little use. This section is twice as long as it needs to be. Many of its illustrations are redundant, while others are simply unnecessary. The reference manual included with OS/2 explains these topics as well as this book does.

Next, Jamsa attempts to explain the complexities of OS/2 programming. He was working with early beta software to explore these topics, so his explanations lack depth. Many of his descriptions read like manuals reworded into book style. But they are poorly organized, and the rewording adds little or no additional information.

The book also has many errors. For example, on page 24 an illustration claims that OS/2 has a 4.8-megabyte virtual address space (48 is the correct number), and on page 473 Jamsa asserts, "both the program and the executable code reside in memory." This statement is only a little less confusing than an earlier assertion that "the key to OS/2's success is not necessarily its powerful capabilities, but rather the number of application programs that make use of these capabilities."

Building Your Library

If you plan to write OS/2 programs, the Letwin and Iacobucci books can add substantially to your understanding of OS/2: They function much like the revered Kernighan and Ritchie "white" book that specifies the C language. PS/2 programmers will also find useful information in *OS/2 Features, Functions, and Applications*. Only novices who find themselves in front of a computer running OS/2 might consider Jamsa's book.

For the general-to-advanced reader, I particularly recommend *Inside OS/2*. For readers who will be doing extensive OS/2 programming, *OS/2 Programmer's Guide* is a necessity.

All four books help shed light on the mysterious workings of OS/2. But none succeeds in revealing why or how OS/2 might change the face of personal computing. I suspect that The Book on OS/2 might be a long time coming. ■

BRIEFLY NOTED

Programming Translation Fundamentals *by Peter Calingaert, Computer Science Press, Rockville, MD: 1988, 366 pages, $36.95.* This book shows perhaps the best balance of theory and application that I've seen. For his examples, Calingaert uses pseudocode reminiscent of PL/1 or Modula-2 for high-level code, and for his assembly language examples he uses an assembly language that you could easily mistake for Knuth's MIX. His explanations are clear-cut and readable, not bogged down by abstract notational syntax that can obscure what is actually going on.

The author starts off with an abbreviated exploration of one- and two-pass assemblers. Then, rather than jump immediately into the subject of program translation for higher-level languages, he takes a dip into what he refers to as "program modules." This is a discussion of how routines (modules) are activated during a program's execution (taken, of course, from a high-level-language point of view), including the important issue of variable scoping. Having thus given the reader a good view of what a compiler (or an inter-

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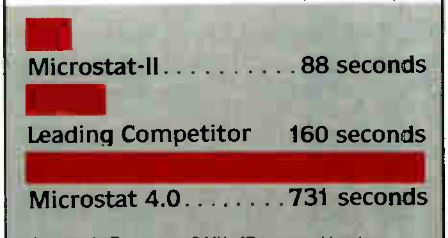

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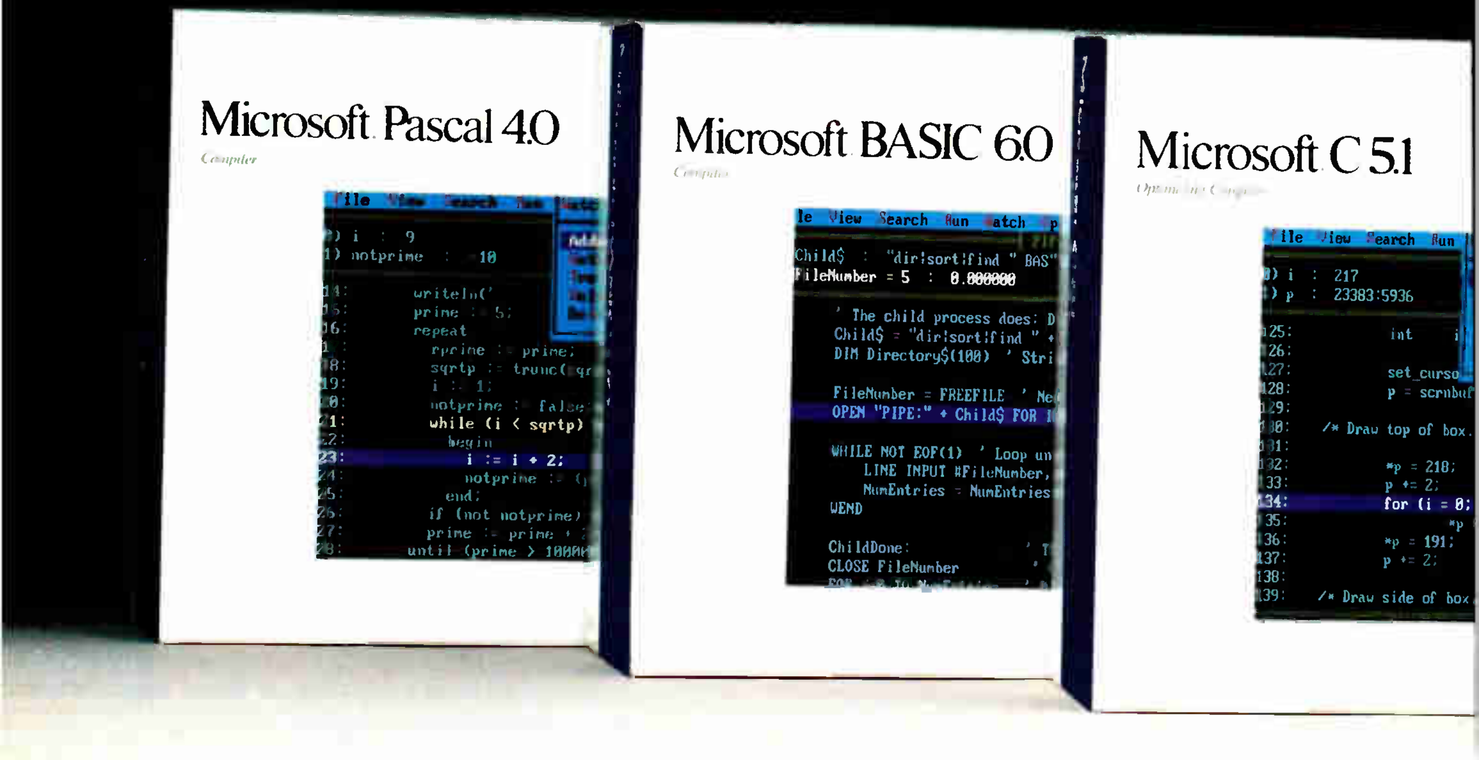
Introducing Mic for OS/2



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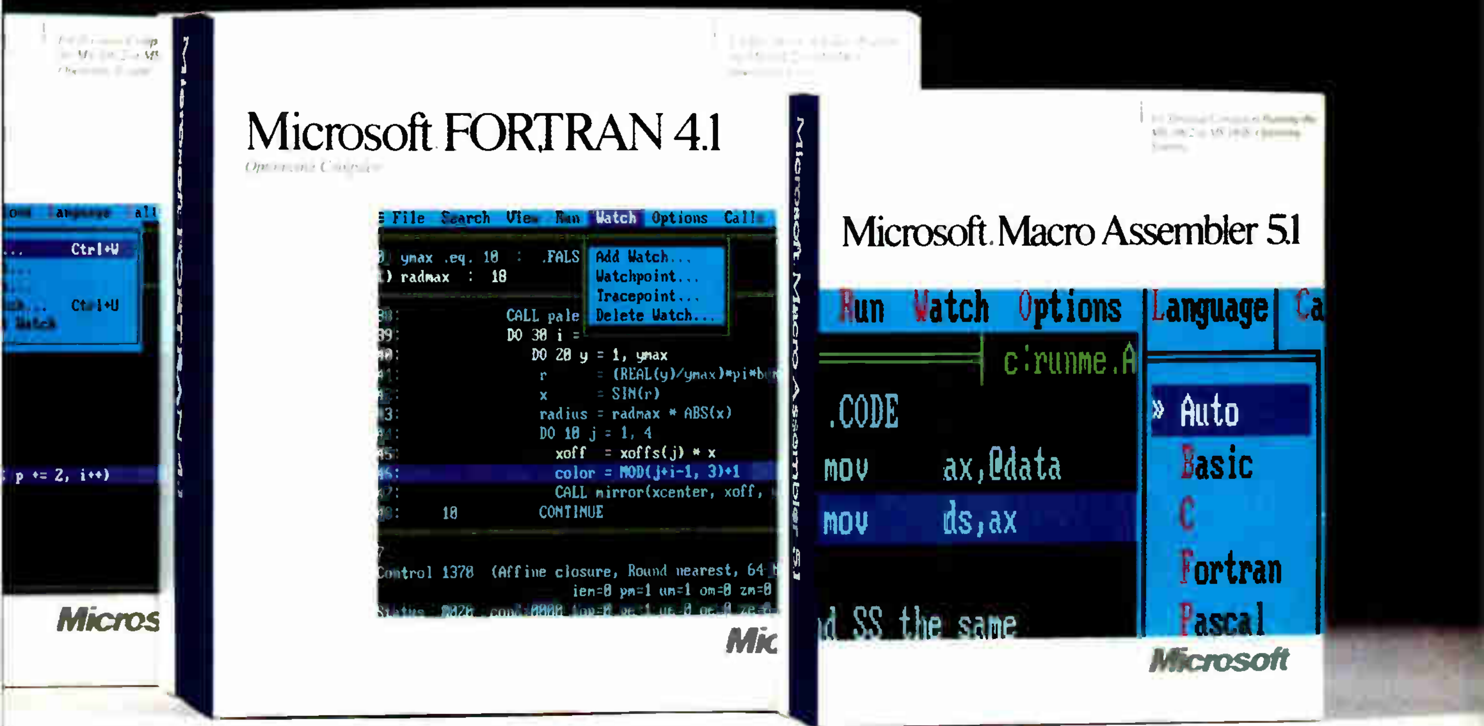

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preter) seeks to accomplish, the author describes the fundamental steps of compilation: lexical analysis, syntactic analysis, semantic processing, storage allocation, and target code generation.

Though none of the material is attached to a specific machine or language architecture (other than that the book examines only procedural languages), the explanations are lucid enough to make the material worthwhile.

—*Richard Grehan*

Programming Language Translation *by Patrick D. Terry, Addison-Wesley, Reading, MA: 1987, 443 pages, $26.95.* This book is aptly named. It includes more source code than many of the currently popular application toolbox books. "Complete" would be a good word to use: You'll find the complete source code for a macro assembler (for an 8-bit processor that looks like a 6800 with a foreshortened index register), complete source code of an interpreter ("simulator" might be a better word) for a hypothetical stack-based processor reminiscent of the Pascal P-machine, and the complete source code for the compiler/interpreter for a Pascal-like language called CLANG (an abbreviation of "concurrent language"). (Although the compiler generates code for a hypothetical stack machine that the author admits is too idealized, he adheres to his own book's title by discussing code generation for a real processor: the Z80.)

Terry's technique is powerful: He details the problem at hand, follows with an outline of the solution, and rounds off with actual source code. All the high-level-language source code examples are in Pascal. It's refreshing to see algorithms backed by executable source code rather than pseudocode. I found that this made an excellent companion book to *Programming Translation Fundamentals*. Whereas the *Programming Language Translation* volume becomes hazy in theoretical descriptions—choosing to let programs reveal the details—*Programming Translation Fundamentals* could have stood more practical examples.

Not to slight Terry, mind you. Working source code often makes the best computer science textbook, and his book delivers the goods.

—*Richard Grehan*

The IBM Programmer's Challenge and **The Apple Programmer's Challenge** *by Steven Chen, TAB Books, Blue Ridge Summit, PA: 1987, 225 pages (IBM), 228 pages (Apple), $14.95.* Just how good a programmer are you? This book, which is available in versions for IBM and Apple II computers, will help you find out. Steven Chen presents 10 sets of problems; each set contains 5 specific programming challenges, with time limits and details on input and output required.

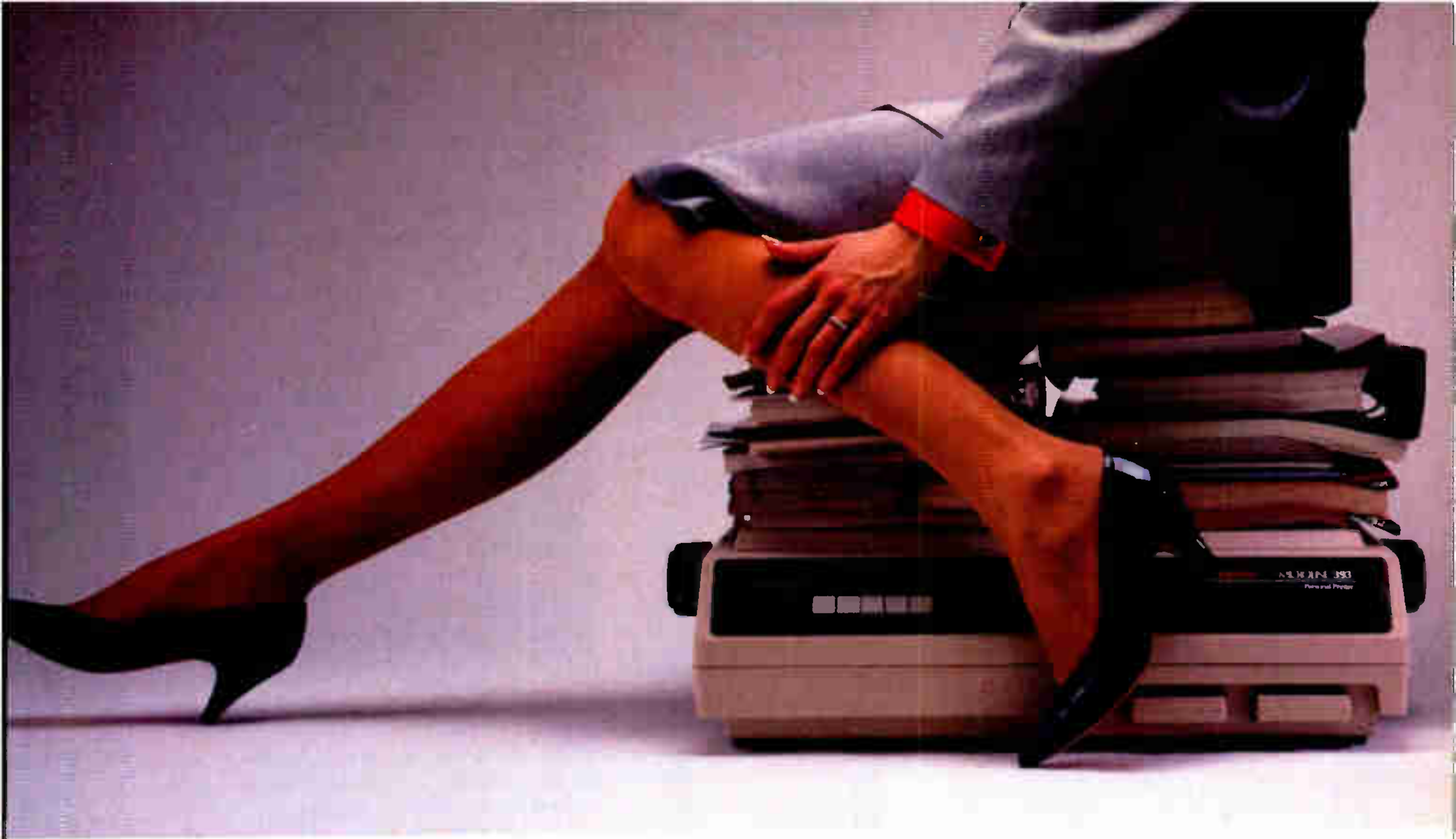
After you solve (or attempt to solve) the problems, you use Chen's guide to compute a rating for your work based on the time required to design, code, and test your program; the number of variables you used; and the execution time of your program. You can compare your results with Chen's programs, which are given in C, Pascal, and BASIC.

Programming areas include number theory, conditional statements, repetition statements, overflow problems, and restricted memory programming. The book includes 50 specific programming challenges in all.

In *The IBM Programmer's Challenge*, source code is given in GWBASIC, Turbo Pascal, and Microsoft C. In *The Apple Programmer's Challenge*, source code is given in Applesoft BASIC, Apple Pascal, and Aztec C.

The book is great for recreational programmers, but, more important, it's a good way to polish up your programming skills. And if you

continued



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know only one or two of the languages used, the book also becomes a hands-on way to begin learning a new language.

—*Eva M. White*

Mind Tools: The Five Levels of Mathematical Reality *by Rudy Rucker, Houghton-Mifflin, Boston, MA: 1987, 328 pages, $17.95.* The Roman numeral *V* may be an abstract picture of a hand with thumb outstretched, but "how many fingers?" is only the most obvious of the number-oriented questions you can ask about your hand. Number of hairs? Length of fingernails? Temperature? Salinity? Blood flow rate?. . .On the first page of *Mind Tools*, Rudy Rucker invites you to think of your hand as a "coding up" of such numbers: as a compact record of the information they contain.

That is one subtle sign of a revolution that has made our old world of hands, cats, trees, and so on, about which we busily collected information, obsolete. This revolution has also opened up a world that already *is* the most compact form of all the information we can possibly have "about" it. Obvious phases of the revolution include Claude Shannon's Information Theory of the 1940s, the cracking of the DNA code in the 1960s, and the coming of the microprocessor in the 1970s. Rucker fits in Conway's Game of Life, Mandelbrot's fractals, Universal Turing Machines, Goedel's Incompleteness Theorem, and a good deal more, not just dropping names but really making concepts clear.

Unlike many math books for nonmathematicians, *Mind Tools* is much more than a gallery full of curiosities. As Rucker's exposition weaves among the exhibits, they cohere with one another to define a cosmos in which Number, Space, Logic, and Infinity are essentially faces worn by Information; physical systems are information processors; and life itself is "a fractal in Hilbert space." If you'll read up to that statement in its context, you'll find to your possible surprise that you really do understand what it says.

—*Hugh Kenner*

Elements of Functional Languages *by Martin C. Henson, Blackwell Scientific Publications, Oxford, England: 1987, 434 pages, $78.75 (hardcover), $40.50 (paperback).* Most programmers, having been raised on imperative programming languages that currently dominate the industry, might find functional languages (e.g., Lisp) a difficult pill to swallow. However, given the rising interest in artificial intelligence applications, some exposure to the fundamentals of functional languages seems necessary. Martin C. Henson's book provides such an introduction.

Not that the entire book is theory. Later material covers the more practical aspects of language implementation details and gives descriptions of data structures and pseudo-machine architectures on which some functional languages are built. Additionally, the chapters on program verification and transformation offer information and examples useful even in imperative programming. For the novice, *Elements* may be too dense. However, experienced users should find the book a worthwhile map for exploration into the growing field of nonimperative programming languages.

—*Richard Grehan*

CONTRIBUTORS

G. Michael Vose (P.O. Box 3160, Peterborough, NH 03458) is a former BYTE editor and the current editor of the newsletter *OS Report: News and Views on OS/2*. **Richard Grehan** is a senior technical editor at large for BYTE. He can be reached as "rick_g" on BIX. **Eva M. White** is a technical editor for BYTE. She can be reached on BIX as "eva." Critic and author **Hugh Kenner** lives in Baltimore, Maryland.

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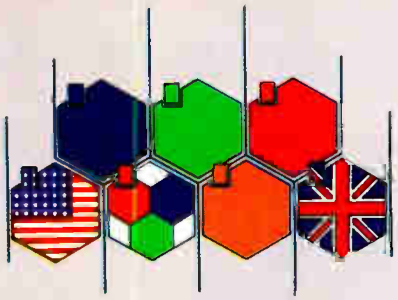

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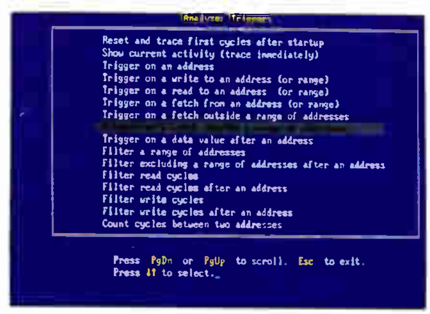

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PRODUCTS IN PERSPECTIVE

The Tandy 5000 MC is the first Micro Channel compatible.

Radio Shack Has High-Speed PS/2 Clone

The Tandy 5000 MC is the first available computer that is compatible with the Micro Channel architecture (MCA) on the IBM PS/2 systems. It's also very fast.

Inside the 5000 MC is a 20-MHz 80386 processor with a 32K-byte cache of 35-nanosecond static memory. For graphics, a VGA graphics controller is included. Memory ranges from 2 to 16 megabytes. The system also has two 32-bit MCA expansion slots and three 16-bit MCA slots. A video bus connector is available for optional high-resolution MCA video cards.

Externally, the new Tandy machine looks about the same size as the company's older 80386-based system, the Tandy 4000. One difference is that the front panel of the new system has space for four half-height data storage devices (two 3½-inch devices and two 5¼-inch devices). One 3½-inch floppy disk drive comes standard.

Price: $4999; $6499 with 40-megabyte hard disk drive.

Contact: Radio Shack, 1700 One Tandy Center, Fort Worth, TX 76102, (817) 390-3011.

Inquiry 751.

Dell's 80286 System Beats Some 80386s

Dell Computer has introduced what may be the fastest 80286 system around. The new Dell System 220 uses an 80286 microprocessor, but it outperforms some 80386-based systems. The reason? A new 20-MHz CMOS 80286 processor from Harris, which allows the system to run faster than many 16-MHz 80386-based systems. For example, according to a small sample of BYTE benchmarks, the System 220 was 5 percent to 25 percent faster than IBM's 80386-based PS/2 Model 80 with a 16-MHz clock speed.

Although the System 220 is rather small—Dell claims its footprint is smaller than that of the IBM PS/2 Model 30—it includes a number of features as standard. Included on the motherboard, for example, are a VGA and 1 to 8 megabytes of memory.

The System 220 has only three AT-style slots and a power supply of only 85 watts. However, the company says that the power supply is sufficient for almost all types of add-in boards because of the system's CMOS processor.

Price: $1595 with a floppy disk drive only; $2699 with 40-megabyte hard disk drive and color VGA monitor.

Contact: Dell Computer Corp., 9505 Arboretum Blvd., Austin, TX 78759, (512) 338-4400.

Inquiry 752.

PICK System Network Supports 16 Users

The Zebra 1620 multiuser business system from General Automation represents the company's first venture into the small systems marketplace. This entry-level, 12.5-MHz, zero-wait-state, multiuser business system is based on the 32-bit Motorola MC68020 microprocessor and functions with the PICK operating system.

The system unit (5 by 17 by 17 inches, weighing 35 pounds) comes with 1 megabyte of RAM (expandable to 2 megabytes), one 40-megabyte or 67-megabyte hard disk drive, and a 45-megabyte or 60-megabyte ¼-inch tape drive. It has 8 asynchronous CRT terminal or serial printer ports, expandable to 16, and there is one parallel printer port. Options include a 16.7-MHz microprocessor. Keyboards and monitors are not included in the standard system package.

Standard software includes Accu/Plot II, for business graphics; Compu-Sheet+, a spreadsheet; and Jet, for word processing. While this model of the Zebra series doesn't support the standard PC graphics cards, there are two full-size expansion slots, one of which you can use for optional hardware to support the ARCnet 2.5-megabit-per-second token-passing-ring local area network (LAN).

You can also purchase boards and other equipment to upgrade the 1620 to a Zebra 1820, a 32-user system that runs at 20 MHz with 4 megabytes of RAM and a total of three 140-megabyte hard disk drives. Several other General Automation higher-end systems are also compatible with the Zebra 1620 and 1820.

Price: $12,500; $4000 for 1820 upgrades.

Contact: General Automation, Inc., 1055 South East Street, P.O. Box 4883, Anaheim, CA 92803, (714) 778-4800.

Inquiry 753.

continued

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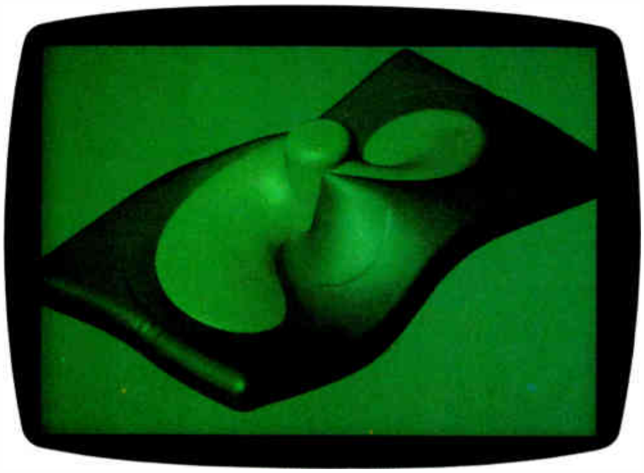
We'd like to consider your product for publication. Send us full information, including its price, ship date, and an address and telephone number where readers can get further information. Send to New Products Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Information contained in these items is based on manufacturers' written statements and/or telephone interviews with BYTE reporters. BYTE has not formally reviewed each product mentioned.

PERIPHERALS

ModelViewer PC Produces High-Resolution Photos

Two- and three-dimensional slides, prints, and transparencies of computer-generated images are the products of the DI-100 ModelViewer PC, an XT- and AT-compatible digital imaging system that works with a camera. Data Innovations has targeted such applications as marketing presentations and design documentation.

In 3 minutes or less, the ModelViewer produces CAD/CAE solid designs, molecular models, and other scientific images. Consisting of a film recorder, a graphics processor card, interface software, and up to three camera adapters, the ModelViewer has a database of up to 32,768 colors for image resolution of 640 by 480 or 1024 by 800 pixels.
Price: $4995; $495 for 35mm camera adapter; $95 for automatic slide developing system; $395 for overhead transparency camera adapter; $50 each for software interfaces for VersaCAD, Personal Designer, or AutoShade.
Contact: Data Innovations, Inc., 323 New Boston St., Wilmington, MA 01887, (617) 933-8170.
Inquiry 754.



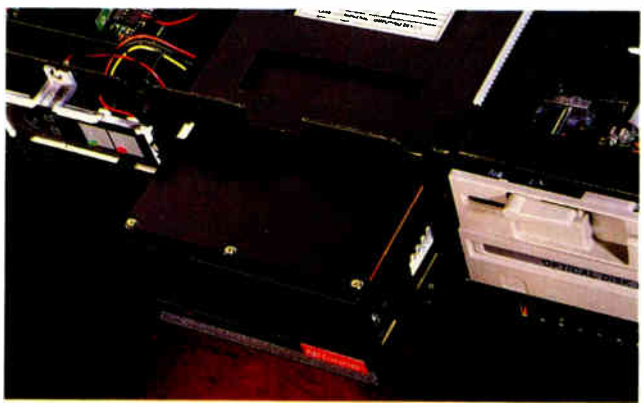
A slide produced by ModelViewer PC.

Keep Your Laptop Data Safe

While there are several companies with hard disk backup equipment for IBM, Macintosh, and other standard-size personal computers, Axonix seems to be the first to offer such equipment for the burgeoning laptop market. Its Thinstream XT/AT is a 40-megabyte streaming tape backup system for laptop storage, which is becoming much more hard-disk-drive-intensive.

Potential markets include intra-office backup, backup of field measurement information, and military information backup.

Double-shielded copper cabling from the floppy disk drive port permits backup of 20 megabytes of hard disk data from an AT machine in less than 20 minutes, at 500 kilobits per second (250 kilobits per second on the XT). The tape system weighs less than 3 pounds and measures 2 by 5 by 8 inches.
Price: $849 for the XT model; $899 for the AT model.
Contact: Axonix Corp., 2257 South 1100 E, Suite 2C, Salt Lake City, UT 84106, (801) 466-9797.
Inquiry 755.



High-capacity hard disk drives from N/Hance.

Solutions for Mass-Storage Problems

For high-end processing applications with PC compatibles, the N/Hance Systems division of Symphony Systems has introduced 150- and 300-megabyte hard disk drives.

Initial applications include CAD/CAM, office automation, process control, and digital imaging. All the full-height 5¼-inch drives are equipped with a small computer system interface (SCSI) and can be daisy chained for multiple drive configurations. A high-speed enhanced small device interface (ESDI) is also available, with disks for both XT and AT systems.

You can install disks for the XT and AT systems both internally and externally with the Model HCS-pcs150 and Model HCS-pcs300 controller/adapter boards.

Models HCS-sun150, HCS-mac150, and HCS-mac300 are available for the Sun-3 and Mac Plus, II, and SE. Track-to-track access time is rated at 4 ms.

All drives will run DOS, Xenix, Unix, and Novell.
Price: $3699 for HCS-pcs150; $5299 for HCS-pcs300; $3999 for HCS-sun150; $3499 for HCS-mac150; $4399 for HCS-mac300. (All prices include interface cards and necessary cabling.)
Contact: N/Hance Systems, 908R Providence Hwy., Dedham, MA 02026, (800) 289-9676; in Massachusetts, (617) 461-1970.
Inquiry 756.

"Scuzzy" Apples

Apple Crate's new 20-, 40-, and 60-megabyte SCSI drives fit under the Mac Plus, SE, and II, and include ports that let you daisy chain up to seven devices. Utilities for formatting, initializing, testing, and verifying the disks are standard. There's also a help function.

Average access time on the 20-megabyte system is 60 ms. For the 40-megabyte and 60-megabyte systems, access time is 40 ms.
Price: $560 for the 20-megabyte drive; $770 for the 40-megabyte drive; $839 for the 60-megabyte drive.
Contact: Apple Crate, Inc., 6850 Vineland Ave., North Hollywood, CA 91605, (818) 766-4001.
Inquiry 757.

continued

Why Paradox 2.0 makes your network run like clockwork

Paradox® runs smoothly, intelligently and so transparently that multiple users can access the same data at the same time—without being aware of each other or getting in each other's way.

With Paradox news travels fast and it's always accurate

Paradox *automatically* updates itself with a screen-refresh that ensures that all the data is up to date and accurate all the time. Record-locking, Paradox-style, safeguards data integrity by preventing for example, two different users from making changes to the same record at the same time.

How to make your multiuser network work

To run Paradox 2.0 or the Paradox Network Pack on a network, you need:

- Novell with Novell Advanced Netware version 2.0A or higher
- 3Com 3Plus with 3Com 3+ operating system version 1.0, 1.1 or higher
- IBM Token Ring or PC Network with IBM PC Local Area Network Program version 1.12 or higher
- Torus Tapestry version 1.45 or higher
- AT&T Starlan version 1.1 or higher
- Banyan VINES version 2.10
- Other network configurations that are 100% compatible with DOS 3.1 and one of the listed networks

System Requirements for the Network Workstation

- DOS 3.1 or higher
- 640K RAM
- Any combination of hard, floppy, or no disk drives
- Compatible monochrome, color, or EGA monitor with adapter

*Customer satisfaction is our main concern; if within 60 days of purchase this product does not perform in accordance with our claims, call our customer service department, and we will arrange a refund.

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“When I saw the record-locking and autorefresh in action, I couldn't believe it. Here was a true network application, a program that can actually take advantage of a network to provide more features and functions, things that can't be done with a stand-alone PC.

Aaron Brenner, LAN Magazine

With Version 2.0, Paradox becomes a sophisticated multiuser product that boasts an impressive selection of data-production features and password-security levels.

Rusel DeMaria, PC Week ”

Paradox responds instantly to "Query-by-Example"

The method you use to ask questions is called Query-by-Example. Instead of spending time figuring out *how* to do the query, you simply give Paradox an example of the results you're looking for. Paradox picks up the example and automatically seeks the fastest way of getting the answer.

Queries are flexible and interactive. And in Paradox, unlike in other databases, it's just as simple to query more than one table as it is to query one.

“The program elegantly handles all the chores of a multiuser database system with little or no effort by network users.

Mark Cook and Steve King, Data Based Advisor ”

“Paradox . . . has quickly become the state-of-the-art product among PC database managers . . . Paradox still reigns supreme as the thinking user's DBMS.

Jim Seymour, PC Magazine ”

You don't have to be a genius to use Paradox

Even if you're a beginner, Paradox is the only relational database manager that you can take out of the box and begin using right away.

Because Paradox is driven by the very latest in artificial intelligence technology, it does almost everything for you—except take itself out of the box. (If you've ever used 1-2-3® or dBASE,® you already know how to use Paradox. It has Lotus-like menus, and Paradox documentation includes "A Quick Guide to Paradox for Lotus Users" and "A Quick Guide to Paradox for dBASE users.") Paradox, it makes your network work.

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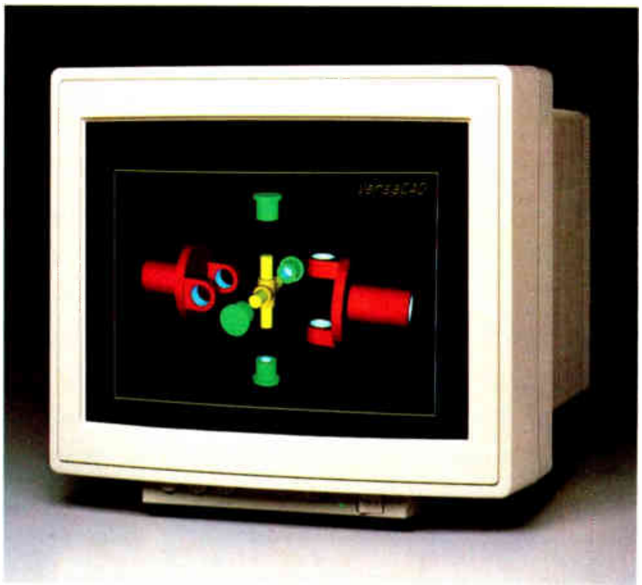
BORLAND
INTERNATIONAL

Sony's CAD/CAM Monitor Competes with the Big Boys

Sony Corporation of America has four new XT- and AT-compatible CAD/CAM color monitors to compete against higher-priced CAD/CAM workstations.

Two 19-inch models, with horizontal scan frequencies of 64 and 48 kHz, respectively, will be available next month to complement the two 16-inch monitors (with the same respective horizontal scan frequencies) that will be available in the fall. Each of the monitors will need CAD add-in boards (available from a number of vendors), bringing system pricing to $15,000.

The 19-inch monitors' specifications include vertical frequencies rated at 60 Hz, a display area of 14½ by 10 inches, dot pitch of 0.31 millimeter, aperture grille resolution of 1280 by 1024 pixels, and a bandwidth of 100 MHz.
Price: $4195 for either 19-inch monitor; $3095 for either 16-inch monitor.
Contact: Sony Corporation of America, Computer Peripheral Products Division, One Sony Dr., Park Ridge, NJ, 07656, (201) 930-1000.
Inquiry 758.



Sony's AT-compatible CAD/CAM monitor.

Acquire and Control Data with Your Mac

Replacing such instruments as oscilloscopes, chart recorders, and voltmeters is the MacPacq, a data acquisition and device-control peripheral designed for the Mac. It is compatible with all Macs from the 512Ke on up.

Modem or printer-port connections from the Mac instruct the MacPacq on how to acquire data from one of up to 16 different devices. The devices can include anything from microphones and solar cells to speakers and indicator lights. Instructions from the Mac enable the MacPacq to control external devices through eight channels.

MacPacq can run as a stand-alone or connected to the Mac. It can simultaneously control external devices and acquire data. Sampling rates range from 2 samples per hour to 10,000 samples per second.

PacqManager software lets you print the data in a chart recorder format or record and save the data in a word-processing, database, or numerical analysis format. For example, the MacPacq can output square waves to 500 kHz.
Price: $995, including software.
Contact: Biopac Systems, 42 Aero Camino, Suite 215, Goleta, CA 93117, (805) 968-8880.
Inquiry 759.

High-Speed, High-Resolution Color Output

The Accel-500, a dot-matrix color printer from Advanced Matrix Technology (AMT), is designed for power users and power computers. AMT, a division of the Singapore-based Lam Soon Group, says speed is rated at 480 characters per second (cps) for 12- and higher-pitch printing of draft documents.

For more important documents, the Accel-500 combines letter-quality text with color resolution graphics and still operates at a sound level of less than 55 decibels. Methods of printing are serial impact, dot matrix, and logic-seeking; movement is bidirectional. During 10-pitch printing, speed is 400 cps. It operates at 200 cps and 80 cps for memo and letter modes, respectively.

Standard features include a 24-pin pinhead, addressable seven-color graphics, a built-in forms tractor, four fonts (each supports six pitches), five coresident printer emulations, and a plug-in IntelliCard for upgrades.

The 37-pound printer measures 7 by 24 by 17 inches. A Centronics-compatible parallel interface and an RS-232C serial interface are standard.
Price: $1185.
Contact: Advanced Matrix Technology, Inc., 1157 Tourmaline Dr., Newbury Park, CA 91320, (805) 499-8741.
Inquiry 760.

MusicMaker from Roland

For IBM XTs, ATs, and PS/2s, RolandCorp US has introduced equipment for recording, playing back, and editing up to eight tracks of music. Included in the package is the EASE (editing, arranging, and sequencing environment) Song Maker software, the MT-32 sound module, and an MPU-IPC musical instrument digital interface (MIDI) card.

Under EASE, menus and submenus let you perform general functions such as recording a musical phrase and scoring individual tracks. You can also perform specific functions, such as deleting incorrectly played notes.

Once familiar with the equipment, you can play all of the eight available synthesized sounds and the one rhythm sound simultaneously. Then you can assign functions to each of the synthesized parts: panning, volume, transposition, bender range, and velocity. A built-in reverb section allows you to select up to four reverb modes from the MT-32, process them, and add them to the composition.
Price: $995.50.
Contact: RolandCorp US, 7200 Dominion Cir., Los Angeles, CA 90040, (213) 685-5141.
Inquiry 761.

continued

Transputer Brings 3-D CAD to PCs

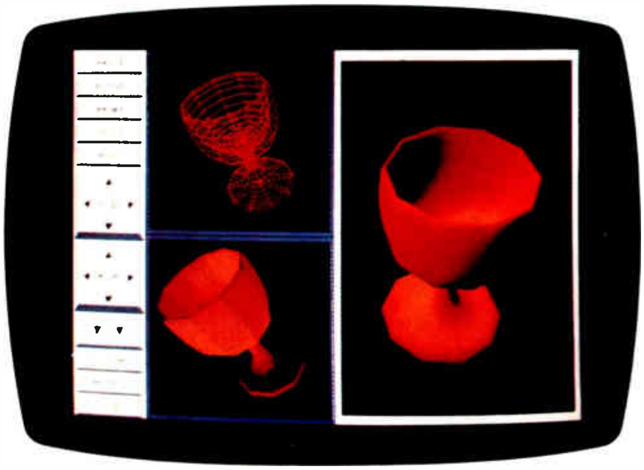
Three-dimensional CAD is now possible on IBM PCs and compatibles with the first Transputer-based graphics card, says manufacturer Nth Graphics Display Products. The company claims the Nth 3D Engine can write 40,000 three-dimensional vectors per second or draw 10,000 constant-shaded polygons (with 500 pixels each) per second. In addition, the famous Teapot model (1200 polygons) can be flat-shaded and rotated in ¼ second.

The board comes with 1 megabyte of video RAM and 2 megabytes of display list RAM. It drives high-resolution monitors with resolutions of up to 1024 by 768 pixels and a 60-Hz noninterlaced refresh rate. The board can display 256 simultaneous colors from a palette of 4096.

There's also an optional full-length expansion card that produces higher resolutions, faster shading speeds, more processing power, and memory for a Z-buffer, the company says.

Power comes from parallel-processing INMOS microprocessors and proprietary graphics coprocessors. One of the microprocessors, a 10-million-instruction-per-second floating-point processor, manages the display list and processes other graphics functions parallel to other on-board processors. Other microprocessors are used in parallel for scan control and complex rendering.

Price: $5995; $2000 for optional expansion card.
Contact: Nth Graphics Display Products, 1807-C West Braker Lane, Austin, TX 78758, (800) 624-7552; in Texas, (512) 832-1944.
Inquiry 762.



The Nth 3D Engine's model manipulation.

"What Was That, R2?"

Helping the physically handicapped answer telephones and activate appliances are the aims of the voice recognition and speech synthesis equipment from The Voice Connection. But inventory control, assembly-line quality control, and medical data entry are also potential applications.

That's what the IBM-compatible IntroVoice VI system is all about. It's designed to "listen" to one of the 500 commands and data entries and respond by sending keystrokes to the computer and text to the on-board synthesizer for audio output verifications and prompting. According to the company, it recognizes the word on the first try 98 percent of the time. Subvocabularies (with 500 words maximum) are also recognized through the main vocabulary.

Included in the package are a half-length circuit board, a hand-held microphone, a manual, and a speaker. Software includes AutoCAD, Voice Executive, and examples of vocabularies.

Price: $595.
Contact: The Voice Connection, 17835 Skypark Circle, Suite C, Irvine, CA 92714, (714) 261-2366.
Inquiry 763.

Board Unites Apple and IBM

The Deluxe Option Board, a PC expansion card from Central Point Software, transforms your standard 720K-byte 3½-inch PC AT or PS/2 floppy disk drive into a dual-purpose IBM/Mac drive.

The board fits into a half-length slot and includes software that emulates the Mac's Hierarchical and Macintosh File Systems. When you use a Mac disk, you need only add an *M* before the usual DOS command. You can also create and delete folders, format and copy 400K-byte and 800K-byte disks, and display Mac directories with a `tree` command.

Central Point says it will introduce a card with Micro Channel PS/2 compatibility next month.

Price: $159.
Contact: Central Point Software, Inc., 9700 Southwest Capitol Hwy., Portland, OR 97219, (503) 244-5782.
Inquiry 764.

Convert Mac II Images to Standard Video

Now you can save Macintosh II–generated video on standard VCRs and other video peripherals. RasterOps Corp. has introduced a color graphics board featuring video output to televisions meeting National Television System Committee (NTSC) and Phase Alternating Line (PAL) standards.

The ColorBoard 100, a full-size card, provides resolution as sharp as 1024 by 768 pixels, with 8 bits per pixel of color information from a palette of 16.7 million colors.

Price: $1495 for board and either interface; $2495 for 16-inch color monitor.
Contact: RasterOps Corp., 10161 Bubb Rd., Cupertino, CA 95014, (408) 446-4090.
Inquiry 765.

AT Engines Rebuilt Cheap

Replacing your AT motherboard with the Absolute 16/0 AT board is like rebuilding the engine on the old car instead of buying a new car.

The new "engines," with three chips from G2 Corp., are comprised of 16-MHz, zero-wait-state motherboards with 1 megabyte of 60-ns RAM. New 80286 machines with 20 ICs do the work that originally took about 150 ICs.

Price: $975; $999 installed.
Contact: AdvanTech Corp., 261 Cedar Hill St., Marlborough, MA 01752, (800) 338-3130; in Massachusetts, (617) 481-6009.
Inquiry 766.

continued

The LOGITECH HiREZ Mouse—the only mouse expressly designed for high-resolution screens.

With a resolution of 320 dots-per-inch (as compared with 200 dpi or less for ordinary mice), it covers the same area on your high-res screen, but needs less of your desk to do it. More than 50% less. Saving you valuable desk space, and effort: mouse maneuvers that used to require a sweep of the hand are now reduced to a flick of the wrist.

The LOGITECH HiREZ mouse needs 50% less desk space to cover the same amount of screen area as a 200 dpi mouse.

Which makes this new mouse a hand's best friend. And a more reliable, long-lasting companion—fully compatible with all popular software, and equipped with a Lifetime Guarantee.

Equipped, too, with other advantages exclusive to all Logitech mice: A unique lightweight ergonomic design. Low-angled buttons for maximum comfort and minimum fatigue. An exclusive technology that guarantees a much greater life span. An exceptionally smooth-moving, dirt-resistant roller ball. And natural compatibility with all PCs, look-a-likes, and virtually any software.

So if you've got your eyes on a high-res screen, get your hands on the one mouse that's agile enough to keep up with it.

The LOGITECH HiREZ Mouse.

For the dealer nearest you, call **800-231-7717 (800-552-8885** in California), or write Logitech, Inc., 6505 Kaiser Drive, Fremont, CA 94555. In Europe, call or write: Logitech Switzerland, European Headquarters, CH-1111 Romanel/Morges, Switzerland (++41-21-869-9656).

LOGITECH

Circle 150 on Reader Service Card (Dealers: 151)

How to pick th

Good instincts run in this family (left to right): the new LOGITECH HiREZ Mouse ($179), the only mouse designed expressly for high-res screens; the LOGITECH Series 2 Mouse for the IBM PS/2 ($99, plugs right into mouse port); and the LOGITECH Mouse for standard screens ($119, in bus and serial versions).

All come with Logitech's own Plus Software, which assures ease of use with virtually any software, mouse-based or not.

Though most mice out there look pretty much alike, they're not all equal in performance. It pays to be just a little choosy to make sure you end up with the right mouse for your needs.

Starting with software. If you want full compatibility with all of your software, all you have to do is look for a mouse with the Logitech name. There are four in all, each one designed for different hardware needs.

THE HiREZ MOUSE

If you've got your eyes on a high-resolution screen, the mouse to get your hand on is the new LOGITECH HiREZ Mouse.

With a resolution of 320 dots-per-inch (as compared with 200 dpi or less for ordinary mice), it covers the same area on your high-res screen but needs less of your desk to do it. More than 50% less. Saving you valuable desk space, and effort: mouse maneuvers that used to require sweeps of the hand are now reduced to a flick of the wrist.

Which makes this new mouse a hand's best friend. And a more reliable, long-lasting companion. And, like all Logitech mice, it's fully compatible with all popular software, and equipped with a Lifetime Guarantee.

The LOGITECH HiREZ Mouse needs 50% less desk space to cover the same amount of screen area as a 200 dpi mouse.

THE SERIES 2 MOUSE

For those who've chosen the Personal System/2,™ the most logical choice is the LOGITECH Series 2 Mouse. It's 100% compatible with PS/2, and plugs right into the mouse port, leaving the serial port free to accommodate other peripherals.

e right mouse.

THE ALL-PURPOSE MOUSE: SERIAL OR BUS

Most people find our standard mouse is still the best choice for their systems. It's available in both bus and serial versions, one of which is sure to fit perfectly with your hardware. And with all your favorite software—whether mouse-based or not.

It's hardly an accident that only Logitech offers you such a complete selection—we're the only mouse company to design and manufacture our own products. We make more mice, in fact, than anyone else. Including custom-designed models for OEMs like AT&T, DEC, and Hewlett-Packard.

The three mice pictured to the left come with all this expertise built right in. Which explains an interesting paradox: while you may pay less for a Logitech mouse, you'll surely get more in performance.

A Logitech mouse plus Logitech application software equals a complete solution (all prices include mouse, Plus Software, and application):

LOGICADD...$189. Turns your PC into a full-featured CADD workstation. Everything you need for dimensioned line drawing and CADD.

PUBLISHER PACKAGE ...$179. PUBLISHER software lets beginners and experts alike produce professional, high-impact documents. Design templates make page layout easy.

LOGIPAINT SET... $149. Eleven type fonts and a 16-color palette. Creates files that move easily into both LOGICADD and PUBLISHER documents.

(800-552-8885 in California). Or fill out and mail the coupon below to: Logitech, Inc., 6505 Kaiser Drive, Fremont, CA 94555. In Europe, call or write: Logitech Switzerland, European Headquarters, CH-1111 Romanel/Morges, Switzerland (++41-21-869-9656).

And in comfort. With a unique lightweight ergonomic design. Low-angled buttons for maximum comfort and minimum fatigue. An exclusive technology that guarantees a much greater life span. An exceptionally smooth-moving, dirt-resistant roller ball. And natural compatibility with all PCs, look-a-likes, and virtually any software.

All of which leads to an inescapable conclusion: if you want to end up with the right mouse, start with the right mouse company.

Logitech. We've got a mouse for whatever the task at hand.

For the dealer nearest you, call **800-231-7717**

Logitech, Inc., 6505 Kaiser Drive, Fremont, CA 94555.
Logitech Switzerland, European Headquarters,
CH-1111 Romanel/Morges, Switzerland.

Yes! Please send me the name of the nearest Logitech dealer.

Name ______________________

Company/Title ______________________

Address ______________________

Phone ______________________

LOGITECH

Personal System/2 is a trademark of International Business Machines, Corporation.

Circle 152 on Reader Service Card (Dealers: 153)

Emulation to the Max

A host-independent in-circuit emulator from Microcosm helps you find faults in hardware and software when you're designing 80386-based systems and applications.

The hyperICE-386 consists of a microprocessor-specific probe and a universal chassis and gives you access to trace, registers, and memory during the emulation process.

It gives engineers with a dumb terminal, host, workstation, or mainframe a way to uncover hardware and software problems and to otherwise debug systems at full speed by emulating the 80386 at clock speeds up to 25 MHz. Overlay memory runs with zero wait states at speeds to 20 MHz for real-time firmware debugging.

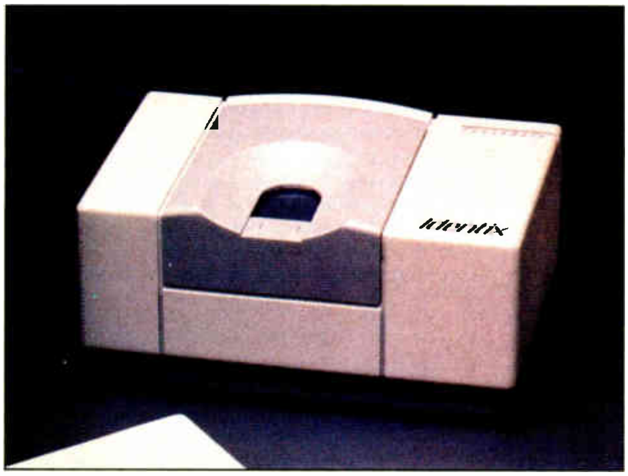
Key features include three 8000-gate arrays for trigger logic—monitoring address, data, and status lines, as well as the 16 logic probe lines. Four levels of triggering are available.

Another feature is the battery-backed RAM trace collection. When combined with the trigger feature, the trace collection feature is said to simplify debugging. System commands, which can be in a macro form and can be modified, are in C.

Price: $17,500, including chassis and probe.

Contact: Microcosm, Inc., 15275-E Southwest Koll Pkwy., Beaverton, OR 97006, (503) 626-6100.

Inquiry 767.



Security Is Only a Fingerprint Away

After a 15-second function enrolls your fingerprint on the hard disk with a mathematic characterization system called the TouchSafe, 2 seconds is all it takes for the future access (or denial of access) to your computer.

Identix has been designing such "biometric" products for several years; the company also sells a similar product for access to high-security military establishments.

Processing hardware can be either an internal module (a single-slot board for PC compatibles) or an external module that connects to any computer system with an RS-232C interface. Included software, Safe Word, is designed by Enigma Logic.

Price: $1795 with internal processor module.

Contact: Identix, Inc., 2452 Watson Court, Palo Alto, CA 94303, (415) 858-1001.

Inquiry 770.

Communications Tester Runs Analog and Digital

Designed to test modems, telephone lines, and computer terminals, the Linktest LT3 combines the functions of a 20-kHz analog test set, a 200K-bps digital bit-error-rate tester, and a digital multimeter. Kapusi Laboratories designed it to test level, noise, and frequency of analog equipment, and volts, ohms, and capacitance of digital equipment.

A built-in intercom allows voice connection between remote testing sites. A front-panel switch allows testing of either CCITT (international) or North American systems. The operating temperature range of the instrument—between −20° and 60°C—facilitates international telephone line testing.

Analog features include frequency measurement to 20 kHz and a transmit-and-receive accuracy of 0.2 decibels, combined. Digital features include data transfer rate measurement of up to 200 kilobits per second (with rated accuracy of ±1 bit per second) and a built-in link scope that the company says is more accurate than a typical oscilloscope.

Price: $3950, with battery charger/AC adapter, cables, and carrying case.

Contact: Kapusi Laboratories, 4701 Patrick Henry Dr., Suite 1702, Santa Clara, CA 95054, (408) 496-1086.

Inquiry 768.

Of Neighbors, Locals, and Those Beyond

You can link personal computers and peripherals to other personal computers by using an entry-level Commix 32 file server and some twisted-pair copper wire. Data rates for file transfer, electronic mail, printer sharing, and terminal emulation range from 300 bits per second to 19.2K bits per second.

Data-switching features include up to 32 asynchronous ports (with an optional synchronous channel module with two ports); expandable user I/O in 4-port module increments; speed and asynchronous format conversion; local echo selectable at any port; and camp-on-queue for port contention.

With an optional Ethernet card and some coaxial cable, you can use the Commix 32 to gain access to mainframe information from your personal computer.

If your business needs expand beyond LANs, a statistical-multiplexing wide-area-network (WAN) board links equipment in different cities with leased telephone lines at up to 64K bits per second, or with an X.25 packet network.

Price: $2595 for a 16-port Commix 32; $3995 for 32-port version; $350 for 4-port cards; $2995 for Ethernet link and additional $218 per port; pricing not set for WAN board.

Contact: Itron, 130 Gaither Dr., Suite 116, Mount Laurel, NJ 08054, (800) 423-8044; in New Jersey, (609) 722-5575.

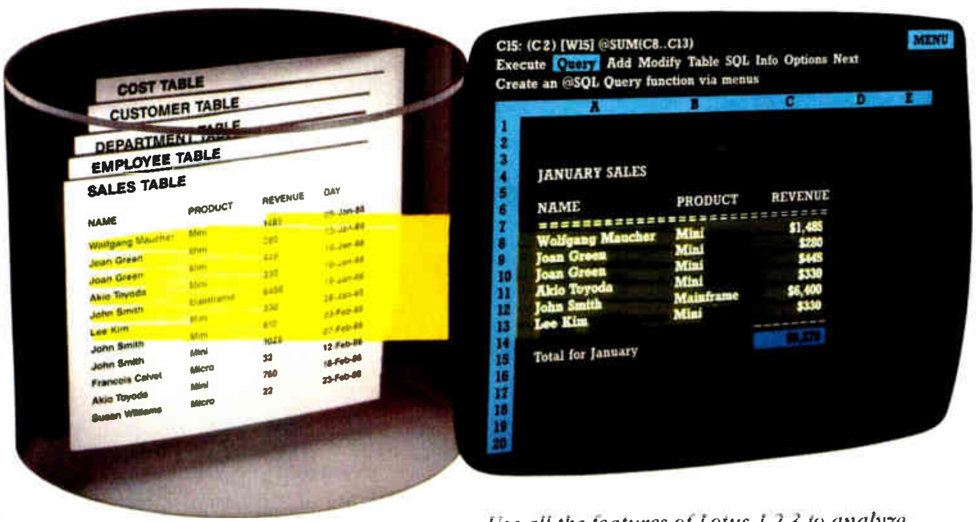
Inquiry 769.

continued

ORACLE® turns Lotus 1-2-3 into a full function database

ORACLE, the world's best selling relational database, now works from inside your Lotus 1-2-3 spreadsheet program. Familiar 1-2-3 menus guide you through creating, modifying and retrieving data in your database. You can even perform ORACLE database functions automatically using standard Lotus macros and formulas. The point is...

> *For a price that's almost unbelievable, this add-in brings the full functionality of a powerful Structured Query Language (SQL) relational database-management system (DBMS) to the PC industry's most popular spreadsheet: Lotus 1-2-3... But perhaps the best news is that Oracle for 1-2-3 is very easy to learn and use. Anyone already familiar with 1-2-3 already knows how to use Oracle for 1-2-3.*
>
> **PC Week, April 5, 1988**



Store unlimited amounts of data in your ORACLE database

Use all the features of Lotus 1-2-3 to analyze, report, and graph data in your ORACLE database.

...If you already know how to use Lotus 1-2-3, then you already know how to use ORACLE, the world's most powerful database.

By putting data into a database, Lotus 1-2-3 spreadsheet's performance is improved, long re-calcs are eliminated and your worksheets are smaller and more manageable.

- Have ORACLE for 1-2-3 build the query automatically for you and retrieve just the data you need.
- A single command automatically creates new database tables from data in any existing worksheet.
- In update mode, changes in your worksheet become changes in your database.

And if you make a mistake, you can...

- Undo changes.

Or save your changes permanently in your database and worksheet.

- Share the same data in multiple worksheets, or even across a network of different computers with many users.

ORACLE®
COMPATIBILITY • PORTABILITY • CONNECTABILITY

Call 1-800-ORACLE1, ext. 149 today.
For international pricing call (415) 598-8290

Act now, get a 30-day moneyback guarantee and we'll pay sales tax and shipping. So fill out and mail the attached coupon, or call today. You can also purchase ORACLE for 1-2-3 at your favorite computer store.

$199* *Yes, this includes the full function ORACLE database.*

Dear Oracle,

ORACLE for 1-2-3 • Oracle Corporation
20 Davis Drive • Belmont, CA 94002

Yes, I have an ☑ 80286/80386 PC running ☑ DOS 3.0+ and ☑ Lotus release 2.01. I also have ☑ 640KB of RAM, plus either ☑ 1MB of extended memory or I will reassign 1MB of my expanded memory as extended memory. Please send me the database I already know how to use — the ORACLE database add-in for Lotus 1-2-3, on ☐ 5¼" or ☐ 3½" disks. Enclosed is my: ☐ check, or ☐ VISA ☐ MasterCard ☐ American Express credit card authorization for $199.*

PRINT NAME DATE

COMPANY TITLE

STREET (No PO boxes please)

CITY STATE and ZIP

PHONE

CREDIT CARD NUMBER

CARD EXPIRATION DATE

SIGNATURE BYTE

TRBA

*Prices valid in U.S. only. © 1988. ORACLE is a registered trademark of Oracle Corporation. Lotus and 1-2-3 are trademarks of Lotus Development Corporation.

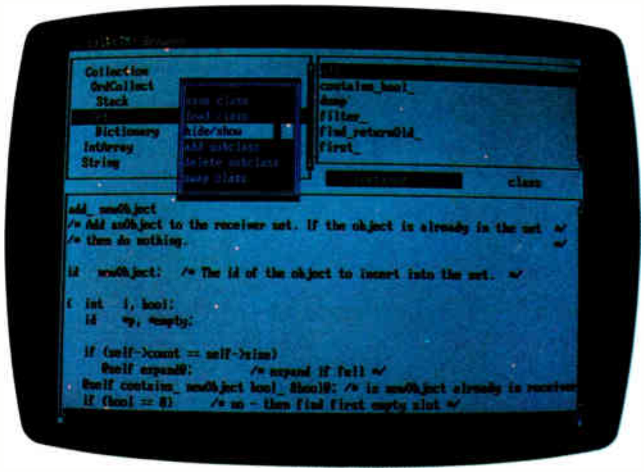
Programming in C

C_talk is an object-oriented programming environment for use with C programming languages. It features a Smalltalk-like browser for defining and editing classes of objects. It lets you browse through all the object classes for a particular application, create new ones, modify existing ones, define the application's structural organization, and edit arbitrary text files.

A preprocessor converts the program's object class descriptions into standardized C source files. The source code for the C_talk run-time environment is also included.

A make utility controls the preprocessing, compiling, and linking of an application program. The browser produces a specification for the make utility based on the set of object classes that you are browsing; you can also add other C source files to the make specification.

C_talk runs on the IBM PC and compatibles with at least 512K bytes of RAM. It supports Microsoft C, Turbo C, Lattice C, and Computer Innovations C86.
Price: $149.95.
Contact: CNS, Inc., 7090 Shady Oak Rd., Eden Prairie, MN 55344, (612) 944-0170.
Inquiry 771.



C_talk features a Smalltalk-like browser.

Debug Turbo Pascal 4.0

In an effort to meet the needs of Turbo Pascal 4.0 programmers, TurboPower Software has developed T-DebugPLUS 4.0. With it, you can control your programs at run time, watch the corresponding source code, single-step, and examine and change values using symbolic names. It also gives you the capability to switch between the debug and output screens.

If you have Expanded Memory Specification or AT extended memory, the debugger uses it for additional storage.

T-DebugPLUS 4.0 runs on the IBM PC, XT, AT, PS/2, or compatibles with at least 256K bytes of RAM.
Price: $45.
Contact: TurboPower Software, 3109 Scotts Valley Dr., Suite 122, Scotts Valley, CA 95066, (408) 438-8608.
Inquiry 772.

Professional Prolog

Applied Logic Systems' Professional Version 1.2 of its Prolog Compiler is now enhanced to assist developers in writing code and distributing applications. It also makes use of virtual code space, letting you create programs larger than available memory.

The ALS compiler is based on Edinburgh-style syntax.
Price: $499.
Contact: Applied Logic Systems, Inc., P.O. Box 90, University Station, Syracuse, NY 13210, (315) 471-3900.
Inquiry 773.

Peabody Helps You Out with Turbo C

If you use Borland's Turbo C 1.5, a pop-up help utility from the Peabody family can give you a hand. Peabody for Turbo C has a database of 560K bytes of information to offer you definitions, examples, and tips on all 563 of Turbo C's functions.

You can place Peabody's help window anywhere on your screen, and a Sticky Key feature lets you post the help message on-screen, return to your program, and copy the syntax of the message. A Hyper Key helps you find definitions, facts, and examples that illustrate keywords in the help windows. And Peabody explains how Turbo C relates to ANSI C, Microsoft C, Lattice C, and other C languages.

The Peabody family is made up of help utilities for Turbo Pascal 3.0 and 4.0 and for Microsoft C 5.0. Copia has plans for an MS-DOS 3.3 utility and one for MASM.

The program runs on the IBM PC and compatibles with at least 256K bytes of RAM and DOS 2.0 or higher.
Price: $89.
Contact: Copia International Ltd., 1964 Richton Dr., Wheaton, IL 60187, (312) 665-9830.
Inquiry 774.

continued

Smalltalk/V: Not So Small Anymore

Smalltalk/V has grown up: Now it's available for 80286 and 80386 systems.

The new version, Smalltalk/V 286, runs in protected mode, can address up to 16 megabytes of RAM directly, and operates under MS-DOS and OS/2. It also supports multitasking, and it is compatible with Smalltalk/V.

Smalltalk/V 286 lets you build systems larger than 64K bytes; they can have over 32,000 objects. It also has expanded debugging capabilities, allowing you to inspect and change all objects and correct source program errors, and allowing single-step program execution. According to Digitalk, the product contains a faster bit block transfer and supports EGA and VGA.

Two extension kits available for Smalltalk/V 286 include Goodies #2—Carleton Tools, which contains a spelling checker and floating-point emulation, and Goodies #3—Carleton Projects, which provides an application browser and a neural network, among other projects.
Price: $199.95; $49.95 each for extension kits.
Contact: Digitalk, Inc., 9841 Airport Blvd., Los Angeles, CA 90045, (213) 645-1082.
Inquiry 775.

Take a peek at Genoa's new PC graphics add-ons.

You've known Genoa as a developer of high performance graphics chips, and a leading manufacturer of graphics boards and tape backup. Soon you'll be able to depend on us for all your PC graphics add-on hardware.

Over the next year, we'll be unwrapping a series of graphics products. Each is designed to give you the most reliable, yet innovative engineering features. And above all, the highest performance possible.

Our SuperVGA HiRes family, featured here, is the first in our new product series. SuperVGA HiRes offers breathtaking color and resolution. From 16 colors in 1024x768. Up to 256 colors in 800x600. You'll see more of your spreadsheets at once with SuperVGA HiRes. 132 columns and 60 rows. You'll do Windows or OS/2. In fact, every SuperVGA HiRes feature is designed to turn your IBM PC/XT/AT and PS/2 models 25 and 30 into real graphics engines.

Delivering SuperVGA HiRes™ now!

- 100% IBM VGA compatible
- Advanced features
  - –1024x768 in 16 colors and 800x600 in 256 colors/Model 5200
  - –512x512 in 256 colors/Model 5100
- 132 columns text
- For both analog and TTL displays

If you're looking for PC graphics add-ons, take a look at Genoa first. Our new line of products is starting delivery *now!*

For the Genoa dealer nearest you or to add your name to our mailing list contact: Genoa Systems Corporation, 73 E. Trimble Road, San Jose, CA 95131. Fax: 408/434-0997. Telex: 172319. Or phone: 408/432-9090. In the UK, contact Genoa Systems Limited, phone: 01-225-3247. In the Far East, contact Genoa/Taiwan, phone: 2-776-3933.

Circle 107 on Reader Service Card

Genoa SYSTEMS CORPORATION

Delivering PC Graphics

408/432-9090

AutoCAD Overlay

CAD Overlay eliminates the usual step of automatic vectorization to convert a scanned image into a vector drawing usable in a CAD model, according to Image Systems Technology. In fact, it works as if you were placing a transparent sheet over an existing drawing and working in CAD on the transparent overlay, the company reports. A scanned image becomes another layer in the CAD model but doesn't interfere with the CAD drawing that you overlay.

CAD Overlay lets you zoom, pan, turn the raster image off and on, remove speckles, change color, and manipulate it like other CAD functions.

The program lets you bring a raster image into AutoCAD so you can scan large numbers of drawings. It stores rasterized plots from any CAD or image system in a universal format, so you don't have to translate between incompatible CAD systems.

CAD Overlay also works with desktop publishing systems, such as Ventura and PageMaker, enabling you to import and export information, drawings, and images in either direction.

The program runs on DOS-based CAD systems with at least 640K bytes of RAM, a hard disk drive, an AutoCAD ADI printer/plotter file-supported graphics card, AutoCAD 2.6X or 9, and DOS 3.0 or higher.
Price: $1000.
Contact: Image Systems Technology, Inc., 251 New Karner Rd., Albany, NY 12205, (518) 452-1147.
Inquiry 776.

Create CAD designs with CAD Overlay.

Create Fast Fourier Transforms in Two Dimensions

Alligator Technologies has announced Two-Dimensional Prime Factor FFT, a two-dimensional-array fast Fourier transform (FFT) subroutine library. The program includes the two-dimensional forward and inverse FFT for integer, single, and double-precision floating-point complex number sets.

The company reports that the two-dimensional program, an enhancement to its Prime Factor FFT program, is the first PC-based FFT product to calculate rectangular FFTs.

You can call the two-dimensional program from any high-level language, including Turbo Pascal, Microsoft FORTRAN, QuickBASIC, Microsoft C, and more. The program supports arrays of more than 256 by 256 data points. You can perform frequency analysis on data set sizes as small as 2 by 2 data points and as large as 65,520 by 65,520 data points.

The program runs on the IBM PC, XT, AT, and compatibles with an 8087, 80287, or 80387 math coprocessor. You also need Prime Factor FFT to run the two-dimensional program.
Price: $159 for two-dimensional program; $159 for Prime Factor FFT.
Contact: Alligator Technologies, P.O. Box 9706, Fountain Valley, CA 92708, (714) 850-9984.
Inquiry 777.

Managing the Lab

If you need a system in the laboratory for tracking, analyzing, and reporting, LSTAR may be just the program for you.

LStar lets you define standard procedures used in studies or lab activities. It then generates a schedule and data slots for the study. You can enter data, generate schedules, and generate standard reports that you can send to a printer or output as an ASCII file.

The program runs on the IBM PC, XT, AT, and compatibles with at least 640K bytes of RAM and a hard disk drive.
Price: $995.
Contact: American CompuStar, Inc., P.O. Box 108, Belle Mead, NJ 08502, (201) 359-0010.
Inquiry 778.

Scientific Words

With Mathor and Chimix, you can enter mathematical or chemical formulas and let the program calculate the size and position of the symbols. It then displays them on-screen as they will be printed and makes adjustments to text as needed, depending on the size of the formulas.

Mathor is the mathematical word processor. It includes the Latin alphabet with accented letters, Greek in upper- and lowercase and italics, and other special alphabets. The program automatically centers the numerator and the denominator and aligns the elements of a matrix. An editor lets you make changes and see them on-screen as they will appear in print. You can also save formulas to memory, so you can use them again in the same or other documents.

Also available is a TEX module that you can use with Mathor to translate documents for typesetting.

Chimix is the word processor that draws your chemical formulas. By pressing function keys, you can insert chemical links and the cyclic and polycyclic compounds into your text. When you make changes, you see the formulas automatically rearranged.

Mathor and Chimix run on the IBM PC, XT, AT, PS/2, and compatibles with 512K bytes of RAM, a Hercules or EGA board, and DOS 2.11 or higher.
Price: Mathor, $595; TEX module, $295; Chimix, $695.
Contact: HiTech Consulting Group, Inc., 1801 Avenue of the Stars, Suite 602, Los Angeles, CA 90067, (213) 556-1628.
Inquiry 779.

continued

Vision is the power of imagination. Seeing beyond the obvious. Being able to grasp and comprehend the obscure.

Introducing IZE™ to realize greater vision.

The information age has presented virtually every field, from research, education, and government to law, medicine, and business, with powerful resources. Resources that, unlike traditional data-based information, are textual. Lacking structure, this ever-growing textbase is most often unexplored, untapped power.

IZE is software designed to automatically discover the underlying structure of textbase resources and provide users the power to tap, explore, manage, and organize them.

The look of IZE is familiar: a table of contents presented in outline form. Yet the power of this elegant structure is considerable. And transparent in use.

Randomly entered reports, proposals, research abstracts, presentations, and correspondence. Ideas, lists, and notes. Documents you've already created and those you'll generate in the future. Imported information from on-line services. Plus any other text capable of being read by an IBM® PC or compatible system, can now be easily viewed in a different light.

IZE will create a fundamental change in the way you use your computer. And the way you use information.

To gain mastery over new resources. To grasp. To comprehend. To see. To focus. To create. To fully utilize the product of the information age.

The promise of IZE is greater vision to share your vision with the rest of the world.

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For more information about IZE, please contact your software dealer, phone us at 1-608-273-6000, or write Persoft, Inc. 465 Science Drive Madison, Wisconsin 53711 U.S.A.

Circle 50 on Reader Service Card

The speed of

Corvus' new Omninet® / 4 is the fastest local area network on easy-to-install, easy-to-pay-for twisted pair. What else can you say about a system that has the lowest cost per user of any high performance LAN?

A great deal!

Omninet / 4 combines high performance, low cost and ease of installation and use. The result—more networking value for the "more demanding" users in workgroups and businesses.

Maximizing throughput. Omninet / 4 has a fast data transmission rate of 4 Mbps and a very efficient collision-avoidance protocol to guarantee transmission accuracy and enhance data throughput. In addition, it utilizes dual port memory on the network card to let your main processor function more efficiently. This combination of greater speed and increased efficiency enables Omninet / 4 to outperform many networks, including Ethernet® and Token Ring®, in many system throughput tests.

Adding value—not cost. Corvus pioneered the low cost twisted pair wiring of local area networks with our Omninet / 1 system. We have over nine years of experience in supporting an installed base of over 500,000 nodes on 50,000 networks.

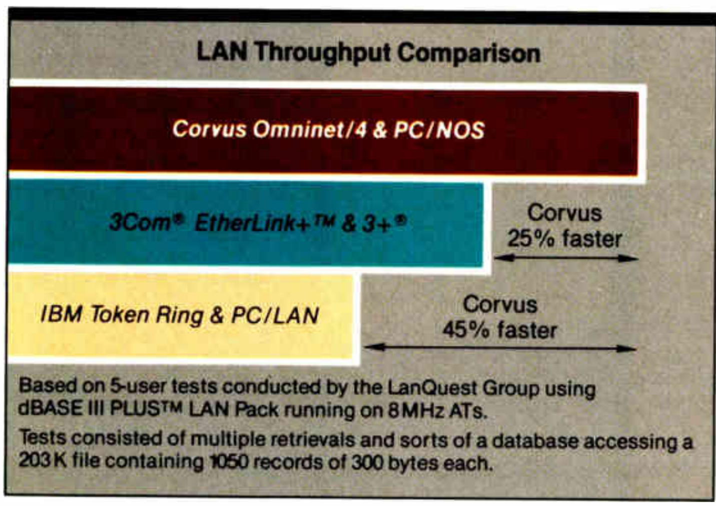
During this time we also developed the twisted pair Omninet Cabling System (OCS) to simplify, economize and improve the reliability of network resource connections. Utilizing these standard OCS products, Omninet / 4 operates over distances up to 1,000 feet. And with our affordable Omninet Repeater you can extend your network to 4,000 feet.

Omninet / 4 is compatible with Corvus' PC / NOS™ and Microsoft® OS / 2 LAN Manager. It also supports Novell Advanced Netware® and can be bridged to an existing Omninet / 1 network.

Making networking easy. You can install a four-user Omninet / 4 Network Kit in less than an hour. No complicated wiring. No tools. No technicians. It's simply a twisted pair "plug and play" system. As your requirements grow, you can add more workstations (up to 64) by simply plugging a network card into each addition and snapping the OCS cables together.

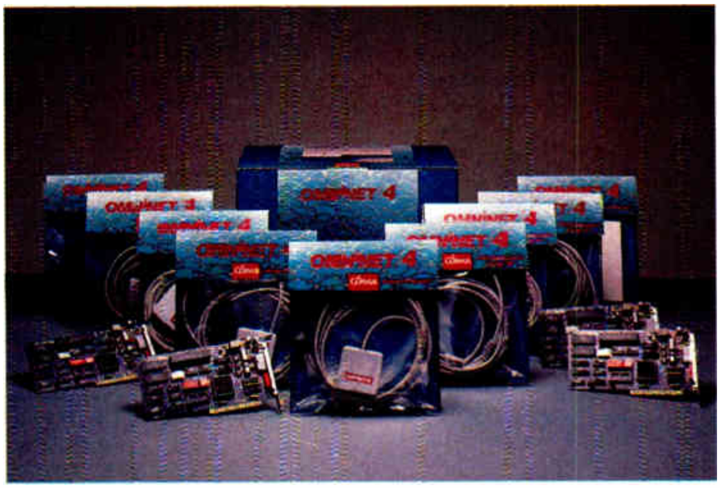
Connect with Corvus. When you need more throughput for less cost check out Omninet / 4—"the speed of a jet net" on twisted pair. Contact your local dealer or call 1-800-4 CORVUS. Corvus Systems, Inc., 160 Great Oaks Blvd., San Jose, CA 95119-1347.

1-800-4 CORVUS

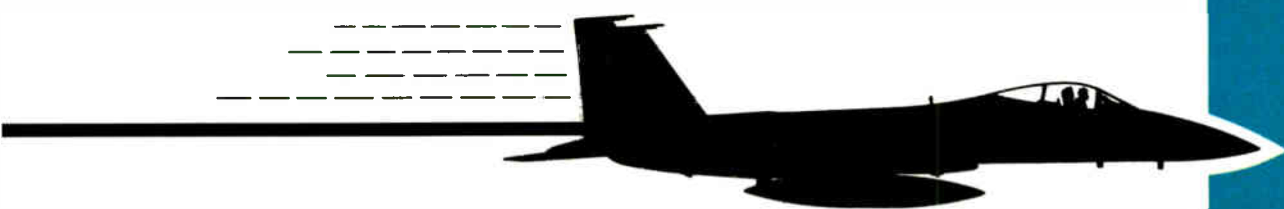


The Corvus Omninet/4 solution proved to be 45% faster than Token Ring and 25% faster than Ethernet in dBASE III PLUS tests.

a jet net.



The Omninet/4 Networking Kit includes four transporter cards, four workstation kits, three trunk cable kits, one termination kit, one software kit and one installation guide.



CORVUS

The Net Works™

Circle 73 on Reader Service Card

Model Molecular Graphics

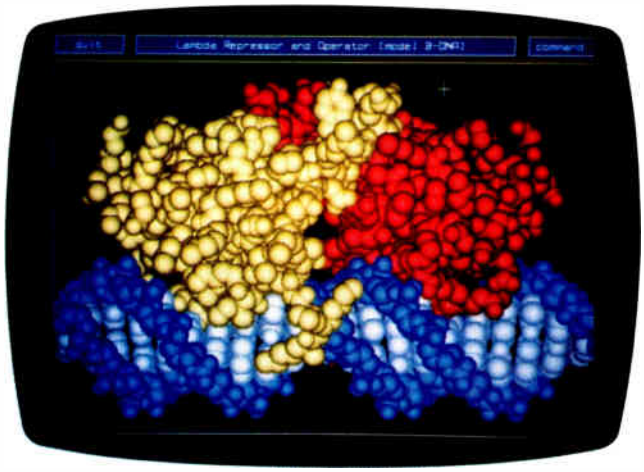
ProModeler I is the first professional macromolecular graphics system for the personal computer, according to New England BioGraphics. The program includes large molecule support, interactive rotations, translations and zooming, stereo viewing, high space filling and bond representations, and interactive side-chain substitutions.

In bond or backbone representations, you can rotate, translate, and scale a molecule. The system can produce shaded, colored, and space-filling representations of large molecules at high speeds. You can also use the system to interactively substitute amino acid side chains from a dictionary that's supplied with the system. And you can save modified proteins to disk in any of the file formats that are supported.

During an interactive session, you can load individual molecules from separate files and have more than one on-screen at a time. You can also define subsets of a given molecule, which you can then color, move, or hide from view. You can color all or part of the molecule according to atom name, residue name, and residue range. Predefined color schemes are included that color molecules based on atom type or side-chain hydrophobicity.

Promodeler accepts structure files from the Brookhaven Protein Data Bank, which you can download using standard file-transfer protocols such as Kermit. The system also supports the Hendrickson-Konnert file format.

How many atoms can you display? New England BioGraphics reports that in a 640K-byte system, you can display and manipulate about 5000 atoms simultaneously in any representation, including stereo views. In a 512K-byte system, you can view about 2500 atoms.



Create macromolecular graphics on an AT with ProModeler I.

The minimum system configuration you need to run ProModeler I is an IBM PC AT or compatible with at least 512K bytes of RAM, an 80287 or 80387 math coprocessor, and a Microsoft or compatible mouse. You also need a Professional Graphics Adapter or compatible; however, the program does not support EGA or VGA boards. Vermont Microsystems offers the Image Manager 640 graphics board, which you can purchase bundled with the ProModeler software.

Price: $750 for the software alone; $2000 for the IM-640 board and software.

Contact: New England BioGraphics, P.O. Box 24, Peacham, VT 05862, (802) 633-4344.

Inquiry 780.

Infinite Plotting the MicroMath Way

Whether you need to create *x,y* plots or develop, evaluate, and plot model equations, MicroMath has programs to suit your needs. MINSQ 2.3, a program for developing, evaluating, and plotting model equations, is enhanced with PostScript plot descriptions that you can send to a file or print on any PostScript output device.

With MINSQ 2.3, you can plot model equations without data. Or, when you supply data, parameters in the model equations may be optimized by a least-squares procedure. You can read model equations from a file or enter them from a keyboard. A built-in editor lets you modify the models interactively. Built-in operators are also available, including Deriv, Integral, and a Unit step function.

The program also offers graphics capabilities that let you zoom in on regions for annotating plots with text, lines, or arrows. You can move or resize objects.

Graph is another new program from MicroMath. It offers many of the capabilities of MINSQ, except for nonlinear model fitting. Graph lets you prepare *x,y* plots, plot the data on the screen, and modify it with a built-in editor. You can also send plots from Graph to PostScript printers.

Model-independent curves available include polynomials, cubic splines, rational fractions, and a Stineman interpolating curve. You can also perform least-squares regression for straight lines, polynomials, or cubic splines.

Like MINSQ, Graph includes a graphics section with zoom capability and the ability to add or delete arrows, text, and lines, and to move or resize objects or change character sets.

MINSQ and Graph run on the IBM PC, XT, AT, or compatible with at least 512K bytes of RAM, DOS 2.0 or higher, and a CGA, EGA, or monochrome graphics board.

Price: MINSQ 2.3, $179; Graph, $79.

Contact: MicroMath Scientific Software, 2034 East Fort Union Blvd., Salt Lake City, UT 84121.

Inquiry 781.

Need a Refresher on Distillation?

Distil Simu is designed to help you brush up on distillation principles.

The program is based on the McCabe Thiele model, which you can bring up on-screen and output to most dot-matrix printers. It allows you to input error checking and generate detailed reports, and it makes use of windowing, file handling, and device error checking.

Also included with the program are the VLE Curve Fit/Plot and several nonlinear regression routines for regressing sets of *x,y* data and plotting the resulting VLE curve on an *x,y* equilibrium plot.

Distil Simu runs on the IBM PC and compatibles with 512K bytes of RAM and a CGA or Hercules graphics monitor.

Price: $79.

Contact: Engrsoft, 1946 Holland, Wichita, KS 67212, (316) 721-1598.

Inquiry 782.

continued

SuperProject Adds Features for OS/2

The project management tool SuperProject Expert now runs under OS/2. The program retains the features found in the MS-DOS version but has added multitasking, virtual memory management, memory protection, and a feature that lets you toggle between applications without exiting one program and reloading.

SuperProject Expert assists you in planning, tracking, and coordinating projects. It also enables you to create a variety of work schedules. It offers multiproject, import/export, and network capabilities. You can also request reports, including detailed costing information. Other features include graphics and word-processing capabilities.

The OS/2 version lets you access up to 16 megabytes of virtual memory and runs in protected mode. SuperProject Expert/2 runs on IBM PS/2s and compatibles with at least 320K bytes of RAM and OS/2.

Price: $795.

Contact: Computer Associates International, Inc., 1240 McKay Dr., San Jose, CA 95131, (408) 432-1727.

Inquiry 787.

Maximize Your Sales

Keep track of clients, prospects, and personal data with The Maximizer. This sales support program from Pinetree Software is broken into seven segments: clients, letters, payment analysis, hot-list, telephone, personal records, and utilities.

In managing clients, you can add as many client names to the database as you'd like, with as much information associated with them as you need. You can also search the database using criteria that you've defined, such as occupation, status, source, and interests. You can also keep track of follow-up dates.

The program's letter-writing facility lets you write and store an unlimited number of letters. It comes with a set of standard letters, and you can edit them or create your own using the program's editor.

A set of calculation programs lets you figure out payment schedules, purchase prices, outstanding balances, financing, and more.

The hot-list feature lists all your appointments and the clients you have to contact. A day-at-a-glance feature is available in the calendar utility, and a telephone directory lets you access your clients' phone numbers individually or in groups.

The Maximizer is written in C and uses Btrieve file access. It runs on the IBM PC, XT, AT, PS/2s, and compatibles with DOS 3.0 or higher and at least 512K bytes of RAM. The program comes on 5¼-inch and 3½-inch disks and is also available in a local-area network version.

Price: $495.

Contact: Pinetree Software Canada Ltd., 8100 Granville Ave., 9th Floor, Richmond, British Columbia, Canada V6Y 1P3, (604) 270-3311.

Inquiry 783.

Bill-It on the Mac

If you run a small business, you can do your accounting on a Macintosh with Bill-It. ShopKeeper Software's accounting program integrates accounts receivable, billing, inventory, invoicing, list of services, sales, and point-of-sale modules.

Bill-It is optimized for about 4000 customers and inventory items, although ShopKeeper reports that the program can handle more than 8000 of each. You can use the inventory section for anything that you can count in units, such as labor charges, lab procedures, golf lessons, and so on. The program is flexible in printing statements, reports, and summaries.

Information is stored as plain ASCII text, so you can transfer data from Bill-It to other programs or export it as SYLK files.

Bill-It runs on a Mac Plus, SE, or II with at least two 800K-byte floppy disk drives or a hard disk drive.

Price: $159.

Contact: ShopKeeper Software, Inc., P.O. Box 38160, Tallahassee, FL 32315, (904) 222-8808.

Inquiry 784.

More for the Investor

Investors wanting to perform technical analysis of the securities market will find that Wall Street Techniques is now enhanced with access to The Source and increased capacity. It includes a free account to both the Dow Jones News Retrieval Service and The Source. The new interface to The Source lets you automatically access historical data on stocks, options, bonds, mutual funds, index options, and commodities. The number of securities that you can monitor is now expanded from 75 to 500 per subdirectory. You can maintain up to 750 days, weeks, or months of data (increased from 250) for each security.

The program runs on the IBM PC and compatibles and supports CGA, EGA, VGA, and Hercules graphics.

Price: $295.

Contact: Smith Micro Software, Inc., P.O. Box 7137, Huntington Beach, CA 92615, (714) 964-0412.

Inquiry 785.

Enhancements to Macintosh Business Software

Layered has enhanced a bundle of its business programs. In the Insight Expert Accounting Series, a Time Billing module has been added, as well as multiuser versions of Inventory, Accounts Receivable and Payable, Insight Forms Design, and Insight Export. The Notes product has been expanded to six products. Front Desk has been upgraded and is also available in a multiuser version.

Price: Insight Expert Time Billing module, $595; Inventory multiuser version, $895; Accounts Receivable multiuser version, $895; Accounts Payable multiuser version, $895; Insight Forms Design, $149; Insight Export, $149; Notes for Ready, Set, Go!, $79; Front Desk multiuser version, $99 per user.

Contact: Layered, Inc., The Schrafft Center, 529 Main St., Boston, MA 02129, (617) 242-7700.

Inquiry 786.

continued

REAL TIME

Speed without compromise.

QNX DELIVERS QNX delivers the speed of a dedicated real-time executive as well as multi-tasking, integrated networking and a multi-user development environment as rich and powerful as UNIX.

SPEED The tightly coded QNX kernel performs 3200 task switches/second on an AT, with full pre-emptive prioritized scheduling.

TASK COMMUNICATION QNX is based on a message-passing architecture, radically more innovative than PC-DOS, UNIX, or OS/2. User tasks and system tasks use the same messaging interface. This results in a single unified environment.

INTEGRATED NETWORKING On the QNX network, any task can send messages to any other task anywhere on the network. This direct communication is not available on other networks. The resultant "feel" of the QNX network is that of a homogeneous, tightly connected array of computers, rather than a collection of computing islands strung together on a network with comparatively limited functionality.

DEVELOPMENT ENVIRONMENT QNX comes with a rich set of utilities including a powerful full-screen editor, C compiler, symbolic debugger and multiple full-screen windows.

RUNTIME ENVIRONMENT QNX architecture is modular not monolithic. The system consists of a set of tasks that provide services. Software developers can easily write tasks that add services to suit their specific application needs. It is straightforward to write tasks that interface to hardware through interrupts, I/O ports, DMA and dual-ported memory.

TECHNICAL SUPPORT Technical support is provided free of charge, and updates can be downloaded 24 hours/day from our online BBS.

QNX is now installed at over 55,000 sites in North America and Europe for manufacturing, process control, process monitoring, point-of-sale and many other applications.

Eliminate compromises in your real-time applications. Call for details today.

THE ONLY MULTI-USER, MULTI-TASKING, NETWORKING, REAL-TIME OPERATING SYSTEM FOR THE IBM PC, AT, PS/2, THE HP VECTRA, AND COMPATIBLES.

Multi-User	10 (32) serial terminals per PC (AT).	C Compiler	Standard Kernighan and Ritchie.
Multi-Tasking	64 (150) tasks per PC (AT).	Flexibility	Single PC, networked PC's, single PC with terminals, networked PC's with terminals. No central servers. Full sharing of disks, devices and CPU's.
Networking	2.5 Megabit token passing. 255 PC's and/or AT's per network. 10,000 tasks per network. Thousands of users per network.		
Real Time	3,200 task switches/sec (AT).	PC-DOS	PC-DOS runs as a QNX task.
Message Passing	Fast intertask communication between tasks on any machine.	Cost	From US $450. Runtime pricing available.

QNX

For further information or a free demonstration diskette, please telephone (613) 591-0931.

Quantum Software Systems Ltd. • Kanata South Business Park • 175 Terrence Matthews Crescent • Kanata, Ontario, Canada • K2M 1W8

Circle 226 on Reader Service Card

A Word Processor That Learns

MindReader is a word processor with artificial intelligence capabilities that teach it how you write, according to Brown Bag Software. It features an expandable dictionary, spelling checker, and calculator, and is distributed as shareware.

To teach MindReader how you write, you switch on the AI Learn feature and leave it on while you write. MindReader will analyze your writing patterns.

WordComplete is a utility that lets you type just the first few letters of a word. It then pops up a window with a list of words, from which you select the one you want with one keystroke. The FrequentWord option lets you designate the words you want to appear in the pop-up window. Using rule-based artificial intelligence, MindReader reprioritizes the words in the dictionary pop-up menus according to your use.

You can call the calculator up on-screen with just a few keystrokes and use it while you're working on a document. Its functions include addition, subtraction, multiplication, and division, and it's accurate to 12 digits with two decimal places. A paper-tape-type feature keeps a running list of every number you enter.

MindReader 2.0 runs on the IBM PC, XT, AT, and compatibles with at least 256K bytes of RAM and DOS 2.0 or higher. To run it on a LAN, you need a network license. The program supports CGA, EGA, and VGA boards.
Price: $49.95 for registration fee.
Contact: Brown Bag Software, 2155 South Bascom Ave., Suite 114, Campbell, CA 95008, (408) 559-4545.
Inquiry 788.

Version 2.0 of Brown Bag's MindReader.

Moving Data Across Formats

Do you ever need to convert dBASE files into Lotus 1-2-3 spreadsheets? DataPlex 2.0 may be your key to moving data among such formats as 1-2-3, DIF, ASCII, and dBASE. The program's strengths lie in the areas of data entry and conversion. Using AI techniques such as dynamic data dictionaries and pattern recognition, DataPlex learns validation rules from the data and creates field formats, according to Tools & Technology.

Connection to other formats is by way of read/write two-way data paths, and you can sort, select, edit, and reformat data records while the data is in transit. You don't need a copy of your destination package.

DataPlex is written in Microsoft C. Version 2.0 requires an IBM PC, XT, AT, or compatible with DOS 2.0 or higher and 384K bytes of RAM. The program also runs on LANs. The company reports that an OS/2 version is currently in the works.
Price: $149.
Contact: Tools & Techniques, Inc., 1620 West 12th St., Austin, TX 78703, (512) 482-0824.
Inquiry 789.

The Soft Drum Machine

Adrum is an Amiga software program that acts like a drum machine. The company calls it a rhythm maker with four voices. It is capable of stereo output using sound samples loaded from disk in Interchange File Format.

You can have up to 26 sounds in memory to create a kit from which you produce rhythms. You can alter any of a sound's parameters, such as pitch, volume, length, and number of repeats, and you can assign any sound to any of the 26 instruments.

Once you set up a kit of sounds, you can program Adrum's sequencer. You can define up to 64 measures of variable beats, from 0 to 64 beats per measure.

Pull-down menus let you select removal, replacement, measure copy, and delete/insert editing commands.

Adrum is MIDI-compatible and runs on the Amiga.
Price: $79.95.
Contact: Haitex Resources, 208 Carrollton Park, Suite 1207, Carrollton, TX 75006, (214) 241-8030.
Inquiry 790.

Put Your Data on the Map

Create, manipulate, and analyze color maps of areas ranging from 52 feet to 5000 miles wide with MapInfo. Working from information in one or more databases, the program helps you generate maps with boundaries, legends, and text. You can label points with street names, demographic information, notes, or symbols.

The program's Thematic Mapping feature lets you assign different shades to specific map areas. You can pan and zoom, locate addresses anywhere on the map, and compute the distance between two or more points.

MapInfo comes with its own database management program; you can also use it with dBASE III Plus. Many maps covering U.S. metropolitan areas are available.

The program runs on the IBM PC, XT, AT, and compatibles with DOS 2.0 or higher, 512K bytes of RAM, a graphics board, and a hard disk drive with 3 megabytes of free storage space. It supports various mice, as well as the Summagraphics SummaSketch and Calcomp 9100 and 2500 series digitizers. It also supports dBASE III Plus files.
Price: $750; metropolitan area maps, from $250 to $2000.
Contact: MapInfo, Hendrick Hudson Building, 200 Broadway, Troy, NY 12180, (800) 327-8627; in New York, (518) 274-8673.
Inquiry 791.

The 3.5" Migration.

As though by the force of nature, computer users are flocking to the new 3.5" standard.

A Clear Flight: A top-quality 3.5" drive allows direct access between older and newer systems, between IBM PC/XT/AT, compatibles and PS/2 systems, and between home office desktops and laptops in the field. And most experts agree that it's better to upgrade an older system with a 3.5" floppy drive than to downgrade a new system with an old-technology drive.

A Third First: Manzana introduced the industry's first 3.5" upgrade in 1985, and the first 1.44MB drive in 1987. Today, Manzana introduces the 3rd Internal™ drive, for those with room for more than two.

Maximum Versatility: Manzana offers several drive configurations, including an internal, a host-powered external, and a self-powered external. All systems come with Manzana's own 3Five® software, which runs with MS-DOS version 2.0 or higher, to read, write and format disks at 1.44MB, 720K, and non-standard MS-DOS formats, including HP 150 and 110.

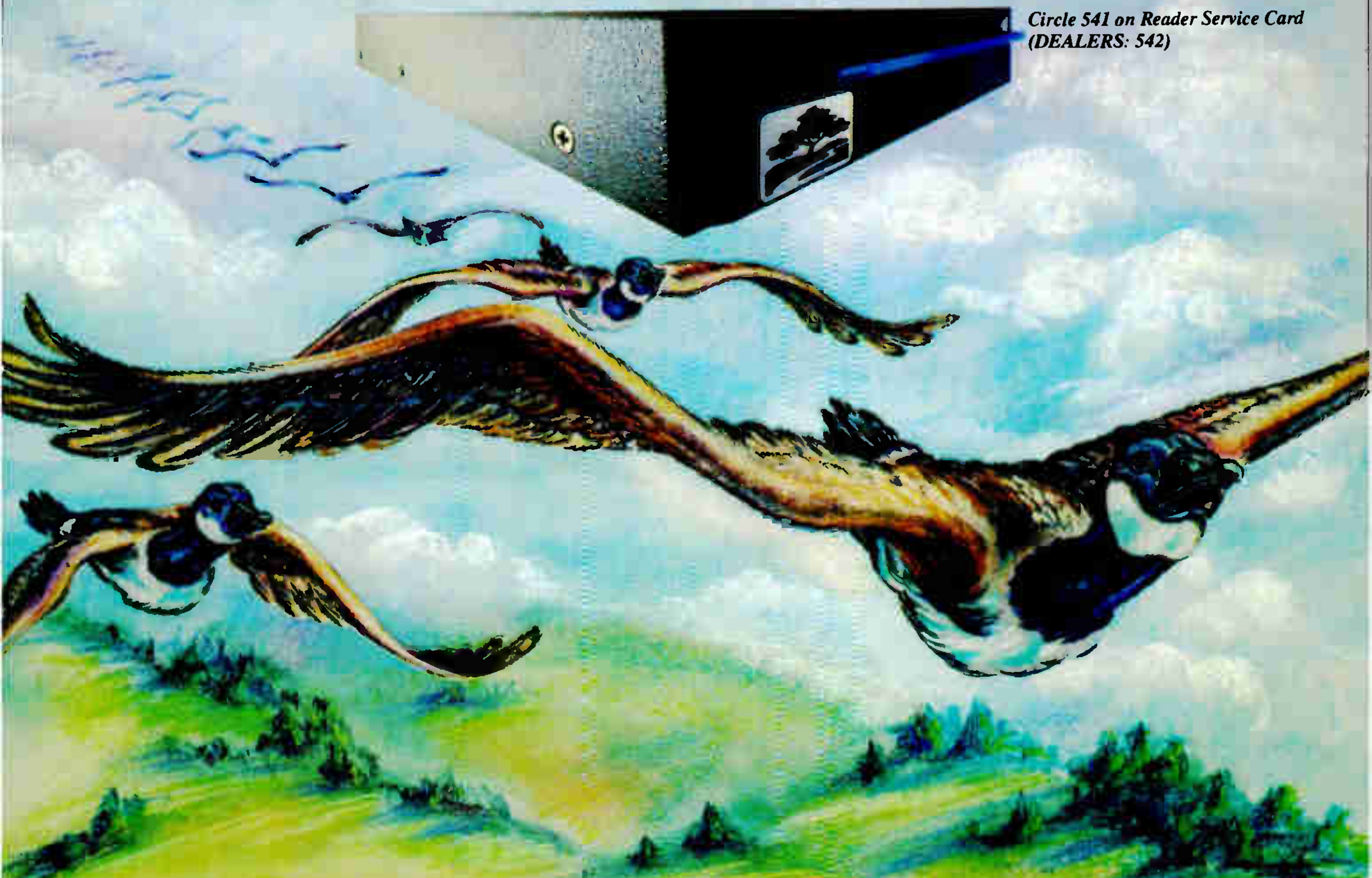
Flying to PC Expo? See us in Booth #2520. Or call 805/968-1387, FAX 805/968-5449, TELEX 4932215 or write for the whole story on The 3.5" Migration, and literature on the full line of Manzana drives: Manzana MicroSystems, Inc., P.O. Box 2117, Goleta, CA 93118.

