BYTE

NOVEMBER 1988 A McGRAW-HILL PUBLICATION

REVIEWS
Compaq 386s
FlexCache 25386
Mac and PC Transputers
SpinRite
FullWrite
Zortech C++
PC Lint

PRODUCT FOCUS
Project A
10 Project Managers

Steve Jobs' new *"machine for the '90s"*

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5 Short Takes

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Turbo Assembler, Turbo D

What started modestly enough in November of 1983 with the launch of Borland's first program, Turbo Pascal® 1.0, became a revolution and it's been going like a rocket ever since.

We've changed the way you program.

We invented integrated environments with Turbo Pascal and we brought them to all our languages. Borland continues to bring you the best programming tools in the world.

New! Turbo Assembler & Turbo Debugger

Two state-of-the-art development tools in one package for only $149.95.

New Turbo Debugger® debugs all sizes

With EMS support, remote debugging, and 386 virtual machine debugging, there's no limit to the size of program you can debug. In fact with 386 virtual machine mode, debugging takes *zero,* bytes of conventional memory!

See what's happening

Overlapping windows give you multiple views of the program you're debugging: source code, variables, CPU registers, call stack, watches, breakpoints, memory dump, and more. And a new "session-logging" feature tracks and records your every move.

You're in control

Our breakpoints give you more control than anyone else's. Ordinary debuggers only get you to a stop, then they stop. When our breakpoints are triggered you can simply stop, or you can print expressions, run code, send messages to the session log, or even evaluate an expression with user-defined function calls. And *all* our breakpoints are conditional.

Shown here are views of source code, CPU registers, watch expressions, and a session log.

Unique Data Debugging

Plain Vanilla debuggers can only give you *code* debugging. Our new Turbo Debugger give you *data* debugging too. You can browse through your data from the simplest byte to the hairiest data structure, inspect arrays, and walk through linked lists. All by point and shoot.

Feature highlights

Breakpoints

- Actions: stop, run code, log expression
- Break on condition, memory changed
- Software ICE capabilites
- 386 debug register support
- Support for hardware debuggers

Debug any program

- Turbo Pascal, Turbo C, Turbo Assembler
- EMS support
- 386 virtual machine and remote machine debugging
- Supports CodeView® and .MAP-compatible programs

Data Debugger

- Follow pointers through linked lists
- Browse through arrays and data structures
- Change data values

New Turbo Assembler® lets you write the tightest, fastest code

Turbo Assembler is faster than other assemblers, and you can use it on your existing code. It's fully MASM compatible, 4.0, 5.0, and 5.1; even MASM can't say that. Turbo Assembler takes you beyond MASM, with significant new Assembly language extensions, more complete error checking, and full 386 support.

Turbo Assembler is designed for easy interfacing with high-level languages like Turbo Pascal and Turbo C. We use Turbo Assembler on Quattro,® our best-selling spreadsheet program; now you can write your own best-seller with Turbo Assembler!

Feature highlights

- Faster than other assemblers
- MASM compatible (4.0, 5.0, and 5.1)
- Significant new assembly language extensions
- Easy interfacing with high-level languages including Turbo C and Turbo Pascal
- Full 386 support

TURBO DEBUGGER FEATURE COMPARISON	TURBO DEBUGGER	CodeView®
Multiple overlapping views	Yes	No
386 virtual-86 mode debugging	Yes	No
Remote debugging	Yes	No
Data debugging	Yes	Partial
Generalized breakpoints	Yes	No
Session logging	Yes	No
Conventional memory used—80386	Zero K	230K
Conventional memory used—remote	15K	N/A

Turbo Debugger version 1.0, Microsoft CodeView version 2.2

TURBO ASSEMBLER BGIDEMO BENCHMARK	TURBO ASSEMBLER	Microsoft® Assembler
Assembly time (seconds)	9.34	27.46
Link time (seconds)	4.15	10.51
FEATURE COMPARISON		
MASM compatible (4.0, 5.0, 5.1)	Yes	No
Thorough type checking	Yes	No
Nested structures and unions	Yes	No
Multimodule cross reference	Yes	No
Assemble multiple files	Yes	No

Run on IBM PS/2 model 60 using Turbo Assembler version 1.0, Turbo Linker version 2.0, Microsoft Macro Assembler version 5.10, Microsoft Overlay Linker version 3.64

ebugger, Turbo Pascal 5.0

New! Turbo C® 2.0 with integrated source-level debugger

New Turbo C 2.0 is the *one* C compiler that does it all; nothing is half done or not done at all—instead, your every programming need is met. We wrote our best-selling word processor Sprint® with Turbo C; now you can write your own best seller with Turbo C 2.0.

At better than 16,000 lines a minute,* Turbo C 2.0 compiles your code 20-30% faster than its predecessor Turbo C 1.5 which was already faster than any other C compiler.

Make bugs bug off

Nice bugs are dead bugs, and Turbo C 2.0's integrated source-level debugger lets you find them and flatten them in a flash. You can set multiple breakpoints, watch variables and evaluate expressions—all from inside your integrated C environment.

Debugging in the Turbo environment: shown here an expression is being added to the Watch window in Turbo C. The Execution Bar highlights the next line the debugger will execute.

TURBO C 2.0

HEAPSORT BENCHMARK	TURBO C 2.0	Microsoft® C 5.1
.OBJ size (bytes)	843	945
.EXE size (bytes)	6896	7731
Execution time (seconds)	8.1	12.2
FEATURE COMPARISON		
Integrated debugger	Yes	No*
Inline assembly	Yes	No
Auto dependency checking	Yes	No
EMS support for edit buffer	Yes	No
Device-independent graphics	Yes	No
Number of memory models	6	5
Price	$149.95	$450.00

Heapsort compiled with full optimization. Benchmark run on an IBM PS/2 Model 60
*Integrated debugger included with Quick C.

Minimum system requirements: For the IBM PS/2™ and the IBM® family of personal computers and all 100% compatibles. PC-DOS (MS-DOS) 2.0 or later. Turbo Debugger minimum 384K. Turbo Assembler minimum 256K. Turbo C and Turbo Pascal minimum 448K (256K command line version)

*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.

Prices and specifications subject to change without notice.

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If you're a registered Turbo C and/or Turbo Pascal owner, you can upgrade and get the latest version of your favorite language, plus both Turbo Assembler and Turbo Debugger, all at special upgrade prices. Whether you order by phone or mail, be sure to include your old Turbo Pascal and/or Turbo C serial numbers and the code PL02.

Mail coupon to: Borland, Attn: Dept. PL02, 1800 Green Hills Road, P.O. Box 660005, Scotts Valley, CA 95066-0005.