Soon you'll be heading in the right direction from instinct alone.

TM

Manzana drives it home.

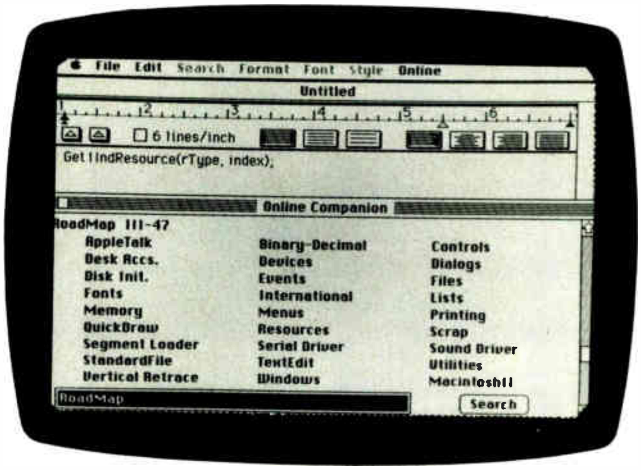
Circle 541 on Reader Service Card (DEALERS: 542)



Mac DA For Programmers

If you program on the Mac and spend a lot of time leafing through reference manuals, The Programmer's Online Companion 2.0 for the Macintosh may help. Based on Inside Macintosh, volumes I–V and the Apple Numerics Manual, the desk accessory includes frequently used system calls, system globals, and assembly language equates. You can modify and add information to the database.

The Programmer's Online Companion 2.0 is designed to be a crib sheet, not a teaching tool. For example, it does not teach what a "clip region" is, but assists you in accessing and modifying one. The desk accessory assumes you know Pascal or assembly and are familiar with Inside Macintosh.



On-line help for Macintosh programmers.

Developed by Steve Capps, a member of the original Lisa and Mac design teams at Apple, the program takes up less than 10K bytes of RAM.

The Programmer's Online Companion 2.0 runs on the Mac 512E, Plus, SE, and II.
Price: $49.95.

Contact: Addison-Wesley Publishing Co., Jacob Way, Reading, MA 01867, (617) 944-3700.
Inquiry 827.

Clear Up dBASE Confusion

If your dBASE program has become a bit of a mess—or if you want to keep it from becoming one—Clear for dBASE will probably help. The program reads the source code of your dBASE applications and automatically produces a system tree chart, program flow charts, and formatted source code listings.

The tree chart represents the hierarchical relationship between the procedures in the system and lets you view the structures of up to eight levels. The flow chart shows the logical structure and control flow of the program. You can view the charts on your screen in WYSIWYG format, or print them. The spacing, number of pages, and placement of symbols are automatically calculated.

Clear supports background printing and enables you to run any DOS command from within the program. It runs on the IBM PC, XT, AT, and compatibles with DOS 2.0 or higher, 512K bytes of RAM, two floppy disk drives or a hard disk drive, and a CGA, EGA, Hercules, or IBM monochrome video card. It supports dBASE II, III, and III Plus; and FoxBASE+, dBXL, and Quicksilver up to the level of the dBASE III Plus standard. Support for the Hewlett-Packard LaserJet printer is optional.

Price: $99.95; with Hewlett-Packard LaserJet driver, $149.95.

Contact: Clear Software, Inc., 637 Washington St., Suite 204, Brookline, MA 02146, (617) 232-4720.

Inquiry 829.

Create dBASE Files with Golden Common LISP

With dBLISP (a set of 50 Golden Common LISP functions and keywords that simulate dBASE III commands), you can define and manipulate dBASE III files.

The functions assist you in writing inference engines, natural language interfaces, hypertext systems, icon-based interfaces, and other front ends for creating and accessing dBASE III files. You do not need dBASE III to use the library for writing dBASE III–compatible data, index, and memo files.

An IBM PC, XT, AT, or compatible and Golden Common LISP is required to run dBLISP. It runs under both small-memory (1.1 or higher) and large-memory (2.2 or higher) versions of Golden Common LISP.

Price: $295; with source code, $495.

Contact: Chestnut Software, Inc., 636 Beacon St., Boston, MA 02215, (617) 262-0914.

Inquiry 826.

Print Labels, Envelopes on the Mac

Sometimes the least expensive, simplest applications are the most useful. Label and Envelope 1.1, a Macintosh desk accessory from Eastgate Systems, lets you print labels, envelopes, and mailing lists. You can choose fonts, type sizes, and formats.

Label and Envelope 1.1 runs on Macintoshes and takes up about 35K bytes of RAM.

Price: $15.

Contact: Eastgate Systems, Inc., P.O. Box 1307, Cambridge, MA 02238, (617) 782-9044.

Inquiry 828.

PC LINK

INDEPENDENT STORE IN NYC DEDICATED TO IBM ® PC SOFTWARE AND PERIPHERALS ONLY

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WYSE
2112 1.2MB D/D 1MB RAM 8/12 MHz CPU, 101-KEY KEYBOARD MS DOS 3.1 .... CALL
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HAUPPAUGE COMPUTER WORKS.
80386-16MHz REPLACES IBM/XT MOTHER BOARD. 1MB RAM, FIVE 8-BIT (2 SHORT), 2-16 BIT, 1-32 BIT SLOTS & SOCKET FOR 80387. WORKS WITH MOST PRESENT HARDWARE INCLUDING HARD/FLOPPY DISKS DRIVES & KEYBOARD. OS/2, 1-2-3 (V2.01), dBASE, AUTOCAD,VENTURA, WINDOWS & OTHER MAJOR SOFTWARE COMPATIBLE 1595.00

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INTRODUCING THE PC LINK 386

Why deal with MICROCHANNEL and find out that present adapters, memory expansion boards & other peripherals are not compatible. **?**

When with **PC LINK 386** you can be fully compatible with current and future hardware and software without spending a bundle in the process. **!**

The **PC LINK 386** is a powerful 80386 16 MHz, zero wait state computer based upon the highly rated **Hauppauge 386 Mother Board .**

Standard Features

- **Memory:** 1 Mb. of high speed 100ns RAM on the motherboard. This memory is configured in four banks and the banks are interleaved so that most memory accesses zero wait states.
- **I/O:** One 32 bit, two 16 bit and 5 eight bit expansion slots,
- **Floppy Disks:** One 5-1/4" 1.2MB or a 3-1/2" 1.4MB
- **Disk Controller:** Supports two floppy drives and up to two hard disk drives.
- **Serial & Parallel Port:** One serial and one parallel port
- **Keyboard:** Datadesk International Turbo 101 Enhanced keyboard.
- **Key Lock:** A physical lock and two keys are provided.
- **Power Supply:** The standard power supply for the PC LINK 386 is 200 watts.
- **Clock:** A battery backed real time clock.
- **Software: Public domain utility software included.**
- **Warranty:** Warranty covers parts and labor for the first three months after purchase. A one year warranty from the date of purchase is provided for parts.
- **Approval:** PC LINK 386 is FCC class A approved.

Software & Hardware Compatibility:

The **PC LINK 386** is fully compatible with IBM PC/AT expansion cards. This includes items such as CGA, EGA, and VGA monitor board, internal modems, network cards (including Novell and 3Comm Ethernet), and the Bernoulli Box board or using it as a dedicated or non dedicated File Server.

The PC LINK 386 is fully compatible with IBM PC-DOS 3.0 or higher, PC-OS/2, Unix, Zenix, PC-MOS/386, Novell Netware 286, Lotus 1-2-3 V2.01, dBase III+, Ventura, Pagemaker, Word, Multimate, Wordperfect and more. (We have not found any business software that does not work except the some older versions of copy protected slower speed dependent business software).

Module I (Basic Unit)

$2445.00

Module II (Basic Unit + 40MB 28MS Hard Disk)

$2945.00

Module III (40MB H/D, Vega Delux & EGA* monitor)

$3945.00

* Choice of Sony CPD 1302 Multiscan or NEC Multisync II

PC LINK 386A & 386B can accomodate upto five 1/2 height devices (three are accesable). 386B has One 32 bit, four 16 bit and 3 eight bit expansion slots. Model & Prices shown above can accomodate upto four devices.

See what some of our customers have to say about PC LINK 386.

The PC LINK 386 represents the amalgamation of the best of all worlds. Most of us, with long-time PC experience, have asked, at one time or another, why one particuler manufacturer cannot have some of the benifits of another, resulting in a combination that would supposedly be greatly superior. PC LINK'S 386 has accomplished the integration of the best of the best. Coupled with support provided by the PC Link organization, and constant updating and testing of new products, **we have not only purchased a "state of the art" computer but it will be the "state of the art" tommorrow and thereafter.**

Sincerely,
Richard D. Hausman, Chairman
BELDING HEMINWAY COMPANY, INC.

I am quite pleased with the 386-based machines that you have provided for us. Their speed is quite impressive and we've yet to discover a compatibility problem. It's a great way to purchase a very powerful PC but protect a substantial investment in software and add-ons. **I certainly intend to purchase additional units as my budget permits.**

Sincerely,
Mike Wittman, Controller
1010 WINS RADIO

These machines have extended the life of one application that was just running too slow on AT's. DOS applications run so much faster that we don't have to pass up features to get performance when selecting software. When enough software is available we will be able to upgrade to OS/2 and continue to get good performance. Finally, my partners and I are delighted that we can afford to equip our staff and ourselves with such high-performance, high-capability machines. **We are looking forward to completing the conversion of all PCs, XTs and ATs to the new motherboard and to standardizing on the PC Link 386 for our new purchases.**

Sincerely
Denis C. During, Vice President
OCEAN CAPITAL CORPORATION

I had to tell you how pleased I am with your PC Link 386. This network we are setting up is going to use one of these machines as file server, and this will be the third PC Link 386 we've purchased. So far, every program I've tried has run on these machines. Windows386, Foxbase/386, Excel, Lotus, and Word 4.0 all work flawlessly. **The only problem I have is that when I have to help someone else in the office, their AT class machines seem to crawl.**

Sincerely,
Henry Citenstein Sr. VP

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PC LINK

Circle 535 on Reader Service Card

Breaking the Baud Barrier

Here's how your 2400 baud modem can send data as fast as a 9600 baud modem for less than $90.00

Leigh Tracy

When you got your first modem—that neat little 300 or 1200 baud job—you really thought you had it made, all the power, speed and convenience you'd ever need to move data from PC to PC. *Right?*

Now, of course, if you've got lots of data to move, you've recently bought or are considering switching over to 2400 baud speed. And, in reality, if your company is a power user it would make a lot of sense in saved time and telephone bills to be running at 9600 baud, if it were not for the initial overwhelmingly high modem hardware costs.

Enter *TurboCom* high performance PC to PC modem software by Datran, the clever Southern California based state-of-the-art data compression specialists that brought you the great *dCompressor* short card that triples the dBASE storage capacity of any hard disk.

Modems Run 4 Times Faster

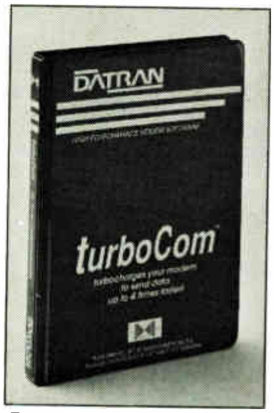
TurboCom turbocharges your Hayes compatible modem to send data files (letters, documents, reports, data bases, spreadsheets, binary files, programs) up to four times faster with your existing 300, 1200 or 2400 baud modems. And it sells for only $89.00 to connect two PCs.

When the good people at Datran sent me *TurboCom 3.0* for a test run, I was amazed at how simple and well thought out it was for the ordinary person (like me) to use.

TurboCom Facts:

Version 3.0	*Requirements*:
Each package has software for use with two PCs. $89.00	IBM PC/XT/AT, 386 or compatible. Minimum 384K RAM, PC-DOS, MS-DOS 2.0 or greater. Internal or external Hayes compatible modem. TurboCom at both *sending* and *receiving* PCs.
Datran Corp. Order direct: 1-800-332-0456	

Leigh Tracy is a consultant and freelance writer whose columns have appeared in many microcomputer magazines.



Transfer data files PC to PC up to four times faster.

Easy to Send and Receive

TurboCom is the easiest to learn and use modern software that I've ever tried. No menus are required. It's as simple to use as the COPY command! To send data with *TurboCom*, all you do is type:

```
C>SEND FILENAME PHONE NUMBER
```

To program for delayed transmission you type:

```
C>SEND FILENAME PHONE NUMBER AT TIME
```

That's all you do. Then, the continuing status of the transmission automatically appears on the screen until file transmission is completed.

Receiving transmitted TurboCom messages is automatic and unattended. Simply type **C>RCV** and TurboCom does the rest.

Any businessman, insurance broker, accountant, office manager, secretary or salesman on the road that can use a PC can simply operate *TurboCom*. It's that simple.

Unattended Electronic Mailbox

TurboCom is ideal as a fast, low cost mailing system between offices or companies. The sending PC is aware of how much disk space is available at the receiving end. If a file is transmitted with the same name and extension, TurboCom will assign it a unique extension, i.e., !-1, !-2, !-3. If the receiving PC does not have sufficient disk space for the file you are sending, *TurboCom* terminates the phone connection, saving time and wasted money.

Increased modem speed allows you to save up to 75% on your telephone time and costs. Because *TurboCom* can be programmed for delayed unattended transmission for automatic sending, you can transmit data when telephone rates are lowest. PC to PC data is transferred perfectly because *TurboCom* was designed with an advanced error-free high speed protocol.

Because of *TurboCom*'s high speed, cost savings, flawless operation and sensational low $89.00 price to connect two PCs, I give this product my highest recommendation.

Turbo Your Laptop

Each TurboCom package comes with both 5-1/4" and 3-1/2" diskettes, which makes it ideal to run with laptops, too. It is not copy protected.

To order direct from Datran, you can call toll free at 1-800-332-0456. They accept MasterCard and Visa and will ship within 24 hours with a 30-day money-back guarantee.

ORDER TODAY TOLL FREE:
1-800-332-0456

$89.00 VISA MasterCard

Plus $5.00 Shipping/Handling

turboCom™

DATRAN

Leadership in Data Compression Technology
Datran Corporation
2505 Foothill Blvd., La Crescenta, CA 91214

Short card for dBase files triples the storage capacity of your existing hard disk

By Leigh Tracy

If your dBASE files are overwhelming the storage capacity of your hard disk, here's a nifty solution

If you bought a 20MB hard disk like I did—thinking it would hold all the dBASE files you'd ever create—were we ever in for a surprise!

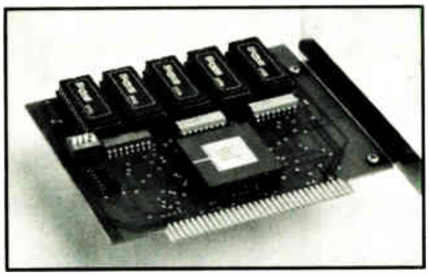
Datran Corp., the Southern Cailfornia based state-of-the-art data compression specialists, have come up with an economical, high performance solution to our problem: the *dCompressor* short card.

The nice people at Datran sent me a *dCompressor* to try, and was I ever impressed. I saw average compression ratios of 3 to 1—and in some cases as much as 10 to 1. I didn't have to be a genius to figure out that my teeni-weeni 20MB disk just became 60MB, and more!

Installation was a snap on my AT. I simply slipped the *dCompressor* into a slot and was up and running after a few minutes of installation. It operates in the background and is completely transparent to the user. I wasn't aware that it was there—except for all the extra data I was able to work with. It even seemed to make my program work faster.

At the heart of the *dCompressor* is a custom designed high-speed parallel microprocessor that uses Datran's powerful high-speed proprietary compression technology. I am told that it allows for an infinite number of compression/decompression cycles with total data integrity.

The *dCompressor* requires no reformatting, as is necessary with RLL controllers. It will even triple the capacity of dBASE files of a disk drive that is using RLL technology.



Datran's new dCompressor board operates at high speeds that software can't touch.

The *dCompressor* not only increases the performance of an existing disk drive, but also eliminates the need of upgrading the PC's power supply, as would be required if an additional disk drive were added. It requires only 1/2 watt of power, as compared with 15 to 30 watts to accommodate a new drive.

dCompressor is a no nonsense high speed data compression product that incorporates state-of the-art technology. It operates at speeds that software compression programs can't touch.

It's not a cutsie software product that squishes, squashes, stomps, squeezes, crushes, crunches, munches, mashes—or generally beats your data to a pulp.

In short, it effortlessly compresses your dBASE files quickly and efficiently with no mess or fuss.

This product eliminates the needless hassle and expense of upgrading to a more expensive hard disk to support those expanding dBASE files. And eventually if you must purchase a larger hard disk, your investment will triple the file capacity of your new drive, too. It works with any size hard disk and floppy.

dCompressor works with dBASE III and III PLUS on IBM PC, XT, AT, 386 and compatibles, DOS 2.0 or higher.

And the best part about *dCompressor* is its low price . . . only $195.00. I can highly recommend this super compression product.

To order direct from Datran you can call toll free to 1-800-332-0456. They accept MasterCard and Visa and will ship within 24 hours. Datran gives a 30-day money-back guarantee.

Datran has another data compression product worth mentioning if you send your dBASE files PC to PC. New *TurboCom* high performance modem software turbocharges your modem to send data up to 4 times faster!

TurboCom sells for only $89.00 to connect two PCs. Now, your 2400 baud modem can send data as fast as a 9600 baud modem! It also makes 300 and 1200 baud modems perform up to 400% faster.

As a special introductory offer for *dCompressor* at its $195.00 price, Datran will give you *TurboCom* software free with every unit you buy. The *TurboCom* package comes with 5-1/4" and 3-1/2" diskettes, which makes it ideal to run with laptops, too.

ORDER TODAY TOLL FREE:
1-800-332-0456

$195.00
Plus $5.00 Shipping/Handling

VISA

dCompressor

DATRAN

Leadership in Data Compression Technology
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2505 Foothill Blvd., La Crescenta, CA 91214

Leigh Tracy is a computer consultant and writer whose pieces have appeared in numerous national publications.

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▸ **Super-16T.** This IBM PC/XT-compatible offers all you need to get started—including software! Features switchable 4.7/8MHz processing speeds, 640KB RAM, one serial and one parallel port, a multi-video display adaptor, and your choice of drives, from one 5.25" floppy to a 30MB hard disk. Comes with **Electric Desk**™ integrated word processing/spell checker/spreadsheet/database management/communications software, and **Keyworks**, for creating menus and keyboard macros.

Packaged from $699.95

▸ **Super-286C.** This powerful 80286-based AT compatible features keyboard-switchable 8/10MHz processor speed and 512KB RAM—expandable to 1MB. Includes six expansion slots, two serial and one parallel port, plus a 5.25" 1.2MB floppy disk drive—all in a small footprint package that fits anywhere.

Packaged from $1049.95

• **Super 286 File Server**
Zero wait state 8/10 MHZ,
12 Expansion Slots, 640 K RAM Expandable,
5-25" 1.2 MB Floppy Disk Drive.

$CALL

EPSON COMPUTERS EQUITY II+

- 80286 three-speed 8/10 MHz microprocessor
- full-size expansion slots, plus built-in serial and parallel ports
- 640KB on-board memory,
- Fully compatible with IBM® PC/AT® hardware and software
- One year limited warranty

$1099

EPSON COMPUTERS EQUITY III+

- 80286 three-speed 6/8/12 MHz microprocessor
- Nine full-size expansion slots, plus built-in serial and parallel ports
- 640KB on-board memory, expandable to 15.5MB
- Fully compatible with IBM® PC/AT® hardware and software
- One year limited warranty

$1499

POWER HAS ITS PRICE. BUT IT'S LOWER THAN YOU THINK.

PowerMate 386 - $CALL

PowerMate™ 1
- 80286 CPU
- 640 KB RAM on motherboard
- Floppy disk drive controller (on motherboard)
- Parallel printer port (on motherboard)
- RS-232C serial port
- Six expansion slots

PowerMate™ 2
- 80286 24/16 bit processor
- Software-selectable speeds of 8 MHz or 10 MHz
- 1.2 MB floppy disk drive
- Parallel printer port
- Two RS-232C serial ports
- Eight expansion slots

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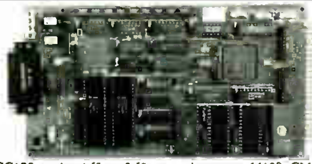
Multitasking Controller



The **BCC180**, only 4.5" x 8.5" uses the same 64180 CMOS Z80 instruction compatible processor as Micromint's SB180 and SB180FX single board computers. Configured primarily for process control w/ 384K of memory, 6 parallel I/O ports, console serial port, RS-232/422/485 selectable auxiliary serial port, and an interrupt driven ROM-resident multitasking BASIC-180 compiler, the BCC180 uses the same 44-pin I/O expansion bus as Micromint's BCC52 controller board.

PROCESSOR
- CMOS HD64180, 9.216MHz 8-bit CPU, 68 pin PLCC package

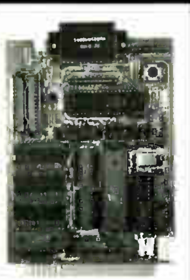
MEMORY
- Up to 384K bytes total memory on board
- 128K of either static RAM (62256) or EPROM (27256)
- 256K dynamic RAM SIMM
- Full function 8K ROM monitor included

INPUT OUTPUT
- Console RS 232 serial port with auto baud rate select to 19,200 baud
- Peripheral serial port, 150 19,200 baud selectable RS 232, RS 422 or RS 485
- 48 bits bidirectional parallel I O
- 64K I O available through the BCC bus edge connector

DIMENSIONS and CONNECTIONS
- Dual 22-pin (0 156") edge connector
- Compatible with all Micromint BCC series I O expansion boards
- Two 26-pin headers for six bidirectional parallel ports
- 25 pin DB-25 for RS 232 console I O
- 20-pin header for RS 232 auxiliary serial port
- 4 screw terminals for RS 422 485 connection

BCC180-1-20	9MHz assembled and fully socketed BCC180 Computer/Controller with 32K bytes of static RAM, ROM Monitor, BASIC-180 development software and user's manual For Additional 256K DRAM add $100.00	$395.00
BCC180-1	100 Quantity w/32K RAM w/o ROM Monitor	$209.00

BCC52 — $189.00
BASIC-52 Computer/Controller



The **BCC52** Computer/Controller is Micromint's hottest selling standalone single board microcomputer. Its cost-effective architecture needs only a power supply and terminal to become a complete development or end-use system, programmable in BASIC or machine language. The **BCC52** uses Micromint's new 80C52-BASIC CMOS microprocessor which contains a ROM resident 8K byte floating point BASIC-52 interpreter.

The BCC52 contains sockets for up to 48K bytes of RAM/EPROM, an "intelligent" 2764/128 EPROM programmer, 3 parallel ports, a serial terminal port with auto baud rate selection, a serial printer port, and it is bus compatible with the full line of BCC-bus expansion boards. The BCC52 bridges the gap between expensive programmable controllers and hard-to-justify price sensitive control applications. BASIC-52's full floating point BASIC is fast and efficient enough for the most complicated tasks, while its cost effective design allows it to be considered for many new areas of implementation. It can be used both for development and end-use applications.

Since the BASIC-52 is bus oriented, it supports the following Micromint expansion boards in any of Micromint's card cages with optional power supplies:

BCC22 Smart terminal board	BCC40R 8-Channel relay output board
ADP500 User vocabulary, digitized speech board	BCC53 Memory and 6 port I/O expansion board
BCC25 LCD display board	BCC13 8-bit and BCC30 12-bit A/D converter boards
BCC33 3 port I/O expansion board	BCC18 Dual channel serial I/O board
BCC40D 8-Channel optoisolated I/O expansion board	

BCC52	BASIC 52 Controller Board	$189.00
BCC-SYST.5	"52 PAK" Starter System includes: BCC52,ROM A&B UTIL.,CC01,MB08,UPS10	$449.00

BCC52 OEM 100 Quantity Price -- $149.00

BCC52C Lower power all CMOS version of the BCC52 $199.00

NOTE: The BCC52 series is available in Industrial Temperature Range, fully tested at temperature. Prices start as low as $294.00 in single quantities. Be sure to call for a quote on your specific Industrial OEM requirements.

BCC11 — $139.00
Z8 BASIC Computer

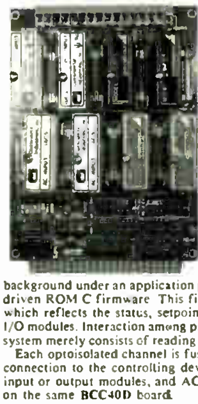
Features:
- Uses Z8 single chip microcomputer
- On-board tiny BASIC interpreter
- 2 on-board parallel ports & serial port
- 6 interrupts (4 external)
- Just connect a terminal and write control programs in BASIC
- 6K bytes of RAM or EPROM memory on-board
- Baud rates 110-9600 bps
- Data and address bus available for 56K memory and I/O expansion
- Consumes only 1.5 watts at +5, +12, and -12V

BCC11*
BASIC System Controller
$139.00

OEM 100 Quantity Price $89.00

* Now Available in Industrial Temperature Range

Announcing BCC40D — $139.00
8-Channel Optoisolated I/O Expansion Board



The Micromint **BCC40D** is an 8-channel optoisolated input/output expansion board designed for use with Micromint's family of BCC-bus Computer/Controllers. Using industry-standard optoisolated I/O modules, the **BCC40D** provides on/off control and input monitoring of eight 115-230VAC or 5-48VDC devices used in data acquisition and control applications.

Up to 16 **BCC40D** boards can be used together in a single system to provide a total of 128 input and output channels. Individual channels can be read or updated by reading from or writing to a single I/O address. The **BCC40D** can be directly controlled from BASIC or it can function completely in the background under an application program using high-speed interrupt-driven ROM C firmware. This firmware sets aside a table in memory which reflects the status, setpoints, and change-of-state flags of the I/O modules. Interaction among programs within a multiboard BCC40x system merely consists of reading or setting these memory table values.

Each optoisolated channel is fused and has screw contacts for direct connection to the controlling device and/or the power source. Both input or output modules, and AC or DC functions can be intermixed on the same **BCC40D** board.

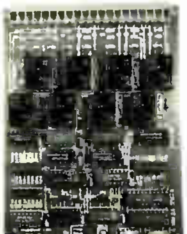
New

SPECIFICATIONS
- Latched outputs
- Uses industry-standard OACS, ODCS, IACS, IDCS type modules
- Dual-ported module addressing
- LED on off indicator on each channel
- Can be used concurrently with BCC40R and other BCC-bus peripherals
- Operates on +5V
- Operating conditions temperature 0-50°C (32-122°F) relative humidity 10-90% non condensing
- 4 5" x 6" board
- dual 22-pin (0 156") edge connector
- 16-terminal screw connector (#14 wire)

BCC40D/0	without modules	$139.00
BCC40D/4	with 4 modules	$189.00
BCC40D/8	with 8 modules	$229.00

OEM 100 Quantity pricing starts at $95.00

Announcing BCC40R — $169.00
8-Channel Relay Output Board



The Micromint **BCC40R** is an 8-channel relay output expansion board designed for use with Micromint's family of BCC-bus Computer/Controllers. Using efficient mechanical relays, the **BCC40R** provides contact-closure on/off control of eight AC- or DC-powered devices for data acquisition and control applications.

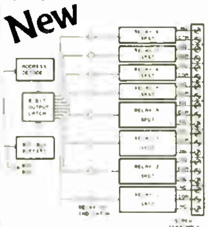
Up to 16 **BCC40R** boards can be used together in a single system to provide a total of 128 relay output channels. The relays are controlled by writing to a board-specific I/O address. The relays on a **BCC40R** board can be controlled either as a set of eight relays at a single I/O address or individual relays at eight separate I/O addresses.

The **BCC40R** can be directly controlled from BASIC or it can function completely in the background under an application program using high speed interrupt-driven ROM C firmware. This firmware sets aside a table in memory which reflects the status and setpoints of the relays. Interaction among programs within a multiboard BCC40x system merely consists of reading or setting these memory table values.

The eight relay outputs have screw contacts for direct connection to the controlling device and/or the power source. Four of the relays have single-pole-double-throw (SPDT) output connections and four relays have single-pole-single-throw (SPST) output connections.

SPECIFICATIONS
- Contacts rated for: 1/10 HP, 3A 120V resistive, or 3A 30VDC
- Latched relay outputs
- LED on/off indicator on each channel
- Power on off failsafe No arbitrary closures on power up down
- Can be used concurrently with BCC40D and other BCC-bus peripherals
- Operates on +12V
- Operating conditions 0-50°C (32-122°F) relative humidity 10-90% noncondensing
- 4 5" x 6" board
- dual 22-pin (0 156") edge connector
- 20-terminal screw connector (#14 wire)

New



BCC40R	8-Channel relay output board	$169.00

OEM 100 Quantity price $124.00

Announcing BCC18 — $175.00
Dual-Serial Board

The **BCC18** is a general-purpose dual-serial-port interface board for use with the Micromint BCC-bus. Optional support software is available for the BCC52 and BCC180 computer/controllers.

The **BCC18** Serial Board contains two serial interfaces. Each interface can be either a 110/300/1200-bps modem, or a hard-wired RS-232C/RS-422/RS-485 interface. The modem interface uses a Xecom XE1201/XE1203 MOSART (MOdem Synchronous/Asynchronous Receiver/Transmitter), capable of 110, 300, or 1200 bps communication and compatible with Bell 103 and Bell 212A standards. The hard-wired serial interface uses an industry-standard 8251A USART (Universal Synchronous/Asynchronous Receiver/Transmitter), capable of supporting asynchronous serial communications at speeds up to 19.2 kbps and synchronous serial communications at speeds up to 64k bps.

The **BCC18** can be configured with two MOSARTs, two 8251As, or one of each. Up to 16 **BCC18s** can be used in a single system (for a total of 32 serial ports).

MOSART
- Connects directly to any phone line
- DTMF or pulse dialing
- DTMF reception and decoding
- Call progress monitoring
- Parity generation checking
- Sync byte detection/insertion
- Extensive built-in diagnostics
- Telephone-line diagnostics
- Synchronous and asynchronous operation
- Voice synthesis capability (XE1203 only)

8251A
- Full-duplex, double-buffered transmitter and receiver
- Fully programmable with several speed and character modes
- Error detection for parity, overrun, and framing
- False start bit detection, automatic break detect and handling
- Supports bisync
- Bit rate is software programmable using an on-board 8253 counter/timer
- RS-232C, RS-422, and RS-485 supported

Software
- MOSART and 8251A use the same program interface, so most software will work with both
- Optional support software for the BCC52 and BCC180 is available that makes it easy to access and use most of the features of the MOSART and 8251A from within user-written programs

BCC18S	OEM configuration fixed dual 8251 RS-232 only serial port board	$175.00

BCC18S OEM 100 Quantity Price $134.00

BCC18U-1	8251/8251 Dual RS-232/485 serial	$209.00
BCC18U-2	8251/1201 Modem and serial port	$359.00
BCC18U-3	1201/1201 Modem /Modem board	$499.00
BCC52/18	BCC52 serial port utilities software	$75.00

BCC-BUS
Expansion Products

		Single Qty. Price
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BCC30	12-bit, 16 Channel A/D Board	$197.00
BCC22	25-line, 80 Character Terminal Board	$249.00
BCC25	LCD Board (4x20) or (8x40*)	$159.00
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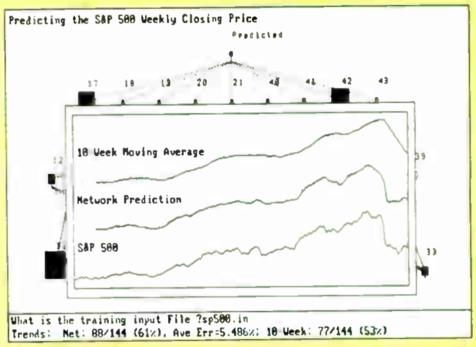

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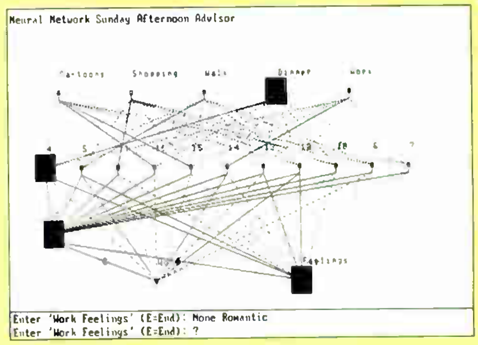

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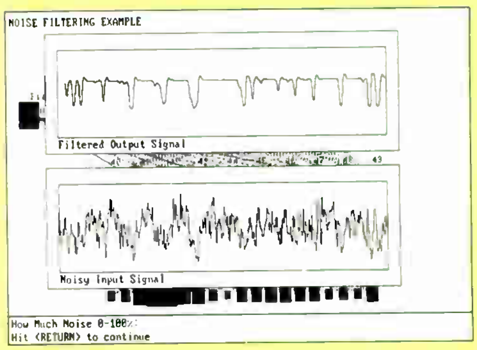

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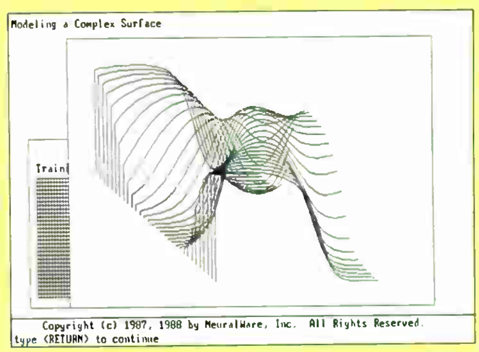

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Circle 531 on Reader Service Card

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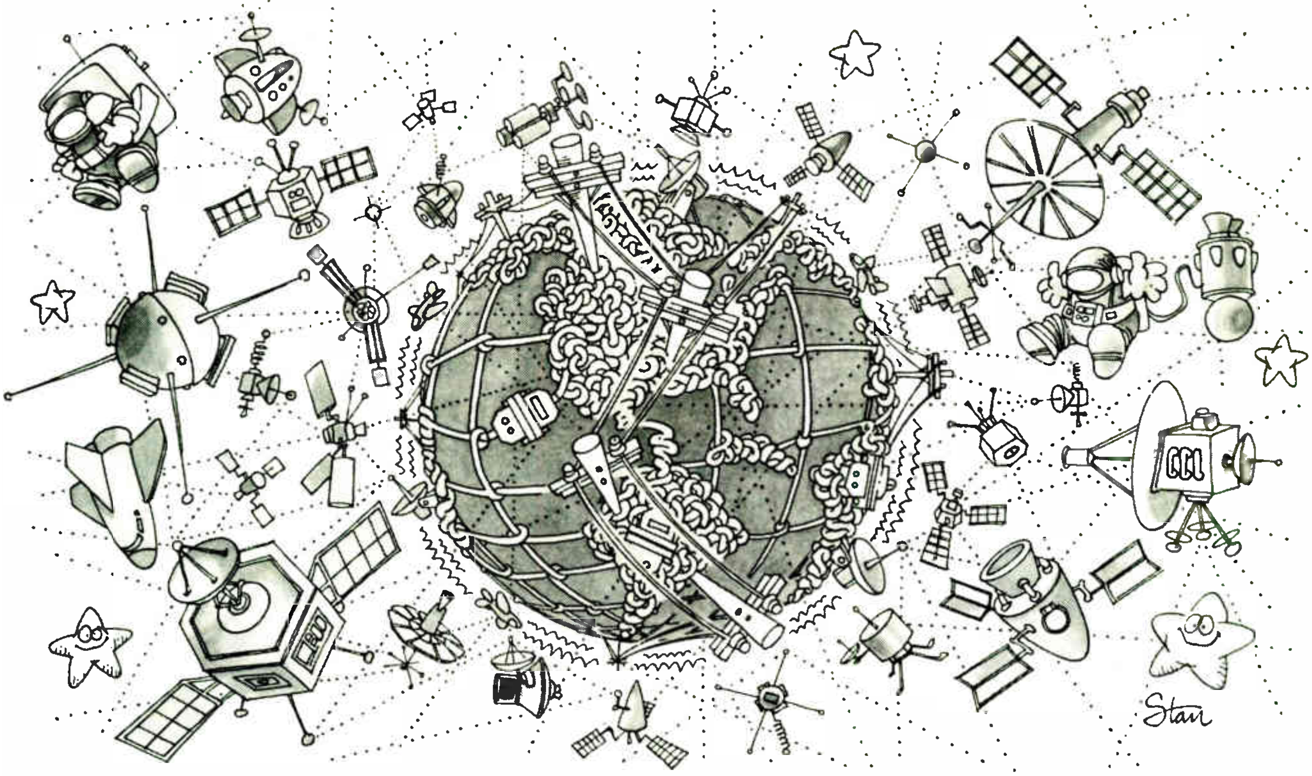

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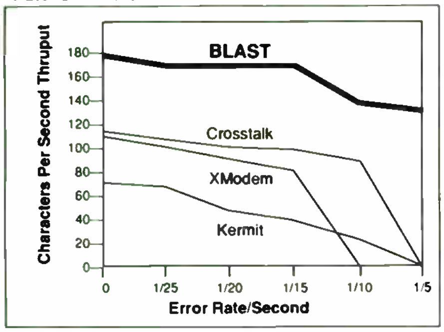

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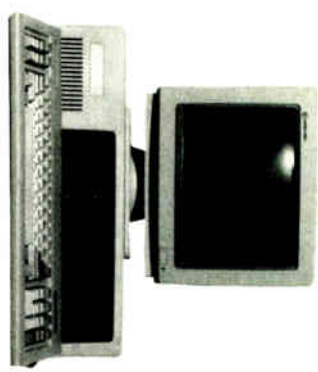

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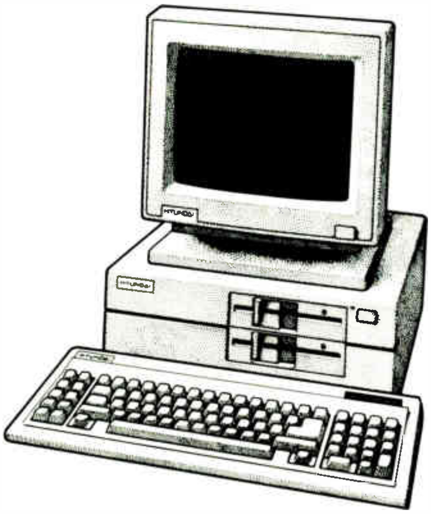

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<tr><td>MODEL</td><td>XT-COMPATIBLE</td><td>AT-COMPATIBLE</td></tr>
<tr><td>CPU speed</td><td>8 MHz</td><td>10 MHz</td></tr>
<tr><td>RAM</td><td>640K</td><td>640K</td></tr>
<tr><td>Floppy</td><td>360K</td><td>1.2 Meg</td></tr>
<tr><td>Hard Drive</td><td colspan="2">30 Meg</td></tr>
<tr><td>Monitor</td><td colspan="2">Amber w/Multi-video graphics</td></tr>
<tr><td>System software</td><td colspan="2">MS-DOS & GW-BASIC, V3.2</td></tr>
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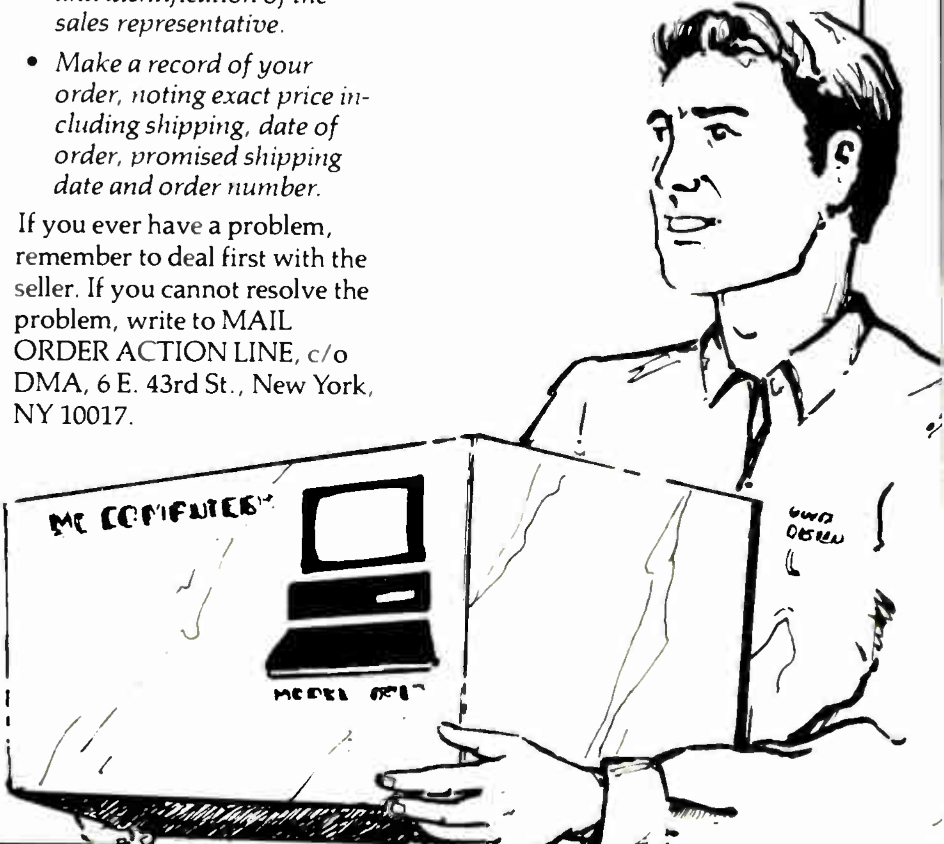


Circle 536 on Reader Service Card

SHORT TAKES

BYTE editors offer hands-on views of new products

THE FACTS

System 310
$2699

Options:
With VGA, color monitor, and 40-megabyte hard disk drive, $3999; with VGA color monitor and 90-megabyte hard disk drive, $4799.

Dell Computer Corp.
9505 Arboretum Blvd.
Austin, TX 78759
(512) 338-4400
Inquiry 856.

Dell's 80386—One of the Fastest

Dell Computer made headlines earlier this year by announcing the first real IBM PS/2 clone. But this groundbreaking system will not ship until later this year. Till then, Dell's most powerful machine will be its new **System 310**, an 80386-based AT-bus system that runs at 20 MHz and may be one of the fastest 80386 systems on the market.

The new Dell system is built on an impressive history. Dell's first 80386 system, introduced under the PC's Limited label in November 1986, was regarded even by some competitors as the fastest machine at that time. That machine used only a 16-MHz processor, but it achieved its high performance through the exclusive use of high-speed static RAM chips.

In the System 310, the static RAM is limited to just a 32K-byte cache. However, the system uses a 20-MHz processor with an Intel 82385 cache controller and paged interleaved memory. This architecture results in some fast performances. In one small sample of benchmarks, a prototype version of the machine outpaced every other system save one, the ALR FlexCache, which it tied.

The System 310 comes in a standard AT-style case with eight AT-style slots. Up to 8 megabytes can be placed on the system's motherboard. Like most 80386 systems, it uses a proprietary 32-bit slot for memory expansion. Here, though, the slot is arranged in an ingenious way: It shares the same space as one of the AT slots. When a memory card is inserted into the slot, the AT slot can still be used by a half-length card.

My system had a fast 90-megabyte enhanced-small-device-interface hard disk drive. Copying large groups of files from one directory to another occurred in less time than it took to type the command. The hard disk drive was also very quiet, a welcome change from some other systems.

The system also came with a Mitsubishi analog color monitor, which produced good-quality VGA color text and graphics. An interesting diagnostics program from Dell lets you test the monitor by creating almost any color you want by varying the red, green, and blue components.

The only thing I didn't like was the keyboard, which seemed a bit too soft. Also, there was no reset button on the front of the system.

One other interesting feature of the System 310 is its price. Although Dell does not publicize it, there are three configurations. The base price—without video adapter or hard disk drive—is only $2699. Fully equipped, the system lists for $4799. In any configuration, this is a fast, low-cost system.

—Rich Malloy

Forth under OS/2

UR/Forth 1.10 for OS/2 Standard Edition 1.0 will appeal to anyone who wants to learn and experiment with the OS/2 API. While the main purpose of Laboratory Microsystems' UR/Forth is to support real-time control applications across a wide range of machines, its designers added the ability to access most API functions directly.

Forth's interactive nature lets you get immediate feedback on what an OS/2 API function call does. You simply push the necessary parameters onto the stack and type the name of the function call. This eliminates the edit, compile, and run loop of a compiled language like C or Pascal.

The UR/Forth system is a complete applications development system, including an

continued

interpreter/compiler (compatible with the Forth 83 standard), a full-screen editor and assembler, a relocating binary overlay utility, and software floating-point and Intel 80x87 support. It also has a multitasker; a native code optimizer; and graphics support for IBM CGA, EGA, and the Hercules graphics adapter.

UR/Forth uses direct threaded code with the top of the stack in a register, a segmented memory model, an object-compiled nucleus, a completely hashed dictionary, and a uniform file interface across all supported operating systems (i.e., MS-DOS, OS/2, 80286 Xenix, and 68000 Unix).

Much source code is included with the system, for things like the editor, the assembler, the tasker, and the floating-point routines. There are also some demonstration programs for the following: graphics routines, the OS/2 API functions, debugging aids, sample programs, and miscellaneous utilities.

In the graphics mode, UR/Forth includes routines for reading or setting pixels, line drawing, arcs, ellipses, circles (with clipping), region fill with patterns or solid colors, bit-block moves, custom character sets, and positioning text at any coordinate.

Because the ability to play with OS/2 API functions is an extra you get with UR/Forth for OS/2, there is no description of the OS/2 API calls in the manual. You will thus need some such documentation (e.g., the OS/2 programmer's reference from IBM [$200] or Norton Guides from Peter Norton Computing [$150]). Also, using the OS/2 API calls will make your application nonportable to Laboratory Microsystems' other Forth systems.

There are some limitations on which OS/2 function calls you can make from UR/Forth. Writing multithreaded applications may cause a problem because not all Forth function calls are now reentrant. This problem is not unique, as many Microsoft C routines are not reentrant either.

Also, because a threaded language is 3 to 4 times slower than a compiled language, the monitor function calls are not available from UR/Forth. But this still leaves many of the 200 or more OS/2 functions to play with. A demonstration program includes calls illustrating the use of queues and semaphores, creating and using shared memory segments, and printing out the global and local information segments.

UR/Forth is the least expensive alternative available so far for getting some hands-on work with OS/2. The closest alternative in price that I know of is the Microsoft Programmer's Toolkit ($350) and the Microsoft C language ($450), though I'm sure this will change soon. While UR/Forth is less expensive, the ability to play with the OS/2 API is intended only as a learning tool. But for a programmer with an open mind, it can be very useful.

—Eva M. White

THE FACTS

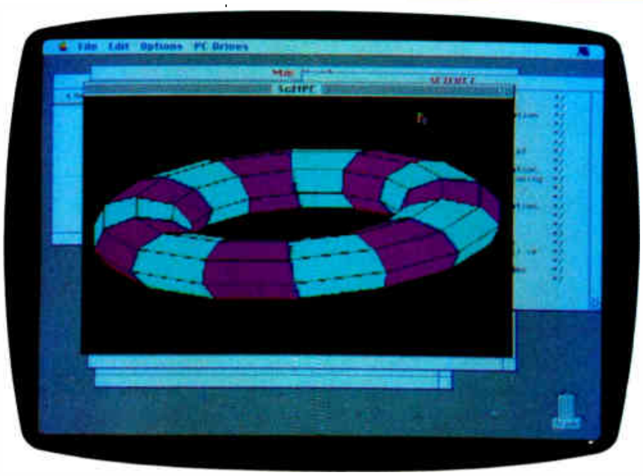
UR/Forth 1.10
$350

Laboratory Microsystems
3007 Washington Blvd.
Suite 230
P.O. Box 10430
Marina del Rey, CA 90295
(213) 306-7412
Inquiry 855.

Requirements:
A high-density (1.2-megabyte) 5¼-inch or 720K-byte 3½-inch floppy disk drive; Microsoft or IBM OS/2 1.0; 2 megabytes of RAM; a video adapter compatible with IBM MDA, CGA, EGA, or VGA.

A Real Virtual Machine

Occasionally, a Macintosh user has to handle data supplied from an MS-DOS computer on a 5¼-inch floppy disk. Some vendors supply IBM PC motherboards, which plug into a Mac SE or a Mac II, to let you deal with this problem. Insignia Solutions provides a different solution with **SoftPC**: It emulates a complete IBM PC XT computer in software on either a Mac SE or a Mac II.



The machine emulated has an 8088 CPU, 640K bytes of RAM, a CGA display (presented as a draggable window on the Mac's screen), three hard disk drives (C, D, and E), a Microsoft Bus Mouse, two serial ports (COM1 and COM2), and a parallel port (LPT1). The C and D hard disk drives are emulated as files on the host Mac's hard disk drive. You can configure these two drives in sizes from 1 to 30 megabytes.

The Mac drive itself is treated as hard disk drive E, which lets you copy files to and from the virtual PC drives with the DOS COPY command. If the combination of an Apple PC card and a PC disk drive is connected to the Mac, SoftPC treats it as drive A and allows file transfers to and from it, again using COPY. You can also format floppy disks or run programs in drive A. Printing to a networked LaserWriter is also supported.

SoftPC comes in 2- and 4-megabyte versions. Installation is straightforward: You pick a configuration, place the floppy disk for its first program into the Mac, and double-click on the Install application. Then you supply disks as the application requests them, until you're done.

You get two files: the

continued

THE FACTS

SoftPC
$595

Insignia Solutions, Inc.
1255 Post St.
Suite 625
San Francisco, CA 94109
(408) 446-2228
Inquiry 852.

Requirements:
Macintosh SE or II with a hard disk drive; System 4.3/Finder 6.0 or higher; at least 2 megabytes of RAM; accelerator card required for the Mac SE.

SoftPC application, and a hard disk file. The hard disk file emulates a 1-megabyte DOS-formatted hard disk drive, complete with MS-DOS 3.30, including the DOS utilities and GWBASIC 3.22.

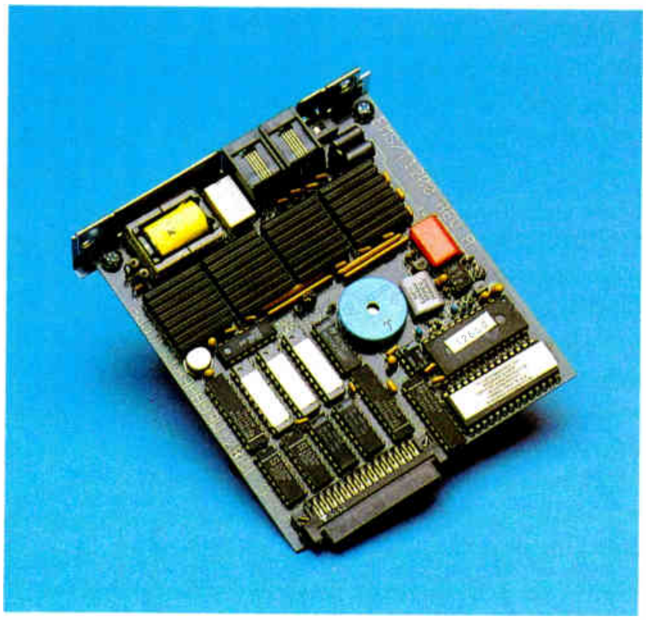
I tried both versions of SoftPC on a Mac II that was equipped with an Apple PC drive card and a 5¼-inch floppy disk drive. Screen response, compared to other PC-compatibility products I've seen, was downright snappy: The window was as fast as a real PC's screen, and no lines were lost during scrolling. XyWrite III Plus, one of the most ill-behaved PC programs in existence, ran perfectly and responded accurately to the extended keyboard's function keys.

Printing to the LaserWriter with the Epson FX-80 mode from within XyWrite was slow but reliable. I encountered no problems when issuing DOS commands to drive A.

SoftPC is MultiFinder-compatible, although it does no background processing, and cutting or pasting to and from the PC window is not supported. You won't be able to run under MultiFinder on a Mac with 2 megabytes of RAM: SoftPC uses 1.7 megabytes of RAM. Even if you don't use MultiFinder, this is a tight fit.

If you need to dabble in the realm of MS-DOS once in a while and own or can afford a PC drive card and disk drive, SoftPC is a viable option.

—*Tom Thompson*



Souping Up the Toshiba Laptop

When I sat down to install EasyTalk from Megahertz on the Toshiba T1100 Plus, I made sure I had some aspirin in the toolbox. It has been a month when everything I've touched has either

continued

THE FACTS

EasyTalk
$299.95

Requirements:
T1100 Plus or T1200.

Megahertz Corp.
2681 Parley's Way
Salt Lake City, UT 84109
(801) 485-8857
Inquiry 857.

crashed, smoked, or simply died. I expected no better from this board. Boy, was I pleasantly surprised.

To install the board, pop off the back plate, slide the board in, tighten two screws, and flip one switch. That's it. The software end is just as easy: Add three lines to your `CONFIG.SYS` file, and you're ready to go.

Now when you boot up your T1100 Plus, you'll not only find a full-function, 1200-bit-per-second modem, you'll also discover a megabyte of additional memory, a RAM disk, a print spooler, and disk-caching capability. EasyTalk turns your floppy disk–based Toshiba into a laptop you can live with.

It takes some extra time, initially, to copy files over to the RAM disk. In about 40 seconds, my `AUTOEXEC.BAT` file activated EasyTalk's utilities, loaded Procomm and PC-Write to the RAM disk, and installed SideKick into conventional memory. This freed up my floppies for data or for additional programs. Also, because I was now working directly from RAM, everything accelerated.

Procomm, the communications software that is shipped with EasyTalk, booted from a floppy disk in 19 seconds; from the RAM disk, it booted in less than 2 seconds. It took 25 seconds to boot dBASE III Plus from a floppy disk, and 2 seconds from a RAM disk. Disk caching slashed dBASE sort and indexing times in half. Also, word-processing tasks requiring disk access enjoyed hearty speed enhancement, and print spooling keeps you working even when the printer is busy.

I also like the version of Procomm (2.4) included with the package. The screen displays were nicely done, and the beep accompanying each keystroke was unobtrusive. Though I had never used Procomm, I had no problem learning how to use it. Pressing Alt-F10 calls a help file that outlines each feature, along with the keystroke sequence required to activate it.

Like PC-Talk, Procomm calls most features by using the Alt key in conjunction with a function key; and, by a simple change of the setup file, you can access your favorite word processor by striking Alt-A. For quicker access, I loaded PC-Write to my RAM disk. However, I could also call WordStar from drive A and use it from within Procomm.

Taking a tour of BIX, I checked many of the modem's functions: auto-dialing, manual dialing, macro log-ins, and multiple file transfers. Of the nine transfer protocols offered from Procomm, I tried five—XMODEM, YMODEM, MODEM7, Kermit, and ASCII—and each worked without a hitch.

EasyTalk adds essential features to a floppy disk–based laptop, and even a hard disk drive's performance will improve with disk caching and a RAM disk. And everything worked flawlessly.

—*Stanford Diehl*

GrandView: More than an Outliner

Software products that promise to organize your business or your life aren't new. But one that works is. I quickly found that **GrandView** is much more than a plain old outline program, and that's where its power lies.

Describing GrandView using a standard software category is difficult because, taken as a whole, it pushes the edge of current software development technology. But for simplicity's sake, I'll call it an integrated software package that's quite adept at planning and project managing.

GrandView handles information in three different ways, called *views*: outline, document, and category. Outline view is indeed a state-of-the-

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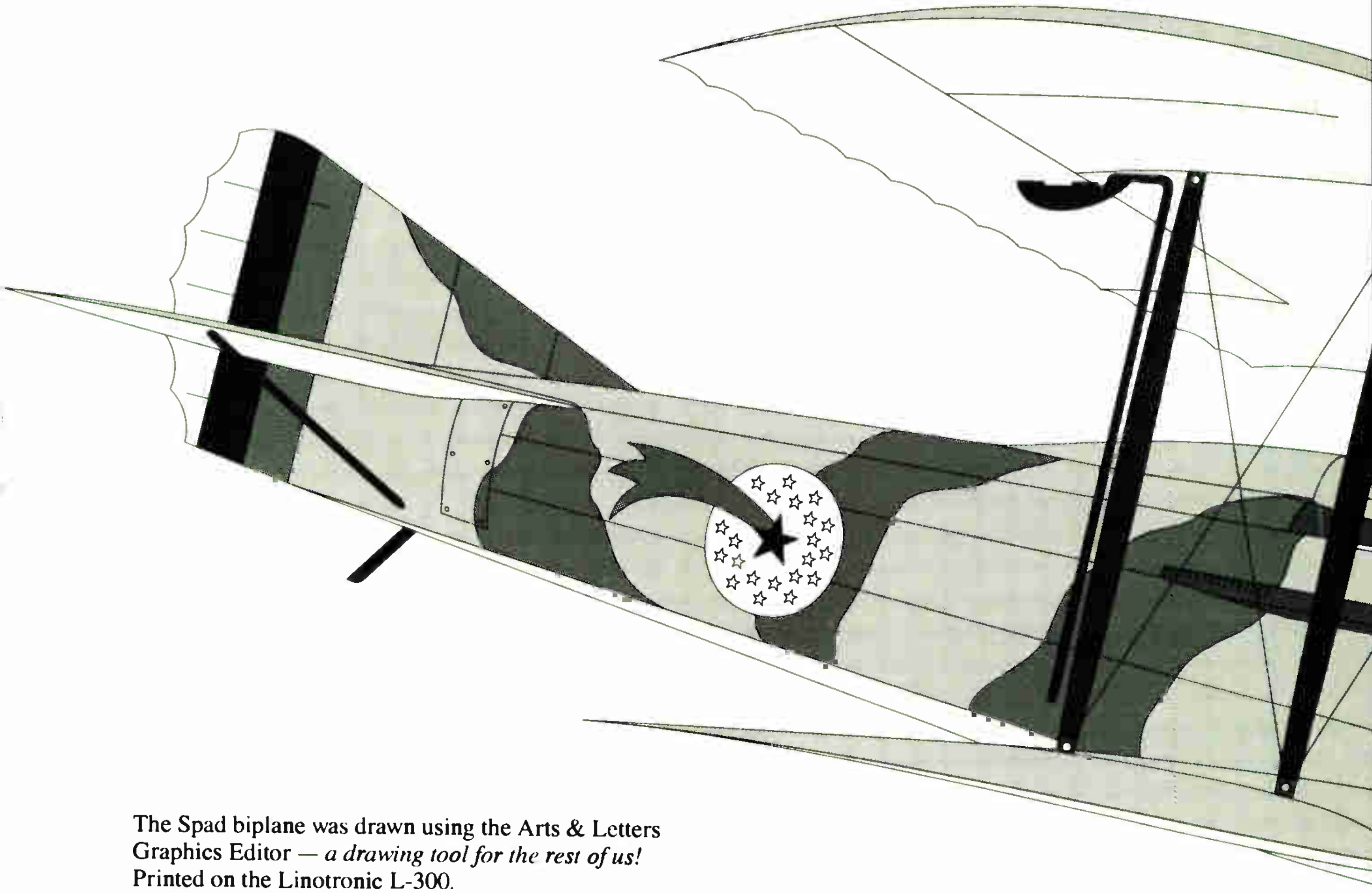
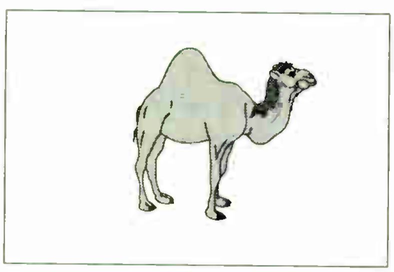
A Drawing Tool...



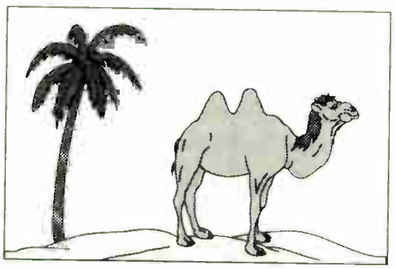
The Spad biplane was drawn using the Arts & Letters Graphics Editor — *a drawing tool for the rest of us!* Printed on the Linotronic L-300.

Short on Time?

For those of us with little artistic skill, and even less time, the Arts & Letters Graphics Editor offers the ability to modify professionally drawn clip art quickly and easily.



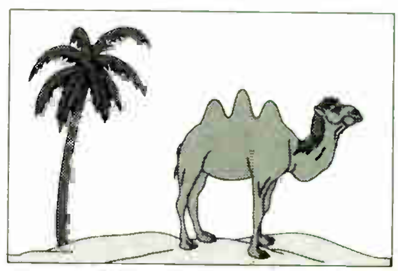
Often you will find the exact drawing you need from among the thousands of clip art drawings available with Arts & Letters. But if you don't, there is usually a drawing you can customize to your requirements.



For example, the drawing of a one-hump camel can easily be changed to a two-hump camel. Just place the cursor at the top of the single hump and drag the curve down to form two humps.

Of course you can also split a shape at a point, delete segments, join shapes, snap to points and move a point or group of points. And the lines and curves will be smoothly joined and stay smooth throughout the editing process.

Because you don't need to specify control points when drawing Bezier curves, freehand drawing is greatly simplified. And don't worry if the lines you've drawn appear squiggly — the Graphics Editor will convert them into smooth curves automatically.



The above drawing was created in about two minutes. If that sounds too good to be true, see for yourself. Order a videotape demonstration of the Graphics Editor today.

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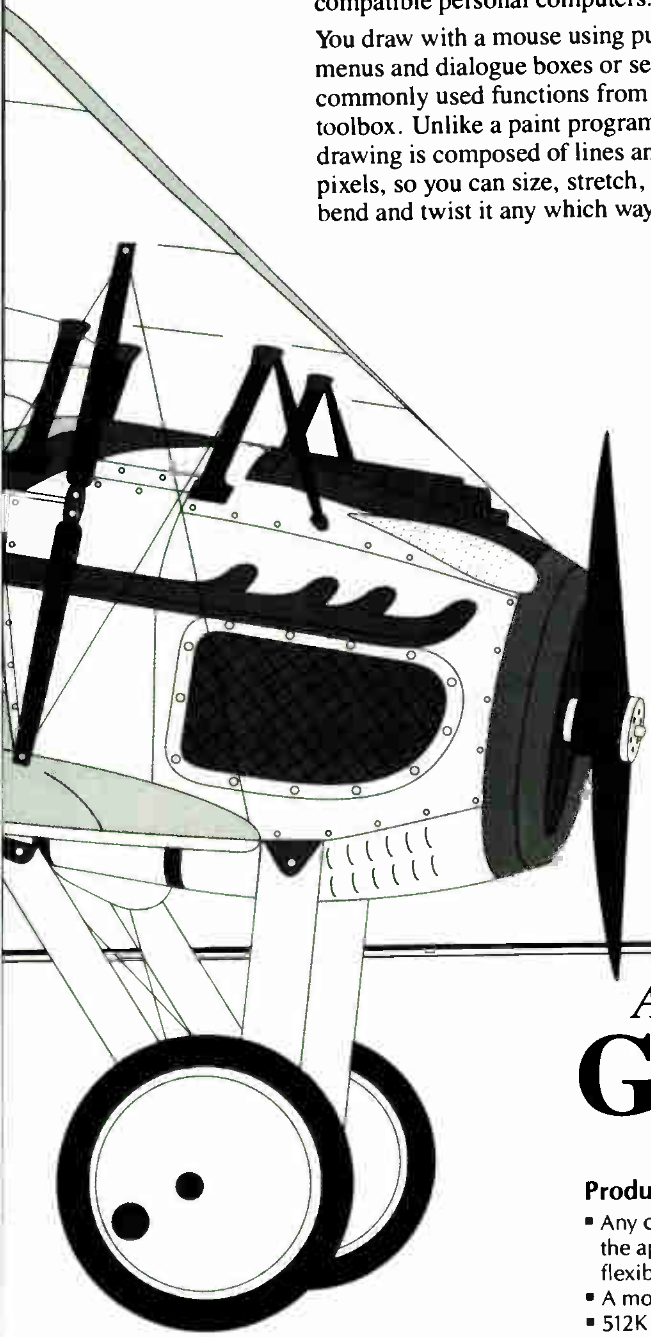

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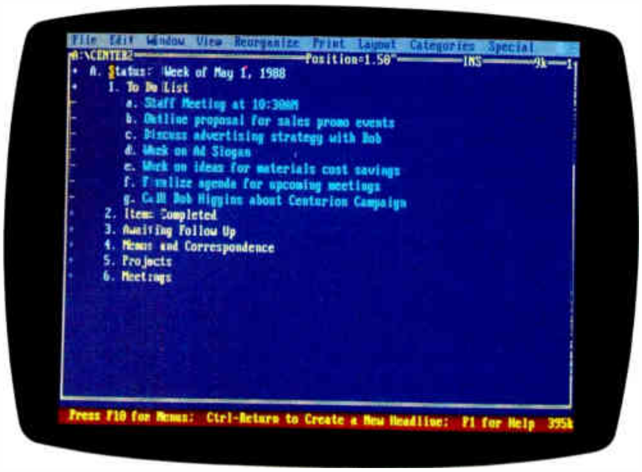

THE FACTS

GrandView
$295

Symantec
Living Videotext Division
117 Easy St.
Mountain View, CA 94043
(415) 964-6300
Inquiry 851.

Requirements:
IBM PC, XT, AT, or compatible, or IBM PS/2; DOS 2.0 or higher and 256K bytes of RAM; hard disk drive recommended.

art outliner, with a host of features that let you expand, contract, and move outline elements around.

Document view is a fancy term for GrandView's word processor. Taken by itself, however, it's a word processor with features that put it nearly on a par with stand-alone word-processing packages with hefty price tags. It's also customized to work seamlessly with the rest of the package.

I found GrandView's category view its most intriguing and potentially most useful feature. It lets you take information from your outline or other document and assign it—as the name implies—to a category. It gathers related information from throughout an outline and displays it on a single screen.

For instance, in a long outline that covered all the aspects of a publishing project, category view let me quickly pull out editorial, circulation, and marketing areas and see their dependencies and schedules.

In category view, an outline or document becomes an effective project manager, though GrandView is far from a full-fledged project-management package.

While it's relatively easy to throw together a quick outline or two, getting the most out of the package's features requires time and dedication. You'll need to learn numerous unfamiliar terms, and I was at first frustrated by keystroke sequences that seemed strange (e.g., Control-Enter to add a new heading to an outline).

If your outlining needs tend toward simple priority lists, GrandView is much more than you need. But if you have a real need to organize scattered pieces of information into viable projects, GrandView—once you get over the top of the learning curve—will save scads of time and money. Considering this program's power, the $295 price tag is more than reasonable.

—Stan Miastkowski

continued

Coming from Lotus.®

What, Me Forget?

Just what I need, an additional terminate-and-stay-resident (TSR) desk accessory program. Well, maybe I don't *need* this one, but it did save me the embarrassment of forgetting two birthdays.

Forget-Me-Not (FMN) from Sterling Castle Software is a calendar/timer TSR program with a unique ASCII-based engine. (I was working with a prerelease version.) It can pop up reminders on your screen at times and dates you choose. Also, it can activate batch files you create to do tasks, such as sending multiple messages via electronic mail or a network and doing backups or disk maintenance when you aren't using the machine. To do network communications, you need a copy of FMN installed at each node.

Sterling Castle bills FMN as "the first timed-release software." The heart of it is the concept of file accessibility. FMN can read all printable ASCII characters in a file and respond accordingly. If you want to set up a biweekly midnight or lunchtime backup process, just get into your favorite word processor and type in the necessary commands, just as you would if you were going to do the backup manually. You must preface the batch file with an FMN control line that specifies the type of message it is and at what times and on what days you wish it to occur.

Save the unformatted file and copy it to the appropriate FMN message file. You can have up to 16 different message types, each customized to fit your situation. When the conditions you specified are met, the file will activate. When it's done, you'll find a message that indicates success. If there is no message, you know something went awry.

If you're worrying about a private reminder popping up while someone is looking over your shoulder, FMN covers that, too. You can attach an acknowledgment attribute to your messages so the computer will beep when the reminder is ready to pop up. Unless you hit the appropriate key, which is also selectable, the message won't be displayed.

If you are already using TSRs like SuperKey, SideKick, Homebase, ProKey, or others that give you some sort of notepad and keyboard macro capability, you can use them to automate the reminder-writing process. For instance, if you have a "call back" file format for returning phone calls, you can set up keyboard macros to leap from your present application into your word processor or notepad TSR.

Once there, you type in the reminder you need, send the file to FMN's "call back" file, and jump back to your original application with a minimum of keystrokes. If your TSRs work with your other applications software and can produce ASCII files, FMN should work just fine for you.

FMN is written in assembly language and requires 24K bytes and some buffer memory, for a total of 64K bytes. A version that will operate in extended memory is being considered for a later release.

—Gene Smarte

THE FACTS

Forget-Me-Not
$79.95

Requirements:
IBM PC or compatible; 128K bytes of RAM; DOS 2.0 or higher.

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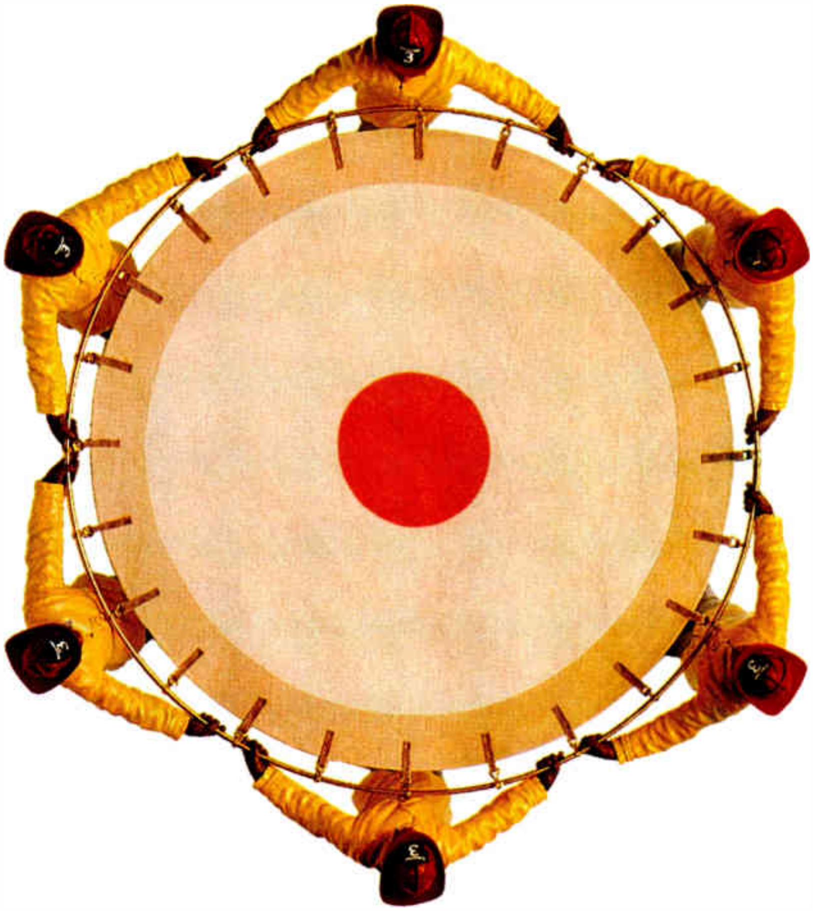
Marina del Rey, CA 90292
(213) 306-3020
Inquiry 854.



Sun's New Workstation: the Sun386i

A microcomputer workstation that combines Unix multitasking, a window-based interface, and the ability to run several virtual PCs

Multitasking operating systems have been promising to provide microcomputer users with many services that mainframe users enjoy, such as electronic mail and background processing. Unfortunately, the promise has so far remained merely a promise.

The Commodore Amiga came with a multitasking kernel from the start, but its baroque command set, low-resolution display, and lack of hardware memory protection makes using it a chore at best.

Microsoft's OS/2 with the Presentation Manager is slated to be released late this year, and programs that take advantage of its multitasking features will undoubtedly arrive even later.

Apple's A/UX system provides multitasking, but it's literally Unix running on a Macintosh II: Gone is the familiar point-and-click user interface that many Mac users enjoy. Currently, some Mac applications can run under A/UX, but others can't. Like the situation with OS/2, Macintosh applications will be revised to be A/UX compatible, but until then, Mac users, like PC users, will have to wait.

A solution to this hurry-up-and-wait dilemma comes in the form of Sun's newest workstation, the Sun386i, designed around an Intel 80386 processor. Typical of its workstation caliber, it runs Unix, a time-proven multitasking operating system; it supports Ethernet communications; and it uses Sun's own Network File System (NFS) to provide access to files across networked devices. A point-and-click window-based user interface with icons and buttons simplifies such operations as examining or copying files and answering mail.

But what has attracted the interest of the microcomputer community is the Sun386i's ability to execute MS-DOS programs simultaneously as sessions in separate windows. A sophisticated monitor program also allows them to utilize the workstation's hard disk and memory without conflict. And this ability to run existing MS-DOS programs while reaping the benefits of a workstation is available now.

The Sun386i comes in two models: The Sun386i/150 uses 20-MHz components and has 4 megabytes of 100-nanosecond (ns) fast-CAS (column-address strobe) paged-mode RAM; the Sun386i/250 uses 25-MHz components and has 8 megabytes of 120-ns fast-CAS paged-mode RAM and a 32K-byte cache of 25-ns static RAM.

There are some minor differences, but for the most part the two microcomputers are identical, so we'll concentrate on the Sun386i/250. A Sun386i/250 with a 16-inch monitor and 91-megabyte hard disk costs $17,990, and a Sun386i/150 with a 15-inch monochrome monitor and 91-megabyte hard disk (available in the third quarter of 1988) costs $9990.

The Hardware

The Sun386i is a short, floor-standing deskside unit with a single 3½-inch floppy disk drive. The system comes with a

continued

three-button optical mouse, a 107-key keyboard that has both Sun software-specific function keys (such as Help and Copy) and PC function keys, and your choice of a high-resolution color or monochrome monitor.

The heart of the Sun386i is a single system board that holds an 80386 processor; an 80387 math coprocessor (standard, not as an option); an 82380 DMA controller; an Ethernet interface using the Intel 82586 network processor, and a custom ASIC for the system interface; three slots for Sun 32-bit memory boards; and a video frame buffer slot that accepts three types of video display boards. All these components are connected on a 32-bit high-speed proprietary bus.

Interface electronics attach this 32-bit bus to a 16-bit AT bus and an 8-bit device bus. The AT bus handles the parallel printer port, floppy disk controller, three 16-bit AT-compatible slots, and one 8-bit XT-compatible slot for expansion cards. The device bus handles the SCSI port, serial port, ROM and nonvolatile RAM addressing, and clock.

The system's memory is contained on an expansion board that plugs into one of the memory slots. The memory board uses 1-megabit-density, parity-checked SIMMs (single in-line memory modules) that mount in a rack of sixteen clip-on sockets.

You can add extra memory to the board in 4-megabyte increments up to the maximum of 16 megabytes. An Intel 82385 cache controller chip is mounted on the board and implements a 32K-byte high-speed memory cache. This cache memory board is optional on the Sun386i/150.

Two optional high-capacity SCSI hard disk drives are available for the Sun386i: 91 megabytes and 327 megabytes (formatted). You can mount these drives internally within the system, or externally in an optional peripheral expansion box supplied by Sun. The 3½-inch floppy disk drive serves double duty as a drive for the Unix operating system or as drive A for a single MS-DOS program. Under MS-DOS, the drive can use both 720K-byte or 1.44-megabyte DOS-formatted floppy disks.

An external DB-50 SCSI port and switched power outlet located on the back of the computer allows you to connect the peripheral box, external tape drive, or other SCSI peripherals to the system. Also located at the rear of the computer is a "thick" Ethernet port with DB-15 connector, and two DB-25 connectors for the serial and parallel printer ports.

You have a choice of monitors and display boards to use with the system. A monochrome video board provides a 1152- by 900-pixel display for a 15- or 19-inch monochrome monitor. For color work, you have a choice of either a video board that provides a 1024- by 768-pixel color display for a 14-inch color monitor, or one that provides a 1152- by 900-pixel color display on a 16- or 19-inch color monitor. Both color video boards use a fixed 8-bit image depth that allows you to display 256 colors on the screen simultaneously from a palette of 16 million colors.

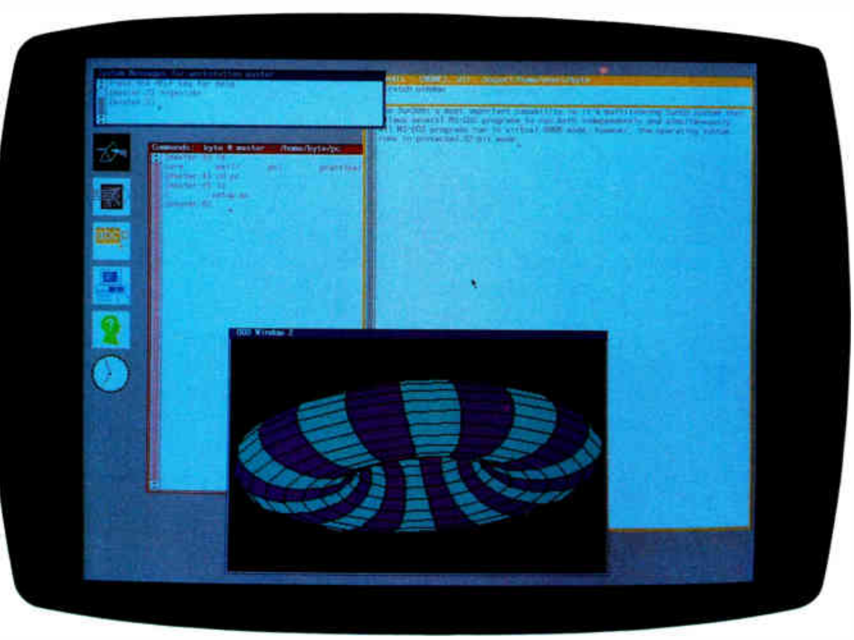


Photo 1: *On the SunView Desktop, icons represent active processes, not files.*

The Software

The core of the Sun386i operating system is SunOS version 4.0, which is a converged version of BSD4.2/4.3 Unix and System V.3 Unix. Besides the usual Unix services, SunOS provides NFS capabilities, a window-based user interface called SunView, and ease-of-use facilities such as the Sun Organizer and Color Editor.

SunView represents active programs as icons, and these icons can be selected (left button) using the mouse. Selecting an icon opens a window, owned by the program, that accepts user commands or displays information. The icons and windows are placed on a desktop image quite similar to the Macintosh desktop display (see photo 1).

These windows allow you to type commands directly into the Unix operating system (the Commands window) or a DOS program (the DOS window). A System Messages window displays error messages issued by SunOS as they occur. A window can also present a specialized display, as determined by the program that owns it. For example, the Organizer program can give you a graphic map of the hierarchy of subdirectories and files in your home directory.

As with the Macintosh, you can open, close, resize, and drag the SunView windows to different parts of the screen using the mouse. The left button of the Sun386i mouse serves as a selector; that is, it selects (or activates) the object you click on the screen.

The middle button is used to move icons or windows about on the Desktop, although you need to place the pointer on a window's name stripe (similar to a Mac window's drag bar) or on its frame (the border) to move it. The right button is used to activate pop-up menus.

Clicking the right button on a window's frame pops up a Frame menu that's used to manipulate the window (for example, resize it) or to terminate the process owning the window. If you click the rightmost button within a window's interior, a program-specific menu pops up (for example, in a DOS window this menu lets you choose the type of PC screen display to use). Clicking on the Desktop itself pops up a Services menu that allows you to start a program not visible on the Desktop, start a copy of a program already running on the Desktop, or log out of the system.

You don't click on a window to make it the active window, like on the Mac. Positioning the pointer over the desired window causes its frame to be highlighted, indicating that the process is ready to accept typed commands.

Some windows can have scroll bars that allow you to scroll through a long document or large display. Pressing the mouse's left button scrolls the window's contents upward, and pressing the right button scrolls the window's contents downwards. A window's name stripe also shows the name of the process that owns it and the current directory that the process is using.

A Mail program lets you send, receive, file, and print electronic mail. Selecting its postage-stamp icon gives you a window in which to examine or compose letters. All you need to know to send a letter is the system name of the recipient (for example, `byte_mag`), and their log-in name on this system (`editor`), so the mail address becomes `editor@byte_mag`. Once you've composed a letter and addressed it, you simply click on the Deliver button and Mail will transmit it to the appropriate remote system.

If you dislike maneuvering through Unix hierarchies by typing commands like `cd/export/home/users/byte/pc`, you can use the Sun Organizer program. The Organizer works like the Macintosh Finder by presenting a graphic representation of the subdirectories and files in your current directory. You navigate up or down directory levels by simply pointing and clicking with the mouse on icons and buttons in the Organizer's window. Unlike the SunView Desktop, icons in the Organizer program do represent files and directories (see photo 2).

You can also copy, move, or delete files within the Organizer by clicking on the desired file icon and then the appropriate button. The Organizer, like most SunOS programs, uses NFS to provide access to remote systems. From your `/net` directory, the Organizer lets you use the same graphic interface to select any remote Sun386i or NFS-based workstation on the network and then work with its files. This ability to seamlessly examine and copy files from a remote system makes the Organizer one of the most powerful programs on the Sun386i. Professional programmers can still use Unix programs such as `cp` to copy files from remote systems.

It Does DOS

OS/2 runs a single MS-DOS program in a Compatibility Box. SunOS allows you to run multiple copies of MS-DOS version 3.3, each in its own window, and each running simultaneously along with other SunOS programs. PC programs can use the Sun386i's hard disk and floppy disk and access PC expansion boards plugged into the AT bus slots. PC programs can also take advantage of the system's networking facilities.

The SunOS DOS Windows program allocates memory and initializes the MS-DOS environment when you open a DOS window. Each PC program runs in the 80386's virtual 8086 mode, letting 8086 program code execute at full speed on the processor. Since the virtual 8086 mode does not support the 80286 protected mode, this type of program won't run on the Sun386i. As the program runs, the DOS Windows program intercepts hardware-specific calls and reroutes them to the appropriate SunOS routines.

For example, a call that writes to the PC's screen is emulated by DOS Windows by using the proper combination of SunView graphics routines. A DOS window can emulate a Hercules, monochrome, or CGA display. An AT-bus expansion card can provide support for EGA/VGA displays. You select the type of display to use by popping up a menu within the window's interior and choosing an item from the Show Screen item.

The DOS monitor allocates 1 megabyte of memory (for a 640K-byte DOS address space) and two megabytes of version 3.2 Lotus/Intel/Microsoft (LIM) expanded memory for a PC program when it starts. DOS Windows redirects LIM memory accesses to this virtual memory space as they occur. Because the PC program and the LIM memory are located in the Sun386i's virtual memory, they can be swapped to and from the hard disk.

You can install four PC expansion boards within the Sun386i. However, it's not enough to physically install the board into a slot. You have to inform SunOS of the board's characteristics so it can respond appropriately when you access the board. To do this, you must become a Unix superuser and edit the `boards.pc` file in the `/etc/dos/defaults` directory. In this file, you supply the address space the board occupies and the interrupt levels it uses (if any).

Each user has a separate `/pc` subdirectory. In this subdirectory are four files: `autoexec.bat`, `config.sys`, `setup.pc`, and `C:`. The functions of the first two files are obvious; the other two files need explaining.

`Setup.pc` describes to SunOS which Sun386i devices are assigned to which DOS devices. For example, drive A is directed to the Unix device `/dev/rfd0c`, the Sun386i's floppy disk drive. `C:` is a specially formatted file made to resemble a 20-megabyte MS-DOS hard disk.

A DOS window normally places you on a drive D, which is actually the current Unix directory you're working in. However, programs with copy protection rely on certain PC hard drive characteristics that are missing on the Sun386i hard disk drive, and thus break during instal-

continued

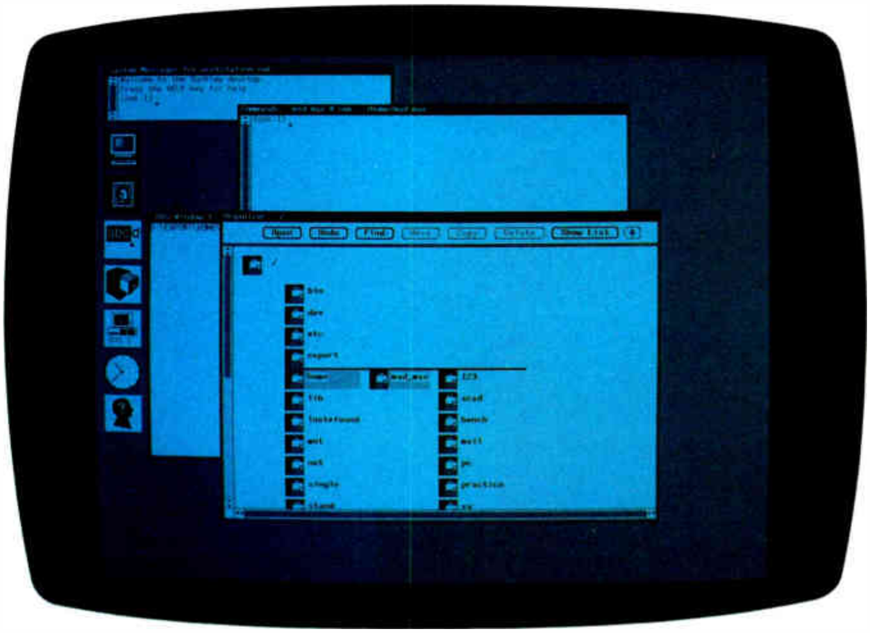


Photo 2: *The SunOS Organizer graphically displays the hierarchy of a directory.*

Table 1: *On the BYTE benchmarks, the Sun386i/250 did better than the Compaq 386/20. Performance dropped as additional DOS windows were opened. Only benchmarks using algorithms were selected to make the performance comparison, since the DOS window is a process running under Unix. (All times are in seconds.)*

	Sun386i 1 task	Sun386i 2 tasks	Sun386i 3 tasks	Compaq 386/20	IBM PS/2 Model 80	IBM PC AT
Matrix	2.77	5.57	10.17	3.06	4.65	11.69
Sieve	19.33	36.99	54.50	23.18	29.11	40.26
Sort	19.05	39.41	60.28	26.89	33.11	84.39

lation or operation. C: is used to sidestep this problem by emulating an MS-DOS hard disk for this type of software.

PC programs assume that they have exclusive access to a computer's resources. This assumption becomes a problem when such programs are run in a shared environment. In the case of memory and screen I/O, the DOS Window redirects these functions to the appropriate section of virtual memory or to the program's DOS window. MS-DOS files located on the Sun386i hard disk are maintained by the Unix file system via DOS Windows, which can resolve I/O conflicts when more than one copy of MS-DOS attempts to access them. However, for drive C or drive A, Unix can't help. This is because drive C is a disk emulation, and is seen as one file by Unix. MS-DOS drivers must be used to access files within C or on drive A, and are therefore subject to the problems described earlier.

Sun came up with a clever solution for this problem: The first DOS window opened has exclusive write access to both drive A and drive C. You release the exclusive access by terminating the DOS window that owns them, or using a menu selection to modify the drive-access mode. This seems awkward, but if you use your files on drive D, you let Unix provide the shared access to your MS-DOS files.

How It Performs

I had an opportunity to examine two production Sun386i/250 workstations using a beta version of SunOS 4.0. Sun also generously supplied two thick Ethernet cables and an Ethernet multiport transceiver unit so that I could look at the system's networking capabilities. The Sun386i comes with the system software installed on the hard disk, so getting a system started was simply a matter of connecting the parts, turning on the power, and answering several questions about the system. This first system was started as a master server.

Sun claims that adding more 386i systems to the network "is extremely easy and requires no technical expertise." I soon put this statement to the test by connecting the second system's Ethernet cable to the transceiver box, which was connected to the master (first) system. Again, the system was turned on and several questions were answered, this time making the system a slave. After exchanging a flurry of data packets (as indicated by the status lights on the transceiver box), the second Sun386i announced its domain and system name, and the connection was completed. We managed to connect a Macintosh II running A/UX to the network only after we had set the Mac II's internet address and domain name correctly and configured it as a yellow pages client. This, needless to say, took a number of attempts. Compared to the few minutes it took for the second Sun386i to connect itself automatically to the network, I'd have to say Sun's statement about ease of network installation is true.

I tried XyWrite III Plus, Lotus 1-2-3 version 2.01, dBASE III Plus 1.01, Designer 1.0, and a program compiled in QuickBASIC 4.0 in the DOS windows. All programs ran reliably. I had a problem when using the DOS window menu to switch to the CGA mode: Once in it, the window seemed to stop operating. The problem was traced to failing to issue a `mode co80` command to switch to the emulated color monitor. Once this command was added to the `AUTOEXEC.BAT` file, I had no further problems.

Of course, how fast are these PC programs if they run as a process on a Unix workstation? To answer this question, I executed a `.BAT` file that ran the new BYTE benchmarks several times and recorded the results, which I then averaged by hand. I next ran the benchmark batch file simultaneously in two DOS windows, and then in three. (Bear in mind that this is a multitasking Unix system, so these numbers are only a measure of the DOS emulation, and not an overall measurement of the workstation itself.) Although I had several SunOS windows open, these processes were idle.

With the system quiescent, one DOS window performs better than a Compaq 386/20 (see table 1). With two DOS windows, you're doing slightly worse than an IBM PS/2 Model 80. With three windows active, performance sags close to that of an IBM PC AT. SunOS doesn't limit the number of DOS windows you can open, but if you expect reasonable performance, you won't use many more than three DOS windows at a time.

Once, while running an AT program on the system, I got an "Unsupported 286 instruction" in the System Messages window, and the DOS window abruptly disappeared. All other processes and DOS windows running were unaffected. A call to Sun got an explanation. The 80386's built-in memory management hardware had trapped the illegal instruction and called the appropriate Unix routine, which then killed the process.

The DOS window's disappearing act was an example of hardware memory protection in action: that is, the ability of the system hardware to isolate a process running amok and leave the other processes intact. This is an important area that shouldn't be overlooked: Multitasking operating systems should not only run processes simultaneously, they should also protect the processes' integrity. Sun has done a good job of implementing this type of protection in SunOS.

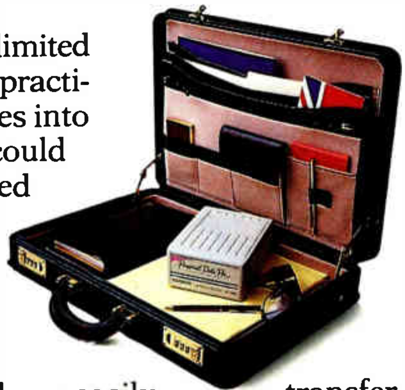
Where does the Sun386i fit in the scheme of the microcomputer industry? As an MS-DOS system, it offers good processing power and can provide it as virtual PCs in several DOS windows. You also reap the benefits of a workstation: good graphics, multitasking, and a networking capability that allows you to share files or send mail messages without becoming mired in the intricacies of learning Unix. For those who use Unix, the complete set of standard BSD and System V utilities is included and can be used in the Commands window.

However, a workstation makes demands of its owner in exchange: You need someone with Unix experience to configure the system software and modify it to accept PC expansion boards, and manage the network as it grows. If you're willing to accept the demands of a microcomputer workstation, the Sun386i will deliver ease of use and performance. ■

Tom Thompson is a BYTE Senior Technical Editor at Large. He can be reached on BIX as "tom_thompson."

"Unlimited."

un•lim'i•ted, a. [L. limitus]: ***The ability to expand your personal computer's storage capacity beyond your wildest imagination.***



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IBM's OS/2 Extended Edition

This greatly enhanced version of OS/2 packs its own database manager and an array of communications interfaces

IBM's shipment of OS/2 last December was only the first in a series that will offer progressively more powerful systems. The first version, Standard Edition 1.0, features multitasking and superior memory management that lets you run several applications concurrently and switch back and forth between them at will.

This month, IBM will release the Extended Edition (EE) of OS/2, which includes all the features of the Standard Edition, plus support for communications and a database management program. At a retail price of $795, the EE may be one of the better values on the market. (Current owners of the Standard Edition can upgrade for $600.)

Unlike the Standard Edition, which is available from other computer manufacturers, the EE will probably be available only from IBM. Later this year, IBM will replace both editions of OS/2 with free upgrades that will include the Presentation Manager, a graphical user interface similar to Microsoft Windows (see figure 1).

Why include a communications manager and a database manager with an operating system? According to IBM's projections, approximately 75 percent of its PC users will be using both database and communications software on their PCs. In addition, many users will want to run both types of applications at the same time. The ultimate goal of the EE is to allow you to access several databases at several locations at the same time, and to have the whole process appear as if you were browsing through a single database on your own hard disk. (Unfortunately, this feature—which IBM calls Remote Data Services—is only a "planned enhancement," meaning that the company will not make it available until some indeterminate date.)

In terms of code size, the EE is probably the most ambitious program to date for personal computers. It will be packaged on approximately 16 3½-inch disks, with each disk having a capacity of 1.44 megabytes. The system requires an OS/2-compatible PS/2 or AT with 3 megabytes of RAM, and if you load the whole package on a hard disk, it may completely consume a 20-megabyte hard disk drive. Thus, even IBM PS/2 Model 50 users may have to consider purchasing a larger hard disk drive, or implementing only part of the EE. An installation program included with the system will let you save disk space by installing only those parts of the operating system you need.

No doubt a large part of the EE's disk space is taken up by its help facilities. In addition to contextual help screens, the EE also has a feature that lets you place the cursor on a particular word and call up a help screen pertaining to it. It also has a tutorial program that, according to IBM, can be easily modified, depending on your particular configuration.

The new OS/2 will also be the first program to conform to IBM's new Systems Application Architecture (SAA). This is a standard set of interfaces for users and programmers, designed so that users can easily switch between different applications on different types of IBM hardware, and source-level programs can be easily ported to different types of IBM systems and communications facilities.

Communicating with Several Systems at Once

The Communications Manager of OS/2 provides support in three areas: asynchronous communications, which you could use to contact Dow Jones or BIX, or to connect with non-IBM host computers; support for the 3270-style terminals used by IBM's System/370 mainframes; and support for peer-to-peer communications using APPC (IBM's Advanced Program-to-Program Communications). APPC differs from the hierarchical structure of terminal-to-host communication in that it lets any machine communicate with any other machine on the network in an intelligent manner. Unfortunately, network support will not be available until version 1.1 of the EE becomes available in November.