UPGRADE OFFERS For registered Turbo Pascal* and Turbo C* owners! (Unregistered owners, see below*)

Upgrades for registered Turbo C and Turbo Pascal owners	Suggested Retail	Upgrade Price
Please check box(es)		
1 ☐ Turbo C 2.0 Professional (includes both Turbo Assembler and Turbo Debugger)	250.00	99.95
2 ☐ Turbo Pascal 5.0 Professional (includes both Turbo Assembler and Turbo Debugger)	250.00	99.95
3 ☐ Turbo Pascal with 5.0 upgrade manual and disks	N/A	49.95
4 ☐ Turbo C with 2.0 upgrade manual and disks	N/A	49.95

Please specify diskette size: Either ☐ 5¼" OR ☐ 3½"

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To qualify for the upgrade price you must give the serial number of the equivalent product you are upgrading.

Turbo Pascal Serial Number

Turbo C Serial Number

Total product amount $ _____

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In US please add $5 shipping/handling for each product $ _____

In Canada please add $10 shipping/handling for each product $ _____

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*If you have not registered your Turbo Pascal or Turbo C, you may qualify for the special price by including your completed registration card with this coupon and payment. Offer good September 1 through November 30, 1988. Coupon must be postmarked before December 15, 1988. Offer good in U.S. and Canada only. This offer limited to one upgrade per valid product serial number. Not good with any other offer from Borland. CODs and purchase orders will not be accepted by Borland.

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The Revolution continues with our new . . .

and Turbo C 2.0!

Turbo C 2.0 has the best of everything

- Includes the compiler, editor, and debugger, all rolled into one
- Integrated source-level debugger lets you step code, watch variables, and set breakpoints
- Develop and debug production-quality code in all six memory models
- Inline assembler support
- Support for Turbo Assembler and Turbo Debugger
- Make facility with automatic dependency checking
- Over 430 library functions, including a complete graphics library
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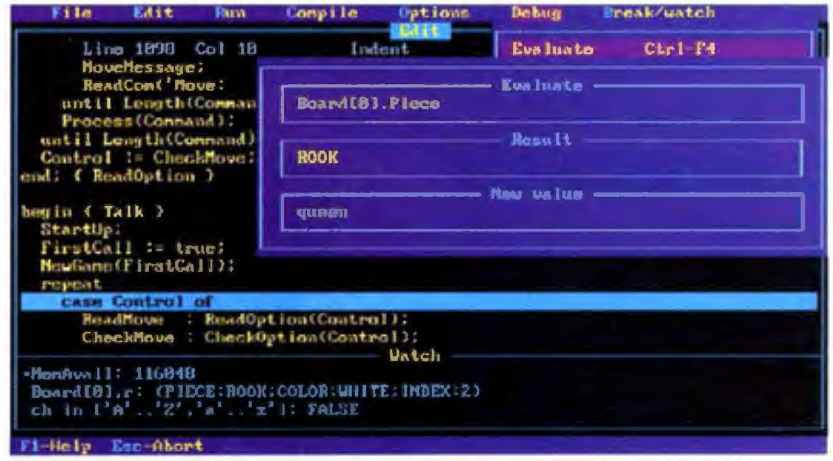
New Turbo C Professional

Turbo C 2.0 plus *both* Turbo Assembler & Turbo Debugger: all three programs rolled into one—the *one* C package that has everything. A complete set of tools that caters to every level of programming expertise. Turbo C Professional: $250. Includes coupon for free T-shirt (while supplies last).

New! Turbo Pascal® 5.0 with integrated source-level debugger

Turbo Pascal, the worldwide favorite with over a million copies in use, just got even smarter. The best got better. Meet Version 5.0. In a word, it's revolutionary.

Not only do you go code-racing at more than 34,000 lines a minute,* you also now go into a sophisticated debugging environment—right at source level.



Shown here is the Evaluate/Modify window of Turbo Pascal: look at expressions, examine structured data types, change variables on the fly.

It's completely integrated and bullet-fast.

Turbo Pascal's new integrated debugger takes you inside your code for fast fixes. You step, trace, set multiple breakpoints. You modify variables as you debug and watch full expressions at runtime.

Separate Compilation

Break your code into units. Your separately compiled units can be shared by multiple programs and linked in a flash with Turbo Pascal's built-in Make utility and smart linker. We give you a powerful library of standard units including the spectacular Borland Graphic Interface and our state-of-the-art overlay manager.

TURBO PASCAL 5.0	TURBO PASCAL 5.0	Turbo Pascal 4.0
SIEVE BENCHMARK		
.EXE size (bytes)	1440	1504
Execution time (seconds)	6.15	7.25
FEATURE COMPARISON		
Integrated debugger	Yes	No
Overlays, including EMS support	Yes	No
8087 floating-point emulation	Yes	No
Turbo Debugger support	Yes	No
Procedural types, variables, parameters	Yes	No
Smart linking of code and data	Yes	No
Constant expressions	Yes	No
EMS support for editor	Yes	No

Benchmark (25 iterations) run on an IBM PS/2 Model 60.

Feature highlights

- Includes the compiler, editor, and debugger, all rolled into one
- Integrated source-level debugger lets you step code, watch variables, and set breakpoints
- Overlays, including EMS support
- 8087 floating-point emulation
- Support for Turbo Assembler and Turbo Debugger
- Procedural types, variables, and parameters
- Smaller, tighter programs: Smart Linker strips both unused code and data
- Constant expressions
- EMS support for editor
- Only $149.95

Debugging: The inside story

Turbo Pascal's new integrated source-level debugger takes you inside your code to fix errors fast. Don't worry about errors, everyone makes them; but with the right debugger, this one, it's a fast fix.

Turbo Pascal Professional®

Turbo Pascal 5.0 plus *both* Turbo Assembler & Turbo Debugger: all three programs rolled into one—the *one* Pascal package that has everything. A complete set of tools that caters to every level of programming expertise. Turbo Pascal Professional: $250. Includes coupon for free T-shirt (while supplies last).

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BYTE

NOVEMBER 1988 VOL. 13/NO. 12

The NeXT Computer/158

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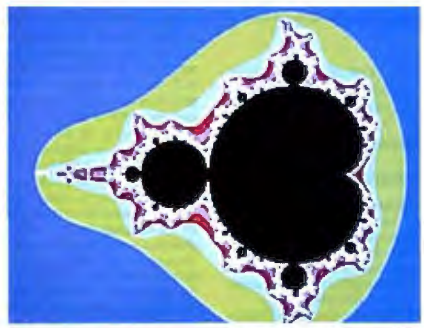

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BYTE

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- ☐ Circuit boards up to 60x60 inches and 256 layers
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- ☐ Design-rule checker
- ☐ 800 number for free support

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- ☐ IBM PC, XT, AT, or PS/2 with 512K RAM, printer port, color monitor, and CGA, EGA, or VGA graphics card
- ☐ Microsoft Mouse
- ☐ IBM ProPrinter or Epson dot-matrix printer, and/or
- ☐ Houston Instrument or Hewlett-Packard pen plotter

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BYTEWEEK, BYTE ON DISK, AND BEST OF BIX

New tools from BYTE to help you manage information overload

Information overload is something we all struggle with—especially in the computer press, which seems to suffer from a disappointingly low signal-to-noise ratio. Not only are there more and more publications dealing with this or that niche, but the quality of reporting frequently proves to be less than stellar.

For example, several of the large weekly publications have well-deserved reputations for low accuracy.

Others (the "Reviews 'R' Us" sort of publications) take a notoriously shortsighted approach to microcomputing. Yes, "state-of-the-market" reviews are important, but the "state of the art" is equally important. Unlike BYTE, a here-and-now, mostly reviews publication can't give you the information you need to prepare for *tomorrow*. That's why we strive to give you an accurate, balanced, useful-today *and* useful-tomorrow magazine.

BYTEweek

Even so, BYTE's staff learns of far more interesting and useful information than we can fit into a magazine, even the size of the one you're now holding. Much of this "extra" information goes into our popular Microbytes Daily news service on BIX (BYTE's on-line conferencing system), where it has earned a reputation for being a fast, reliable source for reports and analysis of significant microcomputing news.

But Microbytes Daily is still a lot of reading. So, several months ago, we asked our News and Technology department to design a weekly newsletter that would, in a compact and readable form, give readers 100 percent factual, unbiased, expert analysis of significant developments in the personal computer industry. It was a tall order—no other microcomputing weekly places so high a premium on accuracy, for example. But, using the resources of our award-winning Microbytes news team, the technical expertise of the BYTE staff, and the resources of the BYTE Lab, Associate Managing Editor Rich Malloy and his staff has succeeded.

The first issues of BYTEweek rolled off the press in October. Now, each week, Rich, Nick Baran, D. Barker, and the rest of the News and Technology department sort through the week's events (including information provided exclusively to BYTEweek, BYTE, and Microbytes), distill the most significant news, and add expert interpretation and evaluation to tell you not just what happened, but why, and what it means. The results are desktop-published for utmost speed and mailed to arrive at readers' desks on Monday mornings. (BYTEweek subscribers also can download each issue from BIX for even faster access.)

If you need the most accurate and timely information available—especially if you're suffering from information overload—our concise, precise BYTEweek newsletter can help. For more information, please see page 271.

BYTE on Disk

There's a shelf in my office that I worry about. It's the one with the full collection of BYTEs. In part, I worry about folks borrowing some of those old, irreplaceable issues for research. Mostly, I worry about the shelf being able to support all that weight. It's a literal case of information overload.

One alternative to paper archives is to use BIX to keyword-search and download BYTE articles; another alternative is to build your own electronic archives with the BYTE on Disk service.

BYTE on Disk offers the full text of each issue of BYTE in a variety of disk formats. The files are plain-vanilla ASCII (no graphics), so they can be searched, read, or imported into almost any word processor, database, or text-retrieval utility you might have. Because it's full text, you're not locked into anyone else's keywords or index—you can search for any occurrence of any word in any article.

It's great for research and reference—instead of manually thumbing through an issue, trying to remember where you saw that mention of the TechnoWidget 999 coprocessor, you just use something like Norton's Text Search or your word processor to search for "widget," "techno," "999," or "coprocessor," and voilà—you've found it! For more information, please see the card following page 288.

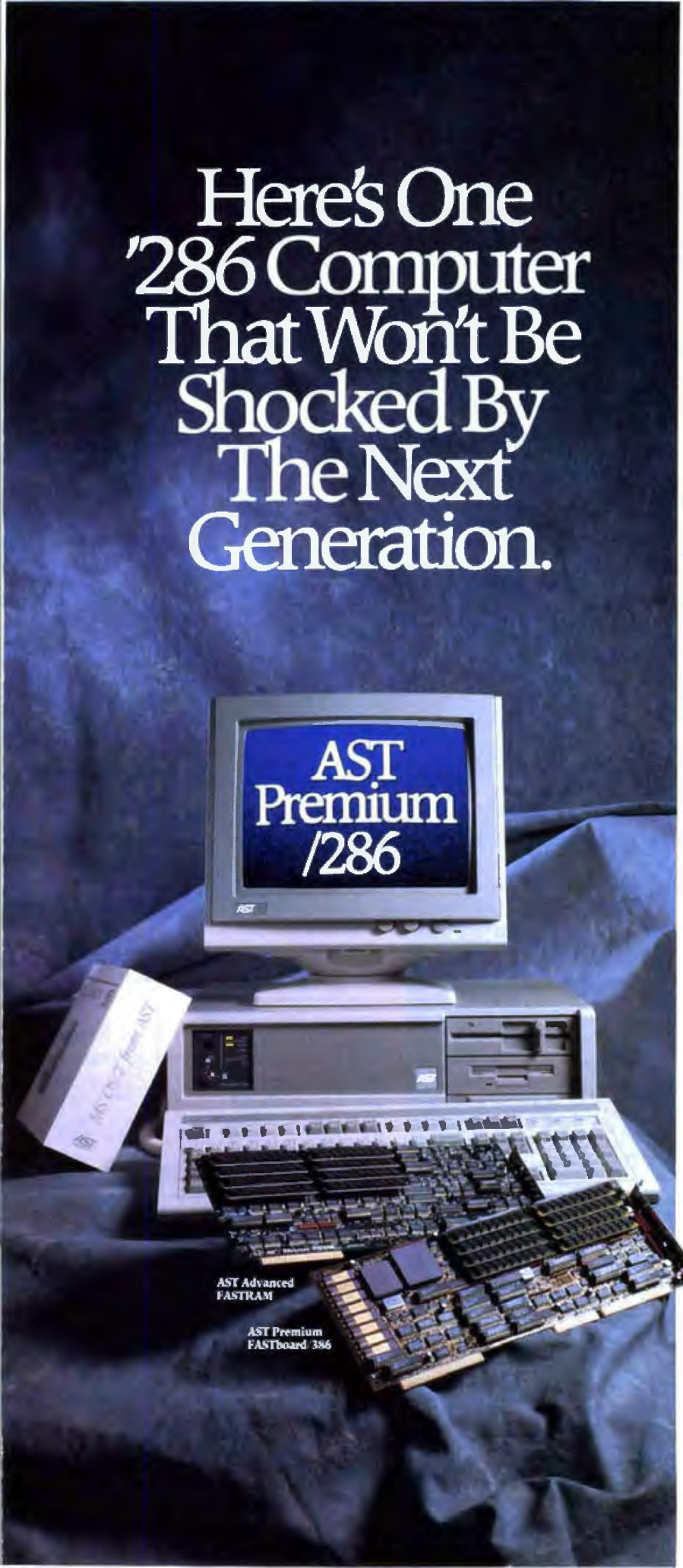
Best of BIX

We're also now producing disks with the highlights of each months' activity on BIX. Like BYTE on Disk, Best of BIX on Disk is plain ASCII, so you can read and search the text with almost any word processor, database, or text utility. Each disk contains the most interesting and informative recent discussions specific to the machine you own. For example, order the IBM disk, and you'll get highlights from IBM-specific conferences. Please see the card following page 288 for additional information.