The goal of the Communications Manager is to allow an OS/2 workstation to interact simultaneously with several other systems. With such a workstation you could check a number of things at once—for example, parts inventory on a mainframe database via a 3270 link, a customer database on another OS/2 system on a local network, and stock prices on a COM link to Dow Jones News Retrieval.

OS/2 Standard Version 1.0 provides good support for asynchronous communications via a device driver that supports up to three serial ports. The device driver operates with some high-level function calls that make it relatively easy to write a communications program.

In the EE, IBM provides such a program, an asynchronous communications program that can emulate a DEC VT-100 terminal or IBM's own 3101 terminal and that supports XMODEM file transfers. Unfortunately, this program can be used on only one of the asynchronous COM ports at a time.

Perhaps the most important value of the Communications Manager is its support of 3270-style communication with IBM System/370 mainframes. With the Communications Manager you may still need a coaxial 3270-style interface card (such as those provided by AST, DAC, or

continued

IBM), but you will no longer need to purchase a 3270-emulation program from IBM. One advantage of the Communications Manager on a PS/2 system is that you can mix and match multiple 3270 and asynchronous adapters on the Micro Channel bus. Thus, the EE is perhaps the first program that can take real advantage of the Micro Channel architecture.

The local-area network support of the Communications Manager will, according to IBM, be part of the November release and will support calls to NETBIOS, IEEE 802.2, and IBM's APPC network functions. One notable omission here is support for Ethernet. IBM claims, however, that it may be relatively easy to write an Ethernet driver based on one of the other sets of functions.

SQL and a Query Manager

When IBM announced in April 1987 that the OS/2 EE would feature a built-in database manager with support for Structured Query Language (SQL), the ripples began to be felt almost immediately in the database world. The announcement has spurred a movement toward the use of SQL and, since the EE's database manager is just one part of a $795 bundle of software, it may initiate an important downward movement in database prices as well.

The EE's database manager consists of an SQL-based relational database engine, called Data Services, and a front-end application for this engine called the Query Manager. The database engine can also be accessed by embedding SQL code into custom applications. Several companies are expected to modify existing database managers so that they can access this database engine. Until these front ends become available, users may choose to use IBM's Query Manager.

Like other SQL database engines, the EE database divides data into a series of relational tables, with rows (records) and columns (fields). You can construct a `VIEW` of a database by `SELECT`ing various columns and `JOIN`ing tables. You have no knowledge of the physical layout of the data; you have access only to the logical layout.

According to IBM, the database engine is very compatible with the company's DB2 database, which runs under the VM operating system on IBM's 370 mainframes. IBM claims that the database will have about 92 percent to 93 percent of the capabilities of the mainframe system, though it will lack a small number of features: the `GRANT` and `REVOKE` commands, which let network users see certain fields and not others; the `UNION` relational operator; a FORTRAN precompiler; and the ability to do date and time arithmetic.

Managing Catastrophes

One planned area of compatibility between the EE and the larger IBM databases is in transaction management. The goal of transaction management is to ensure that a transaction—a set of changes or additions to the database—is completed successfully even if a catastrophe (such as a power failure) occurs while the transaction is being processed.

This problem is handled by a pair of functions called `COMMIT` and `ROLLBACK`. All transactions are first written to a buffer. If the transactions are completed, they are written (or "committed") to the database files. But if a problem occurs before they are completed, the transactions are "rolled back" and executed over again.

The `COMMIT` and `ROLLBACK` functions are performed automatically, but a programmer can also have explicit control over them. You can set up a "unit of

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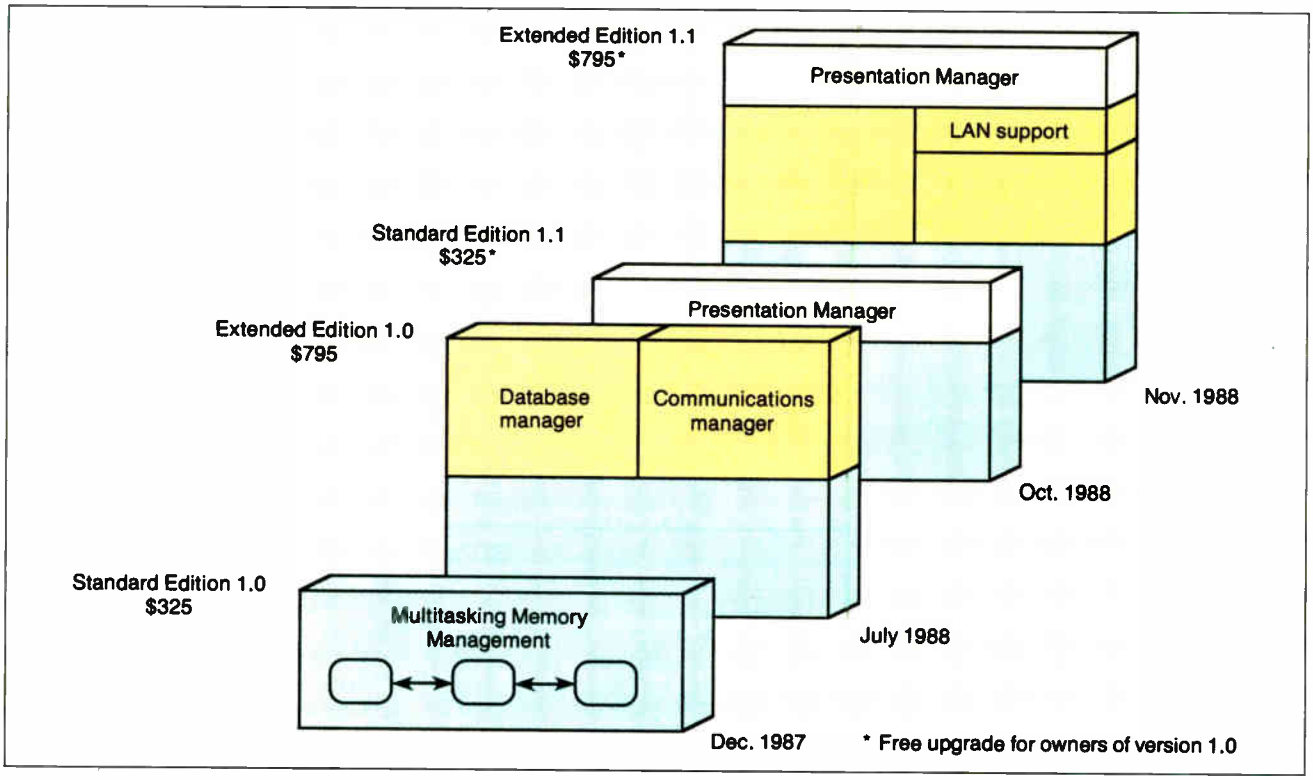

Figure 1: *The Extended Edition of OS/2 adds database and communications managers to the base operating system of the Standard Edition. Later this year, both editions will be upgraded to include the Presentation Manager, a Windows-like graphic user interface.*

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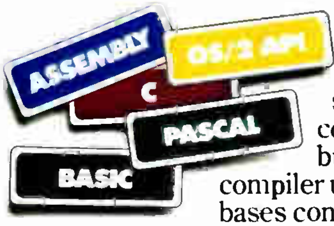

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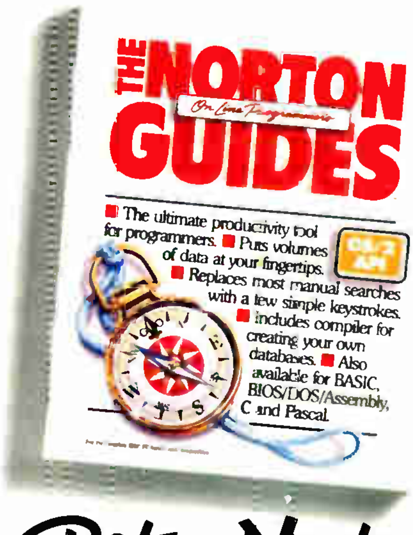

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work" in which, for example, one account is credited by some amount and some other account is debited. Here, again, if the unit of work is completed, you can COMMIT it; if not, you can ROLLBACK and do it over.

Another feature of the database engine important for transaction management is a Recovery Log. This log lists each new record and the record that was replaced. Also, the Recovery Log is written to disk before the database on the disk is updated. With the log, you can reconstruct the database or complete the updating of the database.

Sharing Performance Features

The data integrity features mentioned above do have a cost in terms of performance. To counter this, IBM has designed the database engine so that it will share some high-performance technology with its mainframe version. IBM claims that as new techniques are developed by the company's research staff, they will be implemented on all the company's database products, including the EE database engine.

One performance feature ported from the mainframe systems is high-concurrency index locking. Many multiuser databases, when they are accessing something, will lock a portion of the index table to keep out conflicting accesses. For example, if you are using a particular set of records, the database engine locks part of the index table so others can't update those records or any other records in the immediate vicinity. IBM claims that it has come up with a new algorithm that locks not on the index but on the record that it points to. Thus, other users will get their data more quickly since they will get blocked only when they try to access that particular data.

The database engine will also use a query optimizer that decides the best way to access data. In most databases, you set up an index to make it easy to find particular data. But if you have set up several indexes, it may become difficult to decide which indexes to use. The query optimizer can analyze a particular query and choose which index to use, or whether to use an index at all.

According to IBM, the optimizer uses artificial-intelligence techniques to determine the best path to take. Though similar to that of the mainframe database engines, the query optimizer on the EE is more compact and makes greater use of heuristics, or educated guesses, to determine the best path. On mainframes, the queries will probably access larger databases and thus will benefit from a larger, more accurate optimization technique.

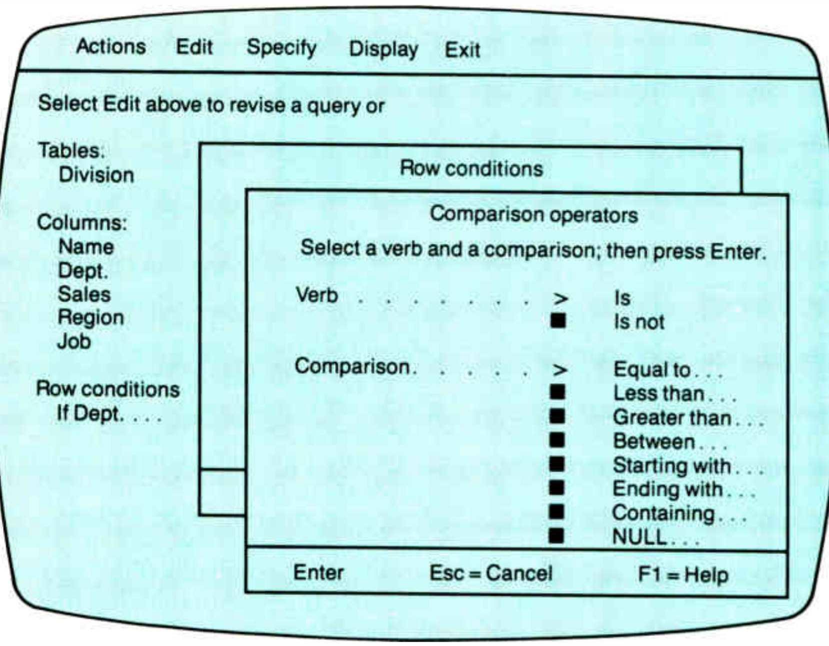


Figure 2: *The Extended Edition's Query Manager uses a Prompted Query interface that lets you build valid SQL queries. The left side of the screen shows the query terms already selected, while menus on the right list the possibilities for subsequent terms. Here, the condition "If Dept" could take the verbs "is" or "is not" and the comparison operators "equal to," "less than," and so on.*

Reading 1-2-3 Files

In addition to its SQL capabilities, the database engine will also include a number of interesting utilities. The first of these is a utility for importing and exporting Lotus 1-2-3 files and delimited ASCII files. These file-import capabilities can be called from your own applications. Surprisingly, the database manager will not be able to import dBASE III files.

The system's BACKUP and RESTORE utilities let you do short, incremental backups, or restore the database to any prior condition.

Two other utilities let you optimize your data for more intensive applications. A RUNSTATS utility gives you statistics on how data has been accessed. It also updates the access plan to take into account new data that has been added. As a database grows, you may want to run this utility to make the access more efficient. A REORG utility lets you reorganize the data on your hard disk drive for more efficient access.

Writing Applications for the Database Engine

As mentioned earlier, programmers can access the capabilities of the database engine by embedding SQL commands in their code. Currently IBM recommends using its C/2 compiler for this. Eventually IBM will also have available Pascal/2 and COBOL/2. In the meantime, programmers can write external SQL functions in C and call these from their favorite language.

Before compiling a program, you must first run it through a precompiler, which IBM provides free with the EE. The precompiler creates a modified source code file, leaving the C code alone but changing the SQL commands so that the compiler can understand them. The precompiler also places some information in a separate "bind file."

You then run the modified source code through the compiler, which creates an executable file. You provide the executable program to users along with the bind files. At installation, the user of the application must submit the bind file to the database engine, which then stores this information in its "catalogs" and creates an access plan for accessing the data.

The bind file may create some compatibility problems between one SQL database and another. The way one database does binding may be quite different from that of another. Thus, the source code may be similar for different systems but the bind files will be different. For this reason, applications developers may find it difficult to support a large number of SQL databases.

The database engine supports two types of embedded SQL: static and dynamic. In static SQL commands, the table names are spelled out explicitly in the SQL commands. In dynamic commands, the table names are represented in the commands by variables, the meanings of which can change at run time. Dynamic SQL is a little slower, since the engine cannot prepare an access plan beforehand but has to do so on the spot. The engine does, however, have a PREPARE command that prepares an access plan once and saves it so that the application can reuse it several times.

With the Extended Edition of OS/2, IBM has recognized that an operating system should be more than just a file handler.

Managing More Than Queries

The Query Manager, despite its name, is essentially a complete database system—it can create reports, procedures, menus, and panels (forms) for data entry, as well as manage queries. IBM apparently chose to call it the Query Manager to be consistent with QMF (Query Management Facility), which runs on large mainframe systems.

Since the Presentation Manager is not available yet, the OS/2 EE uses a text-based version of the interface called the Dialog Manager. The Dialog Manager conforms to the Common User Access (CUA) protocol of the SAA (including windows, pull-down menus, mouse support, and so on), but it does not use graphics. When the Presentation Manager becomes available, IBM will port the EE over to it.

The Query Manager has an additional interesting user interface called the Prompted Query interface. This interface, which uses the features of the Dialog Manager, lets you build an SQL query term by term, by selecting the next term from a list of possible valid terms (see figure 2).

Once a query is complete, you can look at the result of the query, further modify the query, or save it for later use. For very complex queries with tree-shaped or subquery elements, you may have to use SQL directly. However, most users can accomplish what they want with just the Prompted Query interface.

For data entry, you can set up forms, which IBM calls panels. Behind a panel there may be up to 11 tables. You can have two different tables available for update, and up to nine tables available for looking up data.

The Query Manager can also be automated by creating procedures. Procedures are essentially Query Manager commands and some conditional logic compatible with REXX, IBM's SAA procedural language. The language has variables and lets you do such things as creating your own menus that conform to the Dialog Manager standards, and even designing custom help screens.

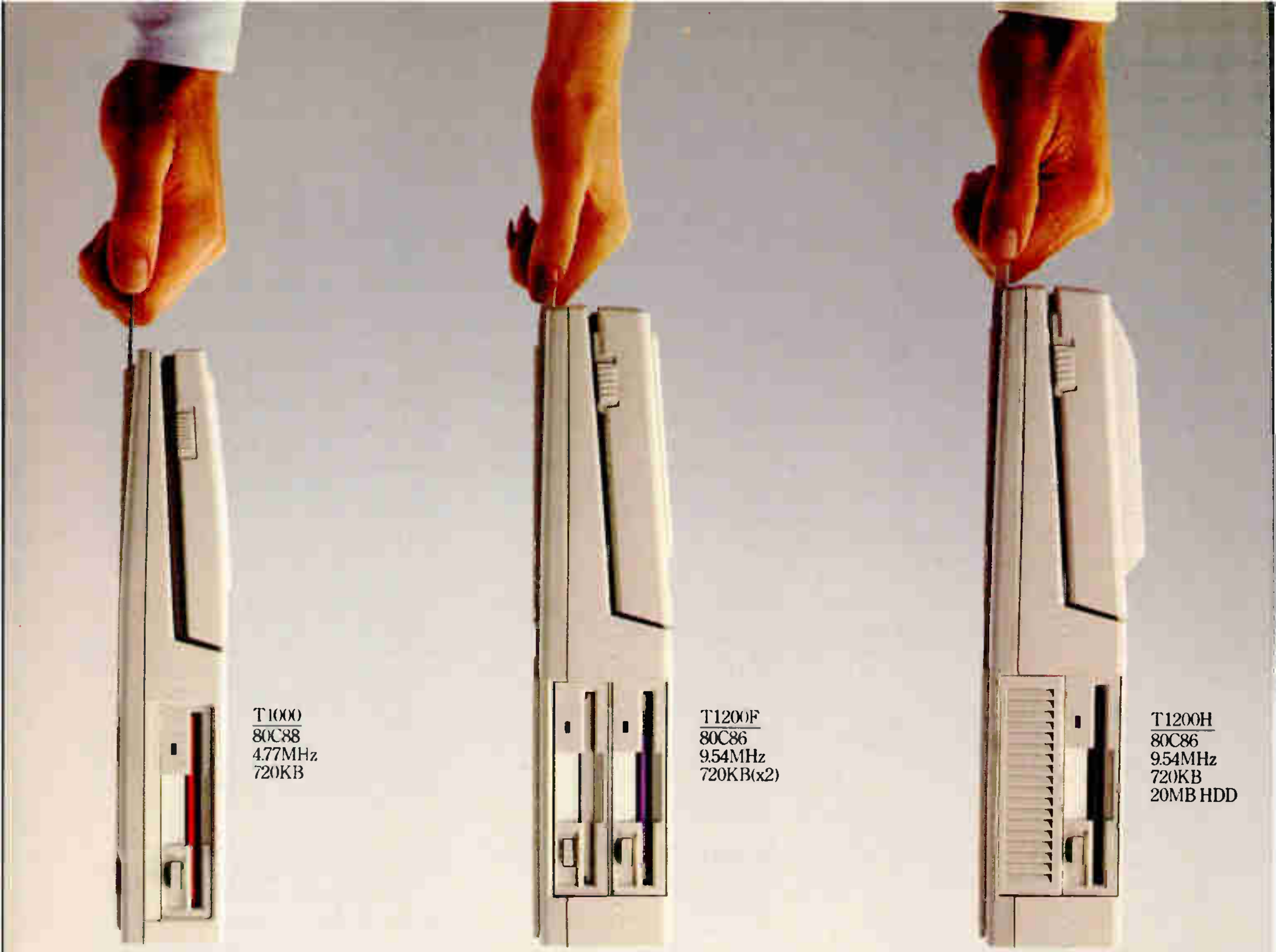
A New Standard?

The OS/2 EE is a large, extensive package of software. It has a fairly reasonable price and a lot of functionality, including a large number of capabilities that will be especially handy for IBM's large corporate customers who need to interconnect with IBM mainframes. Indeed, large-volume purchasers will be able to pick up licenses for the package for $417, just $214 more than what they would spend for the Standard Edition alone.

The question is, how appropriate will this impressive collection of software be for single users and small network groups? It may simply be too big for many users, who may balk at having to get additional memory and a larger hard disk drive in order to use it.

Nevertheless, the EE is a very important move by IBM. It is a recognition of the fact that an operating system should be more than just a file handler, and that various types of computers should have greater connectivity between them. IBM does not have an exceptionally good track record at selling application software in the volatile personal computer market. But even if the EE does not sell well in the short term, it will probably—if nothing else—establish a standard for a large number of related products. ■

Rich Malloy is an associate managing editor at BYTE. He can be contacted on BIX as "rmalloy."



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Fast Drives for Modern Times

BYTE selects the top performers from a group of high-speed 40-megabyte hard disk drives

Stan Miastkowski

Hard disk drive performance is second only to system clock speed in affecting the overall performance of your computer. The 10-megabyte hard disk drive with an access time of 85 milliseconds (ms) that did so much for an IBM PC XT—and even the 30-megabyte, 40-ms hard disk drive for an IBM PC AT—seem slow and limited when attached to one of today's high-speed 80286- or 80386-based computers.

As spreadsheets, databases, desktop publishing documents, and engineering drawings grow in complexity and size, many microcomputer users are choosing 40-megabyte hard disk drives as standard equipment in their new computers. Aggressive pricing strategies and ready availability from computer dealers and mail-order houses have also made 40-megabyte drives the first upgrade choice for users trying to improve the performance of their existing systems.

I looked at a group of fast-access hard disk drives, almost all with claimed access times of 28 ms or less and with capacities of approximately 40 megabytes. It is clear that today's buyer has a wide variety of prices, sizes, speeds, and technologies to choose from.

The group that I looked at ranged in price from the $370 Seagate ST251-1 to the $2592 Core AT40F. I worked through full-height 5¼-inch drives, half-height 5¼-inch drives, half-height 3½-inch drives, and hard disk drive cards. While none of these drives are slow, the benchmark results show definite differences in their speeds. The drives I looked at use three distinctly different interfaces: small computer system interface (SCSI), used by the Tandy and Columbia Data Products drives; enhanced small device interface (ESDI), used by the Core AT40F; and the standard ST506, used by the rest of the drives. (For a closer look at SCSI and ESDI, turn to "The Importance of Being Intelligent" on page 120.)

Differences and Similarities

When I started this review, I thought one of the biggest potential problems would be how to differentiate this many drives with specifications that were, at least on paper, quite similar. The drives are indeed similar in size and general performance, but price, ease of installation, and the specifics of performance made it easy to distinguish them from one another. Documentation, cables and other accessories included, and software included also served as distinguishing characteristics.

All the drives I tested came configured for internal mounting. Some of them came to me from the manufacturer; others came from an OEM, like Tandy or Columbia, that made significant additions to the basic drive.

Many of these drives are available from other OEMs and distributors, in a variety of interface, mounting, and software combinations. The broad variety of sources and the widespread presence of discount mail-order vendors mean that prices may vary drastically, depending on your source of supply.

I judged the drives using a combination of objective and subjective measurements. For the objective tests, I used the hard disk drive benchmark programs from the new BYTE benchmark suite. As these tests show, access time is only one factor in determining a drive's performance, and it's not the measure you should rely on. (For details on these tests, see "Putting the Drives through Their Paces" on page 121.) I made subjective calls on ease of installation and setup, the quality of construction, and how cool and quiet the drive ran.

Since SCSI and ESDI have been getting much attention recently, I was a bit surprised to find that most of the drives I tested still use standard ST506-interface controllers, like Western Digital's venerable 16-bit hard/floppy disk drive controller used in the IBM PC AT.

Developed originally by Seagate Technology, the ST506 interface is one of the uncommon instances in the computer industry where a standard quickly caught on. The interface uses a 3-bit head-select code that allows up to eight heads to be used. When the interface was first developed, many drives used two platters and three heads.

So how do today's ST506-interface drives pack so much data into so little space and access it so fast while maintaining industry standards? The basic answer is to use more platters and more heads.

In addition, the old-style stepper-based head positioning has been largely replaced by the much more efficient voice-coil technology. A stepper does just what its name implies—steps incrementally from track to track on the disk. A voice-coil head positioner moves smoothly and directly to the track where the data you want is located, without having to stop at each and every track on its way. This is largely the reason for access speeds up to 3 times faster than on stepper-based systems.

Speaking of Standards

Most of the controllers for these drives use modified-frequency-modulation

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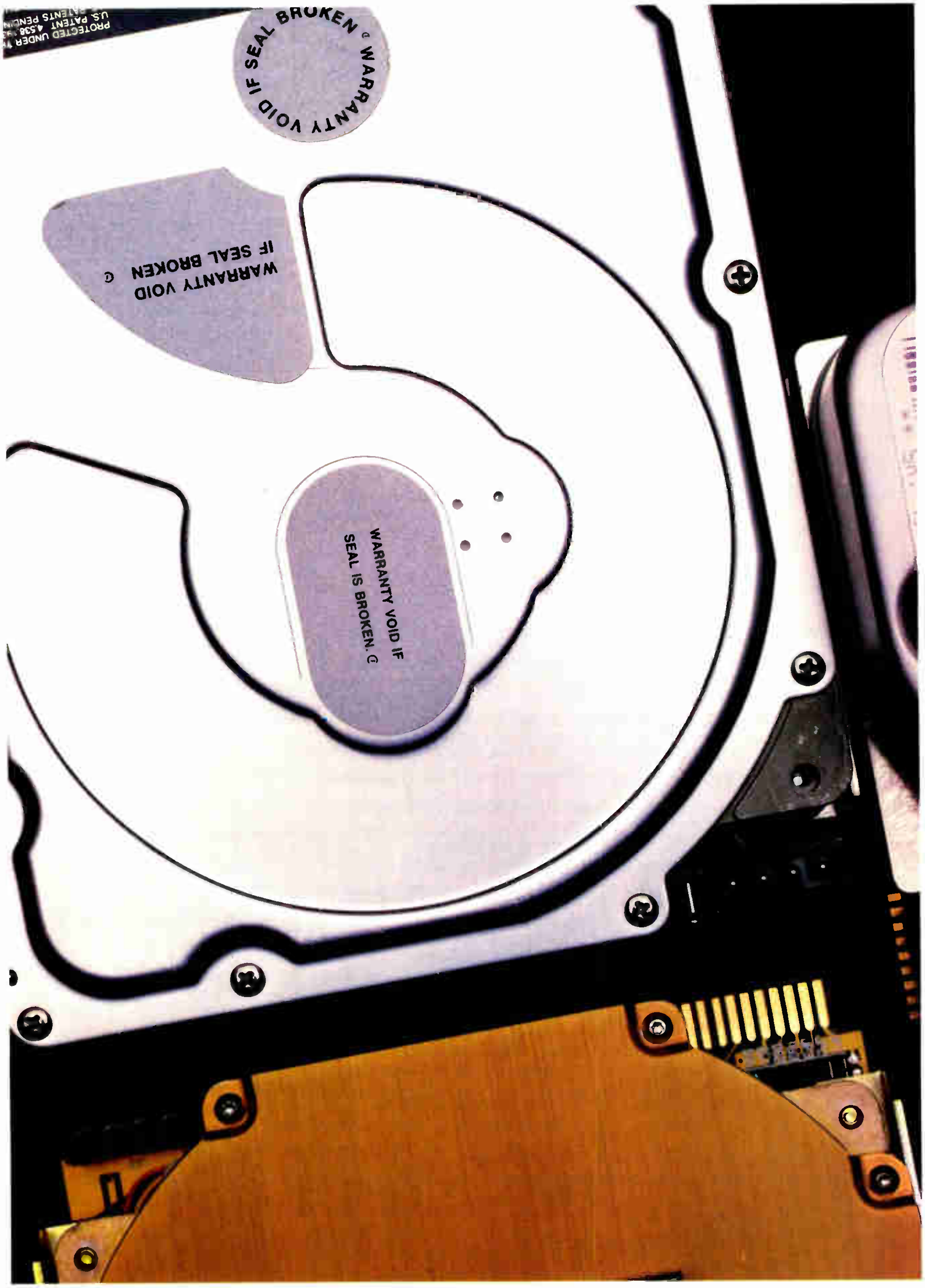

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The Importance of Being Intelligent

In the group of drives reviewed for this article, three have moved beyond the basic ST506 interface. The two interfaces that are being used with more and more frequency are SCSI and ESDI. These devices are similar in their use of more powerful logic in their control circuits, but they differ in their approach and capabilities.

SCSI is a microcomputer-oriented serial interface that was proposed as a standard in 1982. It first came to the attention of many computer users when Apple included it as a standard interface on the Macintosh Plus. SCSI offers four main advantages to system designers.

First, SCSI devices can be "chained" together, so that a single bus controller can work with multiple devices of different types. SCSI allows those devices not in current use to go "off-line," so that their mere presence on the bus does not degrade system performance.

Second, the SCSI design allows the individual device controller to be integrated into the device itself, saving money in the design and fabrication processes that, theoretically, can be passed on to buyers. This advantage is already available in Macs that have built-in SCSI ports; on the MS-DOS side, the Sun 386i, a new Unix/DOS system, has a built-in SCSI port.

Third, SCSI hides the physical layout of the devices from the programmer or user, making them deal only with a standard logical device. In theory, this assures more compatibility between devices, since it is much more difficult for any single device to "break the rules."

Finally, SCSI is fast, with a top speed of 1.5 megabits per second (mbps) in asynchronous modes and up to 4 mbps in synchronous handshaking mode.

ESDI is a low-level serial interface that was initially designed for and used in minicomputer installations. It is similar to SCSI in its level of intelligence, but it differs from SCSI in two important respects, flexibility and speed. Where SCSI was designed from the start as a generalized interface, ESDI has been confined much more to implementation as a disk interface. More important to most users, ESDI has a higher potential speed, up to 24 mbps. Unfortunately, a product with a data transfer rate of 24 mbps is unlikely, given system overhead and the limitations of current microcomputer buses.

(MFM) coding, which uses magnetic flux-field reversals to store data. It's much like FM radio, except the music doesn't change. MFM is a proven technology, prompting most manufacturers to recommend it for their drives. There's a plus for your wallet, too, since you don't need to buy a new controller when you upgrade your drive.

Run-length-limited (RLL) coding is becoming more common, especially for 3½-inch hard disk drives, because it stores more data in a given physical space than MFM coding does. RLL is more correctly called "2,7 RLL encoding," because it uses an algorithm that encodes each byte into new code that's 16 bits long and has from two to seven zeros between each magnetic fluctuation.

The strange thing about RLL is that although it increases the number of bits it takes to store data, the longer RLL bit pattern doesn't need as much space as the shorter MFM pattern. However, RLL requires a very consistent, high-quality medium to handle the higher density of information. Because of the greater demands of quality placed on the medium, reliability problems crop up with some RLL controller/drive combinations.

Installation: A Trying Experience

If you buy one of the drives reviewed here, you'll find that, unfortunately, the era of the "plug in and play" hard disk drive has not yet arrived. The problem starts when trying to deal with a hard disk drive, a controller, a computer, and setup/installation software. When any component does not recognize the type of any other one, problems quickly begin to mount.

I used an 8-MHz IBM PC AT to test these drives, and the biggest problem came with the requirement of the AT's CMOS memory to "know" what type of hard disk drive was connected. With both ATs and the numerous available clones, you're required to enter a number that corresponds to the type of drive installed. If you don't enter the right number, the hard disk drive just won't work. If the drive's installation documentation doesn't tell you what drive type to enter, you'll need to determine what it is. Trial and error isn't a recommended method for figuring out drive types, but solutions do exist.

I used two formatting and partitioning programs: Storage Dimensions' SpeedStor and Ontrack Computer Systems' Disk Manager, both of which can determine the drive type. Both can also do low-level formatting, media analysis, and partitioning of hard disk drives. Partitioning is important, since DOS can handle a maximum of only 32 megabytes in each partition.

I used SpeedStor for the majority of drives and Disk Manager for the MiniScribe 3053 and the Toshiba MK-54FB. Both Core drives and the Plus Hardcard 40 came with their own custom installation software.

Focusing In

Because the drives differed in the installation and setup procedures, testing them turned out to be a most time-consuming process. Overall, I found that manufacturers have settled on a number of ways to make the performance and features of an individual drive stand out—an important feat for a product that many people consider a commodity item. For a side-by-side comparison of benchmark results and features, see tables 1 and 2.

Standard ST506 Drives

The drives in this section did not come with their own controllers. As a group, they tended to cluster in the middle of the performance results. I tested them with the 16-bit Western Digital ST506 combination hard/floppy disk drive controller present in my IBM PC AT.

CMS F40-K: This full-height 5¼-inch drive carries a suggested retail price of $995 and a hefty weight of 10 pounds. The 42-megabyte unit ran quietly and kept its cool. Its performance was unexceptional, with a 1-megabyte file read time that ranked next to the bottom of the standard drives and other results that were squarely in the middle of the pack.

CMS rates this drive as a 22-ms-access device. According to the Coretest, however, the average seek time is 29.2 ms. The F40-K comes with a 40-page installation manual and does not include software. Since the documentation included the drive type to enter for the setup program, installation and setup were straightforward.

Control Data Wren II: The Wren II, with 42 megabytes, is Control Data Corp.'s latest incarnation of a well-respected drive that has earned a reputation for being unusually rugged. It's a half-height 5¼-inch drive. Although CDC doesn't sell directly to end users, the company estimates it will cost you in the vicinity of $900, a relatively steep price for a half-height drive.

But this drive exudes quality. The 3.8-pound unit has a solid, hefty feel, and you hardly know it's running. CDC has built high-capacity drives for large computers for years, so it's a safe bet that this drive would be particularly well suited to full-time, heavy-duty use. When you turn it off, there's a satisfying clunk as the heads are automatically parked.

The Wren II has a rated average access speed of 28 ms, but I found that it actually showed a better speed, 23.6 ms. In the BYTE benchmarks, the drive showed up in the middle of the ST506 pack on nearly every test. In all, a solid, middle-of-the-road performance.

The drive I reviewed came with two manuals. A 16-page OEM manual is well written but is designed for experienced users. If you're into the technical nitty-gritty, a 63-page technical specification will tell you everything you ever wanted to know and more about the inner workings of the drive.

continued

Putting the Drives through Their Paces

BYTE recently unveiled a new suite of total system benchmarks that includes a set of programs to evaluate hard disk drive performance. I used these benchmarks, along with the Coretest, to evaluate the drives for this review. (For more information on the complete suite, see "Introducing the New BYTE Benchmarks" on page 239 of the June BYTE.)

Here is a brief look at the tests and what they are designed to measure.

Hard seek: This makes direct calls to the BIOS to directly manipulate the position of the read/write heads of the drive. This test measures the average track-to-track seek time of the hard disk drive, without adding operating-system interaction. A drawback of this test is its inability to give meaningful results on SCSI drives.

DOS seek and read: This test measures the time required by the hard disk drive to seek to a given location and read 1 or 8 sectors of data. It uses the operating system's most basic level of disk-access functions.

File I/O: File I/O is a reworked version of a longtime BYTE benchmark. This test uses the full file structure support of the operating system to measure the time required by the hard disk drive to seek, write, and read while under the control of the operating system.

1-megabyte file write and read: These are straightforward tests of the time required to first write, then read, a 1-megabyte file. Because I believe these tests offer closer approximations of real-world use than do the others, they were given a predominant position in determining overall performance winners and losers.

Coretest: This test, developed and distributed by Core International, was used to verify average access-time ratings as supplied by the manufacturers of the various drives.

Table 1: *The benchmark results show that the Northgate Turbo kit tops the list, followed by the SCSI and ESDI drives. The three hard disk drive cards were the slowest performers. (All times are in seconds, except where noted.)*

Hard disk drive	Hard seek (average)	DOS seek and read		File I/O			1-megabyte file		Coretest (ms)	
		1 sector	8 sectors	Total seek	Read 1K byte	Write 1K byte	Write	Read	Average seek	Average trk/trk seek
Northgate Turbo kit	16.6325	12.72	26.42	0.33	0.02	0.019	4.74	3.77	36.47	15.63
Columbia SCSI drive	N/A	N/A	N/A	0.28	0.015	0.018	5.9	4.32	19	6
Core AT40F	4.545	8.35	12.8	0.35	0.014	0.014	4.25	4.48	10.43	2.27
Tandy SCSI drive	N/A	N/A	N/A	0.18	0.016	0.019	5.6	4.65	28	6
Core AT43	7.485	10.61	20.09	0.24	0.017	0.016	5.64	5.55	20.08	4.08
Priam ID45-AT-D2	6.64	9.7	25.75	0.09	0.018	0.016	7.41	6.81	19.88	3.89
Toshiba MK-54FB	7.03	9.96	24.21	0.58	0.015	0.03	16.5	7.74	25.7	4.6
Fujitsu M2242AS2	9.8875	10.66	24.11	0.44	0.016	0.029	16.51	7.76	37.8	5.1
Rodime RO 3055	7.4575	10.67	26.97	0.35	0.016	0.018	8.26	7.78	21.86	6
Seagate ST251-1	7.8425	10.31	26.89	0.59	0.017	0.03	16.74	7.84	N/A	N/A
Control Data Wren II	7.0175	10.65	26.97	0.48	0.016	0.029	16.7	7.87	23.6	4.1
Micropolis 1333A	7.4575	10.54	26.95	0.45	0.016	0.03	16.73	7.87	27.83	5
MiniScribe 3053	7.1775	10.56	26.89	0.4	0.016	0.03	16.83	7.87	29.5	5.4
CMS F40-K	7.4375	10.59	26.86	0.24	0.016	0.029	16.66	7.88	29.2	4.7
Microscience HH-1050	8.2625	10.58	26.78	0.44	0.016	0.03	16.62	7.89	26.5	4
Plus Hardcard 40	10.24	12.39	52	0.14	0.025	0.031	17.21	13.77	39.5	6.88
CompuAdd FlashCard 49	6.9725	10.2	81.34	0.29	0.047	0.045	36.45	36.29	27	7.61
SPC Scorecard 44	8.3125	10.8	81.22	0.31	0.045	0.043	36.58	37.89	24.07	4.77

Table 2: *Features and prices vary widely, even among supposedly similar disks.*

Hard disk drive	Suggested list price	Formatted capacity (megabytes)	Form factor	Cylinders	Heads	Platters	Interface
CMS F40-K	$995	42	Full-height, 5¼ inches	1024	5	3	ST506
Columbia SCSI drive	$995	42	Half-height, 3½ inches	834	3	2	SCSI
CompuAdd FlashCard 49	$549	49	Plug-in, 1½-slot card	615	6	3	ST506
Control Data Wren II	$900	42	Half-height, 5¼ inches	989	5	3	ST506
Core AT40F	$2156	40.4	Full-height, 5¼ inches	564	4	N/A	ESDI
Core AT43	$876	43	Half-height, 5¼ inches	988	5	3	ST506
Fujitsu M2242AS2	$1000	43.2	Full-height, 5¼ inches	754	7	4	ST506
Micropolis 1333A	$799	44	Full-height, 5¼ inches	1024	5	3	ST506
Microscience HH-1050	$750	44.56	Half-height, 5¼ inches	1024	5	3	ST506
MiniScribe 3053	$550	44	Half-height, 5¼ inches	1024	6	3	ST506
Northgate Turbo kit	$695	42	Half-height, 5¼ inches	809	6	3	ST506
Plus Hardcard 40	$995	42.26	Plug-in, single-slot card	612	4	2	ST506
Priam ID45-AT-D2	$1050	42	Full-height, 5¼ inches	1166	5	3	ST506
Rodime RO 3055	$1395	45.5	Half-height, 3½ inches	872	7	4	ST506
Seagate ST251-1	$370	42.8	Half-height, 5¼ inches	820	6	3	ST506
SPC Scorecard 44	$795	44	Plug-in, 1½-slot card	753	7	4	ST506
Tandy SCSI drive	$1799	80	Half-height, 5¼ inches	823	6	3	SCSI
Toshiba MK-54FB	$1190	49.2	Full-height, 5¼ inches	830	7	4	ST506

N/A—Information not available

Core AT43: The AT43 is a half-height 5¼-inch drive with a fast average access time of about 20 ms. It sells for $876 (plus $436 for the optional controller), but it was the fastest standard ST506 drive I tested. It's built like that proverbial tank and remains cool even after hours of hard running.

Even though the AT43 is shipped with extensive setup software and manuals, installation is on the difficult side and time-consuming. Successful installation of the drive was dependent on one key step that was not spelled out: It's vital that you run the AT's setup program before beginning Core's setup. You should also be prepared to get a floppy disk error at every boot-up for the life of the machine if you also use its controller to control the floppy disks in your system. You can still use the floppy disks with safety, but the computer will have trouble during the post portion of booting.

Fujitsu M2242AS2: This full-height

Recording code	Head positioning	Average power consumption	Weight (pounds)	Controller included/ recommended	Software included	Documentation
MFM	Voice coil	0.9 A	10	CMS recommended	None	40-page installation manual
RLL	Stepper motor	22.45 W	1.9	Western Digital 7000-ASC controller included	Installation software	50-page controller, 149-page disk drive, and 30-page owner's manuals
RLL	Voice coil	N/A	1.6	Controller included on card	PC-FullBak	35-page installation, 30-page controller, and 17-page drive manuals
MFM	Voice coil	20 W	3.8	CD-506 recommended	None	16-page manual and 63-page technical specification
MFM	Voice coil	33 W	7.3	Core CNTHCF controller ($436) recommended	Partitioning software	47-page disk drive, 24-page controller, and 59-page software manuals
MFM	Voice coil	1.5 A	3.8	Core CNTHCF controller ($436) recommended	Partitioning software	47-page disk drive, 24-page controller, and 59-page software manuals
MFM	Voice coil	29.6 W	6.6	None	None	194-page technical specification
MFM	Voice coil	2 A	6	None	None	31-page installation guide and 30-page technical specification
MFM	Voice coil	N/A	4.2	Adaptec, Data Technology, SCI, Western Digital, or Xebec recommended	None	31-page documentation
MFM	Voice coil	N/A	4.1	None	Disk Manager	34-page documentation
RLL	Voice coil	N/A	3	Adaptec ACB-2372 RLL controller included	Benchmark software	37-page documentation
RLL	Voice coil	0.48 A	N/A	Controller included on card	Partition and install. software	74-page manual
MFM	Voice coil	35 W	6	None	Installation software	41-page installation guide and 132-page user's manual
MFM	Voice coil	0.8 A	1.65	Any capable of controlling 872 cylinders with a step rate of 5 μs to 15 ms	None	29-page documentation
MFM	Stepper motor	12 W	2.75	Any MFM, 5.0 Mbit/sec recommended	Disk Manager	13-page installation guide
MFM	Voice coil	10 W	1.8	Controller included on card	SpeedStor, SpeedCache	6-page manual
RLL	Stepper motor	24 W	3.5	Adaptec AHA-1540 ($299)	None	13-page manual
MFM	Voice coil	N/A	6.6	None	None	47-page installation guide and 15-page manual

5¼-inch drive—with four platters and seven heads—ranked in the top half of all the drives in overall performance. Despite results that rank it near the bottom of the ST506 group in most of the benchmark tests, it ends up in the middle of the pack because of a relatively strong showing in the 1-megabyte file read and write.

A slow average access time is one of the reasons for its average showing; while Fujitsu rates the drive as a 30-ms-access device, the Coretest gave it a 37.8-ms score—the second slowest among all drives tested. One thing it has going for it is that it runs cool, making it a particularly good choice for a cramped installation or an environment that isn't always comfort-controlled.

One area where the M2242AS2 falls short is its documentation. With a 194-page technical specification—the biggest manual of any of the drives I tested—you'd think you have it made. But the

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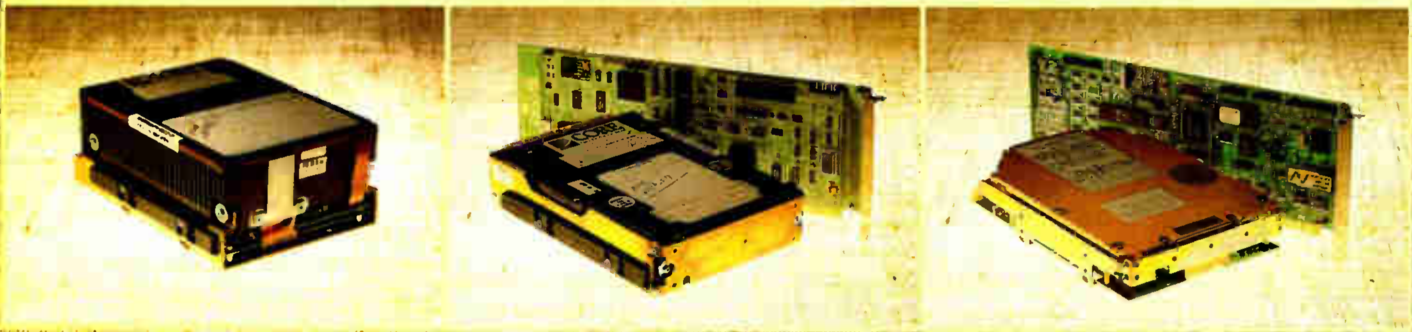
BEST PERFORMERS



Core AT40F Core AT43 Northgate Turbo kit

manual is long on technical information and short on practical information.

Because no end-user-oriented material is found in the documentation, the drive was relatively hard to install. After much puzzling, I finally had to call Fujitsu's customer service to find out how to set a jumper for DS2 (Disk Select). It was easy to do—once I knew where the jumper was; it wasn't marked either on the drive or in the manual. This type of problem just shouldn't happen in a $1000 product of this complexity.

Micropolis 1333A: Another full-height 5¼-inch drive, the 1333A, with a price of $799, is 20 percent less expensive than comparable full-height drives. This 44-megabyte drive is not one of the hotter performers in the group, ranking in the bottom half of the results in every test. With a rated average access time of 28 ms versus a Coretest average access time of 27.83 ms, this was one of the few drives where my results were almost identical to the manufacturer's specs.

After wrestling through the documentation and installation procedures of some of the other drives, the clearly written, well-illustrated installation manual that accompanied this drive made it a joy to install. The 31-page manual is one of the best examples of sparse yet useful technical communications I've ever seen.

Microscience HH-1050: This half-height 5¼-inch drive packs 44.56 megabytes of storage into its three platters and five heads. Unfortunately, Microscience wasn't able to pack top performance into the $750 unit, which ended up resting at the bottom of the standard ST506 benchmark results. The ranking is based on the device's lackluster performance in the 1-megabyte file read and write.

Other tests place the HH-1050 in the middle of the speed curve, but it is the slowest drive in this group on the important 1-megabyte read test. Access time isn't to blame for the problem, since my 26.5-ms average access time Coretest results were even better than the 28-ms rating from the factory.

Like many of the drives here, it came with a very technical manual. But I didn't really need it. There were no surprises or special case instructions needed to install this drive in the AT, so it was easy to install. Its vaned outer case is effective in keeping it cool.

MiniScribe 3053: MiniScribe is another well-respected drive maker whose reputation shows in the sheer number of drives the company has sold. At $550, this half-height 5¼-inch drive is one of the lowest-priced drives I looked at. It's a solid, though not spectacular, performer, with a showing in the bottom half of the results. Its Coretest result, a 29.5-ms average access time, didn't live up to the 25-ms time stated by MiniScribe.

The 3053 was easy to install because it came with a custom version of Disk Manager. I didn't even need the 34-page manual, which was full of technical detail.

A unique feature of the 3053 among the drives I tested is that it has internal diagnostics that flash 32 different error codes when something goes wrong. Telling the service folks that the drive light is flashing "long short long long" is considerably more effective than saying "my drive doesn't work."

This drive shares one unfortunate trait with other MiniScribe units: It gets quite warm after several hours of use. While heat is a frequent problem with 3½-inch drives, most 5¼-inch drives get only slightly warm. Not the 3053, although I can't say whether this has any long-term implications for the drive's reliability. One thing is certain—you should use it only in a well-ventilated case.

Priam ID45-AT-D2: Unlike most of the other drives I tested, this full-height 5¼-inch drive is designed for end-user installation. At $1050, it's on the high side of the pricing scale, but it is one of the fastest standard ST506 drives I tested, with an average seek time for the Coretest that comes in below 20 ms. This drive has no thermal problems and is barely warm to the touch after extended operation.

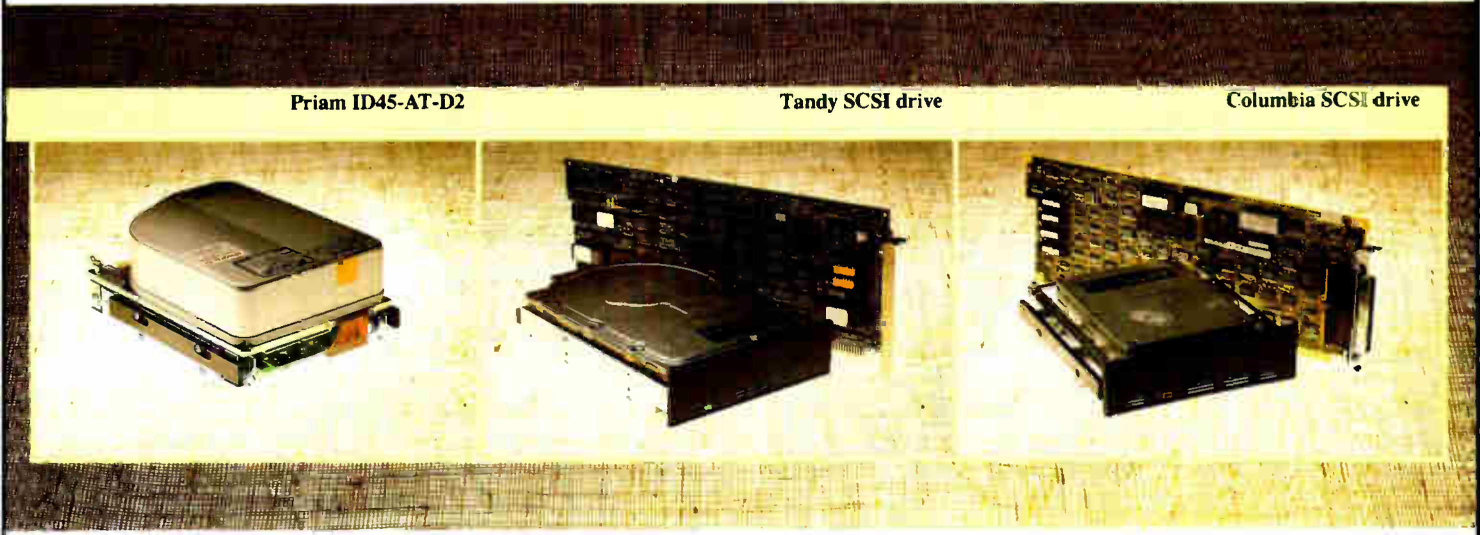
Installing the 42-megabyte drive isn't a problem, but it is a time-consuming task. You're warned not to do a low-level format of the drive, since you'll destroy special format data that's already on the drive. Installation software is included, and you need to prepare an installation disk with MS-DOS on it. Still, the 41-page installation guide takes you quickly and easily through the installation process.

Last but not least, a particularly nice touch is a 132-page user's manual that covers all the technical bases not contained in the installation manual. Need instructions on installing the ID45-AT-D2 in a Novell Network or under Xenix? You'll find it here.

Rodime RO 3055: This is a quirky little half-height 3½-inch drive that, at $1395, is quite expensive. The expense may come because of its rated capacity of 45.5 megabytes, using four platters and seven heads packed into a tiny package. But there's a problem: I couldn't format it as a 45.5-megabyte drive because AT setup, Disk Manager, and SpeedStor didn't contain a setup for a drive this large.

I contacted the company and found that Rodime has software for formatting the drive to its full capacity, but none was available in time for this review. It was suggested that I either partition the disk into two logical drives, one of 32 megabytes and one of 13.5 megabytes, or use formatting software from Golden Bow to try and establish a single large partition.

So I formatted it, using type 11 in the AT setup, as a 35-megabyte drive. The 29-page manual that came with it was nicely designed but essentially useless. Between the problems of trying to take



advantage of the drive's full capacity and a manual that contains no information on end-user installation, this one was a real pain to install. And to top it all off, it ran hot to the touch (116°F) after only a few hours.

Seagate ST251-1: Venerable old Seagate is the drive company that almost everybody knows, and one of its latest drives is the half-height 5¼-inch ST251-1. It's a solid, though not spectacular, performer that consistently turned in results that placed it in the middle of the overall grouping. The stated average access time of 28 ms is also a solid speed in the middle of the pack. The drive runs a bit warm, though not uncomfortably so, and it makes strange raspy noises on power-down. The saving grace of all this is its price, $370, which makes it the least expensive drive in this review.

The ST251-1 comes with Disk Manager, a data cable, and a faceplate. It isn't difficult to install. If you need help, though, you're not going to find it in the 13-page "universal installation" manual that's packed with the drive.

Toshiba MK-54FB: A full-height 5¼-inch drive, the $1190 MK-54FB has good performance and a large capacity of 49.2 megabytes. The unit I tested was quite noisy on reads and writes, but that's common on some drives and doesn't seem to be detrimental.

The MK-54FB was one of the fastest drives I tested, coming in as the third-best performer among standard ST506 drives. The rated access speed of 25 ms was corroborated by the Coretest. While the price of this unit is high, the performance is also high, and it may be enough of a factor for those users who need very good performance to spend the extra money.

Toshiba recommends Disk Manager for installation but doesn't supply it. The OEM manual shipped with the drive was written for technicians, not end users, but there were no surprises or particular problems in installation, so I wasn't forced to plumb the depths of the manual too often.

Dedicated-Controller Drives

The drives in this category share one important feature: They come from the vendor with a controller specially designed to work optimally with the drive. This category includes drives that win on performance and lose on convenience, like the Core AT40F and the two SCSI drives.

The difference between the drives in this category and those listed above is like the difference between a tailored suit and one you get off the rack: The dedicated-controller drives, like the tailored suit, will certainly fit better when your needs are special. But the price you pay, either in money or performance, will almost certainly be higher than for off-the-rack standards. The exception to this is the Northgate kit, which turns in top performance for an excellent price.

Core AT40F: Core's drives have a reputation of being "Cadillac" drives, and the full-height 5¼-inch AT40F fits into that category. If you have the need for a *very* fast hard disk drive, there's little to compare with this one, a 40.4-megabyte drive with a wallet-clearing price of $2156 (plus $436 for the optional controller).

Why is it so expensive? For one thing, it comes with its own ESDI card for the IBM PC AT and compatibles. The full-length 16-bit board replaces your current disk controllers. It also offers incredible speed. The benchmarks for the AT40F were, across the board, among the fastest of any drive I tested. We're talking average seek times in the vicinity of 10 ms.

Like its non-ESDI AT43 cousin, the AT40F is obviously designed for heavy full-time use; and if you're going to pay $2592 for a hard disk drive and controller, that's the type of use you'll be putting it to. It comes with extensive setup software and three manuals, and the complex setup procedure makes it difficult and time-consuming to install. However, the results are worth it.

Columbia SCSI drive: This drive uses the Western Digital 7000-ASC Host Bus Adapter (which has its own Z80 processor) and the Quantum half-height 3½-inch drive, giving it a capacity of 42 megabytes. It is faster than the Tandy SCSI drive and has documentation and installation software designed for end users. Unlike Tandy's policy for its drive, Columbia ships a friendly setup program and an easy-to-follow setup manual.

This ranked as the second-fastest drive in the review, with a Coretest-established average access time of 19 ms and consistently fast results in the BYTE benchmarks. Its $995 price tag isn't cheap, but if they follow the trends established by other small computer equipment, SCSI prices will be coming down.

But there's more. Columbia includes extensive technical documentation on the interface and the drive itself. You don't have to read it; but if you're technically inclined, it's an excellent look at how SCSI and ATs manage to fit together.

As I was writing this review, Western Digital announced that it will sell its controller, the 7000-FASST, directly to end users. For a suggested list price of $485, you get the board alone; for $495, you get a kit that includes the board, software, manual, and cable.

Northgate Turbo kit: This is an Adaptec ACB-2372 RLL controller coupled with a MiniScribe 3650R drive. The $695 kit doesn't rely on SCSI or ESDI for throughput, but with its 16-bit RLL controller and a 1-to-1 interleave, it managed to come out on top of the performance chart. The half-height 5¼-inch drive provides 42 megabytes of formatted

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space and lets you use that space at a high rate of throughput.

When you look at the testing results for this drive, you'll notice that the average access time is quite slow for this group—36.47 ms. Northgate maintains that it doesn't care about the access time, that it optimizes for throughput. Judging from the overall results, I can't argue with Northgate's point of view.

The kit includes a disk of Northgate's benchmark software and a fairly small (under 40 pages) manual. The disk I got had been low-level formatted, and installation and setup were straightforward procedures.

Tandy SCSI drive: Using a half-height 5¼-inch Quantum SCSI drive that stores 80 megabytes and a 16-bit Adaptec controller, Tandy's high-capacity, high-speed SCSI drive is a good example of where hard disk drives may indeed be headed. To pack 80 megabytes into the drive, RLL encoding is used. The Adaptec controller has a 10-MHz direct-memory-access chip to help speed up performance.

The board is capable of controlling up to three SCSI drives, ranging in size from 40 to 786 megabytes. I had hoped to be able to test this controller with a 40-megabyte drive, but Tandy is currently selling only 80-megabyte SCSI drives.

At $1799 for the drive and $299 for the controller, this drive is not cheap, but it's not an unreasonable price for the speed and capacity. And this drive is quite fast. It consistently came in as one of the best performers, ranking fourth overall. Its access time is only average for the group tested, 28 ms. The good performance is the result of the high (1.5 megabytes per second) data transfer rate possible with SCSI.

Tandy intends this drive to be installed by an authorized Tandy service center, and the documentation does not include clear information for end-user installation. I did not have to lean on the documentation, since I simply plugged the controller and drive in and had a working combination. If you are not so fortunate, the documentation won't help to shorten the troubleshooting time.

Drives on a Card

High-capacity hard disk drives have come to add-in cards, and, like the ESDI and SCSI drives, these cards use dedicated controllers. But while the ESDI and SCSI drives win on performance and lose on convenience, the hard disk drive cards win on convenience but lose on performance.

SPC Scorecard 44: You'll still need a full 8-bit slot and a half in your IBM PC or AT to fit in the $795 Scorecard 44 from Systems Peripherals Consultants. It uses a Micropolis 3½-inch hard disk drive and is very slow—a common problem with hard disk drive cards. As a matter of fact, this was the slowest drive among all those I tested.

As an idea of its speed, it takes 10 times as long to read a 1-megabyte file from the Scorecard 44 as it takes to read the same file from the fastest drive in the group. The Scorecard 44 comes with SpeedStor for installation and also includes SpeedCache, a disk-caching program that can at least help a bit with the speed.

The CompuAdd FlashCard 49, SPC Scorecard 44, and Plus Hardcard 40 trade top performance for compact size and ease of installation.

The Scorecard 44 packs four platters and seven heads into a tiny space, and, surprisingly enough, it runs relatively cool for all this. Since ease of installation and use are large parts of the reason behind this type of drive, it came as no surprise that it's quite easy to install.

CompuAdd FlashCard 49: Like the Scorecard 44, the FlashCard 49 consists of a 3½-inch drive and a card that requires a full 8-bit slot and a half in your IBM PC or AT. As the name implies, it stores 49 megabytes in an incredibly small space. The price is eyebrow raising: $549 seems too little to pay for all this capacity.

Unfortunately, it joined the other drives-on-a-card at the bottom of the benchmark table. The drive is rated with an average access time of 28 ms, and the Coretest supported this with a rating of 27 ms. But the FlashCard 49, like the Scorecard 44, fell short in the 1-megabyte file read and write times. These two drives had similar times on the test—2 to 3 times slower than the next slowest drive.

The FlashCard 49 uses a Seagate ST157R drive coupled with a Western Digital RLL controller. It comes with a well-written manual that features specific installation instructions and useful illustrations, and it is easy to get up and running. PC-FullBak software was included with the drive.

Plus Hardcard 40: Plus Development was the first company to sell hard disk drive cards. As its competition has grown, the company has branched out to provide cutting-edge technology, often at premium prices. A case in point is the $995 Hardcard 40. This little drive requires only a single 8-bit full-length add-in slot in your IBM PC or AT and delivers 42.26 formatted megabytes of storage. Truly amazing. There are only two platters and four heads packed into the space, but Plus uses RLL coding (and a few other proprietary tricks) to get it all to work.

The Hardcard 40 was the fastest of the drive cards, and it turned in a performance that placed it third from the bottom of the benchmarks. The rated average access time of the Hardcard was one of the slowest of any drive I looked at, 35 ms, and the Coretest turned in an even slower figure of 39.5 ms.

Installing the Hardcard takes a bit longer than the other drive cards because of the custom installation and partitioning software, but the same software makes the installation relatively easy. It comes with everything you need for in-

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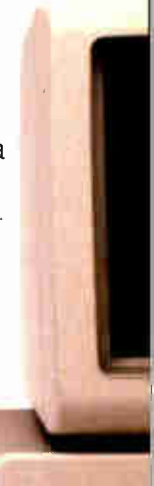

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Fujitsu America, Inc.
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stallation, including a custom device driver.

Which One for You?

When it comes time to buy a hard disk drive, it's important to remember that not all the drives covered here are available to end users directly from their manufacturers. Many are sold by distributors or value-added retailers, or sold only as part of complete systems.

The type of dealer you buy from—and the value of the software, hardware, and support they add to the basic hard disk drive—will have a dramatic impact on the price of the hard disk drive package and its ultimate worth to you. If you're buying a hard disk drive, it behooves you to *ask* what brand and model you're buying and precisely what is included.

I've also made it clear that few of these drives are easy to install. Some require advanced system knowledge to get them working, and even the easiest require some knowledge of DOS and computer hardware. If in doubt, go to a reputable dealer who will install the drive for you.

Finally, what about reliability? All the drives reviewed here have a claimed mean time before failure of between 25,000 and 50,000 hours. That's a long time, and most drives haven't been out long enough to prove or disprove the number in the general case. In any case, reliability does seem to be increasing. I wouldn't be reluctant to count on any of these drives for my important data.

But hard disk drives are notorious for being flaky, and many's the computer user who's found months of work lost in a bum hard disk drive. The obvious answer is to make backups. This month's Views from BIX on page 129 looks at the factors that go into purchasing a tape backup system and the reasons behind the choices a number of users have made.

Choosing which drive is best for your system is far from an easy call. As I've noted, each drive has its own idiosyncrasies. Prices vary widely, from less than $400 to almost $2600. Though it's far from the cheapest, my particular favorite is the Priam ID45-AT-D2, which just about anyone can install, given a bit of time and patience. The absolute price leader is the Seagate ST251-1, which, at $370, sells for a relatively small premium over many 20-megabyte drives.

Finally, if you're looking for the best price/performance ratio, you'll have trouble beating the Northgate Turbo kit. At $695, it has a better overall performance than some drives, like the Tandy SCSI drive and Core AT40F, costing over $2000. ■

Stan Miastkowski is a BYTE contributing editor, director of K+S Concepts (a documentation and consulting firm), and editor in chief of the OS Report *newsletter. He can be reached on BIX as "stanm."*

Views from BIX: Tape Backup Units

When a hard disk drive crash can destroy months of work, a reliable backup method becomes vital. BIX users have turned to tape backup units for many applications and are free with their opinions and recommendations. Speed, ease of use, cost, compatibility, and reliability are the main issues they deal with here.

—Curt Franklin, Senior Testing Editor, BYTE Lab

NICK BARAN (technical editor, BYTE) [nickbaran]: "I'd strongly recommend the Genoa or a similar tape backup system for disk image backup. It's definitely worth the investment. I've already had occasion to use it after my hard disk drive crashed."

LES TROYER [ltroyer]: "Buy an Irwin for backup and make an image to tape. It takes about 5 minutes (while you drink coffee). The Irwin takes care of bad sectors automatically. Occasionally, do a full file backup and restore to up the performance due to fragmented files."

RUSSELL SCHNAPP [rschnapp]: "We use the Emerald tape drive to back up and archive our IBM PC-based office automation product. We were having problems with tapes seeming to go bad. Since we bought the cartridges from them, Emerald suggested we turn them in, and they'd replace them. We did, and they didn't.

"They just sent them back and said nothing was wrong, once they were re-erased. They had no interest in the cause of the tape failures. Then Emerald came out with a new version of the tape backup software called ASP.

"We purchased ASP and found we couldn't get it to seek to the end of the last backed-up volume on the tape. Rather than trying to diagnose the problem (the drive was only a few months old), they told us to buy a new drive. That cost us $700 more. On the other hand, when it works, it works well. There are other companies that make you pay through the nose for crud. At least Emerald makes you pay through the nose for useful stuff. They simply don't try to engender any customer loyalty through goodwill."

RAY DUNCAN [rduncan]: "We have been using the Emerald 60-megabyte tape drive and 60-megabyte hard disk drive unit for about a year on a 3Com Ethernet system as the server. We've had pretty good luck with the hardware. Customer service at Emerald was pretty good a year ago but has been going downhill since they got so 'successful,' it seems. We recently bought an expansion drive for our IBM PC AT. It didn't fit in the box, we couldn't get any reasonable answers on the phone, and we finally just had to stop payment on the check to get their attention."

RUSSELL SCHNAPP: "We use an Emerald 60-megabyte tape drive to back up several servers over our TiaraLink LanWare network. It allows multiple volumes per tape, file by file or image (though we never use the latter). The transfer rate is good, somewhere around 1 or 2 megabits a minute. The only problem is that I don't like Emerald's attitude. When the drive began rejecting tapes right and left, they charged us almost the full cost of a new drive to fix/replace it. It has now begun to reject more and more tapes again. ASP will not archive hidden or system files (and maybe not even read-only files). This is supposedly on purpose."

TED BELZER [bunnyrabbit]: "We just installed an Everex streaming tape in an IBM PC AT with Novell NetWare 86. In order to be able to do both image and file-by-file backups, the tape unit must be co-located with the hard disk drive to be backed up. This means the file server must be booted as a nondedicated file server when doing backups. The Everex software allows for backup of Novell's system files when doing a file-by-file backup should you wish to do so, but for frequent file-by-file backups, the inclusion of system files and executables just wastes tape."

BARRY NANCE [barryn]: "I've used the Tecmar QIC-60 tape backup for the IBM PC AT and the Maynstream tape backup unit. I greatly prefer the Tecmar tape machine; it's quicker and seems to be more reliable."

BRIAN COLLETT [bcollett]: "I have an Everex tape drive (20-megabyte streamer) in my machine, and it seems to be working out very well. It backs up the 10 to 12 megabytes I have on my disk at the moment in under 10 minutes (I think it's closer to 5, but I tend to go elsewhere).

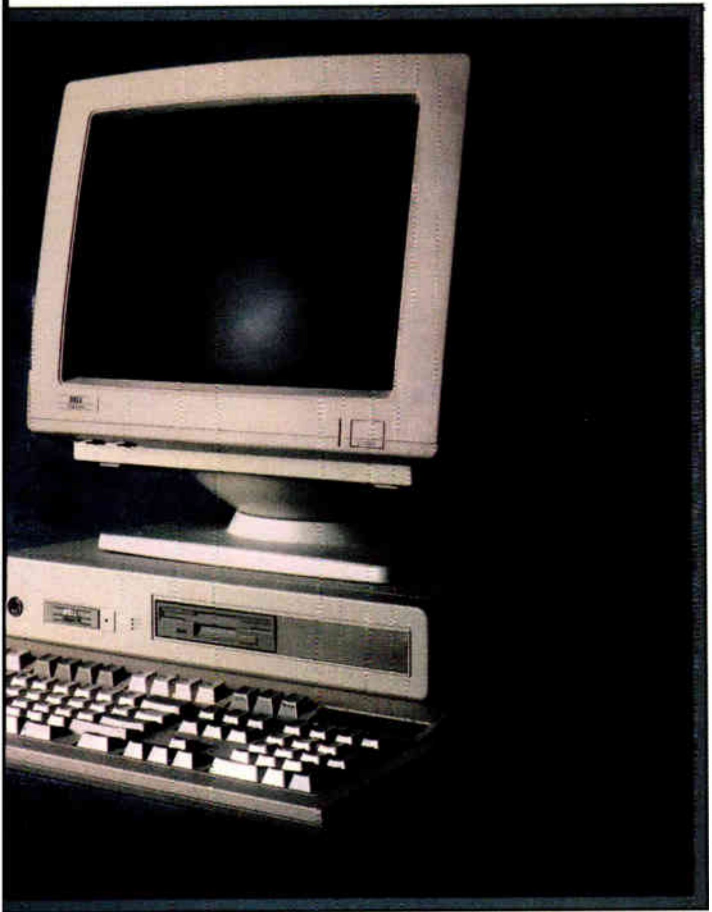
The Everex tape drive comes with some very easy-to-use menu-driven software that should make backing up pretty nearly foolproof for just about anyone, and it can even be set up so that it knows when you should be doing your backups."

BARRY NANCE: "We used to have the Maynstream tape backup unit at work; we trashed it and got a Tecmar QIC-60 in its place. Sometimes the Maynstream would work, and sometimes it wouldn't. We kept nursing it along, eventually getting a new interface card for it so that it would work with ATs, and one day we just decided it was more work than it was worth in backup/restore situations. We also decided we couldn't trust it any longer. In my opinion, the Tecmar is a much better unit."

TIM FROST [tfrost]: "We have a Cipher 5400 that comes with Sytos software. We use the same box on several machines, with an interface card in each. Sytos is fine for straight backups, but the user interface is a bit impenetrable if you need to do some of the more complex selections and exclusions. If you do a complete DOS disk backup, it can take an age to restore an individual file. And remember to remove all RAM disks, etc., before doing a backup; it doesn't tell you it's short of RAM, just runs very, very slowly.

"I have the Xenix version of Sytos. but I never use it. The Xenix support software also comes with a `/dev/mt` driver, and we simply use `tar` or `cpio`. You can make tapes with AT Xenix (SCO) that are readable on several other systems. Sun and NCR Tower are certainly OK. In some cases, you need to use `dd` with `conv=swab`. Transfer in both directions is OK. I don't know what the QIC number is, but it can use DC600A or DC300XLP tapes. We use the latter."

Editor's note: *Views from BIX presents a variety of informal, diverse opinions from users of a selected class of products. Messages chosen for publication may be edited for length or clarity. The views expressed are those of each message's author and do not necessarily reflect those of BYTE or BYTE's reviewers.*



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The top of the line. It's the highest performance 80386 computer available, faster than the IBM† PS/2† Model 80 and the Compaq† 386/20. It runs at 20 MHz, with the latest 32-bit architecture for maximum performance. And it's completely MS® OS/2 compatible. Since it also has Intel's† Advanced 82385 Cache Memory Controller, and high performance disk drives, the System 310 is ideal for intensive database management, complex research and development, CAD/CAM, and desktop publishing. As a network file server the system offers an unbeatable combination of price and performance.

Standard Features:

Intel† 80386 microprocessor running at 20 MHz.
1 MB of 80 ns 32-bit RAM expandable to 16 MB without using an expansion slot.
Advanced Intel 82385 Cache Memory Controller with 32 KB of high speed static RAM.
Socket for 20 MHz 80387 coprocessor.
5.25" 1.2 MB or 3.5" 1.44 MB diskette drive.
Dual diskette and hard disk drive controller.
Enhanced 101-key keyboard.
1 parallel and 2 serial ports.
200-watt power supply.
Real-time clock.
8 expansion slots (6 available with hard disk drive controller and video adapter installed).
Dell System Analyzer.
MS-DOS® and MS OS/2 compatible.
Security lock with locking chassis.
12 month on-site service contract (Available on complete systems).

Options:
1 MB RAM upgrade kit.
20 MHz Intel 80387 math coprocessor.
2 MB or 8 MB memory expansion boards.

SYSTEM 310	With Monitor and Adapter		
Hard Disk Drives	VGA Mono	VGA Color	VGA Color Plus
40 MB-28 ms	$4,099	$4,299	$4,399
90 MB-18 ms ESDI	$4,899	$5,099	$5,199
150 MB-18 ms ESDI	$5,399	$5,599	$5,699
322 MB-18 ms ESDI	$7,399	$7,599	$7,699

THE NEW 20MHz 286 SYSTEM 220.

As fast as most 386 computers, at less than half the price—more power for the money than any other system. An 80286 system that runs at 20 MHz, with less than one wait state. Completely compatible for both MS-DOS and MS OS/2 applications (it runs OS/2 faster than IBM PS/2 Model 80), and with a remarkably small footprint, the System 220 is the ideal executive workstation for database management, business, or sophisticated connectivity applications. The system uses page-mode interleaved memory; the page-mode RAM operates at less than one wait state, and inter-leaving results in a performance increase of about 15 percent.

Standard Features:

80286 microprocessor running at 20 MHz.
1 MB of RAM expandable to 16 MB (8 MB on system board).
Integrated diskette and VGA video controller on system board.
One 3.5" 1.44 MB diskette drive.
Integrated high performance hard disk interface on system board.
Enhanced 101-key keyboard.
1 parallel and 2 serial ports.
LIM 4.0 support for memory over 1 MB.
Real-time clock.
Three full-sized AT† compatible expansion slots.
Socket for 80287 coprocessor.
Dell System Analyzer.
MS-DOS and MS OS/2 compatible.
Security lock with locking chassis.
12 month on-site service contract (Available on complete systems).

Options:
3.5" 1.44 MB diskette drive.
Intel 80287 coprocessor.
1 MB RAM upgrade kits.

SYSTEM 220	With Monitor		
	VGA Mono	VGA Color	VGA Color Plus
One Diskette Drive	$2,299	$2,499	$2,599
40 MB-29 ms Hard Disk	$2,999	$3,199	$3,299
100 MB-29 ms Hard Disk	$3,799	$3,999	$4,099

Outclassing the AT

Of these five AT compatibles, Amdek's system ranks tops in performance, and PC's Limited comes in as the best buy

John Unger and
Stan Miastkowski

Amdek System/286A

Arche Rival 286

The current crop of PC AT–compatible computers is pushing performance beyond that of the IBM PC AT. Granted, most AT compatibles don't yet have the speed and flash of 80386 machines. But high-speed 80286 systems are more and more closely approaching the performance of 80386 systems, are well-tested and reliable, and still sell for far less than fully equipped 80386 systems. In short, they don't shirk in performance, don't break budgets, and don't break down.

The Amdek System/286A, Arche Rival 286, Epson Equity II+, Leading Edge Model D2, and PC's Limited System 200 are 80286-based computers that run at 10 MHz or higher. While they are all IBM PC AT–compatible, they differ in details: Besides varying clock speeds, internal components such as graphics cards and hard disk drives are different, and the basic design of the motherboards differs significantly from machine to machine. In this review, we'll look at each machine and then do a side-by-side comparison with BYTE's new benchmarks to give you a good idea of where each computer's strengths and weaknesses lie.

Amdek System/286A

The Amdek System/286A is a small-footprint microcomputer built on the same chassis as the Amdek System/386 computer I reviewed in the May BYTE. Amdek takes advantage of the modularity built into its system bus design. The CPU, system RAM, and ROM are mounted on a card that fits into one of the standard 16-bit AT-style expansion slots on the system bus. This configuration allows Amdek (or WYSE Technology, Amdek's parent company, which actually manufactures the Amdek microcomputers) to change the computer models by simply replacing the CPU board.

The 12.5-MHz CPU on the System/286A can be switched to run at a slower 8-MHz clock speed for better compatibility. The machine has a convenient 16-character LCD window on the front panel that displays the time or date and CPU clock speed, or a bar graph that shows the amount of CPU activity.

My test system had an EGA monitor, along with a 1.2-megabyte 5¼-inch floppy disk drive, a 40-megabyte hard disk drive, and 1 megabyte of dynamic RAM (DRAM). The cost for this configuration is $4345. The review unit was also equipped with the Paradise EGA card.

The View

The combination of Paradise's half-length EGA card and the Amdek Monitor/722 produced excellent color graphics and text. When it's in monochrome text mode, the monitor has the capability to switch from white characters on a black background to either orange or green characters on a black background. All my "serious" software and my CGA games ran perfectly on this display combination.

Hardware and Performance

As the benchmark results show, the System/286A is one of the best-performing 80286-based microcomputers that BYTE has reviewed. The system's fine performance is due to the CPU clock's high speed (12.5 MHz) and to the fact that the hardware imposes no wait states on the system. For compatibility with some software and expansion boards, you can

Epson Equity II +

Leading Edge Model D2

PC's Limited System 200

also run the CPU at 8 MHz with one wait state. You switch the CPU speed by pressing a button on the front panel or by invoking a utility program. For mathematically intensive tasks, the system accepts either a 6-MHz or 10-MHz 80287 coprocessor.

The Control Data Corp. (CDC) 40-megabyte hard disk drive in my review system did not degrade the system's performance. It had an average access time of 24 milliseconds and a data transfer rate of 165K bytes per second, as reported by the Coretest program. Using Amdek's disk-caching program increases the speed of some disk-intensive tasks by as much as 20 percent.

The 1 megabyte of system memory is mounted on a piggyback daughterboard that is connected to the CPU motherboard via a special bus. This card combo is mounted in an extra-wide expansion slot on the left-hand side of the computer. Two DB-9 RS-232C male serial ports and a single DB-25 female parallel port are located on a half-length expansion card mounted in one of the 8-bit slots. The full-length disk controller card fills a 16-bit slot and has cabling for two floppy disk drives and two hard disk drives. The EGA video card takes up a second 16-bit slot.

This configuration leaves you with three 16-bit slots and one 8-bit slot free; the 8-bit slot isn't really usable for some purposes, though, because the second serial port is mounted on the cover of the adjacent empty expansion slot.

Essential Software

For the System/286A, Amdek supplies an enhanced version of MS-DOS 3.20 that includes a number of utility programs. The most useful of these is an on-line HELP command for all the DOS commands and programs. This feature is essential; Amdek's documentation on MS-DOS is skimpy and includes no explanation of EDLIN or Debug.

Fast computers can come in small packages. If you are looking for one of the top-performance AT compatibles and don't need to install more than three half-height storage devices, the System/286A is an excellent choice. Its modular CPU design gives it the added benefit of being easily upgraded—you can simply add a new expansion card.*—John Unger*

Arche Rival 286

Arche Technologies is a new contender in the AT clone sweepstakes, with a distinctive yellow-arch corporate logo that's reminiscent of a certain fast-food chain. The Arche Rival 286 has the rather unusual distinction (for a compatible) of being made in the U.S., although many of its parts, including the floppy disk drive and some of the chips, are, not surprisingly, of Japanese extraction.

The system comes in a rather bewildering array of choices. The entry-level model goes for $1995 and includes 640K bytes of RAM, a single 1.2-megabyte 5¼-inch floppy disk drive, and a 14-inch diagonal monochrome monitor.

If you have Cadillac tastes, you can equip your Arche Rival 286 with the works: 1 megabyte of RAM, a second 1.2-megabyte 5¼-inch floppy disk drive, a high-speed 80-megabyte hard disk drive, and an EGA monitor. That will set you back $4395.

The unit I tested had 1 megabyte of RAM, a single floppy disk drive, the

continued

	Amdek System/286A	Arche Rival 286	Epson Equity II+
Company	Amdek Corp. 1901 Zanker Rd. San Jose, CA 95112 (800) 722-6335	Arche Technologies, Inc. 48835 Kato Rd. Fremont, CA 94539 (800) 422-4674	Epson America, Inc. 2780 Lomita Blvd. Torrance, CA 90505 (800) 421-5426
Components	**Processor:** 12.5-MHz 80286 with zero wait states, switchable to 8 MHz with one wait state; optional 80287 (6- or 10-MHz) math coprocessor **Memory:** 1 megabyte of DRAM, expandable to 16 megabytes; 32K bytes of ROM; Phoenix ROM BIOS version 1.83 **Mass storage:** 1.2-megabyte 5¼-inch floppy disk drive; optional 40-megabyte hard disk drive **Display:** Optional Amdek color EGA display, 80 characters by 25 lines, 640- by 350-pixel resolution **Keyboard:** 102 keys in IBM enhanced keyboard layout **I/O interfaces:** Two DB-9 RS-232C serial ports; one DB-25 parallel printer port; six 16-bit and two 8-bit expansion slots	**Processor:** 12-MHz 80286 with one wait state, switchable to 8 MHz with zero wait states; socket for 80287 math coprocessor **Memory:** 640K bytes of 100-ns RAM, expandable to 1 megabyte on system board; diagnostics in ROM **Mass storage:** One 1.2-megabyte 5¼-inch floppy disk drive; optional 20-, 40-, 65-, 80-, or 140-megabyte hard disk drive **Display:** Amber-phosphor monochrome; 14-inch diagonal flat screen, 1000-line resolution **Keyboard:** 101 keys in IBM enhanced keyboard layout **I/O interfaces:** One DB-9 and one DB-25 RS-232C serial port; one DB-25 parallel port; one DB-9 monochrome monitor port; two 8-bit and six 16-bit expansion slots	**Processor:** 12-MHz 80286 with one, two, three, or four wait states, switchable to 8 MHz with one wait state; optional 80287 (8-MHz) math coprocessor **Memory:** 640K bytes of DRAM, expandable to 15.5 megabytes; 32K bytes of ROM **Mass storage:** 1.2-megabyte 5¼-inch floppy disk drive; optional 40-megabyte hard disk drive **Display:** Optional Epson Enhanced color display **Keyboard:** 101 keys in IBM enhanced keyboard layout **I/O interfaces:** One DB-9 RS-232C serial port; one DB-25 parallel printer port; three 16-bit and three 8-bit expansion slots
Size	6¼ × 15 × 17 inches; 23 pounds	6 × 17 × 17 inches; 52 pounds	6 × 15¾ × 16⅝ inches; 23 pounds
Software	Microsoft MS-DOS 3.20; Microsoft GWBASIC 3.20; custom utilities	MS-DOS 3.3; system setup on hard disk drive	Microsoft MS-DOS 3.3; Microsoft GWBASIC 3.20; custom utilities; hard disk cache
Options	Monitor/432, VGA monochrome: $245 Monitor/732, VGA color: $625 Monitor/722, EGA color: $750	384K-byte memory expansion: $200 EGA monitor: $600 1.2-megabyte 5¼-inch floppy disk drive: $200 20-megabyte hard disk drive: $300 40-megabyte hard disk drive: $600 65-megabyte hard disk drive: $800 80-megabyte hard disk drive: $1400	Multimode graphics adapter: $149 EGA card: $299 Monochrome monitor: $149 Color monitor: $449 EGA monitor: $599
Documentation	64-page Amdek System 286A Installation and Assembly Guide; 110-page Amdek Enhanced MS-DOS 3.2 User's Guide	User's Guide; Microsoft MS-DOS User's Guide and User's Reference; Microsoft GWBASIC User's Guide and User's Reference	User's Guide and Diagnostics; Epson GWBASIC for the Equity+ System; Epson MS-DOS for the Equity+ System
Price	With 1.2-megabyte 5¼-inch floppy disk drive; no monitor or display adapter: $2495 With 1.2-megabyte 5¼-inch floppy disk drive and 40-megabyte hard disk drive; no monitor or display adapter: $3595 System as reviewed: $4345 **Inquiry 883.**	With 1.2-megabyte 5¼-inch floppy disk drive and monochrome system: $1995 With two 1.2.-megabyte 5¼-inch floppy disk drives, an 80-megabyte hard disk drive, 1 megabyte of RAM, and EGA monitor: $4395 System as reviewed: $2595 **Inquiry 884.**	With 1.2-megabyte 5¼-inch floppy disk drive; no monitor or display adapter: $1899 With 1.2-megabyte 5¼-inch floppy disk drive and 40-megabyte hard disk drive; no monitor or display adapter: $2999 System as reviewed: $3897 **Inquiry 885.**

Leading Edge Model D2	**PC's Limited System 200**
Leading Edge Hardware Products, Inc. 225 Turnpike St. Canton, MA 02021 (800) 872-5323 (617) 828-8150	Dell Computer Corp. 9505 Arboretum Blvd. Austin, TX 78759 (800) 426-5150
Processor: 10-MHz 80286 with one wait state, switchable to 8 MHz and 6 MHz with one wait state; socket for 80287 math coprocessor **Memory:** 640K bytes of 120-ns RAM, expandable to 1 megabyte on system board **Mass storage:** 1.2-megabyte 5¼-inch floppy disk drive; optional 30-megabyte or 64-megabyte hard disk drive **Display:** Green-phosphor monochrome; 12-inch diagonal **Keyboard:** 101 keys in IBM enhanced keyboard layout **I/O interfaces:** One DB-9 RS-232C serial port; one DB-25 parallel port; one EGA monitor port; two 8-bit and four 16-bit expansion slots	**Processor:** 12.5-MHz 80286 with one wait state, switchable to 6.25 MHz with one wait state; optional 80287 (either 6-MHz or 8-MHz) math coprocessor **Memory:** 640K bytes of 120-ns DRAM, expandable to 16 megabytes with up to 4.6 megabytes on system board with optional SIMM modules; 32K bytes of ROM; Phoenix BIOS version 3.07 08 **Mass storage:** 1.2-megabyte 5¼-inch floppy disk drive; optional 1.44-megabyte 3½-inch floppy disk drive; optional 40-megabyte hard disk drive **Display:** Optional Mitsubishi XC-1429C color VGA display **Keyboard:** 101 keys in IBM enhanced keyboard layout **I/O interfaces:** Two DB-9 RS-232C serial ports; DB-25 parallel printer port; four 16-bit and two 8-bit expansion slots
6 × 15½ × 16 inches; 46 pounds	6¼ × 21⅛ × 17½ inches; 41 pounds
MS-DOS 3.20; GWBASIC 3.20; system diagnostics; system setup; Leading Edge Word Processor	Microsoft MS-DOS 3.30; Microsoft GWBASIC 3.22; custom utilities
None available	14-inch VGA monochrome monitor: $250 14-inch EGA monitor: $700 VGA card: $300 20-megabyte hard disk drive: $370 40-megabyte hard disk drive: $600 40-megabyte 28-ms hard disk drive: $900 1.44-megabyte 3½-inch floppy disk drive: $200 360K-byte 5¼-inch floppy disk drive: $150 512K-byte RAM: $200
Operator's Guide; MS-DOS Reference Manual; Guide to BASIC; Word Processing User's Guide	286 Owner's Manual; MS-DOS 3.30 Enhancement Guide; System 200 Support Manual; MS-DOS User's Guide; MS-DOS 3.30 User's Reference; Microsoft GWBASIC Interpreter User's Reference
With single 1.2-megabyte 5¼-inch floppy disk drive: $1495 With 1.2-megabyte 5¼-inch floppy disk drive and 30-megabyte hard disk drive: $1995 System as reviewed: $2495	With 1.2-megabyte 5¼-inch floppy disk drive, monochrome display adapter and monitor, and 20-megabyte hard disk drive: $1799 System as reviewed: $3599
Inquiry 886.	**Inquiry 887.**

monochrome monitor, and a 20-megabyte Seagate ST225 hard disk drive—a configuration with a list price of $2595.

Using 100-nanosecond RAM, the Rival 286 runs at 12 MHz with one wait state or at 8 MHz with zero wait states. Speed selection is a simple matter of pressing a button on the front panel of the system unit. There's also a reset switch and a keylock on the front.

Keeping It Small

Inside the case, the Rival 286 has a particularly neat appearance; in fact, it looks almost empty. The motherboard is an incredibly small 8½ by 12 inches; yet, despite its size, it doesn't look crowded. The primary reason for this is that the Arche folks decided to use the whole Chips & Technologies 80286 support set—a group of six application-specific integrated circuits (ASICs) that eliminate a multitude of individual chips. Another reason for the small motherboard is that some functions that are normally supported on an AT-type motherboard, such as I/O ports, are relegated to add-in boards.

The Rival 286 has eight expansion slots: two 8-bit and six 16-bit. A Hercules-compatible monochrome graphics adapter takes up one of the 8-bit slots. A serial/printer/game-port card takes up a single 16-bit slot, as does a hard disk drive/floppy disk drive controller that accepts both 3½-inch and 5¼-inch drives. The hard disk drive is mounted at the very bottom of a drive stack that can take a total of three half-height drives.

Easy on the Eyes

The display of the Rival 286 is most immediately noticeable for its 14-inch diagonal size. It uses the flat-screen technology that Zenith first introduced last year. The Rival's monitor is Taiwan-made and of indeterminate manufacture; the monitor's only internal identification, Zemintron Ltd., is on the neck of the flat-screen tube. Couple the flat display with the large character size, and it's a great monitor for pampering your eyes.

Although the Rival 286 is available without a hard disk drive or with various floppy disk drives of various capacities, the unit I tested came with a venerable, albeit slow, Seagate ST225. The Coretest showed an average seek time of 70.8 ms and a data transfer rate of 159.1K bytes per second—not exactly speedy. In a disk-intensive application such as a database, using a drive this slow can seriously bog down system performance, 12-MHz processor speed notwithstanding.

continued

Outclassing the AT:

Amdek System/286A   PC's Limited System 200   Arche Rival 286   Leading Edge Model D2   Epson Equity II+

APPLICATION-LEVEL PERFORMANCE

WORD PROCESSING	Amdek	PC's Ltd.	Arche	LE-D2	Epson
XyWrite III+ 3.52	Med/Lrg	Med/Lrg	Med/Lrg	Med/Lrg	Med/Lrg
Load (large)	:11	:13	:15	:15	:15
Word count	:04/:28	:05/:34	:03/:36	:06/:42	:06/:43
Search/replace	:06/:25	:08/:33	:08/:37	:09/:37	:10/:37
End of document	:02/:11	:03/:22	:02/:24	:02/:23	:03/:22
Block moves	:12/:12	:12/:12	:07/:07	:08/:08	:15/:15
Spelling check	:12/1:29	:15/1:49	:16/1:56	:17/2:16	:18/2:17
Microsoft Word 4.0					
Forward delete	2:12	:22	:24	:28	:28
Aldus PageMaker 1.0a					
Load document	:05	:06	:19	:13	:07
Change/Bold	:31	:40	:47	:53	:50
Align right	:26	:31	:37	:38	:38
Cut 10 pages	:24	:26	:31	:30	:32
Place graphic	:07	:07	:09	:09	:08
Print to file	2:00	2:34	3:19	3:03	3:06
Index:	**2.2**	**1.9**	**1.8**	**1.7**	**1.6**

SPREADSHEET	Amdek	PC's Ltd.	Arche	LE-D2	Epson
Lotus 1-2-3 2.01					
Block copy	:05	:05	:06	:07	:07
Recalc	:02	:02	:03	:03	:03
Load Monte Carlo	:20	:22	:23	:36	:38
Recalc Monte Carlo	:05	:06	:09	:14	:11
Load rlarge3	:05	:05	:06	:09	:09
Recalc rlarge3	:01	:01	:02	:02	:02
Recalc Goal-seek	:04	:05	:09	:07	:08
Microsoft Excel 2.0					
Fill right	:06	:08	:09	:10	:10
Undo fill	2:32	3:13	3:25	4:05	4:04
Recalc	:01	:01	:03	:04	:01
Load rlarge3	:31	:38	:41	:48	:46
Recalc rlarge3	:02	:02	:02	:03	:02
Index:	**2.2**	**2.1**	**1.5**	**1.3**	**1.6**

DATABASE	Amdek	PC's Ltd.	Arche	LE-D2	Epson
dBASE III+ 1.1					
Copy	1:01	:56	2:52	1:07	1:17
Index	:14	:22	:23	:20	:23
List	2:24	2:05	1:56	2:43	3:13
Append	2:25	1:50	3:27	2:09	2:31
Delete	:03	:03	:04	:02	:04
Pack	1:02	1:42	2:04	1:48	1:50
Count	:11	:19	:19	:16	:18
Sort	1:07	1:23	1:55	1:20	1:39
Index:	**1.6**	**1.4**	**1.0**	**1.4**	**1.1**

SCIENTIFIC/ENGINEERING	Amdek	PC's Ltd.	Arche	LE-D2	Epson
AutoCAD 2.52					
Load SoftWest	1:34	1:25	1:37	2:06	1:58
Regen SoftWest	1:01	1:06	1:17	1:45	1:39
Load StPauls	:23	:20	:21	:25	:23
Regen StPauls	:11	:12	:14	:16	:16
Hide/redraw	18:41	21:11	24:53	30:01	29:16
STATA 1.5					
Graphics	1:54	1:27	:31	2:22	3:27
ANOVA	:27	:24	:21	:30	:31
MathCAD 2.0					
IFS 800 pts.	:29	:33	:33	:39	:43
FFT/IFFT 1024 pts.	:32	:36	:35	:41	:47
Index:	**2.1**	**2.0**	**2.0**	**1.5**	**1.5**

COMPILERS	Amdek	PC's Ltd.	Arche	LE-D2	Epson
Microsoft C 5.0					
XLisp compile	5:39	6:50	8:41	7:01	7:56
Turbo Pascal					
Pascal S compile	:07	:07	:10	:10	:09
Index:	**1.7**	**1.5**	**1.1**	**1.2**	**1.2**

All times are in minutes and seconds. Indexes show relative performance; for all indexes, an 8-MHz IBM PC AT = 1.

LOW-LEVEL PERFORMANCE[1]

CPU	Amdek	PC'S Ltd.	Arche	LE-D2	Epson
Matrix	6.06	7.18	7.83	9.00	8.98
String Move					
Byte-wide	34.07	50.24	53.23	63.49	63.00
Word-wide					
Odd-bnd.	34.06	50.26	53.40	63.49	63.00
Even-bnd.	17.05	25.12	26.53	31.74	32.00
Sieve	35.65	46.12	48.64	57.70	58.00
Sort	40.39	52.82	55.58	67.00	66.00
Index:	**2.11**	**1.61**	**1.51**	**1.28**	**1.28**

FLOATING POINT[2]	Amdek	PC'S Ltd.	Arche	LE-D2	Epson
Math	31.55	29.1	31.1	37.2	40.53
Error[3]	0.0	0.0	0.0	0.0	0.0
Sine(x)	12.37	11.05	13.34	15.98	16.03
Error	2.0E-9	2.0E-9	2.0E-9	2.0E-9	2.0E-9
e^x	10.89	9.78	11.43	13.75	13.81
Error	1.0E-9	1.0E-9	1.0E-9	1.0E-9	1.0E-9
Index:	**1.6**	**1.7**	**1.5**	**1.3**	**1.2**

DISK I/O	Amdek	PC'S Ltd.	Arche	LE-D2	Epson
Hard Seek[4]					
Outer track	3.33	3.35	6.66	3.32	3.33
Inner track	3.32	3.28	6.68	3.31	3.31
Half platter	9.98	9.97	19.94	6.66	9.99
Full platter	13.33	13.36	33.3	10	13.29
Average	7.49	7.49	16.64	5.82	7.48
DOS Seek					
1-sector	10.81	10.78	15.96	12.11	10.68
8-sector	33.70	24.99	47.45	12.55	26.98
File I/O[5]					
Seek	0.11	0.19	0.45	0.13	0.27
Read	0.01	0.01	0.0194	0.03	0.0201
Write	0.02	0.0158	0.025	0.08	0.0231
1-megabyte					
Write	8.04	8.06	9.7	4.7	8.4
Read	7.56	7.5	8.1	5.8	7.65
Index:	**1.3**	**1.2**	**0.8**	**1.3**	**1.0**

VIDEO	Amdek	PC'S Ltd.	Arche	LE-D2	Epson
Text					
Mode 0	14.86	11.37	N/A	N/A	12.32
Mode 1	14.88	11.4	N/A	N/A	12.33
Mode 2	14.52	11.2	N/A	N/A	11.84
Mode 3	14.54	11.2	N/A	N/A	11.83
Mode 7	N/A	10.18	6.0	9.9	N/A
Graphics					
CGA:					
Mode 4	2.74	3.18	N/A	N/A	4.14
Mode 5	2.73	3.2	N/A	N/A	4.16
Mode 6	2.88	3.41	N/A	N/A	4.35
EGA:					
Mode 13	4.87	5.29	N/A	N/A	6.9
Mode 14	5.31	5.86	N/A	N/A	7.52
Mode 16	5.25	5.84	N/A	N/A	7.51
Hercules					
Mode 225	N/A	N/A	3.24	3.90	N/A
Index:	**1.0**	**1.1**	**1.5**	**1.2**	**0.9**

CONVENTIONAL BENCHMARKS

	Amdek	PC'S Ltd.	Arche	LE-D2	Epson
LINPACK	633.40	574.19	669.76	803.95	805.48
Livermore Loops[6] (MFLOPS)	0.04	0.0419	0.0355	0.0297	0.0296
Dhrystone (MS C 5.0) (Dhry/sec)	3584	2741	2557	2136	2177

N/A = Not applicable; mode not supported by graphics adapter.

[1] All times are in seconds. All figures were generated using the 8088/8086 version of Small-C (16-bit integers). Figures for 80386 machines do not use 80386-specific instructions.

[2] The floating-point benchmarks use 8087-compatible instructions only.

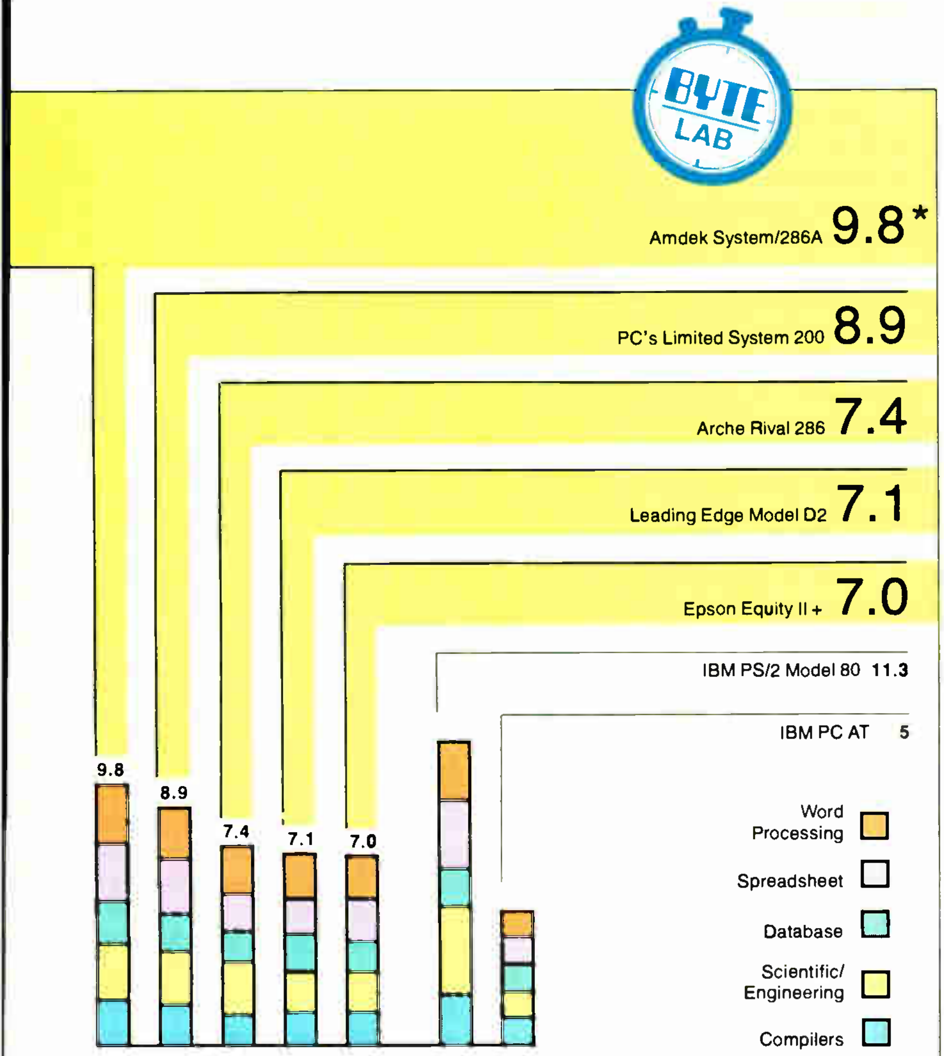
[3] The errors for the floating-point benchmarks indicate the difference between expected and actual values, correct to 10 digits or rounded to 2 digits.

[4] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100.)

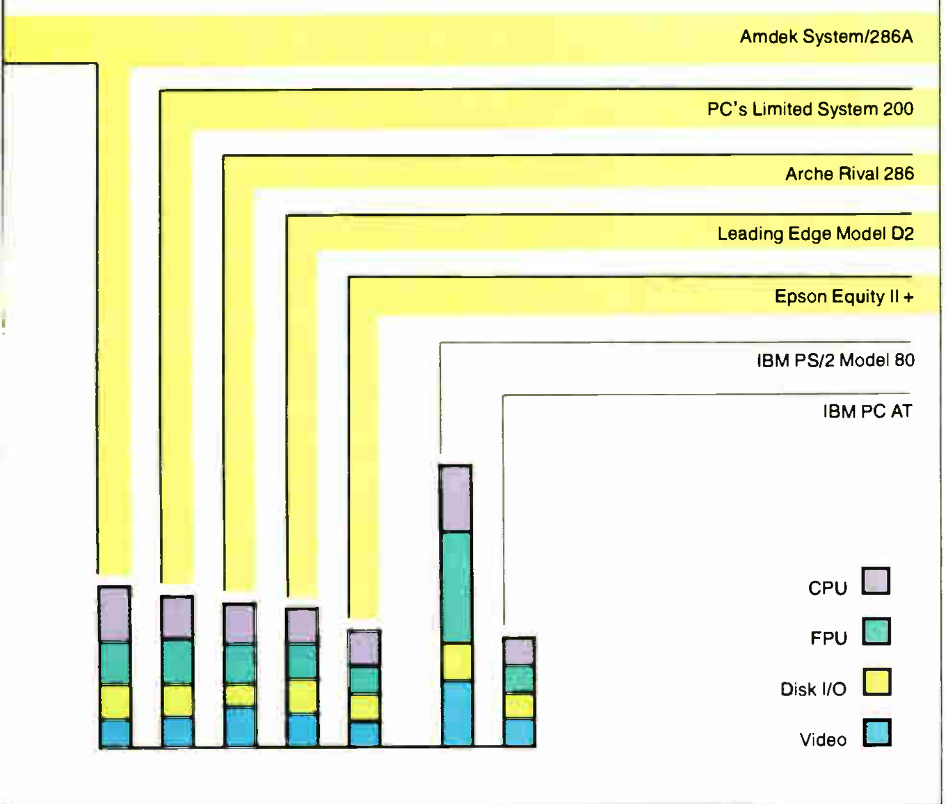
[5] Read and write times for the File I/O benchmarks are in seconds per Kbyte.

[6] For the Livermore Loops and Dhrystone tests only, higher numbers mean faster performance.

For a full description of all the benchmarks, see "Introducing the New BYTE Benchmarks," June BYTE.



*Cumulative applications index. Graphs are based on indexes at left and show relative performance.



If you buy a Rival 286, you should seriously consider opting for a faster hard disk drive.

All the memory chips in the Rival 286 are socketed, and if you have a 640K-byte machine, it's a simple matter to plug in a few extra chips to bring it up to the full 1-megabyte AT complement.

Between the Covers

The Rival 286 ships with a generic version of MS-DOS 3.3. The excellent Microsoft manuals are included, although the relatively high level of their technical content can be daunting if you're a beginner. The User's Guide is a better place for most folks to start. It's a terse, though well-written, 54 pages of essential information.

Another plug-it-in-and-run machine, the Arche Rival 286 bears all the marks of careful design and construction. And it's frankly a comfortable system to use. On the unit I tested, the slow hard disk drive was a noticeable drag on the system. Arche Technologies has warranted its system for 24 months, and the company was in the process of setting up toll-free help lines as I was writing this review.—*Stan Miastkowski*

Epson Equity II+

The Epson Equity II+ is a big jump forward from the original Equity II. This new model has an 80286 CPU that you can switch between 8 and 10 MHz. The improved performance of this machine is not due only to the new processor: All the critical hardware components have been upgraded. My review unit had a fast 40-megabyte hard disk drive, a 1.2-megabyte 5¼-inch floppy disk drive, and 640K bytes of 120-ns DRAM. All this is attractively packaged in a light-gray, small-footprint unit. The price of this system, including Epson's Autoswitch EGA card and EGA monitor, is $3897.

As in earlier Epson computers, the Equity II+ has a small door on the bottom left of the front panel, behind which you'll find a hardware reset switch, a toggle switch for the 8-MHz and 12-MHz CPU speeds, and another toggle for monochrome and color monitors. The keyboard cable connects to a recessed plug hidden behind another small panel at the bottom left corner of the machine.

An LED power indicator on the front of the Equity II+ glows green when the computer is turned on and running at 10 MHz; it changes to orange when the CPU

continued

is set to its 8-MHz speed. You can change the processor speed only with the switch mentioned above; it cannot be changed with a keystroke combination or by software—an inconvenience compared to other systems with switchable CPU speeds. A second green LED glows when the system's CDC 40-megabyte hard disk drive is active. This hot drive shows an average seek time of 23 ms with a data transfer rate of 169K bytes per second, according to the Coretest program.

Internals
The basic layout of the Equity II+ components is similar to that of most other small-size AT clones. Three half-height storage device bays occupy the right front corner of the computer; behind them sits the 140-watt power supply. The left side of the box contains three 16-bit and three 8-bit expansion slots.

There are a few surprises inside, though. The 640K bytes of RAM are installed on a special memory card rather than on the motherboard. This small card is mounted vertically on its own expansion connector, just to the left of the disk drive enclosures. Also, the computer uses two separate disk drive controller expansion cards. The floppy disk drive controller is mounted in an 8-bit slot and has connections for two floppy disk drives and the DB-9 RS-232C serial and DB-25 parallel ports. The hard disk drive controller is mounted in a 16-bit slot and has connectors for two drives. Because the video adapter card occupies another of the 8-bit slots, the machine is left with only one 8-bit and two 16-bit slots available for further expansion.

My review computer came with an EGA card and EGA monitor. The half-length Epson Autoswitch EGA card appears to be almost identical to the Paradise Autoswitch EGA card. The monitor and adapter performed perfectly with CGA and EGA software such as Brief 2.0, WordPerfect 4.2, Borland's Quattro 1.0, and my kids' current favorite, Chuck Yeager's Advanced Flight Trainer 1.2.

One peeve I have about this computer is its keyboard. The keys felt loose and somewhat flimsy, and their action was light and uncertain; it did not inspire confidence when typing fast. It's a bothersome component of an otherwise fine computer.

Software and Documentation
The Equity II+ comes with MS-DOS 3.3, GWBASIC 3.20, and an easy-to-use setup and diagnostics disk. The manuals for the operating system and BASIC interpreter are in softcover binders and are quite complete. The Equity II+ user's guide makes setting up the computer straightforward even for novice users. Epson also includes a useful utility program from Storage Dimensions called SpeedStor, which allows you to partition your hard disk drive in a variety of ways, including into DOS partitions that exceed the normal 32-megabyte limit.

Bottom Line
The strengths of the Equity II+ are its convenient size and the fact that it is manufactured by one of the most reputable companies in the microcomputer game. The machine's performance would have been considered outstanding a year ago, but standards change quickly in this business, and a 10-MHz 80286 running with one wait state is a rather ordinary configuration these days. [Editor's note: *Epson has recently announced a new version of the Equity II+ with a clock speed*

of 12 MHz. The new version retains the same case design and sells for $2699 with a 40-megabyte hard disk drive.]

Another possible minus for the Equity II+ is its limited expandability because of the need for two separate disk controllers and for the installation of a memory-expansion card if you want more than 640K bytes of RAM.—*John Unger*

Leading Edge Model D2

Leading Edge is a familiar company in the battle for personal computer users' dollars. Its new Model D2 is a direct descendant of the still-available 8088-based Model D, which I reviewed in the September 1986 BYTE. Like its predecessor, the Model D2 is manufactured in Korea by Daewoo Telecom. With its 16-inch-square footprint, it even looks like the Model D, although it's a bit taller.

The Model D2 comes in three configurations, all with 640K bytes of RAM, a single 1.2-megabyte 5¼-inch floppy disk drive, a 12-inch high-resolution monochrome monitor, and a multimode EGA card. The basic model lists for $1495. You can get the same with a 30-megabyte hard disk drive for $1995, or with a 65-megabyte high-speed hard disk drive for $2495. The last is the one I tested.

Leading Edge sells no other accessories. If you want a color monitor, or if you want to expand the memory to 1 megabyte (on the motherboard), you'll have to fend for yourself.

The system uses 120-ns RAM and runs at either 10, 8, or 6 MHz, all with a single wait state. You switch the processor speed via the keyboard. There's a reset switch and keylock on the front, and single RS-232C and parallel ports are also standard issue.

Under the Hood

Inside, the Model D2 has a close-to-conventional-size motherboard (11 by 12 inches). The Daewoo folks opted to use most of the Chips & Technologies AT-compatible chip set, although for some reason they didn't use the C&T 82C206, preferring to incorporate their own direct memory access (DMA) controller, interrupt controller, timer, and real-time clock/calendar using discrete chips.

The Model D2 has four 16-bit and two 8-bit expansion slots. The hard disk drive controller takes up a 16-bit slot, and the EGA card takes an 8-bit slot. The floppy disk drive controller and the circuitry for single RS-232C serial and parallel ports are all included on the motherboard. There's space for two 5¼-inch floppy disk drives in the main drive bay, and if you opt for a hard disk drive, it gets mounted vertically to the right of the floppy disk drives—an efficient use of space.

High-Test Hard Disk Drive

The 65-megabyte Microscience HH-1060 hard disk drive that came with my high-end version of the system is a veritable speed demon. The Coretest showed an average seek time of 20.6 ms with a data transfer rate of 716.6K bytes per second. The 16-bit controller coupled with 1-to-1 interleave definitely does the job. If you're doing disk-intensive processing, there's absolutely no question that this is the hard disk system to use.

The Model D2 comes configured with 640K bytes of RAM, 512K bytes of

continued

which is permanently soldered into the motherboard; this can be a real pain if problems develop. Although there's room for the full standard megabyte of AT memory on the motherboard, the Model D2 has one slightly maddening idiosyncrasy: If you want to expand your 640K-byte system to 1 megabyte, you need to buy 512K bytes of RAM, not 384K bytes. The reason for this is that the 128K bytes of RAM from 512K to 640K is configured with 64K-byte chips. To expand the board to 1 megabyte, you need to remove the 64K-byte chips and replace them with 256K-byte chips. And you'll probably never have a use for those leftover 64K-byte chips.

The Model D2 comes with a pile of disks and a pile of manuals. There's MS-DOS 3.20, a diagnostics disk, a setup disk, and the Leading Edge Word Processor thrown in for good measure. The two MS-DOS manuals are full start-from-scratch rewrites of generic MS-DOS manuals. They're particularly effective at explaining some of the vagaries of the operating system. The Operator's Guide is also a joy; it was obviously written by someone sympathetic to the needs of both new users and the more experienced.

Thoughtful touches abound on the Model D2. There are long keyboard, power, and monitor cables, and even a depression on the keyboard for a pen or pencil. And in keeping with the increased reliability of today's hardware, it has a 20-month warranty.

The Model D2 is a prime example of today's high-quality plug-in-and-run systems: You can take it out of the box, plug it in, and be doing productive work in minutes. In addition, software compatibility just doesn't seem to be an issue anymore. The system's high-speed hard disk drive is a pleasure to use, especially with a disk-intensive application like Paradox. Last but not least, its low price makes it a real value.—*Stan Miastkowski*

PC's Limited System 200

The PC's Limited System 200, manufactured by Dell Computer, is an up-to-date, high-performance system. Except for its size and the general layout of its components, the System 200 bears little resemblance to the original IBM PC AT it purports to mimic. This computer can use virtually all the software and hardware designed for the original AT, but it does so with new and better components and much faster.

The CPU runs at a maximum clock rate of 12.5 MHz, more than twice as fast as the first ATs, and Dell makes good use of very-large-scale-integration (VLSI) components, including three Chips & Technologies chips, to keep the motherboard chip count down to a minimum. My review system came with a 1.2-megabyte 5¼-inch floppy disk drive, a 1.44-megabyte 3½-inch floppy disk drive, and a fast 40-megabyte hard disk drive—and it still had room for two more half-height storage units. It was also equipped with a VGA/EGA/CGA video card and monitor and a total of 1.6 megabytes of RAM. The total price for this configuration is $3599.

Internal Layout and Components

The physical layout of the major hardware components resembles that used in most full-size AT clones. The right rear corner is occupied by a hefty 200-watt power supply. In front of the power supply are two storage-device bays; the one on the right is set up to take three half-height devices, and the left-hand bay can be used by one full-height or two half-height hard disk drives. The bottom half-height bay on the right is suitable only for a hard disk drive, because you cannot access it from the front panel.

The System 200 has six expansion slots on the motherboard: four 16-bit and two 8-bit. The hard disk drive/floppy disk drive controller uses one of the 16-bit slots, and the video adapter uses an 8-bit slot. Two DB-9 RS-232C serial ports and one DB-25 parallel port are mounted on the motherboard; you don't have to use up an expansion slot for them.

The computer comes standard with 640K bytes of 120-ns DRAM mounted directly on the motherboard. My review unit had an additional 1 megabyte of DRAM installed in special single in-line memory module (SIMM) sockets, also located on the motherboard. Using SIMMs, you can install up to 4 megabytes of memory on the motherboard.

You can switch the 80286 CPU between 12.5 and 6.25 MHz with either a keystroke combination (Ctrl-Alt-Backslash) or a utility program. The expansion bus clock rate switches between 8 and 6.25 MHz when you toggle the CPU speed. The system's memory access uses one wait state independently of the clock speed. I had no trouble installing an 8-MHz 80287 math coprocessor on the motherboard.

Storage and Display

My System 200 had a versatile trio of data storage devices installed. The mainstay is a 40-megabyte hard disk drive with an average access time of 25 ms and a data transfer rate of 167K bytes per second, according to the Coretest. For convenience in running software and exchanging data, I had the choice of using either a 1.2-megabyte 5¼-inch floppy disk drive or a 1.44-megabyte 3½-inch floppy disk drive. This drive combination ensures easy compatibility with all MS-DOS systems, including laptops and the new PS/2 computers.

The System 200 also came with a Video Seven Vega VGA card and a Mitsubishi XC-1429C color monitor. This display system is VGA/EGA/CGA compatible and ran all my CGA and EGA software flawlessly. I don't have any commercial software that uses color graphics in VGA mode, so I wrote some simple graphics routines to show off the VGA's colors using Borland Turbo C version 1.5. The results were stunning.

Performance

When running my software on the System 200, I never got the feeling that I had to wait for the computer to catch up with me. (And I have built up quite an impatience quotient over the years.) The benchmark results back up my feelings about the machine's performance: It is near the top for 80286 machines. [Editor's note: *Dell Computer has recently announced the Model 220, a 20-MHz 80286 system with a 3½-inch floppy disk drive, 1 megabyte of RAM, and a 40-megabyte hard disk drive. It lists for $2499.*]

Dell Computer, the manufacturer of PC's Limited computers, deals strictly by mail order. Dell has a toll-free number for technical assistance, and its employees are fast and knowledgeable.

continued

However, if its technicians cannot solve your problem, you can take advantage of free, on-site service provided by Honeywell Bull if you live within 100 miles of one of that company's 180 customer-service dispatch offices. This service is free for one year and can be extended for four extra years with an additional fee.

The System 200 is an ideal choice if you need a full-size, high-performance AT-compatible microcomputer with a large capacity both for extra storage devices, such as disk drives and tape backup units, and for plug-in expansion boards. *—John Unger*

Side by Side

We were not surprised by the benchmark results. The fleetest CPU gets the gold medal; in this case, it is the Amdek System/286A with its 12.5-MHz 80286 with zero wait states.

All the computers had a respectable showing against an 8-MHz IBM PC AT. But when you get further into the benchmark results, the distinctions are less clear.

In the FPU test, the PC's Limited System 200 is the clear leader, leaving the Amdek behind. This is significant if you plan to do intensive number crunching.

A hard disk drive can be a bottleneck for any computer system, and in the Disk I/O tests, the Arche Rival 286 was betrayed by its slow Seagate ST225. All the other reviewed systems had respectable hard disk drive performance.

The lead again changed hands in the Video tests. The Arche Rival 286's EGA card put on a good performance.

The Applications benchmarks give real-world results that reflect how a computer would perform in your home or office. In all these tests, the Amdek System/286A was the leader, consistently outperforming its competition. Its nearest rival was the PC's Limited System 200. The Arche Rival 286, while excelling in the Word Processing tests, was again slowed by its hard disk drive in the disk-intensive Database tests.

In terms of performance, then, the stand-up winner in our benchmark tests was the Amdek System/286A. The only test where it stumbled was in the Video benchmarks, and that has more to do with the function of the graphics adapter card than with the whole computer.

You should, of course, select the system that excels in the categories you work with most. Also, be aware that the prices given here are list prices. Many systems, such as Epson's Equity II+, are sold by independent retailers and may be available at heavily discounted prices in your area. But given our benchmark results and list prices, a couple of clear choices emerge. Top performance goes to the Amdek System/286A, but at a cost of $4345. At $3600, a PC's Limited System 200 is close in performance and more fully equipped. And if top-notch performance is not essential, the Leading Edge Model D2 comes in at $2500, the bargain of this bunch. ■

John Unger is a geophysicist for the U.S. government and lives in Hamilton, Virginia. He writes graphics software and uses computers to study the earth's crust. He can be reached on BIX as "editors." Stan Miastkowski is a BYTE contributing editor, director of K+S Concepts (a documentation and consulting firm), and editor in chief of the "OS Report" newsletter. He can be reached on BIX as "stanm."

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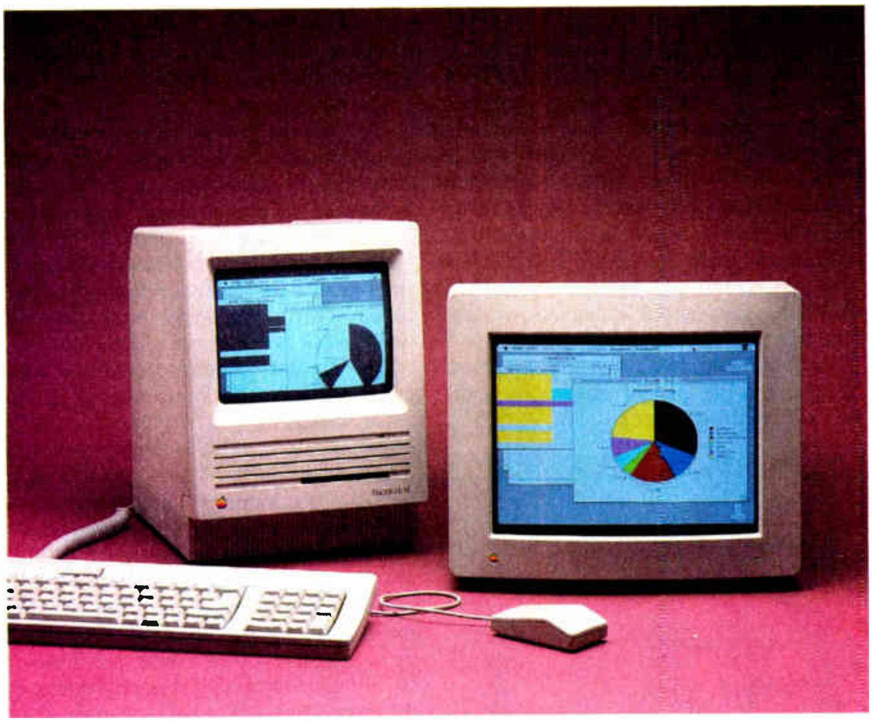
Seeing Colors on the Mac SE



Orchid's ColorVue SE board taps hidden color capabilities

Don Crabb

To the world at large, it's obvious that the Macintosh II supports color. Not so obvious is that both the Mac SE and the Mac Plus, even with their black-and-white displays, also support color. These Mac ROMs use conventional QuickDraw calls to handle eight basic colors: black, red, green, blue, white, cyan, magenta, and yellow.

This limited color capability allows the Mac SE to print in color on an Imagewriter II, Imagewriter LQ, Hewlett-Packard PaintJet, and other devices. But because the Mac SE lacks a way to display these eight colors, achieving good color output is a matter of trial and error. The demand for a way to view color on a Mac SE has grown because of the increasing sophistication of desktop presentation and publishing software and the need to review the output before committing the results to the printer.

Orchid Technology's ColorVue SE provides an add-on solution. The ColorVue SE is a $695 adapter card that lets the Mac SE display colors on an attached color monitor while still allowing use of the computer's built-in screen.

The ColorVue SE version 1.0 supports a 1024- by 512-pixel virtual screen, with a region of 640 by 480 pixels visible at a given time. The board supports horizontal panning to let you view the entire virtual screen in sections (if your software provides the necessary assistance—via a horizontal scroll bar, for example). The board can display as many as 16 colors or gray scales at a time (the ColorVue software supplies eight additional colors besides the eight that QuickDraw provides) from a palette of 262,144 possible RGB values. The board also supports 2- and 8-color (or gray-scale) modes.

The video output can drive either an Apple RGB analog monitor, such as the Mac II color monitor, or a VGA monitor, such as the IBM 8513 and 8514 color monitors. Many multiscan monitors, such as the Sony Multiscan and the NEC MultiSync, can also be used.

The Hardware of Color

The ColorVue SE is a standard-size SE daughterboard that plugs into the Mac SE's 96-pin Euro-DIN slot. The ColorVue board does not include an extra bus connector, so if you install it in your SE, you will not be able to install other add-on cards. The basic design fault is the Mac SE's, though, with its limited slot space. The SE that I used already had a SuperMac (Levco) Prodigy SE board installed, which I had to remove to test the ColorVue.

The ColorVue SE comes packaged in an antistatic bag and is well protected during shipment by closed-cell foam padding. The package includes a user's manual, a support software disk, two nylon standoffs to help anchor the board, a customer service booklet and warranty card,

continued

an output connector with two sockets for the color monitor connection, and ribbon cable to join the board to the output connector. A color monitor is not included.

The output connector includes both a large-format DB-15 Apple connector and a small-format DB-14 VGA-style connector. The user's manual provides a schematic of the pin-outs for each.

The board has a very clean design, with no engineering afterthoughts (see photo 1). It contains two proprietary Orchid ROMs (version 1.0), 2 megabytes of video RAM, a number of programmable-array-logic (PAL) chips, a couple of oscillators, a connector for the ribbon cable, and some unmarked custom chips. The ROMs are socketed, so the company can upgrade the board's firmware.

Installing the ColorVue board is quite easy. The instructions supplied in the user's manual are sufficiently detailed if you've had some installation and modification experience with Macs before. However, Orchid warns against novices attempting the installation; this advice is warranted because of the high voltage danger presented by the SE's CRT yoke and analog board.

Installation and initial testing of the ColorVue SE took a little longer than an hour from removal of the computer's outer shell to its replacement. You need a Phillips screwdriver, a small flat-blade screwdriver, a long-shafted T-15 Torx driver, and a case-cracker to complete the installation. Orchid does not supply these tools.

You can set the external display for 2, 8, or 16 colors.

After the board is installed, you attach the output connector to the board, using its ribbon cable, and then you mount the output connector in the SE's accessory access port; this process took another 10 minutes. The output connector is fastened by screws to the SE's chassis and fits through the access port after you have popped out its plastic cover. A small metal finishing bracket fits over the monitor connectors in the port, giving a nice finished appearance to the installation and offering further anchorage for the monitor connectors.

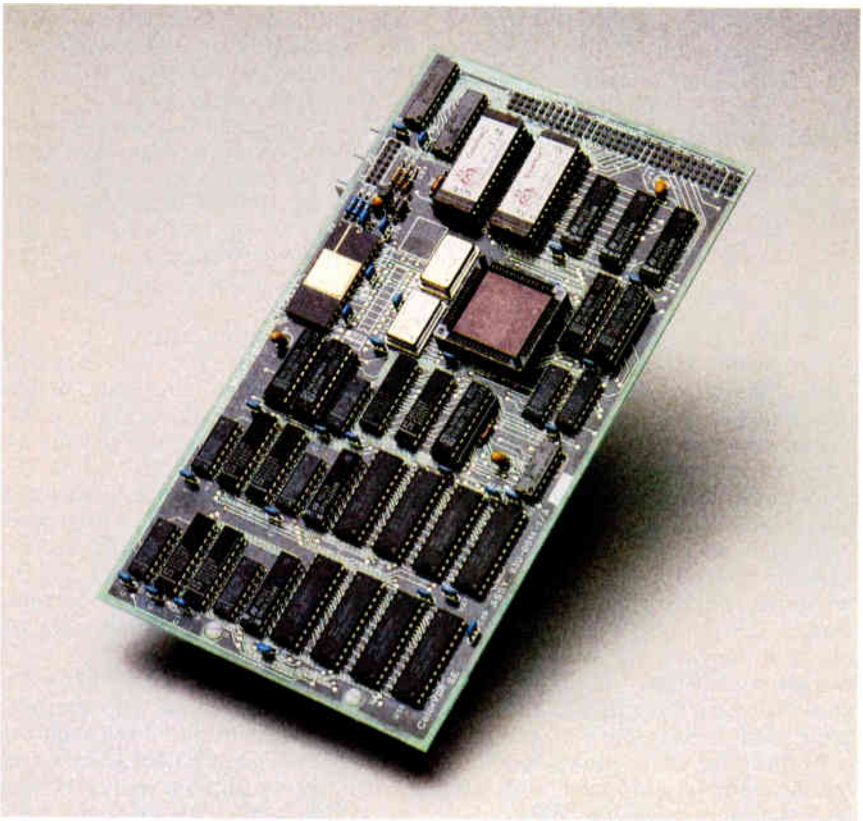


Photo 1: *The ColorVue SE add-on board, with 2 megabytes of video RAM.*

The Software of Color

The software assist for the ColorVue SE comes in the form of a Control Panel CDEV called ColorVue. To install the software, you simply drag the CDEV from the supplied disk to the system folder of your start-up disk. The CDEV lets you set a number of functions, including the number of display colors; a screen saver, which you can activate manually or time to dim the screen within 5 or 30 minutes of inactivity; and the monitor type you have connected (Apple or VGA, color or monochrome).

You can set display colors to 2, 8, 16, or automatic. The 2-color mode turns the external monitor into a monochrome screen. This improves screen performance for noncolor programs, because you're manipulating bits instead of pixels for the display. It also eliminates compatibility problems for software that won't work properly with ColorVue.

The 8-color mode displays the 8 standard colors used in printing on the Imagewriter II and Imagewriter LQ: black, red, green, blue, white, cyan, magenta, and yellow. When you switch to the 16-color mode, the ColorVue board adds 8 more colors to the available palette (dark gray, orange, olive, purple, light gray, gray, brown, and tan). At this writing, current applications don't utilize these extra colors, but Orchid Technology says that 19 programs modified to use this capability will be ready to ship by August. These include PageMaker, Adobe Illustrator, SuperPaint 2.0, MacDraw II, and dBASE Mac.

The recommended mode of operation is the automatic color mode. The automatic setting displays 16 colors if they are present; if no colors are visible, the software treats the screen as a black-and-white display. This improves video performance by using the faster 2-color mode to update the Mac SE desktop until you open an application using color.

Other screen attributes and functions are set with the ColorVue CDEV, including the ability to fine-tune your color choices on-screen to match your own tastes or to match those of your color printer (Imagewriter or PaintJet). The CDEV also lets you activate either or both of the internal and external monitors. If you use the internal monitor, it duplicates the top left (512- by 342-pixel) rectangle of the larger screen.

continued

ColorVue SE

Type
Color display board for the Macintosh SE

Company
Orchid Technology
45365 Northport Loop W
Fremont, CA 94538
(415) 683-0300

Features
640- by 480-pixel display in a virtual window of 1024 by 512 pixels; displays 16 colors out of a palette of 262,144; 2-, 8-, 16-, and auto-color modes; prints in color on the Apple Imagewriter II, Imagewriter LQ, and HP PaintJet color printers; automatic or manually triggered screen-saving feature; connector- and signal-compatible with the Mac II monochrome/color monitors or PS/2 series color/monochrome monitors; 2 megabytes of video RAM; Orchid ROM version 1.0; ColorVue SE CDEV

Size
4 9/16 × 8 7/16 inches; conforms to SE daughtercard form factor

Hardware Needed
Macintosh SE; Mac II monochrome/color monitor, VGA-compatible monitor, or multiscan monitor

Software Needed
None

Documentation
76-page ColorVue SE User's Manual

Price
$695

Inquiry 888.

The ColorVue SE's virtual screen is 1024 by 512 pixels, although you can view only 640 by 480 pixels at once. The documentation makes no mention of how to invoke, control, or use this capability, but I found through trial and error that the horizontal scroll bars on some applications let you move the viewable screen around in that virtual space.

I tested the ColorVue using an AppleColor 13-inch high-resolution RGB monitor (the Mac II color monitor); an IBM 8513 PS/2 VGA monitor; a Zenith 14-inch FTM VGA monitor; a Zenith 13-inch RGB monitor; an Apple 12-inch high-resolution monochrome monitor (the Mac II monochrome monitor); a Sony Multiscan color monitor; and an NEC MultiSync color monitor. The ColorVue drove each monitor successfully, although I had to adjust the sharpness and focus controls on the Zenith RGB monitor to get a clear picture.

The power connectors of many color monitors use a special power cord that connects them to the switched outlet on a computer chassis. This is true for the AppleColor monitor, which comes with a cord meant to be hooked to the Mac II. Fortunately, this same cable is detachable at the monitor so you can substitute a "generic" power cable. Bear this in mind if you use a different monitor with the ColorVue SE, since the Mac SE does not have a switched power outlet of its own.

A Few Compatibility Snags

I ran virtually every Macintosh application I had on the ColorVue SE–equipped Mac. Nongraphics software, such as word processors, did not have a problem with the ColorVue, since they don't support color anyway. One exception was dBASE Mac 1.01, which produces color on a Mac II. The dBASE database I used to test the ColorVue had color graphics and text in it. Neither color text nor graphics displayed properly with the ColorVue SE. Orchid Technology is aware of this problem and is currently working on a fix.

My software test list naturally included lots of graphics and desktop publishing applications, since presumably the biggest reason for buying the ColorVue board is for color graphics. Among the applications I tested were FullPaint 1.1, SuperPaint 1.0, MacPaint 1.4 and 2.0, Cricket Draw 1.0, Cricket Graph 1.1, MacProject 1.5, MacDraw 1.9.5 and 2.0, PowerPoint 1.0 and 2.0, Quark XPress, GraphicWorks 1.1, VideoWorks 1.0, VersaCAD 1.1, More 1.1c, MegaImages B6.c, ImageStudio 1.0, MaxWrite 0.80, MapMaker 1.0, Zoomation! 1.5, Color MacStar, PixelPaint 1.0, and Slide Show 1.0.

Of this list, only FullPaint, MaxWrite, and MacPaint would not run properly on the ColorVue in color mode, although they would work in 2-bit monochrome mode. Display problems ranged from menus with multiple ghosts, to invisible menu bars, to confused images. Color MacStar, MegaImages, PixelPaint, and Zoomation! would not work at all in either monochrome or color mode, and the computer required a hard reset to clear. Since these four programs were

continued

written for the Mac II, I expected this problem. The rest of the graphics software worked in monochrome mode on the external screen.

I printed color output using Cricket Draw, Cricket Graph, More, and other applications on an Imagewriter II, Imagewriter LQ, and HP PaintJet without a hitch; the pages had the colors that the screen displays led me to expect. I also printed color output on an HP 7475A flat-bed plotter, although the matchup between the displayed color on the screen and the plotted color on the paper usually did not match.

The most noticeable difference between the regular Mac SE screen and the color screen driven by the ColorVue (besides the color) was in screen-drawing performance. Cricket Draw, for example, took at least twice as long (and often much more for complex images) to redraw a color graphic on the ColorVue SE-driven screen, compared to the same image in monochrome on the internal screen of an unmodified Mac SE.

The same was true for other applications working in color (e.g., GraphicWorks, VersaCAD, and Cricket Graph). Of all the other applications I tested, More 1.1c showed the most slowdown when redisplaying an image with color text in it, compared to displaying on the internal monitor. Thus, the price of having color is some screen-drawing slowdown when you use the 8- or 16-color mode. However, you can always switch to monochrome to improve drawing speed, or you can use the automatic-color setting and let the ColorVue switch to monochrome when no color is present.

Skimpy Documentation

The user's manual supplied with the ColorVue board does a good job as an installation guide, but it is anemically thin on other issues. It doesn't mention anything about using the ColorVue SE with actual software. There is no list of compatible software, nor a discussion of which software vendors can be expected to provide ColorVue drivers with their products. The manual also fails to give any information about the card's 1024-by 512-pixel virtual screen and how you're supposed to move around in it (horizontal panning).

From an end user's point of view, Orchid needs to go back to its technical writers for about 40 more pages of software and usage discussion. An updated manual should also include complete technical specifications (such as a detailed board schematic and a discussion of the board's design) and should address other technical concerns. No on-line help is provided with the ColorVue CDEV.

Orchid is a proven accessory board manufacturer for the IBM PC. This is the company's first Apple-compatible product. I tested the customer-support phone lines by asking some questions about installation and software compatibility. The support technicians dealt with installation problems easily, but those I talked with knew much less about the ColorVue's software compatibility or about the availability of new software releases that would drive the ColorVue properly.

The ColorVue SE has a two-year hardware warranty that you can extend to four years at no extra charge by filling out and returning your warranty card.

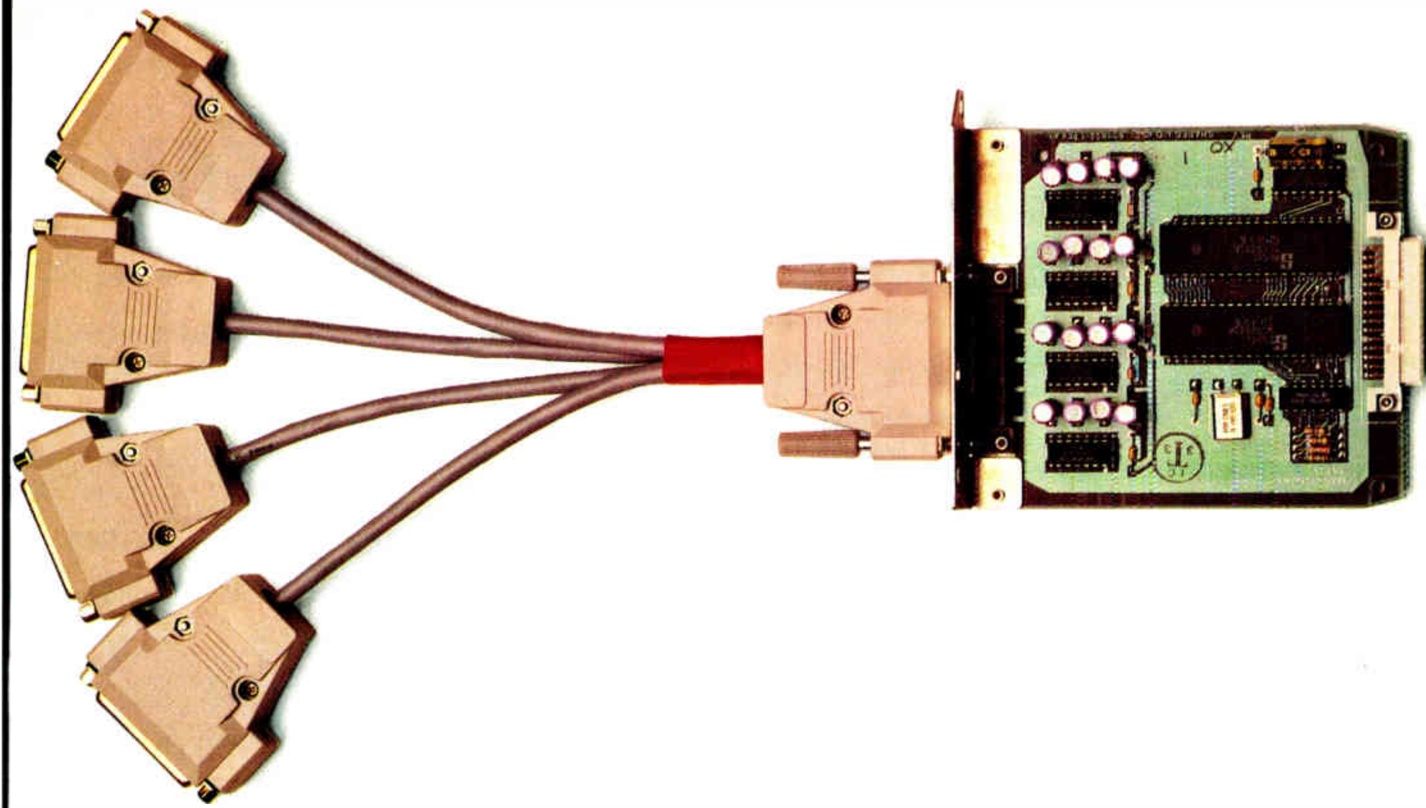
The Big Draw: Color Now

The question you have to answer before buying a ColorVue SE is: Do you really need a color Mac SE? And at what price? At $695, the ColorVue SE isn't cheap, but it's reasonable. However, you have to add the price of a color monitor to your shopping list when you go with SE color. This will add another $500 to $900 to the tab, depending on the monitor you buy. That puts the price of SE color at $1200 and up. Not cheap, but still much less expensive than scrapping (or selling) your Mac SE and buying a Mac II. Besides, you can opt to buy one of Apple's color monitors and then continue to use it when your budget permits you to buy a Mac II.

The main reason for buying the ColorVue SE is that it provides a usable color display for the Mac SE *now*. If you need color for your graphic design, CAD, or publishing work, and you don't want to replace your Mac SE, the ColorVue SE is a reasonable solution. Although the board's color display lacks the subtlety of the 256-color Mac II display, you'll be surprised just how appealing 8 or 16 colors can be. And if you need 16 gray scales for your desktop publishing work, the ColorVue SE does that job nicely, too. The cost of acquiring this capability won't bankrupt you, either.

Finally, the ColorVue SE doesn't tie your Mac SE to your desk. Any time you need to move your Mac or take it on the road, you can disconnect the color monitor cable and go. ■

Don Crabb is the director of instructional laboratories for the computer science department of the University of Chicago and is a lecturer in the department and the college. His articles and reviews have appeared in microcomputer magazines, newspapers, and journals. He can be reached on BIX as "decrabb."



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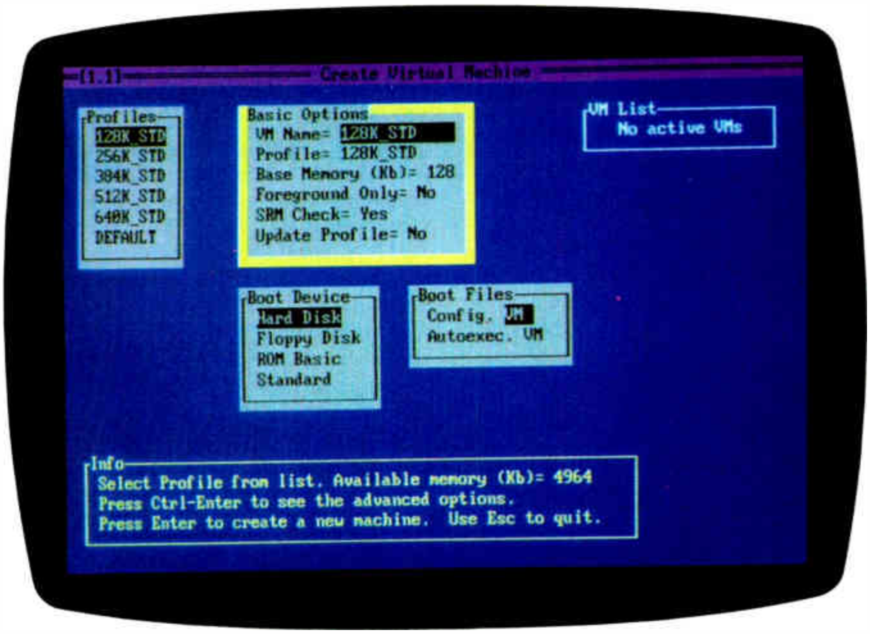
VM/386: A Virtual Solution



A multitasking program manager for 80386-based DOS machines

Namir Clement Shammas

VM/386 is a control program that lets you run DOS applications concurrently. It uses the virtual 8086 mode of the Intel 80386 CPU chip to create multiple 8086-based virtual machines. The amount of physical memory limits the number of virtual machines.

VM/386 1.1 ($245) from Intelligent Graphics Corp. requires an 80386-based computer with at least 2 megabytes of RAM. The system requires one high-density floppy disk drive, and the manual recommends that you use a hard disk drive. VM/386 supports monochrome display adapters and VGA, CGA, EGA, and Hercules-compatible graphics adapters. I used a Compaq Deskpro/20 with 5 megabytes of memory and a 40-megabyte hard disk drive running MS-DOS 3.3.

Multiple Virtual IBM PC XTs

The VM/386 control program takes up 640K bytes of memory, and lets you divide up the rest of the physical memory into virtual machines. It uses a preemptive multitasking scheduler to share the processor among the virtual machines. You can choose to have the System Resource Manager (SRM) adjust and optimize the scheduling of a virtual machine, or you can turn off the SRM and adjust these parameters yourself.

Each machine operates as though it were an independent IBM PC XT, with its own copies of DOS, AUTOEXEC and CONFIG files and memory-resident programs. These virtual machines are protected from each other; a software crash in one does not affect the others. In fact, you can even reboot an individual virtual machine with the Ctrl-Alt-Del key combination. To move among the virtual machines, you call up a switcher list by pressing SysReq (or Alt-SysReq if you have an enhanced keyboard). From this list, you can choose either to enter the virtual machine manager menu or to go to a virtual machine.

To use VM/386, you first boot up under DOS and then type VM/386, which is the name of a batch file that starts the Virtual Memory Manager (VMM). The VM/386 control program uses multiple text-based windows containing menus and help or status information. The VMM contains six main menus: Virtual Machine Control, Hardware Control, System Options, Status Display, Help Information, and Exit VM/386. All these menus except the last have submenus. It is important that you exit from VM/386 via the menu option so that VM/386 can close any files it has open.

Creating a virtual machine involves two screens, each with a set of options. The first contains basic options, while the second contains advanced ones. You can alter and fine-tune the default values, with the option of storing a new set of default values in a profile file.

The basic options for creating a virtual machine are assigning a virtual machine a name, a profile, and an amount of memory (128K to 640K bytes); as shown in the photo. You can also specify whether this virtual machine will run only while it is in the foreground and whether the SRM will adjust its time slice.

When you estimate the total amount of memory required, you must take into account that the video screen requires 16K bytes and 112K bytes in text and graphics modes, respectively. You can assign foreground-only mode to highly interactive applications that do not perform any task while in the background.

continued

VM/386 1.1

Type
Multitasking environment

Company
IGC
4800 Great America Pkwy.
Santa Clara, CA 95054
(408) 986-8373
(800) 458-9108

Format
One high-density 5¼-inch floppy disk

Language
Assembly

Hardware Needed
IBM AT with an Intel Inboard 386, Compaq Deskpro 386, IBM PS/2 Model 80, or 80386-based computer with at least 2 megabytes of RAM, one high-density floppy disk drive (hard disk drive recommended), monochrome display adapter, and VGA, CGA, EGA, or Hercules graphics adapter

Software Needed
DOS 3.0 or higher

Documentation
200-page user's manual

Price
$245

Inquiry 895.

The SRM is responsible for adjusting and optimizing the time slice of a virtual machine based on I/O activities. The more I/O a virtual machine performs, the more time slice the SRM will give it. You can turn off the SRM for a virtual machine that is running an important number-crunching application. Such applications tend not to perform many I/O operations and, with the SRM turned on, they are considered idle and are consequently allocated a smaller CPU time slice.

Other basic options for creating a virtual machine let you select the boot device and files. You can start a virtual machine from a hard disk drive, a floppy disk drive, and from ROM BASIC. The boot files are AUTOEXEC.BAT and CONFIG.SYS by default. You can specify other boot files such that the primary filenames are the same, but you have to designate the extension names. The AUTOEXEC.VM and CONFIG.VM filenames are suggested for alternate filenames. This enables you to customize the configuration during the virtual machine reboot.

Each virtual machine can have its own AUTOEXEC batch file to load RAM-resident utilities and related applications. VM/386 does not support DOS redirection and piping commands placed inside batch files. These commands work fine when issued at the DOS command level.

The advanced options for creating a virtual machine let you adjust parameters that relate to the performance, extended or expanded memory allocation, and hardware device drivers.

The performance parameters are probably the most interesting and most frequently adjusted. With these parameters, you can control the speed of virtual machines relative to each other. The parameters include the queue, priority, time slice, SRM burst, SRM swapout, realtimer switch setting, and the I/O privilege level.

The queue parameter designates the interrupt level for a virtual machine and ranges from 1 to 5, with a default of 4. The lower the queue number, the higher the priority of a virtual machine for handling external interrupts. The VMM, with a queue number of 0, has the highest interrupt level.

For virtual machines with the same queue number, you use a second parameter (called priority), which ranges from 0 to 255, to decide which machine has precedence. Low-priority values yield a higher precedence.

The third parameter is the time slice (in milliseconds) that defines the CPU time spent on each virtual machine. The time slice values range from 1 to 255, with a default of 6. The manual recommends that for optimum performance, the sum of the time slices of the virtual machines should be 60 ms.

VM/386 offers an additional level of sophistication in managing virtual machines. You can run a virtual machine for a specific number of seconds and then suspend it, either completely or for a fixed time span. The SRM burst parameter assigns the total CPU seconds before a virtual machine is suspended. The SRM swapout parameter defines the number of seconds before the suspended machine resumes running. A 0 value implies a permanent suspension.

Once a virtual machine profile is defined, you can create one or more virtual machines by pressing the Enter key after a final confirmation message. You then use the switcher to move among the virtual machines.

To automate the systematic creation of a set of virtual machines, VM/386 supports the creation of start-up files. These files create the preselected combination of virtual machines, but they do not load or launch their applications.

You terminate a virtual machine by selecting an option from the virtual machine manager menu. You should first close any applications that perform file I/O before you terminate them because the selected application is abandoned at once. Updating a virtual machine is another option that permits you to adjust some of its parameters (e.g., the time slice) while it is running. This lets you alter the real-time speed of execution for an application.

Hardware Constraints

VM/386 supports the use of two hard disk drives (connected to the same controller) and two monitors. VM/386 also supports hard disk partitions beyond 32 megabytes if you are using Compaq DOS 3.31. If you have an EGA that autoswitches to CGA mode, you must disable this feature.

You can specify that monitors and hard disk drives be used in either floating or exclusive modes. In exclusive mode, the designated device is tied solely to a specific virtual machine. You can employ exclusive video output to monitor a special application on a secondary monitor. In floating mode, several virtual machines can intermittently access different files located on the same hard disk. Also there is a RAM disk that virtual machines and a VGA can share.

You can also specify the allocation of extended or expanded memory to work with your applications. Using either genre of memory reduces the amount of memory available for virtual machines.

In creating a multitasking environment out of the single-tasking DOS environment, VM/386 must take steps to allocate resources, such as the printer and communications ports, to specific virtual machines. It does this from the device allocation menu by letting you assign these resources to specific virtual machines. The explicit device allocation prevents various applications from simultaneously printing, which could lead to an utterly confusing hard-copy printout. The application allocated to the communications port should have its virtual machine queue parameter set to 1 so it will have a high level of access to external interrupts. This enables the communications software to keep up with the pace of the transmitted characters.

The Status Display main menu permits you to monitor the status of the virtual

Table 1: *The time for the primary benchmark essentially increases proportionally with each additional background process.*

	Number of operating programs	Time (seconds)	Comparison to DOS performance (percent)
Compaq DOS 3.31	1	10.5	100
VM/386	1	10.5	100
	2	21.8	208
	3	32.8	312
	4	42.5	405
	8	81.7	778

Note: All processes are running at a time slice of 60 ms.

machines. The information is presented in tabular form indicating the queue number, the priority level, the time slice, the remaining time slice (for a running virtual machine), and the total number of unprocessed interrupts. You can also query the status of the total amount of storage: actual, expanded, extended, and virtual. VM/386 also enables you to peek at memory locations, presenting you with a debug-like memory dump.

Testing The Performance

To test the speed of the multitasking feature of VM/386, I wrote two Turbo Pascal 4.0 programs: BEN1.EXE and BEN2.EXE. BEN1.EXE contains the primary benchmark program that runs in the foreground; BEN2.EXE is the secondary benchmark program that runs in a background virtual machine. Both programs loop infinitely and use the Turbo Pascal function KeyPressed to exit.

The primary benchmark program performs integer calculations in a For loop, beeps, and then displays the time required to execute the For-Do loop. The secondary benchmark program performs the same calculations and displays the loop-control variable. Printing the loop-control variable in the secondary benchmark gives you a visual indication of whether or not a copy of the program is actually running. It also gives you a feel for how fast or slow a copy of the secondary benchmark is running.

To run the multitasking benchmark, I first saved the following settings in a 128K_STD profile file: I set the SRM to OFF, queue to 4, priority to 128, and time slice to 60 ms.

I then created a virtual machine using the modified 128K_STD profile and started a copy of BEN1.EXE in that virtual machine and measured the time between beeps.

Once I had the time for BEN1.EXE running alone, I then added copies of the secondary benchmarks to a virtual machine that runs in the background and measured how much subsequent copies of BEN2.EXE slow down BEN1.EXE. I used the switcher to load copies of BEN2.EXE in a virtual machine and then to switch BEN1.EXE back into the foreground. Table 1 shows the effect adding subsequent background virtual machines has on executing BEN1.EXE.

I also tested the effect of running the primary benchmark in a 512K-byte virtual machine with a 60-ms time slice, while four copies of the secondary benchmark ran in four 128K-byte machines with a 15-ms time slice. The results show that the timing of the primary benchmark was 31.2 seconds, instead of the estimated 21 seconds (10.5 seconds × (4 × 15 + 60) /60). The difference between these two timings can most likely be attributed to the extra size of the virtual machine running the primary benchmark.

The second benchmark program, DSKBEN1.EXE, examines the ability of VM/386 to support multiple virtual machines that appear to simultaneously or intermittently access different files on the same hard disk. The program repeatedly reads the same text file. It displays the time that each loop iteration takes to read a text file.

The name of the text file read by each running copy of DSKBEN1.EXE is supplied on the argument list. I prepared three 128K-byte text files to be read by three copies of the benchmarks running concurrently. I used the 128K-byte profiles with the SRM setting turned on. Up to three copies of the benchmark programs were run in three different virtual machines. The process used to bring out

continued

Table 2: *The disk benchmark program,* DSKBEN1.EXE, *shows that VM/386 allows several applications in virtual machines to access different files on the same hard disk.*

Total number of programs	Time (seconds)
1	4.1
2	7.5
3	11.6

Note: All processes are running at a time slice of 60 ms.

each virtual machine is basically the same as the one described for the first benchmark program.

Table 2 shows the results that confirm the ability of VM/386 to allow the intermittent access of different files in the same drive. Each of the benchmark copies ran at about the same speed shown in the table. The timings fluctuated more than in the first benchmark. I also investigated the same feature in Microsoft Windows/386 and discovered that it doesn't support the intermittent file I/O.

Short-Term Solution

VM/386 1.1 is an interim solution to the DOS single-tasking bottleneck that OS/2 is designed to address. VM/386 is like a heart bypass for the current DOS 3.x application base: It gives more life and flexibility to these applications by letting you run two or more of them simultaneously. It also provides you with excellent control for adjusting the performance and operation of each virtual machine and requires practically no effort to learn or use.

VM/386 and Windows/386 are two very similar products (see my review "Microsoft Windows 2.03 and Windows/386," May BYTE). They both let you run DOS 3.x applications in 640K bytes of memory. The main differences are that VM/386 does not allow two or more virtual machines to share the same display. With Windows/386, you can run different applications within the windows on the screen. With VM/386, you have to use the switcher to move from one virtual machine to another, but it does give you control over the multitasking scheduler, whereas, in Windows/386, you don't have the options of adjusting parameters for the scheduler.

Both VM/386 and Windows/386 are very different from OS/2. Where VM/386 and Windows/386 let you run the current base of DOS 3.x applications concurrently, OS/2 provides only the ability to run one single DOS 2.x application. Most DOS applications must be substantially redesigned to run under the protected mode in OS/2. However, the OS/2 environment removes a lot of constraints that limit DOS applications. Unfortunately, there aren't many OS/2 applications around. In the meantime, VM/386 offers an interim solution while we're waiting for OS/2 applications to appear.

Editor's note: *The source code listing for the programs* BEN1.PAS, BEN2.PAS, *and* DSKBEN1.PAS *is available in a variety of formats. See page 3 for further details.* ■

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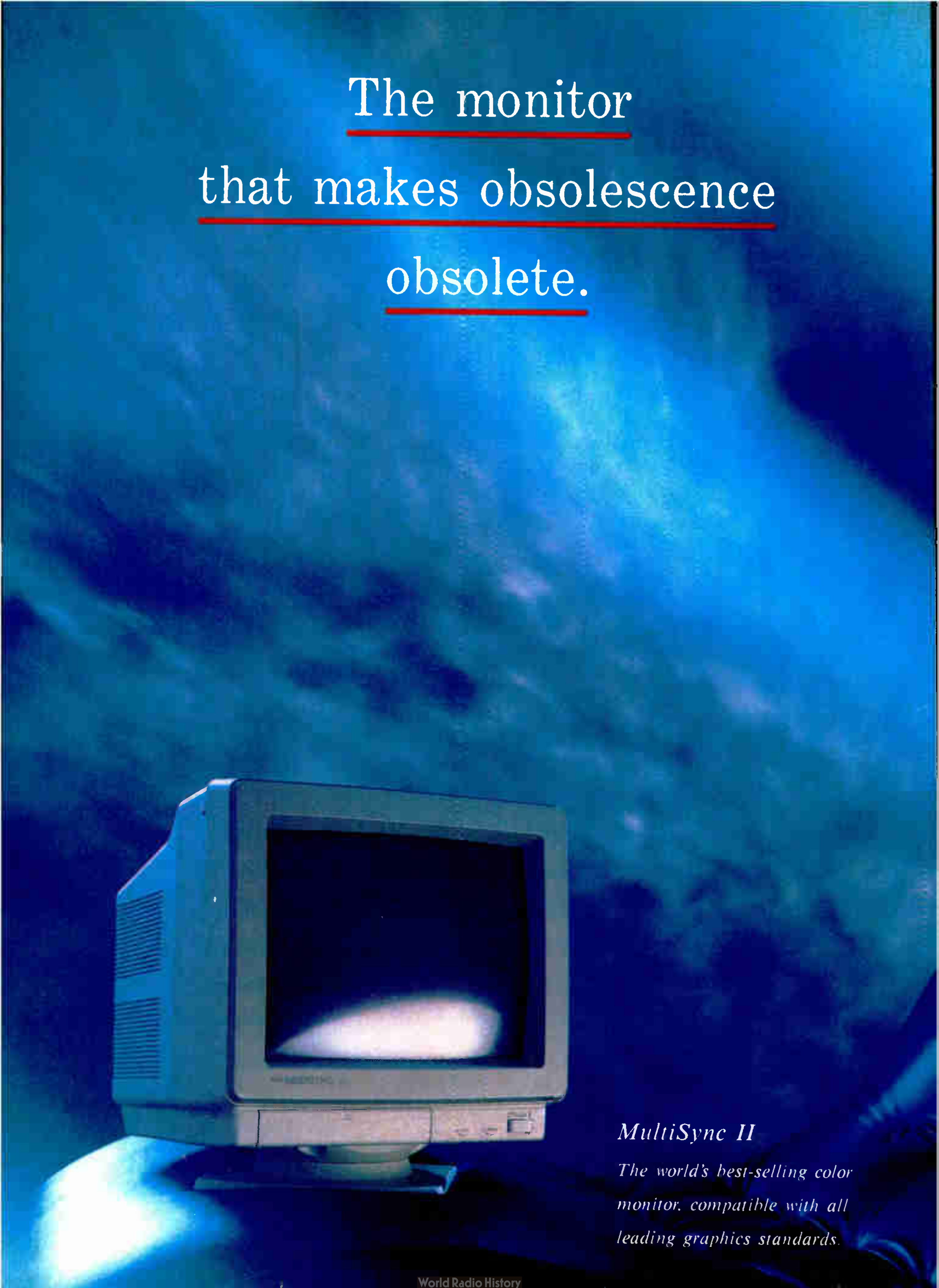
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Concurrent DOS 386

A multitasking operating system that also supports additional terminals

Alex Lane

Some people have been quick to sum up the state of 80386-based computers: All revved up with no place to go. They're referring to the inability of MS-DOS (and PC-DOS) to fully exploit the multitasking aspects of the 80386. Concurrent DOS 386 from Digital Research, Inc. (DRI) is one multitasking alternative to MS-DOS for the Compaq Deskpro 386 and compatibles with as little as 512K bytes of RAM.

The basic Concurrent DOS 386 package ($395) is capable of multiuser operation, supporting two RS-232C serial terminals in addition to the main console. The console can run up to four tasks concurrently in separate screens, while the serial terminals can run up to two virtual tasks each. DRI also markets a version of Concurrent DOS 386 that supports up to nine serial terminals; it sells for $495.

I tested Concurrent DOS 386 version 2.0 on an ARC 386i microcomputer with an Award BIOS (version 2.09), but it also runs on systems with the Phoenix BIOS.

Concurrent DOS 386 comes on two 5¼-inch high-density floppy disks and two 3½-inch 720K-byte floppy disks. The accompanying documentation consists of four books that include information applicable to both Concurrent DOS 386 and Concurrent DOS XM—a DRI product for PC XTs and ATs.

Automatic Setup

Installing Concurrent DOS 386 is painless. You just boot your system with the appropriate Concurrent DOS 386 disk in drive A and then press F10. Once you indicate which drive the software is to be installed on, the installation routine creates a subdirectory on that drive, copies the appropriate files from the distribution disks, and installs the system files in the drive's root directory. Once transferred to a hard disk drive, the files occupy about 1.5 megabytes of storage.

During installation, the AUTOEXEC.BAT file is modified so that each time you boot the system, it asks you whether Concurrent DOS 386 should be loaded in place of DOS. This ability of Concurrent DOS 386 to coexist with DOS on the same drive is a big plus.

Once the software is installed, you must run the Setup program to configure the system for a multiport expansion card, or to connect printers and serial devices such as modems and terminals.

Device drivers are loaded and system parameters are set using the information contained in the Concurrent DOS 386 file CCONFIG.SYS (analogous to the DOS file CONFIG.SYS). Some of the parameters, such as BUFFERS and FILES, will be familiar to DOS users.

Concurrent DOS 386 would not initialize my hard disk device driver, which, when installed under DOS, allows a 20-megabyte partition of my 40-megabyte hard disk drive to be addressed as drive D. In effect, Concurrent DOS 386 recognized only half my hard disk drive. Although this problem is not hard to solve, it does involve a time-consuming reformat. There is no 32-megabyte limit to the size of a partition if Concurrent DOS 386 becomes the only operating system installed on a hard disk drive. The maximum hard disk drive partition that is allowed under Concurrent DOS 386 is 512 megabytes.

According to DRI, you should be able to install and run Concurrent DOS 386 with a minimum of 512K bytes of memory installed, although, admittedly, there'll be little you can do with such a

continued

Concurrent DOS 386 version 2.0

Type
Multitasking operating system

Company
Digital Research, Inc.
60 Garden Court
P.O. Box DRI
Monterey, CA 93942
(408) 646-6464

Format
Two high-density 5¼-inch floppy disks; two 720K-byte 3½-inch floppy disks

Language
Assembly and C

Hardware Needed
Compaq Deskpro 386 or 100 percent compatible with a hard disk drive and 512K bytes of RAM; the 10-user system requires a multiport card

Documentation
35-page Installation Guide; 170-page User's Guide; 150-page Reference Guide; 26-page Applications Guide

Price
3-user license: $395
10-user license: $495

Inquiry 893.

small system other than run a very small application. With a bare 512K bytes of memory, I was unable to install Concurrent DOS 386 on my machine.

The first paragraph of the memory configuration section in the Installation Guide tells you to disregard the rest of the section if you're installing Concurrent DOS 386—a note you may miss (as I did). The rest of the information is for Concurrent DOS XM users, who must use Expanded Memory Specification (EMS) or enhanced EMS (EEMS) with their system. I admit to fiddling a lot with the settings on my memory board, with varying degrees of success, before going back and rereading the chapter from the first word. Even so, it finally took a call to a DRI technical-support representative to convince me that I didn't need to do anything special about memory configuration.

Multitasking and MS-DOS Compatibility

Concurrent DOS 386 performs multitasking using the time-slice technique. Basically, this means that each of the programs residing simultaneously in memory is given 1/60 second to run, after which control is passed to the next program. In an 80386 environment, this constant switching occurs so quickly that programs appear to run simultaneously.

Without having verified every permutation of every DOS command, I found Concurrent DOS 386 to be substantially compatible with DOS. However, it was missing several commands found in the MS-DOS 3.2 that was supplied with my ARC. Among the missing are `CTTY`, `EXE2BIN`, `JOIN`, `SHARE`, `GRAFTABL`, and `GRAPHICS`. On the other hand, there are over 30 commands that are unique to Concurrent DOS 386, including commands for password maintenance, programming function keys, and rebooting the system. A separate command processor shell, `DOS.COM` (analogous to the DOS `COMMAND.COM`), is provided to act as a buffer between troublesome programs, such as SideKick and other terminate-and-stay resident programs, and Concurrent DOS 386.

Concurrent DOS 386 offers several keyboard enhancements, including the ability to program up to 50 function keys using the `FUNCTION` command. In addition, Concurrent DOS 386 maintains a history buffer of commands entered at the system prompt, which you can recall by using the up and down arrow keys and edit by using a set of WordStar-like commands.

Perhaps one of the most titillating features of Concurrent DOS 386 is the ability to run up to 255 processes simultaneously. To the novice, this may sound like being able to run 255 programs at once. However, by "process" DRI means a specific operating system construct (e.g., one that maintains a text buffer or keeps system time). For example, each virtual terminal has two processes associated with it: a flush process that maintains a DOS video buffer (thereby allowing the terminal to perform pokes into a virtual video RAM), and a command shell process that runs the basic user interface.

About the only concession to systems programming in Concurrent DOS 386 is the inclusion of `SID86.CMD`, a symbolic debugger with roots going back to 8-bit CP/M days. It was included solely to allow the user to incorporate patches that are anticipated as minor bugs in the software surface over time.

Concurrent DOS 386 reads disks formatted under DOS, as well as under other DRI operating systems for the PC architecture (e.g., CP/M-86, Concurrent CP/M-86, and Concurrent DOS 4.1 to 5.2). Concurrent DOS 386 also executes DOS `.EXE` and `.COM` programs, although they cannot take advantage of undocumented DOS functions (Microsoft's Word 4.0, for example, is not executable under Concurrent DOS, although Word 3.1 will run).

Other features that are familiar to DOS users include redirection of I/O using the <, >, and >> symbols, and the use of ? and * characters as wild cards in filename descriptions. One wrinkle that's not found in DOS is the executable `.CMD` file, which is a contribution from previous DRI products. Another unique feature is the ability to control file access in Concurrent DOS 386 by using password-protected file attributes that can make a file a system file (invisible to the casual user) or a read-only file, or both.

If you've ever used any of DRI's earlier concurrent systems, such as Concurrent CP/M-86 or Concurrent DOS XM, the look and feel of Concurrent DOS 386 will be no surprise to you. Most system utilities like Dskmaint (for disk maintenance) and Setup (for system setup) have a function-key menu interface that involves a minimum of typing. The utility Editmenu lets you build on this interface; you can create, change, copy, or delete a menu, and use special effects such as reverse video and blinking in menu displays. Another menu utility, Runmenu, runs the menu files that you created with Editmenu, while the Copymenu utility lets you copy menu files for editing or backup purposes.

Other Concurrent DOS Applications

The Concurrent DOS package includes several other programs that can be considered applications in themselves: File Manager, Printer Manager, DR EDIX, and Cardfile.

The File Manager is a useful utility program that executes most common commands, which you can select from a menu. The main menu of File Manager consists of three parts: a command panel, which lists important Concurrent DOS 386 commands ranging from obtaining a simple directory to setting up the system; an object panel, which typically offers a list of files, directories, or drives for selection; and a prompt panel, which describes the currently selected command. You can select commands by pressing the up and down arrow keys until the desired command is highlighted, by typing enough of a command to uniquely identify it, or by pressing F10 and entering a complete command from the keyboard.

The Printer Manager is a Concurrent DOS 386 program that allows one or sev-

continued

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eral printers to print multiple files (up to 254). You can run the program either from the command line or from a set of conventional DRI function-key menus. Files that are sent to print are each assigned a job number and placed in a queue for processing. The job number can subsequently be used to remove the file from the queue, and the job queue itself can be suspended or erased by the Printer Manager. If you wish, you can specify a variety of options, such as number of copies, format, margin, and tab length, when you send a file to the printer.

DR EDIX is the editor supplied with Concurrent DOS 386. It is a general-purpose WYSIWYG editor that permits up to four files to be worked on at one time, although you can view only two in the program's two screen windows. An online tutorial is provided, as well as four help screens. It amused me to read in the user's guide the suggestion that DR EDIX is equivalent to DOS's EDLIN facility. While DR EDIX is a basic editor, it is a sleek Maserati compared to EDLIN's staid Model T.

The Cardfile program that comes with Concurrent DOS 386 is a name and address filer that lets you maintain a set of electronic index cards that hold all the usual information about business associates. I was unimpressed with this program because of its limited field size (the business name is limited to 20 characters and the address to 24 characters) and its maddening interface. Specifically, the cursor automatically advances to the next field once the current field is full, and (short of applying grease pencil to your monitor) there is no way to tell how close to the end of the business or address field you are. If you overstep, you must endlessly tap cursor keys to get to where you can make the previous field fit; the Home and End keys are ineffectual.

Using Concurrent DOS 386

For the most part, Concurrent DOS 386 acts the way a proper operating system should and stays out of sight to let you run your applications. Out of the box and freshly installed, the package let me run Word 3.1 in one window, Micro Logic's Tornado Notes 1.8 in another, DRI's File Manager in a third, and Microsoft's Multiplan 1.06 in a fourth. Although there was a perceptible slowdown in Word's performance, it was acceptable. Other programs that ran successfully under Concurrent DOS 386 included Turbo Pascal 4.0, Turbo Prolog 1.1, Framework 1.1, SideKick 1.56A (in conjunction with `DOS.COM`), and Command Plus.

The Wmenu utility lets you determine the shape, placement, and colors used in each of the four windows available on the console. Another useful utility is Stop, which you can invoke to specifically stop a particular program in a specified window, or to show general system statistics regarding what programs are running and how much of which type of memory remains free.

As I became more comfortable with Concurrent DOS 386, I discovered a number of commands that can optimize program performance, such as `MEMSIZE`, `LIMSIZE`, `BANK`, and `SUSPEND`. You can use `MEMSIZE` to restrict the amount of memory allocated to executable files (DOS `.EXE` or `.COM` or Concurrent DOS 386 `.CMD` files). `LIMSIZE` restricts the amount of LIM (Lotus/Intel/Microsoft) expanded memory allocated to a program. The `BANK` command controls how a program executes in banked memory.

continued

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Benchmark Results: *A single task took about the same time under Concurrent DOS 386 as it did under MS-DOS.*

	Number of operating programs	Time (seconds)	Comparison to DOS performance (percent)
ALR MS-DOS 3.3	1	32	100
Concurrent DOS 386	1	32	100
	2	72	44
	3	109	29
	4	144	22

Note: SUSPEND was set to OFF in all windows.

If BANK is ON, then the program can be paged in and out of memory; otherwise, the memory taken by the program is no longer available for paging. The SUSPEND command is used either to cause a program that's in the background to execute or to prevent it from doing so. Typically, any program that spends a lot of time waiting for user input should have SUSPEND=ON set before being invoked.

So as not to continually have to issue these commands, there is the Pifed utility that lets you create or modify Concurrent program information embedded in .EXE and .COM files. Concurrent DOS 386 uses this information to allocate the proper amount of memory for a program, to prevent corruption of interrupt vectors, and to keep other processes from accessing devices that are being directly manipulated. My only complaint about this whole gamut of commands and programs is that it requires some time to become familiar with them.

Comparable Performance

With the minimum 512K bytes of memory in your system, it's not much of an exaggeration to say that about all you can do is sit and admire the system prompt. Unlike DOS, which is relatively small, Concurrent DOS 386 takes up about 200K bytes of the address space available to the typical DOS task. Consider that memory above 640K bytes is pretty much off limits to DOS applications, which leaves about 440K bytes per application running under Concurrent DOS 386. You can adjust this figure somewhat by invoking the Setup utility and enabling 16K-byte chunks of high memory past the 640K-byte address for Concurrent DOS 386 buffers and so forth. However, making these adjustments requires a good working knowledge of what's going on inside your 80386 system, and the added available memory may not be worth the effort. Taking the figure of 440K bytes as a rough measure, 1 megabyte of memory installed in addition to the 640K bytes of base memory gives Concurrent DOS 386 the ability to handle three full-size tasks like Word or Multiplan.

continued

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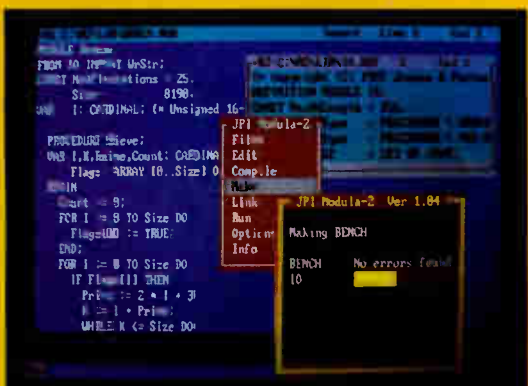

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The BYTE Lab ran the benchmark tests on an ALR FlexCache 386. It was equipped with 2 megabytes of RAM and Phoenix BIOS version 1.00 04.

Concurrent DOS offers multiuser support while Windows/386 does not.

The benchmark program that the lab used to test the speed of Concurrent DOS 386 was the same one used to test Windows/386 (see "Microsoft Windows 2.03 and Windows/386" by Namir Clement Shammas in the May BYTE). This test runs a program that performs integer arithmetic in a FOR-DO loop in each window. The results of running the primary program are shown in the table on page 168. Generally, Concurrent DOS 386 ran a single task in about the same time as did MS-DOS. However, the execution speed of a program under Concurrent DOS 386 is roughly inversely proportional to the number of tasks being executed.

Based on the compute-intensive benchmark tests, Concurrent DOS 386 fared well compared to MS-DOS. In fact, the overhead for running BYTE's benchmark tasks, again compared to MS-DOS, is less than that for Microsoft Windows/386, although as the number of programs increases, Concurrent DOS 386's comparative performance deteriorates. Also, Concurrent DOS 386 proved to be as much as nearly twice as fast as MS-DOS when handling video I/O, and it provides multiuser support while Windows/386 does not.

Much hoopla has been directed up the road, where bigger and better operating systems for the 80386 are expected to roll some time in the future. Concurrent DOS 386 is a multitasking *and* multiuser operating system that is here today and ready to go. And even though it's not the only choice for multitasking alone, the fact that it is a complete operating system may make Concurrent DOS 386 the best choice. ■

Alex Lane is a knowledge engineer with Technology Applications, Inc., in Jacksonville, Florida. He can be reached on BIX as "a.lane."

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ProBas 2.0 is a $99 collection of over 200 subroutines callable from BASCOM or QuickBASIC programs. Many of the subroutines enable you to tap into the hardware and operating system in ways not afforded by the BASIC language itself; others provide enhanced or speeded-up versions of built-in BASIC routines.

The programs are, for the most part, coded in assembly language and compiled to `.OBJ` format according to Microsoft conventions for library files. You can integrate them into your programs at link time (when using BASCOM or the compiler of QuickBASIC). ProBas 2.0 works with all BASCOM versions and QuickBASIC 1.0 to 4.0.

Considering the advances made in QuickBASIC 4.0, in particular, the ProBas routines are remarkably compatible with the various levels of compilers from Microsoft. The only areas where you have to use caution are with arrays and communications.

In QuickBASIC 4.0, so-called static arrays are, in fact, dynamic internally: Their location in memory can change during execution of a program. This necessitates a little caution; you may as well declare all arrays dynamic if you intend to pass arrays to external routines such as those from ProBas. A known bug in 4.0 causes QuickBASIC to write zeros to the communications ports during certain initialization conditions such as exiting to the shell; this can lead to problems when you use the communications libraries. However, in both cases (communications and arrays), ProBas documentation provides the needed workarounds.

A Taste of ProBas

Table 1 lists all the ProBas library routines, arranged by category and alphabetized within categories. Space limitations preclude me from explaining every one, but the library name typically provides a clear indication of the routine's purpose.

Among the most useful routines are those that assist you in setting or querying your hardware and operating system. Thus, you can detect the amount of base, expanded, and extended memory; query the computer and processor/coprocessor types (80x86/80x87); obtain disk space information; query the video display type; and request information about communication status and parameters.

Memory management routines include sorting indexed and unindexed arrays, string to integer-array copy and its inverse, and storing and recalling arrays in expanded memory. ProBas provides two routes to accomplish the latter function. The first family of routines allocates space in the expanded memory area, writes and reads array elements, and deallocates the memory area. To store or recall an element from expanded memory, you employ a Call subroutine and use a memory handle and an array-like index. The second family of routines resembles file I/O routines and transfers data between the expanded memory and entire arrays.

ProBas offers a collection of routines that quickly save, recall, and swap screens. The routines are very flexible. First, you are able to save and recall entire or partial screens to arrays (ideal for creating windowing applications). ProBas permits you to specify the video page number saved, so you are not tied to the visible page number 0 in a CGA or EGA monitor. The second feature is the ability to handle resizable virtual screens (areas of user RAM that operate like the video memory but are under your own control)—this is also good for windowing applications. In addition, ProBas provides a special version of the screen recall/store routines that can handle screens of any dimension. The third feature is the ability to store and recall a text screen in graphics mode using an array to store the screen image. The ProBas routines handle only text screens.

Putting some speed into screen output requires the ability to write directly to the video display. The BASCOM and QuickBASIC compilers still use calls to the BIOS in compiling `print` and `print using` statements. ProBas provides two sets of direct-to-memory screen output routines: one for any video page and the other for the virtual screen. The `xqprint` routine replaces `print` with the ability to put strings on the screen. The arguments of this subroutine include the cursor location, video page number, display attribute (to control the foreground and background colors), and screen mode. A variation of `xqprint` exists to display a string at a specified screen location using the existing display attributes. Other versions of `xqprint` permit you to write to medium- and high-resolution screens. In addition to writing in text mode, ProBas provides routines to write characters to graphics screens (e.g., large characters used to create eye-catching titles).

A third collection of screen-related subroutines offer support for windows. ProBas offers a couple of routines that let you create windows in which you can place, insert, and delete text in them. You can create windows with titles, exploding effects, and optional shadows. The demonstration program quickly displays 300 colored windows.

For the applications that need to query the files in a directory, ProBas offers a family of related routines. They enable you to obtain the names of the files that match wild cards and specific file attributes. ProBas uses the DOS calls to find

continued

Table 1: *Routines included in ProBas, listed alphabetically by category.*

Category	Routines
Communication	setcomm
Data Conversion	any2dec, date2int, daten2s, dates2n, dec2any, doub2long, int2date, int2time, long2doub, time2int, timen2s, times2n
Disk	copyfile, delfile, delsub, dfread, dfwrite, diskstat, drvspace, drvspacel, exist, fclose, fcreate, fgetloc, findfirstf, findnextf, fopen, fread, fsetend, fsetloc, fsetofs, fsetrec, fsize, fwrite, getattrf, getdatef, getdrv, getfattr, getfdate, getftime, getnamef, getsizef, getsizefl, getsub, getswitch, gettimef, getverify, gload, makesub, rename, setdrv, setfattr, setftd, setsub, setverify, sfread, sfwrite, subexist, writebitf
Equipment	equipment, getddos, getdosv, getextm, gettview, numproc, pctype, processor
Expanded Memory	emsclose, emsget, emsopen, emsput, getlimm, getlimv, lclose, lget, lopen, lput
Input	checkkey, clrkbd, getkbd, getkey, setkbd, sinput, sinputset
Keyboard	dosinkey, getvalidkey, keypress
Miscellaneous	addmati, blockmove, breakoff, carrier, checksum, crc, crc2, dataseg, ddostasks, delay, delay18th, dgetrec, dputrec, dtr, dynptr, prtcheck, prtswap, readbitf, reverseptr, seterror, setmati, shiftl, shiftll, shiftr, shiftrl, speaker
Mouse	getmouseloc, mmbutton, mmcheck, mmclick, mmcursoroff, mmcursoron, mmgetloc, mmsetloc, mmsetrange, setmouseloc, setmouserange
Sort	dsort, dsortb, iptrsort, lptrsort, sptrsort
String	bickel, bsq, busq, busqlen, cipher, cipherp, crunch, elapsed, extract, locase, lrotate, multiand, multior, multixor, numformat, parsefspec, replace, reverse, rrotate, soundex, ssrch, strip, stripblanks, stripchar, striprange, tinstr, upcase, xlate
Time	gettime, month, weekday
Video	bigprint, bkscroll, bkspace, blink, calcattr, calcsize, clrcols, clreol, clreop, clrsol, clrsop, dbigprint, dclear, dclearss, delchr, delline, dgetscreen, dgetscreens, dgqprint, dgxqprint, dissolve, dmprint, dputscreen, dputscreens, dwindowmanager, dxqprint, fadeout, getcrt, getega, getline, getrows, getscreen, getvidmode, gqprint, grafprint, grafrest, grafsave, gxqprint, inschr, insline, lscroll, mdelchr, minschr, mprint, mwindow, printscreen, putscreen, qprint, recolor, recolorarea, resetpoint, rscroll, scr2file, scr2filess, scroll, scrrest, scrsave, scrunch, setpixel, setpoint, setrows, testpixel, testpoint, unscrunch, vgetscreen, vgetscreens, vputscreen, vputscreens, windowmanager, xmprint, xqprint

the first and next matching files. Other routines enable you to obtain the file size, the time and date stamps, and the attribute. These ProBas routines are a welcome addition to a BASIC programmer's toolbox.

In the category of subroutines that provide improved versions of predefined BASIC routines are the ProBas file I/O routines. While these routines pass information via integer-typed arrays, they offer a form of file I/O that is available in C and Pascal. This includes the ability to read a specified number of bytes; query and set the file pointer; and directly handle file I/O errors by returning numeric error codes.

In the area of console input, the ProBas library offers routines that enhance user input. The highlight of this set of routines is one that provides a one-line editor with Microsoft and WordStar editing commands. Another routine waits until you enter a single character from a list of valid characters. This is appropriate for menus, letting you select options with a single keystroke.

Another interesting set of subroutines provides support for mouse input devices. They enable an application to check the status of the mouse buttons, to count the number of times you click the mouse buttons, to set and query the mouse cursor, and to define the valid window area for the cursor. These routines empower you to write highly interactive applications.

Error-handling of the subroutines appears to be quite robust. For instance, I experienced a program crash while using one of the expanded-memory library routines—apparently due to my use of a nonstandard extended memory driver. Upon crashing, ProBas didn't hang the system. Instead, it presented me with an error message and the opportunity to make a graceful exit from the program.

How Fast?

I wrote a number of BASIC programs to test the speed of a few routines. I then performed these tests on an IBM AT with an Intel Inboard 386 running at 16 MHz. The system has 640K bytes of basic RAM and a 2-megabyte RAM disk running under PC-DOS 3.1. An 80387 numeric coprocessor was present, but I did not use it in the testing, since the data manipulated was either integers or characters. I

continued

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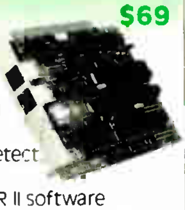

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Documentation
602-page manual

Price
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then used the QuickBASIC 4.0 command-line compiler (BC.EXE) and linker to compile and link the test programs. The benchmark programs were a sorting test, a screen recall test, and a direct screen output test. [Editor's note: *Listings for the four benchmark programs (filenames* pbsort.bas, pbqsort.bas, pbscrn.bas, *and* pbprt.bas*) are available in a variety of formats. See page 3 for further details.*]

For the sorting test, I wrote two programs to test the iptrsort subroutine used to perform indexed sorting on an array of integers. The first program, pbsort.bas, compared the speed of iptrsort with the Shell method coded in BASIC. The second program, pbqsort.bas, compared the same ProBas routine with the recursive QuickSort methods written in BASIC. In each program, an array of 1000 integers with indexes were created and sorted, with the entire process being repeated 100 times. The BASIC-coded Shell method sorted the indexes of the array in 34 seconds, compared to the 22 seconds it took the ProBas routine. However, the QuickSort method managed to sort the indexes in only 5 seconds, versus the 22 seconds it took the ProBas routine.

The pbscrn.bas screen recall program fills two screens, one at a time, and saves them in an integer array. The program tests the speed of recalling screens from the storage arrays, alternating between the two arrays. The program prompts for the number of iterations used in the timing, as well as the numeric code for the screen mode. It took 48 seconds to recall 500 screens, in screen mode 0 or 1.

To test direct screen output, I wrote the pbprt.bas benchmark to compare the speed of compiled print statements with that of the xqprint subroutine, which is a faster print version that writes directly to the screen. In filling 1000 screens, it took the print statement 24 seconds, compared with 9 seconds for the xqprint subroutine. This is a 266 percent increase in screen output speed.

A Big Manual for a Big Package

The ProBas package includes two distribution disks. If you use a color monitor, one of the disks offers an impressive and very informative demonstration of ProBas's features. You can query the demonstration program about the collections of libraries and their features. The installation of ProBas is fairly easy and includes the use of a batch file to create the appropriate version (i.e., matched to your hardware) of the library file PROBAS.LIB.

The 602-page manual is written in a friendly style and consists of tutorial and reference sections that are generally readable and thorough.

The ProBas Advantage

The ProBas library routines bring added power and convenience to programmers who use Microsoft BASIC compilers. Using the routines saves you the trouble of writing your own in BASIC, and, in most cases (sorting being one possible exception), ProBas will far outperform an equivalent routine in BASIC. The manual is thorough and fairly well written, so that you won't have too much trouble learning to use the routines.

If you are involved in developing advanced and well-polished applications using a Microsoft BASIC compiler, the ProBas library can provide you with a time-saving and valuable software toolbox. ■

Namir Clement Shammas is a columnist for several computer magazines and a freelance writer living in Glen Allen, Virginia. He can be reached on BIX as "nshammas."

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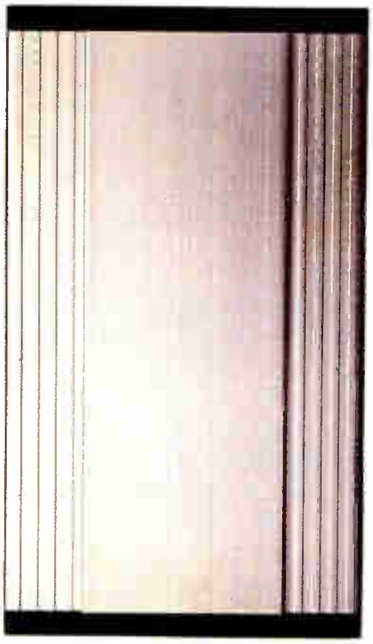

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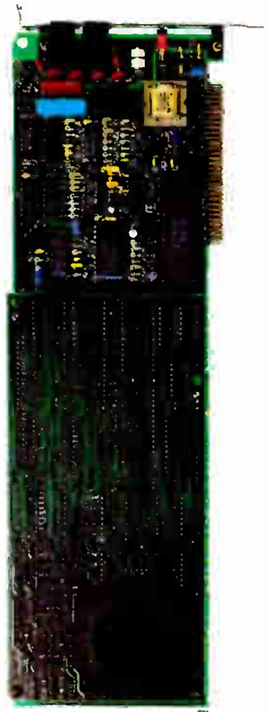

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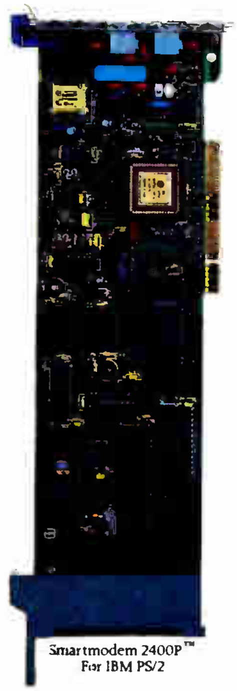

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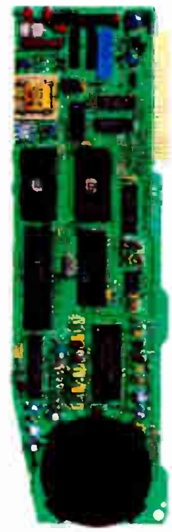

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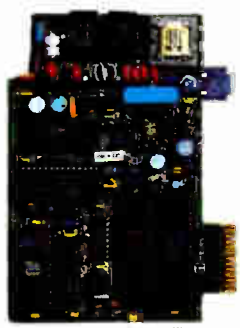

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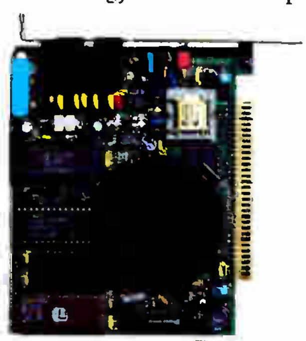

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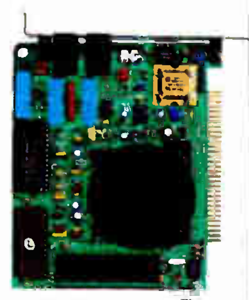

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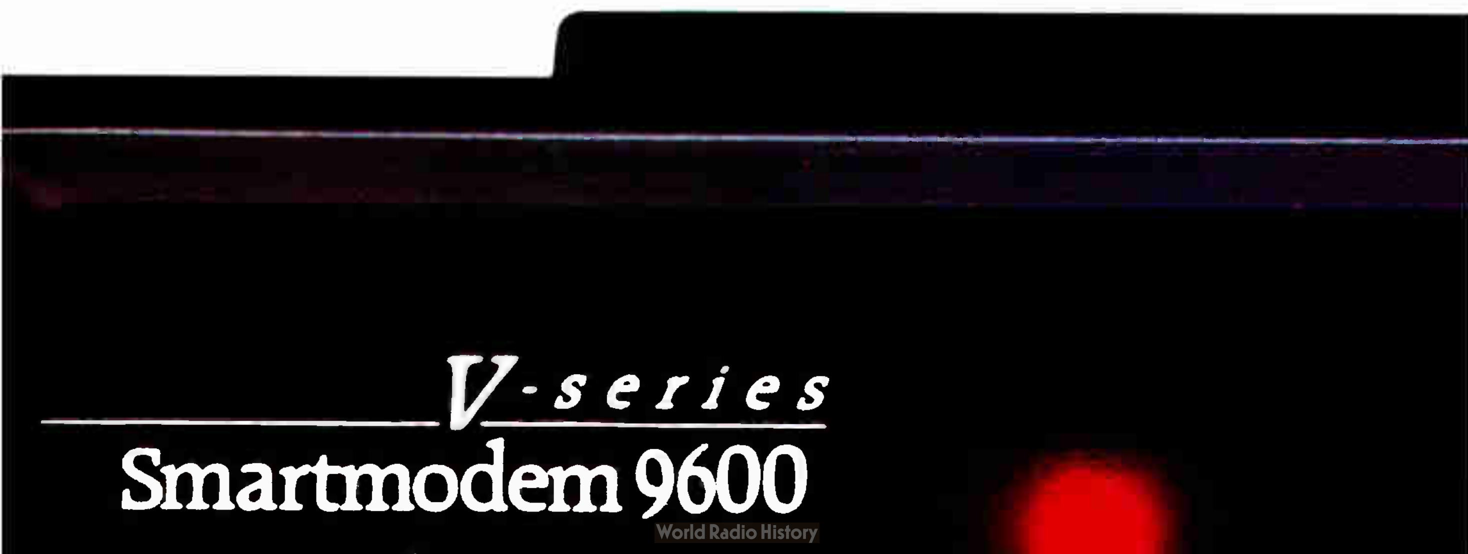

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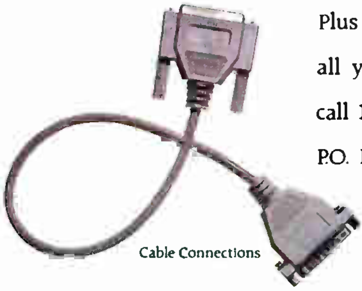

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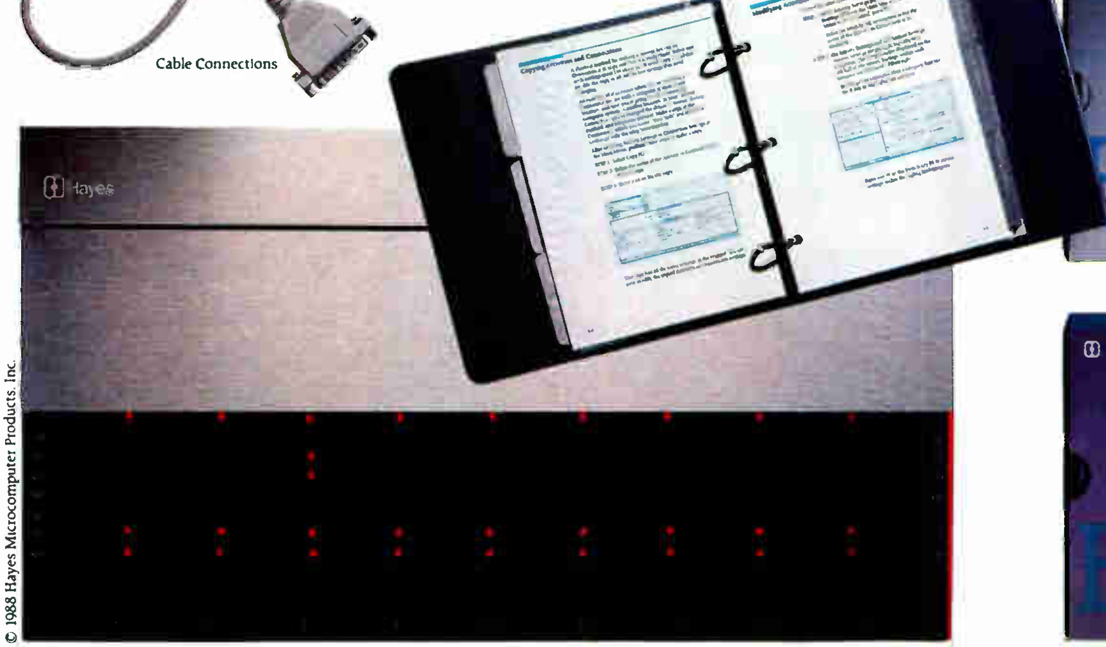

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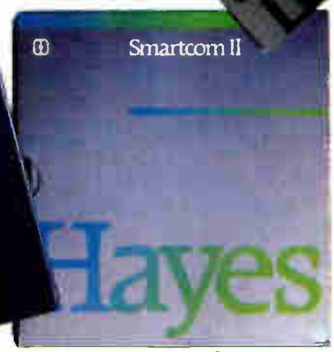

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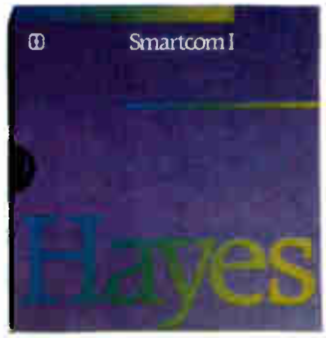

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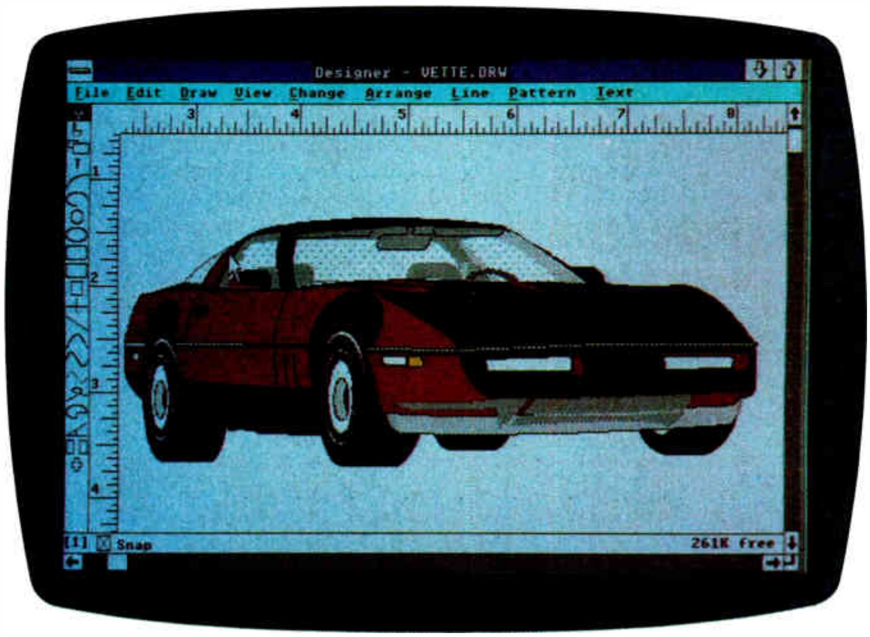

Designer bridges the worlds of drawing and bit-mapped images

Lamont Wood

When you approach the world of graphics for MS-DOS computers, you quickly discover (aside from a swamp of incompatible file formats) that you can draw, or you can paint, but not both. Now there's Designer from Micrografx that can do both.