A monthly magazine that gives you a thorough, in-depth, one-stop briefing on important developments across the entire field of personal computing; a weekly newsletter that gives you accurate, concise reporting and evaluation of microcomputing news; compact, machine-readable/searchable versions of BYTE and Best of BIX. We're proud to be the first publication to offer these tools to help you find and use the information you need, when you need it, in the format you prefer.

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

Here's One '286 Computer That Won't Be Shocked By The Next Generation.



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	AST Premium/286 Model 140X	IBM® PS/2® Model 50Z 031	Compaq® DeskPro 286® Model 40
CPU speed (MHz)	10, 8, 6	10	12, 8
Wait States	0	0	1
Max. 0 Wait-State Memory	16 MB	2 MB	0 MB
Expanded Memory	EEMS/EMS 4.0 Included	Extra Cost	Extra Cost
Hard Disk Size/Speed	40 MB/28ms	30 MB/39ms	40 MB/28ms
DOS 3.3 and GW-BASIC®	Included	Extra Cost	Extra Cost
Easy 386 CPU Upgradeability	Yes	No	No

Only the AST Premium/286 offers up to 16 MB of zero wait-state RAM, using AST Advanced FASTRAM™ memory. Which is the kind of wide-open power you need to run memory-intensive Lotus® 1-2-3® and dBASE® applications today.

★★★★ Top Rated '286 PC —PC Digest* May 1988

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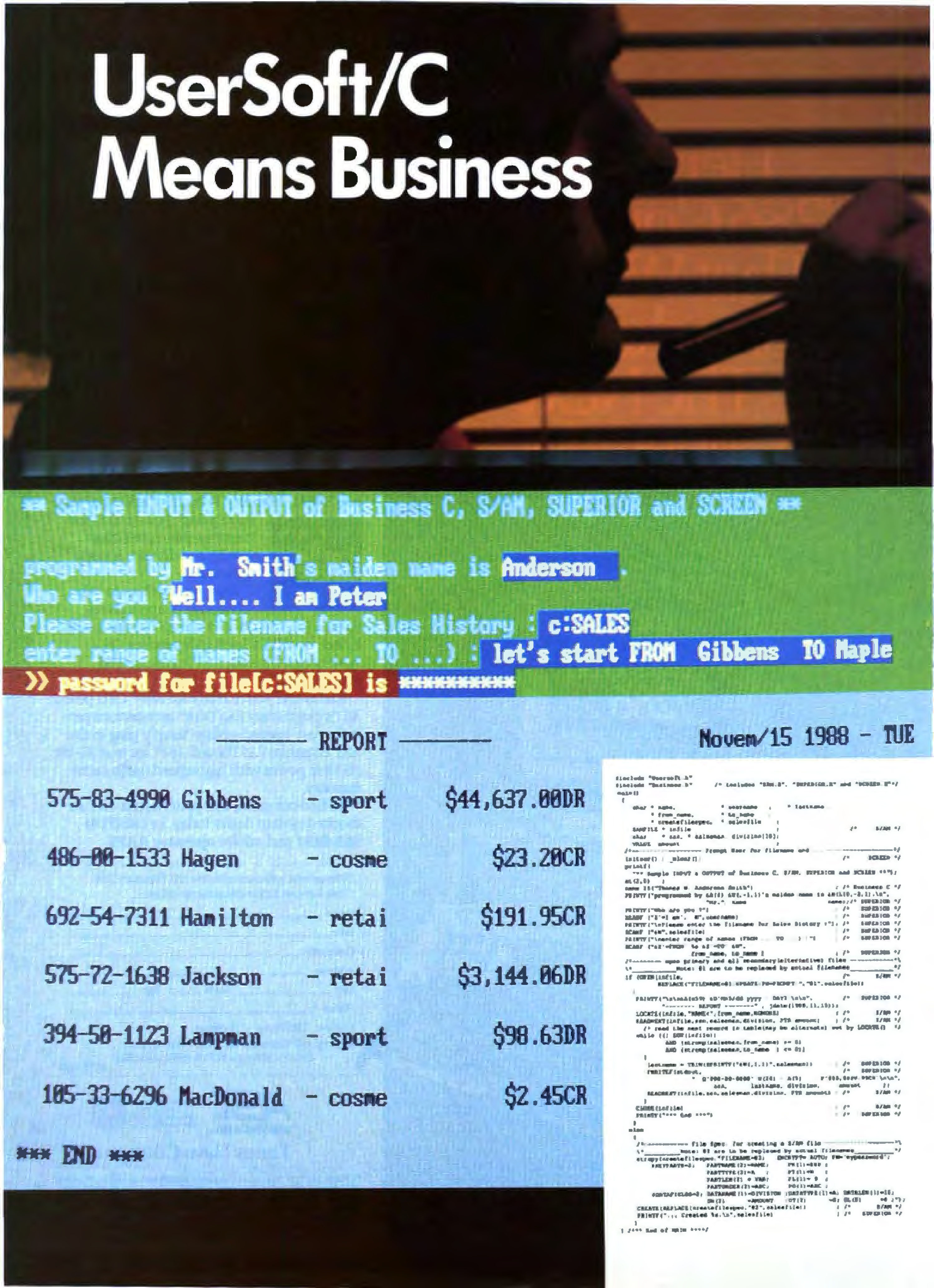
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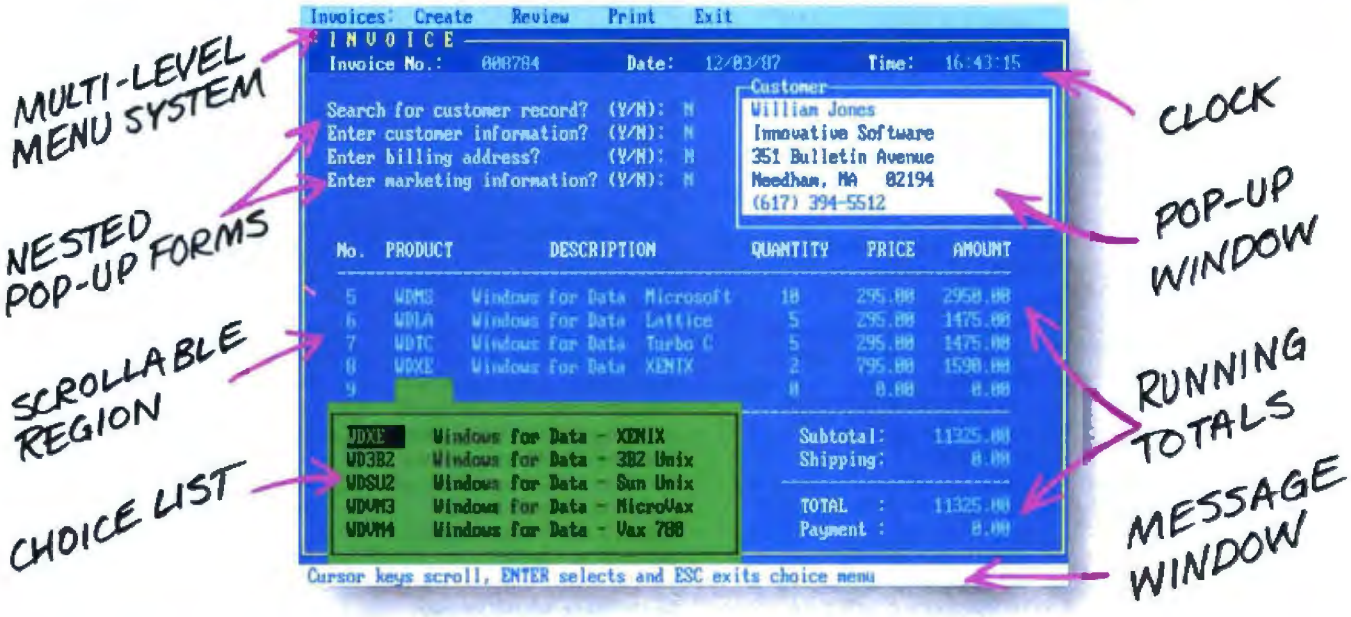