Designer is a $695 software package for PC ATs and compatibles with at least 512K bytes of RAM and an EGA, VGA, Hercules, or other graphics adapter compatible with Windows 2.0 or higher. Micrografx recommends that you use an 80286- or 80386-class machine. While Designer has provisions for using a keyboard instead of a mouse, I tested it with a mouse. Not only does Designer let you bridge the two worlds (with a big assist from Microsoft Windows), but it also offers design tools previously seen only on minicomputer CAD systems.

First, consider the difference between drawing and painting. Drawing packages normally use "primitives" such as circles and lines to compose drawings, much as a draftsman uses a compass, a ruler, and related tools to compose even the most complex blueprint. Freehand drawing (with a mouse or other input device) is used only for special cases, and some drawing packages don't even provide for it.

Such "object-oriented" graphics software produces "line art": The drawing is ultimately just a collage of line and circle segments drawn to precise specifications. The advantage of line art is that the resolution of the final product is independent of the computer screen's resolution. Output devices can follow these specifications using whatever resolution is available, whether it's a laser printer of either 75 or 300 dots per inch, or a 1200-dpi phototypesetting machine.

Meanwhile, painting involves bit-mapped images. The picture is composed of pixels or dots. The device from which the pixels were mapped (i.e., the computer screen on which the original picture was drawn, or the scanner that digitized a picture) sets the resolution of the image. Since laser printer resolution is generally much higher than screen resolution, the quality of bit-mapped printouts on such a device can be disappointing.

Designer's Solution

By merging these two worlds, Designer lets you import bit-mapped images, trace over them using its drawing primitives, and then discard the bit-mapped image. You can add gray scales or colors to the resulting drawing to match the original image, and then print the drawing in the same resolution-independent fashion that you print any drawing.

Designer also imports bit-mapped images by using functions built into the Microsoft Windows environment. An application designed for Windows includes cut-and-paste facilities that load or unload material to a Windows entity called the Clipboard. Having cut an image into the Clipboard, you can load another Windows application and paste the contents of the Clipboard into it. The bit-mapped image that you load into Designer need only be compatible with Windows.

Note, however, that you need other Windows-compatible software besides Designer that can generate or manipulate bit-mapped images; Designer can only paste them from the Clipboard. It has no way to load them into the Clipboard, and certainly no way to generate them. I used Windows Paint for this review.

continued

Designer 1.0

Type
Technical illustration software for the Windows 2.0 environment

Company
Micrografx Inc.
1820 North Greenville Ave.
Richardson, TX 75081
(800) 272-3729
(214) 234-1769

Format
Five 5¼-inch floppy disks and five 3½-inch high-density floppy disks; other media available upon request

Language
C and assembly

Hardware Needed
PC AT or compatible running DOS 3.0 or higher with one high-density floppy disk drive, 512K bytes of RAM, and an EGA, VGA, Hercules, or other graphics adapter compatible with Windows 2.0 or higher

Documentation
90-page Installation Guide
320-page User Manual
82-page Clip Art Pictorial Guide

Price
$695

Inquiry 897.

Designer's image integration lets you scan or trace almost anything and turn it into a powerful illustration. For example, you can add corporate logos to blueprints or design a building plan on top of a site photo. You can combine elements from multiple pictures, since you're not limited to your screen or scanner resolution. Because of this, you can afford to set your scanner to a low resolution (e.g., 75 dpi) and save file space.

You will find that tracing even random blobs is no problem, requiring only a little attention to drafting, especially for the curves. When you finish, you just slide the original image out from under the drafted copy and either discard it or admire its similarities. These similarities evaporate when you print out the images. While they may look the same on the screen, the line-art copy is much snappier, being composed of smooth lines rather than jagged trails of dots. Gray areas are actually gray, rather than bit-mapped grids of dots.

However, with Windows and image integration aside, Designer is primarily a drawing package, so I'll look at its drawing features.

Object-Drawing Features

Like many other drawing packages, Designer gives you a screen that is bordered by rulers as your drawing surface and a selection of tools that is represented by icons along the edge of the screen. The rulers are important, because with the snap command invoked, you can draw lines only to connect the intersections of ruler gradations. Using snap makes it easy to line up and connect objects. You can specify the unit of measure (e.g., inches or centimeters) for use with the picture rulers and the number of gradations per unit (from 1 to 100).

In default mode, the drawing is shown at approximately actual size (see photo). You can zoom in for detail work, with the desired portion of the drawing blown up to fill the screen. How close you can zoom in depends on the setting you give for the coordinate grid, which is separate from the rulers. You can set the grid from 200 to 2900 points per inch, or 100 to 1100 points per centimeter. A finer coordinate grid gives you greater accuracy, but also a smaller drawing surface. The default setting of 480 points per inch provides a 68- by 68-inch area, while 2900 points per inch gives you an 11- by 11-inch area.

Use of the tools is fairly standard. You select a tool, go to the spot where you want it to start on the screen, press the mouse button, and drag a "rubber band" (dashed outlines) of the shape until you get the size you want. If it's not in the right place, you can move it later. The drawing tools include the arc, elliptical arc, circle, ellipse, rounded rectangle, rectangle, square, horizontal or vertical line, diagonal line, parabola, curve, polyline, freehand, and pie.

An elliptical arc is an ellipse with only the part of the circumference that you specify drawn in. Both arcs and elliptical arcs are drawn by designating the two endpoints, with an arc or elliptical arc stretching to connect them. The pie tool is similar, except that lines connect ends of the arc to the center of a circle, creating instant pie chart segments. Parabolas and curves are a different matter. After selecting the tool, you simply draw a line. Next, you go to the middle of the line and "push" it in the direction that you want it to bulge.

You can move objects around or resize them by selecting and then dragging them with the mouse. You select an object by placing the cursor on it and clicking the mouse, or by enclosing it with a dashed line using the block-select tool. Eight black square dots, called "handles," sur-

continued

round the selected object. You can resize an object by dragging one of the handles in or out. You can also treat bit-mapped images this way, but the effect is more a distortion than a resizing.

Advanced Features

All the things listed above are fairly standard for a PC drawing package. But Designer also boasts a unique `reshape` command. You select an object and then invoke `reshape` from the command menu. "Reshape handles" then appear at each of the object's "vertices" (i.e., every place a line changes direction). You place the cursor on one of these handles and drag it to a new location. The object is redrawn with the bend, as represented by the handle's new location, with the lines running to and from it curving appropriately. The effect is as if the object was made out of fairly stiff rubber and, by moving the handle, you have dented it in or out with your finger—a very intuitive way of doing it.

The power of the `reshape` command becomes apparent when you use the `block-select` command with the `reshape` command to select a group of handles and move them all with one nudge of the mouse. Thus, you can proportionally change part of an object in relation to the rest. An example in the user's manual demonstrates using the `block-select` and `reshape` commands to make the tail on a drawing of a fish wag up and down.

The `connect-closed` command is useful while tracing bit-mapped images. This command connects objects made with different elements. If you use a line, a curve, and then a freehand element to trace something, you can use `connect-closed` to turn them into a single object that you can move, rotate, scale, and so on. If the elements don't quite touch each other, lines automatically link their closest endpoints. I discovered that this command made it much easier to be precise, especially as the `snap` command was a hindrance during tracing, since I had to place the lines fairly randomly. There's a `connect-open` command to combine elements without linking them, and a `break-apart` command to reverse the procedure.

Multiple Layers and Colors

When using a color monitor, you can assign colors to objects, just as you can assign fill patterns and levels of gray when you use a monochrome monitor.

But a graphic artist will be interested not so much in the screen colors as in Designer's layers facility. You can define and give names to up to 64 layers. You can also assign a selected object to a layer and define which layers will be displayed at any one time: one, all, or a combination. The `printer` command prints only the layers currently displayed.

This last feature is important. If you define three layers and name them red, green, and blue, Designer becomes a tool to do color separations. You would keep objects of a particular color in the appropriate color layer and arrange the objects until you get the desired image on your color monitor. Then you print out the individual layers on a laser printer. Of course, these printouts will be black and white, but a commercial printer uses the correct ink when printing them. By overprinting the various color separations, an accurate copy of your screen image is reproduced. Please realize that this description is a gross simplification. Color printing is fraught with complications that should be left to professionals—al-

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though professionals can use Designer for this purpose.

Filing Capabilities

Remember that swamp of file incompatibilities? Designer tries to slash a path through it, but unfortunately without enormous success.

Designer has two file formats: DRW and PIC. DRW is Designer's internal format, while PIC is a format inherited from earlier Micrografx products. PIC should not be misinterpreted for the similarly named Macintosh PICT format. Through the Clipboard, Designer also accepts Microsoft Windows bit-mapped images and outputs Windows object-oriented format "metafiles."

Designer comes with a coupon for a free copy of a program that converts between the PIC format and the DXF format used by AutoCAD files. The conversion program lets you use Designer files with Xerox Ventura Publisher and Aldus PageMaker, two desktop publishing programs. You can import Designer files into PageMaker directly through the Clipboard, since the latter also runs under Windows.

Designer also comes with a clip-art library. Micrografx offers about two dozen clip-art libraries, with contents varying from world flags and maps to electrical symbols. Each library costs $49.95. Designer comes with a general library, with some flowchart and geometrical symbols, symbols suitable for logos, and a world map.

If you don't have Windows, Designer can run stand-alone using a run-time version of Windows that comes with Designer. Most of Designer's distribution disks are, in fact, for the purpose of installing this abbreviated version of Windows. The installation procedure for run-time Windows is the same as for standard Windows, even down to the screen messages. And, of course, there's no way to import bit-mapped images from outside Designer. For those using the run-time Windows and who presumably don't have the Microsoft Windows user manual, Designer's Installation Guide has several chapters of basic Windows information. Expect Windows and Designer to occupy about 1 megabyte on your hard disk drive.

Micrografx gave Designer powerful commands like `reshape` and `connect-closed` because it assumed the use of an AT- or 386-class machine, making functions that would have been unacceptably slow on a PC practical. Designer also makes no use of a math coprocessor, since the software uses integer numbers for the coordinate grid instead of floating-point numbers. Lookup tables are used to speed up the math where necessary.

I reviewed Designer 1.0 with a 4.77-MHz Eagle XT, and I found Micrografx's warnings about performance to be somewhat overstated. Aside from file loading and printing, the only response-time problem with the program was with the `reshape` command. It took 40 seconds to redraw a reshaped object. Otherwise, the program ran at interactive speeds.

File loading and printing are slow, but usually you have to cope with it only once per session. A sample file that contained a complex rendering of a Ferrari engine took 5 minutes to be displayed on the screen, element by element. As the screen redraws after major changes, you'd think working on such a drawing would be rather sluggish with an AT and unbearably slow with a PC. However, you normally do most of your work zoomed in on a small part of the drawing, where only a couple of elements are on the screen. These elements redraw themselves within moments. The same drawing takes 20 minutes to print on a Hewlett-Packard LaserJet-compatible laser printer, even at a resolution of 75 dpi. Simple drawings take 1 minute at 75 dpi and 4 minutes at 300 dpi.

Obviously, it would be better to have an AT-class machine. You can do simple drawings with no strain on a PC, but if your aims are simple you may as well save your money and stick with Windows Paint or the like.

The Overall Design

Designer has all the attributes of a two-dimensional drafting package: dimensioning, rotation of objects, and control over line width and endings. Three-dimensional features, like selectable points of view and hidden lines, are not present.

But Designer is aimed not so much at architects or mechanical engineers as at graphic artists who have to illustrate technical manuals with detailed drawings. Such drawings have to be not only precise but also based on real objects (possibly by tracing scanned images). The use of color will also be attractive to graphic artists. If you want to turn your MS-DOS machine into a precise yet flexible artist's tool, Designer may be what you're looking for. ■

Lamont Wood is a freelance writer from San Antonio, Texas, in the computer and electronics fields. He can be reached on BIX as "editors."

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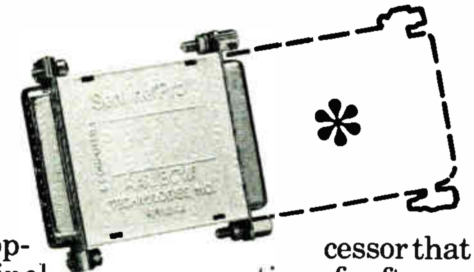

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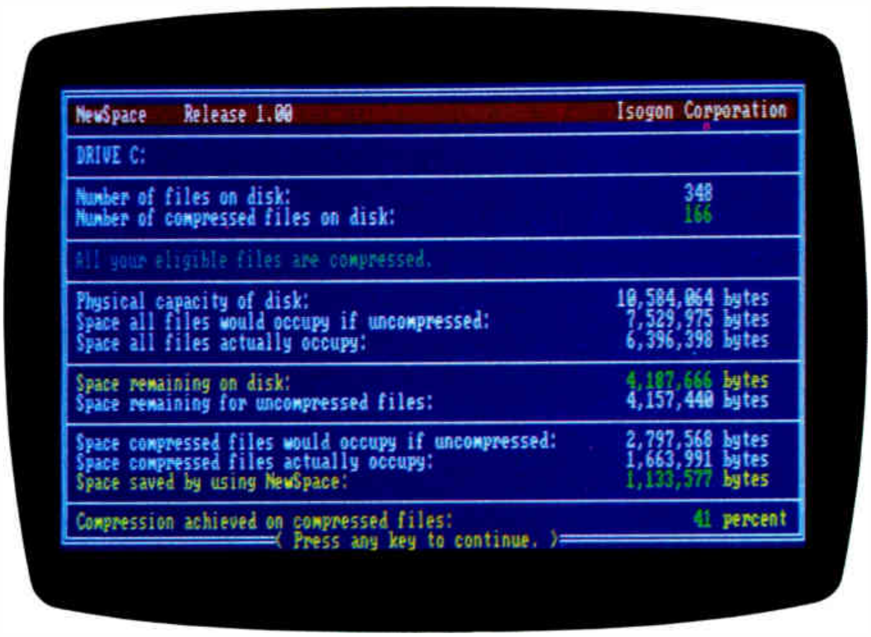

Increase the capacity of your hard disk with NewSpace

Diana Gabaldon

There's no addiction more pernicious than the lust for more hard disk storage space. Beginning with a deceptively modest craving for 10 megabytes or so, your needs rapidly escalate to 20 megabytes, then 30 megabytes—soon no amount of space is enough. Data files breed like coat hangers in a dark closet. Eventually, subdirectories bulge at the seams, and the hapless space addict looks for a new solution. NewSpace, a hard disk file-compression utility, promises some temporary relief.

NewSpace 1.00 is a terminate-and-stay-resident (TSR) program that automatically loads each time you reboot the computer. The installation routine rewrites your AUTOEXEC.BAT and CONFIG.SYS files, inserting the proper FILES and PATH commands for automatic execution. NewSpace also places itself between DOS and the data files on your hard disk drive. It compresses your data files into a proprietary file format. (For more detailed information on how NewSpace functions, see the text box on page 192.) When DOS or an applications program, such as a word processor, calls for a file, NewSpace intercepts the call, retrieves the compressed file, decompresses it in memory, and sends the file to DOS and the applications program.

DOS stores data files in clusters of 2048 bytes or 4096 bytes, depending on your version of DOS and your hard disk drive. This is a constant, regardless of the actual size of the data file, which means that data files of 2 bytes, 2K bytes, 20K bytes, or 200K bytes all use hard disk space in the same way. Small files cannot fill an entire cluster, and large files can be broken up into clusters or portions of clusters.

NewSpace compresses data files and reallocates storage space so that each file occupies only the actual number of bytes it really needs, rather than taking up space in whole clusters. This frees considerable wasted space, which can then be used for additional storage.

NewSpace compresses only data files into its own file format. Because compressed files are no longer stored according to standard DOS file format, read and write operations, which are controlled by DOS, are affected. In the case of data files, you'll see a slight slowdown in operation when using NewSpace. Files are automatically decompressed in memory when called by an applications program, such as a word processor.

NewSpace does not compress hidden, system .EXE or .COM files. In the case of program files, the program calls to DOS would be affected by compression, so NewSpace ignores these files.

As an added attraction, NewSpace lets you recover erased files. The program creates compressed copies of the last five files erased. If you want these back, you just use the Recover command. As a convenience, NewSpace keeps a listing of the erased files that are available for recovery, so you can check to see whether the one you want back is still in the lineup.

NewSpace in Action

I tested NewSpace on a variety of IBM PC compatibles, with a variety of DOS versions, hard disk sizes, and software.

Initially, I had a minor problem with installation on the first computer I tried, an IBM PC XT with 540K bytes of RAM, a 10-megabyte hard disk drive, and Orchid Technology's TinyTurbo 286 accelerator board running Microsoft MS-DOS 3.10. The documentation instructs

continued

NewSpace 1.00

Type
Data compression utility

Company
Isogon Corp.
330 Seventh Ave.
New York, NY 10001
(212) 967-2424

Format
One 5¼-inch floppy disk; a 3½-inch floppy disk is available on request with a registration card and a fee of $5

Language
C and assembly

Hardware Needed
IBM XT, AT, PS/2, or compatible with a hard disk drive, 256K bytes of RAM, and PC-DOS or MS-DOS 2.0 or higher

Documentation
69-page user's manual

Price
$69.95
(additional $3.50 for postage and handling)

Inquiry 894.

you to type `a:install` to begin installation. When I tried this, I got an error message stating that one or more files was missing from the installation disk and that the install procedure was canceled. After some experimentation, I discovered that I could get the program installed by logging onto drive A and then typing `install`. However, once installed, the program didn't work; every command resulted in an error message saying `invalid function`, and the help screens failed to work. A conflict with the accelerator board may have caused the problems with the installation and operation of NewSpace.

I tried NewSpace on five other machines. Two machines had the same type of installation problem, but once installed, the software worked fine. The other three machines had no difficulty with either installation or performance.

Of the five machines I tested, three were IBM PC XTs. With two of these, I ran IBM's PC-DOS 3.30, and the software installed properly. The third computer, an IBM PC XT that was running PC-DOS 3.10 and TOPS software in a local-area network, had problems with the NewSpace software. The NewSpace documentation states that the software currently doesn't work in a multitasking environment, such as Microsoft Windows or IBM's TopView. It also does not work on the file server(s) in a network, but does work on individual workstations in a network. Once the networking software was disabled and the computer was operating as a workstation and not a file server, the software did install and work correctly.

The other two machines tested were a Zenith Data Systems Z-158, running Zenith's MS-DOS 3.21, and a Phoenix 286 AT clone, running IBM's PC-DOS 3.30. The Zenith was also initially running TOPS networking software. The Zenith exhibited the same installation problem, but once the networking software was disabled, NewSpace ran well. The Phoenix 286 computer had no installation problems, and the software ran fine.

An Isogon technical-support representative said that the software runs on systems that have PC-DOS or MS-DOS 2.0 or higher. The NewSpace program requires 120K bytes of hard disk space. NewSpace itself requires very little RAM: 10K bytes of RAM is the default setting, but it can use up to 99K bytes of RAM, if specified during installation. The technical-support person also said that a few TSR programs might interfere with NewSpace installation; I found no difficulty in using SideKick 1.56 or a prerelease version of an executive organizer program with NewSpace.

Performance

After I installed NewSpace, performance was good. It has only four commands: `Compress`, `Disk`, `Status`, and `Recover`. `Compress` is used to compress eligible files. An eligible file is a data file that does not have one of the prohibited file extensions, such as `.COM` or `.EXE`. Once you install NewSpace, you must use `Compress` to squash all your eligible files; thereafter, new files are automatically compressed when you save them.

The `Disk` command assesses the compression status of the entire hard disk drive and produces a table that tells you which of your files are eligible for compression, how many bytes the files occupy in a decompressed state, how many bytes they actually occupy, how many files you have, and how much space is left on your disk for compressed and decompressed files.

The `Status` command tells you if a given file is compressed, decompressed, erased but recoverable, or not found. If the file is compressed, this command gives you statistics on the compressed versus decompressed size, and the percentage compression achieved. You can also use the wild-card characters ? and * to check the status of a group of files.

The `Recover` command is what you use to recover an erased file. If you use the command without specifying a filename, you get a display that tells you which files are available for recovery. When you want to recover a specific file, you just add the filename to the command `newspace recover` *`filename`*. The `Recover` command works even if you have another file existing with the same name as the erased file. In this case, the recover routine changes the extension of the existing file to .))) and recovers the erased file under its original name.

The `Compress` routine ran to completion on two of the five machines. The results for the first machine's 10-megabyte hard disk drive are shown in the photo on page 189. However, the `Compress` routine ended on the 80286 machine when a `Data error reading Drive C:` message occurred, presumably as a result of a bad sector on the hard disk drive. The abnormal ending did not abort the compression routine; several subdirectories had been compressed, and these remained in the compressed state. In fact, the `Compress` routine is interruptible; since it may take as long as an hour to compress a very full hard disk drive, you can interrupt the process at any time and resume at the point where you left off.

All the commands worked well on all the machines except, of course, the first XT with the accelerator card. The `Compress` routine ran approximately 3 times as fast on the 80286 clone as on the XT machines.

I tried compressing files of all sorts: word processors (WordStar 4.0, WordPerfect 4.2, Microsoft Word 4.0, XyWrite III Plus, and PC-Write 2.72), spreadsheets (Lotus 1-2-3 version 2.0, Quattro 1.0, and Excel 2.0), databases (dBASE III and dBASE III Plus), and miscellaneous others.

The amount of savings in hard disk space was an average of 35 percent for all the machines I tested, considering all types of data files. Small files (less than 1K bytes) showed proportionally higher percentages of savings than large files, presumably because these files are not taking up most of the space in their original cluster, while the large files are. Overall, word-processing documents, which averaged 8K bytes to 14K bytes in size, showed space savings rates of 40 percent to 50 percent. Spreadsheet worksheet files compressed as much as 50 percent to 60 percent in the case of fairly

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How NewSpace Works

NewSpace sits in RAM and examines the calls to DOS. When it encounters an interrupt 21 hexadecimal, it intercepts the call to see if it is a file access. If a file is being accessed, NewSpace swings into action and compresses or decompresses the specified file.

The program uses three techniques to compress files: It uses its own file format to store files in sectors (typically 256K bytes to 512K bytes) rather than in clusters (1K bytes to 2K bytes), and reduces wasted hard disk storage space for small files; second, long strings of identical characters (e.g., blank spaces) are handled with a repeat string compression routine; the third method uses a self-adapting Huffman Encoding Binary Tree algorithm.

DOS files are composed of ASCII characters. Each ASCII character is composed of an 8-bit binary string. In essence, the NewSpace program using the Huffman algorithm takes data files composed of ASCII binary strings and translates the ASCII strings into variable-length bit strings. For example, the letter *E* is represented as 01000101 in binary. NewSpace would translate the *E*, the most commonly used letter in the English language, into a much shorter bit string. The letter *X*, not as commonly used, would be translated into a slightly longer bit string. Each one of the 256 ASCII bit strings is translated into a correspondingly shorter NewSpace bit string, according to the frequency of its use. This is why text files show the greatest degree of compression.

In rare instances, when dealing with a file composed mostly of rarely used characters (e.g., ASCII graphics or control characters), a compressed file may take up more space than the original version. NewSpace compares the compressed version with the original version and will not compress a file if there is no decrease in size.

Files are stored with file-control information to allow random access to a file. NewSpace can retrieve only the portion of the file actually required, not the entire file.

—Stan Wszola, Technical Editor

small (10K bytes or less) files, though larger files had rates of around 20 percent to 25 percent. Database record files compressed about 20 percent to 25 percent, while database index files compressed as much as 90 percent, these being usually quite small files. Graphics files in the .PIC format compressed, though only by about 15 percent to 20 percent. Compression rates for very large files, such as word processor dictionaries and thesauri, which are usually in a compressed format already, were as low as 2 percent to 3 percent. Considering all file types, compression ranged from 25 percent to 35 percent for an entire hard disk drive, which means that, by using NewSpace, you might increase the capacity of the average hard disk drive by an extra one-third.

Data files automatically decompress when programs load or use them and automatically compress again when they are saved. New files are also compressed when they are saved. I didn't notice that much of a difference in storage speed or retrieval between compressed and decompressed files; in cases where it was noticeable (mostly in spreadsheet files), the difference amounted only to 2 or 3 seconds for large files. The negligible difference in speed is because large files require more time for storage and retrieval. They also show the smallest amount of compression. With small files, which can be substantially compressed, you can generally save or quickly retrieve them even when not compressed.

Operation of NewSpace is very smooth. I noticed no difference in the operation of my normal software when I used NewSpace; normal DOS commands, such as `DIR`, showed no change. The `DIR` command still shows data files and available storage space as occupying the same amount of space as before compression; you must use NewSpace's `Status` or `Disk` commands to find out how much space a compressed file actually does occupy.

Ease of Use

The documentation consists of a single user's guide in booklet form. It starts out with the disarming statement, "You Don't Have to Read This Manual," followed by a single page of instructions for installation and use. The rest of the manual consists of very clear explanations of the four main NewSpace commands and the ways in which NewSpace does or does not work with the common DOS commands. The error messages listed in the manual are clear and well documented.

This program couldn't be any easier to use. If remembering the four commands is too complicated, you have the option of using only the initial letter of each command. You can then specify parameters, such as a single filename or a group of files, for each command to operate on. There are excellent help screens that explain the form and use of each command, as well as a general help screen, accessible at any time by typing `newspace /?` from a DOS prompt.

Software Problems

NewSpace can cause problems with the operation of a few software programs that don't make standard calls to DOS, such as Tecmar's tape backup program, or that demand an enormous amount of RAM, such as Xerox's Ventura Publisher, which is so huge that it requires all the available RAM, begrudging even the modest amount needed by NewSpace. Programs known to cause problems are mentioned in a `README` file on the distribution disk. An Isogon technical-support representative was also helpful in resolving problems.

Some utility programs, such as the Norton Utilities, bypass the normal DOS system calls for accessing data. If you use these programs to look at the contents of your hard disk drive, you will not be able to read compressed files, since the utility program is bypassing the NewSpace program, which acts as an interface between DOS and most programs. The manual warns against using such a utility program to modify data on the hard disk.

Last Words

While there are some freeware/shareware utility programs available that do file compression, these all require the user to manually compress and decompress files as they are saved or retrieved. NewSpace does all this offstage, without interfering noticeably with your normal operations.

Barring the touchiness I encountered in the installation routine, NewSpace is a remarkably smooth and elegant utility, especially for version 1.00. Overall, I would rate its performance as excellent. NewSpace is competent, simple to use, and unobtrusive. ■

Diana Gabaldon is the editor of Science Software *and an assistant research professor at the Center for Environmental Studies at Arizona State University, Tempe, Arizona. She can be reached on BIX as "editors."*

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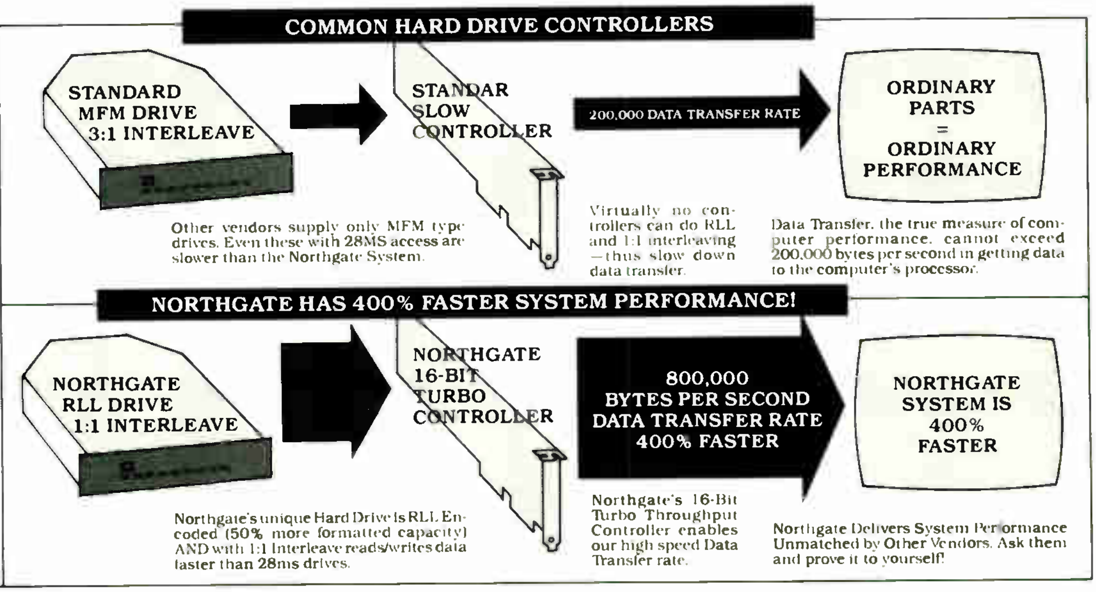

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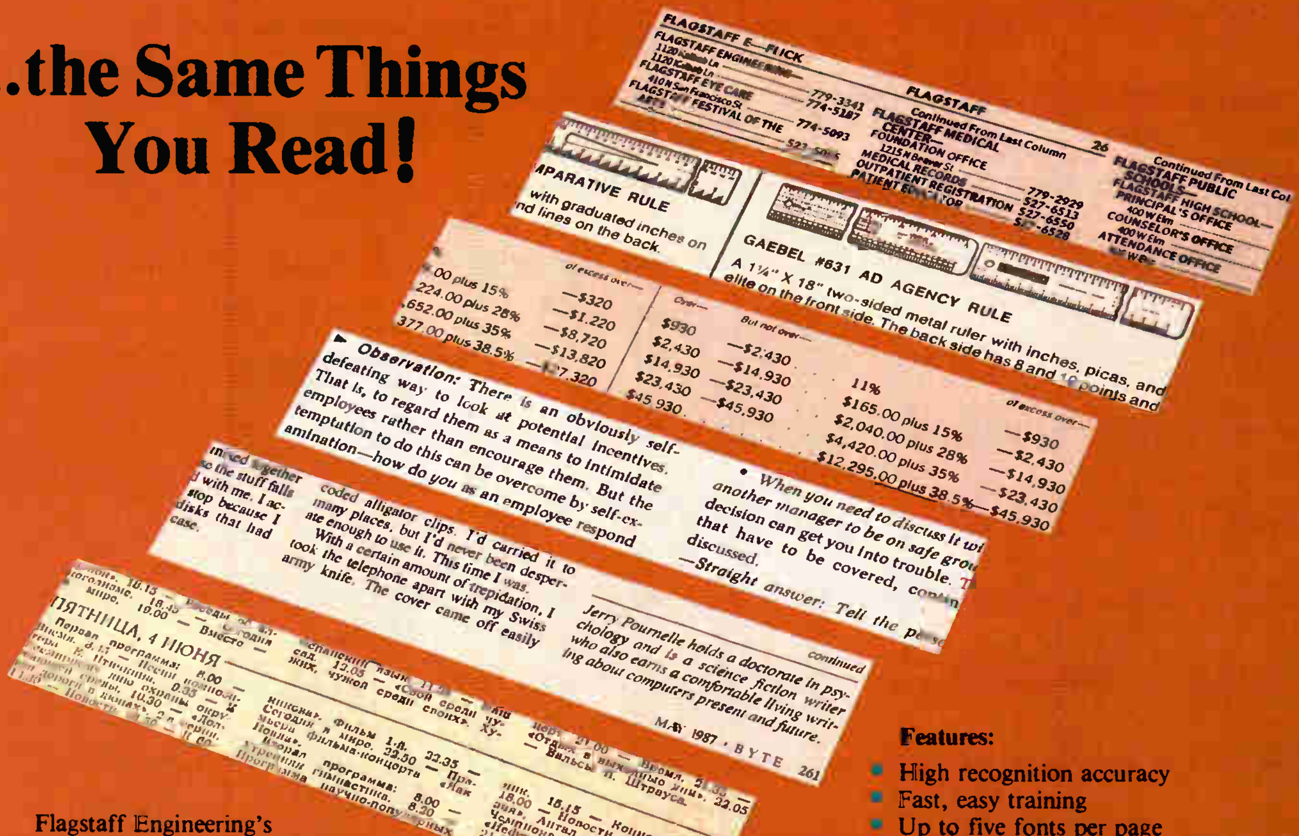

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DR. POURNELLE VS. THE VIRUS

Jerry observes the West Coast Computer Faire and gives a prescription

I was late getting to the West Coast Computer Faire this year because William Lowell Putnam, the new sole trustee of the Lowell Observatory, appointed me to the observatory's advisory board. The board meeting was held the same week as the Faire, and while I've never missed a West Coast Computer Faire, I wasn't about to pass up the chance to look through the telescopes that Percival Lowell used to map Mars and Clyde Tombaugh discovered Pluto with.

Incidentally, while those are the best known of the Lowell Observatory's discoveries, the most significant thing done there was probably V. M. Slipher's discovery of the red shift and the recession of faraway galaxies.

Anyway, the meeting was held at the observatory on Mars Hill outside Flagstaff, Arizona, and while it wasn't a lot of trouble getting to Flagstaff, getting out of there in time for my speech at the Faire was a bit more difficult. I wasn't able to get to San Francisco until early Saturday morning.

Even so, I had time to see all the exhibits. I can remember when it just wasn't possible to see everything at the Faire, even getting in a day early and running hard every moment.

On the other hand, I did miss most of the conference sessions, which is a pity, because the Faire continues to attract the best speakers and panelists in the industry. Also, they talk about meaningful subjects rather than just hyping products, the way so many people do at other computer shows.

Although there seemed to be fewer booths, there was no shortage of people. I'm told that once again there was a record attendance, and from the crowds I can believe it. There were the usual feeding frenzies at Jade, Jameco, and other large discount equipment vendors.

WordPerfect attracted its standard cheering crowds and got the standard complaints from other exhibitors. I have mixed emotions about that. On the one hand, having people cheer and shout in unison is a bit disruptive for those trying to conduct a more serious discussion of their products. On the other hand, WordPerfect certainly adds to the general air of excitement. I'm also curious as to how they get people to *do* it: when I was invited to give "the WordPerfect cheer," I managed one straight out of the Bronx. Oh, well.

Signs of the Times

Early Faires were dominated by Apple, which used it to get acquainted with hackers and end users. Apple now seems more interested in keeping their customers away from the rest of the microcomputer community. They hold their own shows and don't come to the Faire at all.

In the old days, we had serious discussions between CP/M, Radio Shack, and Apple users, and were able to get some cross-fertilization. When the IBM PC and compatibles came in, Apple was still there, and the debates were illuminating. That doesn't happen much anymore. The only Apple presence at the Faire are the stacks of Apple machine boxes at vendor booths.

Meanwhile, IBM, which used to all but ignore end users, comes to the Faire in a big way. Their impressive booth was filled with knowledgeable people, including a couple of genuine programmers, one of whom I actually managed to talk into removing his necktie. I hope they don't fire him.

Borland wasn't at the Faire, which surprised me. Neither was Microsoft, which wasn't a surprise since they haven't been coming for a while. I think both ought to be there. It can't hurt the big language houses to come to the one place where hackers and language users get together. Neither Borland nor Microsoft has such perfect products that they can afford to ignore their customers.

For years, the biggest question at the Faire was which group would throw the largest and wildest party, Microsoft or *InfoWorld*, and this year neither one was there. I don't know about parties on Thursday and Friday, because I wasn't there.

Saturday evening, Logitech furnished a large open area, tortilla chips and dip, beverages, and no loud noises masquerading as entertainment, a perfect setting for conversations. For me it was the high point of the Faire: a place to sit and talk to everyone. A lot of people showed up, legendary figures from the early days, like Lee Felsenstein, as well as new users and readers. I sure hope Logitech makes that one an annual tradition.

One outfit that I'd as soon have skip the Faire is the FCC. Since they keep bureaucrat hours, they weren't there a good part of the time anyway; but I don't see why taxpayers should pay for them to be there at all. As far as I can see, the FCC's major role in the computer industry is to make it very difficult for start-up companies: it doesn't matter how well your machine is designed, you can't sell it until you get FCC approval, and that takes time and money; meaning that small undercapitalized outfits can't bootstrap their way to success. If the FCC had been around at the first West Coast Computer Faire, there would be few companies other than IBM and the Japanese. Apple wouldn't exist.

My vote for the most spectacular Faire exhibit goes to Koei, producer of two IBM PC games: Nobunaga'a Ambition and Romance of Three Kingdoms. Both are strategic-level multiplayer games, one set in sixteenth-century Japan, and the other in Han dynasty China, which

continued

followed the Warring States period. The booth was decorated with fantastically beautiful Chinese and Japanese armor, and it attracted my attention from the other side of the hall. The games were shown only in demonstration versions; but from everything I can find out, the finished versions will be pretty spectacular, too.

Prodigy

BIX wasn't at the Faire, but several other on-line services, including General Electric's Genie, were.

The oddest one was Prodigy. Prodigy is a partnership of IBM and Sears, and it is supposed to be the on-line information service for the rest of us. You can't (as of April) subscribe to Prodigy just yet, but they did have an on-line demonstration, and they handed out demonstration disks that ape what Prodigy does on your home computer.

The demonstration disks say they can be "copied in whole and given to others solely for use in demonstrating the Prodigy service. Copying for any other use is prohibited by law." I can't conceive of any reason I'd want to copy the disk at all. My guess is that the joint venture got some of the IBM and Sears lawyers as a bonus....

Anyway, Prodigy will shortly be available at a flat rate of $9.95 a month for unlimited time on-line. They can do that because it isn't a conferencing system like BIX; it's mostly a one-way information service. You get news, weather reports, financial information, *Consumer Reports*, and special newsletters. The demonstration had messages from Sylvia Porter, John Dvorak, and Stewart Alsop.

There is a limited capability for sending messages to information providers (but not to other subscribers). I sent notes to Alsop and Dvorak, but so far neither has acknowledged getting them.

There are also advertisements: on every screen full of information, a significant part is taken up with an advertising blurb. You have the opportunity to expand the ad to a full page if you like. The ads weren't very clever, and I didn't have much temptation beyond curiosity to do that. I wonder how many paying customers will? For that matter, I wonder how many companies will "advertise" in the Prodigy format.

Prodigy is still under development, which is just as well. The demonstrated interface was pretty grim, simplified to the point of near imbecility. There are menus everywhere. No mouse support. It was all very slow. After watching it for a while, Brett Glass struck a pose and pronounced it "Stodigy!" The people in the Prodigy booth were not amused.

We'll just have to wait and see. I wasn't terribly impressed by Prodigy at the Faire, and the demonstration disk hasn't changed my opinion; maybe when it's up for real it will be better. From what I've seen, though, for $119.40 a year I'd rather have my local newspaper and the *Wall Street Journal*.

Trilogy

The West Coast Computer Faire has long been the spawning grounds for important microcomputer products. Dozens of start-ups—including MicroPro (WordStar), Broderbund, Logitech, and Sorcim (SuperCalc)—got their first real exposure at the Faire. It doesn't happen so often now, but it's still possible. Take, for example, Trilogy from Complete Logic Systems.

Trilogy is a new computer language. Now I know most of us put new languages a long way down on our needs list, but in fact there is room for one. I've written before that I wished I had a language that combined the logic/constraint features of Prolog with the procedural techniques of Pascal and the modularity of Modula-2. I even said it would be nice if the result was a bit faster than any of those.

Trilogy was designed to meet those criteria. It may have done that.

It's pretty easy to get the wrong idea about Trilogy. Indeed, Alex Lane's review in the March BYTE did just that; a Prolog expert, Lane compares Trilogy exclusively to Prolog, which is at least as wrong as my initial impulse to compare it exclusively to Pascal. The fact is that Trilogy combines many of the features of both languages. [Editor's note: *For more information on Alex Lane's review, see the letter on page 22.*]

Trilogy doesn't have the cut (`!`) operator or any other extra-logical additions put into Prolog to achieve efficiency. Instead, it uses `IF...THEN...ELSE` and `CASE` to achieve the same end, and it adds *constraints* to guide the logical solution without endless backtracking. This gives the language an enormous speed advantage in analyzing complex problems.

I haven't had a lot of time to play with Trilogy, but what I saw at the Faire and what I've been able to do with it here have really impressed me. I may use it to write a major program if Complete Logic Systems brings out the graphics and DOS modules in time (they're supposed to be finished before you read this). At my suggestion, they're also adding a number of I/O and string-handling functions that should also be available when this is in print.

Deciding to adopt a new language is a pretty serious step. If it doesn't catch on, you could find yourself with a useless orphan. On the other hand, if it works but doesn't catch on, you might find yourself with a secret weapon that dramatically improves your productivity; after all, users don't care what language an application program is written in.

My impression of Trilogy is that it's fast and easier for a Pascal programmer to learn than Prolog is. More as I experiment more; but if you're interested in logic programming languages, you might want to look into Trilogy. Incidentally, Peter Grogono, whose *Programming in Pascal* (Addison-Wesley, 1980) is one of the best language books I've ever seen (it has the best explanation of pointers in any book on any language), is doing a book on Trilogy, so I'm not alone in my impression that it may have the potential to be one of the "big" languages like Prolog or Pascal. Recommended for those willing to take a chance.

Virus

The specter of computer piracy stalks the land. One promising new start-up company recently called me to ask my view of yet another copy-protection scheme, this time a hardware device that plugs into the printer port where it is transparent to printing but responds to coded inquiries in a way that enables the software.

Hackers call this a "dongle," and I won't put one on my computer. Leave alone the problem that it's not easy to access the back of my machines, and that if very many companies do this I'll have a train of dongles 2 feet long sticking out of the printer port: the real problem is that I don't know precisely what the thing is doing. If I did know, the dongle would be useless.

For all I know, the gizmo may infect my machine with a virus. Now, sure, no reputable company would do that—but companies don't always know what's going on. Recall that back when Microsoft used copy protection—to their credit they abandoned that a few years ago—a summer hire inserted deep into the Microsoft kernel a worm that, on detecting what it thought was an illegal copy of a Microsoft program, said `Illegal Copy. Now trashing your master disk.`

In fact, the worm did nothing of the sort, but no one who saw that message was amused, especially since it could be triggered by a bad disk or a power failure. How am I to know that the guy who wrote the dongle PROM doesn't have an even weirder sense of humor?

Some people do. Someone once took the trouble to make up a board and sent it to me for "evaluation." I forget what the cover letter said it would do, but I got suspicious and wouldn't put it in my machine. I later learned that copies went to several others. One editor turned the thing over to Brett Glass, who disassembled the PROMs and discovered that if the board were in the machine on bootup, it would change the partitions on your hard disk drive, rendering it unusable until reformatted. I don't know anyone who got burned by this elaborate scheme, but it does show there are some sick people out there.

Anyway, I won't use a dongle for fear of catching a fatal computer virus; but interestingly enough, the fear of a virus may help mitigate the software piracy problem (which, except with games, I think is less severe than most suppose; but leave that for another time).

A computer virus is eerily similar to a real one: what it does is infect a computer program, often the operating system, then await a chance to reproduce itself. A virus can be stupid, like the board I described above, or quite clever. Simple viruses add themselves to programs and can be detected by a check of program size.

More clever ones find empty areas in the program and hide there. Sometimes they hide only a tiny part of themselves in the infected program; that part points to a new file disguised as an ordinary system file that is generally hidden from the user's view. They all try to reproduce themselves by examining susceptible files for hiding places.

What happens next depends on the virus's creator. Some hackers only want to prove they're clever. An example of that was the Christmas Message Virus that went around last year. Even so, adding needless code to a system can have unintended but disastrous side effects.

Many viruses are deliberately destructive. There was the Lehigh Virus, which infected hundreds of disks at Lehigh University. After sitting about harmlessly for days, the virus woke up and erased all data on infected systems. Backup copies were often similarly affected, so that some users were bitten more than once.

I have also heard of the Israeli Virus, although I never met anyone who has actually seen it. This one is supposed to do nasty things on May 13, 1988, the fortieth anniversary of the founding of Israel (and the extinction of Palestine as a sovereign state). It is said to be defused.

The Israeli Virus may be a legend, but many are not; one bulletin board sysop found that a full 15 percent of the programs posted on his board were infected. If he counted only programs posted by people he didn't know, the percentage went up to about 50 percent. Many sysops are getting scared enough to deny upload capabilities to new users. Recent reports in the *Wall Street Journal* indicate that a number of businesses have infected computers. Viruses can affect Macintoshes as well as PCompatibles.

The best way to avoid computer virus infections is to be careful where you get software. If you don't put strange programs in your system, you can't get strange results. That "free" copy of a program you got from a bulletin board may be more costly than you think. You're not even safe getting pirated software from a friend; even if there have been no signs of infection, some virus programs don't wake up for a long time.

continued

Vaccine

One possible defense is to use a "vaccine" program.

Obtaining one is a simple matter if you're on BIX: simply download the program called Flushot. This was written by one of the BIX regulars; people I respect say it's very good. Fair warning: I have not tried it yet and know it only by reputation.

You can also get a vaccine from a commercial source.

There were at least two at the Faire. One, called Vaccine, is published by FoundationWare. I didn't get a copy of the program, but that could be because I missed their cocktail party Friday night. I mention them because they had an impressive booth and gave out expensive brochures that contain both hype about their program and some pretty good (if sensationally presented) information about computer viruses.

FoundationWare's brochure says Vaccine gives "5 levels" of protection. The first is to write-protect critical system files, like COMMAND.COM, and watch out for unusual disk writes that bypass DOS. The second level is to write-protect the hard disk drive. In both cases, if the program detects a write operation, it asks if you really want to do that.

Their third level is what they call the "Quality Assurance Mode"; it appears to be a checksum program that runs against COMMAND.COM, CONFIG.SYS, and other critical files each time you start up the system or invoke Vaccine. They say this will reduce the odds of virus infection to one in a billion. I hereby offer to bet 10 of my dollars against 10 million of theirs that their program will fail within a year. I might be wrong, but I sure like the odds.

The other virus-protection program I saw at the Faire was Mace Vaccine, from Paul Mace Software. This is a 4K-byte memory-resident program to be installed using AUTOEXEC.BAT. Once invoked, it offers two levels of protection: (1) write protection of vital areas and system files, and (2) protection against all direct writes, things like DOS FORMAT, CHKDSK/F, DEBUG, Vopt, and UNFRAG; other disk optimizers; and, hopefully, viruses.

Whereas FoundationWare says of their program, "The probability of a system 'fully secured' by Vaccine having a disastrous and damaging write-to-disk by an unauthorized or altered software program is less than 1 in 100 million," Mace says, "Understand, the people who make these things are clever and we haven't seen their worst. We're clever too, and will keep on improving the vaccine. We can only hope they will tire of this malicious nonsense before we do." I leave it to the reader to decide which is the more reasonable attitude.

Mace, you'll recall, is the publisher of the Mace Utilities, which I consider to be nearly as essential as DOS.

VP-Planner Plus

VP-Planner Plus, the flagship product of Adam Osborne's Paperback Software, has always offered at least as much bang for the buck as any other spreadsheet. Version 2 is even faster—the fastest spreadsheet around—and adds do/undo keys. There's not a lot that Lotus 1-2-3 and Borland's Quattro can do that VP-Planner Plus can't match, and neither can hold a candle to it when it comes to macro power. Excel can, and with a 386, Excel under Windows is a thing to behold; but it costs a lot more, too. Unlike

continued

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Quattro and 1-2-3, VP-Planner Plus has a handy text editor and report generator. All in all, it's a more-than-just-adequate package.

Paperback Software began with tirades and crusades; I recall Dr. Osborne's speech about "obscenely high retail prices" given the low cost of software production. For all that, his prices have been creeping ever higher. I suspect it's because Osborne, like many others, has run up against a curious fact about the computer market: within wide limits, computer software doesn't obey the classical laws of economic demand.

If you prefer to say it exhibits an unusual demand curve structure, feel free. The bottom line is that lower prices do not necessarily result in more sales. One reason is dealers: unless the list price is reasonably high, there is not enough profit in it to serve dealers and distributors. In any event, the street price of VP-Planner Plus is lower than Quattro, but not all that dramatically so.

Anyway, VP-Planner Plus is a good, solid spreadsheet and limited database program, complete with a text editor, oodles of statistical and mathematical functions, good macro capability, and, as they say, much more. The newest version is a definite improvement over the last one, too. Lotus 1-2-3 remains the "standard" spreadsheet; Quattro is running hard to catch up; Excel under Windows is as nice on the IBM PC as it was on the Mac; but when you come down to it, nearly any job that you can do with the others can be done with VP-Planner Plus. They're all good enough for any job I've needed a spreadsheet for.

The Transfer Game

One perennial visitor to the Faire is Xenosoft. The booth tends to be a hangout for hackers, which is one reason I spend more time there than most places. Xenosoft's only current product is Xeno-Copy-PC, which is one of those programs you don't need often, but when you do need it not much else will do.

Some of you may not remember the bad old days of 5¼-inch-disk CP/M, when every computer company had its own notion of how 5¼-inch floppy disks ought to be formatted, with the result that you couldn't transfer programs from one machine to another without a great deal of work.

IBM and PC-DOS ended all that. Actually, we still have the problem that high-density IBM PC AT floppy disk drives can *read* IBM PC XT floppies all right, but they can't *write* anything the IBM PC can read reliably; still, that's nothing compared to the mess we had back in the old days.

Anyway, XenoCopy-PC is a program that will read foreign disks and transfer their files. It will handle about 200 5¼-inch formats and a dozen or so 8-inch formats; it can also format blank disks into those foreign formats, so you can use your PC to, say, read a disk made by a Bondwell 12, then format a disk for the Epson QX-10 and transfer to that.

Just after I got home from the Faire, Norman Spinrad called me. Years ago, partly on my advice, Norman bought a Kaypro 10 CP/M system. He wrote several novels and most of his book review columns on it. The machine still works fine, but Norman kept hearing about all the new software available for PCompatibles; and when he needed a portable machine to take on location, he decided to change to a PCompatible.

After consulting with me, he bought a Zenith Z-183. He clearly likes it: he just ordered a second one for Lee Wood, his fiancée and traveling companion. I've always said the best maintenance policy is a second computer, and that's especially true if you're traveling.

The Z-183, like most laptops, uses 3½-inch floppy disks. It's no big deal to transfer files between the Z-183 and a PCompatible desktop; but Norman just got a contract to turn some of his columns for *Isaac Asimov's Science Fiction Magazine* into a book, and those columns were written on the Kaypro 10.

"No problem," I told him when he called. "We'll use XenoCopy-PC to move them onto my Zenith 386 and then pipe them over to your machine with LapLink."

There was only one problem. When Norman got here, I couldn't find XenoCopy-PC. I still can't imagine what happened to it: I *know* they handed me one at the Faire. In some embarrassment, I called Fred Cisin at Xenosoft and left a message on his machine.

"Well, I've got this CP/M program called Uniform," Norman said. "It's supposed to let the Kaypro write stuff an IBM can read, but it says first you have to format the disks with a PC." (Workman and Associates sell Uniform.)

That was no problem. You can't trust a high-density AT floppy disk drive to format 360K-byte PC disks, but my new Cheetah 386 system has an old-fashioned 360K-byte standard floppy disk drive as the B drive. This would be a good test of the Priam enhanced-small-device-interface controller. The controller's main job is the 330-megabyte hard disk drive, but

continued

it also does floppies in both XT and AT formats. I used it to format some disks in vanilla XT format.

The next day XenoCopy-PC arrived, and Fred Cisin called. "You've got a problem," he said. "The Kaypro 10 has a flaw in its format routine. Kaypro used the Western Digital chip, and the floppy disk controller doesn't pay any attention to the Head Number field on the sector headers. Most of the double-sided Kaypro disks put a 0 in that field, even when they're formatting side 1. It doesn't matter to the Kaypro because the WD controller ignores the field. PCs use an NEC 765 [Intel 8272]. That chip can't ignore the field and gets all choked up. . . . "

"So what do we do?"

"Simple enough. Use XenoCopy-PC to format some floppies in Kaypro 10 format on your machine. XenoCopy-PC will put the right head number in the field. Copy the data onto those, and XenoCopy-PC will do the rest."

That worked, too. I did find some ambiguities in the XenoCopy-PC help screens, but there weren't any real problems. Actually, we didn't have to do that except as a test, because Uniform let the Kaypro 10 write onto the disks I'd formatted as DOS disks the day before. Norman brought them down, and we used LapLink to move his files onto the Z-183. LapLink was impressively speedy—and reliable—as always.

The moral of the story is that data transfer still isn't simple.

Amiga 2000

I've always had mixed emotions about the Commodore Amiga. On the one hand, it's an incredibly *fun* machine, the kind of thing that BYTE readers in particular will just love. You can do things with an Amiga that simply can't be done with anything else.

On the other hand, it can be a real pain in the neck. The operating system *almost* works. The floppy disk access is incredibly slow. Commodore, having bought Amiga, proceeded to fire nearly all the machine's developers and move the rest to Pennsylvania, where, except for networks like BIX, they're out of touch with the rest of the ferment in Silicon Valley.

Worst of all, Commodore cuts corners when they shouldn't.

The Amiga 2000 is a case in point. The basic idea is excellent: PCompatibles are (or at least were when the 2000 was designed) pretty boring machines, with little capability for graphics. On the other hand, there's a lot of software for PCompatibles, and many need that. Why not combine the graphics and just plain fun of an Amiga with a PCompatible? People can use the PC software until they find something as good for the Amiga side of their computer.

The idea was exciting, and many of us looked forward to seeing the result. The original machine Commodore described had a 68020 chip on the Amiga side and could accommodate an 80286 in the IBM half. There would be PC expansion slots. The result would have been a truly great machine. Alas, that's not what they brought out. The Amiga 2000 has a standard 68000 for the Amiga and an 8088 on the PC Bridge Board.

The Amiga half, with a hard disk drive and plenty of memory, is none the less a very nice machine. I still see the guru meditation—Amiga's not so very amusing system error message that appears when the machine crashes—more often than I like, but then I run a fair amount of untried software, and I don't always know what I'm doing.

I don't know what I'm doing because the Amiga has a goofy operating system. In fact, it has two of them. First, there's the icon-based system based on work done at Xerox's Palo Alto Research Center; it's similar to Windows, Niklaus Wirth's Lilith, or the Mac. Behind that is the command line interface (CLI), which sort of works like DOS.

Now the idea of having both icon command and CLI systems is a very good one; but the Amiga implementation of it leaves a *lot* to be desired. For one thing, the CLI system is harder to learn than DOS, doubly so because the commands are, for some silly reason, just slightly different from DOS. For another, if applications programmers don't create proper icons, you must use the CLI; but the user must deliberately turn on the CLI, and if I don't use it regularly, I forget how it works.

When we first got the Amiga 2000, I invited several Amiga experts, including Joanne Dow ("jdow" on BIX) and David Joyner ("talin" on BIX), to help set it up. One thing we wanted to do was test a number of speedup boards for the PC side since what comes standard is very vanilla (and thus slow). We tried a Sota MotherCard; genuine Intel boards, both 286 and 386; and a few others.

Alas, none of them worked, because Commodore employs the same interrupts to communicate between the Amiga and the PC sides that the PC enhancement boards use. I don't have one, but I understand there are boards, including at least one 386 board, that do work. At the moment, though, the Amiga runs all my PC software exactly as fast as the original 1981 PC. The Atari Mega ST using an emulator runs PC software even slower, about 80 percent of the PC's speed. I don't often use PC software on either machine, but that could change when I get a 386 card.

The Amiga 2000 has a lot more memory than my original Amiga did. Incidentally, I sent that Amiga off to be used in some Lunar Society experiments, and Henry Vanderbilt ("hvanderbilt" on BIX) found that it had a defective mouse: the left mouse button worked most of the time, but it would sometimes fail. That may have been the reason for some of the problems I had; but mostly, I think, I just kept running out of memory. That does not happen with the 2000.

I've had the Amiga 2000 for some months now. In some ways, it's still the most exciting machine I have. It's terrific for games. It's great for artists. There's a lot of fun software for it. It can be blooming frustrating to work with, but the results are often worth it. If you like computers and know what you're doing, it can be one terrific machine. I would *not* recommend it for people just trying to get some work done.

Dream Machines

When IBM first brought out the Micro Channel bus, I liked it a lot. Now I'm not so sure.

One thing is certain: you don't need the new bus to get a lot of speed from a PC; at least you don't if you have a Cheetah 386 motherboard.

The Cheetah 386 is the hottest machine here. It has Intel 20-MHz 80386 and 80387 chips, a Priam 330-megabyte internal hard disk drive, an Award BIOS, an Award EGA/VGA board (that at the moment connects as EGA to the Logitech Autosync monitor but works fine as VGA with the Electrohome 19-inch monitor), and a Maximum Systems WORM (write

continued

once, read many) drive. It also has 8 megabytes of fast Cheetah memory.

My Cheetah 386 is in a "tower" configuration (i.e., it sits on edge on the floor, but the floppy disk drives are horizontal). The tower has a number of advantages. The boards are kept cooler. It doesn't take up space on the desk. The reset button and power switch are on the front, where they're easy to reach. The main disadvantage is that I had to get extension cables for my video board and the mouse.

Anyway, you don't need to put the Cheetah board in a tower; it's made to drop into any IBM PC AT case. If you replace your 80286 motherboard with the Cheetah 386 board, you'll have a machine as fast as any PS/2, without the expense. The really neat part is that if I get faster Intel chips, I can step up the speed to 25 MHz and maybe faster. There's also software to slow the Cheetah down for real-time programs like games.

The Cheetah has become our major experimental machine: we're setting it up to run Santa Cruz Operations Unix. That's said to run DOS programs. Since I got the American Management Systems' Unix Directory Shell, I'm not so afraid of Unix; indeed, I'm actually looking forward to getting DOS-under-Unix up and running. We'll see.

WORMs

The Cheetah tower has a Priam InnerSpace hard disk drive. This thing is awesome. Not only does it have 330 megabytes formatted, but the access time is 11 milliseconds! It's reliable, too. Priam invented the technique of mechanically lifting the disk head on power-down or power failure and a number of other safety features. I've had several machines with Priam hard disk drives, and so far I have not had a single problem. I don't anticipate any with this one.

I don't anticipate trouble, but I still like to back up my data. The only trouble is that even with Fastback, backing up data takes enough time and trouble that I don't do it often; at least I didn't until I got WORMs.

I already had an Information Storage WORM drive on my Zenith Z-386, and that works fine. The Cheetah tower came with another WORM, the APX-3200 from Maximum Storage. As I understand it, Maximum Storage licenses hardware technology from Information Storage but developed their own WORM operating system.

Whatever they did, this thing is a bloody wonder. It's as simple to use as any drive I have. You can even "erase" files if, like me, you manage to write them onto the wrong subdirectory. Of course, the files aren't really erased anymore than a file is erased if you save another with the same name to the same subdirectory. In both cases, you can use Maximum Storage's XDIR program to find previous versions of a file and CPY to copy any version anywhere you like.

The WORM is a wonderful backup system. Removable WORM cartridges cost about $100 and hold 300 megabytes, and for all practical purposes, the copies made on the WORM are eternal. I routinely copy everything. With novels, I even copy new work onto a separate cartridge I keep in my box at American Vault.

WORMs are also great for software developers.

Did it ever happen? You did some programming work; tested the new version and liked it; and when you saved it, you erased the old. Later you discover a hidden bug; something that used to work won't work at all. If you had the old code you could compare, but you don't have it.

That won't happen if you back up everything onto a WORM, because you can always go back through the versions and select whichever one you like.

You can also run programs off a WORM drive, meaning that you can put your compilers, editors, and other large programs you never write to on the WORM to save hard disk drive space. If you have a Priam InnerSpace, you may not need to do that for a while, but consider this: since nothing can alter a WORM file, a WORM is the ultimate in protection from virus infections.

I've been using the Maximum Storage WORM for about a month and have 100 megabytes of files on it. I've yet to have a problem.

If you're in the software development business; if you write books on a PC; if you develop valuable data; you have to be nuts not to get a WORM. It's faster and easier to use than any other backup system I've seen, including tape.

Winding Down

I'm completely out of space, and once again my desk is piled high with stuff I meant to tell you about. We're taking another look at Fact Cruncher; Lattice has a new data-encryption system that works like a charm; MacInTax and Excel both work beautifully with the IBM PC, so you don't have to buy a Mac to use those wonderful programs; and if you have any interest in self-replicating systems, you will *love* Cellular Automata, a $34.95 program from Intelligrafix to create graphics life on your PC. Just be careful you don't spend so much time with it that you don't do anything else.

The book of the month is by Martin van Creveld, *Command in War* (Harvard University Press, 1985). Creveld is a professor of history at the Hebrew University of Jerusalem, and he has a fresh and valuable approach to military history.

The text editor of the month is the newest version of Q&A Write, which fixes most of the problems I mentioned in previous reviews. I'll say one thing about Symantec, they *listen*. The utility of the month is Word Exchange. This thing painlessly translates formatted Microsoft Word text files to and from a number of formats, including DisplayWrite (2, 3, and 4), WordPerfect, WordStar, Wang PC, and a bunch of others. It will even read and analyze an ASCII file to make guesses about page lengths, centering, headers, footers, and so forth. Since it translates both ways, you can use it (with Microsoft Word as an intermediate) to translate among any of those and other formats. Alas, it doesn't know about Q&A Write.

The game of the month—and maybe of the year—is FTL Dungeon Master for the Atari ST. Everything you heard about this is true; the graphics are incredible. I'm told there will soon be an Amiga version.

Next month, with luck, I'll look at Unix versus OS/2. ■

Items Discussed

APX-3200 .... $2675
Maximum Storage
5025 Centennial Blvd.
Colorado Springs, CO 80919
(719) 531-6888
Inquiry 935.

Cheetah 386 Motherboard
16 MHz $1495
20 MHz $1995
Cheetah International
107 Community Blvd.
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Longview, TX 75602
(800) 243-3824
Inquiry 936.

InnerSpace $4890
Priam Corp.
20 West Montague Expy.
San Jose, CA 95134
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Inquiry 937.

Mace Vaccine $20
Paul Mace Software
400 Williamson Way
Ashland, OR 97520
(503) 488-0224
Inquiry 938.

Nobunaga's Ambition $59.95
Romance of Three Kingdoms . $69.95
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Inquiry 939.

Prodigy .... $9.95 per month
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Inquiry 942.

Vaccine $189
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Inquiry 943.

VP-Planner Plus $179.95
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Berkeley, CA 94710
(415) 644-2116
Inquiry 944.

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Suite 600
Chicago, IL 60611
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Inquiry 945.

XenoCopy-PC $79.95
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2210 Sixth St.
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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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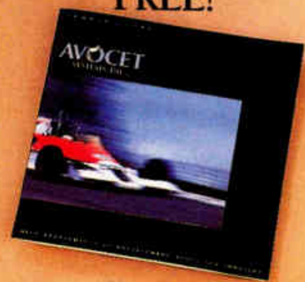

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FROM SHAREWARE TO HYPERWARE

Two word processors, MicroSpeed's nifty add-in, and an easy way to read HyperCard stacks

A few weeks ago, I was walking around a fairly large computer show and stumbled across two booths pushing shareware word processors. One was MindReader (Brown Bag, $49), and the other was PC-Write (Quicksoft, $89). What a world of difference!

I wrote about MindReader two years ago, before it had become a shareware product; that is, it cost four times as much, and you could get it only from dealers or the manufacturer. It struck me then as an odd but occasionally wonderful piece of software; I always enjoy seeing new ways to do old things, and MindReader was certainly brimming with wacko concepts.

In its earlier incarnation, MindReader gave you an opening screen and sound effects worthy of an arcade game. The program itself featured an as-you-type spelling checker, a truly impressive glossary feature for storing and retrieving chunks of boilerplate text, a decent address book for mail merge, and a process called WordComplete.

WordComplete would interrupt you a few characters into every word you typed and present you with a list of alternatives. You'd select the right choice, and the program would finish typing the word for you. This was disconcerting at first, but once I got into the rhythm of it, it wasn't bad. It sure saved me lots of keystrokes. I figured that if a typist could adjust to the WordComplete system, it could be a device that would save time and labor.

My final reaction, though, was mostly negative. Although I urged anyone that was developing a word-processing program to study MindReader carefully for its innovative features, I recommended against its purchase for day-to-day use. Unfortunately, it just wasn't up to snuff on the fundamentals.

As an example of one problem, you could perform block operations only on complete lines or groups of lines; if you wanted to move or copy a sentence that began in the middle of a line, you were out of luck. I felt guilty about trashing MindReader, but I just couldn't see using it for real work.

So here we are, two years later. How does MindReader stack up these days? Well, it's basically the same program. The block-operation problem has been fixed—you can now manipulate sections of text that start somewhere other than the beginning of a line. WordComplete, the address book, and the glossary are all still as fine as they were the first time around.

But I noticed something that I hadn't reported on in 1986 (probably because I was listing some of its other flaws, like the block problem): Every time you access one of the pull-down menus, MindReader goes off and sucks in the information from disk. On a hard disk drive, this represents a jerky hesitation that might not distract some people. Run from a floppy disk drive, however, it's absolutely unacceptable.

Essentially, MindReader seems to have been dusted off, bandaged a little, and then exiled to the Land of Shareware to live out its twilight years. Which is sad. There are still some great touches in this program, but it's waiting to die. I really wish its authors had looked on "going shareware" as a new beginning rather than as a way to salvage a few bucks and cut their losses from the first go-around. If they had rebuilt MindReader around the good stuff and thrown out the bad, the program could have been a real contender in the low-end word-processor market. Pity.

Quite a contrast to PC-Write, which was selling like the proverbial hotcakes. Bob Wallace continues to improve his program, which now boasts a fast spelling checker, and his company has turned out to be one of the biggest success stories in shareware.

Quicksoft is the only firm I know of that actually shares its profits with its customers. If you buy the program from the company and pass a copy to a friend, and the friend proceeds to register the copy by sending in money, Quicksoft will cut you in to the tune of $25.

After using an unregistered copy every so often (shame on me!), I finally became guilt-ridden enough to register my own copy two years ago. I distributed copies to friends, posted the program on a number of bulletin boards, and waited to see what would happen. To my great surprise, I made money on the deal. So yes, the scheme does work. It's all pretty amazing if you think about it; I'd guess Quicksoft has given away over 10 percent of its revenues up front, and it's going like wildfire.

The difference between PC-Write and MindReader is the difference between a healthy athlete and a zombie. One program is still on the rise; the other is sinking into the sludge of obscurity.

Mice on the Bus

From the gang at MicroSpeed, the trackball manufacturer, comes one of the niftiest IBM PC add-in cards of the epoch. Called the PDA, for Pointing Device Adapter, it started out as a bus card for the company's trackball product, so you'd no longer need to tie up a precious serial port. Purchased with one of the MicroSpeed trackballs, the card adds $20 to the list price. Purchased by itself, the card is $69.

However, MicroSpeed didn't stop there. The PDA functions as a bus card for *any* serial pointing device. Not only can you retrofit one of the MicroSpeed

continued

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XHELP $59.95
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Oakland, CA 94621
(415) 430-1876
Inquiry 951.

trackballs, you can plug in any serial mouse from Microsoft or Logitech and mouse off into the sunset. Whatever pointing device you attach, you're still freeing a serial port. The PDA is a universal card for pointing devices.

If that weren't enough, MicroSpeed has developed a magnificent universal mouse driver, distributed with the company's own products or available separately for $49. It will work with any mouse out there.

Why do I say magnificent? Well, I'm one of those people who frequently move back and forth between a Macintosh and an IBM PC AT clone. The Mac mouse has a well-mannered, smooth feel. The AT mouse seems light and uncontrollable in comparison, and I'm always missing my target on the AT screen. For a long time, I thought that the problem was inherent in the weight and other physical properties of the different mice. This is not so.

According to Tim Barry of MicroSpeed, the problem lies in the driver software. The standard Microsoft mouse driver is set up to offer only two rates of speed. Let's say you start off moving the mouse slowly; the motion translates to the screen at a 1-to-1 ratio. When you hit a predetermined speed, that ratio suddenly jumps to 2-to-1, and the mouse flies across the screen. That's all the control you have.

The Apple mouse, on the other hand, is designed for what is called "ballistic" gain. Rather than two speeds, the driver uses a number of speed ratios that fit on an exponential graph; the result is less choppiness in the feel as you speed up or slow down, because the jumps in ratio are less severe.

MicroSpeed has implemented a similar ballistic algorithm for its driver. It uses 10 different speed ratios for nice, even gain. Further, the ratio set is selectable. A command line switch (or a `CONFIG.SYS` parameter, if you use the device-driver version of the software) lets you choose among steeper and shallower curves for the gain. In other words, you can fine-tune the feel of the pointing device.

If all this is as far over your head as it is over mine, sit down with a Mac and a PC and play with the mice. Imagine how pleasant it would be and how happy you'd feel if the PC mouse moved like the Mac mouse. Then go check out the MicroSpeed product line.

Help, Help

I recently stated that if I saw another pop-up "MS-DOS made simple" program, I'd throw up. There are too many of these things on the market, and most of them aren't worth the price of a blank disk. It's perhaps my least favorite product category, and that's saying a lot. Thus, when I saw a demonstration of XHELP (Exwells Software, $59.95) that looked suspiciously like a DOS guide, I was tempted to move on. Quickly. I confess I didn't listen too closely to the first few minutes of the pitch, but when I figured out what was really happening I quickly got drawn in.

XHELP is a help authoring system; the demonstration I was watching used a sample database that offered assistance to MS-DOS users, but you can write help or information systems for anything you like. Need a help system for order entry of auto parts? How about a study guide for nuclear physics? The awful cliche is "you're limited only by your imagination," but in this case it happens to be true.

The organizing metaphor is the one most people are most familiar with: table of contents, data organized by page number, and index. You look up your area of interest in either the table of contents or the index, enter the page number, and you're on your way. XHELP will take an ASCII document, compress it, and break it into pages for you, or you can insert characters to indicate page breaks and have the screens look pretty when they pop up. Compiling the table of contents and the index is equally simple.

The lookup engine is a straightforward memory-resident program that works as well as any. This is not a supersophisticated package, but it does its job efficiently and it lets you get on with your life.

My only criticism is that the product was still very new when I looked at it, and the company hadn't figured out pricing for site licenses, which is how I think XHELP will be sold. But that's a minor point indeed.

This is a good tool if you need it.

Hyper De-hype-er

Over on the Macintosh, there's HyperDA (Symmetry, $69), a desk-accessory program that lets you read HyperCard stacks (or programs or applications or databases or whatever you call them) without needing HyperCard itself. Which is fine by me.

For some reason, I've never thought that learning how to program is a revolutionary new idea in computing, and it's the last thing I want to do. Maybe it's neat, but I really don't have the time. With a powerful machine like the Mac, I'm waiting for tools to let me write little Hyper-like programs by sliding pictures or symbols around on the screen.

I'll grant that HyperTalk could easily serve as the underlying language in tomorrow's advanced system for program development—a system that used actual code at only the deepest level—but I don't have much desire to master it in its present form. HyperDA lets me use other people's HyperCard work without having to become an expert.

Written by Bill Appleton, an expert and prolific Mac programmer with such gems as CourseBuilder and some excellent games to his credit, HyperDA is a terrific solution for anyone who wants to read HyperCard stacks but doesn't have the oodles of memory required. It's a desk accessory, and you can run it on anything from a 512K-byte Mac on up. Note that HyperDA is only a reader; you can't use it to modify programs or add to databases.

The HyperDA implementation is not perfect. You can't see fancy screen dissolves, wipes, or other visual tricks. Playing sounds stored in stacks is impossible. Also missing is the HyperCard flowchart—a visual display of the screens you've viewed, shown in chronological order. But if you're merely flipping through a stack of cards, do you really need all that stuff? HyperDA does have a good "find" function, which will jump you quickly to the right spot.

In my experience, it was easy enough to move from card to card, but it wasn't always possible to pop open a card's windows in the correct sequence. Sometimes I found dealing with HyperCard's hypertext aspects confusing; HyperDA is better suited for reading stacks that display only full screens of information rather than ones that move you all over the place by presenting large assortments of buttons and hidden text chunks. But even with its obvious flaws, HyperDA is still a quick way to get at data buried in your stacks.

"But wait," you say, "I have MultiFinder. Can't I just run HyperCard as a single application under MultiFinder and gain the ability to modify stacks?" Sure, if you've got a huge amount of RAM and nerves of steel. I'm always edgy about the devastating crashes that can occur when running MultiFinder. And HyperCard is a big program that takes a while to load, particularly annoying if you launch it every time you start work. If all you want is access to information, HyperDA is faster.

Finally, HyperCard stacks seem to want to take over the entire screen on my standard SE (I don't know about third-party big-screen monitors); HyperDA lets me look at stacks in a window that I can resize and reposition. At last I can look at stack data and other data at the same time.

Hooray for this product. My most major problem with it is that I keep wanting to pronounce it as "hyper-dah" rather than "hyper-dee-ay." It is definitely recommended. ■

Ezra Shapiro is a consulting editor for BYTE. You can contact him c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458, or on BIX as "ezra." Because of the volume of mail he receives, Ezra, regretfully, cannot respond to each inquiry.

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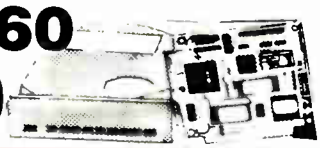

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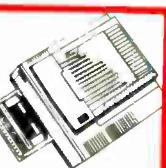

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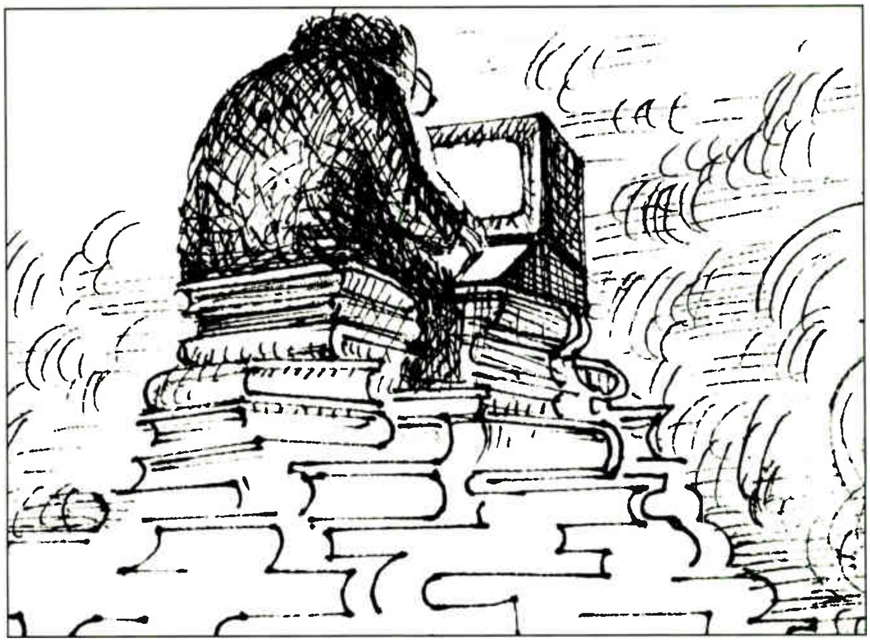
Introducing a new column that illustrates programming concepts and techniques that underlie the software you use today and will use tomorrow, and gives you lots of useful, hands-on code



Editor's note: *"Some Assembly Required" serves a dual purpose: First, it will show you, via concrete examples, the programming techniques that shape the current and future generations of software. For example, once you see how complex a relatively simple port is, you can understand why it's taking so long for DOS-to-OS/2 ports to show up. Information such as this will give you a better understanding of the hows and whys of your software.*

Second, this column is the place you can come for working sample code that's useful in its own right, and that serves to define and illustrate larger issues such as those mentioned above. Because the column is geared toward illustrating real-world programming issues and techniques, it will rely on the tools of today's software industry: assembly language for optimum performance, plus lots of C and some Pascal.

The column's author, Rick Grehan, is primary programmer of BYTE's new low-level system benchmarks, and has programmed everything from a KIM-1 to a building-size mainframe; written everything from accounting software to programs for Schroedinger wave equations; gotten as high as COBOL on a mainframe and as low as toggle switches on an ALTAIR 8800.—FSL

In an industry where new computer systems are rolled out as frequently as new car models, all the major software companies are counting on porting to save their popular programs from landing in the scrap heap.

For example, with the success of the Mac II, companies who previously offered programs only for the DOS machines are porting their software to the Mac and vice versa. And with the release of OS/2, every major software company in the DOS world—including Microsoft, Lotus, and Borland—is scrambling to prepare OS/2 versions of its programs.

Successful porting can ensure the survival of a good program in a world of rapidly evolving CPUs and operating systems. "Effective porting" sounds simple, but, in reality, it's a bloody job.

I know from experience: I recently ported the original incarnation of a C compiler to MS-DOS, and then ported that version to the Macintosh, as part of the task of creating our new benchmarks.

Looking at this specific case—porting a language—can serve in several ways: First, it illustrates the general concepts in porting, and thus can give you some insight into what's happening now in the major software development houses. Second, if you're a programmer, you'll also come away with useful, working code and practical examples of how you can apply the general principles.

High-Level Headaches

One of the major benefits of working with a high-level programming language

continued

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is that it insulates you from the system you're programming on; the language handles the intricacies of talking to the hardware and operating system so that you don't have to go gray writing assembly language. Altering a high-level language to deal with a new operating system and different hardware can get pretty hairy.

Sometimes there are ways to make the porting process easier. For example, it is sometimes possible to alter a compiler to port itself—use an existing compiler to write a new compiler. This is exactly what I did when I created the BYTE version of Small-C. In the first two installments of this column, I'll outline some of the problems I had to overcome in porting it to MS-DOS (this month) and the Macintosh (next month).

Here's how the procedure looks broken into an actual step-by-step example. (This example is specific to the Small-C port, but the general steps apply to any similar project.)

Step 1: Modify the source of the 8080 CP/M compiler to emit 8088 code. Compile that, yielding a compiler that runs under CP/M but produces 8088 code.
Step 2: Write the C source code for an MS-DOS-compatible run-time library (the part that talks to the operating system). Pass that through the new compiler to yield 8088 assembly source. Transfer this source to a PC and use MASM (Microsoft's assembler) and LIB (Microsoft's library manager) to create the actual library.
Step 3: Take the modified source of step 1 and send it through the new compiler; you now have 8088 assembly source for Small-C on a CP/M disk. Move that source to a PC, assemble it with MASM, and link it to the library from step 2 to create an 8088 version of Small-C running on the PC.

Now that we see the broad brush strokes of using a compiler to port itself, how about the fine-line definitions that made this specific project work? This demands that we first take a closer look at Small-C.

Small-C

A complete description of the original Small-C would be inappropriate here. Suffice it to say that Small-C executes a subset of Kernighan and Ritchie C, with its most noticeable restrictions being the following:

- The only data types are `int` and `char` (it supports pointers)
- There are no structures or unions
- Arrays may be only one-dimensional
- The only control structures are `for`, `while`, `do`, `if`, and `goto`
- Small-C emits assembly source code; you must have an assembler and linker to execute programs you create with the language

For more details regarding Small-C's external appearance, check the references at the end of this article. As for its internals:

- *The "Small-C Machine"*: Much as some languages (e.g., UCSD Pascal) define a hypothetical processor and emit instructions in that machine's repertoire, you can think of Small-C as executing on a theoretical machine. That machine would have three registers (a primary, a secondary, and a stack pointer) and an unspecified amount of memory. (For BYTE Small-C, BX is the primary, DX is the secondary, and SP is the stack pointer.)

All mathematical and logical operations take place in the primary and secondary registers, and results always end up in the primary. The stack holds temporary results during the execution of complex instructions, and also serves as a repository for a function's local variables. The original Small-C ran on an 8080, so all registers (and therefore integers and pointers) were 16 bits.

- *Code, Data, and Stack*: The 8080 had no segment registers, so Small-C views memory as equally available to code, data, and stack. You'll discover later on that it makes things easier if we locate code at the bottom of physical memory, with data and stack space near the top.
- *Support Library*: Small-C possessed a respectable library. It's only real disadvantages were the restrictions its file-handling routines suffered at the hands of CP/M (and even these were minimal).

Making It Work

File-access techniques differ from system to system; a successful port has to deal with this. For example, the original version of Small-C was born within CP/M, an operating system that only accesses files a sector at a time (where one sector is 128 bytes). The original version of Small-C carried this restriction with it; you had to do some extra high-level coding if you wanted to implement Unix-style (files as streams of bytes) file access.

For example, most C language implementations allow you to position a file-pointer to any byte within a file using `seek()`. In the original Small-C, you would have had to do something like:

```
mode=0;
 sect=off/128;
 soff=off%128;
 cseek(fd,sect,mode)
 while(soff!=0) {
  fgetc(fd);
  --soff;
 }
```

where `off` is the byte offset to which you intend to position the pointer, and `mode=0` tells `cseek` to treat offsets as being from the beginning of the file. In case you're wondering, the repeated calls to `fgetc()` did not make multiple requests to the operating system in the original Small-C. The language's standard library could optionally buffer sectors. In fact, an easier way to accomplish the above would be to simply read the entire sector and work with its 128 bytes of data as an array.

None of this is unique to my port. For example, Kernighan and Ritchie mention similar contortions they had to go through with a PDP-11 version of C. In that version, to access a given byte in a file, you had to issue two `seek()` function calls: the first call required that `mode` be 3, 4, or 5, which set the file pointer to the start of the *n*th 512-byte sector; you had to make the second call with `mode` set to its expected value of 0, 1, or 2, which selected the byte within that sector.

To proceed with the port, I therefore rewrote the library for the 8088 version of BYTE Small-C so that it used the MS-DOS file-handling function calls (interrupt 21 hexadecimal, functions 3Ch through 42h). This allowed me to make the `seek()` function more akin to its counterpart in "big" C packages. I say "akin" because BYTE Small-C's `seek()` requires two `int` arguments where most big C packages would use a single `long`.

As an example, say you have a 128K-byte file, and you want to read the 355th byte into character array `buff`. In BYTE Small-C, you could do this with

```
mode=0;
seek(fd,0,355,mode);
read(fd,buff,1);
```

You can see that this `seek()` function adds at least the overhead of an additional argument. In addition, once you begin working with files bigger than 64K bytes, you have to do what amounts to treating a pair of integers as single 32-bit quantities. So, to access byte number

continued

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Listing 1a: *Divide operation for the original Small-C.*

```
DIV:
  MOV   B,H
  MOV   C,L
  MOV   A,D
  XRA   B
  PUSH  PSW
  MOV   A,D
  ORA   A
  CM    CCBCNEG ;Negate BC
  MVI   A,16
  PUSH  PSW
  XCHG
  LXI   D,0
CCDIV1:
  DAD   H
;Rotate DE left 1 bit
  CALL  CCRDEL
  JZ    CCDIV2
:Compate BC and DE
  CALL  CCCMPBCDE
  JM    CCDIV2
  MOV   A,L
  ORI   1
  MOV   L,A
  MOV   A,E
  SUB   C
  MOV   E,A
  MOV   A,D
  SBB   B
  MOV   D,A
CCDIV2:
  POP   PSW
  DCR   A
  JZ    CCDIV3
  PUSH  PSW
  JMP   CCDIV1
CCDIV3:
  POP   PSW
  RP
  CALL  CCDENEG ;Negate DE
  XCHG
  CALL  CCDENEG
  XCHG
  RET
```

Listing 1b: *Division in BYTE Small-C.*

```
MOV   AX,DX
IDIV  AX,BX
MOV   BX,AX
```

65536, you would write

```
mode=0;
seek(fd,1,0,mode);
read(fd,buff,1);
```

I decided that the additional software (and mental) gyrations you'd have to go through to manipulate integer pairs was worth the reduced number of calls you'd have to make into the library. This became especially important when we decided to use BYTE Small-C as a basis for benchmarks; had I gone with the CP/M version's style of `seek()`, we would be forced into timing two physical calls to the MS-DOS seek function per one logical seek operation.

Using MS-DOS's Unix-style file I/O also relieved me from having to worry about buffering; I could let the operating system (or any disk-caching terminate-and-stay-resident programs that might be in place) do it. Finally, the MS-DOS file-open call (INT 21h, function 3Dh) returns a handle, and is therefore easier to interface with C's file-handle I/O routines. (BYTE Small-C doesn't support the standard I/O functions that make use of the `FILE` type; it manipulates all files via handles.)

Adolescent Processors

When you consider Small-C's birthplace, it's obvious that 16-bit math and logic operations there would be nontrivial operations. If you're familiar with the 8080, you might think about what would have to go into a 16-bit divide operation on that processor (I'll show you one in a minute). The original Small-C had to perform all substantial math and comparison operations by making calls into a math/logic library. Space-wise, it was impractical to emit code for a 16-bit division every time a division operation appeared in the C source program. Consequently, the original suffered from the added time overhead of making piles of subroutine calls.

The 8088's instruction set gave me the ability to reduce most of BYTE Small-C's math and logic routines to in-line instructions. As compared to a program written in the original Small-C (as much as we can compare across processors), the same program in BYTE Small-C will certainly have a smaller run-time library, likely include slightly more instructions per operation, and run substantially faster.

As a direct example, compare the code in listing 1a with listing 1b. Listing 1a shows the original Small-C's library routine for performing a 16-bit signed division. Listing 1b is the same operation in BYTE Small-C. Keep in mind that the original Small-C would have generated a `CALL` to function `DIV`, and so incurred the additional time for the `CALL` and `RET` instructions; BYTE Small-C's three instructions compile in-line.

Life In the 16-bit World

This first version of BYTE Small-C for the MS-DOS machines supports only 16-bit integers. I'll agree with anyone that this is a less-than-desirable legacy of the language's ancestry, but it made my life easier by orders of magnitude. I could also reasonably argue that since 16 bits is the size of the 8088/80286's primary registers (accumulator and index registers, in particular), it should also be the size for Small-C's integers.

Since Small-C informally defines integers and pointers to be the same size (there is no coercion), it follows that all addressing is restricted to 16 bits. Consequently, the 8088/80286 version of BYTE Small-C runs within a 64K-byte window; if I was making a commercial announcement of Small-C, I would probably say that "the product supports the small-memory model exclusively."

Integer size is something you should be aware of as you interpret benchmark results obtained in BYTE Small-C. As you'll discover next month, the 68000 version uses 32-bit integers. Therefore, an operation in BYTE's 68000 Small-C—especially an integer math operation—is essentially handling twice the throughput of an equivalent operation in 8088/80286 Small-C.

Getting Logical

Examine the following code fragment:

```
int i,j,k;
i=12;
j=(i==12);
k=(i!=12);
```

Execution of this code would assign to `j` a nonzero value (typically 1, but officially defined in the standard header file as Yes), and assign to `k` a value of 0. In essence, Small C does not define a separate, Boolean type (as in Pascal, for example); logical operations yield an integer result.

This produces some problems when you go to translate logical operations to their machine language equivalents on the 8088/80286. Why? Because logical operations on those processors ultimately translate to comparison operations, and comparison operations serve only to alter bits in the flags register. Consequently, you have to somehow map the contents of the flags register to an integer quantity. One way is to move the flags register into the AH register with the `LAHF` instruction, but I ruled this technique out for two reasons: First, it would resolve into too many instructions per logical operation. Second, different logical operations would yield different results for a true condition.

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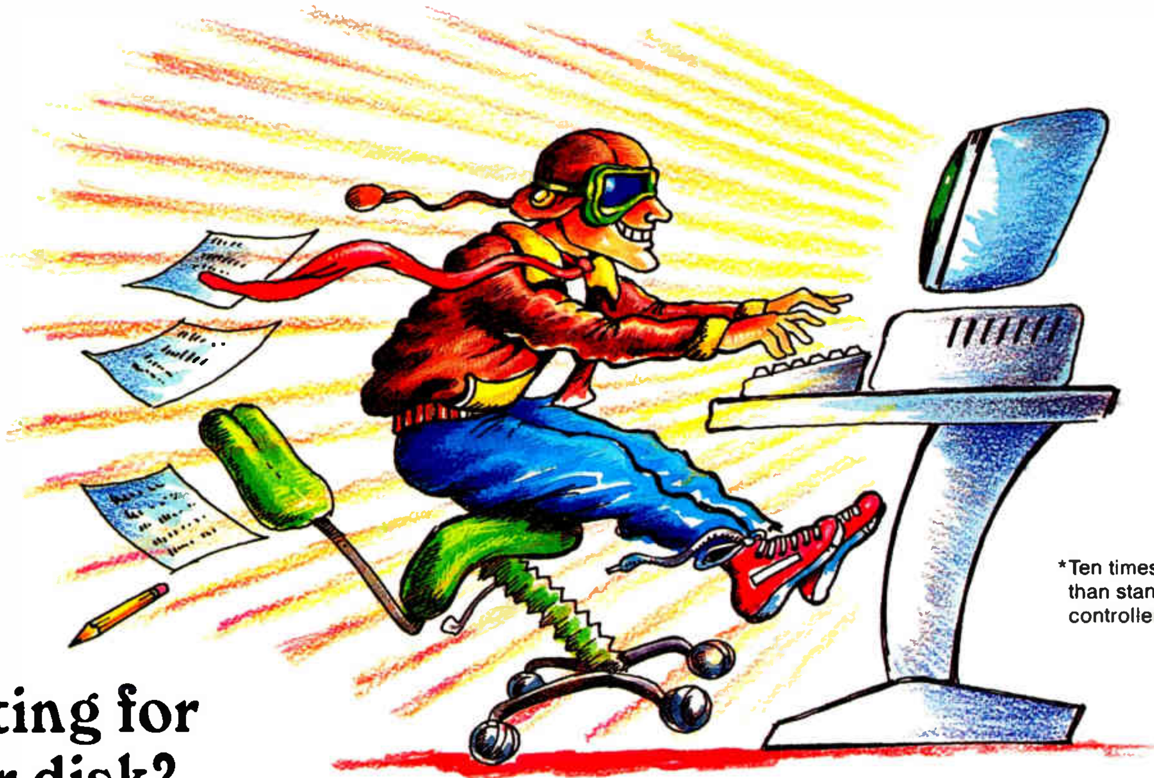

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Instead, I chose to use short conditional branches to control the setting or clearing of a 16-bit register. For example, an equality test in BYTE Small-C emits code like:

```
    CMP   BX,DX
    MOV   BX,CX
    JNZ   L1
    INC   BX
L1: ...
```

Here's where I took advantage of two features of the 8088/80286. First, (and I realize this isn't apparent in the above code) BYTE Small-C requires that the CX register always be 0. This requirement saves a few bytes and clock cycles—a `MOV BX,CX` is one byte and several cycles shorter than a `MOV BX,0` instruction—and it doesn't cost us anything because the CX register isn't used to support the "Small-C machine" model. Second, on the 8088/80286, moving the contents of one register to another does not alter the flags. I couldn't clear the BX register with an `XOR BX,BX` instruction, as `XOR` alters the flags register.

Notice how the above code ensures that a TRUE condition always results in a 1 in the primary register (BX), while a FALSE condition leaves a 0 in that register. This brings BYTE Small-C in line with the Kernighan and Ritchie definition of comparison operation results for C (i.e., TRUE is 1, FALSE is 0). All other comparison operations in BYTE Small-C work in this fashion; simply replace the `JNZ` instruction with the appropriate conditional branch.

Memory

I wanted BYTE Small-C to support the storage allocation functions (`alloc()` and its ilk), so I had to be careful with the memory layout. Figure 1 shows the scheme I ultimately settled on (which, if you ignore segmentation, actually looks a lot like the layout of the original Small-C). BYTE Small-C's library defines entry point `_Uend` as the starting address of any program you create in that language.

Notice that `_Uend` is in segment `SCSEG1`, while the remainder of the code is in segment `SCSEG`. The source code generated by BYTE Small-C includes the preamble instructions shown in listing 2. This preamble ensures the segment `SCSEG1` loads higher in physical memory than segment `SCSEG` (`Link` controls this), and that `_Uend` is, therefore, the topmost code routine in memory. BYTE Small-C uses the remainder of memory above `_Uend` as the stack and dynamically allocated memory.

The `_Uend` routine sets the stack pointer to near the top of the segment, loads global variable `_Umemptr` with the offset of `_Uend`, and transfers control, ultimately, to `main()`. The initialization routine sits in memory that is claimed as data space the first time the program calls `alloc()`; this is not a problem since the initialization code will have done its job.

You'll notice things are on a collision course: The stack grows down, and allocated memory grows up, so if the two run into each other, things go bonkers at clockspeed. Small-C does not incorporate stack overflow checking, like its bigger commercial cousins. However, Small-C programs tend to be, at most, modest in size, and none of the many benchmark programs the BYTE lab has run have crashed on account of stack overrun.

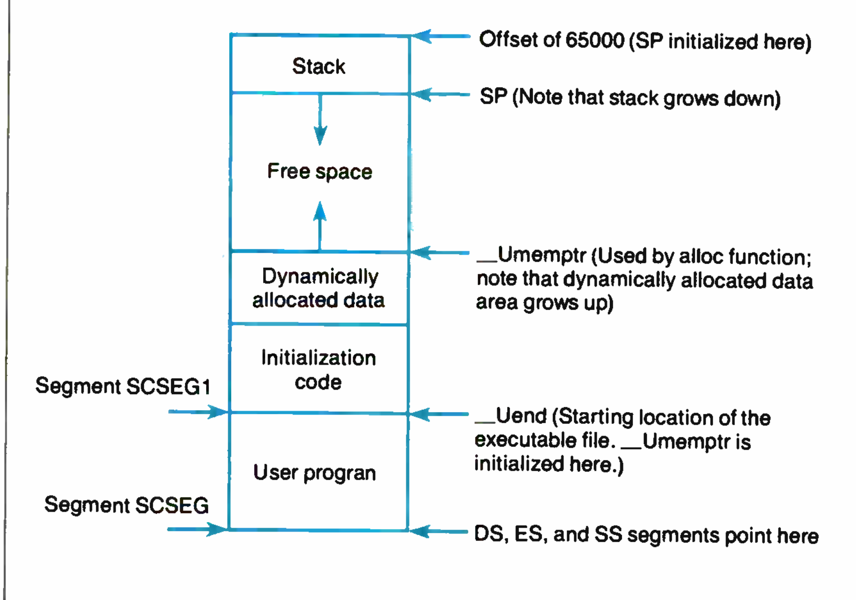

Figure 1: *BYTE Small-C's memory map.*

Listing 2: *This preamble to the source code ensures that segments load into physical memory in the proper order.*

```
SCSEG    SEGMENT WORD PUBLIC
SCSEG    ENDS
SCSEG1   SEGMENT WORD PUBLIC
SCSEG1   ENDS
SMC      GROUP   SCSEG,SCSEG1
SCSEG    SEGMENT WORD PUBLIC
    ASSUME CS:SCSEG,DS:SCSEG,SS:SCSEG,ES:SCSEG
```

So Long to 16 Bits

If you want to discover more about what I had to do to make the port, I encourage you to get a copy of the 8088/MS-DOS version of BYTE Small-C and examine the source code. I've tried to cover the most important points, here; you may find something that's important for you in the actual source.

Next Month

Small-C on the Macintosh. ■

REFERENCES

1. *Dr. Dobb's Toolbook of C*, A Brady Book, New York, NY: Prentice Hall, 1986.
2. Hendrix, James E. *The Small-C Handbook*, Reston, VA: Reston Publishing Company, 1984.

Rick Grehan (bixname: "rick_g") is a BYTE senior technical editor. He has a BS in physics and applied mathematics and an MS in computer science/mathematics from Memphis State University.

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Multitasking

Multitasking is the computer equivalent of walking and chewing gum—that is, the ability to do more than one thing at a time. Minicomputers and mainframes have been multitasking for years, and now microcomputers are gaining ground on them.

The faster and more efficient our machines become, the more impatient we seem to become. Waiting time seems interminable now when it reaches into the minute range—especially when that waiting means we must sit idly by while the computer works. We want to be able to tell our machines what to do, then forget that task and go on to something else while the computer handles both that internal task and the work we are currently doing.

Enter multitasking—the subject of this month's In Depth section. Multitasking involves the sharing of resources; "Fair Share" by Jonathan Robie discusses all the combinations and permutations that this sharing can encompass. Jonathan provides an explanation of the different parts of multitasking, the various means of scheduling tasks, and the communication required between tasks for all this to occur in an orderly fashion. He also deals with some of the problems you can run into when you try to do more than one thing at a time.

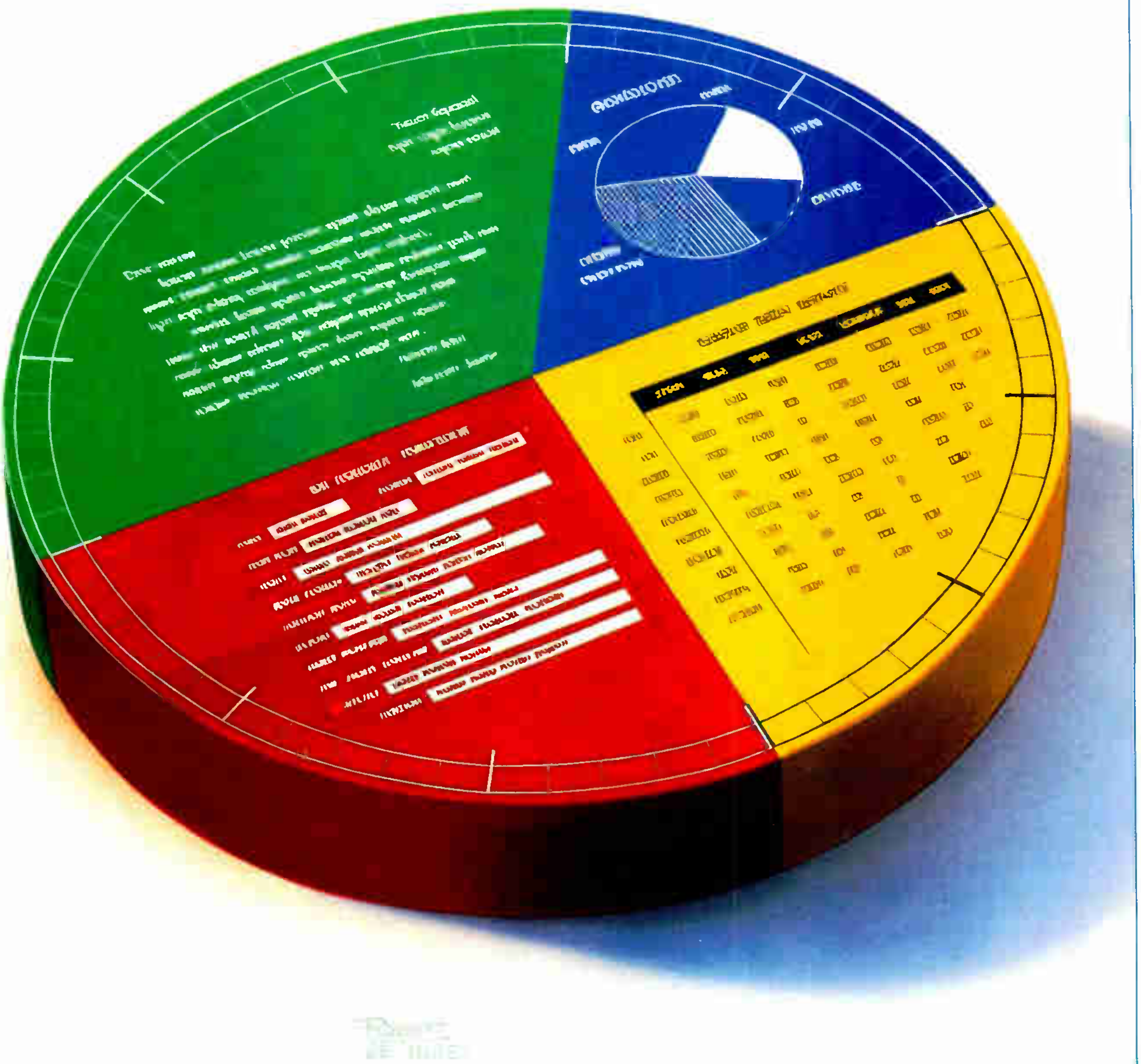
Some microprocessor chips are actually designed with multitasking in mind—in fact, with multitasking built in. The 80386 chip is one of these. In "It's a Natural," Bud E. Smith explores some of the internals that give this chip a jump on multitasking, including its hardware support for paging and virtual memory.

The 80386 machines, however, are not the only option for multitasking—not by a long shot. The Amiga comes with a multitasking system, and the Macintosh's new operating system, MultiFinder, is set up for it as well. In "Weighing the Options," Brett Glass discusses the many different systems available and contrasts and compares them by capability and by how they choose to handle the various functions of multitasking.

And, finally, Michael Benjamin Parker gives you a multitasking system with which you can experiment. In "First Come, First Served," he provides his Mailbox system, a portable multitasking environment written in C. It's user-portable to a variety of systems and operating systems. You'd have to call it a cross between ready-to-use and do-it-yourself, but we think you'll enjoy it.

Once again, microcomputers enter what was once the exclusive realm of minicomputers and mainframes—and once again, we come out the winners.

—Jane Morrill Tazelaar,
Senior Technical Editor, at Large



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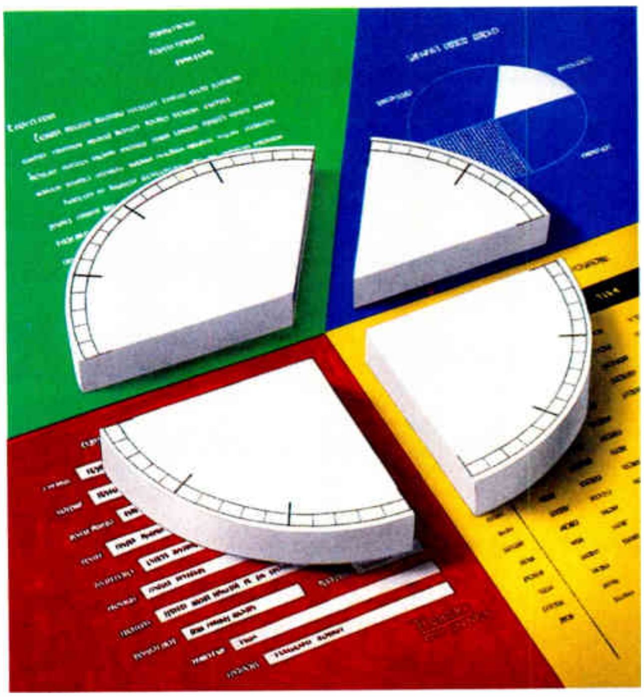
Fair Share

In a multitasking system, resource sharing determines whether your applications fly—or die

Jonathan Robie

Efficiency means different things to different people. Multitasking is a way of using the computer more efficiently by sharing both it and its resources among programs. Many different multitasking strategies have evolved, each of which optimizes those things that were most important to the designer of the system. Some approaches evolved to optimize use of the computer, others to allow certain programming problems to be more easily solved, and still others to let you keep working on the computer even when long jobs are being run.



Multitasking originated on early mainframes as a way of using expensive computer resources efficiently. When a program performed relatively slow I/O operations, it could not continue execution until the I/O operation was complete. This wasted the power of the CPU during I/O. With commercial data processing, this I/O wait time often took between 80 and 90 percent of total run time. A multitasking operating system takes the CPU from the program that's waiting for I/O and gives it to another program that's ready to use it. If enough jobs are in memory, it's possible to keep the CPU in use most of the time. This form of multitasking, called multiprogramming, provided dramatic improvements in computer throughput. But this improvement came at a cost: Although more programs could run, each one took longer to complete. During this time, most programmers longed for a computer that they wouldn't have to share.

On minicomputers, Unix provided programmers with a straightforward model for multitasking. At first, this was used mainly at the operating-system level, but programmers quickly realized that this tool could help them to simplify many complex programs.

Multitasking on micros evolved as a convenience to the user. It has become so popular that almost every modern microcomputer has an operating system or a custom program that allows some form of it. Compiling a program, downloading a file, and sorting a large table in a database all have one thing in common—they can all hog the computer for quite a while. Most of us hate to wait. Multitasking allows us to keep working while another job is being completed. Because different types of programs make different demands on the computer, it's often possible to combine several programs without dramatically slowing performance. For instance, I have found that I can do background communications with RamNet while I compile and link large programs without significantly changing the time it takes to compile and link.

continued

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Many people who have had to share a computer with others are surprised to learn that multitasking can make their work more efficient.

If I May Interrupt...

The simplest form of multitasking is called *serial* multitasking, or simple context switching. This is nothing more than stopping one thing temporarily to work on another. If you have used the Macintosh Desktop or SideKick, then you have used serial multitasking. While a program is running, you decide that you want to use the calculator, so you pop up the calculator and use it. When you stop using the calculator, the program continues running. This is analogous to how many of us do our work—while I'm programming, I often stop to answer the telephone, drink a cup of coffee, or clean my glasses. Afterward, I continue with my work.

To switch contexts, you need some way to interrupt the program that's currently executing and to remember everything necessary to continue work on it later—the program and all current data, plus all information that was in the computer's registers when the program was interrupted. This information is called the *process image*. The computer uses one or more of its registers to keep track of which program instruction should be executed next, so this information is also preserved when you save the registers. Therefore, if the program and its data are still in memory (and in the original location), then you can start the program up again by restoring the contents of the registers.

MS-DOS pop-up utilities generally use a DOS call to terminate and stay resident—that is, to remain in memory and update DOS so that it won't try to put another program in the same location. Programs that do this are called TSRs. They install a keyboard interrupt handler that looks for special key combinations. When it detects the appropriate key combination, it saves all the registers and passes control to the TSR. After you are finished with the TSR, the registers are restored and the original program continues where it left off.

Time by the Slice

While serial multitasking can help you work more efficiently, it makes the computer work much less efficiently. If the computer is performing calculations when you interrupt it, then all work on these calculations stops. If you have interrupted it for word processing or to use the calculator, you're using only a small fraction of its power, but none of the surplus capacity is used to continue work on the original program. It would be nice to give the new program only part of the computer's time and use the rest to continue work on the calculations. You could write a program called a *scheduler* to determine which program should run at any given time. But you can do this only if you can find some way to divide up time on the computer.

Virtually all multitasking operating systems run on computers that have some form of timer interrupt, which generates an interrupt at some fixed interval. On the IBM PC and its clones, this interrupt occurs about 18 times per second. On many other computers, it's in the range of 50 to 60 times per second.

You can use this timer interrupt to ensure that the scheduler gets control after each program has run for a specified period of time. This period, known as a

continued

quantum or a *time slice*, must be a multiple of the interval between timer interrupts so that you have some mechanism for enforcing it. If you give each program enough time slices every second, then it will seem as though all the programs are running at the same time, but each program will run more slowly than it would without multitasking.

Now that you can divide up the CPU time and allocate it to various programs, you have to decide how much time to give to each program and when. This is known as *processor scheduling*, and much has been written on the subject. Since you can't make these decisions without some concrete purpose, let me propose some widely accepted goals for scheduling algorithms.

- Maximize the usage of the CPU.
- Maximize the number of jobs processed in each hour.
- Finish each program as quickly as possible.
- Make sure the time required to run a given program is always consistent.
- Minimize response time for interactive users.

Unfortunately, some of these goals are contradictory. You can minimize response time for interactive users only by giving interactive use more access to the CPU, which means that programs running in the background will run more slowly. Whenever you share the CPU among a variable number of processes, you make it difficult to judge exactly how long a program will take to execute.

Scheduling algorithms are just like everything else—you have to decide what is most important and how much of the other desirable things you can sacrifice. It should come as no surprise that different systems show different sets of values and use different scheduling algorithms. I'll examine two of the commonly used scheduling algorithms, round-robin and simple priority-based scheduling.

It's My Turn

One approach is to have all processes take turns. Each process that's currently running can run for one time slice. Then it must wait until all other processes have had a turn before it receives its next time slice. This approach, called round-robin, is eminently fair. It is especially well suited for sharing the computer equally among interactive users.

The major design question in round-robin scheduling is the size of the time slice. If it's too large, jobs are forced to wait too long to support interactive use. If it's too short, the overhead of switching between programs becomes greater than the time available to run them.

VIPs Go First

A round-robin scheme assumes that all programs are equally important, but this assumption is not always useful. For instance, you may want to ensure that interactive processes have a very high priority so that you can always work on your computer even if a lot of long programs are running. In multiuser environments, priority schemes are often used to give one class of users priority over another.

In a priority scheme, each program receives a priority code. If there's only one CPU, and one program has the highest priority code, then that program receives the CPU. If several processes have the same priority code, this scheme implements a round-robin scheduling algorithm among them.

This simple priority algorithm is precisely that of the Commodore Amiga. The original implementation of Unix has a similar scheme, but all system processes are guaranteed to have priority over user processes. Unix dynamically changes the priority for user processes to ensure that interactive processes receive precedence. OS/2 uses a slightly more complicated scheme that divides tasks into several classes based on a variety of factors. Like Unix, it also changes user-process priority to favor interactive processes.

Mixing It Up

Regardless of the scheduling algorithm, it almost never makes sense to allow a process to hold the CPU while it's waiting for something to happen. Looping while waiting for an event is called *busy waiting*. It's considered a cardinal sin in the world of multitasking, because it steals valuable CPU time from other processes that could be using it. Since I/O is generally slow, programs almost always relinquish the CPU while doing I/O.

Most multitasking systems seek to keep the computer's devices busy; those systems favor processes that quickly relinquish the CPU in order to begin I/O. Since I/O can usually be performed while the CPU is doing other things, this increases throughput. If the device isn't currently available, the system remembers that it has a program that needs the device as soon as it's free.

Of course, if all programs are heavily I/O-bound, the CPU can sit idle while the programs are waiting for I/O. Multitasking systems are most efficient when there's a blend of CPU-bound programs and I/O-bound programs. In many batch-oriented systems, another scheduler, called a *long-term* scheduler, seeks to choose an appropriate blend of programs to use the computer optimally.

Block That Run

To this point, I have discussed the handling of programs. But a program may actually consist of a number of tasks that operate "in parallel" and that are scheduled separately (actually, they don't operate in parallel, but multitasking gives the illusion of parallelism). For instance, a word processor might contain one task that accepts user input and another that runs a spelling checker at a lower priority. Each task has its own memory, register image, and resources.

The terms *process* and *task* can be used interchangeably. I'll call the task that currently has the CPU a *running* task. If it's waiting for some event to occur (e.g., for an I/O operation to complete), then I'll call it *blocked*. If it isn't blocked and doesn't have the CPU, I'll call it a *ready* task (see figure 1).

Any task that's capable of running is ready. When it receives the CPU, it runs. The process that's currently running ends either because its time slice is done or because it's blocked when it requests I/O or a resource of some type. In the first case, the process is ready again; in the second, it's blocked. In general, a number of programs will be ready or blocked at any particular time, but only one program will be running. (If the system has more than one processor, it's considered a multiprocessing system, and one task may be running on each processor.)

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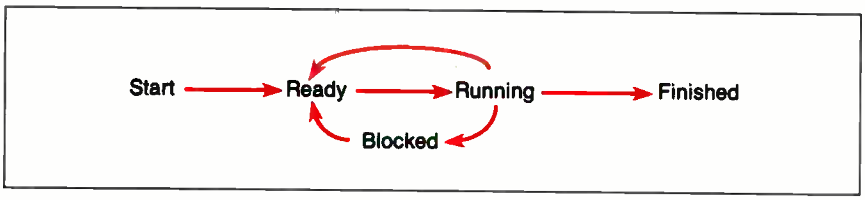
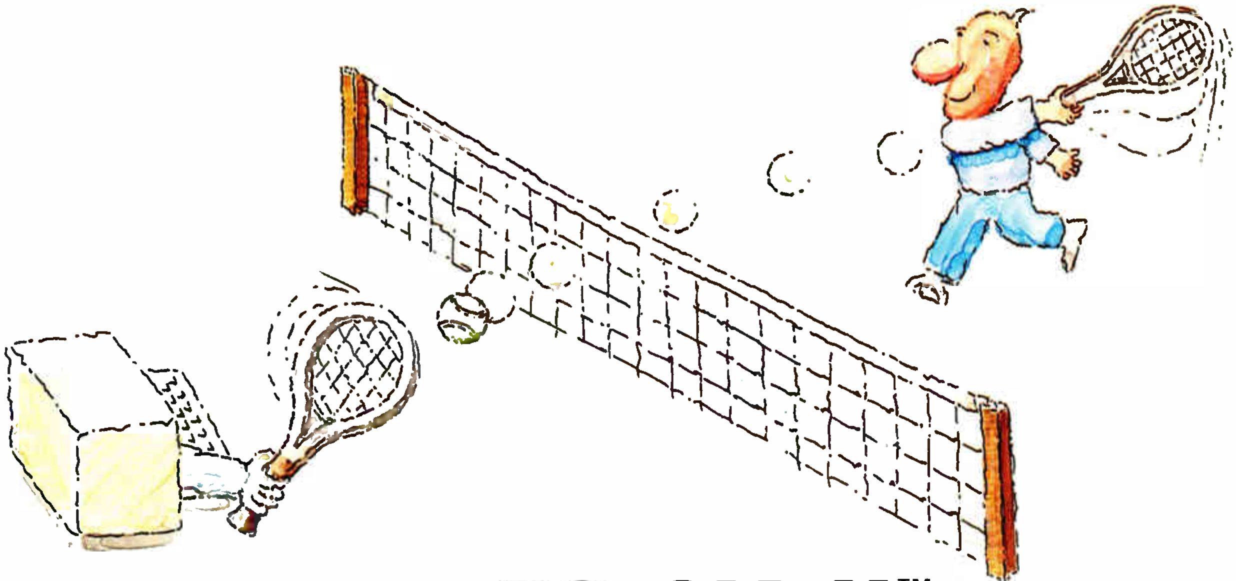


Figure 1: *The various state changes that can occur as a task proceeds from start to finish.*



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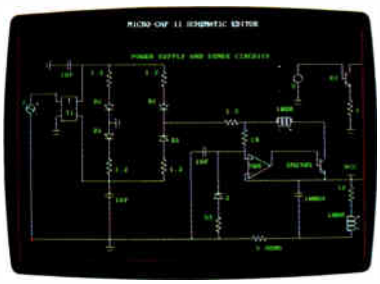

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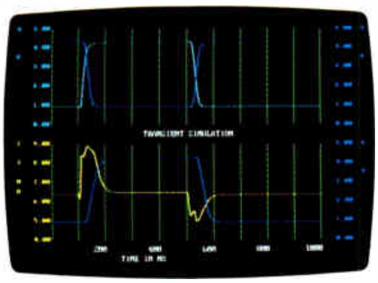

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Off to the Races

Tom Wagner

When one task starts to write a message to the screen, you want it to finish before another task starts to write its display. This contention is known as a *race condition*: If the first task loses the race, weird things can happen. For example, the single C statement `printf()` initiates the execution of a great many assembly language statements, so it's likely that another task's `printf()` may interrupt them; if it does, the screen will display a garbled mess of characters.

Critical regions are regions of code for which it is critical that they not be reentered by other tasks while they are still active. You have to build some form of protection into your system so tasks will mutually exclude each other from entering a critical region in parallel.

One possible form this protection can take is the use of a lock variable (see listing A). Each task that wants to enter a critical region must first check the lock variable. If it's already set, the task waits (and gives up its time slice) for the task currently using the critical region to clear the lock. Then the task sets the lock and enters the critical region. After processing, the task clears the lock.

When you examine listing A closely, you'll discover another race condition. Suppose the task is interrupted between `while (lock)` and `lock=1`. Both the current task and the waiting task will see the lock as zero, and both will enter the critical region. One remedy to this situation would be that shown in listing B: You first set the lock and then check to see if it was already set. If it was, you reset the lock to its prior state.

This code might work on the 8086 processor series, which has increment- and decrement-memory instructions. But the same routine executed on an IBM RT PC or a similar reduced-instruction-set-computer processor will fail, since the `++lock` and `lock--` expressions expand to more than one processor instruction. If the tick interrupt occurs between the LOAD and STORE instructions, both tasks will again find the lock free and enter the critical region.

A number of complicated solutions have been devised for this, most notably by Dekker and Peterson. They address the problem by providing additional variables to check for interruption and to restrict write access to a variable to a single task. However, these solutions are based on the principle of busy waiting. In a real-world multitasking system, you would never allow busy waiting, due to its inherent shortcomings. The most obvious of these is the waste of processor time; the most serious is the possibility of deadlock. In a prioritized system, the task with the higher priority will run if it's ready. If one of the two tasks vying for a critical region has a higher priority than the other, it will wait forever for the lock to be cleared, since the task that could clear it is never scheduled. (For a further discussion of deadlock, see the text box "A Deadly Embrace" on page 236.)

To solve the deadlock problem, every preempting multitasking kernel that deserves the name provides at least one task-blocking mutual-exclusion construct. Task blocking means that the task no longer receives processor time; it is marked as waiting for a specific event. Only if and when this event occurs is the task awakened.

In CTask, the appropriate construct for this example would be the resource. [Editor's note: *CTask is a public-domain multitasking package written in C by Tom Wagner. It is available with full source code in the ibm.arc area on BIX under the name ctask.arc.*] The kernel makes sure that only one task can own a resource at one time. All other tasks that request the resource while it's busy are blocked. When the resource is released, the waiting task with the highest priority is unblocked and assigned the resource (see listing C).

Naturally, race conditions exist in requesting and releasing resources as well. But in all kernel routines, the multitasking system provides the necessary mutual exclusion, so the user doesn't have to worry about it. On the kernel level, this is usually done with interrupt disables, since the time spent in the kernel routines is relatively short. Using interrupt disables in user routines to implement mutual exclusion, however, might prove fatal to overall system operation. If you disable interrupts for too long, overruns, which usually lead to the failure of critical system services, may occur.

There is an often-overlooked alternative to these mutual-exclusion concepts. Device drivers are commonly used to access peripheral devices, but you can easily expand the driver concept to en-

Talk to Each Other

Multitasking evolved as an operating-system construct, but it's also an extremely powerful model for building complex software systems. By using multitasking primitives, you can leave the actual intermingling of separate tasks to the programming environment and program at a higher conceptual level.

You might use this capability to write a telecommunications package for commercial bulletin board services like BIX. Since connect time is expensive, it's best to log in and out of the bulletin board as quickly as possible. The program should log in, collect all messages into a file, download the file, and log out. Unfortunately, downloading tends to be slow, forcing the program to wait. Since reading and commenting to messages is even slower, you'd like to be able to do these functions while the download is occurring. This would give you the feeling of an interactive system with the connect-time charges of a batch download.

Without a multitasking environment, this would be complicated—you'd need to determine when to call the routines for downloading, viewing, and commenting. This kind of program is hard to structure well without multiple tasks.

In a multitasking environment, the solution is somewhat simpler. You can create two tasks: The first dials the bulletin board, downloads the data, and logs out; the second displays the messages and lets you add responses with a special editor. You can then activate the first task again to post your responses in the appropriate places on the bulletin board.

These two tasks need to communicate if they are to work effectively. For one thing, they'll both be writing information to the status line; if these messages become intermingled, the display will be confusing (see the text box "Off to the Races"). If you establish a semaphore for the status line, you can ensure that only compass other shared-data problems. *Resource drivers* can enforce mutual exclusion without blocking tasks.

One device driver in CTask is a printer driver. The user task writes data to the driver's input pipe, and the printer-driver task handles the port I/O to actually write the characters to the printer. If you wanted to implement spooling—that is, ensure that a file is completely printed before another task has access to the printer—you could create and request a printer resource. However, this would mean that all other tasks that want to print a file would be blocked while your file prints; this isn't usually desirable. Instead, you can provide a spooler task. Tasks place the names of the files they want to print in the spooler task's mailbox. Only the spooler has direct access to the printer driver; it will wait while the printer's pipe buffer is full, and the other tasks can continue with more useful work.

To ensure that only one task writes to the screen at a time, you may want to delegate screen writing to a screen-resource task. The original tasks no longer call `printf()` directly, but send messages to the screen-resource task telling it what data to write. Thus, the original tasks can continue with other work; they need not be concerned with synchronizing screen usage.

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Listing A: *To enter a critical region of code, you first check the lock variable to see if it's already in use.*

```
   int lock = 0;
   ...
/* wait for lock release */
   while (lock)
      schedule();
   lock = 1;
   printf (...);
   lock = 0;
```

Listing B: *To avoid one race condition, you first set the lock variable, then check to see what it was before you set it.*

```
  C Code                  80x86                    RISC Processor

while (++lock > 1)   xx0: INC  lock           LOAD     REG,lock
   {                      CMP  lock,1         INC      REG
                          JLE  xx1            STORE    lock,REG
                                              COMPARE  REG,1
                                              JLE      xx1
   lock--;                DEC  lock           DEC      REG
                                              STORE    lock,REG
   schedule ();           CALL schedule       CALL     schedule
   }                      JMP  xx0            JMP      xx0
printf (...);        xx1: ...                 ...
lock--;
```

Listing C: *Only one task can own a resource at one time, so you request it just before you use it and release it immediately afterward.*

```
resource screen_resource;
...
request_resource (&screen_resource, 0L);
printf (...);
release_resource (&screen_resource);
```

one process will use the line at a time.

The second type of communication is more interesting and more complex—the display task must receive all its data from the telecommunications task; this task must tell the display task when new data arrives and how much there is. It might also communicate other information about the status and format of messages.

For this kind of communication, either *mailboxes* or *pipes* would be appropriate. Different systems use these terms somewhat differently, and a full discussion would have to delineate differences in terminology. For my purposes, I'll use the terms generally to indicate a means of passing messages from one task to another.

The Amiga accomplishes message passing with messages and ports; OS/2 and Unix do it through pipes of various sorts. Any full-fledged multitasking system must provide a way for tasks to exchange messages.

Finally, the telecommunications task must deliver the downloaded messages to the display task. You could do this with a single file, but that could be slow if you're exchanging large amounts of data. You could also do it through a pipe or a mailbox, which would be faster. Or you could use shared memory, which is faster yet; this is what OS/2 uses. Two processes can share a segment of memory so the display task can have access to a memory buffer used by the telecommunications task.

The task scheduler specifies when to call each task. Since download protocols are time-critical, it's essential to give the telecommunications task a priority that's high enough to execute promptly. You will also want a rapid response time. Balancing priorities is essential to the operation of this system. Using the multitasking system gives you added flexibility—most hard-coded solutions to this kind of

continued

A Deadly Embrace

When tasks are running, they need access to disk drives, memory, printers, and other resources. The operating system grants these resources to a task, which generally holds them until it's done with them. Since each task competes with others for the same resources, it's likely that one task will have the resources needed by another. It's also possible to allocate resources in such a way that it becomes impossible for any task to proceed. This condition is known as *deadlock*.

Suppose two tasks each read images from a scanner into a file on a hard disk. While a task is reading, it has exclusive access to the scanner and to the disk. Now suppose that the first task has the scanner and the second has the disk. The first cannot proceed until it obtains the disk, and the second cannot proceed until it obtains the scanner. This is deadlock.

The resource allocation graph is one way of showing which processes are holding which resources; computer representations of this graph are used to detect deadlock. It also provides a basic model for discussing the algorithms used to combat deadlock. This graph has two kinds of nodes: Tasks are shown as circles, and resources are shown as squares. Arcs between the nodes indicate requests for resources and the resources being held. A cycle in your resource graph means deadlock is possible (see figure A).

Deadlock occurs only when you let tasks hog resources even though they can't use them to finish execution. This happens only if some resources are restricted to being held by one task at a time. Also, deadlock can't occur unless you let tasks hold a resource while they wait for additional resources held by others. If you require that a task relinquish all resources when it is denied a resource request, deadlock cannot occur. (Unfortunately, this tends to destroy system performance for many programs.) Further, if your multitasking system preempts resources from some tasks in order to grant them to others, you can always prevent deadlock.

In the detection-and-recovery method, the multitasking system keeps track of the resource-allocation graph. If it finds cycles in the graph, it kills as many processes as necessary to eliminate the deadlock condition.

If deadlock happens quite rarely, many people prefer to do nothing at all. This is known as the *ostrich* algorithm: Put your head in the sand and ignore the problem. This is precisely what most microcomputer multitasking systems do. All deadlock detection, prevention, and avoidance algorithms increase system overhead, and many times you don't want to pay this price. Most computers have special hardware support for the ostrich algorithm—the on/off switch.

Deadlock is guaranteed to bring your entire system to a grinding halt. All the approaches mentioned here impose significant overheads, so when deadlock is rare, some people would rather face the risk than try to find a way to avoid it.

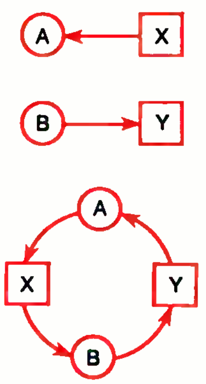

Figure A: *Deadlock will occur if and only if a cycle exists in the resource-allocation graph.*

problem don't easily let you change priorities or modify the relationships between modules.

Share and Share Alike

When computers were very expensive, multitasking maximized the number of programs you could run. When computers became less expensive, multitasking made programmers more efficient by giving them a better programming environment and a better programming model. In the user-oriented world of microcomputers, multitasking lets you make more efficient use of your time.

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Jonathan Robie is a freelance systems consultant working in Berlin, West Germany. He can be reached on BIX as "jrobie."

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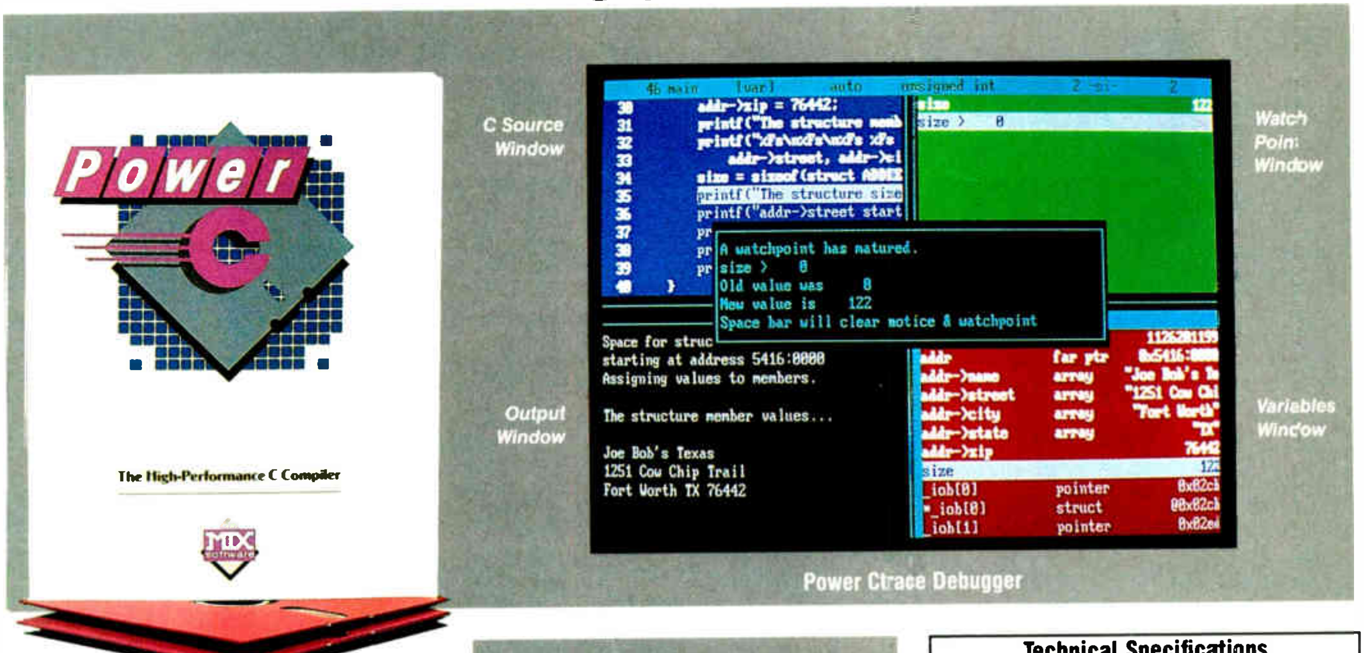

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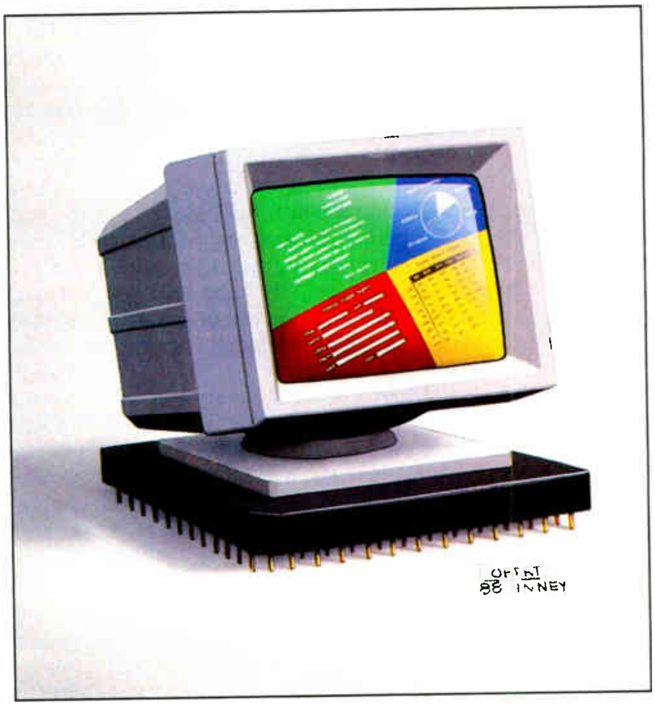
It's a Natural

The 80386 was designed with multitasking in mind —and it shows

Bud E. Smith

The 80386 is a natural for multitasking. With a speed of up to 4 million instructions per second and capabilities like paging and virtual memory support built into the chip, microcomputers built around Intel's 80386 processor have many capabilities of minicomputers and mainframes. And much of the work done to optimize those computers, such as support hardware and efficient, capable operating systems, applies to 80386 machines.



Multitasking

The 80386 allows multitasking of several different operations at once, while still viewing at each application as if it were running on a simple, single-function computer. In a "task switch" on the 80386, program X controls the entire system for a while, then, based on some "trigger" such as elapsed time, the processor (in conjunction with the operating system) saves the values of all program X's registers in an area of memory called a *task-state* segment (TSS). Then, the processor reloads the registers from the TSS of the program that's taking control, program Y. When execution proceeds, program Y is in control, and program X is waiting to be called again.

For multitasking, the 80386 recognizes several data structures, which are stored in a standard form for quick handling, and a special register, the task register (TR), which points to the current task. The TSS, which is a special kind of segment, is always at least 26 doublewords long. It has room for copies of all the 80386's registers, including EFlags and EIP, the instruction pointer. It also contains a 16-bit pointer to the TSS that previously had control in case there is a need to return to it. This pointer is useful when the current task is a subordinate task (like an exception handler) that has been called by the previous task and, when finished, must return control to it.

All segments have descriptors that contain necessary information about them, including location, size, and privilege level. A TSS has a special descriptor. Its limit, or length, must be at least 103 bytes (104 if an I/O permission map is used; the last word of the TSS contains a pointer to it). Longer limits let you use bigger TSSes, but you must define the values in the additional bytes. TSSes are not reentrant; if a task is busy (based on the available bit in the segment descriptor), you can't start it again.

There is also a task-gate descriptor (see figure 1). The task gate is a short data structure that allows access to a TSS (other gates allow access to other data structures). The descriptor privilege level (DPL) field contains the task gate's privilege level. A procedure must op-

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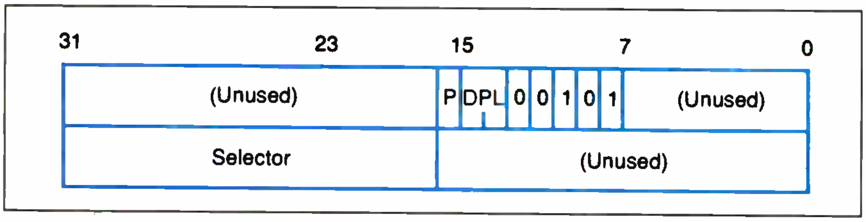

Figure 1: *The task-gate descriptor. A procedure may gain access to a task through a task gate rather than the task-gate segment. Once it passes the privilege-level check at the task gate, no further protection checking takes place.*

erate at a privilege level as high as or higher than that of the task gate to access it. If a procedure meets this criterion, the selector lets it access the TSS without further protection checking. In other words, a procedure that couldn't normally access a given TSS through the TSS descriptor may be able to reach it via a task gate.

Unlike the TSSes, the task-gate descriptor can be kept in a local data table and be visible to some procedures, such as interrupt and exception handlers. This process allows flexible access to a task, which can have several task gates, each accessible to different procedures and each having a different privilege level, but all sharing the same selector field.

In addition to these software structures, the 80386 has a register dedicated to multitasking—the TR register. Its upper 16 bits are visible and contain a selector that points to the current TSS descriptor. Most of the TR register, however, is invisible. The hidden part holds a 16-bit TSS base and a 16-bit TSS limit. The TR acts as an on-processor cache so the processor can access these fields quickly when a program references the current TSS.

Using these elements, the processor can switch between tasks in 268 clocks (about 17 microseconds on a 16-MHz system). If it did no other work between task switches, this would allow nearly 60,000 of them per second (not counting operating-system overhead). In other words, the processor can make many task switches per second and still have plenty of time left in which to execute programs.

A task switch is triggered when a `jmp` or `call` refers to a TSS descriptor or a task gate, when an interrupt or exception points to a task gate, or when the current task executes an `iret` and sets the nested-task (NT) flag. If the NT flag is set, the processor uses the pointer to the previous TSS, which is stored in the current TSS, to bring back the calling task.

The processor makes several checks for privilege level and for the presence in memory of the current TSS; if it's "paged out" (stored on disk by a virtual-memory operating system), an exception occurs. If the checks are passed, the processor saves the current task's registers in the current TSS. Then it loads the TR register with the selector of the new TSS and the rest of the registers with the new information. Finally, the task-switched (TS) bit in the machine-status word is set to alert coprocessors that a task change has occurred.

80386 à la Mode

The 80386 operates in one of two modes: *real* and *protected*. In real mode, one operating system and one program run at a time; this system is compatible with PC- and AT-style programs but uses little of the power of the processor other than its sheer speed. To the operating system and the programmer, the 80386 in real mode seems much like a fast 8086/8088 with additional instructions and registers but with the same 1-megabyte memory limit. (To avoid redundancy, I will use "8086" to mean 8086/8088 for the rest of this article.) An 80386 microcomputer running DOS operates in real mode.

The alternative to real mode is protected mode, which has two "flavors": 80286 protected mode, and 80386 protected mode, also known as 80386 native mode. In 80286 protected mode, the processor uses the 24-bit addressing and 16-bit data-element size of the 80286. An 80386 microcomputer running OS/2 operates in 80286 protected mode. 80386 protected mode, or native mode, offers access to all the capabilities of the 80386: multitasking, paging, virtual memory, and so on.

While the processor is in native mode, individual tasks can run in virtual 8086 (V8086) mode, which provides an 8086-style environment just as real mode does. This task can be a single program with or without a copy of its own operating system. Meanwhile, the 80386's operating system and other programs are running in protected mode and thus have access to all its capabilities.

An 8086 operating system, like DOS 2.x or 3.x, can run as a task in V8086 mode. While this task is running, you can start up, run, and exit nearly any program that runs in real mode, such as Turbo Pascal or Lotus 1-2-3. This creates a situation in which an operating system is running as a task under the 80386's own operating system, which handles paging, virtual memory, and priorities among all the tasks running together. To avoid confusion, I'll call the 80386's own operating system a *hypervisor* to differentiate it from any other operating system that may be running under it. The hypervisor lets you set priorities and switch control among the different tasks in a multitasking environment.

Operating Room

Instead of the 64K-byte segments of the 8086, the 80386 allows segments as large as 4 gigabytes each. You have a great deal of flexibility in managing memory, but the operating system determines the possible memory structures. An 8086 operating system (or any 80386-real-mode or V8086 program) running on the 80386 imposes the 64K-byte segment limit of the 8086 on it. Even an 80386 operating system may impose arbitrary restrictions to maintain compatibility with existing code or to simplify its work.

The 80386 can support a totally unsegmented and unprotected memory model. If you set all the segment registers to 0 and give each segment a limit of 4 gigabytes, the instruction pointer, stack base, index pointer, and data pointers can all refer to the same 4-gigabyte area, so you can intermix them at will. This is called a *flat-memory* model. A flat-memory model has only one segment: in this case, a 4-gigabyte segment. It is available on the 80386 only in protected mode. This setup isn't necessarily good for all applications, but it does, for instance, let you port Unix-type operating systems (which generally use a flat-memory model) directly to 80386-based systems. This configuration will attract ports of many operating systems and large programs from minicomputers.

The important difference between operating systems for this processor lies in the amount of access they provide to the potential power of the 80386. Many different levels of capability exist. The simplest level is a *control program*, a hypervisor that lets one or more V8086 tasks run under one or more copies of an 8086 operating system. To extend this initial model, a hypervisor can support virtual

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memory (the 80386 has built-in support for swapping variable-size segments or fixed 4K-byte pages), mixing 80386 native mode and 8086-type programs, and other features. (For more details of the paging process, see the text box "Page By Page.")

This level lets several V8086 tasks run at once. When multitasking, however, the hypervisor may need to trap all accesses to instructions that change the interrupt flag; otherwise, one program can hang the entire system. The operating system can also turn such trapping on and off or offer it as a user option. The hypervisor can be a single-user multitasking system, a multiuser system with each user running one task, or even a multiuser multitasking system. The hypervisor must either require that the computer have enough physical memory to support all tasks, or use virtual memory (which utilizes a hard disk for page or segment swapping). The individual tasks, however, are still V8086 tasks that don't use the full power of the 80386.

A full-featured hypervisor would include multiuser and multitasking support with virtual memory and let 80386 protected-mode programs run along with the V8086 tasks. It would include a full operating system to handle system calls by the protected-mode programs.

Despite the support given by the 80386, an operating system with all these capabilities is difficult to write. There are many decisions to make, such as which pages to have in memory at any given time, and which pages to overwrite first when memory fills up (called "page-replacement strategies"). Debugging such an operating system is also a large task. Only when such a system is available, however, will programmers be able to tap the full power of the 80386.

Virtual Memory ad Infinitum

At this point, we should review virtual memory on the 80386. In general, virtual memory gives programs access to more physical memory than the computer actually has. The amount of free space on the hard disk can be seen as main memory, and RAM can be seen as a holding area for the code and data that the processor is currently using. The number of bits in the largest address that a processor can construct determines the size of its virtual address space.

An advanced processor like the 80386 has two different address sizes: A large address determines the virtual address space, or the amount of memory that you can access; a smaller address determines the real address space, or the amount of real memory that the processor can support. On the 80386, the address information in paging tables allows a virtual address space of 64T bytes (over 64 trillion bytes). This is equivalent to 64,000 1-gigabyte CD-ROMs. (As a point of reference, one copy of every book ever printed would require fewer than 64,000 CD-ROM disks.)

The real address space on an 80386 can be directly accessed with a 32-bit address, with or without paging, allowing access of up to 4 gigabytes of real memory. However, these limits exceed the reach of current hardware. In practice, real addresses are used to access RAM, and virtual addresses are used to address large spaces for convenient systems and large applications programming.

Some large programs already use a simple form of virtual memory. In this form, a core part of the program remains resident in memory while the rest of it is divided up into sections of about 64K bytes each. As different parts of the program are accessed, these sections, or "overlays," are brought in from disk. However, dividing a program into overlays and managing their swapping in and out of memory is a big chore.

In the 80386's virtual memory, every program, data file, and so on is seen as a series of 4K-byte "pages." The real address space, RAM, is divided into 4K-byte "page frames," and the virtual address space, the hard disk, is divided into 4K-byte "page slots." The paging capability of the 80386 is one of its most interesting and novel aspects, yet it is completely a tool of the operating system and invisible to the application programmer. However, it will probably be the main tool used to access large amounts of actual memory, and it is vital to the operation of V8086 mode. (80286-based operating systems such as OS/2 use segment swapping instead.)

As different parts of a program are accessed, different pages are brought from their page slots on disk to page frames in real memory. When real memory is full and a new page is needed (i.e., the system is "overcommitted"), the processor overwrites an existing page frame so long as it hasn't been changed since it came into memory; if it has been changed, the processor copies the page frame out to its page slot on disk before overwriting it. All this takes place invisibly; the program simply accesses code and data at different virtual addresses, and the processor and operating system cooperate to bring the page into memory when it's actually needed.

The 80386 processor supports virtual memory with its abilities to access large address spaces, translate virtual addresses into real addresses for accessing real memory, and cause an exception if a "page fault" occurs (a needed piece of code or data is not currently in memory); it also supports virtual memory with instructions that can be restarted if a page fault prevents their completion.

This is a lot for a processor to do, but much of the work is still left to the operating system. When a page fault occurs, the operating system must get the desired page from disk and bring it into memory. When memory is full, the operating system must write an existing page to disk, if necessary, and then overwrite the page frame with the desired page.

How much real memory do you need to support a given amount of virtual memory? Estimates based on existing work vary from 1 megabyte of RAM per megabyte of external storage, to the 80/20 rule: 80 percent of virtual address space must be backed by real RAM. The important issue is the size of the "working set" of each program. If each program in an overcommitted system accesses a large number of pages repeatedly (i.e., has a large working set), the operating system will have to access the disk frequently for more pages, causing "page thrashing." For example, repeatedly recalculating large spreadsheets while doing a large compile or sort at the same time might well cause page thrashing.

Preserving Your Environment

On the 80386, you can run V8086 tasks that duplicate the 8086 environment, and then 8086 programs and operating systems can be run in those tasks, but 80286 and 80386 operating systems can't be run as tasks under an 80386 hypervisor. That is, the 80386 can "virtualize" the 8086, but it cannot virtualize the 80286 or itself.

In other words, the 80386 can run 8086-style operating systems under itself, but not OS/2 or Xenix 286 as guest tasks. However, it can run this type of program as its sole operating system; the processor will emulate an 80286 completely and won't have the capabilities of the 80386, such as paging, multitasking, and so forth. Thus, these operating systems are only stopgaps until the development of true 80386 operating systems.

When the 80386 runs in real mode, it acts like a fast 8086. When it runs an 80286 operating system, it acts like a fast 80286. But when it runs a V8086 task, the operating system and native-mode tasks running concurrently with the

continued

Page by Page

An 80386 page is a 4K-byte piece of memory. Pages are placed at locations, called *page frames*, whose addresses are 4K bytes apart (0, 4K, 8K, and so on). A data item that starts at one of these 4K-multiple addresses is said to be "aligned on a page boundary." Only the first 20 bits of a 32-bit page address are significant; the last 12 are always 0. When virtual memory is in use, pages are swapped between disk and memory as needed. The 4K-byte sections on disk that hold pages are called *page slots*.

Paging doesn't have to be used at all; in real mode, it can't be. A bit in the MSW, which is inaccessible to real-mode and application programs, allows paging to be on or off.

However, paging is an almost irresistible tool for a systems programmer, since it provides an easy way to assign almost any actual address to replace the linear address calculated by a program. Nearly all 80386 operating systems will do at least some paging.

Let's Get Physical

The *physical address* is the address that comes out of the paging unit. (The 80386 is divided up into functional pieces called *units*. Each has its own function, which is described, in brief, by its name: prefetch, instruction decode, control, timing, execution, segmentation, paging, and bus units.) When paging is off (or even sometimes when it's on), the linear address from the execution unit that goes into the paging unit is the same as the physical address that comes out. However, the process of translation is complicated and can affect every aspect of the system.

A physical address has three parts: a 10-bit directory (`dir`) entry, a 10-bit page entry, and a 12-bit offset. They generate a physical address in the following way:

The 32-bit CR3 register holds the address of the current page directory. The low-order 12 bits of CR3 are always 0s, because the page directory always starts on a page boundary. The 10-bit `dir` value from the linear address points to the page-directory entry (PDE).

The high-order 20 bits of the PDE point to a page table (12 low-order 0s are added to make a 32-bit linear address). The 10-bit page value from the middle of the linear address points to the page-table entry (PTE).

The high-order 20 bits of the PTE point to a page frame (12 low-order 0s are added to make a linear address). The 12-bit offset value from the low-order bits of the linear address points to the location in memory.

The PDEs and PTEs are nearly identical. Figure A shows an entry like that found in either table. Bit by bit, this is how it breaks down:

- *Paging address (bits 31 through 12).* For a PDE, this address points to a page table; for a PTE, it points to a page. The low-order 12 bits of the address are always 0s, since both page tables and pages are aligned on 4K-byte boundaries.
- *Operating system reserved (bits 11 through 9).* These bits are available for the operating system to use. Typically, it might use them to keep statistics on virtual memory and page swapping—such as the number of times a page has been accessed in a given period.
- *Bits 8 and 7.* These bits are set to 0.
- *D (bit 6).* This is the "dirty" bit for a PTE; when the page is written to, the D bit is automatically set to 1.
- *A (bit 5).* This is the "accessed" bit for both a PDE and a PTE; when the page is read from or written to, the A bit is automatically set to 1.
- *Bits 4 and 3.* These bits are set to 0.
- *U/S (bit 2).* This is the "user/supervisor" bit. If it's set to 1, then user access is allowed, and programs with a protection level of 3 (the lowest level) can access the page.
- *R/W (bit 1).* This is the "read/write" bit. It works in conjunction with the U/S bit. If U/S is 0, then R/W doesn't really matter: The page can be neither read from nor written to by nonprivileged code. If U/S is 1 and R/W equals 0, then the page can only be read from; if U/S and R/W both equal 1, then it can be written to as well. U/S and R/W are meaningful for PDEs and PTEs. An individual page's protection depends on the *most restrictive pair* of bits from its PDE and PTE.
- *P (bit 0).* This is the "present" bit that indicates whether or not the PDE or PTE points to a page currently in memory. If the P bit is 1, the rest of the bit fields defined here mean what they say. However, if the P bit is 0, the desired page is on disk, and the remaining 31 bits in this descriptor-type record can be the location of the page slot on the disk that has the page.

Each page directory has up to 1024 entries, allowing that many page tables. Each page table can point to as many as 1024 pages, each 4K bytes long. This means that a single page directory can address 1024 × 1024 × 4096 bytes, or 4 gigabytes (the entire physical address space of the 80386).

While the PTE contains a lot of useful information about a page, it's very hard to get to; you need two memory accesses just to get the address of each page. The translation look-aside buffer (TLB) in the paging unit contains the 32 most recently used PTEs. The TLB often has the desired PTE, eliminating the need to actually look at the memory-based tables over 95 percent of the time.

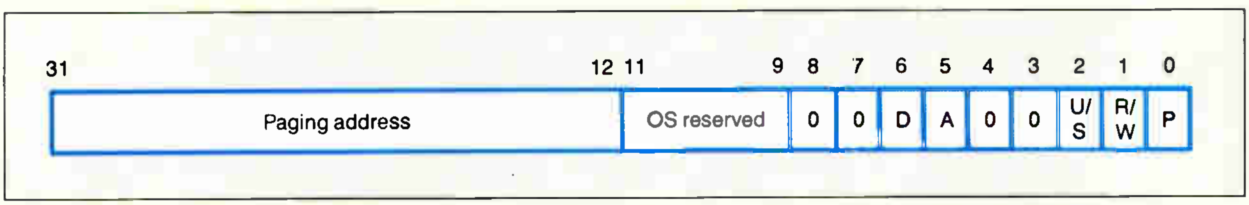

Figure A: *Page-directory entry and page-table entry layout. PDEs and PTEs are almost identical, but a PDE points to a page table, while a PTE points to a page.*

V8086 task have access to the full power of the 80386. The V8086 task doesn't need all these powers; it just wants to think that it has its own 8086-based computer.

If multitasking is going on, the V8086 task may be slower than it was in real mode, because it's not running all the time. Even if it's the only task running, it is still one more system layer away from the processor. Many DOS calls result in task switches to the hypervisor, which must determine what has happened and what to do before it returns control to the calling task. Many lines of code outside the task may execute between the call and the return, increasing the time it takes for the application to execute. The exact effect on a particular application depends on which DOS calls the hypervisor traps—and how many of them there are—and which ones it doesn't.

When a hypervisor supports multiple V8086 tasks, it must use paging, because each task produces addresses in the same range: from 0 to 1 megabyte. Paging remaps most of these addresses to physical addresses beyond 1 megabyte, helps the various tasks share the hypervisor, and protects the I/O areas from direct access by a V8086 task.

The Power of Paging

Operating systems that allow some degree of multitasking on the 8086 have problems with ill-behaved programs. For example, to update the video display, a well-behaved program calls the operating system to write to the screen. However, this is a slow process. An ill-behaved program writes directly to the screen map in memory, which is a much faster process. It can cause problems, however, when two programs run at once, one in the foreground where the user interacts with it, and one in the background. The foreground program controls the video monitor, if running full-screen, or the foreground window in a windowed system.

The operating system can intercept any calls from a well-behaved background program to the monitor. But if the background program writes directly to video memory, its results appear on the foreground screen, or it "crawls out" of its window.

On the 80386, a multitasking operating system can use the paging tables to remap the background task's direct accesses to video memory. Now the background task updates some other area of memory; the operating system controls the actual video memory and thus completely controls what appears on the screen.

A Machine of Your Own

A virtual machine extends the concept of virtual memory to the entire computer: the keyboard, the monitor, the register set, everything. A program acts as if it had the whole machine to itself—in the case of virtual 8086 mode, an entire 8086-based computer. When a program calls on system resources—for example, writes to the video RAM—the 80386's hypervisor can take one of three actions: let the write execute, trap the call and perform some other write itself, or not do the write at all, before it returns control to the calling program.

For example, if a well-behaved 8086 assembly language program (running under DOS 3.1 in V8086 mode) wants to write `Hello` on the screen, it issues an `int 21`, and DOS executes a write to the screen. However, DOS is running as a

continued

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V8086 task, which has a privilege level of 3. The I/O area has a privilege level of 0, so the DOS write causes a protection exception.

The interrupt vector initiates a task switch to the hypervisor's TSS, which must decide what the V8086 task is trying to do, emulate it (by doing the actual write or by ignoring the attempt), and then return control to the V8086 task. The more of this intercept-and-decide work there is, the slower the program becomes as it tries to perform I/O or use other system resources.

In V8086 mode, addresses are created with the 1-megabyte limit of the 8086. The 8086-style address is sent to the paging unit, which can map it to any page, either in memory or out on disk (in other words, virtual memory). Thus, the operating system can enforce page-based protection whenever a V8086 task is running; it can also support virtual memory for several V8086 tasks at once with the paging unit and page tables. This type of protection checking and simulation can occur whenever the 80386 runs multiple tasks.

How does V8086 mode fool the program into "thinking" that it's running on a 16-bit 8086 instead of a 32-bit 80386? When a V8086 task begins executing, bit 17 of the EFlags register, called VM, for virtual mode, is set. This bit tells the 80386 to generate addresses and handle segments for this task the same way it would if the whole machine were in real mode. So, the processor generates addresses by shifting the proper segment register four positions to the left, adding the appropriate 16-bit offset, and then using the result as a memory address, exactly as on an 8086. This 20-bit number can address a maximum of 1 megabyte of memory.

The VM bit also tells the processor that the current task can access only the lower 16 bits of the 32-bit registers. This means that a V8086 task cannot access the VM flag in bit 17 of EFlags. Also, the VM bit tells the processor not to accept certain privileged op codes; only 80386 real-mode instructions and address modes, an extended version of those found on the 8086, are allowed to execute.

The 80386's real mode functions in a similar way. When the protection-enable bit in the 80386's machine status word (MSW) is not set, the machine is in real mode, and the 16-bit addressing and op code restrictions described for V8086 mode apply. The difference is that the MSW controls the whole machine, while EFlags controls only the current task. In protected mode, the hypervisor and other protected-mode tasks can use privileged instructions and address modes, while the V8086 task cannot.

Dressed for Success

From virtual memory and paging to virtual machines, the 80386 is designed for the multitasking world. As the operating systems to take advantage of its capabilities are written, we will begin to see not just the already obvious speed increases, but the real power of the 80386. ■

Editor's note: *This material is adapted from* Programming the Intel 80386 *by Bud E. Smith and Mark T. Johnson. Copyright © 1987 Bud E. Smith. All rights reserved. By permission of Bud E. Smith.*

Bud E. Smith is technical writing manager for IGC (Santa Clara, California), makers of the VM/386 control program.

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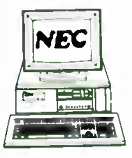

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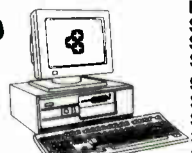

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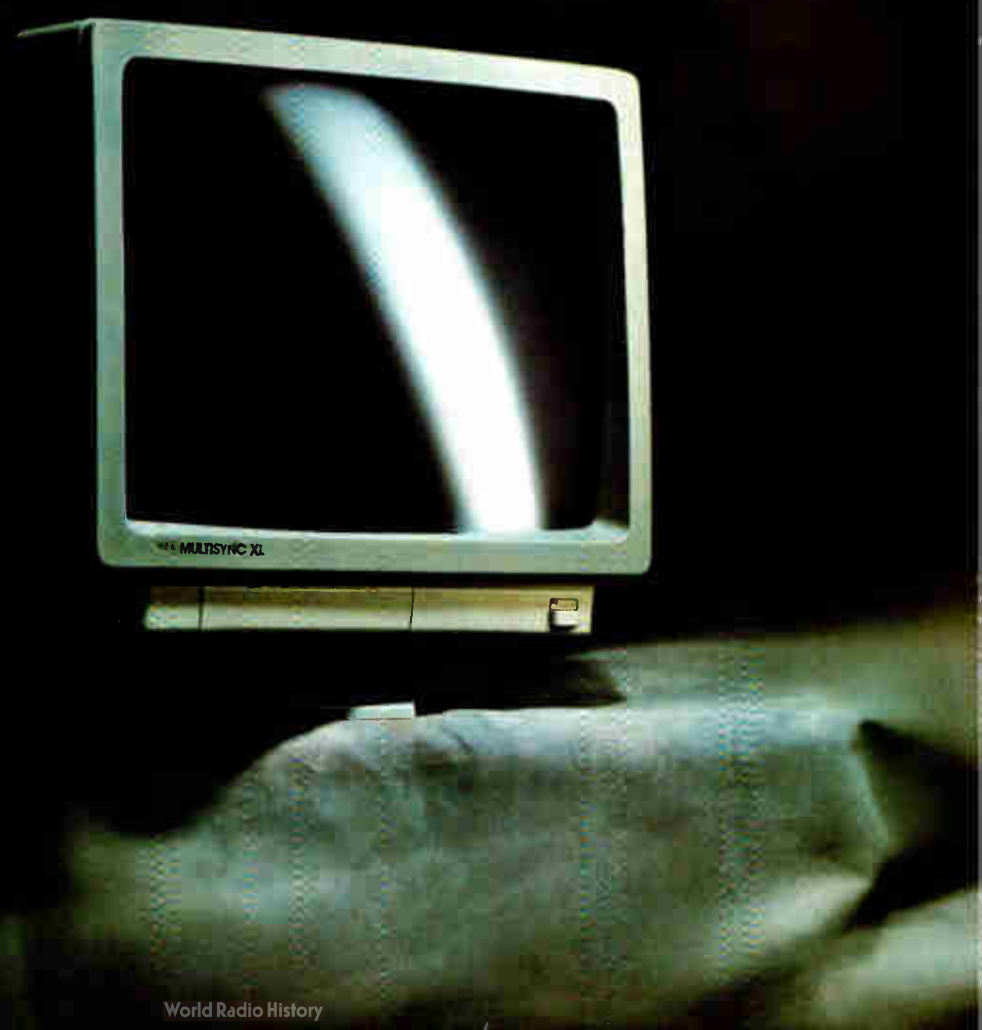

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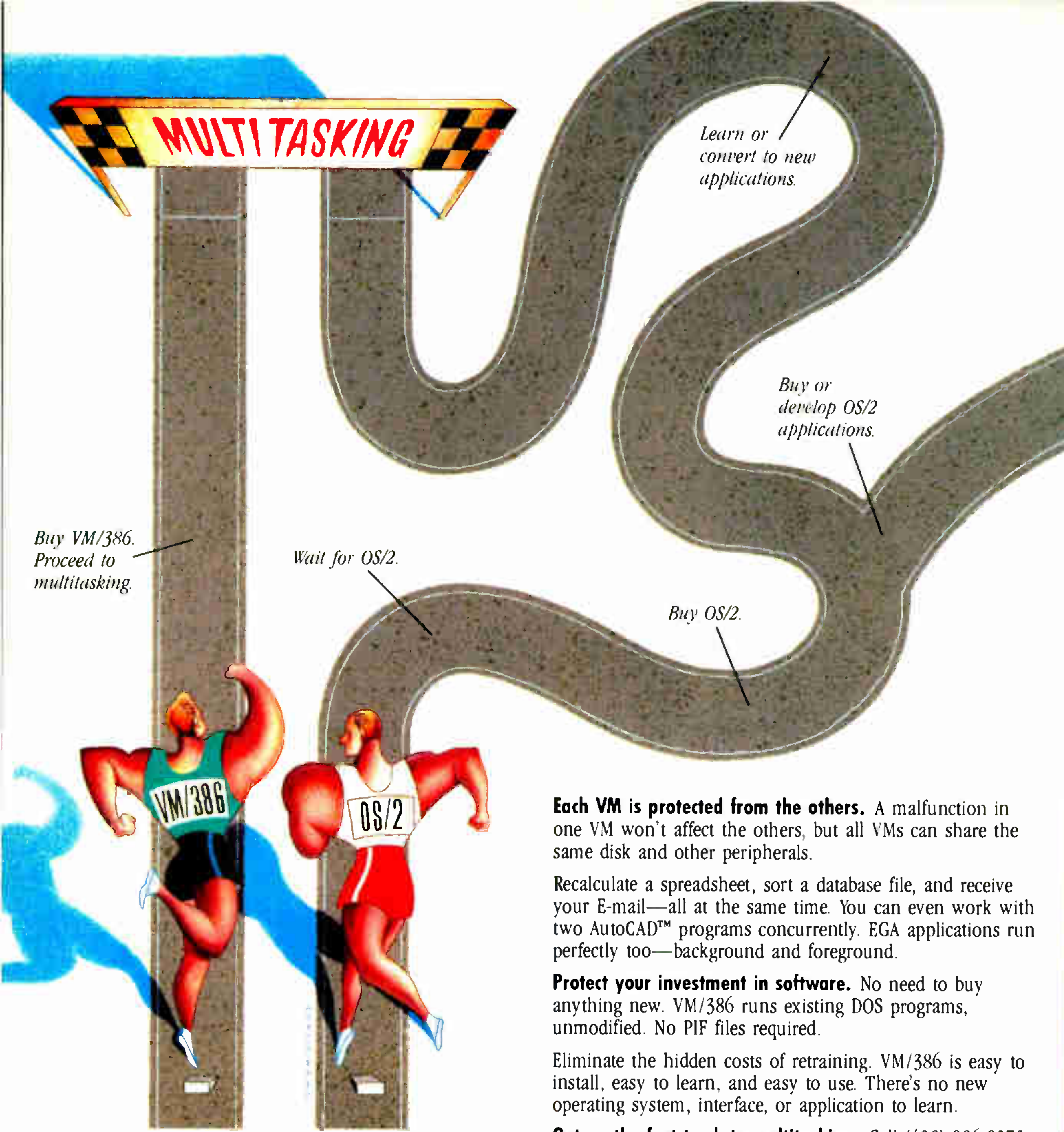

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Weighing the Options

Comparing the many flavors of multitasking

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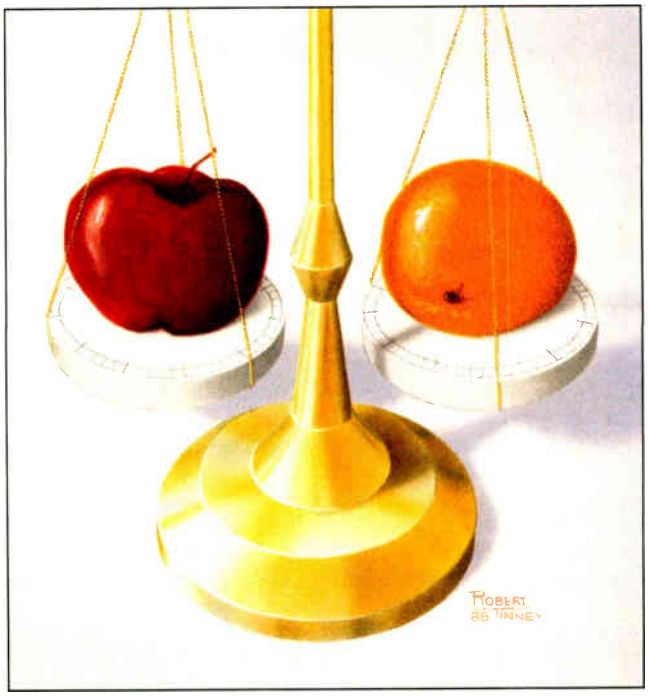

Broadly defined, multitasking is the ability to execute more than one program, or many copies of the same program, at the same time. Long the domain of expensive minicomputers and mainframes, this ability has now become a desirable feature for all computer systems, regardless of size or cost.

Multitasking in mainframe computers was a product of economic necessity: Computing power was too scarce and expensive a resource to be wasted. However, in the microcomputer world, the move to multitasking has been driven primarily by a desire for greater convenience and increased personal productivity. In this article, I'll explore the features and limitations of some of the most popular multitasking environments available for personal computers today.

Contrary to what you might think, multitasking is not a new development on small personal computers. As early as the mid-1970s, vendors offered environments such as Cromemco's Cromix, a Unix-like operating system hosted by a 4-MHz Z80 with bank-switched memory. But the overwhelming majority of microcomputers available today, such as the IBM PC and the Apple Macintosh, weren't designed originally with full multitasking capabilities in mind.

For these systems, the technology that allowed concurrent use of several programs evolved in three stages: desk accessories (termed TSRs in the IBM PC world from the MS-DOS terminate-and-stay-resident call), program switchers, and complete add-on multitasking environments. At the same time, manufacturers (and, in some cases, innovative third parties) began to reengineer existing hardware and software to multitask smoothly by design, rather than as an afterthought.

Add-On Program Switchers

The first personal computers ran a single program at a time. If you were, for instance, running a database program and wanted to make a quick change to a word-processing document, there was no way to do it other than to save your work, quit the database application, enter the word-processing program, and bring up the document. On floppy disk-based computers, this might require a change of disks, and would certainly take enough time to let you forget the inspired idea you were going to add to the document.

Clever developers perceived this problem and began to come up with solutions. The result was a small program called a *desk accessory* that could instantly "pop up" when needed, regardless of what application was running. Examples of these

continued

Table 1: *The multitasking environments compared.*

Features	"Add-on" multitasking environments			
	Windows 2.0	**Windows/386**	**DESQview**	**MultiFinder**
Scheduling	Cooperative	Preemptive	Preemptive	Cooperative
Run "ordinary" applications?	Yes	Yes	Yes	Yes
In windows?	No	Yes	Any with 80386; some otherwise	Yes
Background execution	Windows applications only	Yes	Any with 80386; some otherwise	Specially written applications
Memory protection	No	Yes	With 80386**	No
Memory management	Purgeable code segments and resources; can swap inactive DOS applications to disk, EMS, and EEMS; dynamic link libraries		Can swap inactive DOS programs to disk, EMS, and EEMS	Purgeable code segments and resources
Interprocess communication				
Semaphores	No	No	Yes	No
Pipes	No	No	No	No
Queues	No	No	Yes	No
Messages	Yes	Yes	Yes	No
Signals	No	No	No	No
Named Pipes	No	No	No	No
Shared Memory	No	No	Yes	Yes
Sockets	No	No	No	No
Other	DDE	DDE		AppleTalk***
Windowing environment?	Yes	Yes	Yes	Yes

* SCO Xenix and Microport Unix for the IBM PC support optional packages that run DOS applications within the Unix environment. Apple's A/UX provides limited support for access to Macintosh tools.
** DESQview requires the use of QEMM (Quarterdeck Expanded Memory Manager) or CEMM (Compaq Expanded Memory Manager) to take full advantage of the 80386 microprocessor.
*** Under MultiFinder, it is possible for tasks on the same machine to communicate with one another via AppleTalk. This mechanism can be used to pass a handle to a block of memory on the system heap, allowing further communications through shared memory.

programs are SideKick for IBM PCs, and the MockWrite desk accessory for the Macintosh.

Although these desk accessories didn't allow the main program to run while they were on the screen, they let you save that inspired thought to a file without quitting your database, or could pop up the day's schedule without leaving your word processor. The limited but useful capabilities of desk accessories made their users ask, "If a small program can be made to 'pop up' when needed, why not a full application of my choice?" Developers once again responded with a new class of utility: *program switchers*.

A program switcher lets you switch quickly between two or more applications without reloading each program or saving your work. Each of these utilities allows switching among several programs, although it's important to note that the program switched in "owns" the entire machine while it runs, while those programs switched out are inactive. Examples include Andy Hertzfeld's Switcher for the Macintosh, and a number of programs for the IBM PC, such as Jason Loveman's Multiple Choice, SoftLogic Solutions' Software Carousel, and Quarterdeck's DESQ.

Finally, programmers began to address the formidable task of making multiple programs appear to run not one at a time, but concurrently, on the same system. These environments are called *add-on multitaskers*. Apple's MultiFinder began as a program switcher that simply switched programs repeatedly (and very quickly), and was refined later to perform more "intelligent" multitasking. In the IBM PC world, TopView, Wendin-DOS, Microsoft Windows, and DESQview made some multitasking possible (subject to architectural limitations). The 80386's appearance in IBM-class machines finally makes multitasking of existing applications possible in environments such as PC-MOS/386, Windows/386 and DESQview.

Multitasking By Design

While some developers struggled to do multitasking with programs that were never written to share a machine with another application, others were developing new and complete environments that were designed from the beginning to run multiple applications concurrently. On the IBM PC were ports of Unix and PICK, two well-established minicomputer multitasking environments, and new systems such as OS/2.

Because of its complexity and the proprietary nature of its internal workings, fewer third parties have attempted to develop new operating environments for the Macintosh. However, the new Mac II, if equipped with the proper resources

"Native" multitasking environments

Unix	OS/2	Amiga
Preemptive	Preemptive	Preemptive
Some versions*	One at a time (Compatibility Box)	N/A
No	No	N/A
Yes	Yes	Yes
Yes	Yes	No
Full virtual memory; code sharing	Full virtual memory; code sharing; dynamic link libraries	Shared code libraries, fonts, and other resources
Yes	Yes	Yes (signals)
Yes	Yes	Yes (add-on device)
Some versions	Yes	No
No	Presentation Manager only	Yes
Yes	Yes	Yes (software interrupts)
Yes	Yes (LAN Manager)	No
Some versions	Yes	Yes
Yes	No	No
Varies	DDE With Presentation Manager	Yes (Intuition)

and memory management chip, runs a version of Unix supplied by Apple known as A/UX.

Many of the multitasking systems for existing machines support some mechanism for running one or more "old" applications, so that you can migrate gracefully from one environment to the other. Microport's Merge 386 and Phoenix Technologies' VP/ix 386 each let MS-DOS applications run under their respective versions of Unix for the IBM PC. QNX, a Unix look-alike for the PC, supports MS-DOS as a task. The OS/2 Compatibility Box lets you run a single MS-DOS application together with multiple new applications. And Apple's A/UX provides a limited ability to launch conventional Macintosh applications from the Unix environment.

Finally, there are the newest machine/operating-system combinations where multitasking is a feature from the time the hardware is designed. Most prominent of these in the microcomputer world is Commodore's Amiga. With special graphics hardware tailored to support tasks running in multiple screens and windows, the Amiga is at least partially responsible for the rush to bring multitasking to other PCs.

What's the Difference?

The words *multiprogramming*, *multiprocessing*, and *multitasking* are often confused. Before continuing, I want to draw some distinctions between these similar, but distinct, terms.

The term *multiprogramming* refers to the situation in which a single CPU divides its time between more than one job. Time-sharing is a special case of multiprogramming, where a single CPU serves a number of users at interactive terminals.

In *multiprocessing*, multiple CPUs perform more than one job at one time. Multiprocessing and multiprogramming are not mutually exclusive: Some mainframes and superminicomputers have multiple CPUs, each of which can juggle several jobs.

Some sources consider multitasking equivalent to multiprogramming. Others define it as any situation that involves multiprogramming, multiprocessing, or some combination of the two. For the purposes of this article, I'll use the term *multitasking* to describe any system that runs, or appears to run, more than one application program at one time.

An effective multitasking environment must provide many services, both to the user and to the application programs it runs. The most important of these are *resource management*, which divides the computer's time, memory, and peripheral devices among competing tasks, and *interprocess communication*, which lets tasks coordinate their activities by exchanging information.

Sharing the CPU

The key resource that all multitasking environments must manage, or schedule, is the use of the CPU itself. While there are many schemes that can be used to distribute CPU time among the different tasks within a system, all fall into two major categories: preemptive and nonpreemptive scheduling.

In preemptive scheduling, a task may lose control of the CPU at any time, and another task is made to run instead. The task that loses control, or is *preempted*, need not know that this has occurred; in fact, it may not even be aware that it's running in a multitasking environment. This is accomplished by system hardware and software that's designed to fool the task into thinking it owns the machine.

Most preemptive-scheduling algorithms give interactive tasks larger and more frequent time slices so that they can respond rapidly to a user's request. Because the level of interaction can vary in different parts of the same program (e.g., a spreadsheet requires a high level of interaction during data entry, but none during recalculation), many environments are designed to monitor the current behavior of each task and adjust its time slice appropriately.

In nonpreemptive scheduling (also called cooperative multitasking), a task that gains control of the CPU continues to do so for any amount of time until it explicitly yields control to the next task. While nonpreemptive schedulers are usually very simple to implement, they

continued

are generally not as robust, or tolerant of errors, as preemptive ones. With nonpreemptive scheduling, a task that fails to relinquish the CPU—due to a software bug or a hardware problem—locks up the entire system, destroying all the data used by every task. Also, a task that yields control too infrequently to other active tasks causes the entire system to appear sluggish. In practice, nonpreemptive scheduling works best when enforced either by the compiler that creates the program or by rigorous program design standards.

Last but not least in the area of time management, a scheduler must determine which task is to run next, and for how long. A preemptive scheduler can interrupt a task when there is something more important to be done (say, to service a peripheral device), and both preemptive and nonpreemptive schedulers can determine how often each task is given a chance to run. Generally speaking, it is desirable to give the task that occupies the frontmost window in a windowed environment priority over those in other windows, since this improves the responsiveness of the system as perceived by the user.

At the other extreme, multitasking systems must also prevent "starvation," the condition in which a task never runs because its priority is set too low. OS/2, for example, sets a maximum amount of time for which a task, regardless of priority, can languish without gaining control of the CPU.

Sharing Memory

Besides sharing CPU time, all multitasking environments must help applications share available RAM with one another. The three main functions that an environment can provide include storage allocation (required on all machines), storage overcommitment (also called swapping or paging), and protection (available only where the hardware permits).

In a multitasking system, each task must be relegated to a specific part of memory, and each task must not attempt to manipulate storage belonging to other tasks without permission. In systems designed from the ground up, tasks are expected to ask the operating system for memory before using it. In add-on multitasking environments, the system often "lies" to a task, telling it that the system has less memory than it actually does. Thus, a task that commandeers all available memory still runs correctly. Some systems also provide the ability to temporarily halt a task and copy its memory to disk, which makes room for other tasks while the first one is dormant.

When a task interferes with others by directly accessing key parts of a machine's hardware (such as the screen), it may not be able to run simultaneously with other applications in a multitasking environment. Both Microsoft Windows 2.0 and DESQview (without an 80386) allow such applications to be "switched" on and off, either swapping them to disk or leaving them inactive in RAM when they are not in use.

Besides sharing CPU time, all multitasking environments must help applications share available RAM with one another.

Making a task dormant and swapping its memory to disk is a primitive form of storage overcommitment—that is, running more tasks than can fit in RAM at one time. However, to overcommit storage without suspending at least one task usually requires a special piece of hardware known as a memory management unit (MMU). Popular personal computers that contain MMUs include the IBM PC AT, AT compatibles, and the Macintosh II (as an extra-cost option). The IBM PC XT, all Macintosh machines developed prior to the Mac II, and the Amiga do not contain MMUs.

An MMU facilitates storage overcommitment by quickly and automatically detecting when a program tries to access information not in RAM. When it sees such an access, it activates special software that reads the needed information off the disk, then restarts the program where it left off. The program that attempted to make the access isn't aware that anything unusual has happened. Execution continues exactly as if the data had been in RAM all along, although perhaps a bit more slowly.

Some systems without an MMU, such as Windows on a PC and the Macintosh, have a limited ability to overcommit storage. The memory occupied by certain parts of the code ("segments") and by blocks of data that do not change ("resources") can be deallocated, or purged, and reused for other purposes.

Another useful function in multitasking systems is memory protection—that is, preventing programs from reading or modifying RAM that doesn't belong to them. This protection contains the damage done by a crashed program, and usually the information being manipulated by other programs survives intact. An MMU also provides memory protection of this level.

The 80386 microprocessor contains particularly powerful facilities for memory protection. Many "ill-behaved" programs (i.e., programs that take over some or all of the IBM PC's hardware) can safely be contained within a virtual machine and prevented from interfering with other applications. DESQview, Microsoft Windows/386, Merge 386, and VP/ix all use this facility on a single 80386-based machine to multitask IBM PC programs (and, in the latter two, Unix applications).

Finally, multitasking systems also control access to resources such as printers, serial ports, disk files, and the computer's screen. Often, a system spools printer output by saving the information generated by each program and printing it separately rather than enforcing exclusive access. (*Spool*, by the way, stands for "simultaneous peripheral operation on-line.") Parts of disk files can be locked to prevent simultaneous access by more than one task. Also, the screen can be divided into windows so that you can simultaneously view the output of many programs.

Interprocess Communication

A multitasking environment becomes vastly more useful if the tasks, or processes, can communicate with one another. While the number of possible communication mechanisms is infinite, a relatively small number have gained wide acceptance. These include semaphores, pipes, queues, messages, signals, named pipes, shared memory, and sockets.

A semaphore is simply a variable (an integer or a yes/no flag) that can be read, incremented, or decremented by more than one process. Most implementations provide a means to attempt to change the variable and retrieve its original value in a single indivisible operation; this feature is necessary to prevent "race conditions" when two processes attempt to manipulate the semaphore at the same time.

A pipe is a mechanism that allows a stream of characters from one task to be passed to another in order. Pipes are a one-way communication mechanism: Data always flows from the write end of the pipe to the read end of the pipe. Pipes are often used to feed the output of one application directly to another as input; the Unix, MS-DOS, and OS/2 command-line interpreters can connect long strings of applications via pipes to accomplish complex tasks.

Queues allow larger blocks of data, usually records larger than one character, to be passed between applications in order. Queues are often used to implement other interprocess communication mechanisms, such as messages.

Many multitasking environments have facilities through which applications can exchange messages—blocks of data with a format defined by the system or the applications involved. The exact formats and semantics of messages vary widely from system to system.

A signal (sometimes called a software interrupt) tells a task to drop what it is doing and immediately handle an asynchronous event. Usually, this is done by executing a special piece of code called, logically enough, a signal handler. Most multitasking environments that implement signals will terminate an application at once if it receives a signal it is not prepared to handle. In the jargon of some systems (like the Amiga), the term *signal* is used to describe what I have defined earlier as a semaphore.

Named pipes are similar to pipes in that they let tasks exchange data a character at a time. Unlike ordinary pipes, however, they can also support the transmission of larger blocks of data, be used across a network, or carry data in both directions (like a pair of ordinary pipes). In systems that implement named pipes, ordinary pipes are often called anonymous pipes to make a clear distinction between the two.

Most multitasking systems provide a way for two tasks to share a common block of memory, and this is perhaps the fastest form of interprocess communication. When shared memory is used, other mechanisms (such as semaphores) are often useful to arbitrate access to the common area. Shared memory is rarely (if ever) available to processes communicating over a network—a constraint that limits its usefulness in some situations.

Versions of Unix developed at the University of California at Berkeley contain a useful interprocess-communication mechanism called sockets. Similar in some ways to named pipes, sockets let a process on one networked computer start a program on another, feed that program input, and collect the output. This feature has proved useful enough that it will likely be implemented in all versions of Unix (and perhaps other operating systems) in the future.

Some Real-World Environments

So far, I've covered most of the points required to understand the inner workings of many real-world systems. What products are available, and what are the capabilities of each?

While a thorough description of any one system could (and often does) fill several volumes, I'll survey some of the most popular multitasking environments for personal computers and discuss how they support some of the facilities mentioned above (see table 1).

Microsoft Windows 2.0

Microsoft Windows 2.0 provides a windowed, graphical user interface and limited multitasking capabilities on the IBM PC and compatibles. The interface conforms to IBM's Systems Application Architecture (SAA) standard, which means that it has the same appearance as the forthcoming OS/2 Presentation Manager.

Applications written specifically to work with Windows run in windows and participate in nonpreemptive multitasking. Some other MS-DOS applications—mostly those written to be compatible with TopView—can be run in Windows, but only one at a time. But for poorly behaved DOS applications, Windows 2.0 can serve only as a program switcher. Windows-specific applications can communicate with one another via a message-passing scheme; no other interprocess communication facilities are provided. TSR programs cannot be run in a Window, but a number of "desktop applications" are provided, including the traditional calendar, calculator, notepad, and clock, as well as simple paint and draw programs.

Windows uses message passing to implement a unique high-level protocol called Dynamic Data Exchange (DDE). Using this protocol, applications can send data to one another on the fly, so that a spreadsheet, for instance, could continually be updated with information that enters the system via a communications program.

Microsoft Windows 2.0 uses a number of unique methods to manage storage. Applications can share the code in dynamic-link libraries: routines linked to

continued

Because it runs in protected mode, OS/2 can often catch errant applications before they crash the machine.

the application automatically when it is loaded. Parts of Windows applications as small as a single procedure or function can be marked as "discardable" and swapped in or out as needed. In addition, conventional MS-DOS applications can be swapped to and from disk.

Microsoft Windows/386

Microsoft Windows/386 provides the same user interface as Windows 2.0, but it uses the virtual 8086 mode of the 80386 processor to let any MS-DOS application run in a window concurrently with other programs. Multitasking is preemptive. All programs can also run in the background without user intervention.

The 80386 architecture provides memory protection; an application that fails cannot crash the entire machine. As in Windows 2.0, interprocess communication is done via message passing.

DESQview

DESQview, by Quarterdeck Office Systems of Santa Monica, California, is billed as a multiwindow integrator. Designed to run on all members of the IBM PC family and compatibles, DESQview's capabilities vary depending on the features of the specific hardware used.

When running on a non-80386 system, DESQview tries harder than Windows 2.0 to make many ill-behaved programs run in windows. Using loaders to apply special patches to programs such as Lotus 1-2-3, it gains the ability to run them in windows. As with Windows 2.0, any MS-DOS program can be run if it is given the full screen and complete control of the processor.

On an 80386 system, DESQview can join forces with another program from Quarterdeck, QEMM (Quarterdeck Expanded Memory Manager) to run each program in a virtual machine. As with Windows/386, this allows any application to run in a window.

Multitasking in DESQview is preemptive, with priority given to the task running in the frontmost window (the foreground task). The DESQview API (Application Program Interface) provides interprocess-communication facilities, including queues, message passing, and signals.

DESQview can use extended or Expanded Memory Specification (EMS) memory to store itself and your application programs, but it works best when as much RAM as possible is EEMS (enhanced EMS, also known as LIM 4.0). However, if you do run out of RAM, you can deactivate an application and swap it out to disk. Some applications, such as communications programs, cannot be retired to the disk in this manner.

OS/2

OS/2, developed jointly by Microsoft and IBM, is a multitasking operating system designed from the ground up specifically for 80286-class machines. It provides preemptive multitasking and a vast range of application services, as well as the ability to run a single MS-DOS application in a special environment known as the Compatibility Box. When augmented by the OS/2 Presentation Manager (to be available during the second half of 1988), OS/2 provides a user interface and multitasking capabilities similar to those of Windows/386, plus powerful facilities for networking, all on a standard 80286 machine such as the IBM PC AT.

Scheduling in OS/2 is performed according to a complex, stratified scheme. Each *thread*, or task, can fall into one of three categories: time-critical, general, or low-priority. Within the general priority category, there are additional sublevels, the highest of which are assigned to tasks that are interactive and in one of the frontmost (foreground) windows. In addition, there are mechanisms to prevent "starvation" and to boost perceived system throughput.

OS/2 implements a vast assortment of interprocess-communications mechanisms (IPCs), including semaphores, pipes, queues, named pipes, shared memory, signals, messages, and DDE (as in Windows). With the possible exception of Unix, no operating system comes with as many IPC facilities built-in as OS/2.

OS/2 implements storage overcommitment for all applications as needed (except in the Compatibility Box).

Because it runs in protected mode, OS/2 can often catch errant applications before they crash the machine. Unfortunately, because the Compatibility Box does not run in protected mode, a misbehaved DOS application can hang the entire system.

Unix

Unix, the granddaddy of modern multitasking systems, is the only environment in this group that was also designed to be multiuser. Virtually all Unix implementations can accept users at terminals as well as the main console.

Unix and its look-alikes are available for many varieties of machines. Apple's A/UX implements Unix on the Macintosh, while Microport and Phoenix Technologies (among others) are the leading suppliers of Unix for IBM PC AT compatibles.

Unix does scheduling by measuring how long each process in the system runs before it stops to perform I/O. Any task that runs for a full time slice without performing any input or output is considered to be hogging the CPU and is given a lower priority. Conversely, a task that does a great deal of I/O gets a higher priority, not only because it has not used much of each time slice, but because perceived performance improves if the keyboard, screen, and disk appear to respond quickly.

IPCs vary from version to version of Unix. However, those most commonly used include semaphores (implemented through the file system), pipes, and signals. Also available in many implementations are shared memory, sockets, named pipes, and more esoteric facilities such as streams and remote procedure calls (used across networks).

Amiga Exec/AmigaDOS

Multitasking on the Amiga is managed by the Amiga Exec, a high-performance multitasking kernel. Together with AmigaDOS and the rest of the Amiga ROM Kernel, Exec manages tasks on a strict priority basis. The Amiga windowing system, Intuition, provides user interface facilities.

Interprocess communications on the Amiga is based on three mechanisms: signals (which are really semaphores), message passing, and software interrupts (similar to what I called signals above). Because of the "lean and mean" nature of the Amiga systems software, interprocess communications must be done with care; sending a signal or a message to a nonexistent task will crash the machine. If used properly, however, the speed of interprocess communications on the Amiga approaches the theoretical limits of the 68000 microprocessor.

MultiFinder

MultiFinder runs on the entire Apple Macintosh line of computers and performs nonpreemptive multitasking on Macintosh applications. By trapping system calls and carefully managing memory, MultiFinder can allow up to 30 applications to run concurrently in windows on the Macintosh screen. The application that owns the frontmost window has the highest priority. Each task relinquishes control when it calls `SystemTask` or `GetNextEvent`. According to the Macintosh programming rules, tasks should call these functions at least 60 times per second. Task switches cannot occur during file operations.

MultiFinder allows only two IPCs: the AppleTalk network (which allows intramachine as well as intermachine communications) and shared memory. Shared memory must be carefully managed so as not to corrupt the system heap space. MultiFinder offers no memory protection, since only the Mac II has an MMU.

Choose Your Environment

The microcomputer world has evolved drastically in the past few years, in terms of both hardware and software. No longer is it merely a matter of higher hardware performance that sells a microcomputer: Hard looks are being taken at how well the computer's operating system performs. Can the software improve your productivity by switching rapidly among several programs all at once? Can you download a lengthy report from the office while working at home in your word processor?

Vendors plan to move slowly so that users can adapt to the powers of the new operating systems and phase out ill-behaved software. Microsoft's OS/2 provides the familiar DOS interface while allowing you access to multitasking capabilities. Apple plans to upgrade MultiFinder and release improvements every 6 months.

Nevertheless, microcomputer multitasking is still in its infancy. Not everyone needs it: You may be content to run in single-user mode, squeezing out every iota of performance from your microcomputer without incurring the penalty in overhead required by multitasking. If you do need the capabilities that multitasking provides, no matter what machine you use, as you can see, you have a choice. ■

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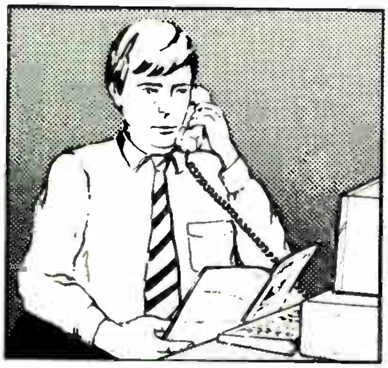

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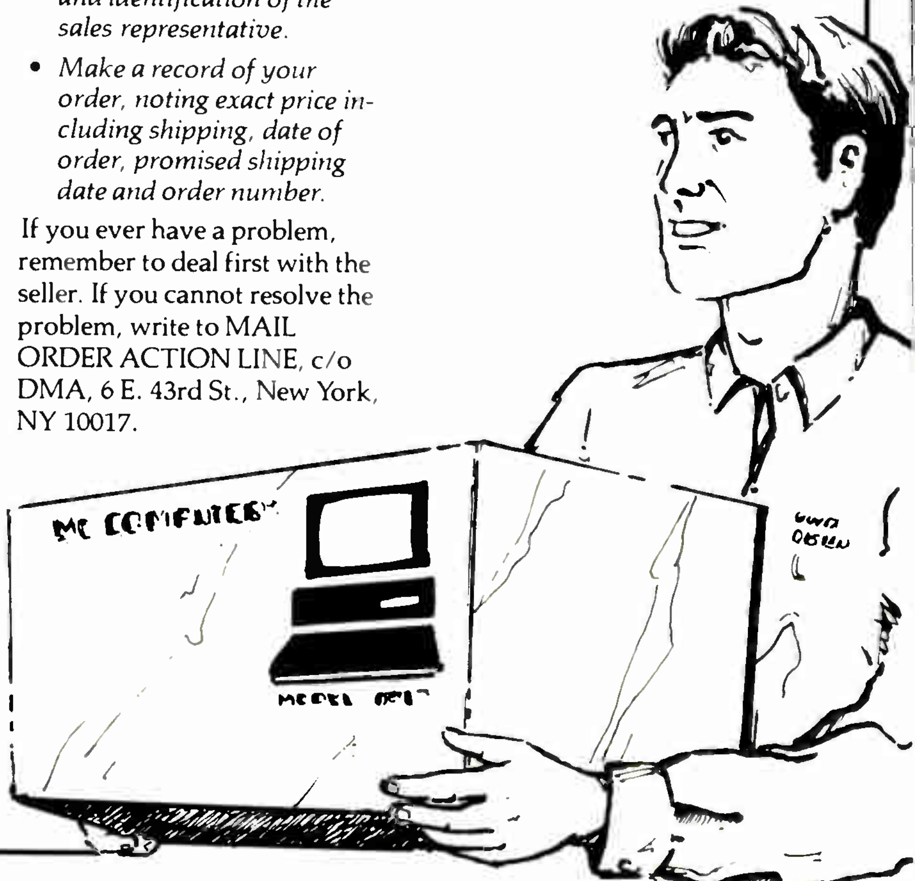
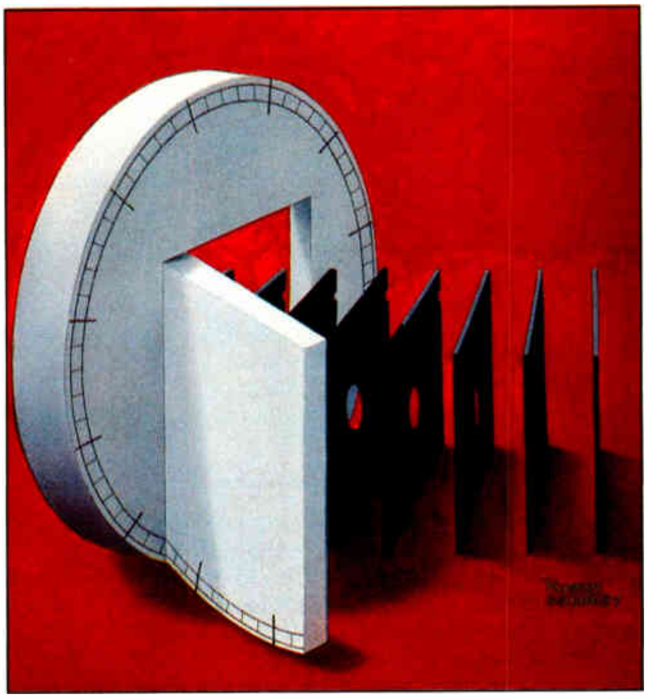


First Come, First Served

Mailbox is a portable multitasking environment written in C

Michael Benjamin Parker



Mailbox is an *environment*, not an operating system. It does not provide the file, memory, and other resource management functions required of a complete operating system. However, it does provide a multitasking environment for the programs that you write with it.