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MICROBYTES

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

Is Software Complexity Slowing the Computer Industry?

The next version of Lotus 1-2-3: late. The forthcoming dBASE IV: late. FullWrite Professional: finally shipped after being famously late. As programs get more feature-bedecked and more powerful, announced shipping dates keep going askew. But there's more to the problem than software houses missing ship dates and users having to wait and wait and the trade press having to write another story about vaporware. Software just isn't keeping up with hardware. While dramatic advances in computer hardware seem almost commonplace, progress in software development is having a hard time keeping up; in fact, it may be going in reverse. Software companies are having more trouble delivering their products, which become increasingly complex as they offer better performance.

Artificial intelligence is a good example of very complex software, software that's very smart and hence very hard to code. "AI is software," said Dr. Philip London of Cognition, Inc. (Billerica, MA), "and the general pace of software advancement will be slow. There's a big difference between research projects and commercial products." While acknowledging that hardware advancements certainly help software technology, London said that software designers need to learn how to write software for advanced hardware systems, like massively parallel architectures, which he said are poorly understood by software developers.

Big advances are needed in software productivity, too. "Converting good ideas into software products is extremely difficult," London said. While engineers are learning how to manage complex engineering projects, complex software projects "resist the efforts of traditional management techniques," he added. Programmers also have to follow rules set by hardware engineers. "Software must interface to external, arbitrary specifications."

London cautioned that "no magical solution exists," and he doesn't expect revolutionary advances in software development. The best thing that can be done is to require "discipline and cleanliness" of computer programmers. "The top 5 percent of software engineers produce most of the best code," London said.

Zenith Implements Multiprocessing in AT-Compatible Unix System; New Bus Links Cards

Zenith Data Systems (Glenview, IL) has implemented multiprocessing in a new Unix-running IBM-compatible machine that can be charged with as many as six Intel 80386 processors and can handle as many as 64 users. The multiprocessor technology consists of both hardware and software innovations. The hardware component centers on a new proprietary multiprocessing bus. The software component consists of a modified Xenix operating system. BYTE was given an early look at a hand-built production prototype of Zenith's first high-end system, called the Z-1000.

The Z-1000, housed in a castored case about the size of a one-drawer filing cabinet, is a dual-bus computer: one bus for the CPUs and memory, and one bus for peripherals. The peripherals bus is a standard 20-MHz PC AT bus, which allows the machine to work with the variety of low-cost peripherals available for the AT. Connecting the two buses is a "bridge card" that contains another 80386 CPU. This CPU actually supports the operation of Xenix and serves as the communications path for the CPU cards on their dedicated bus and the peripherals on the AT bus. The system designers decided not to use IBM's Micro Channel bus because it would not operate reliably at the speeds required of the Z-1000, an engineer said.

The Z-1000's CPU bus, called the C-Bus, is electronically similar to the NuBus in the Apple Macintosh and Texas Instruments 1500 but uses different connectors, Zenith engineers said. The CPU cards use this bus to communicate with each other and with the Z-1000's fast 32-bit memory. The machine can take as many as five of these CPU cards,

continued

NANOBYTES

• Despite all the talk about **erasable optical disks**, such media doesn't scare Paul Schroeder, president of WORM-maker **Maximum Storage** (Colorado Springs, CO). Comparing erasable and nonerasable media is the proverbial apples and oranges, Schroeder says. Erasable is certainly remarkable, but there are some situations in which you don't want the information to be susceptible to obliteration, deliberate or accidental, he points out. Permanent archives is where WORM (write once, read many times) technology shines. "Let's not put write-once in the hands of someone who needs a Winchester," says Schroeder. "That's dumb." Maximum recently brought out its APX-4000 optical disk subsystem, which puts 500 permanent megabytes on a 5¼-inch cartridge.

• **Apple** (Cupertino, CA) said at SIGGRAPH that it will be shipping **X-Windows software** to go with A/UX by the end of the year. The kit will include X-Windows execution software, display managers, and both end-user and programmer documentation.

• If you think you see a **difference in picture quality** between comparable color monitors from different companies, look closer or call a doctor. These days, a select few manufacturers make

continued

NANOBYTES

the **color picture tubes** for all those different brand names, says Amnon Rosen of monitor-vendor **Relisys**. So chances are the monitor made by Company X has the same picture tube as the monitor made by Company Z. Three companies in the Far East make everybody's tubes except Zenith's, he says. Zenith makes its own. Rosen says he likes to set up a Relisys multiscan monitor next to an NEC multiscan monitor and ask people which monitor is better. "People tell us they don't think our picture is any better," he says. "Of course not—our picture tubes come from NEC."

• The biggest barrier to using computers in Japanese schools is a **shortage of computers**, according to a report released by Japan's Computer Education Development Center. About half of the schools surveyed said a lack of computers, insufficient funds for buying software, and a shortage of teachers who can develop computer-based programs are holding back computer use in education. About 50 percent of the high schools surveyed teach programming classes, particularly BASIC, Logo, FORTRAN, and COBOL.

• While neural networks are still largely in the realm of exotica, several companies are **mixing neural networks and image processing**, according to reports from a recent conference. An official of Nestor (Providence, RI) said firms have integrated the neural-based **Nestor Development**

continued

which are used to support remote users. The cards, C-Bus, and modified Xenix kernel were developed by Corollary, Inc. (Irvine, CA), in cooperation with Zenith.

According to George P. White, president of Corollary, the new C-Bus has an advantage over the NuBus because it supports "cache coherency." Cache coherency ensures that the contents of each 80386 processor's memory cache are updated correctly. The C-bus is also significantly faster, running at 16 MHz versus the 10 MHz of the NuBus. The difficulties of promoting a new, proprietary bus can be avoided if the bus can be linked to a standard bus, White said. Thus, Corollary developed the bridge card that connects to both the C-Bus and the AT bus.

Each CPU card will support four serial ports, and each serial port will work with a concentrator to support eight serial devices. The Z-1000 will support a total of 160 serial devices, but the practical upper limit for users is 64, a spokesperson said. In all, 20 expansion slots are available on the Z-1000's backplane. The design for the backplane was developed from the similar structure in the Zenith Z-248, one engineer said.

The base model of the Z-1000 will sell for about $19,000, a company official said. Zenith credits the relatively low price to basing the machine on readily available personal computer components. The Z-1000 is meant to work with any drive that uses a SCSI hookup. The drives are removable; they mount in carriers that slide into the machine and attach to a matching connector in the rear of the bay. The drive bays will hold full-height 5¼-inch disk, tape, or optical disk drives.

One disadvantage of multiprocessing systems is that they spend a lot of time coordinating the various processors compared to the time spent doing real work. When asked about the processing overhead of the Corollary system, White said that it depends on how you test it. In one test using four 80386 processors, the system performed three times faster than a system with one processor.

The new technology could give Zenith a significant advantage over competing manufacturers (e.g., TI with its 68020-based 1500), especially in the government and Unix markets. One advantage of the Zenith system is that it could use 16-MHz 80386 processors rather than expensive and scarce 20- and 25-MHz chips. Also, the 80386 chips allow for DOS compatibility. Theoretically, DOS applications can be run under Xenix and thus take advantage of the high speed offered by the multiprocessing capabilities.

Database Servers Seen as Key to Unix Success

Unix might never overtake DOS or the Macintosh Finder as the leading operating system for personal computers, but it could do very well as an operating system for database servers in networks connected to PCs. Leading Unix database developers predict that the powerful operating system will become more important in the commercial database market.

A new database market is emerging in which high-end Unix-based computers act as database servers for client machines running MS-DOS, OS/2, or the Macintosh OS, said Mark Hoffman, president of Sybase (Berkeley, CA). In this model, the large relational database operates on the Unix server, while connected personal computers run a graphics-based interface for accessing and updating the server's database. One of the advantages of the client/server model, said Hoffman, is that you can upgrade and update the server without making any changes to the client systems. Hoffman predicted that Unix will compete favorably with OS/2 at the low end and VMS at the high end as the operating system of choice for database networks.

Informix (Lenexa, KS) chairman Roger Sippl agreed that personal computers are "taking over the desktop from character-based terminals" and will provide "novice user interfaces" to get output from database servers.

Unix-based database servers also threaten the domain of the corporate mainframe. According to Larry Ellison, CEO at Oracle (Belmont, CA), "We can perform 120 transactions per second on a $1 million [Unix] machine versus 256 transactions per second on a $10 million IBM mainframe. Unix is fast approaching mainframe performance."

However, there are some major problems to be solved before Unix systems will displace corporate mainframes. Probably the most difficult task is providing transparent access to nonrelational databases from the Unix relational database server. As Gary Morgenthaler of Relational Technology (Alameda, CA) pointed out, most of the existing data on corporate mainframes is not in relational format.

The Open Systems Interconnect (OSI) committee is

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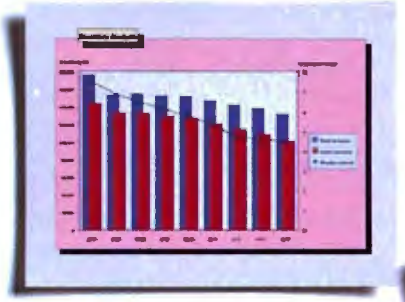

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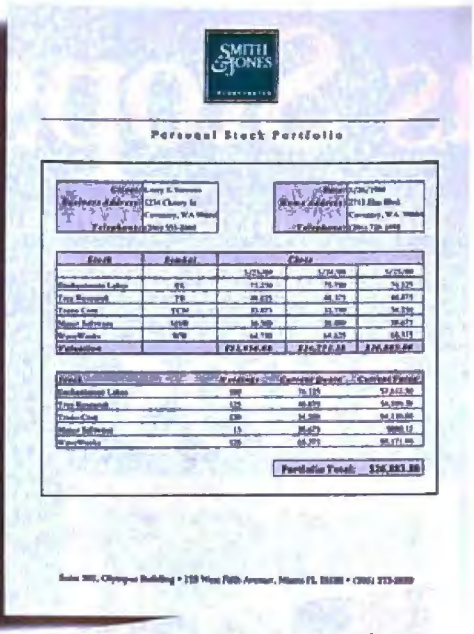