With Mailbox, you can write multitasking programs that are portable to many different machines and operating systems. Because the code for Mailbox is easily ported and its interface is the same on all machines, your own multitasking code can also be portable. What's more, if the machine has multiple processors, your program can take advantage of them.

Traditionally, multitasking, when available, has been a function of the operating system and usually machine-specific. Macintosh MultiFinder, for example, provides some multitasking support, but the programs that use it are limited to the Macintosh. Microsoft's OS/2 provides an impressive library of multitasking functions, but OS/2 is highly IBM PC AT specific. Although Unix provides portable multi*processing*, the operating system is usually found only on workstations and mainframes; also, its common Berkeley Standard Distribution (BSD) processes are big and "expensive" and cannot share memory. See table 1 for a comparison of the features of some of today's multitasking systems for microcomputers and workstations.

The Mailbox package is built on three layers of portability. Each layer adds a degree of functionality and machine independence.

- MPTHD (context switching): independent threads of execution and simple multiprocessor context switching.
- MPTSK (task organization): prioritized multiprocessor scheduling and "mailbox" message passing, with provisions for user schedulers and communication protocols.
- MPRES (resource management): preemptive concurrent processing; regulated access to the basic resources, with provisions for sophisticated user resources, resource managers, and optimizations.

(All global names in the package are prefixed with my initials, MP, to prevent naming conflicts with other global names your environment may have.)

The lowest and most device-dependent layer, MPTHD, implements the basic context switching required for any multitasking package, it provides threads of execution. The middle layer, MPTSK, implements scheduling and interprocess communication, nonpreemptive multitasking based on MPTHD's; it provides

continued

ILLUSTRATION: ROBERT TINNEY © 1988

Table 1: *A feature comparison of some multitaskers. (Tele is both a programming environment and an operating system.)*

Features	Applications Integrators			Prog. Environments		Both	Operating Systems		
	DESQ-View 2.0	Multi-Finder 1.0	Windows 2.0	Mailbox 1.0	TimeSlicer 5.0	Tele (Kernel)	OS/2 1.0	Xenix 2.00	Unix BSD 4.3
"Lightweight" threads (with shared memory)	●	●	●	●	●	●	●	●	○
"Heavyweight" processes (with protected memory)	○	○	○	○	○	○	●	○	●
Low-level resource management (contention management)	●	●	●	●	●	●	●	●	●
Medium-level resource management (I/O waiting, deadlock handling)	●	○	●	★	★	●	●	●	●
High-level resource management (high-level optimized interfaces)	●	○	●	○	○	●	●	★	★
Intertask communication	●	○	●	●	○	★	●	●	●
Preemptive multitasking	●	○	○	●	●	●	●	●	●
Multiprocessor support	○	○	○	●	○	○	○	●	●
Task delay/alarm timers	●	○	●	★	●	●	●	●	●
Task priority levels	○	○	○	●	●	●	●	●	●
Task hierarchies/inheritance	●	○	○	●	○	○	●	●	●
Task suspension/termination (forced)	●	●	●	★	●	●	●	●	●
User context switching	○	○	○	●	○	★	○	○	○
User interrupt handling	○	○	●	●	●	★	●	★	●
User task schedulers	○	○	○	●	○	★	○	○	○
User resource management	★	○	★	●	★	★	●	●	★

● Present
○ Not present
★ Can be implemented

independent, communicating tasks. The top layer, MPRES, implements basic resource management for all standard resources and those you may add, and preemptive multitasking based on MPTSK's. Since each layer depends only on the layer below it, you can incorporate only those layers you need.

MPTHD: Context Switching

Essential to any multitasker is the ability to switch the processor's context from one process to another. Traditional multitaskers do this by having interrupt handlers save the state of the processor; they push the state on the stack when they are invoked. This is an efficient but complex and machine-dependent approach. The MPTHD layer achieves the same effect in an easy-to-understand portable way.

The MPTHD layer introduces the notion of an independent thread of execution. Like a normal process, a thread has its own stack on which it executes. With this stack, you can save the state of the thread so you can resume it later.

To perform this context switch, the thread must call the `mpthd_switch()` function (see listing 1), which is not an ordinary function. Like an ordinary function, `mpthd_switch()` can return to you, but it can also return to anyone else you specify. Indeed, it can return to *any* active `mpthd_switch()` call. You specify as an argument the thread you want the switch to go to, and it returns from *that* thread's call of `mpthd_switch()`. In fact, it tells *that* thread (via the switch's returned argument) the thread it switched from (see figure 1).

The `mpthd_switch()` function also works in a multiprocessor environment. If another processor is executing a thread when you switch to it, it will wait until the other processor switches out of the thread before you switch in. If you switch to an invalid thread or one with a corrupted stack, `mpthd_switch()` returns `nil`, indicating the error.

The `mpthd_switch()` interface is also portable. In many cases, you can directly implement it with C's standard `setjmp()` and `longjmp()` functions. In other lan-

continued

Listing 1: *The* `mpthd_switch()` *function suspends the current thread of execution and switches into the new thread.*

```
MPTHDID mpthd_switch(newmpthd)
  MPTHDID newmpthd;

{
  if (newmpthd->stackoverflow) return((MPTHDID)0);

  if (newmpthd!=mpthd_me()) {
    mpsem_critsect(&(newmpthd->mpsem),(

      if (!setjmp(mpthd_me()->state)) {
     newmpthd->oldmpthd= mpthd_me();
     mpthd_me()= newmpthd;
     longjmp(mpthd_me()->state,1);
      }

      newmpthd= mpthd_me()->oldmpthd;
    ));
  }

  /* return old thread switched from */
  return(newmpthd);
}
```

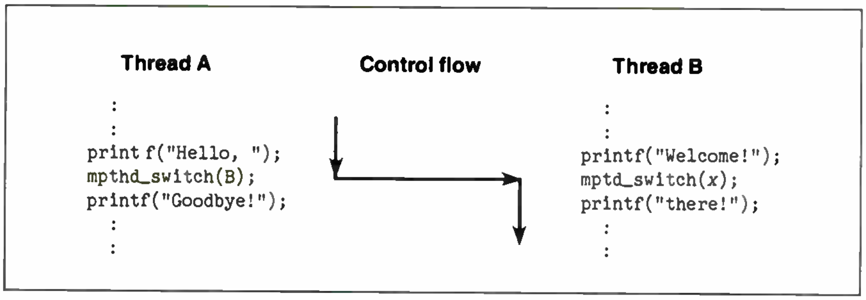


Figure 1: *Context switching as performed by* `mpthd_switch()`. *The output from this context switch would be "Hello, there!"; "Hello," comes from thread A, which switches to thread B for "there!".*

guages, you can quickly code the function in assembly language and "link it in." And even if you're not programming in C, most stack-based languages and machines can support an implementation of `mpthd_switch()` (see figure 2 for internal data-type representation). With a few additional support functions, you can easily create and destroy threads.

The initialization function, `mpthd_init()`, requires three arguments: `buff`, the memory buffer used to store the thread; `size`, the size of the buffer; and `mpthdfn`, the function to execute. Since all this is awkward to specify, a default size stored in a global variable would be convenient. However, you're in a concurrent environment: Different tasks may change the default value, and different tasks may want different defaults.

Therefore, a thread maintains its own heap, private to its current task. Instead of a default size, you can set up a global constant containing an offset into the current thread's heap; the default buffer size resides here. This way, each task has its own defaults but refers to them with the *same* variable name.

MPTHD automatically copies the parent's heap when initializing a new thread, so defaults are inherited. This simple feature can also be used for passing arguments from the parent to the child thread.

If you also don't want to specify `buff`, the buffer storing a thread, you could have MPTHD call `malloc` to dynamically allocate storage for you. But storage is a *resource*. Not all languages have this resource, so using it would limit portability. More important, dynamic memory allocation sometimes takes time; it

continued

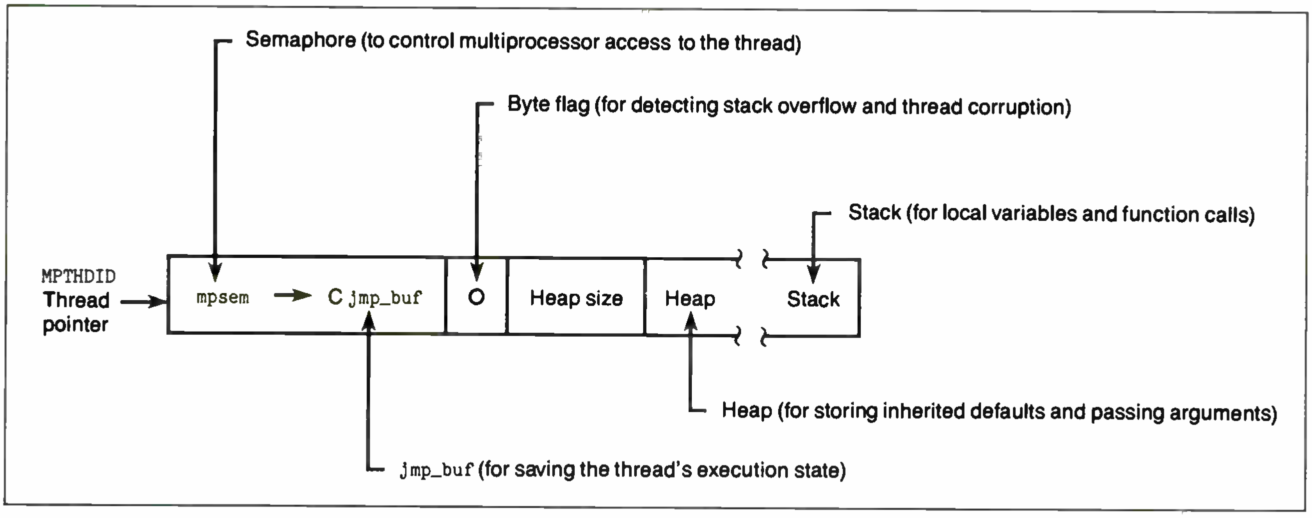


Figure 2: *Internal representation of the thread data type.*

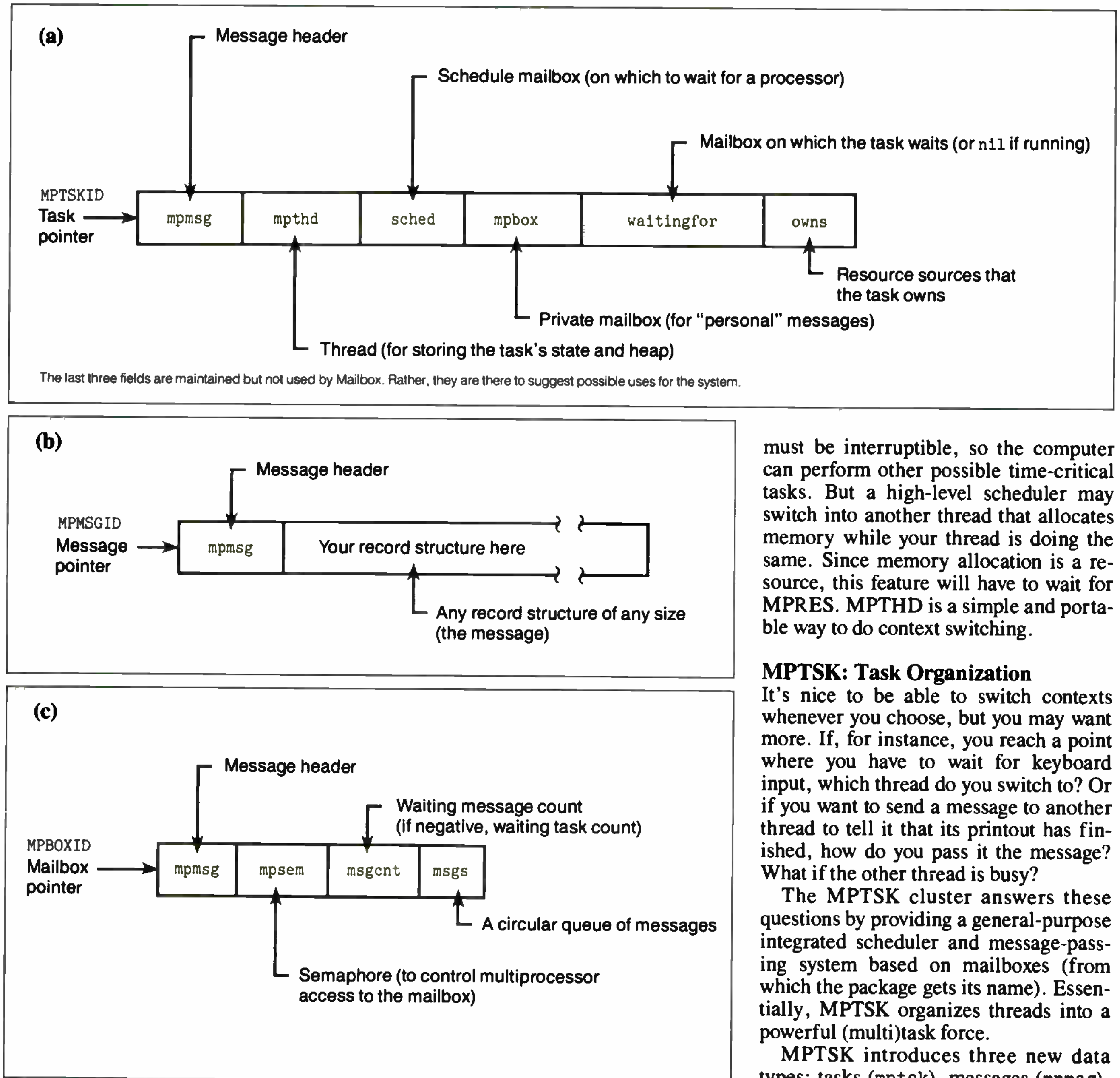


Figure 3: *Internal representations of the* **(a)** *tasks,* **(b)** *messages, and* **(c)** *mailboxes data types.*

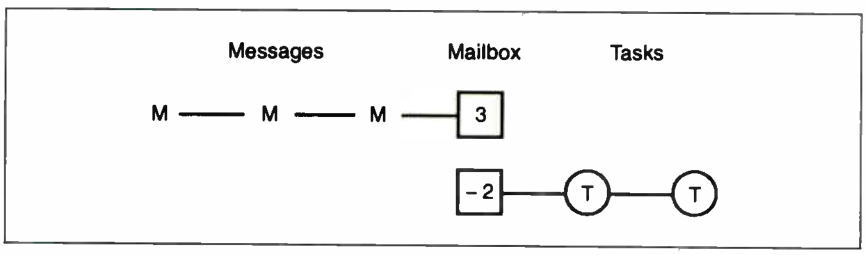


Figure 4: *Mailbox "message bank." The upper diagram is of a mailbox with messages waiting for tasks (positive count); the lower diagram is of a mailbox with tasks waiting for messages (negative count).*

must be interruptible, so the computer can perform other possible time-critical tasks. But a high-level scheduler may switch into another thread that allocates memory while your thread is doing the same. Since memory allocation is a resource, this feature will have to wait for MPRES. MPTHD is a simple and portable way to do context switching.

MPTSK: Task Organization

It's nice to be able to switch contexts whenever you choose, but you may want more. If, for instance, you reach a point where you have to wait for keyboard input, which thread do you switch to? Or if you want to send a message to another thread to tell it that its printout has finished, how do you pass it the message? What if the other thread is busy?

The MPTSK cluster answers these questions by providing a general-purpose integrated scheduler and message-passing system based on mailboxes (from which the package gets its name). Essentially, MPTSK organizes threads into a powerful (multi)task force.

MPTSK introduces three new data types: tasks (mptsk), messages (mpmsg), and mailboxes (mpbox) (see figure 3). Tasks are essentially enhanced threads. They are automatically scheduled, and you don't need to explicitly switch between them. They can also send and receive messages.

Messages can be of any record type for maximum flexibility. Its structure needs only to begin with an mpmsg field (for internal message-management purposes). Indeed, even tasks and mailboxes are treated as messages.

Mailboxes tie tasks and messages together and make the package work. A hybrid of the queue data structure, a mailbox contains either a list of messages or a list of tasks (waiting for messages). If the count of items in the mailbox is positive, it contains a list of messages; if the count is negative, the mailbox contains a list of tasks (see figure 4).

Tasks can either send or receive messages in a mailbox. If a task sends a message and there are no tasks waiting for it, then the sending task adds it to the end of the list of waiting messages; if there are tasks waiting for it, then the sending task gives it to the first task waiting in line. On the other hand, if a task attempts to receive a message from a mailbox, and there are no messages waiting, then it adds itself to the end of the list of waiting tasks; if there are messages waiting, then it takes the first message and proceeds.

As an analogy, think of a mailbox as a bank account and messages as money. Like a bank account, a mailbox has either a credit or deficit of messages. And messages, like money, can be deposited or withdrawn. Of course, when people come to the bank, they must usually wait in line. Likewise, a mailbox services its tasks and messages on a first-come, first-served basis.

Although it's a simple concept, the mailbox, mpbox, is a remarkably versatile structure. It's used not only for intertask communication, but also for scheduling, resource management, and even message-passing semaphores. For instance, if you view the three messages waiting in the printers mailbox as representing the computer's three printers, when a task wants a printer, it simply receives a printer message from the printer's mailbox. The message tells it which printer to use. If no printers are available, the task is queued; when a printer becomes available, it will go to the next task in line, which will automatically be restarted. Since this first-in/first-out (FIFO) ordering holds for messages as well, the least recently used printer is always chosen, ensuring that the three printers are evenly used.

If you think of a processor as a resource as well, the mailbox abstraction makes a good scheduler. You can imagine a schedule mailbox with tasks waiting to "receive" a processor to run them. Due to the FIFO ordering, tasks are automatically processed in round-robin fashion. For prioritized scheduling, a task receives a priority by assigning a mailbox in which to schedule it whenever it can be run. You list these schedule mailboxes in order of priority. When a processor needs to run a task, it searches this list sequentially—it's a short list—until it finds the highest-priority task (see figure 5).

A key advantage to mailbox multitask-

continued

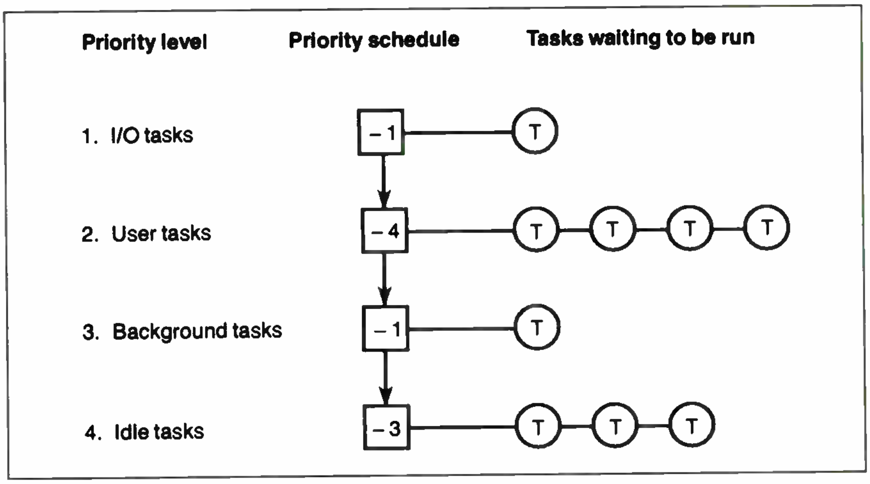


Figure 5: *A mailbox scheduler example. To find a new task to run, a processor simply searches down the schedule list until it finds a task.*

Listing 2: *The* `mptsk_xfer()` *function contains the routines to send, receive, and schedule messages.*

```
MPMSGID mptsk_xfer(MPBOXID mpbox, MPMSGID mpmsg, BOOL block,
  MPBOXID sched) {
mpsig_critsect(do { /* disable interrupts */
/*SEND*/
  if (mpmsg) { /* if sending a message */
    MPTSKID mptsk;
    mptsk= mpbox_xfer(mpbox, /* queue msg XOR get task */
      mptsk_sendside, block?mpmsg:(MPMSGID)0);
    if (mptsk) { /* a task was waiting */
      /* transfer message */
      mptsk_mpmsg(mptsk)= mpmsg; mpmsg= 0;
      /* schedule both tasks */
      mpbox_xfer(mptsk_sched(mptsk),mptsk_recvside,mptsk);
      mpbox_xfer(mptsk_mysched(),mptsk_recvside,mptsk_me());
    } else {
      if (block) mpmsg=0; /* message sent */
      break;        /* return immediately */
    }
/*RECEIVE*/
  } else { /* if receiving a message */
    mpmsg= mpbox_xfer(mpbox, /* get msg XOR queue task */
      mptsk_recvside, block?mptsk_me():(MPMSGID)0);
    if (mpmsg) break; /* message recvd: return immediately */
    if (!block) break; /* don't wait for msg: rtn at once */
  }
/*SCHEDULE*/
  { /* schedule a new task to run */
    MPTSKID mptsk;
    MPBOXID cursched= sched;  /* use user sched list */
    /* search from high to low priority until task found */
    while (!(mptsk= mpbox_xfer(cursched,mptsk_recvside,
     (MPMSGID)0))){
      cursched= mprng_next(cursched);
      if (cursched==sched) /* if end of user sched list */
     cursched=  mptsk_topsched(); /* use system list */
    }
    mptsk_mympmsg()=mpmsg; /* save msg between switches */
    mpthd_switch(str2fld(mptsk,mpthd));
    mpmsg= mptsk_mympmsg(); /* return result message */
  }
} while (0););
return(mpmsg);
}
```

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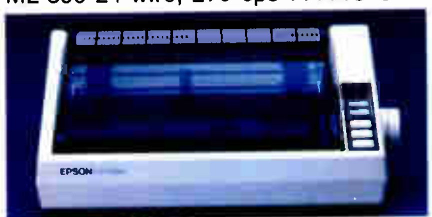

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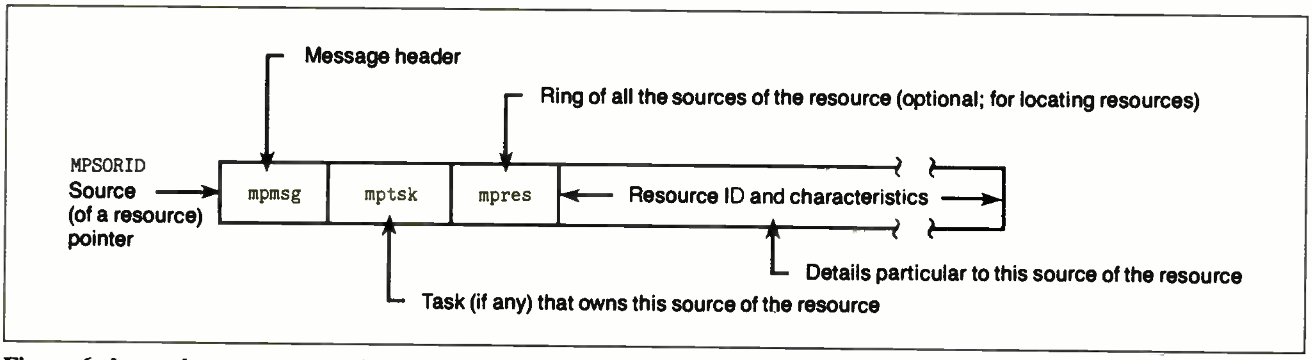

Figure 6: *Internal representation of a source (of a resource) data type.*

Listing 3: *The one-argument thread-initialization routine. Notice how the resource is claimed before allocating memory and released afterward.*

```
MPTHDID mpthd_create(MPTHDFN mpthdfn)
{
  int mydeftasksize= mpthd_mydef(mpdef_tasksize,int);
  MPTHDID mpthd;

  /* claim memory resource */
  mpres_take(mpres_memory);
  mpthd= (MPTHDID)malloc(mydeftasksize);
  /* release memory resource */
  mpres_give(mpres_memory);

  if (mpthd) mpthd_init(mpthd,mydeftasksize,mpthdfn);
  return(mpthd);
}
```

Listing 4: *This Turbo C code will enable preemptive multitasking in Mailbox.*

```
void interrupt (* mpsig_oldclocktick)();
void interrupt    mpsig_clocktick()
  {
    mpsig_oldclocktick();
    mptsk_yield();
  }
/* interrupt 0x08 on IBM PC */
#define MPSIG_CLOCKTICK (0x08)
void mpres_setup()
{
  ....
  mpsig_oldclocktick= getvect(MPSIG_CLOCKTICK);
    setvect(MPSIG_CLOCKTICK,mpsig_clocktick);
  ....
}
```

ing is speed. Many multitasking systems have a single kernel task that schedules all processes and manages all resources. To switch between tasks, or even to send a message, requires at least two context switches (into and out of the kernel). Mailbox requires, at most, one context switch—sometimes none—to send a message, and only one to switch between tasks. This is because it does these kernel functions simply and within the current task. Mailbox achieves this efficiency at the cost of some intertask protection, an acceptable price since all the memory is shared anyway.

Also, multitasking systems usually let only one processor execute inside the kernel at once. Thus, the kernel scheduler itself becomes the bottleneck as you add more processors. For this reason, it is unusual to find a shared-memory machine with more than half a dozen processors.

A mailbox can likewise be opened by only one processor. However, a processor can open only one mailbox at a time—and then only momentarily. More important, mailbox multitasking distributes message passing and scheduling between multiple mailboxes. Although its scheduling algorithm is simple, Mailbox is fast and potentially independent of the number of processors. For this reason, Mailbox should be able to make good use of multiprocessing machines.

An apparent disadvantage of mailbox multitasking is that it doesn't come with functions that allow one task to force another to stop or suspend, a feature common in other multitaskers. But this is because Mailbox has been designed to also work in multiprocessor environments, where the scheduler can't automatically assume that other tasks are suspended while it executes a task. Although I don't have a multiprocessor machine at my disposal, I designed Mailbox to take advantage of multiprocessing environments when they become available, and to better understand the issues involved in real concurrent environments.

Actually, Mailbox is easily extended to support sophisticated task-control operations due to its uniformity. Everything, even scheduling, works by sending and receiving messages. More sophisticated operations follow logically and don't need to be tailored. For example, to yield the current task so other tasks can run (useful when polling some condition), the task merely attempts to "receive" a processor "resource" from its schedule mailbox. It's also possible for a task to specify which tasks (which schedule list) it wants to yield to. Thus, when optimizing performance, a task can implement its own scheduler and "break" the strict priority scheduling. Or, for modular programming, it can duplicate (i.e., a task can multitask itself).

Even the send and receive "primitives" are special instances of a general `mptsk_xfer()` function (see listing 2), with flexibility similar to that of `mpthd_switch()`. Since all task switching and message passing go through this single function interface, any sort of performance monitoring, message monitoring, or task control is possible simply by patching the desired instructions into the `mptsk_xfer()` function. Instead of being big and complicated with every possible feature included, Mailbox has been kept simple so you can tailor it to your own needs.

MPTSK implements prioritized multiprocessor scheduling and simple "mailbox" message passing based on threads. It introduces the message, task, and mailbox data types, and a simple set of operations with which you can build many sophisticated scheduling, communication, and monitoring environments. Still, the MPTSK layer only takes into account the tasks' interaction among themselves, not with the outside world. If two or more tasks want to use the same resource at the same time, you will need the final layer, MPRES, to share resources.

MPRES: Resource Management

The MPRES layer is best viewed as an open-ended extension of the MPTSK environment. Unfortunately, only basic resource management (regulated access) can be defined in a portable fashion

Mailbox has been kept simple so you can tailor it to your own needs.

(short of writing an entire operating system). Although all machines have processors and memory, they vary widely in what devices they have. MPRES contains support for a default set of resource types. For other devices, it shows how you can build resource managers tailored to your environment.

MPRES introduces the *resource* and *source* data types. The resource is merely a mailbox data type, used for storing the available sources of the resource as messages. The source data type is a message with two extra fields. The first specifies the task that owns the source (`NIL` if none), and the second is a double-pointer structure (the same as the `mpmsg` header) that keeps all the sources of a resource in a ring (see figure 6). You can take (`mpres_take()`) and give or release (`mpres_recv()`) a source of a resource (these routines are implemented with `mptsk_send()` and `mptsk_recv()`). MPRES also provides operations to initialize—and to deinitialize—a resource of a particular type.

These two fields in the source data type allow you to locate all sources—and users—of a resource. This feature could be useful for reclaiming resources from crashed or discourteous tasks, although it's not currently taken advantage of.

By incorporating the knowledge gained from the `waitingfor` and `owns` fields of tasks (see figure 3a), it's also possible to detect deadlock (a cycle of tasks waiting endlessly for each other) before it occurs. When a task is about to be suspended to wait for a resource, it first checks if any other tasks that have

continued

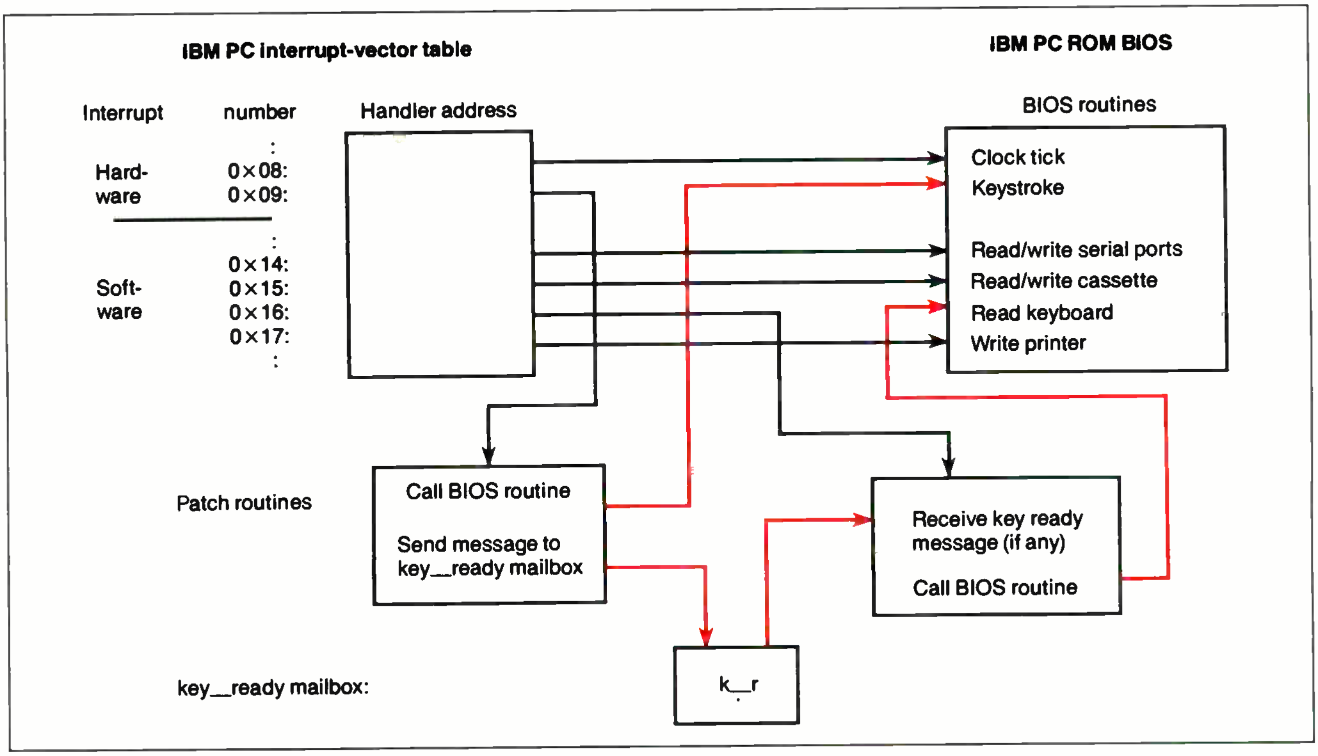

Figure 7: *Intercepting interrupts (advanced optimizations). To prevent tasks from wasting processor time waiting for keystrokes, you can intercept the IBM PC's BIOS interrupt routines to check and signal when a keystroke has occurred. Since you can call Mailbox's send and receive primitives within interrupts, many such schedule optimizations are possible without rewriting the scheduler.*

A Few Rules of Thumb for Concurrent Processing

1. Divide problems into modular tasks, units of highly coupled data and control.
2. Know the order in which things must happen, and the order in which they could be allowed to happen.
3. Know which objects are shared, and which objects are local.
4. Synchronize access to all shared objects.
5. Know the unit of transaction, what operations should be atomic, and when they should commit.

Note: Modular and object-oriented programming styles are also helpful for reasoning about concurrent systems.

the resource are already waiting for it. (Since this check potentially involves a great deal of searching for every access to a resource, it's not implemented, but it could be if deadlock is a serious problem.) You should be wary, however, of the base case of deadlock, where a task requests a resource that it already has.

The MPRES layer also defines a few general resources, the most universal of which is `mpres_memory`. With memory-contention management, you can finally write a one-argument thread-initialization routine (see `mpthd_create()` in listing 3). Notice how the memory resource must be claimed and released around the standard `malloc` memory-allocation call. This ensures that no other task can allocate memory at the same time. Likewise, protection must be provided around `free`, the memory-deallocation call, and other memory management calls.

In general, every C function that accesses resources must be executed within an appropriate resource lock. This is true for any concurrent system. To make the job easier, the MPRES package defines a macro, `mpres_critsect`, which takes as arguments a resource and a block of code. The macro claims the resource, executes the code, and then frees the resource before exiting.

MPRES also duplicates many of the common C function calls with this extra locking added (e.g., `mpres_malloc()`). Operations such as `malloc()`, which are completed in a single transaction, are well suited for this. In contrast, operations such as `printf`, which usually require several calls ("or the," "Hello," "output may not stick," "Goodbye," "together") are best locked explicitly by the caller. Explicit locking is also necessary when calling library functions that use resources and are unaware they are executing in a concurrent environment.

One way to simplify the complexities of having to lock and unlock resources is to assume a single-processor environment, which is often the case, and to have tasks yield control explicitly only when they're not holding any resources. This may be an acceptable compromise in many circumstances, and Mailbox allows for this style of programming.

MPRES also provides three levels of I/O *locking granularity*. On the high-stream level are the standard streams: `mpres_stdin`, `mpres_stdout`, and `mpres_stderr`. On the middle-component level are standard operating-system components: `mpres_filesystem`, `mpres_network`, `mpres_terminalin`, and `mpres_terminalout`. And on the low-device level are the standard devices: `mpres_harddisk`, `mpres_floppydisk`, `mpres_modem`, `mpres_printer`, `mpres_parallel`, and `mpres_serial`. Locking at a lower granularity level allows for a higher degree of concurrency at a cost of complexity and portability. These locking levels are likely to be incomplete and to overlap; they are merely suggested names for resources and their locks. It is up to you to tailor the locking appropriate to your environment and task.

One optimization you may want is to tap into the power of the hardware and operating-system interrupts. Both the MPTHD and MPTSK layers have been carefully designed so you can also call their functions from interrupt handlers with no modifications. For example, if you add the Turbo C code in listing 4, the package becomes a *preemptive* multitasker. Now, 18.2 times a second (the frequency of the IBM PC clock), the current task will yield if another task is waiting to run. You can achieve a similar effect in Unix by using the alarm signal.

Putting Idle Time to Work

In general, you can tailor Mailbox to take advantage of almost any interrupt-driven resource. For example, personal computers waste most of their processing power waiting for keystrokes.

Suppose you wanted to suspend tasks waiting for keyboard I/O, without modifying the standard functions, like `scanf()`, which might access the keyboard. On the IBM PC, the keyboard is typically read through a ROM BIOS software interrupt. The keyboard also generates a hardware interrupt each time a key is pressed. By intercepting requests to read the keyboard and signaling when a key is available (see figure 7), you can put this idle time to more productive uses—like saving the data you're working on.

You can use a similar trick in Unix with `signal(3C)` and `fcntl(2)`. The calling task must explicitly wait for a mailbox, associated with a particular stream, if an I/O operation exists on the stream `EWOULDBLOCK`; in turn, a signal handler for `SIGIO` would restart the task by sending it a message that the stream was ready. Likewise, you could make optimizations for the other computer resources.

Resource management is a difficult issue. Since computer devices differ and most languages have several wired-in I/O calls, *portable* resource management is nearly impossible, short of writing another operating system. Mailbox provides portable processor (preemptive multitasking) and memory (dynamic allocation) resource management, and contention management for many standard resources. Beyond this, I encourage you to tailor Mailbox to your own particular resource needs.

Thinking Concurrently

Concurrency buys you modularization, the ability to divide your programs into their logical "tasks"—in the full sense of the word. It also buys performance. But the price is high. You must face complex issues of managing resources and ensuring data integrity. You must learn to think concurrently. A few rules of thumb are given in the textbox above.

A major problem with concurrent systems, especially distributed systems, is "getting them right." The concurrency issues introduced here are just the tip of the iceberg. No language extension can provide a complete solution. We need to write new operating systems to take real advantage of concurrency; Microsoft's OS/2 is just the beginning. Nevertheless, Mailbox allows you to explore multitasking and learn to appreciate the pros and cons of concurrent processing. ■

Editor's note: *The source code listing for the Mailbox package is available in a variety of formats.* *See page 3 for details.*

Michael Benjamin Parker is a computer science major at MIT. Mailbox is part of his larger research project, SHARE, a distributed shared-information operating system for personal computers.

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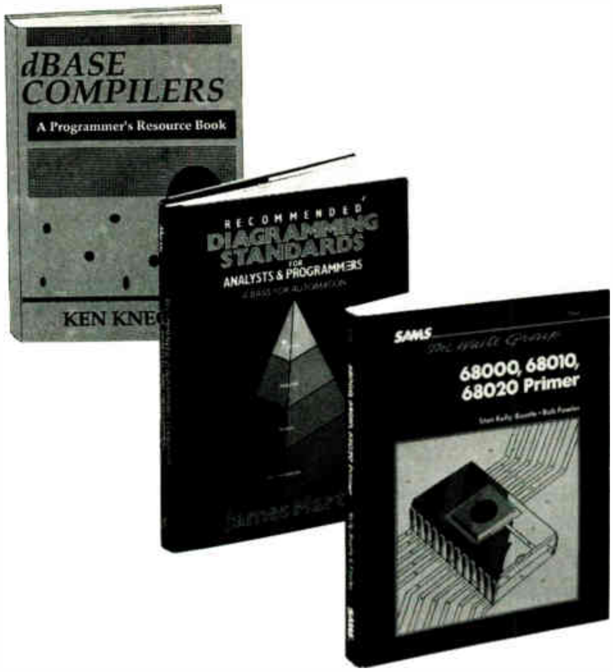

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(206) 882-8080
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PC-MOS/386 .... $195
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The Software Link
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Atlanta, GA 30092
(404) 448-5465
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QNX $450
Multitasking operating system; runs on IBM PC, AT, PS/2, and compatibles.

Quantum Software Systems, Ltd.
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VP/ix
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THE ULTIMATE LINK?

ISDN—a new communications technology that could change the way we use our computers and telephones

Jay Duncanson and Joe Chew

You are sitting at your desk, first thing in the morning. Your computer downloads several large files from a shared hard disk over the telephone system. Sipping your coffee, you start another download from an information service, then check your electronic mail (E-mail) while the error-free transfers continue.

The telephone rings. A window pops up on your computer, telling you it's your mother calling. In the midst of the conversation with your mother, the window reappears: Your division manager is calling from headquarters. Putting the personal call on hold, you and your manager discuss a new assignment, augmenting the discussion with interactive graphics.

As you return to Mom's call, the pop-up window informs you that a call from a pesky salesman has just been automatically rejected. At the same time as all this, your laser printer has made a hard copy of a facsimile that has come in from one of your remote divisions.

Sound futuristic? It is, but not by much. Even as you read this, functions like these are being demonstrated in field trials and actual commercial implementations of ISDN, the Integrated Services Digital Network. (The grammatically proper usage is "an ISDN" or "the ISDN," as if the acronym were spelled out, but most use it without remorse as a noun in its own right.)

ISDN is a technology that integrates digitized voice and data—not only computer data, but other digital information, such as fax and video. It works over simple twisted-pair wiring such as that currently in use for telephones (see figure 1). At monthly rates from 20 percent to 60 percent higher (depending on the services chosen) than we are now paying for basic telephone services, ISDN will offer high-speed digital transmission and many enhanced communications services.

More Than Just a Service

The keys to understanding the concept of ISDN are in its name. First and foremost, its services are integrated. Voice and data, circuit switching, and packet switching all come to you on one line from one source. Standards for interoperability are being developed and approved by the CCITT, or International Consultative Committee for Telephone and Telegraph, under the aegis of the United Nations.

Whereas today's conventional networks have islands of modern digital apparatus in a sea of analog technology, ISDN is completely digital (except, of course, for certain parts of the telephone, such as the microphone, speaker, and tone pad). This approach allows performance unheard of in analog days.

With a few local exceptions, these integrated digital services will eventually be provided over existing telephone wiring to all subscribers who want them. The first tentative commercial offerings are already in place, and ISDN lines should be available in most places by the mid-1990s. However, technical and financial problems may slow its progress.

Batteries Not Included

The telephone system uses the complex embedded technology you'd expect from an international network that serves hundreds of millions of people. Fortunately, to understand how ISDN affects end users, we need to deal with only two key elements: the central offices (electronic switchboards that route calls and provide services) and the local loop from the central offices to the customers' premises.

In most of the Western industrial countries, the central offices and the networks connecting them are well on the road to complete digitization, a process that began in the early 1960s. Most circuits from the central office to the customer, though, still use the analog technology that Alexander Graham Bell would have recognized: talking by modulating a continuous DC signal across a loop. A present-day telephone's interaction with the central-office switch is both limited and simple-minded, especially during a call. The burdens of knowing the state of a connection and of providing extra services, such as call waiting, rest entirely upon the switch.

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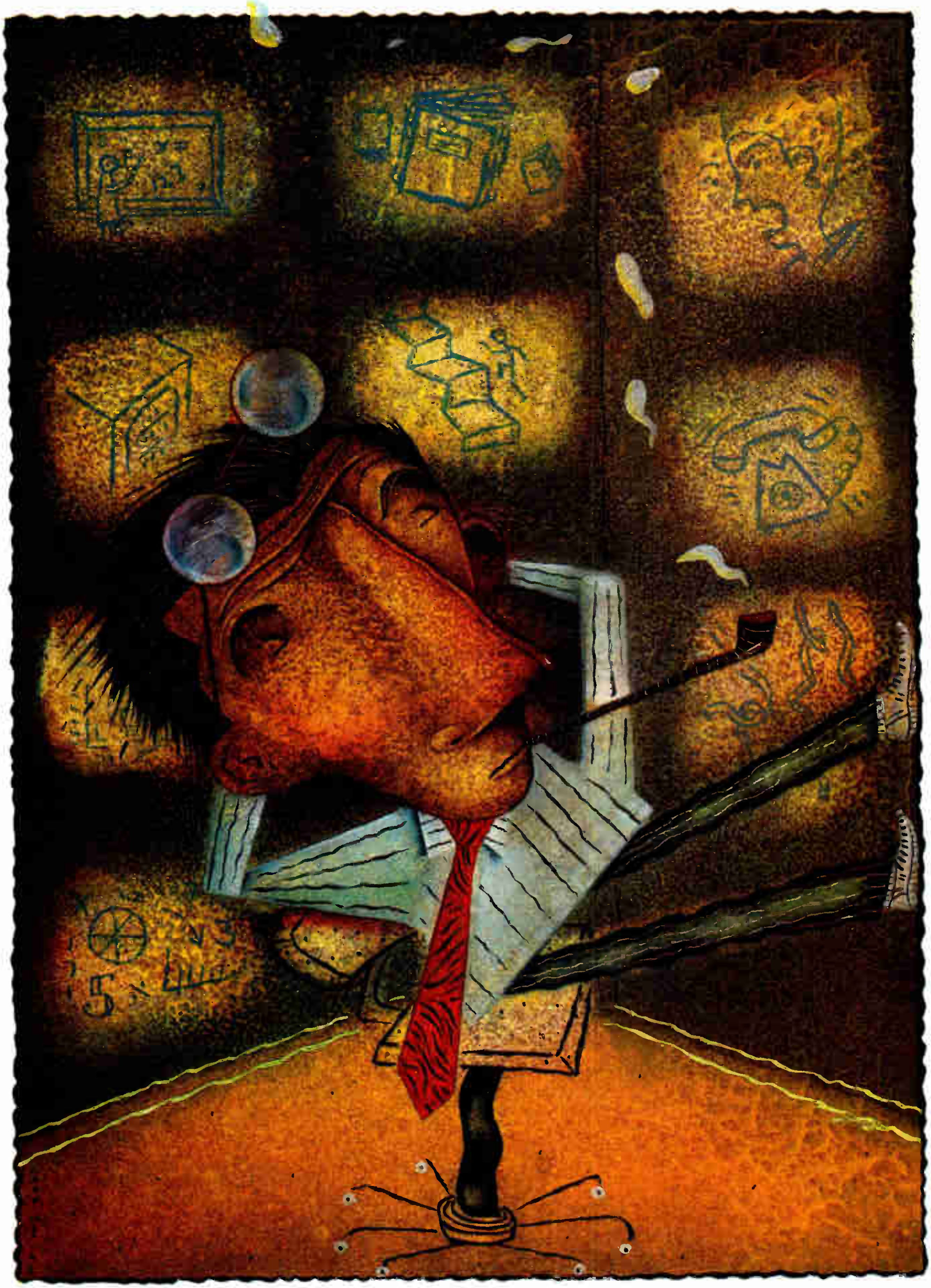

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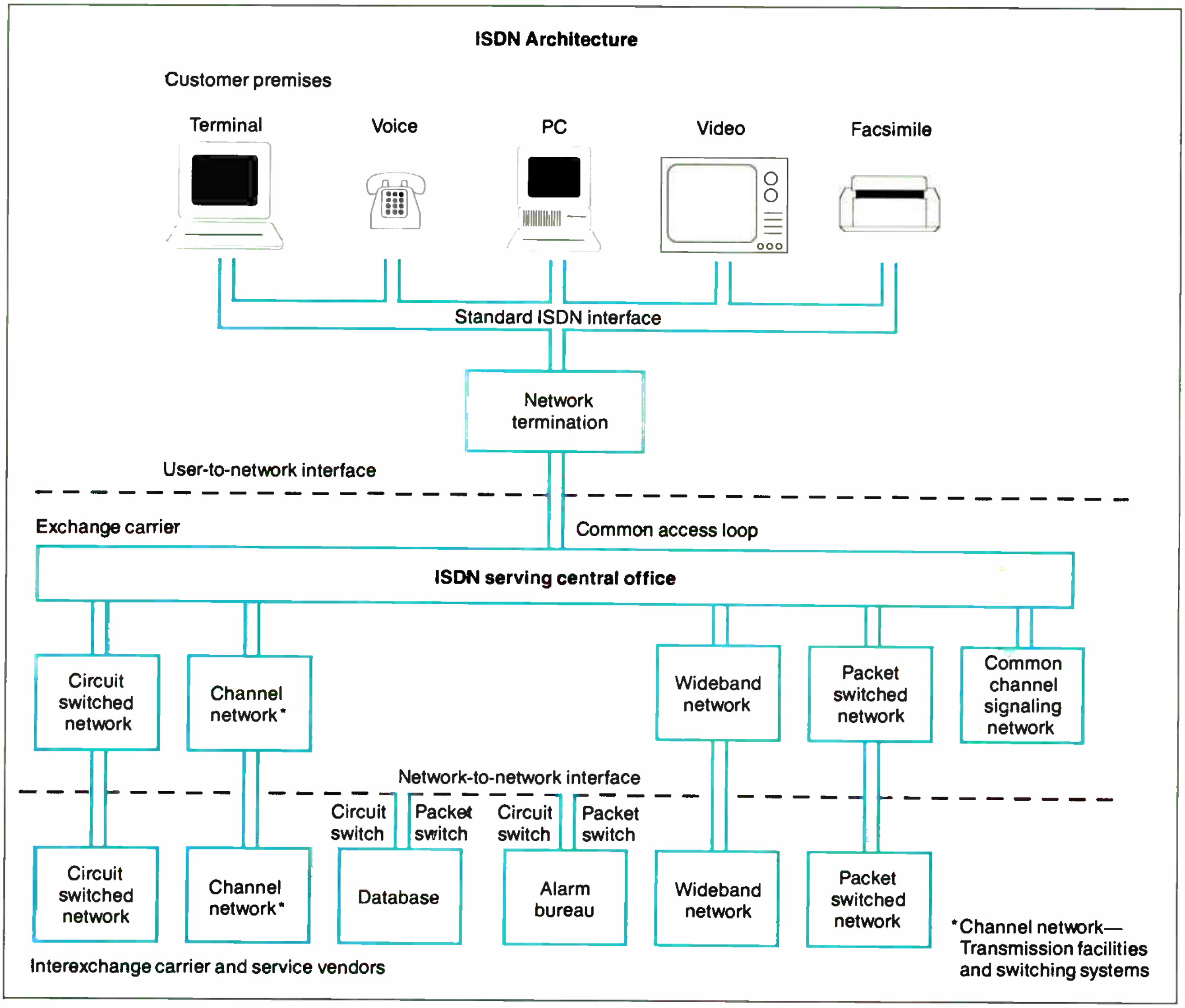

Figure 1: *ISDN is an evolving international standard for voice and data communications. Its major features include integrated access of multiple services over a single access line, network transparency via standard customer-to-network and network-to-network interfaces, and end-to-end digital connectivity.*

Some interaction can be done with brute force, such as applying voltage to a telephone to make it ring, or interrupting the current loop to send dialing numbers. Modern extensions to this approach, like dialing tones, are more sophisticated and capable, but they still tread upon the bandwidth used for the connection.

ISDN represents a fundamental severing of the ties with Bell's technology. Whereas today's conventional telephone and network services are cost-inefficient and awkwardly configured mixtures of digital and analog technology, ISDN is a completely digital approach. Under ISDN, the telephone is a computer. It sends digital rather than analog information, and it talks interactively with central-office switches that are themselves large, specialized mainframe computers. The difference opens many doors—and creates a few problems as well.

Since ISDN customer equipment can communicate intelligently with the switch, even during a call, it is easier to implement advanced features. Furthermore, features that are currently implemented only in proprietary ways on private branch exchanges can be provided in standard ways through the telephone companies.

This change in signaling methods has some drawbacks, which will probably be temporary. One is that different manufacturers' ISDN switches now use subtly different signaling methods. As an early ISDN customer, you would have to be aware of what is in the central office and set up your equipment accordingly. This situation will change, but achieving compatibility among products from different manufacturers is always slow and difficult.

Another problem is the huge installed base of "dumb" analog equipment that must be accommodated during the changeover period. Analog telephone sets, for instance, will have to be adapted to ISDN or replaced with ISDN units. Interoperability between ISDN and analog subscribers will also have to be accommodated.

In the new ISDN environment, you will be able to pick and

ISDN to Date

Implementation of ISDN is well under way. Hundreds of millions of dollars have been invested in equipment purchases, research and development, and marketing efforts. The government has given it a vote of confidence by making a smooth migration path to ISDN a requirement for FTS-2000, the new federal telephone system now in the bidding stage. But the odds are slim right now that you'll see workers around your home climbing poles and digging up the street to install ISDN.

For over a year now, all seven regional Bell holding companies (RBHCs) have been conducting ISDN trials through their subsidiaries, the local telephone companies. Only one or two local carriers per RBHC, however, have really gotten involved to this date.

The trials and first implementations so far have generally involved only large companies with considerable telecommunications experience. Southwestern Bell, for instance, has signed contracts to provide ISDN services to Shell and Tenneco. Illinois Bell is developing a commercial relationship from its ongoing field trial with McDonald's. Lockheed, 3M, and the Lawrence Livermore National Laboratory are among the other companies that have done considerable work with ISDN.

In Atlanta, Georgia, Southern Bell Telephone is offering ISDN as a new class of commercial business service. AT&T, Hayes Microcomputer Products, Contel Corp., Prime Computer, Suntrust Banks, and Digital Equipment Corp. have already begun using the network's services.

Perhaps the most audacious of all early adopters is Boeing. It has just installed the last of five central-office switches of its own as part of a multiyear, $100 million effort to build a private ISDN system. Boeing's telecommunications needs are so huge and sophisticated that, in the long run, the company expects to save money with ISDN by building its own ISDN system rather than using the public network.

However, most businesses, followed by residential customers, can expect to wait awhile for ISDN, depending on their proximity to central offices where ISDN-capable equipment is being installed.

As this was being written, AT&T became the first domestic carrier to announce ISDN service supporting the primary rate interface. And Illinois Bell Telephone Company filed a tariff proposing two types of basic rate service. A single circuit-switched voice channel with a signaling-only D channel will carry a one-time installation fee of $146.50 and a monthly charge of $16.58 per line. 2B+D service, with circuit-switched data on the other B channel and packet-switched data on the D channel, costs $246.50 plus $29.68 a month.

choose the services you want. If, for instance, you are satisfied with your present telephone services, you will be able to use your telephone in exactly the same way after ISDN is installed. In order to take full advantage of ISDN's benefits, though, you will have to learn to live with the new complexity, just as you learned to cope with the esoteric features and moon-mission control panels of today's audio and video equipment.

Two Types of Services

ISDN services will be provided to customers in two classes: the basic rate interface and the primary rate interface. The basic rate is referred to as 2B+D and consists of two 64K-bits-per-second (Kbps) B channels that can carry either voice or data, and one 16-Kbps D channel used for network signaling and control, and user packet data. An additional 48Kbps is also used for other purposes, such as echoing the D channel, synchronizing the terminal units, and conveying other internal network information.

In North America, the primary rate is referred to as 23B+D. It consists of 23 64-Kbps B channels and one 64-Kbps D channel. Primary rate will support 1.544-megabyte-per-second (Mbps) bidirectional transmission rates. It could be used, for example, to interconnect computing facilities and to connect private branch exchanges (PBXes) to the network rather than to directly serve residential end users.

Basic rate access can include various combinations of circuit-switched voice, packet-switched data, and circuit-switched data. The difference between circuit switching and packet switching lies in the way the data is routed through the network. Circuit-switching technology is the closest thing to a traditional telephone connection; it can be compared to a pair of wires dedicated to a particular connection for the duration of the call. In packet switching, data bits are grouped into packets with origin address, destination address, and error-control information. The packets are routed to their destinations through networks of packet switches at the central offices and elsewhere, taking whatever paths the intelligent network considers best at the time.

Packet switching has several advantages for data transmission. The individually addressed packets can be intermingled; packet switching is more akin to a conveyer belt in the post office than to a conventional telephone connection. Like time-sharing on a large computer or the multiplexing of several terminals onto one communication line, it keeps high-capacity facilities from sitting idle between sporadic bursts of usage.

Packet switching has other advantages as well. With appropriate equipment, the user can maintain multiple simultaneous connections over a single channel. Packet switching also opens the door for services such as remote meter reading, polled security monitoring, and wide-area versions of local area networks (LANs).

Traditionally, circuit switching and packet switching have used different equipment, and in fact have reflected opposing philosophies. ISDN will be the first widely available network to integrate them.

An ISDN switch can also provide supplementary voice services such as call forwarding, conference calling, and hold—all the services now available on office telephones—plus a few more that are not currently feasible, such as prescreening and selective answering. It can provide these services without modification of the twisted-pair wiring scheme used in today's phone service.

This seems like a trivial issue, but it is tremendously important. A substantial fraction of the world's copper production has gone into "last mile" telephone circuits, and the labor costs of

continued

What a Tangled Web We've Woven...

While drafting the ISDN specifications, the CCITT defined five interfaces—R, S, T, U, and V—that are access points into the network (see figure A).

The R interface is an access point for existing, non-ISDN equipment (a TE2 in the CCITT specification), such as an analog telephone or an RS-232C port, which requires terminal adapters to tie into the network. While the other interfaces are associated with ISDN standards and are ISDN-specific, the R interface implements whatever standards are required for a particular piece of customer equipment. For example, the analog telephone and RS-232C port, which differ greatly in physical, electrical, and logical needs, both meet the network at the R interface.

The S interface connects the ISDN-compatible equipment and the computer side of the network termination (an NT2, such as a PBX or a LAN). The T interface is where the premise-based ISDN switching equipment connects to the carrier's side of the network termination (NT1). The U interface is the connection between the customer premises and the central office equipment, while the V interface connects the central office to the rest of the network.

Both the S and T interfaces use two twisted pairs of wire, for a total of four wires. The T interface uses one pair for transmit and one for receive, to provide full-duplex operation, and it has the capacity to operate at the primary rate.

At the U interface, the use of echo-cancellation techniques permits full-duplex operation over a single twisted pair. It operates at the basic rate. This interface has a greater range (2500 to 6500 meters versus 1000 meters for the S and T interfaces) and doesn't need that extra pair of wires. It allows the existing local loop—a single pair—to be used all the way from the central office to the user.

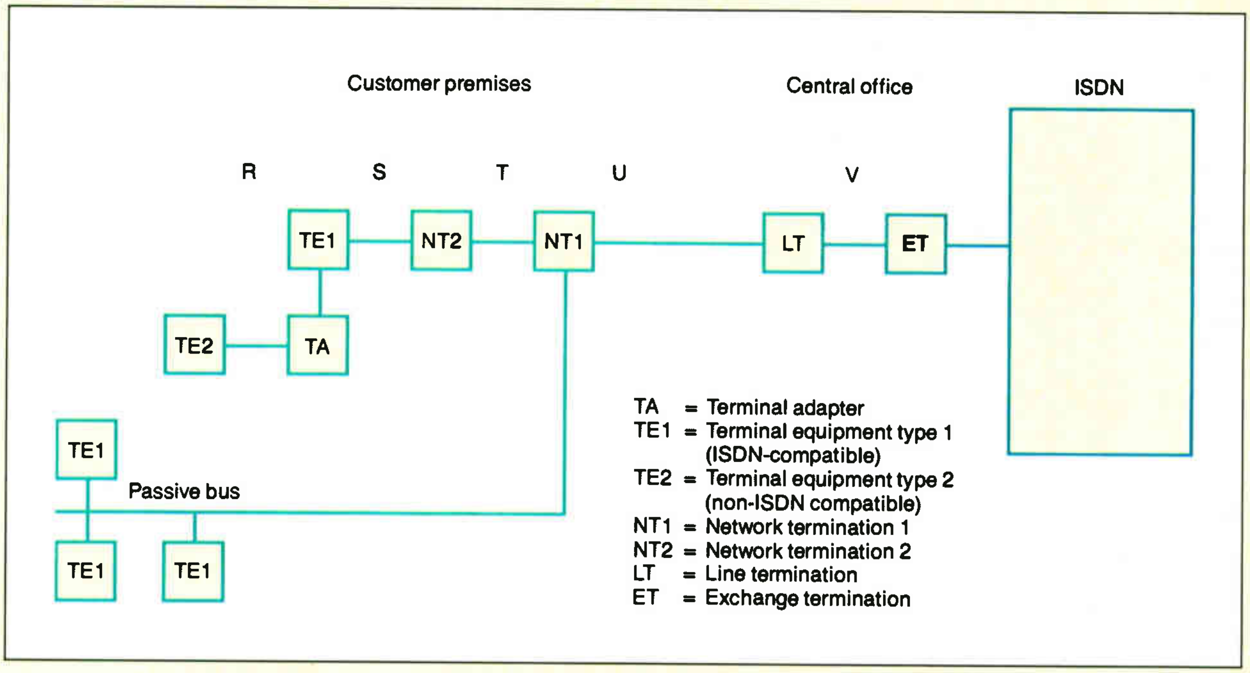

Figure A: *The CCITT, a communications governing body of the United Nations, has designated five ISDN reference points: R, S, T, U, and V. These are places in the network where one or more interfaces for specific functions will occur.*

replacing it would dwarf the material costs. Despite the best-laid plans of supporters of fiber optics, it is axiomatic that the next generation of the telephone system, whatever its other characteristics, has to work over twisted-pair wiring already in place.

ISDN and Computing

Most of ISDN's impact on the public will come from voice service, which, after all, is the main business of the telephone companies. But ISDN integrates voice and high-speed data. For the first time, data will stand beside voice as an equal partner in the public telephone network.

Establishing data connections over ISDN from a personal computer can be accomplished with the addition of a terminal adapter (TA). A TA is like a modem in one way: It allows the computer to talk over the telephone network. But the similarity ends there.

TAs are being designed so that existing terminal-emulation programs can work with them after little or no modification. (Generally speaking, TAs and other ISDN equipment will isolate the user from the complexities of dealing directly with ISDN.) But taking full advantage of ISDN's capabilities will call for special software that is just beginning to appear.

Take the wide-area network, or "metroLAN," for instance. When you think of a LAN, you probably think of high performance, great complexity, and someone standing on a ladder in your office to run coaxial cable through the ceiling. The high-speed packet-switching capability of ISDN makes it feasible to build a LAN that runs over switched connections through the public telephone system.

Such a LAN can interconnect users across the street or across the continent. It doesn't need dedicated cables and adapter cards—just the existing telephone wiring, plus ISDN terminal adapters and software. And you can reconfigure the network without having to call in someone with a ladder.

Multiple simultaneous connections, each fast enough to accomplish something useful, will also become feasible under ISDN. With a personal computer running a multitasking (or at least multiwindowed) operating system, you will be able to exchange information with different parties simultaneously. What's more, you will be able to do so without sacrificing voice quality or capabilities.

Some computers that include ISDN interfaces and features are already on the market; they are often called "integrated voice/data terminals." That term, though, is also used for telephones with small displays, such as a receptionist might use.

One of the major issues of the transition years, a special case of the analog-interoperability problem, will be connecting ISDN-equipped computers to other computers that have modems. This could be done either through centralized modem pools or by digitizing the modem signal at the modem and sending it over a B channel as circuit-switched data.

The Holdup

One obstacle in the adoption of ISDN comes from the financial rather than the technical side. Converting to digital technology is expensive, and the telephone companies, operating under heavy regulation, will have to get their money back somehow.

For the first several years, they will probably get it from business users. Residential users could provide a great deal of revenue, but at present, they don't have much use for ISDN. It has been proven time and again that the celebrated Man in the Street wants nothing more than analog voice (known to the trade as Plain Old Telephone Service, or POTS), and at the lowest possible tariffs.

Should the phone companies force this new, expensive, and perhaps intimidating technology upon residential customers who already have adequate phone service? Or should they resign themselves to a long, long transition period of providing both analog POTS and ISDN while private individuals figure out what to do with their connectivity?

Thus far, ISDN has been used in familiar ways: as a more capable phone and as a faster modem. Only time will reveal the effects of having 144 Kbps of communications power in every home and office. ISDN could be revolutionary, changing the way we live and work. Then again, it could be evolutionary, merely updating the telephone without changing the familiar uses and social rituals surrounding it.

In either case, ISDN will be the hidden engine behind the changes. The changes themselves will come through applications. And therein lies the quandary and the opportunity.

The Pull Forward

In marketing parlance, the telephone companies and equipment manufacturers are pushing ISDN, but, so far, only a few venturesome companies are pulling it with demand. In a classic chicken-or-egg problem, the demand will presumably be increased by applications, but the applications won't arrive until there is a market.

Here's a look at a few of the possible applications that could

continued

pull ISDN and some of the obstacles that it would face (see figure 2).

• *Telemetry.* If ISDN were ubiquitous, utility companies could install smart meters and read them remotely. But this would not happen overnight. The hundreds of millions of existing meters have no intelligence or communications capabilities.

• *Networking.* We've already mentioned wide-area networks—LANs that use the phone lines to connect to other, more distant environments. They are much less trouble than traditional hard-wired LANs, but there are disadvantages. For one thing, your connectivity habit shows up on the phone bill each month. Furthermore, they have comparatively low performance. The slowest traditional LANs run at about 4 times the speed of a B channel, and many users have become spoiled by the now-commonplace 10-Mbps LANs, such as Ethernet.

Although its performance may not be adequate for every need, an ISDN LAN would probably serve most users quite well. However, the argument is not entirely technical. Analyzing throughput needs and spotting performance bottlenecks is not nearly as difficult as changing customers' perceptions. Only time will tell if the real price/performance characteristics of these networks can overcome their pokey image.

The ISDN wide-area network might also catch on as a personal convenience. Nearly everybody who uses E-mail at work comes to love it, so how about a standard, public, nationwide E-mail system? The catch here is obvious: Although embedded processors are in everything from TVs to thermostats, the computer, per se, has not entered the personal lives of many people. Since home computing has not emerged as a force strong enough to push ISDN, perhaps ISDN will pull home computing.

• *Video.* Even that old science-fiction standby, the videophone, could be born anew. AT&T showed a videophone at the 1964

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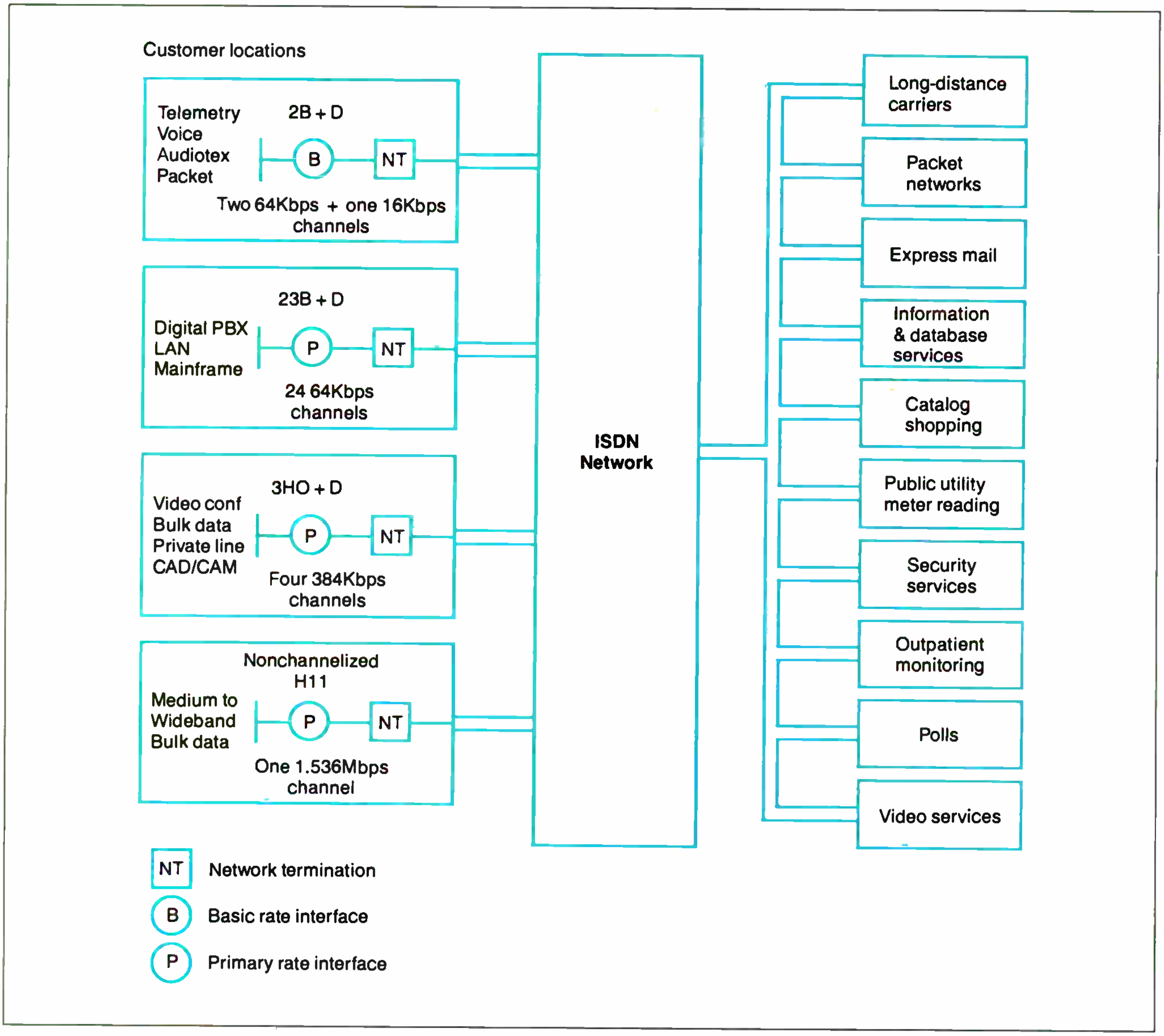


Figure 2: *Many services will be available over ISDN's basic and primary rate interfaces when the technology is fully employed. Some of the potential applications are shown here.*

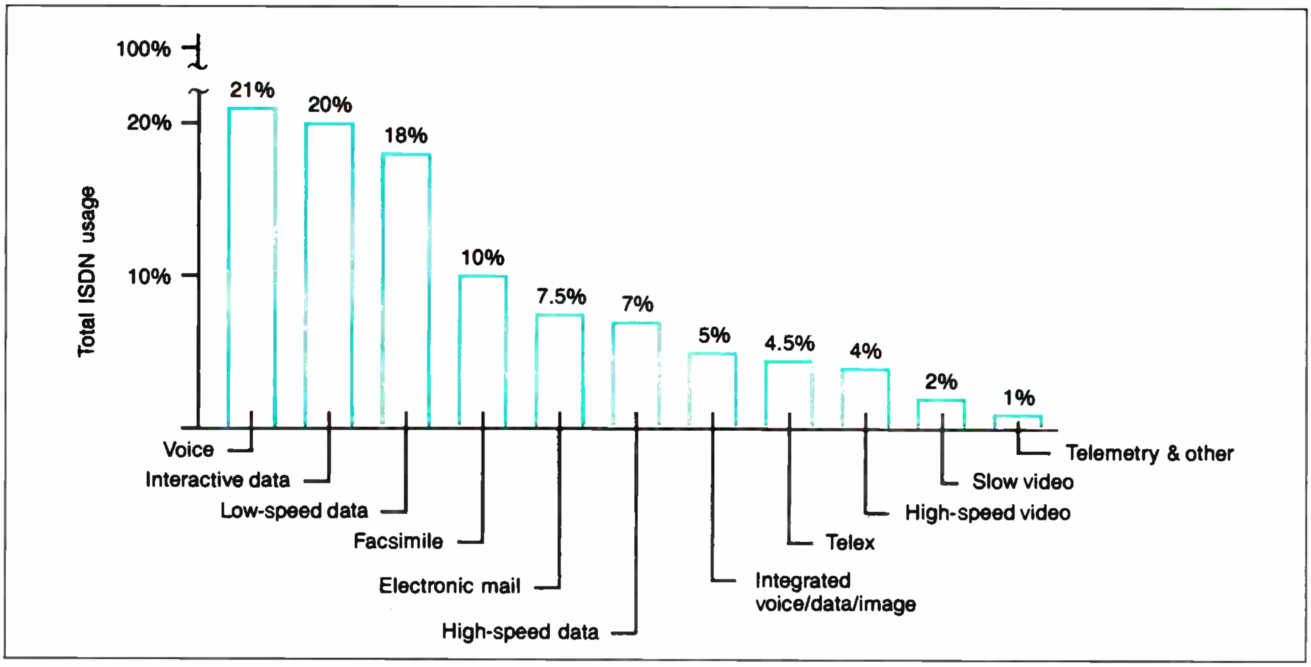


Figure 3: *When ISDN is fully implemented, its largest usage will be for voice, interactive data, and low-speed data. As an emerging technology, however, ISDN may take off in directions unpredicted at this stage of the game.*

World's Fair, but the technology and economics of the day would not support its commercial adoption. Granted, a 64-Kbps channel will not provide broadcast-quality television images, but it can transmit real-time video with acceptable resolution. Imagine working at home and "sitting in" on a meeting at the office, or showing a document and your honest, trustworthy face to a bank's customer-service representative. Or even sending live images of a heart attack victim to paramedics while they simultaneously transmit a videodisk refresher course on cardiopulmonary resuscitation to you.

But will videophones or nationwide E-mail networks ever really catch on? It depends on ISDN, but ISDN depends to some extent on whether applications become popular.

ISDN is an "enabling technology." Think of it as a highway that enables new cities to spring up. It is more than just a new switch or even a new network; it is a potential revolutionary force for the role of technology in society.

But the revolution requires demand as well as capacity. Fast new chips don't sell personal computers. The ability to process words, calculate finances, keep databases, and so forth sells personal computers. And as others have pointed out, no one foresaw word processing when computers were invented.

Technology for technology's sake is almost never a success. The right applications may not be invented until after ISDN has been around awhile, but the conversion to ISDN will be slow and piecemeal until the applications come about.

This situation leads to much ulceration in the telephone service and equipment businesses. The developing ISDN technology is well on the way to being implemented. Strategic commitments, the momentum of vast equipment purchases, and ever-increasing demands on the network will see that it continues. But fortunes will be made and lost over the details.

ISDN equipment and services will reach businesses first, and then probably residential users in islands of high-tech connectivity, such as new construction, and neighborhoods that are near facilities being upgraded to serve businesses. While not exactly egalitarian, this approach makes economic sense.

A Taste of the Future?

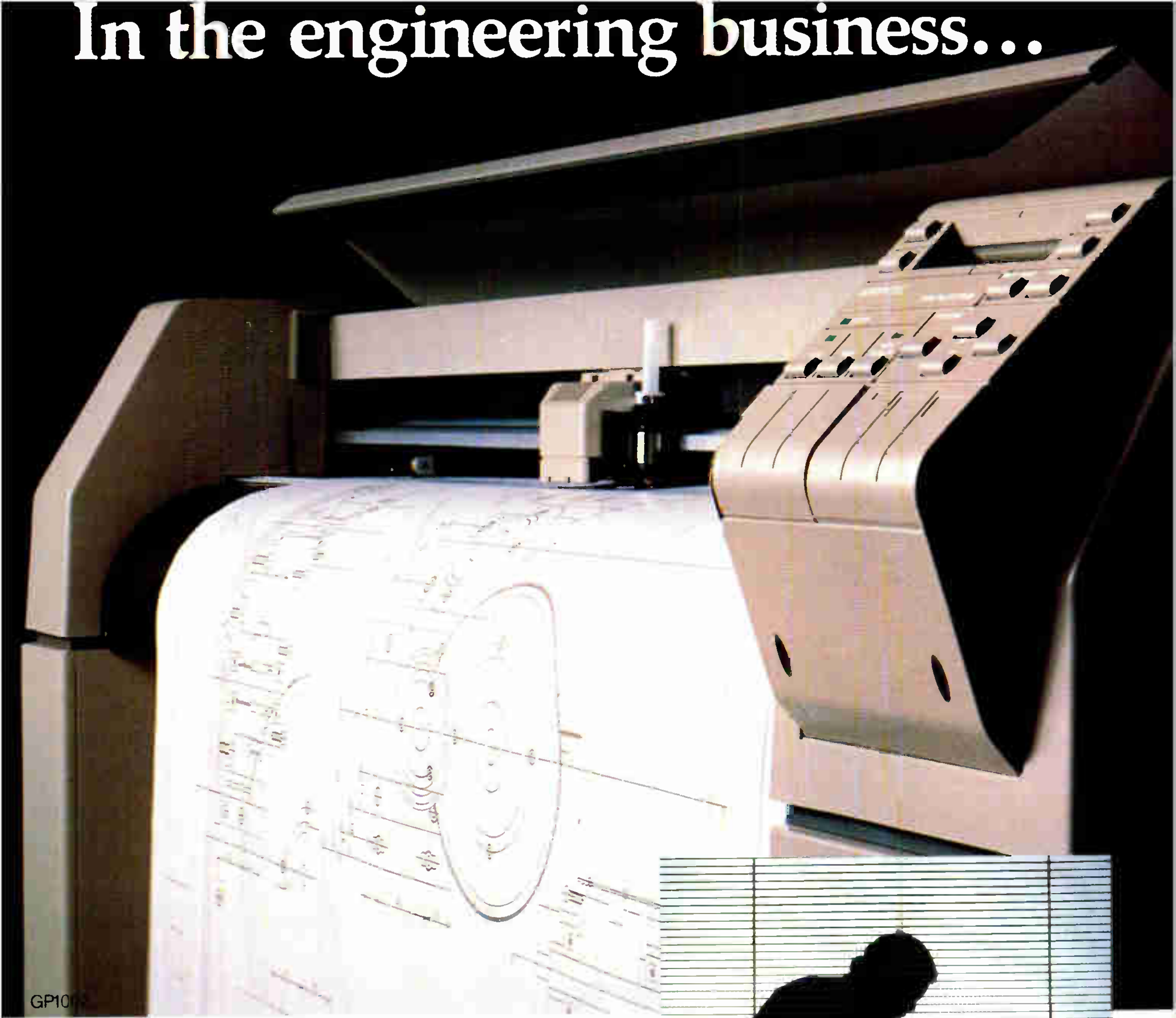
Though the implementation of ISDN has just begun in earnest, standards committees have begun talking about its successor. A technology known as broadband ISDN will eventually provide individual subscribers with performance in the megabit range—enough for television-grade video and high-performance LANs. Adoption of a broadband ISDN could take place at the beginning of the next century. ISDN might suffice for many years; then again, it might merely whet customers' appetites.

Ben Bova once wrote an essay comparing the Douglas DC-2 with its successor, the DC-3. The DC-3 made air travel safe, reliable, and, above all, profitable. The DC-2 did not have the necessary capabilities, but it gave Douglas Aircraft the technical expertise needed to develop the DC-3. It also gave the fledgling airlines an idea of what the next generation of equipment could do. The DC-2 was an enabling technology.

In all likelihood, the capabilities of the ISDN basic-rate interface will be an embarrassment of riches to residential users. But not long ago, you could have said that about a microcomputer with 64K bytes of memory. If it turns out that what the world wants is packet-switched voice or high-resolution video, ISDN will be a DC-2: merely a tantalizing taste of the future.

Neither regular nor broadband ISDN will take off just because the technology is there. Technology vendors have seen the future, and, much to the chagrin of their planning departments, it consists of yet-unforeseen applications. ISDN is coming, but what shape it arrives in remains to be seen. ■

Jay Duncanson is the ISDN department manager, and Joe Chew a staff information developer, at the San Francisco office of Hayes Microcomputer Products Inc. They can be reached on BIX as "editors." The views expressed in this article are their own and not necessarily those of HMP.



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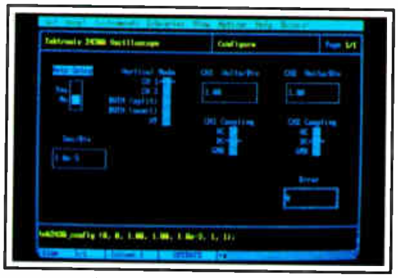

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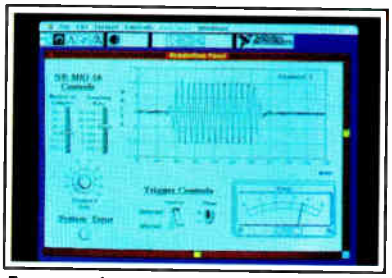

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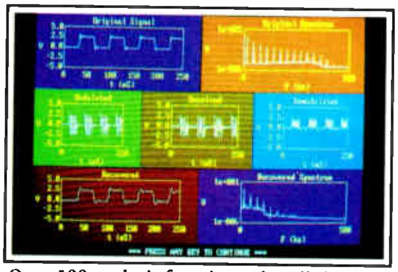

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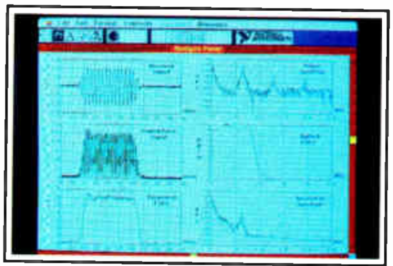

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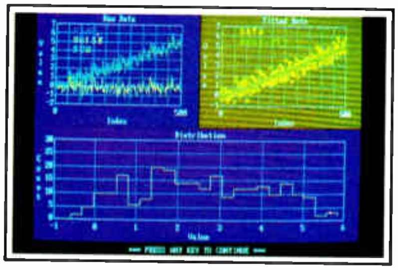

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Part 2

COMPUTERS ON THE BRAIN

Making sense out of the data

by Steve Ciarcia

Last month, I introduced you to the Circuit Cellar electroencephalogram (EEG) monitor called HAL (Hemispheric Activation Level Detector) and discussed its hardware design. This month, I'll look at the system software and provide some directions for HAL's use.

Software Overview

The overall operation of HAL is relatively straightforward. It samples four channels of analog brain-wave data 64 times per second and transmits this data serially to a host computer. The host analyzes two channels of the data to determine frequency components, and it then displays the results on a monitor as a series of continuously changing bar charts.

As I mentioned last month, the frequency range of interest in brain-wave detection is 4 Hz to 20 Hz, which includes alpha, beta, and theta waves. I could have designed HAL with many independent band-pass filters to separate each channel's complex waveform into discrete sinusoidal components, but that would have involved much more hardware. Instead, HAL's raw digitized analog data is analyzed on the host computer using a fast Fourier transform (FFT).

An FFT is like a mathematical prism. Just as a prism breaks down light into its component colors, the FFT breaks down a waveform into the sinusoidal components that make up the signal. In this way, I can extract amplitude and phase values for any given frequency in the target spectrum of 4 Hz to 16 Hz (I didn't display frequencies from 16 Hz to 20 Hz because of speed constraints on the IBM PC).

The system software coordinates four major tasks, which are graphically outlined in figure 1. The Intel 8031 microcontroller's task is precise sampling of hemispherical data and transmission via an optocoupled RS-232C link to the host IBM PC (the 8031 firmware is called BIO31). An IBM PC task called COMMO is an interrupt-driven communications routine that receives HAL's incoming data. Being interrupt-driven, COMMO operates independently of the activities of the FFT analysis-and-display routine (and any other tasks that happen to be running on the IBM PC).

As the data comes in, the host loads it into 1024-byte sample queues for left brain and right brain data. The FFT algorithm reads this incoming data, calculates amplitude and phase values per frequency, and updates integer arrays. Finally, the BIO program reads these arrays to continually update the bar graphs on the video display.

Simple—right? Just like using a hammer to make gravel out of a boulder. Simple in theory, at least.

While HAL is technically independent of the host computer (by virtue of its serial interface), I chose to present the demonstration display on an IBM PC for the sake of convenience. (I invite conversion to other computers and will make such conversions available through the Circuit Cellar bulletin board system.)

Because HAL is supposed to be both an educational and a functional presentation, my fundamental goal for the software was to keep it simple and fast. To that end, I used BASIC wherever possible. However, to maintain processing speed, I incorporated certain assembly language routines that are called from BASIC (i.e., the QuickBASIC compiler).

Refer again to figure 1, the overview block diagram of the system. The COMMO and FFT routines are written in assembly language. COMMO is really a group of subroutines; BASIC merely calls the initialization code.

I wrote the FFT block in assembly language for maximum speed in the FFT calculations. Using a BASIC program, a 64-point FFT took about 20 seconds to do. The existing FFT algorithm in assembly language will calculate 64-point transforms for both channels in about 240 milliseconds (ms). More about this later.

HAL's Brain

The 8031 is a remarkably capable processor that I have been using for many stand-alone projects lately. I described the inner

continued

workings of BIO31 last month with the hardware description, since BIO31 works so closely with the hardware. Basically, BIO31 is a simple read-transmit-wait loop (see figure 2). The read portion of the loop samples the switches and the A/D converter. It then places this information in the output buffer and transmits it out the serial port at 4800 bits per second (bps) to the host computer. The transmission is a 5-byte sequential string: switch position/sync, channel 1, channel 2, channel 3, and channel 4.

Once transmission is completed, the program waits for the 8031's internal timer to time out. Since proper sampling of a continuous waveform requires sampling at a fixed rate, this precise time delay is what provides the host program with data samples that the FFT can successfully analyze.

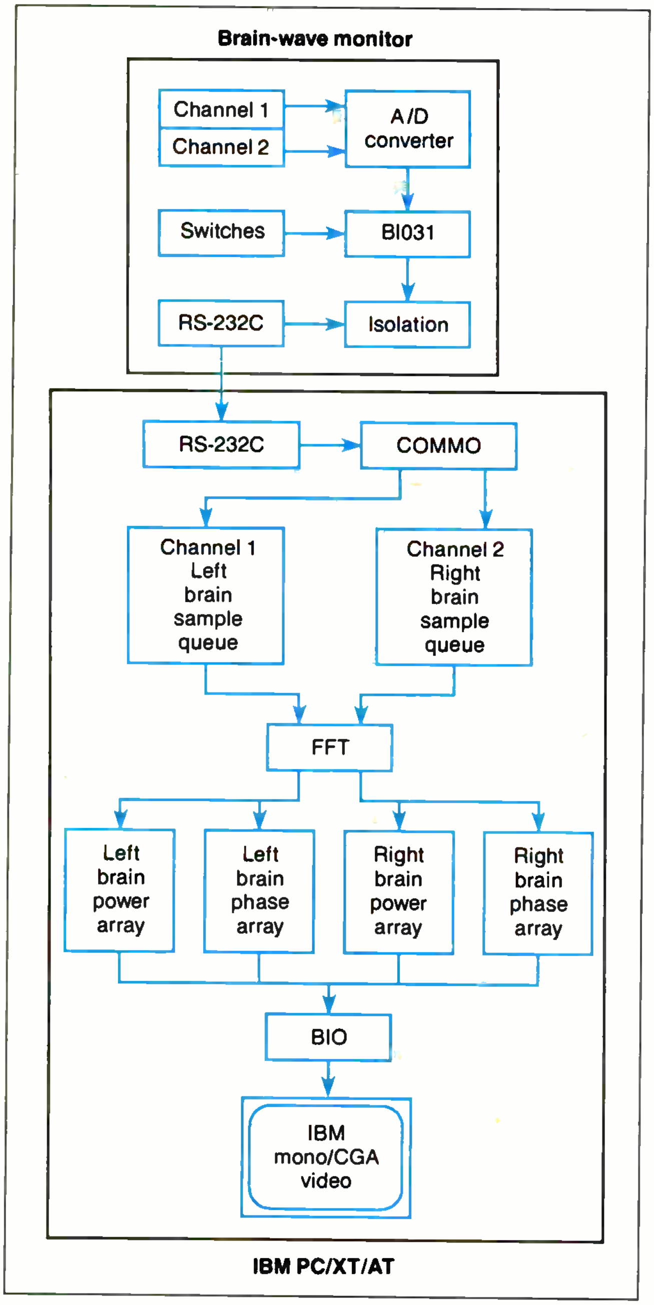

Figure 1: *A block diagram of the complete HAL system, showing major components of the brain-wave monitor and the host machine.*

The IBM PC Communications Interface

The IBM PC's COM1 port is configured as the headset interface port. Recall that the data coming from HAL arrives at 4800 bps in packets of 5 bytes, transmitted 64 times a second. The first byte indicates HAL's switch configuration, and the host computer uses this byte for synchronization purposes.

A switch position/sync byte value of 00000011 binary indicates that both the left and right switches are closed; a value of 00000000 indicates they are both open. The maximum value the switch position/sync byte can have is 3. BIO31, as one of its functions, tests all outgoing data and limits the lowest A/D channel data to a value of 4. Since any incoming data with a value of 3 or less must therefore be the switch position/sync byte, it is possible for COMMO to synchronize easily with the incoming data stream.

COMMO's service routine uses a state machine to synchronize itself with the incoming data (see figure 3). It reads the data byte from the Data Receive register and stores it according to which state the routine is in. If state equals 0, it saves the switch bits and advances to the next state. If state equals 1, it loads the sample data into the left brain sample queue. If state equals 2, it loads the sample data into the right brain sample queue. If a value of 3 or less is encountered, the state will automatically change to 0, and it will save the data as switch parameters.

The Software Prism

After the computer receives HAL's data, the FFT takes over, transforming the collected information into something useful. In this application, I wanted to see what frequencies are active in whatever brain is connected to the EEG and how powerful those frequencies are.

My first impression of the FFT was stated earlier: a mathematical prism. I've read articles that have used the FFT on everything from spectral analysis and digital filtering to biorhythms and random numbers. But what does the FFT do here?

Consider figure 4. The four sine waves on the bottom represent energy levels at four different frequencies plotted with respect to time. The vertical bars represent a 1-second sample window. (The 64 dots on each graph between the two vertical lines represent $1/64$-second intervals.) The top squiggle is an integrated waveform, the sum of the four waveforms below it at any given point in time.

This integrated waveform is similar to what we find in the real world. I used values generated from this integrated waveform to test HAL's software. The results of the FFT on this waveform appear on the screen shown in photo 1. The bars are read side to side, with their respective frequencies labeled in the middle. Energy levels are defined both above and below the bar charts. Notice that I applied the same test data to both the left brain and right brain sample queues. I will discuss the display in greater detail later.

There is a little more to structuring an FFT than just using an algorithm out of a book. Without getting into any mathematical formulas, I will explain the impact of modifying FFT parameters. The text box "Understanding the Fast Fourier Transform" on page 292 explains the FFT, using a version written in BASIC. The initial lines of code are configuration data, and only the last 11 lines perform the actual transform on the data in the array RAWDATA.

You must address three major factors when building a simple FFT algorithm: the duration of the sample window, the sample

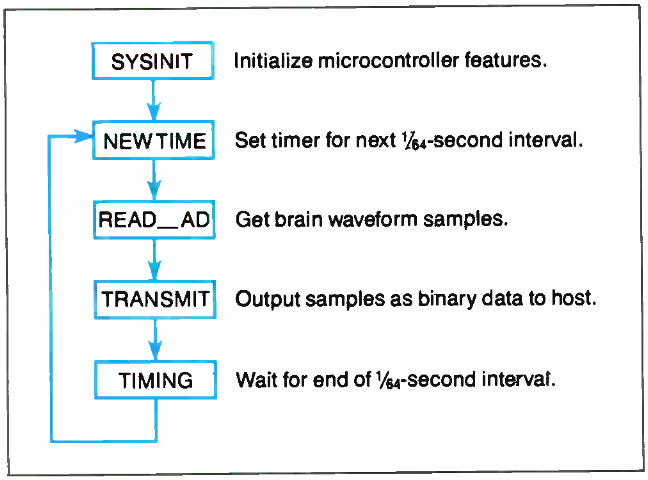

Figure 2: *A flowchart for HAL's firmware program, BIO31.*

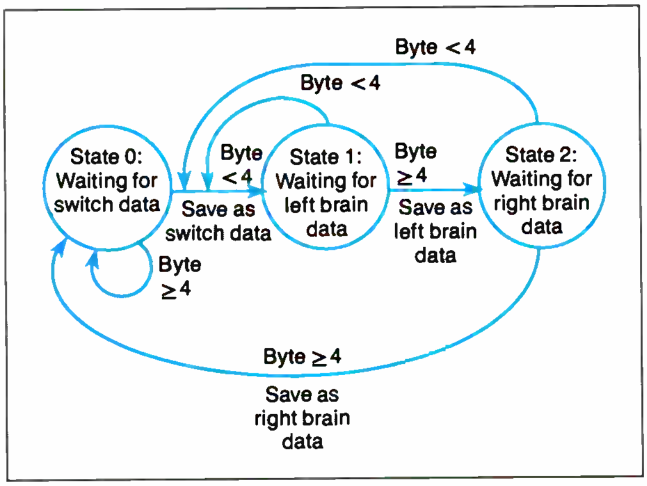

Figure 3: *The host computer's receiver routine executes a finite-state machine, shown here graphically. Each circular node of the graph represents a state, and transitions from state to state occur when the system receives a byte.*

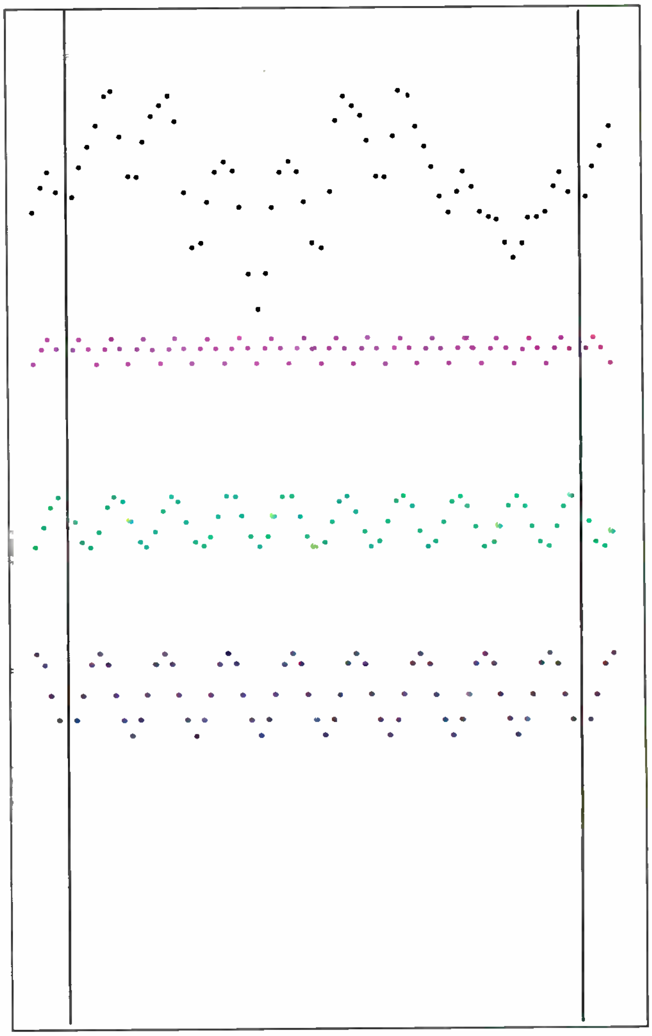

Figure 4: *If you add together the lower four sine waves, you get the topmost, random-looking waveform. The FFT does just the reverse: It takes the composite waveform and extracts its components.*

rate, and the actual frequencies desired for output. These factors are identified as:

- WDW: The sample window in seconds.
- PT: The number of samples to be taken in the sample window.
- MIN and MAX: Lowest and highest frequencies to be evaluated.

The FREQ array represents the sinusoidal frequencies to be integrated into the waveform I talked about earlier, A represents the peak amplitude of these sine waves, and P serves to introduce a phase offset in a given channel. The variable SM specifies the starting offset of the points of data to be analyzed by the FFT. Graphically, SM locates the vertical bars on the display seen in figure 5.

Faster FFT

Speed was a key issue in this project. For a visual display to be of any value to a user, the software has to analyze and display the brain-wave data as quickly as possible. Ideally, you should

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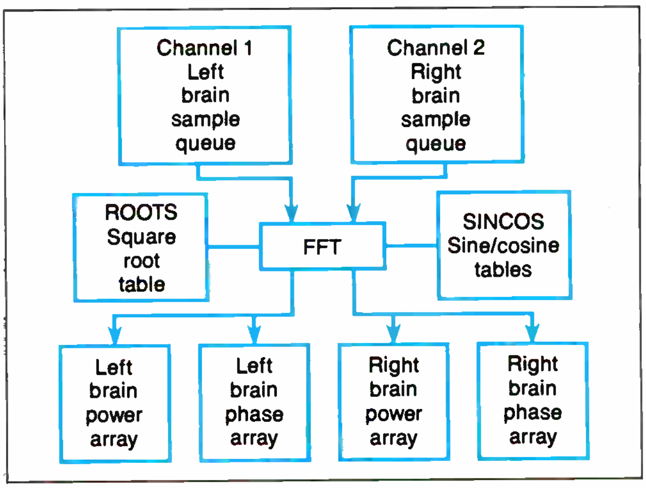

Figure 5: *Main components of the FFT.*

Understanding the Fast Fourier Transform

Listing A is a heavily commented code fragment in BASIC that performs the FFT on an array of data points (RAWDATA). The following are important program variables and their usage in the program.

WDW, the sample window: The time period over which the sample is taken will affect the resolution you can expect in your output. A period of 1 second will yield 1-Hz intervals of frequency. This is the way the program is set up now. If you reduce the sample window to half a second, the resolution is halved and the frequency output will be in 2-Hz increments. By increasing the sample window to 2 seconds, you get 0.5-Hz intervals.

PT, the sample rate: The number of points taken during the sampling period determines the range of frequency increments (dependent on window period) you can calculate. According to the Nyquist sampling theorem, you must sample at a frequency of at least twice as fast as the greatest frequency you expect to encounter. If your high end is 40 Hz, you must take at least 81 samples during that sample window. HAL takes 64 samples during a 1-second window, so it should be able to evaluate frequency output up to 30 Hz.

MIN and MAX, the output frequencies: The countervariable HZ need only be the frequencies desired. The FFT algorithm is really an accelerated version of what is called a discrete Fourier transform (DFT). The DFT calculates frequency output from 0 to the number of points taken. But this output includes something called negative frequencies. These mathematical monkeyshines can be ignored for the purpose of understanding this project. However, FFT.BAS can easily be tweaked to display this graphically, also.

Listing A: *This BASIC program performs the FFT on an array of data points.*

```
REM FREQUENCY(Hz)
FREQ(0)=16:   REM  Channel 1
FREQ(1)=9:    REM  Channel 2
FREQ(2)=8:    REM  Channel 3
FREQ(3)=2:    REM  Channel 4

REM AMPLITUDE
A(0)=10:  REM Channel 1
A(1)=20:  REM Channel 2
A(2)=30:  REM Channel 3
A(3)=40   REM Channel 4

REM PHASE  (Radians)
P(0)=0:   REM Channel 1
P(1)=0:   REM Channel 2
P(2)=0:   REM Channel 3
P(3)=0:   REM Channel 4

WDW=1.0: REM Sample period in seconds
PT=64:   REM Number of sample points
MIN=2:   REM Min freq to evaluate (1 - 25)
MAX=16:   REM Max freq to evaluate (MIN - 25)

SM=040:    REM Offset to start of sample period

FOR HZ = MIN TO MAX
REM ** Clear the real and imaginary
REM ** components.
  REAL = 0
  IMAG = 0
REM ** Begin the frequency analysis
REM ** loop.
  FOR X=0 TO PT-1
REM ** Calculate reference angle
    G = 2*PI*HZ*X/PT
REM ** Calculate real components
    REAL = REAL + RAWDATA(X)*COS(G)/PT
REM ** Calculate imaginary component
    IMAG = IMAG - RAWDATA(X)*SIN(G)/PT
  NEXT X
REM ** Power calculation
  FFT(HZ,0) = 2*SQR(IMAG*IMAG + REAL*REAL)
REM ** Phase calculation
  FFT(HZ,1) = ATN(IMAG/REAL)
NEXT HZ
```

be able to see changes in hemispherical activity every half second or sooner.

Clearly, a high-level language was not going to do the trick. (Running the FFT algorithm above in compiled BASIC takes about 5 minutes.) Ultimately, I created a machine language version of the FFT algorithm described in FFT.BAS. Figure 5 shows the flow of sample data from the left and right brain sample queues through the algorithm and into the power and phase arrays defined in the BASIC program. On an IBM PC XT, it takes about 2 seconds to complete the entire feedback cycle; an IBM PC AT processes a cycle in about half a second.

To get the necessary speed, I used a variety of techniques to optimize the FFT:

• *Number of data points*: I chose 64 data points as the sample size for a few reasons. First, you can perform integer division by 64 using shift operations instead of a divide instruction. When I used the 8088's integer-division instruction, it took about 340 ms to calculate a single 64-point FFT. In contrast, division using shift operations takes about 120 ms to accomplish the same thing.

Second, taking the division by shifting into account, 64 points per second will give the resolution and the range needed to evaluate frequencies from 4 Hz to 20 Hz. The Nyquist sampling theorem dictates that you must sample a waveform at a frequency of at least twice its highest frequency component. Consequently, 32 points would not be enough samples to analyze anything above 15 Hz. On the other end, 128 points would give you a greater frequency range for analysis, but it would take considerably longer to calculate.

• *Table lookup*: The FFT algorithm requires only a fixed number of sine and cosine values. By building these 64 values into a table rather than calculating them on the fly, you can save a lot

continued

You can display HAL's output in either CGA or monochrome.

of time. Using a table of square roots is similarly much faster than calculating them.

- *Scaling*: When I built the tables, I took care to scale the integer values so power calculations can divide by 256. This magic number lets the software shift bytes instead of bits, giving considerable savings in time.
- *Phase octants*: Because the accuracy of this device is limited to integer calculations—and again because of speed—the program reports phase results in 45-degree increments. Instead of using the arctangent to calculate phase results, it is quicker in machine language to determine them using the sign and absolute amplitude of both real and imaginary components. The result is in phase octants.

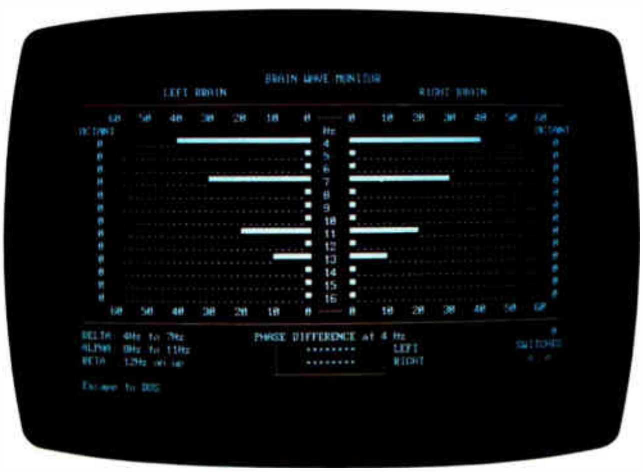

Photo 1: *HAL properly unravels the complex waveform shown in figure 4. Note the four long horizontal bars; each corresponds to one of the four component sinusoidal waves.*

Finally, the FFT is a much deeper subject than I can possibly cover in this article. I recommend a book entitled *The FFT: Fundamentals and Concepts* by Robert W. Ramirez (Prentice Hall, 1985). It provides an excellent look at the FFT and the theory behind it.

Driving the IBM Video Display

The last major block in the system diagram is called BIO. This module takes calculated output from the power and phase arrays just loaded by the FFT, converts this output into character strings, and writes them to the display. This part of the software displays the window opened by HAL into your brain.

Photo 2 shows a typical HAL display. You can display HAL's output in either CGA or monochrome. The horizontal bars represent the relative energy levels found in the frequencies evaluated. The bars that lead to the left represent the energy in the left hemisphere (channel 1); the bars to the right of center are the right hemisphere (channel 2).

Respective frequencies are labeled down the middle of the display under the "Hz" heading. The numbers 0 to 60 located in the rows above and below the energy bars represent relative energy levels only (pressing F3 changes the scale). They do not necessarily indicate absolute voltage levels that a much more expensive EEG machine might provide.

The phase angle of any given frequency is shown under the "OCTANT" heading for its respective hemisphere. An octant is nothing more than an eighth of a cycle. Octant 0 means the waveform is within the first 45 degrees of its cycle. A value of 1 puts it between 45 and 90 degrees, and so on.

Relative phase is indicated in a box at the bottom center of the screen under the "PHASE DIFFERENCE" heading. This feature selects the frequency from the left hemisphere with the greatest energy level and compares its phase angle with the phase angle of the corresponding frequency in the right hemisphere. The two rows of asterisks represent the position of the right hemisphere relative to the left hemisphere. If the right

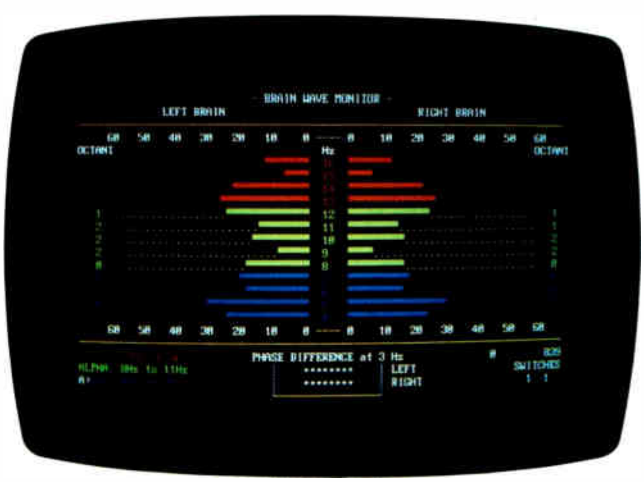

Photo 2: *HAL's output can be displayed on an IBM PC using the CGA.*

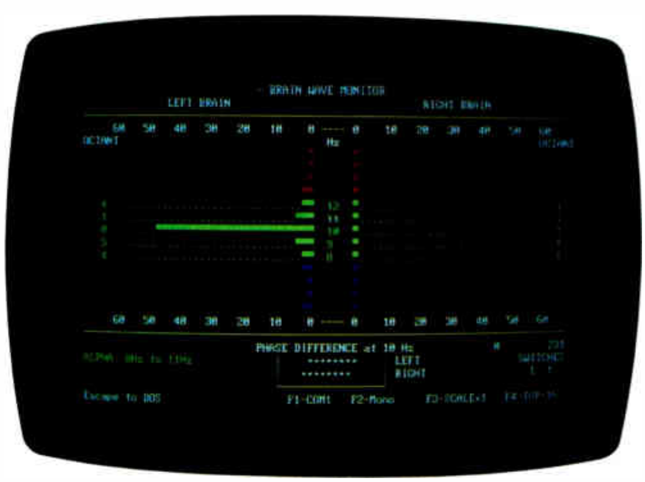

Photo 3: *While testing HAL, I injected a 10-Hz sine wave through the headset electronics. The resulting output, shown here, indicates that the system works properly.*

hemisphere is one octant ahead of the left hemisphere, the right hemisphere indicator will be advanced one column in front of the left hemisphere indicator.

Yes, But Does It Work?

How do we know that what we see on the display is really what is going on in our head? What makes data from the headset electronics different from a string of random data? Testing, of course.

I've already discussed the first test: Taking a waveform built of known sinusoidal components, passing it through the FFT algorithm, and verifying that the frequency and energy levels coming out are what I put in. The next level of confidence comes from using a sine-wave generator to force-feed the hardware with real data. Photo 3 is a sample of a 10-Hz sine wave being introduced into the headset electronics channel 1 input. Note that all other frequency bands are null.

Once we know how the FFT algorithm works—and we have the confidence that the hardware will deliver the data correctly—the rest is up to interpretation by the users. A sample session using the complete system seems to indicate that many frequencies are active. There also appears to be a difference between the right and left hemispheres in both amplitude and phase. But just what that means will have to be left to a person more involved with biofeedback.

Using HAL

HAL is one of the few Circuit Cellar projects in which the circuitry and software are relatively simple in comparison to the application. While the basic EEG apparatus has been in use for 60 years, we are just beginning to understand the "circuitry" and "software" operating within our own heads. Hundreds of volumes are devoted to clinical and research electroencephalography. I have included some possibilities for further reading at the end of the article; you may find them interesting as you explore this complex and fascinating field.

HAL provides an effective demonstration of how our gross behavior is in some way mirrored in the electrical activity of the brain. To view this behavior, however, you must learn how to connect HAL to your head.

You can purchase disposable EEG electrodes with adhesive pads and conductive gel from medical supply houses. Reusable silver/silver-chloride electrodes are also available. The reusable electrodes are more expensive initially, but you can use them almost indefinitely if you care for them properly.

Five wires are involved in a two-channel HAL connection: common reference, left-channel differential input pair (J1A and J2A), and right-channel differential input pair (J1B and J2B). You should construct the differential pair wires with shielded cable. I found that standard shielded microphone cable—with a male RCA connector at one end and a snap to mate with the electrode at the other end—is quite sufficient. The shield is, of course, grounded only at the RCA jack on HAL. Be careful not to accidentally short the shield to the differential input electrodes or HAL will produce erroneous results.

You can place the common reference electrode on the mastoid, the bony projection just behind the ear. You should first clean the area with soap and water to remove oils from the hair and scalp. Next, rub the area lightly with a piece of alcohol-dampened gauze. Finally, peel the adhesive from a disposable electrode, fill the well with conductive gel (but do not overfill), and place the electrode on the selected spot.

Follow a similar procedure to place the differential-pair electrodes on each hemisphere. One wire (J2A or J2B) goes over the frontal lobe—directly above the eye and just below where your

Warning

HAL is presented as an engineering example of the design techniques used in acquiring brain-wave signals. It is not a medically approved device, no medical claims are made for it, and it should not be used for any medical diagnostic purposes. Furthermore, the safe use of HAL requires that the electrical power and communications isolation described in its design not be circumvented. HAL is designed to be battery-operated only. Do *not* substitute plug-in power supplies.

hairline was before it started receding! The second electrode (J1A or J1B) is more difficult to place (unless you happen to be completely bald). You should put it over the occipital lobe, which in most people is covered with hair.

On the back of your head is a ridge, where your skull begins to bend inward toward your neck. Find a spot about a third of the way from the midline of your head to the common electrode placed on the mastoid and just on or below the ridge. Prepare the scalp as before, taking care to hold the hair carefully away from the site. You might try using a sweatband to hold the electrode in better contact with the scalp, making several small holes in the sweatband to allow easier access to the electrode connector.

Figure 6 shows the general location and nomenclature for commonly used electrode placements. If you build a multichannel model of HAL, you should refer to more detailed literature about electrode placement, monopolar and bipolar placement, and other esoteric subjects.

Assuming that you have successfully placed both channels of electrodes appropriately, it is time to fire up the software supplied with HAL. Remember, to retain its electrical isolation,

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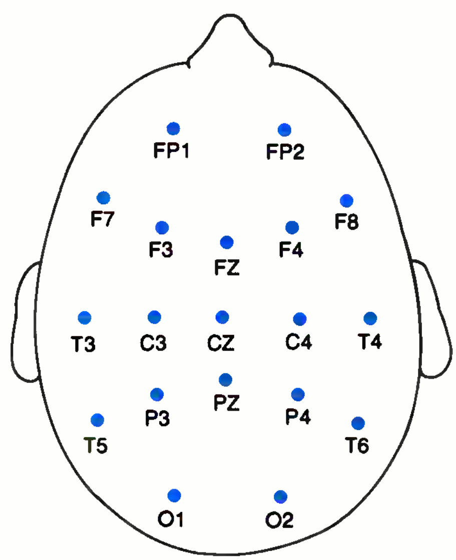

Figure 6: *Commonly used locations and nomenclature for electrode placement.*

you should operate HAL only on batteries, *exactly* as presented.

Attach the electrode wires to the electrode connectors, connect HAL to the computer's COM1 port, turn on HAL, load BIO.EXE into the computer, and watch your monitor. The sample display illustrated previously will let you see your own brain activity as you produce it. Actually, due to sampling and processing time, you will see it delayed by about half a second.

You may see little high-amplitude activity, and the dominant frequency may drift quite a bit (pressing F3 will change the amplitude range). But if you close your eyes and make your mind less blank than usual, your "lab partner" should see a dominant frequency appear somewhere in the alpha-wave range. Of course, if you open your eyes to see it, it will immediately disappear. Somehow this is reminiscent of the old question about a tree falling in a forest making a sound or not. Since HAL's data is serial, you could store a session to disk and view it "off-line" later.

The display also shows the condition of the two optional switches that can be attached to HAL. The intent here was to provide a way for you to monitor either some external condition or internal state, so you can correlate it with your brain-wave activity. You could use two momentary contact switches, one for each hand perhaps, to see if you can correctly identify from internal cues some aspect of brain functioning (e.g., what band you are producing a dominant frequency in, whether the left or right hemisphere is showing greater power output for different mental tasks, and so forth).

Alternatively, some external source—the presence or absence of music, a strobe light, or other stimulus—could trigger the switches. Since you have two switches, you could test for four different conditions.

You can also modify the BIO code to turn HAL into a standard biofeedback device. In this case, you would want to add threshold controls. That is, the program could provide audio feedback only when you had achieved certain minimum values of relative amplitude within a certain frequency band. You could provide different feedback for each channel, or feedback could be tied into both channels meeting the same (or different) criteria.

A multichannel HAL would need a completely different display to provide meaningful feedback about the brain's activity. An EGA display could be mighty useful here, in some way showing activity in terms of color on a map of the brain.

A Final Thought

As I said earlier, we are only starting to understand the relationship between our brain-wave activity and our mental states. HAL is not intended to take the place of a $100,000 EEG analyzer in a modern neurologist's lab, but it certainly can provide the serious experimenter a valid vehicle for entry into the fascinating world of neuroscience.

Next Month

I'll present a development system for Intel's 8051 family of microcontrollers using the IBM PC as a base. ■

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Special thanks for help provided on this article to Dr. Robert Stek, David Schulze, Rob Schenck, Jeff Bachiochi, and Ed Nisley.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Co., P.O. Box 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I covers articles in BYTE from September 1977 through November 1978. *Volume II* covers December 1978 through June 1980. *Volume III* covers July 1980 through December 1981. *Volume IV* covers January 1982 through June 1983. *Volume V* covers July 1983 through December 1984. *Volume VI* covers January 1985 through June 1986.

Circuit Cellar Ink

It's virtually impossible to provide all the pertinent details of a project or cover all the designs I'd like to in the pages of BYTE. For that reason, I have started a bimonthly supplemental publication called Circuit Cellar Ink, which presents additional information on projects published in BYTE, new projects, and supplemental applications-oriented materials. For a one-year subscription (6 issues), send $14.95 to Circuit Cellar Ink, P.O. Box 3378, Wallingford, CT 06494. Credit card orders can call (203) 875-2199.

The following item is available from

CCI
P.O. Box 428
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Inquiry 934.

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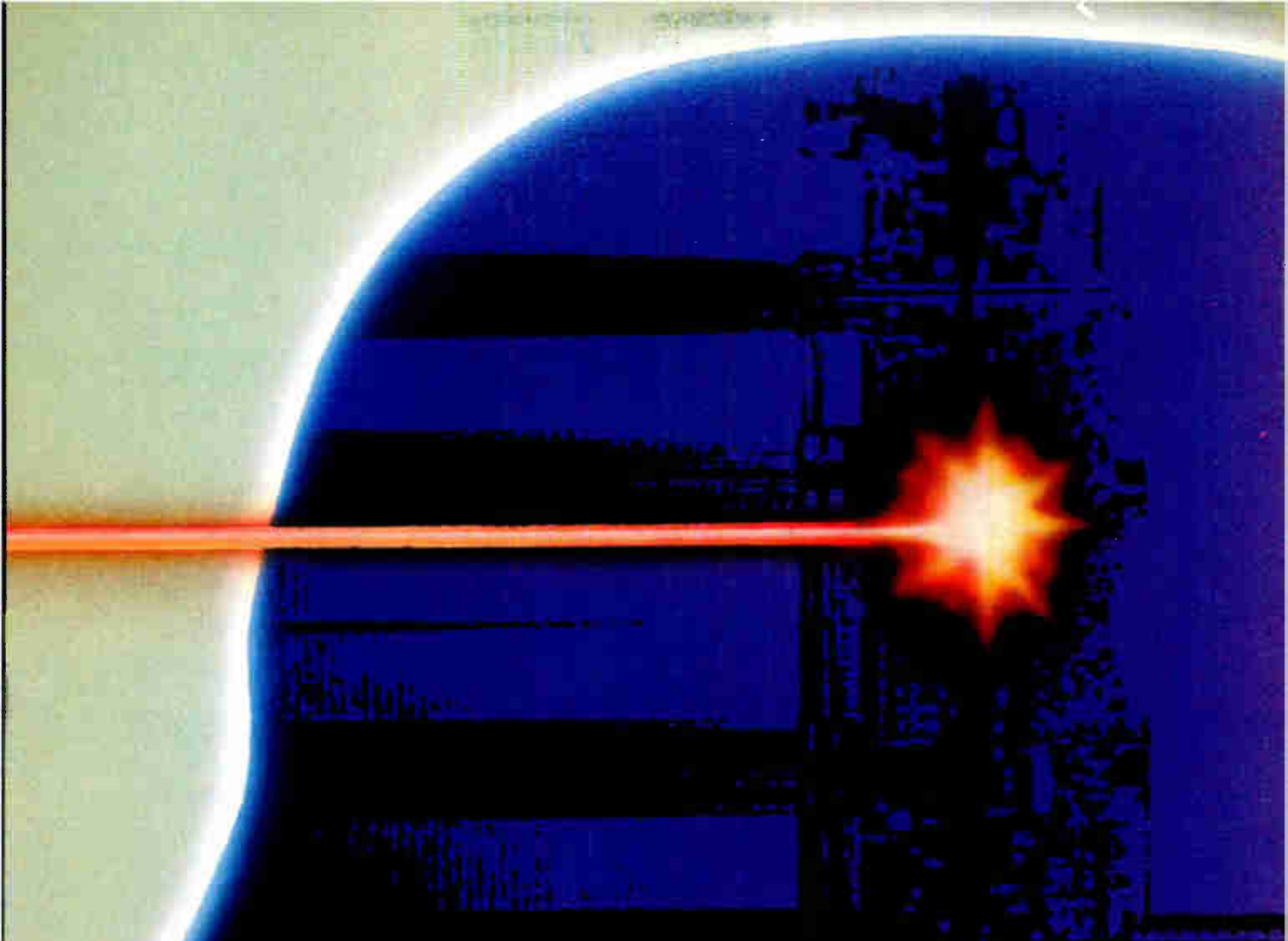

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A TURBO TSR

Turbo Pascal 4.0 has everything you need to craft your own TSRs

Scott Robert Ladd

Terminate-and-stay-resident (TSR) utilities are popular among users of the IBM PC family of computers, and it's easy to see why. A TSR can fill just about any utilitarian need you have: spelling checker, keyboard macro generator, pop-up calendar and notepad, special device driver, LAN manager, and the list goes on. What's the secret behind the TSR's flexibility?

A TSR performs some sort of task, either automatically (in response to some interrupt) or when you request it. After it has executed, it returns control of the system to MS-DOS but remains resident in the computer's memory. Since MS-DOS is a single-tasking operating system, a TSR can provide a limited level of multiprocessing. Borland's SideKick and Living VideoText's Ready are two currently successful commercial TSRs.

By their nature, TSRs violate many rules of "proper" programming. They often commandeer system resources that documentation clearly states should *not* be commandeered, and they can interrupt an unsuspecting program. However, with careful planning and design, you can create a TSR that minimizes its impact on the other programs that are running on your computer.

Nearly every programmer I've talked with has had the desire to write a TSR program. Until recently, most TSRs were written in assembly language, which requires some fairly advanced technical skills. With the advent of Turbo Pascal 4.0, you can now write a well-behaved TSR entirely in a high-level language.

The advantage of this is the ease of code creation and maintenance. Turbo Pascal 4.0 (for the remainder of this article, any references to Turbo Pascal will mean version 4.0) provides many facilities applicable to creating TSRs; facilities the programmer would otherwise have to spend hours creating (see the textbox "Turbo Pascal 4.0" on page 303). I believe these conveniences far outweigh the only disadvantage of using Turbo Pascal to create a TSR: larger program size. It adds about 8K to the resident size of a TSR, although this becomes less important as the size of the TSR increases.

Case Study: The Quick Time TSR

The TSR that I designed displays a clock on a PC's CRT when you press a special key sequence known as a *hot key.* Once the clock appears, you can press any key to make the clock vanish and return control to the interrupted application. I call this TSR Quick Time (QT for short), and, although it is not terribly complex, it has all the elements found in more complicated TSR utilities:

- A hot key activates the program.
- Since QT will make changes in the video display, the program saves the current display and cursor of the underlying application, then restores them upon exit.
- QT can determine if it has already been installed and will not allow multiple copies of itself in memory.
- MS-DOS is not reentrant—meaning it must not be interrupted by a TSR when it is in the middle of doing something. QT will not activate during critical MS-DOS activities.
- If QT is already activated, it will not allow itself to be activated "on top of itself."
- You can deinstall QT (remove it from memory) when you no longer need it.

[Editor's note: *Pseudocode for Quick Time is in listing 1. The complete source for QT is available on disk, on BIX, on BYTEnet, and in the Quarterly Listings Supplement. See page 3 for further details.*]

Getting Your Toe in the Door

From the user's standpoint, installing a TSR program proceeds in the same way as executing a normal program: You simply enter the name of the program at the MS-DOS prompt. A normal program goes about its business and, when finished, frees the memory it was using. A TSR program, however, does several things before returning control to the system. For instance, QT does the following:

continued

Turbo Pascal 4.0 provides many facilities applicable to creating TSRs; facilities you would otherwise have to spend hours creating.

1. It checks to see if a copy of itself has already been installed. If so, it aborts the installation.
2. It determines the type of video adapter installed.
3. It intercepts required interrupt vectors and reroutes them to its own interrupt handlers. For example, QT captures the keyboard interrupt to watch for the hot key.
4. It locates the INDOS flag. This is an undocumented feature that QT uses to determine if it can interrupt MS-DOS.
5. It terminates using the Turbo Pascal procedure Keep, returning control to MS-DOS and remaining resident in memory.

It is essential that a TSR determine whether or not a copy of itself has already been installed. Unfortunately, MS-DOS has no built-in functions for identifying which programs are in memory. Some TSRs search through the memory allocated for an identifying sequence. This is a slow method that may not work with all flavors of MS-DOS. Other TSRs check for special codes in and around the entry points to specific interrupts. That method is simple to implement in assembly language, but very difficult to use from a high-level language such as Turbo Pascal.

QT uses an entirely different method. BIOS interrupt 11 hexadecimal returns the equipment status word from a fixed location in low memory. When first installed, QT intercepts interrupt 11h and watches the CX register for a special 2-byte code. If QT receives this code, it places a second (answering) code in CX. In any case, QT will load the AX register with the equipment status word, so that any program calling this interrupt will still get the proper information. The first thing QT does when executed is load CX with the first code, execute an interrupt 11h, and then look for the response code. If CX does not contain the response code, QT knows that it has not been installed, and so it proceeds normally. Otherwise, the installa-

Listing 1: *Pseudocode for Quick Time.*

```
START:
  Display heading;
  Call INITIALIZATION;
  If INITIALIZATION = TRUE then
    Tell user of successful install;
    Terminate and stay resident (Use
     Turbo Pascal's KEEP procedure).
  else
    Tell user of failure;
    Exit.

INITIALIZATION:
  If QT already installed then
    return FALSE.
  Set display buffer based on video mode;
  Reroute INT 28H vector;
  Reroute INT 11H vector;
  Reroute INT 09H vector;
  Locate the INDOS flag;
  Store location of QT's stack;
  Set BUSY to FALSE;
  Return TRUE.

INT28: (INT 28H handler)
  Clear interrupts;
  Call original DOS INT 28H handler;
(A):
  If BUSY = TRUE and HOTKEY pressed then
     call DEINSTALL.
  If BUSY = FALSE and HOTKEY pressed and
  current video mode is text mode then
   Begin
     Set BUSY to TRUE;
     Save caller's stack;
     Set stack to QT's stack;
     Save current display (SaveScrn);
     call PROCESS;
     Restore display (RestScrn);
     Set BUSY = FALSE;
   End.
  Restore interrupts;
  Exit.

INT11: (INT 11H handler)
  Call original DOS INT 11H handler;
  If CX register has call code then
     Load CX register with response code.
  Load AX register with equipment list word;
  Exit.

INT09: (INT 09H handler)
  Disable interrupts;
  Call original BIOS INT 09H handler;
  ...
  (Remainder of code identical to (A) in
   INT 28H HANDLER routine.)

PROCESS:
  Turn the cursor off;
  Repeat
    Get current time;
    Position output location;
    Display time;
  Until key is pressed.
  Restore the cursor;
  Exit.

DEINSTALL:
  Save caller's stack;
  Set stack to QT's stack;
  Turn cursor on;
  Restore screen;
  Restore original INT 28H, 11H, and
  09H vectors;
  Deallocate QT's memory;
  Restore caller's stack;
  Exit to DOS (Use Turbo Pascal's
```

tion terminates with an appropriate message. You can use this method for multiple TSRs by just changing the request and response codes (InstCode1 and InstCode2 in QT's source code).

QT displays information on the screen, and so must save the display of the current application when activated. QT gets the current video mode using function 0Fh of BIOS interrupt 10h. If the mode is 7, QT knows it is dealing with a monochrome adapter with video memory beginning at segment B000h. Otherwise, QT knows it is dealing with a color adapter (CGA or EGA) whose video memory begins at segment B800h.

Next, the program must intercept several interrupts. You can declare a Turbo Pascal procedure to be an interrupt handler by using the interrupt statement in the procedure definition. An interrupt handler must save all registers when called, and return using a special IRET (interrupt return) function. The interrupt statement tells Turbo Pascal to handle all this automatically.

QT uses the Turbo Pascal function GetIntVec to obtain a current interrupt vector address. QT saves the vector (a pointer to the interrupt handler code in the BIOS) and "wires" a new interrupt handler into the interrupt. I used the Turbo Pascal SetIntVec procedure, which assigns a Turbo Pascal procedure's address to an interrupt. In this way, any program that calls the old interrupt will pass through QT's new handler code, which transfers control to the saved vector. This keeps other programs that use the same interrupt from being "cut off." When you deinstall QT, it restores the old interrupt vector.

QT intercepts three interrupts: 11h, used for determining the TSR's installation status (see above); and interrupts 09h and 28h, so that QT can watch for its hot key. (Pressing a key invokes interrupt 09h. Interrupt 28h is the MS-DOS "idle" interrupt; the operating system calls this interrupt when the system is at the DOS prompt, waiting for a key.)

An undocumented MS-DOS function, 34h, retrieves the address of what is known as the INDOS flag. This counter represents the number of currently active MS-DOS functions. MS-DOS is non-reentrant. Simply put, this means a program cannot interrupt an MS-DOS procedure in progress to call another MS-DOS procedure. QT's Int09 interrupt handler uses the INDOS flag to avoid interrupting MS-DOS when it is busy (e.g., when INDOS is greater than 0). The TSR has to be clever, however, because INDOS is set to 1 whenever MS-DOS is awaiting input at the DOS prompt. However, since MS-DOS periodically executes an interrupt 28h while waiting, and since QT intercepts this interrupt, the TSR can deduce when it's safe to activate.

Finally, QT sets a Busy flag to FALSE, indicating that the TSR is inactive. (The Int09 and Int28 interrupt handlers check the Busy flag to ensure that QT is not activated while it is already active.) It then calls Turbo Pascal's Keep procedure, which calculates the program's size and uses MS-DOS interrupt 21h, function 31h to terminate the application and keep it resident. You can use Turbo Pascal's $M directive to set the size of a program's stack and heap (where the program keeps dynamically allocated variables); I have set each to 1K bytes. If you're writing a more complex TSR, you'll probably need to set your stack and heap size to some larger value.

Pop It Up

The interrupt-handling procedures Int09 and Int28 watch for QT's hot key. When either interrupt is invoked, the handler executes the CallInt function (which I wrote in in-line code) to execute the original interrupt handler. Upon return from the original handler, QT compares the hot key code in constant Activate against the keyboard status byte. Each bit in the keyboard status byte represents the current state of the shift and toggle keys. The 8 bits are mapped as shown in table 1.

QT looks for the value 0Ah in the status byte, which indicates that the user is pressing the Left Shift and Alt keys simultaneously. (If you're going to write your own TSR, you should make sure that different TSRs use different key combinations for activation.) QT then checks the Busy flag to verify that it is FALSE, proceeds if so, and exits if not. As a final check, the TSR confirms that the video display is in one of the text modes. If not, QT will not activate. (Graphics modes use large amounts of memory—from 4K bytes to 256K bytes on standard PC video adapters—and QT would have to reserve enough memory within itself to preserve the graphics screen, making QT's memory requirements prohibitive.)

Once QT has determined that it can activate, it saves the current value of the stack segment and pointer (the SS and SP registers). QT then sets the stack to the TSR's own local stack. This is a preventative measure that guarantees there will be enough stack space for QT to execute. Of course, QT will restore the interrupted programs stack at exit time.

QT also saves the current video mode, display buffer, and cursor position using Turbo Pascal's SaveScrn procedure. Because some programs (e.g., SideKick) don't use the BIOS to manipulate the cursor (they talk directly to the 6845 video controller chip), SaveScrn must save the position in two ways: through the BIOS, and by accessing cursor information internal to the 6845. SaveScrn's counterpart is RestScrn, which restores the original mode, display, and cursor.

QT's Process procedure handles the actual visuals. The program simply runs in a loop, retrieving, formatting, and display-

continued

Turbo Pascal 4.0

Here's a quick list of the Turbo Pascal 4.0 features that relieve some of the burdensome work of writing a TSR:

GetIntVec—This procedure accepts an interrupt vector number (must be in the range 0–255) and returns the address stored at that vector's location.

Interrupt—Not a procedure itself, the interrupt directive defines a user-written procedure as being an interrupt handler. Such a procedure automatically saves all registers upon entry and initializes the DS register.

PrefixSeg—A predefined word variable that contains the segment address of the Program Segment Prefix.

SetIntVec—Inverse of GetIntVec. You pass an interrupt vector number and the address of an interrupt service routine (ISR) to SetIntVec. The ISR becomes the new interrupt handler for the vector.

Keep—This procedure calls the DOS terminate-and-stay-resident function (interrupt 21h, function 31h). The program's code, data, and stack segments remain in memory, and control returns to DOS.

Halt—Stops the program and returns control to the operating system.

Table 1: *Format of the keyboard status word. If a bit is set to 1, the associated key is activated; if 0, it is not.*

Bit	Meaning
0	Right shift
1	Left shift
2	Control
3	Alt
4	Scroll lock
5	Num lock
6	Caps lock
7	Insert state

ing the time. The loop exits when you press any key. I've defined procedures `CursorOn` and `CursorOff` (using BIOS interrupt 10h, functions 1 and 3) to turn on and off the display of the cursor, avoiding a flashing cursor on the screen.

Out! Out! Damned TSR!

Often, you will want to remove (or "deinstall") a TSR once it has become resident. This is usually done to make the memory taken up by the TSR available to other programs.

The `Int09` and `Int28` procedures watch all keystrokes, and if they see that you've pressed the hot key while the `Busy` flag is TRUE (i.e., while the TSR is activated) they call procedure `DeInstall`.

`DeInstall` first restores the original screen and cursor. Then it reinstalls the previous interrupt handlers for interrupts 28h, 11h, and 09h (saved during the initialization of the TSR).

Finally, the TSR must free the memory blocks it has taken control of. There are two such blocks: one for the program itself and one for its environment. When you execute a program under MS-DOS, the operating system places a program segment prefix (PSP) in the first 256 bytes before the program. The PSP includes several items of information, but there's only one that we're really interested in: the segment program's environment block, located at an offset of 44 bytes within the PSP.

Fortunately, Turbo Pascal provides a predefined variable, `PrefixSeg`, which contains the segment of the PSP. Using `PrefixSeg`, QT creates a pointer to both the environment block and the program block. The TSR then uses MS-DOS function 49h to free a given block of memory beginning at a specific segment. Once QT has released its memory, it exits using Turbo Pascal's `HALT` procedure. QT is no longer resident.

There is one significant problem you can encounter when you deinstall QT (or any TSR, for that matter). QT does not know if any other programs, TSR or otherwise, are loaded into memory after it. If QT is not the last program in memory when you deinstall it, a hole will be created in memory, causing the operating system to fail with the message "Memory Allocation Error." Your only recourse in this situation is to reboot your PC.

Termination

Using QT, it should be easier for you to develop advanced TSRs like pop-up calculators and notepads. I hope I've helped bring the writing of TSRs down from the rarefied altitude of assembly language to environs frequented by programmers who might feel more comfortable using a high-level language. ■

Scott Robert Ladd owns Elegant Technologies, a consulting firm in Denver, Colorado that specializes in IBM PC compatibles.

FAST TRACK VS. FAILSAFE

It may not be as fast as other RISC chips, but VIPER's error-free design could be a life-and-death matter at Mach 3

Dick Pountain

Most microprocessor manufacturers are quite shameless in their pursuit of execution speed. The latest architectures use massive register files, pipelined instruction fetches, on-chip caches, internal concurrency, and many other tricks to get data through the chip as fast as possible. Unfortunately, this pursuit of speed often comes at the expense of accuracy.

By contrast, in the design of VIPER (Verifiable Integrated Processor for Enhanced Reliability), a new 32-bit RISC design microprocessor, speed was of only secondary importance. England's Ministry of Defense plans to use VIPER in control systems for the Royal Air Force's next generation of "fly-by-wire" military aircraft. Such aircraft have no mechanical link to the pilot's control stick, but depend on a microprocessor to move the airplane's control surfaces. These chips must be absolutely correct—any bug could be fatal. In the U.S., NASA is also evaluating possible applications for VIPER.

Designed by the Royal Signals and Radar Establishment (RSRE) in Malvern, England, VIPER is the first microprocessor designed using mathematical correctness proof techniques. These prove that the chip meets its specifications and that it will always function as intended.

Bugs vs. Bucks

In applications where human lives are directly at risk, microprocessor system integrity takes on a special importance. But ever since the first IC microprocessors were invented, chips have had bugs in them that programmers have had to work around. The recent spate of bug reports for the Intel 80386 is typical of the early days of any major new CPU chip.

The reason chip makers don't immediately fix microprocessors with known bugs is simple: The masking process for making VLSI (very large scale integration) chips is so expensive that it's not commercially feasible to make a new mask and a new chip revision for every minor bug that emerges. However, "minor" bugs are only as minor as their consequences; if they could crash the control program that is the only thing connecting your joystick to your elevator at Mach 3, you have a right to regard them as major.

There's no need to fear bugs that everyone knows about. However, there may be a deep-rooted fault in the logic that becomes apparent only in a rare combination of circumstances. Such bugs can slip through the best-constructed test regimens and remain undetected until Murphy's Law dictates that they surface.

System integrity and safety problems aren't new. For centuries, engineers have had to

continued

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create systems where human life is at stake, and they have established many strategies for coping with risk. One of the most effective is to create redundancy by duplicating critical components to reduce the probability of system failure. For example, a truck might have two braking systems, or an aircraft two or more hydraulic systems.

Unfortunately, the introduction of digital computers has created almost intractable problems with this strategy. Computers, especially those using VLSI technology, are so complex that no one can comprehend the entirety of their possible states, interactions, and failure modes. Even designers are wholly dependent on automated aids to create these chips. This complexity can undermine a safety strategy based on redundancy.

Crisis of Confidence

Imagine a control system that uses three identical, independent microprocessors that make all decisions by majority vote. This provides an effective solution in cases where one of the processors fails due to physical damage. But a deep-seated bug is likely to appear in all three processors simultaneously. For genuine redundancy it's better to use processors from three different manufacturers, all running different programs. However, this makes the task of writing the control systems more complex and introduces more opportunities for error.

And that's only the hardware side of the problem. A similar crisis of confidence exists in the software world and has spawned the discipline of software engineering. A few years ago, I attended a seminar where a transport safety engineer described a redundant system he'd designed using Forth on twin Intel 8008 microprocessors. He felt personally responsible for the safety of railway passengers but couldn't guarantee the integrity of an 80286 or a 68000 chip. Instead, he stockpiled 8008s (which have been out of production for 10 years) because he was sure he understood all its bugs. He chose Forth because it was a simple language in which to write his own compiler, and he felt that he could trust no one else's. Even after going to such lengths, however, the engineer will never know for sure whether he provided 100 percent reliability—unless the system fails.

VLSI computers and related software are so complex that designers can't progress without depending upon the work of previous generations of designers and programmers. Unfortunately, this means that, as far as reliability is concerned, designers can have little confidence in the correctness of their work. For the defense industry, it was this potentially deadly paradox that prompted the design of VIPER.

VIPER's Architecture

VIPER's design was completed in 1987, and the RSRE staff first implemented it using a standard gate array. Marconi Electronic Devices has now licensed VIPER and implemented it as the MAS1908 VIPER-1. The company fabricates VIPER-1 chips using both bulk CMOS technology and Silicon on Sapphire for radiation hardness, and packages them as a 120-pin grid array. In redundant systems, designers may use versions of the same architecture implemented using different fabrication technologies. This reduces the chance of bugs appearing as a result of the manufacturing process (i.e., the 80386's temperature-sensitive math bug).

VIPER is a 32-bit processor with a 20-bit address bus and a 20-bit I/O space that can address up to 1 megaword of memory (1 megaword equals 4 megabytes) and 1 megaword of I/O space. It uses a very small instruction set and a minimum of functional units to make the correctness proof feasible. Unlike typical RISC designs, which execute 1 instruction per clock cycle, VIPER's instructions take between 6 and 26 clock cycles to execute, and the number of registers provided is very small. Its performance is rated at 1 million instructions per second (MIPS), which, while far from breaking records, is not to be sniffed at.

A VIPER programmer sees only three 32-bit registers—the accumulator A and the two index registers X and Y—plus a program counter, P. The programmer can use the A, X, and Y registers interchangeably as general-purpose registers, but VIPER uses the Y register to hold the return address during subroutine calls. Only one flag is used, a 1-bit B register that holds the result of comparison operations (see figure 1).

In addition to the B flag, the VIPER's ALU has a "stop" output, which goes out to an external pin. Whenever VIPER computes an illegal operation, arithmetic overflow, or an ille-

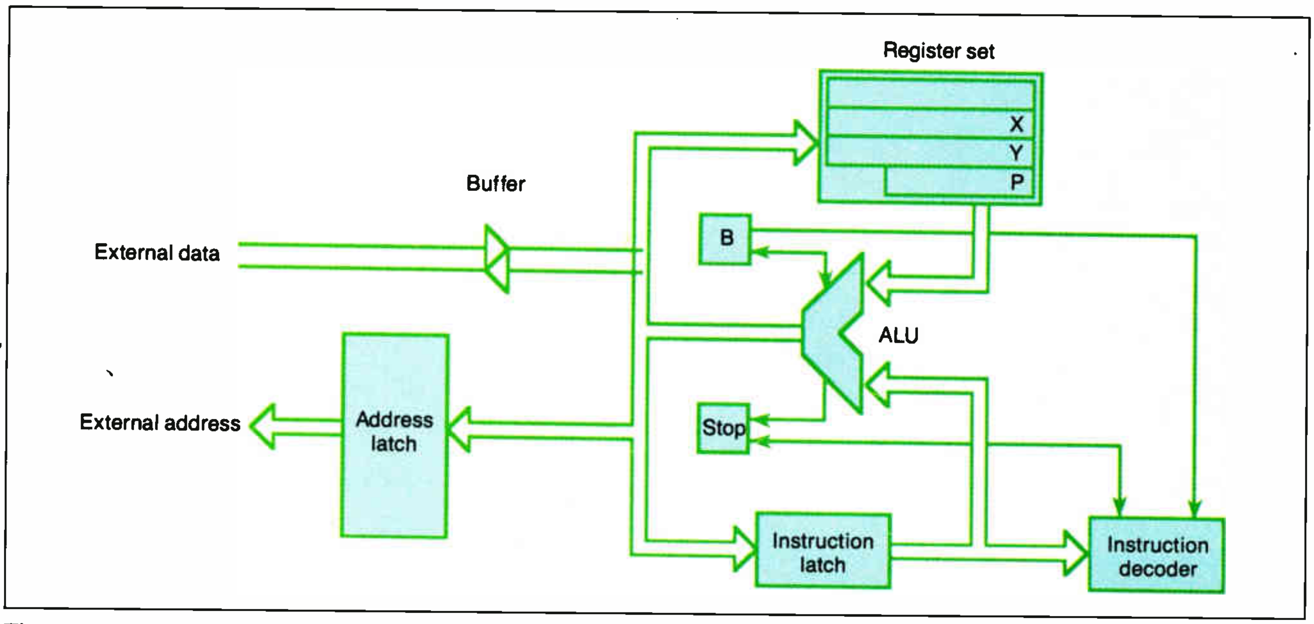

Figure 1: *Proving the mathematical correctness of the VIPER-1 microprocessor required a simple architecture, as shown here.*

gal address (i.e., more than 20 bits), it stops and raises an exception signal on this pin. The system in which it is embedded then knows that an error has occurred. The only way to continue after a stop is to reset the processor, which clears all registers. The stop condition also occurs when a read from memory or a peripheral device exceeds 63 clock cycles. This stop feature reflects the strict view that when an error occurs, it's dangerous to continue processing. The external system must heed the stop signal and perform some predefined corrective action, like switching to another processor or loading a new program.

Unsafe at Any Speed

VIPER's designers deemed certain hardware features to be so intrinsically unsafe that they excluded them. There's no hardware stack, because overflow and underflow pose insurmountable problems for validation. For similar reasons, there's no interrupt system. Hardware validation is currently possible only for fully synchronous systems, so VIPER avoids the internal concurrency that provides the high performance of the 68030 and most new RISC processors. No refresh circuitry is provided for dynamic RAMs, so VIPER must be used with static RAMs.

All instructions have the same 32-bit-word format, of which 20 bits can hold an immediate constant, an address, or an offset. The remaining 12 bits select source and destination, registers or memory, and the function to perform. VIPER has 32 function codes, 16 of which are comparison operations. The rest are arithmetic, logical, shift, and memory-read operations.

Every ALU operation has a stop condition that can stop the processor and raise an exception. For example, most operations cannot use the P program counter as a destination. For those operations, destination P is a stop condition. Only Read from Memory, Call, Increment, and Decrement can be performed on P, and the latter two cause a stop if an overflow occurs.

Proving Correctness

VIPER's designers chose an extremely Spartan architecture so that a small number of state machines could describe the processor (a finite-state machine is a mathematical device that has a finite number of mutually exclusive states).

When in a particular state, the state machine can perform actions that determine which state it will move to next. A simple analogy is a typewriter, which has uppercase and lowercase states controlled by the Shift and Shift Lock keys. When in the Shift Lock state, pressing any alphabetic key causes an uppercase letter to print, but pressing the Shift key causes a transition back to the lowercase state. A state machine is an attractive model for simple physical systems, because designers can completely define their behavior by describing the states and the allowed transitions between states.

Eleven simple state machines, or *major states*, describe VIPER, and these combine to form the major-state machine in figure 2. The node marked `dummy` represents the state immediately before an instruction fetch. Any VIPER instruction can be represented by a path through this diagram, starting and ending at `dummy`. For example, the path `dummy->fetch->dummy` represents the `skip` (i.e., do nothing) instruction, because it simply fetches the next instruction. Four of VIPER's pins are called major states 0 to 3. They indicate the processor's current major state to the outside world, for use in debugging and testing.

VIPER's top-down design has four description and documentation levels. The top level is an abstract specification of what the machine is to do. It's written in LCF-LSM (logic of computable functions/logic of sequential machines), a functional logic language based on first-order predicate calculus developed by Dr. Michael Gordon at the Computer Laboratory of Cambridge University.

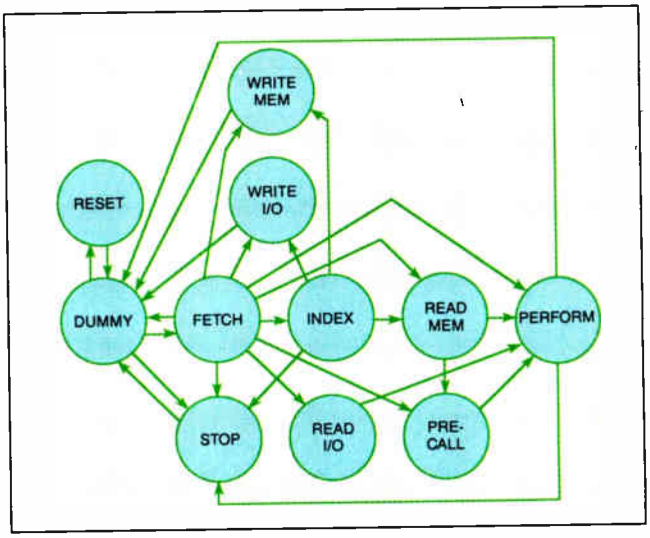

Figure 2: *Eleven major states represent the mathematical model of the VIPER microprocessor.*

A state vector that holds the contents of the memory, registers, flag, and stop status describes the state of VIPER when resting between instructions:

```
state:(RAM, A, X, Y, B, stop)
```

Writing the top-level specification consists of defining a function called `next:(state -> state)` that describes all possible transitions of this vector when the machine executes a single instruction. `Next` is itself defined in terms of auxiliary functions, including a function called `ALU`, which completely specifies the machine's arithmetic. The full specification for VIPER comprises some 240 lines of LCF-LSM and can be printed on a single sheet of paper. By contrast, if the Motorola 68000 had a formal specification, it would probably fill a telephone book. A sample of the specification for `ALU` is shown in listing 1.

The second description level is the major-state machine itself, which is also written in LCF-LSM. It describes the inner workings of the component state machines. To describe the major states, VIPER's designers concatenated a second vector that contains the values of the control fields in the first 12 bits of a VIPER instruction with the following state vector:

```
major:(RAM, A, X, Y, B, stop)(T, regselect, memselect,
destination, compare, function)
```

`T` is an internal register not available to the programmer. This combined vector represents the transient state as an instruction executes. The description of each node in figure 2 now comprises two functions, one defining the exit conditions from this node and another defining the corresponding transformation of its major-state vector.

The third level is the electronic block model, consisting of an ALU, an instruction decoder, and the rest of the units shown in figure 1. This is written in both LCF-LSM and ELLA. A lower-level language, ELLA's advantage is that tools already exist to convert it into input for a VLSI CAD/CAM system. No such tools exist for LCF-LSM. A library of LCF-LSM functions in ELLA provides the bridge between the two languages.

continued

The final description level, a gate-level circuit description, was written entirely in ELLA and converts directly into CAD/CAM input for Ferranti or Marconi's fabrication processes.

Proofs Performed

The task of verifying that VIPER was a correct implementation of the top-level specification in figure 3 involved proving that each level of the hierarchy was a faithful translation of the one above it in every respect. Between the first three levels, from top level to major state, and from major state to electronic block diagram, VIPER's designers performed the proofs algebraically using first-order logic within the LCF-LSM language.

While the details of the proofs used are beyond the scope of this article, an overview is in order. The first-level proof involves generating a *spanning tree*, which contains all the paths through figure 2 to establish the completeness of the proof. Completeness is extremely important, as unforeseen processor states are more likely to cause hidden bugs than are the well-studied main states.

This use of a spanning tree is valid only for synchronous systems in which transitions occur in a regular time sequence. (This accounts for the design restrictions mentioned earlier.) Chief VIPER designer, Dr. John Cullyer, performed a first informal proof by hand, and the proofs have subsequently been repeated by researchers at Cambridge University using a powerful automatic theorem prover. The automated prover, which had to perform over 1 million primitive inferences, detected three errors in the manual proof.

Listing 1: *A fragment of the top-level specification of VIPER in the LCF-LSM language, which defines 32-bit addition. This language can represent values either as positive integers, as machine words of various lengths, or as lists of Boolean values (bits). It provides built-in functions like* V, TL, EL, WORDn *and* BITSn *to convert between these representations and to manipulate bit lists.*

```
TRIM34TO32 :word34 -> word32
TRIM34TO32(w) == WORD32(V(TL(TL(BITS34 w))))

ADD32 :(word32 # word32) ->
       (word32 # bool # bool)
ADD32(r,m) ==
LET sum = WORD34((VAL33(SIGNEXT r))
          + (VAL33(SIGNEXT m))) IN
LET opposite = (EL31(BITS32 r))
            XOR (EL31(BITS32 m)) IN
(TRIM34TO32 sum, (EL32(BITS34 sum)) XOR opposite,
((EL32(BITS34 sum)) XOR (EL31(BITS34 sum))))
```

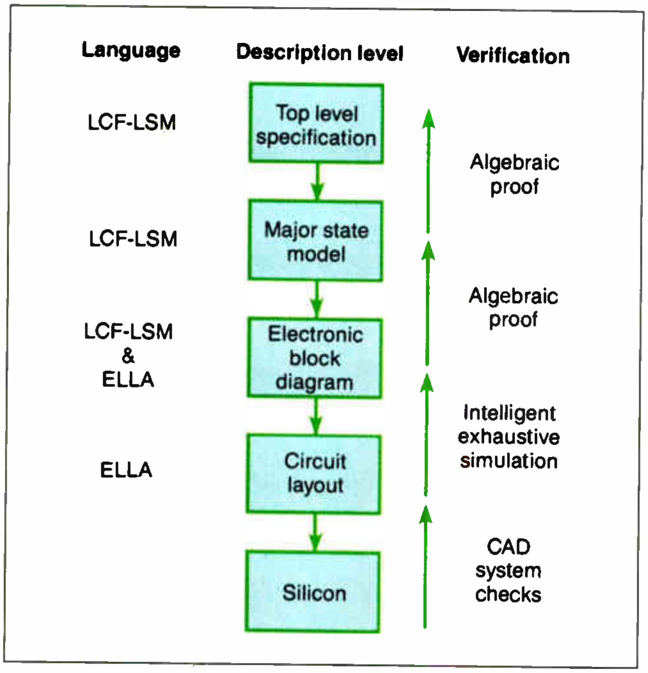

Figure 3: *VIPER's hardware validation process uses a hierarchy of description levels.*

To prove the correctness of the translation from electronic block diagram to circuit layout, the design team devised the Intelligent Exhaustive Simulation technique. In principle, to verify the circuit for a function block, you would have to prove for every combination of inputs that the block specification and the circuit produce the same results. However, this is often impractical, since for n inputs, 2^n tests are needed.

Intelligent Exhaustive Simulation relies on ELLA's ability to handle multivalued logic where, in addition to `true` and `false`, the values `don't care` and `don't know` are possible. The programmer can set inputs that, according to the specification, should be irrelevant to `don't care`. If they're truly irrelevant, the output is unaffected. But if, due to an implementation error, they do have some effect, the output will expose this by delivering a `don't know` value. With this technique, far fewer than 2^n tests can yield an equivalent level of proof, given that the multivalue logic is first verified as correct. For example, the VIPER instruction decoder has 18 inputs. This theoretically required 262,144 (2^{18}) tests, but 995 tests were sufficient.

VIPER'S designers assumed that the semicustom CAD/CAM system would deliver correct masks from a correct circuit network, and they deemed the final level of proof, from circuit layout to silicon, unnecessary. The grounds for this belief are that the VLSI companies have invested tremendous sums to ensure that this is the case, and the CAD/CAM system itself performs numerous checks on which it's hard to improve. The design team backed up the formal mathematical proofs by conducting extensive simulations of each level. To do so, they wrote a compiler from LCF-LSM into Algol68 and then compiled and executed the actual specifications.

As well as establishing that VIPER contains no fundamental logic errors, the proof process provides complete, unambiguous documentation of the processor's operation at each description level with the LCF-LSM descriptions. This is of great importance, as incorrect or ambiguous documentation of a correct hardware feature can produce bugs in a program just as easily as can a fault in the hardware. Similarly incomplete documentation has plagued microprocessors since their earliest days.

VIPER Software

Although VIPER's designers have established the correctness of the chip's design, the problem of writing correct software for it remains. There has been much research into mathematical software verification techniques, such as Oxford University professor C.A.R. Hoare's work on the laws of programming (see "Mathematics of Programming," August 1986 BYTE), but few such techniques are practical for commercial use. Even so, programmers can apply several methods to improve the prospects of writing correct VIPER programs.

Most programmers will write VIPER programs either in

VISTA (VIPER Structured Assembler), a block-structured high-level assembly language with a Pascal-like syntax, or in SPADE-Pascal. Two sophisticated program-analysis tools are available to handle programs written in these languages. The RSRE staff developed MALPAS (Malvern Program-Analysis Suite) to analyze VISTA programs, while researchers at Southampton University developed SPADE (Southampton Programs Analysis and Development Environment).

Both programs perform static analysis; that is, they investigate the structure of a program from its source text without running it. Both also require translation of the source program into an intermediate language in which the programmer can write the high-level specifications of the program's behavior. Finally, both provide the automated tools to do the translation.

MALPAS performs six different analyses on translated VISTA programs. Control Flow Analysis finds all routes through the program and isolates dead code; Data Use Analysis identifies program inputs and outputs; and Information Flow Analysis checks the dependencies between inputs and outputs. Partial Program Analysis decomposes the program into modules for checking by the Semantic Analyzer, which determines the relationship between inputs and outputs for all paths through the program. Compliance Analysis compares the results of the Semantic Analyzer with the program's intermediate language specification and reports noncompliances. Static analysis can find many deep bugs in a program structure, and programmers can use the results of the analysis further to help design test suites for dynamic analysis of the running program.

SPADE-Pascal is a subset of ISO-Pascal, minus some potentially unsafe constructs, such as variant records and procedural parameters. Soon, SPADE will include translators for Ada and Modula-2 in addition to Pascal. SPADE-Pascal uses formal comments, or "annotations," that SPADE can use to verify programs. SPADE includes a verification condition generator that works on programmer assertions expressed in these annotations, and a proof checker (written in Prolog) that can prove that the conditions are satisfied. Both of these tools, and the language systems they support, run under the VIPSE (Viper Integrated Programming Support Environment) operating environment.

A Failsafe Future?

It will be some time before hardware and software verification impinges significantly on the mainstream of personal computing. One reason is that the technique used to verify VIPER can cope only with chips with a complexity of up to 10,000 gates (VIPER has 5,000, while processors like the 68020 have closer to 100,000). In the interim, while researchers develop more powerful proof methods, it may be possible to use a verified chip like VIPER as a watchdog that checks the inputs and outputs of riskier chips. Marconi intends to use this approach to interface VIPER-1 to an off-the-shelf floating-point coprocessor, since the verification of floating-point arithmetic is currently controversial.

The prospect of a bug-free microprocessor may seem unexciting to those who love to argue over who has the fastest 80386 system and swap stories of bugs in their C compilers. But, sooner or later, hardware and software verification will affect everyone directly. Beyond its application in military aircraft control and weapons arming systems, VIPER may appear in control systems for nuclear power plants and even commercial passenger jets, which are moving toward fly-by-wire technology. ■

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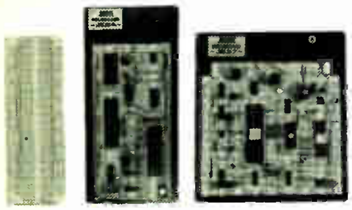

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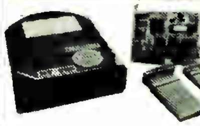

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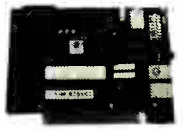

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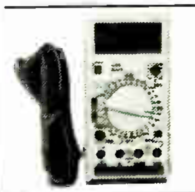

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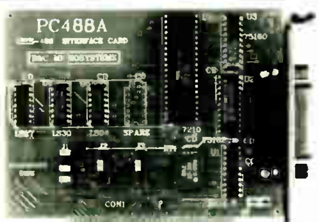

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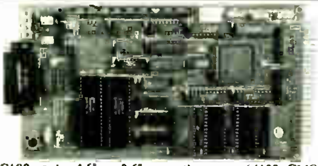

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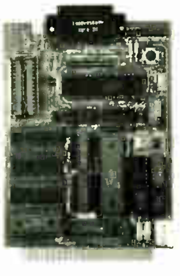

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ADP500	User vocabulary, digitized speech board	BCC53	Memory and 6 port I/O expansion board
BCC25	LCD display board		
BCC33	3 port I/O expansion board	BCC13	8-bit and BCC30 12-bit A/D converter boards
BCC40D	8-Channel optoisolated I/O expansion board	BCC18	Dual channel serial I/O board

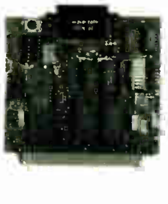
BCC52	BASIC 52 Controller Board	$189.00
BCC-SYST.5	"52 PAK" Starter System includes: BCC52,ROM A&B UTIL.,CC01,MB08,UPS10	$449.00

BCC52 OEM 100 Quantity Price -- $149.00

BCC52C Lower power all CMOS version of the BCC52 **$199.00**

NOTE: The BCC52 series is available in Industrial Temperature Range, fully tested at temperature. Prices start as low as $294.00 in single quantities. Be sure to call for a quote on your specific Industrial OEM requirements.

BCC11 — $139.00
Z8 BASIC Computer



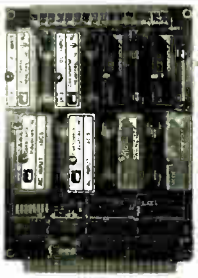
Features:
- Uses Z8 single chip microcomputer
- On-board tiny BASIC interpreter
- 2 on-board parallel ports & serial port
- 6 interrupts (4 external)
- Just connect a terminal and write control programs in BASIC
- 6K bytes of RAM or EPROM memory on-board
- Baud rates 110-9600 bps
- Data and address bus available for 56K memory and I/O expansion
- Consumes only 1.5 watts at +5, +12, and -12V

BCC11*
BASIC System Controller
$139.00

OEM 100 Quantity Price $89.00

* Now Available in Industrial Temperature Range

Announcing BCC40D — $139.00
8-Channel Optoisolated I/O Expansion Board

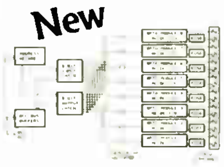


The Micromint BCC40D is an 8-channel optoisolated input/output expansion board designed for use with Micromint's family of BCC-bus Computer/Controllers. Using industry-standard optoisolated I/O modules, the BCC40D provides on/off control and input monitoring of eight 115-230VAC or 5-48VDC devices used in data acquisition and control applications.

Up to 16 BCC40D boards can be used together in a single system to provide a total of 128 input and output channels. Individual channels can be read or updated by reading from or writing to a single I/O address. The BCC40D can be directly controlled from BASIC or it can function completely in the background under an application program using high-speed interrupt-driven ROM C firmware. This firmware sets aside a table in memory which reflects the status, setpoints, and change-of-state flags of the I/O modules. Interaction among programs within a multiboard BCC40x system merely consists of reading or setting these memory table values.

Each optoisolated channel is fused and has screw contacts for direct connection to the controlling device and/or the power source. Both input or output modules, and AC or DC functions can be intermixed on the same BCC40D board.

New

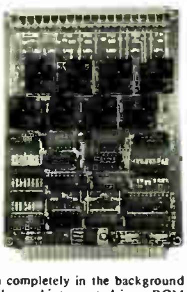


SPECIFICATIONS
- Latched outputs
- Uses industry-standard OAC5, ODC5, IAC5, IDC5 type modules
- Dual-ported module addressing
- LED on/off indicator on each channel
- Can be used concurrently with BCC40R and other BCC-bus peripherals
- Operates on +5V
- Operating conditions: temperature: 0-50°C (32-122°F) relative humidity: 10-90% non-condensing
- 4.5" x 6" board
- dual 22-pin (0.156") edge connector
- 16-terminal screw connector (#14 wire)

BCC40D/0	without modules	$139.00
BCC40D/4	with 4 modules	$189.00
BCC40D/8	with 8 modules	$229.00

OEM 100 Quantity pricing starts at $95.00

Announcing BCC40R — $169.00
8-Channel Relay Output Board



The Micromint BCC40R is an 8-channel relay output expansion board designed for use with Micromint's family of BCC-bus Computer/Controllers. Using efficient mechanical relays, the BCC40R provides contact-closure on/off control of eight AC- or DC-powered devices for data acquisition and control applications.

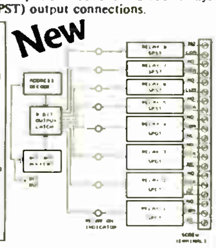
Up to 16 BCC40R boards can be used together in a single system to provide a total of 128 relay output channels. The relays are controlled by writing to a board-specific I/O address. The relays on a BCC40R board can be controlled either as a set of eight relays at a single I/O address or individual relays at eight separate I/O addresses.

The BCC40R can be directly controlled from BASIC or it can function completely in the background under an application program using high speed interrupt-driven ROM C firmware. This firmware sets aside a table in memory which reflects the status and setpoints of the relays. Interaction among programs within a multiboard BCC40x system merely consists of reading or setting these memory table values.

The eight relay outputs have screw contacts for direct connection to the controlling device and/or the power source. Four of the relays have single-pole-double-throw (SPDT) output connections and four relays have single-pole-single-throw (SPST) output connections.

SPECIFICATIONS
- Contacts rated for: 1/10 HP, 3A 120V resistive, or 3A 30VDC
- Latched relay outputs
- LED on/off indicator on each channel
- Power on/off failsafe. No arbitrary closures on power up/down
- Can be used concurrently with BCC40D and other BCC bus peripherals
- Operates on +12V
- Operating conditions: 0-50°C (32-122°F) relative humidity: 10-90% noncondensing
- 4.5" x 6" board
- dual 22-pin (0.156") edge connector
- 20-terminal screw connector (#14 wire)

New



BCC40R	8-Channel relay output board	$169.00

OEM 100 Quantity price $124.00

Announcing BCC18 — $175.00
Dual-Serial Board

The BCC18 is a general-purpose dual-serial-port interface board for use with the Micromint BCC-bus. Optional support software is available for the BCC52 and BCC180 computer/controllers.

The BCC18 Serial Board contains two serial interfaces. Each interface can be either a 110/300/1200-bps modem, or a hard-wired RS-232C/RS-422/RS-485 interface. The modem interface uses a Xecom XE1201/XE1203 MOSART (MOdem Synchronous/Asynchronous Receiver/Transmitter), capable of 110, 300, or 1200 bps communication and compatible with Bell 103 and Bell 212A standards. The hard-wired serial interface uses an industry-standard 8251A USART (Universal Synchronous/Asynchronous Receiver/Transmitter), capable of supporting asynchronous serial communications at speeds up to 19.2 kbps and synchronous serial communications at speeds up to 64k bps.

The BCC18 can be configured with two MOSARTs, two 8251As, or one of each. Up to 16 BCC18s can be used in a single system (for a total of 32 serial ports).

MOSART
- Connects directly to any phone line
- DTMF or pulse dialing
- DTMF reception and decoding
- Call progress monitoring
- Parity generation/checking
- Sync byte detection/insertion
- Extensive built-in diagnostics
- Telephone-line diagnostics
- Synchronous and asynchronous operation
- Voice synthesis capability (XE1203 only)

8251A
- Full duplex, double-buffered transmitter and receiver
- Fully programmable with several speed and character modes
- Error detection for parity, overrun, and framing
- False start bit detection, automatic break detect and handling
- Supports bisync
- Bit rate is software programmable using an on board 8253 counter/timer
- RS-232C, RS-422, and RS-485 supported

Software
- MOSART and 8251A use the same program interface, so most software will work with both
- Optional support software for the BCC52 and BCC180 is available that makes it easy to access and use most of the features of the MOSART and 8251A from within user-written programs

BCC18S	OEM configuration fixed dual 8251 RS-232 only serial port board	$175.00

BCC18S OEM 100 Quantity Price $134.00

BCC18U-1	8251/8251 Dual RS-232/485 serial	$209.00
BCC18U-2	8251/1201 Modem and serial port	$359.00
BCC18U-3	1201/1201 Modem /Modem board	$499.00
BCC52/18	BCC52 serial port utilities software	$75.00

BCC-BUS
Expansion Products

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BCCxx	X-10 Power Line Controller	$ 59.00
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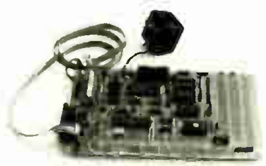

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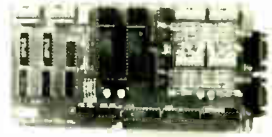

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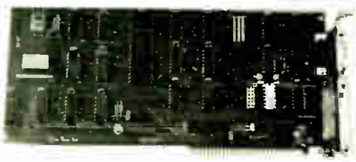

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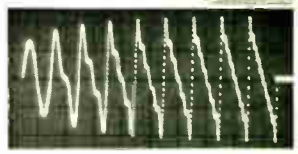

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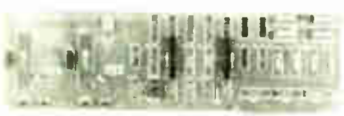

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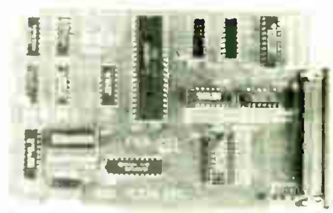

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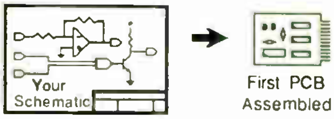

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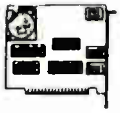

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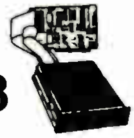

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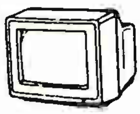

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Circle 270 on Reader Service Card

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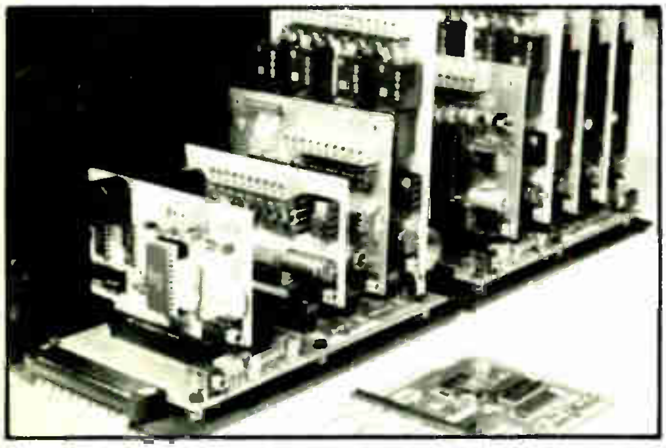

An A-BUS system with two Motherboards
A-BUS adapter (IBM) in foreground

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The A-BUS is backed by Alpha's continuing support (our 11th year, 50000 customers in over 60 countries).

The complete set of A-BUS User's Manuals is available for $10.

About the A-BUS:

- All the A-BUS cards are very easy to use with any language that can read or write to a Port or Memory. In BASIC, use INP and OUT (or PEEK and POKE with Apples and Tandy Color Computers)
- They are all compatible with each other. You can mix and match up to 25 cards to fit your application. Card addresses are easily set with jumpers.
- A-BUS cards are shipped with power supplies (except PD-123) and detailed manuals (including schematics and programming examples).

Relay Card — RE-140: $129
Includes eight industrial relays. (3 amp contacts, SPST) individually controlled and latched. 8 LED's show status. Easy to use (OUT or POKE in BASIC). Card address is jumper selectable.

Reed Relay Card — RE-156: $99
Same features as above, but uses 8 Reed Relays to switch low level signals (20mA max). Use as a channel selector, solid state relay driver, etc.

Analog Input Card — AD-142: $129
Eight analog inputs. 0 to +5V range can be expanded to 100V by adding a resistor. 8 bit resolution (20mV). Conversion time 120us. Perfect to measure voltage, temperature, light levels, pressure, etc. Very easy to use.

12 Bit A/D Converter — AN-146: $139
This analog to digital converter is accurate to .025% Input range is −4V to +4V. Resolution: 1 millivolt. The on board amplifier boosts signals up to 50 times to read microvolts. Conversion time is 130ms. Ideal for thermocouple, strain gauge, etc. 1 channel. (Expand to 8 channels using the RE-156 card).

Digital Input Card — IN-141: $59
The eight inputs are optically isolated, so it's safe and easy to connect any "on/off" devices, such as switches, thermostats, alarm loops, etc to your computer. To read the eight inputs, simply use BASIC INP (or PEEK).

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Connect 24 input or output signals (switches or any TTL device) to your computer. The card can be set for: input, latched output, strobed output, strobed input, and/or bidirectional strobed I/O. Uses the 8255A chip.

Clock with Alarm — CL-144: $89
Powerful clock/calendar with: battery backup for Time, Date and Alarm setting (time and date); built in alarm relay, led and buzzer; timing to 1/100 second. Easy to use decimal format. Lithium battery included.

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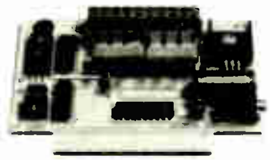
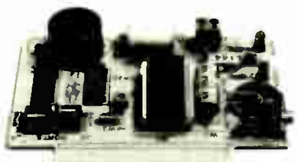
A-BUS Prototyping Card — PR-152: $15
3½ by 4½ in. with power and ground bus. Fits up to 10 I.C.s

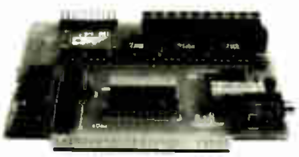


ST-143

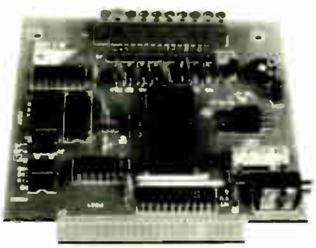


CL-144

RE-140



IN-141



AD-142

Smart Stepper Controller — SC-149: $299
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Remote Control Keypad Option — RC-121: $49
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Breakout Board Option — BB-122: $19
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Special Package: 2 motors (MO-103) + ST-143 **PA-181: $99**

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TRS-80 Model 4P Includes extra cable (50 pin bus is recessed)	AR-137	$62
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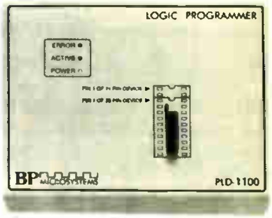

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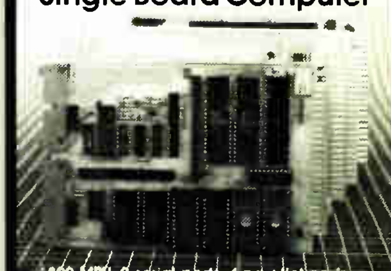

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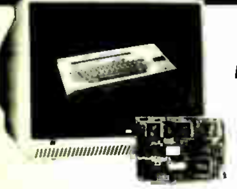

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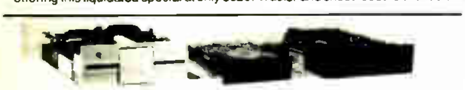
Features: bullet proof construction, your choice of either Centronics parellel or RS-232 serial interface, Diablo 630 wheels and commands, programmable line spacing in increments of 1/96" and column spacing of 1/120". The printer is also capable of underscoring, bold overprint, shadow print, centers and justifies along with vector plotting.
Factory suggested price of the Daisy Max 830 was $2495, California Digital is offering this liquidated special at only $629. Tractor and sheet feeders available.



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MITSUBISHI new 501 half ht.	119	109	105
MITSUBISHI 504A AT comp.	149	139	135
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TEAC FD55FV 96 TPI, half ht.	119	109	105
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Don't loose data because you didn't back up. The All/40 is an inexpensive way to save and restore files in the event that your data has been distroyed.
This 40 megabyte half height tape back is manufactured by North Americas largest producer of data retrieval equipment.
No need to purchase a separate tape controller... the ALL/40 attaches directly to your existing floppy disk controller. Supplied software allows your computer to back up any time **Day or Night.** Come back in the morning and 40 megabytes of irreplacable data has been stored on one Scotch DC/2000 data cassette. Back up entire hard disk, modified files only, or by file name. Loss of data is inevitable but when you are backed up on an ALL/40 its not a catastrophe.

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The Hitachi 672/XD is a four color 11 by 17 (B size) plotter with superior accuracy and repeatability (.3mm).
The 672 accepts HPGL 7475 commands and is both Centronics parallel and RS232C compatible.
The 672 plots at a fast eight inches per second in axial direction and eleven inches at an angle of 45 degrees.
The plotter also features a self contained digitizing function that allows data to be entered into your computer from printed graphs and blue prints.
Four different color pens are supplied with the plotter but a wide variety of technical pens are available.

NEC/8500 Laptop

$319

The NEC PC/8500 laptop computer incorporates a 25 line liquid crystal display and modem that plugs directly into any RJ/11 wall jack. An auto log/on feature instructs the 8500 to phone the users host computer and automatically send password and log/on information. The computer also includes both serial and Centronics parallel ports packaged in this six pound laptop.
This is the ideal computer for Realtors, insurance people or any individual that requires immediate access to remote information
ROM based telecommunication software, spreadsheet and Wordstar also make the 8500 a great computer for students.
Files can be transferred from this CP/M computer to any other including the IBM/PC.

Heath H/89 Computer

$179

Hard to believe... but we found a stash of brand new Zenith/Heath Model H/89 computers These computers feature the Zilog Z-80 CPU and operate under CP/M. The unit incorporates a 12 inch green screen, three serial ports and one 5¼" disk drive.
Zenith's original price was $1895. We have 350 units available for sale, while supplies last we are offering the H/89 at only $179.
Word processing and communication software included.

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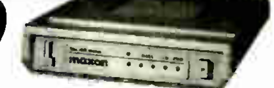

2400 Baud Modem

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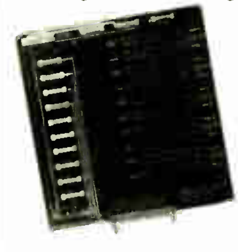

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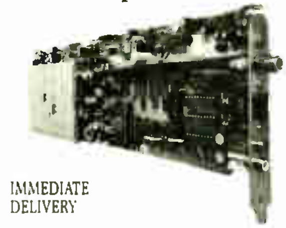

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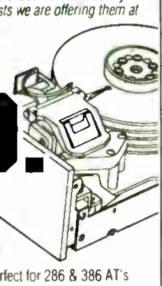

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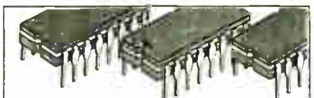

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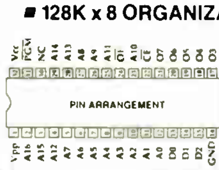

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7400	19
7402	19
7404	.19
7406	.29
7407	.29
7408	24
7410	19
7411	.25
7414	.49
7416	25
7417	.25
7420	.19
7430	19
7432	29
7438	.29
7442	49
7445	.69
7447	89
7473	.34
7474	33
7475	45
7476	.35
7483	50
7485	59
7486	.35
7489	2 15
7490	39
7493	35
74121	29
74123	49
74125	45
74150	1.35
74151	.55
74153	55
74154	1 49
74157	55
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2.0 MHz

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3.0 MHz

6502B	4.25

Z-80

2.5 MHz

Z80-CPU	1.25

4.0 MHz

Z80A-CPU	1 29
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6.0 MHz

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MB8877	12 95
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2.0 MHz

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74F74	.39
74F86	.55
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74F139	.79
74F253	.89
74F157	.89
74F240	1.29
74S00	.29
74S02	.29
74S04	.29
74S08	.35
74S10	.29
74S32	.35
74S74	.49
74S86	.35
74S112	.50
74S124	2.75
74S138	.79
74S153	.79
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74S571	2.95

CMOS/HIGH SPEED CMOS

4001	.19	4066	.29	74HC154	1.09
4011	.19	4069	.19	74HC157	.55
4012	.25	4070	.29	74HC244	.85
4013	.35	4081	.22	74HC245	.85
4015	.29	4093	.49	74HC273	.69
4016	.29	14411	9.95	74HC373	.69
4017	.49	14433	14.95	74HC374	.69
4018	.69	14497	6.95	74HCT00	.25
4020	.59	4503	.49	74HCT02	.25
4021	.69	4511	.69	74HCT04	.27
4023	.25	4518	.85	74HCT08	.25
4024	.49	4528	.79	74HCT32	.27
4025	.25	4538	.95	74HCT74	.45
4027	.39	4702	9.95	74HCT138	.55
4028	.65	74HC00	.21	74HCT139	.55
4040	.69	74HC02	.21	74HCT161	.79
4042	.59	74HC04	.25	74HCT240	.89
4044	.69	74HC08	.25	74HCT244	.89
4046	.69	74HC10	.25	74HCT245	.99
4047	.69	74HC14	.35	74HCT273	.99
4049	.29	74HC32	.35	74HCT373	.99
4050	.29	74HC74	.35	74HCT374	.99
4051	.69	74HC86	.45	74HCT393	.99
4052	.69	74HC138	.45	74HCT4017	1.19
4053	.69	74HC139	.45	74HCT4040	.99
4060	.69	74HC151	.59	74HCT4060	1.49

Circle 134 on Reader Service Card

CAPACITORS

TANTALUM

1.0µf	15V	.12	1.0µf	35V	.45
6.8	15V	42	2.2	35V	.19
10	15V	.45	4.7	35V	.39
22	15V	99	10	35V	.69

DISC

10pf	50V	.05	001µf	50V	05
22	50V	.05	005	50V	.05
33	50V	05	01	50V	.07
47	50V	.05	05	50V	07
100	50V	.05	.1	12V	.10
220	50V	05	1	50V	12

MONOLITHIC

.01µf	50V	.14	1µf	50V	18
.047µf	50V	.15	47µf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1µf	25V	14	1µf	50V	.14
4.7	50V	.11	10	50V	16
10	50V	.11	22	16V	14
47	35V	.13	47	50V	19
100	16V	15	100	35V	19
220	35V	.20	470	50V	29
470	25V	30	1000	16V	29
2200	16V	.70	2200	16V	70
4700	25V	1.45	4700	16V	1 25

VOLTAGE REGULATORS

7805T	49	7812K	1.39
7808T	.49	7905K	1.69
7812T	.49	7912K	1.49
7815T	.49	78L05	.49
7905T	.59	78L12	.49
7908T	.59	79L05	.69
7912T	59	79L12	1.49
7915T	.59	LM323K	4.79
7805K	1.59	LM338K	6.95

DISCRETE

1N751	.15	4N28	.69
1N4148 25	$1.00	4N33	.89
1N4004 10	$1.00	4N37	1.19
1N5402	.25	MCT-2	.59
KBP02	.55	MCT-6	1.29
2N2222	.25	TIL-111	.99
PN2222	.10	2N3906	.10
2N2907	.25	2N4401	25
2N3055	.79	2N4402	25
2N3904	.10	2N4403	25
4N26	.69	2N6045	1.75
4N27	.69	TIP31	.49

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JDR-PR16V	16 BIT CARD FOR VIDEO APPLICATIONS	39.95

FOR AT

JDR-PR10	16 BIT CARD WITH I/O DECODING LAYOUT	34.95
JDR-PR10PK	PARTS KIT FOR JDR-PR10 ABOVE	12.95

FOR XT

IBM-PR1	WITH +5V AND GROUND PLANE	27.95
IBM-PR2	AS ABOVE WITH I/O DECODING LAYOUT	29.95

BYPASS CAPACITORS

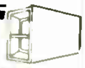
.01 µf	CERAMIC DISC	100	$5.00
.01 µf	MONOLITHIC	100	$10.00
.1 µf	CERAMIC DISC	100	$6.50
.1 µf	MONOLITHIC	100	$12.50

RESISTOR NETWORKS

SIP	10 PIN	9 RESISTOR	.69
SIP	8 PIN	7 RESISTOR	.59
DIP	16 PIN	8 RESISTOR	1.09
DIP	16 PIN	15 RESISTOR	1.09
DIP	14 PIN	7 RESISTOR	.99
DIP	14 PIN	13 RESISTOR	.99

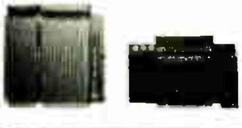
SHORTING BLOCKS

5/$1.00



EXTENDER CARDS

FOR PROTOTYPE DEBUGGING AND TROUBLESHOOTING



EXT-8088	FOR XT SYSTEM	29.95
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EXT-32	MICROCHANNEL 32-BIT	99.95

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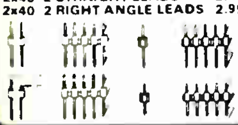

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WBU-204-3	1360 TIE PTS.	17.95	WBU-208	3220 TIE PTS.	39.95

IDC CONNECTORS/RIBBON CABLE

DESCRIPTION	ORDER BY	CONTACTS					
		10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2 20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1 76	2 31	2.72	3.39
WIREWRAP HEADER	IDHxxW	1.86	2.98	3 84	4 50	5.28	6.63
RIGHT ANGLE WIREWRAP HEADER	IDHxxWR	2.05	3.28	4 22	4 45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.63	.89	.95	1 29	1 49	1 69
RIBBON HEADER	IDMxx	...	5.50	6.25	7 00	7.50	8 50
RIBBON EDGE CARD	IDExx	.85	1.25	1 35	1 75	2 05	2 45
10' GREY RIBBON CABLE	RCxx	1.60	3.20	4.10	5 40	6.40	7.50

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS BELOW

3 VOLT LITHIUM BATTERY $1.95

HOLDER $1.49

SPECTRONICS CORPORATION EPROM ERASERS

Model	Timer	Chip Capacity	Intensity (uW Cm²)	Unit Cost
PE 140	NO	9	8,000	$89
PE 140T	YES	9	8,000	$139
PE 240T	YES	12	9,600	$189

D-SUBMINIATURE CONNECTORS

DESCRIPTION		ORDER BY	CONTACTS					
			9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.45	.59	.69	.69	1 35	1.85
	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2 29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.69	...	.79	2.27	...
	FEMALE	DBxxSR	.55	.75	...	.85	2 49	...
WIREWRAP	MALE	DBxxPWW	1 69	2.56	...	3.89	5.60	...
	FEMALE	DBxxSWW	2.76	4.27	...	6.84	9.95	...
IDC RIBBON CABLE	MALE	IDBxxP	1.39	1.99	...	2.25	4.25	...
	FEMALE	IDBxxS	1.45	2.05	...	2.35	4.49	...
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	...	...
	GREY	HDDDxx	.39	.39	...	.39	.69	.75

ORDERING INSTRUCTIONS.
INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED xx OF THE ORDER BY PART NUMBER LISTED EXAMPLE A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

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DATARASE

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- VERY COMPACT, NO DRAWER
- THIN METAL SHUTTER PREVENTS UV LIGHT FROM ESCAPING

$34.95

IC SOCKETS/DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS								
		8	14	16	18	20	22	24	28	40
SOLDERTAIL SOCKETS	xxST	11	11	12	15	.18	15	.20	22	30
WIREWRAP SOCKETS	xxWW	.59	.69	.69	.99	1.09	1.39	1 49	1 69	1 99
ZIF SOCKETS	ZIFxx	...	4.95	4 95	...	5.95	...	5.95	6.95	9 95
TOOLED SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
TOOLED WW SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2 90	3 15	3.70	5.40
COMPONENT CARRIERS	ICCxx	49	.59	.69	.99	.99	.99	.99	1.09	1.49
DIP PLUGS (IDC)	IDPxx	.95	.49	.59	1.29	1.49	...	.85	1 49	1 59

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS ABOVE

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FOR 25 PIN D SUBMINIATURE CONNECTORS

GENDER-FF	FEMALE-MALE	7.95
GENDER-MM	MALE-MALE	7.95
GENDER-MF	MALE-FEMALE	7.95
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GENDER-JB	JUMPER BOX	8.95
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WITH MCT-ATFH CONTROLLER	$339.00
30 MB RLL, 65 MS, ST-238	**$249.00**
WITH MCT-RLL CONTROLLER	$299.00
WITH MCT-ATFH-RLL CONTROLLER	$389.00
40 MB, 40 MS, ST-251	**$429.00**
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60 MB RLL, 40 MS, ST-277	**$499.00**
WITH MCT-RLL CONTROLLER	$549.00
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- SUPPORTS BOTH DS DD & DS QD WITH DOS 3.2

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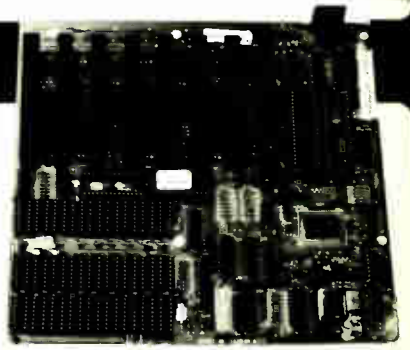

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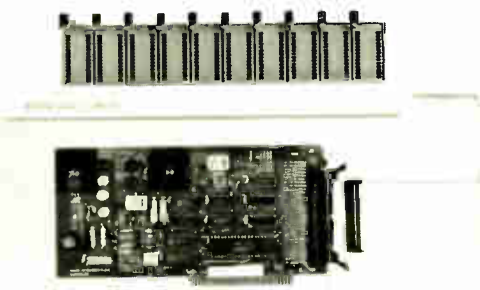

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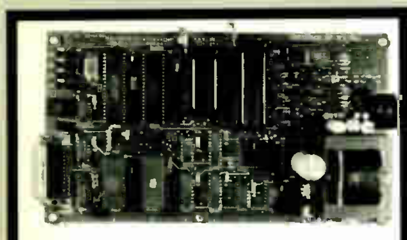

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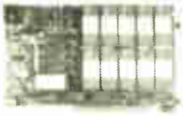

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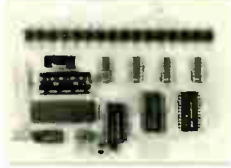

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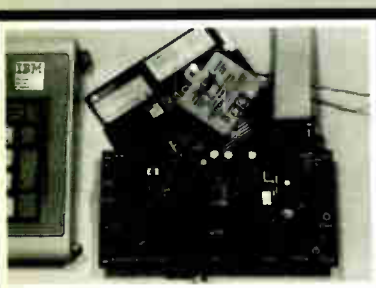

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COMING UP IN BYTE

PRODUCTS IN PERSPECTIVE:

We are rounding up 14 state-of-the-art communication packages for August's **Product Focus**. These programs are made for the IBM PC and compatibles, and they all have advanced features that take some of the frustration out of telecommunications. We'll test them for their ease of use. Then we'll check their performance when working with varying file sizes and with batch tasks.

System review: Since Compaq and Advanced Logic Research released the first 20-MHz 80386-based computers several months ago, many companies have announced such systems. They offer levels of performance higher than 16-MHz 80386-based systems, usually for higher prices. We'll look at computers from Everex, Proteus, and Tatung.

Hardware review: Alternate input devices for the IBM PC are back in the news. We'll compare several and let you know what we think of their prospects.

Software reviews: When it's time to talk languages, what you won't find in most computer magazines is Ada. However, it has finally made its way to the Macintosh in the form of Meridien's AdaVantage.

We'll also review Apple's A/UX system for the Mac II. A/UX is a hefty implementation of Unix that is sold only on its own hard disk drive.

Application reviews: First up is VersaCAD's Macintosh Edition. Next, we've slated Tornado, a memory-resident "random information processor" from Micro Logic. Finally, we'll look at Dataplex from Tools and Technologies, a new data-entry and format-conversion program.

IN DEPTH:

Our August spotlight will fall on **the C language,** which has a commanding position in the microcomputer industry. While BASIC is what most people learn first—and other languages have their proponents—C is where you find the heaviest concentration of attention.

Within broad boundaries, C is considered to be the most portable language. The advantages for the program developer rest on the reduction in time it takes to make an IBM PC program, for example, operational on a Macintosh. With complex programs, this translation time can be both time-consuming and costly if a language is too rigidly identified with a particular microcomputer family. Not only will the programs be prone to erratic behavior, their performance will likely be much slower—if they can be made to perform at all.

FEATURES:

A few years from now, you may be able to interact with your computer using your eyes, your voice, and even your whole body. Our lead feature will discuss some of the **innovative technologies** that are already working in research centers around the country.

Will there be a glut or a dearth of new programs to run under **OS/2**? We've lined up top programmers, who will discuss **porting** their popular programs from MS-DOS to OS/2—and what that process means for OS/2 users.

BASIC, the language that everyone owns and loves to pick on, has grown up. We'll talk about features of several **new versions of BASIC** that make it a serious programming language.

Steve Ciarcia's **Circuit Cellar** will be a construction project on an 8051 development system. He'll demonstrate how to build a controller development tool that can be guided, instructed, and manipulated from your IBM PC.

MACINTOSH SPECIAL COVERAGE

August has other surprises as well. It's the advent of a special Macintosh supplement. The topics will run the gamut of what matters most in the Mac community. This actually is a "daughter" publication carried within the same binding as the normal August BYTE. It will include Short Takes, columns, and features. Jerry Pournelle and Ezra Shapiro will both provide bonus Mac columns. Also, Bruce Webster returns with a special column.

Features will cover local-area networking with Macintoshes, inside MultiFinder, working with NuBus, effective programming on the Macintosh, color on the Mac II, writing HyperCard applications, and programming in Apple's version of Unix.

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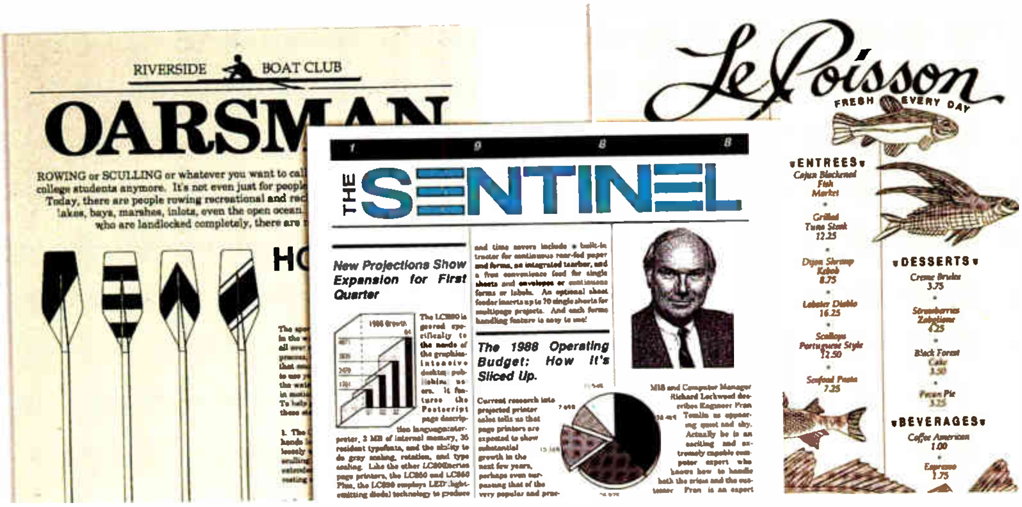

Our Silentwriter™ LC890 is the first desktop publishing printer that gives you both popular standards for creating graphics and type: true Adobe PostScript® and LaserJet Plus emulation.

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