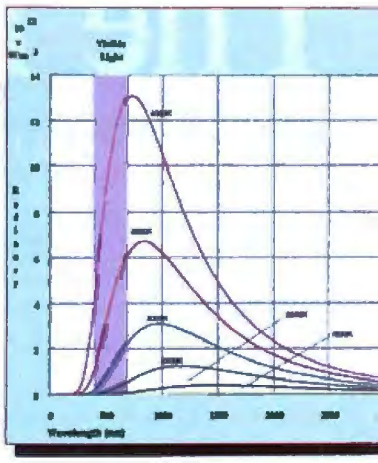

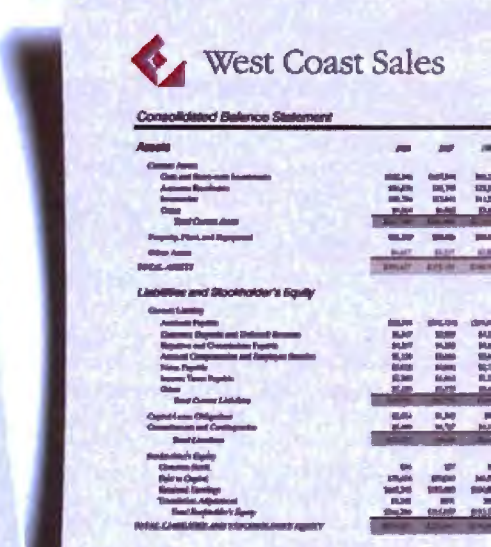

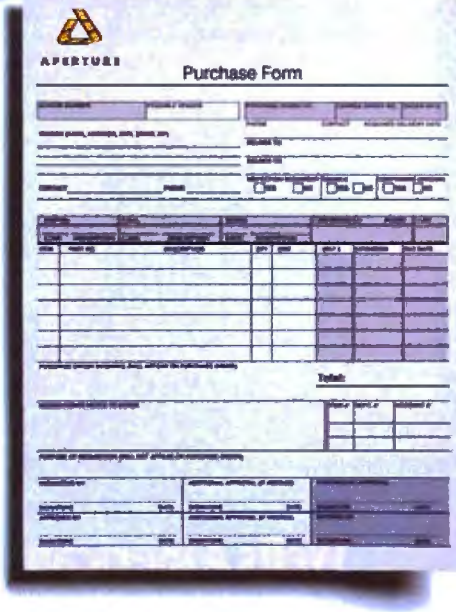

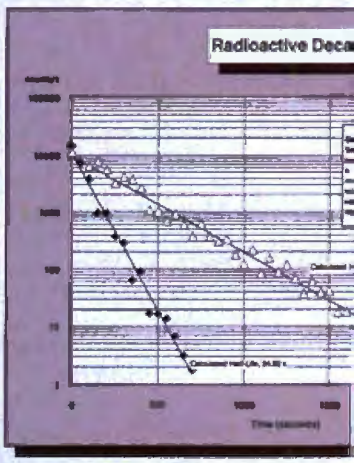

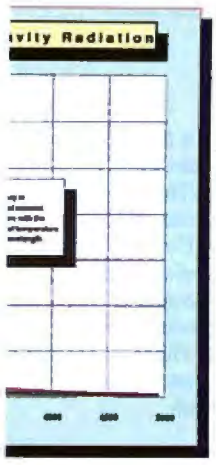

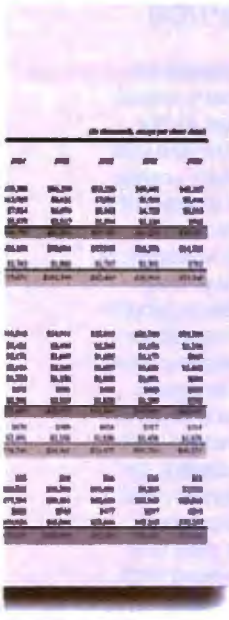

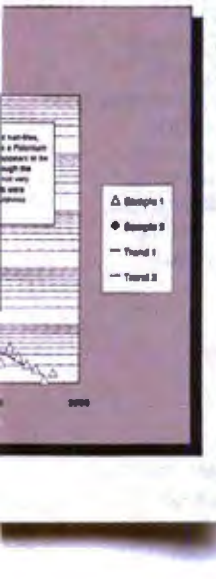

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• A proposed massive cut in the budget for the **Ada Technology Insertion Program**, planned as part of the Department of Defense budget slash for next year, has some Ada proponents concerned. The program, which is set to be cut from $13 million to $1 million, makes grants to companies that might help establish Ada as a standard programming language. But an exec with Alsys (Waltham, MA), one of the major Ada houses, isn't worried. Most of the funding has been used to get people to switch from COBOL to Ada, said vice president Jerry Rudisin, and it's now too late to stop Ada's momentum, he said. Ada is "already making inroads into the classic COBOL world. It's being used to write database systems and banking applications," he said. Alsys recently signed a deal to develop Ada compilers for the INMOS transputer.

• The European Community Commission, the administrative arm of the Common Market, has recommended a special category of copyrights for computer software that would protect programs from copying or translation for 25 years after

continued

working on remote database transfer protocols for nonrelational databases, such as IMS, BSAM, and RMS, Morgenthaler said. "Half the world's data is in IMS databases," he said. "The real challenge is not connectivity to SQL data, but providing gateways to older, nonrelational databases."

Another problem facing Unix is the lack of software applications, said Oracle's Ellison. "Application development tools are not enough," he said. "Unix is rich in DBMS software, but very poor in applications like electronic mail and basic accounting software." Ellison said application software is essential to the success of Unix. However, others are skeptical that companies specializing in database applications could provide the necessary office automation applications. Ellison countered that "E-mail is fundamentally a relational database problem. People want to transmit objects from databases," he said. However, Sippl argued that word processing and spreadsheets are also key applications.

"Floptical" Drive Matches Hard Disk Capacity and Price

Thinking about a 20-megabyte hard disk drive? Maybe you should think again. Insite Peripherals (Santa Clara, CA) claims you'll soon be able to get the same capacity on a floppy disk drive—and at the same price. The company hopes to start selling its Floptical disk drive, designed to combine the advantages of optical storage and magnetic floppy-disk technologies, early next year.

Insite's Jim Adkisson, who worked on the original 5¼-inch floppy disk while at Shugart Associates, says floppy disk technology has been stagnant ever since Japanese companies took over that market in the early 1980s. "We're not exactly trying to take on Japan," he told Microbytes Daily, "but we're bringing back the technology leadership."

The Insite I325 drive will be a plug-and-play substitute for a SCSI-equipped Seagate 225 hard drive, Adkisson said. The difference is that the Insite drive uses removable 3½-inch disks that are like IBM's 2-megabyte floppy disks but with optical tracking guides engraved on the disks by laser, pushing the capacity to just over 20 megabytes.

Magnetic floppy disks have a much higher inherent capacity than current floppy disk drives offer. The problem, according to Adkisson, is floppy disk instability: a typical floppy disk has a lot of wobble, which makes it tough for the magnetic heads to track the data on the disk, which thus limits track densities. (A conventional 3½-inch floppy disk has only 135 tracks per inch; an optical disk drive, which uses much more stable media, can have as many as 15,000 tracks per inch.)

Insite's drives solve the wobble problem by tracking the laser-etched track markers with a closed-loop optical servo system. Since the tracks are laser-etched, they can't be accidentally erased—and, unlike some high-capacity floppies, the tracks are soft-formatted, so the disks aren't limited to one kind of magnetic encoding. But Insite says its big breakthrough is the low cost of the tracking head—using an infrared LED instead of a laser to follow the tracks, the head carriage assembly is much less expensive than any of its competitors (about the same as a 20-megabyte hard disk, the company says).

The company designed the drive, Adkisson said, to have the same average seek time (65 milliseconds), capacity (20 megabytes), and price as a SCSI-equipped Seagate 225. His plan is to compete head-to-head with 20-megabyte hard disk drives.

Insite has already signed up Kodak and Xidex to manufacture the 1250-track-per-inch (tpi) floppy disks (for about $8 each), Adkisson said. The company plans to initially sell the drives to OEMs. Quantity prices are "expected to be under $250," Adkisson said, but the final price will depend on the price of the Seagate 225.

Silicon Graphics Brings Down Cost of 3-D Graphics

Real-time, three-dimensional graphics has been the domain of high-priced machines costing $50,000 and up. Repainting three-dimensional images on the screen 20 or 30 times per second takes a lot of computational power and also some very sophisticated graphics processing hardware.

However, the price of three-dimensional graphics is dropping, as indicated by systems like the new Personal IRIS workstation from Silicon Graphics (Mountain View, CA). The Unix-based Personal IRIS

continued

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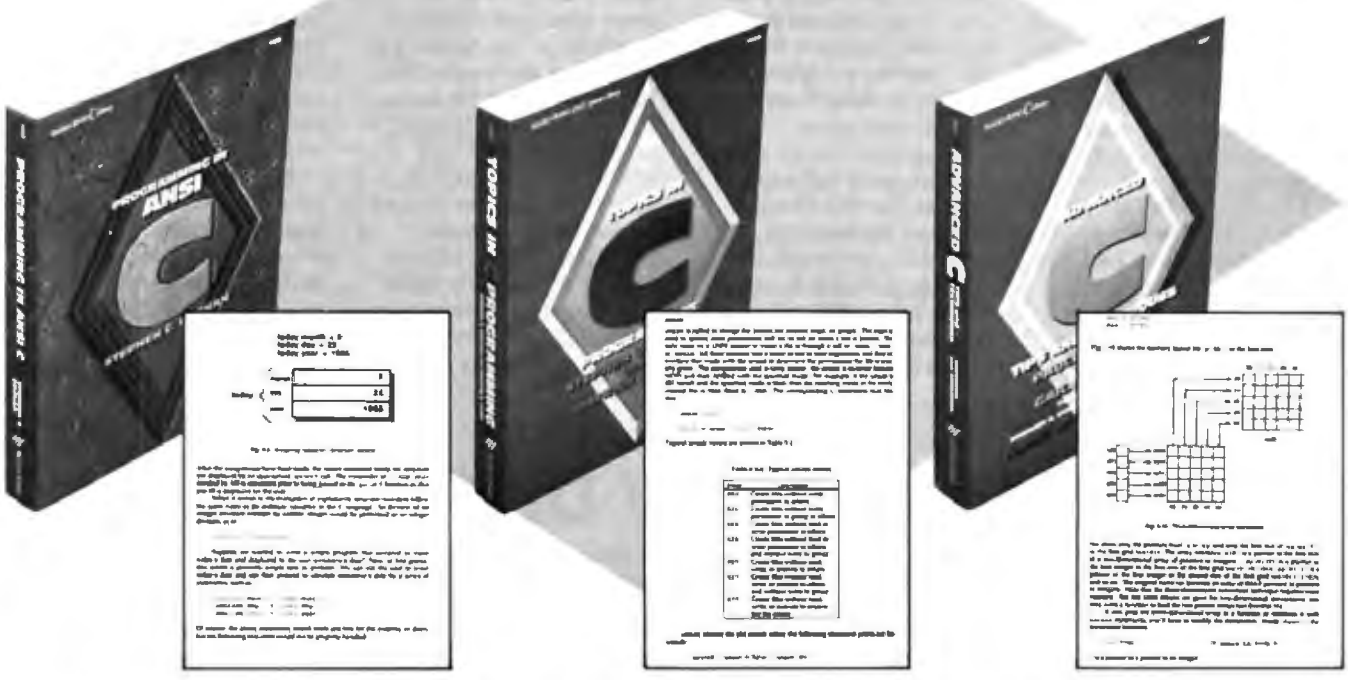

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Byte 11/88

NANOBYTES

they are created. The group also proposed protection, in the form of "exclusive rights," for semiconductor designs.

In other news from the Continent, the ECC has accused **Japanese computer printer makers** of selling their wares at unfairly low prices. According to the commission, Japanese vendors dominate the printer scene, with as much as 75 percent of the dot-matrix market. The group wants punitive tariffs of about 40 percent.

• **Cirrus Logic** (Milpitas, CA) has two new chips designed to increase the speed and decrease the cost of **laser**

continued

starts at about $20,000, which includes a 32-bit reduced-instruction-set-computer (RISC) processor, 8 megabytes of dynamic memory, 8 megabytes of video memory, a 170-megabyte hard disk drive, and a 19-inch, 1280-pixel by 1024-pixel color monitor. That price might sound steep, but if you examine the machine's capabilities and consider outfitting a PS/2 Model 80 or a Mac II with similar memory and storage capacities, the Personal IRIS may be a viable alternative for mechanical and graphics designers.

In addition to Unix and the third-party applications available for other Silicon Graphics workstations, the new IRIS can run MS-DOS applications using Insignia Solutions' SoftPC software emulator.

The heart of the Personal IRIS consists of a million-instruction-per-second (MIPS) R2000 32-bit RISC processor running at 12.5 MHz and coupled to a Silicon Graphics proprietary Geometry Engine graphics processor. The graphics processor and CPU fit on single boards and are connected back-to-back. Silicon Graphics engineers claim that new application-specific integrated circuit designs allowed them to fit on one board what used to take up four boards. The system has an 8K-byte data cache and a 16K-byte instruction cache. Silicon Graphics claims a performance of 10 VAX MIPS for its CPU (about three times the performance of most 80386 systems). The Personal IRIS I/O bus runs asynchronously to the CPU bus at 10 MHz. According to Silicon Graphics engineers, this design allows upgrading to higher-clock-speed versions of the MIPS processor without affecting the rest of the system.

The system has an Ethernet port, two RS-232C ports, one Centronics port, one SCSI port, an audio port, and a single VME-bus slot. Two half-height slots are available for a second hard disk drive or a tape drive. (Silicon Graphics is working on an internal floppy disk drive.) The floppy connects to the SCSI interface and can read and write MS-DOS 5¼-inch disks. The system comes with a high-resolution optical mouse and pad as well as a 101-key keyboard.

The entry-level model provides 8 color bit planes and 4 bit planes for window management, overlay and underlay, and pop-up menus. A "super" version of the Personal IRIS features 24-

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printer controller boards. The very-large-scale-integration coprocessors, called the Raster Printer Accelerator CL-GP315 and CL-GP340, will work with the Motorola 68000 and other processors used in laser printers; they can be used on a board in the printer or on an add-in card in the computer. The GP315 is rated at 15 pages per minute; the GP340 is rated at 40 ppm. They speed things up by taking over basic page imaging and page printing tasks, such as shading, pattern filling, and clipping. Page printing parameters are passed to the coprocessors instead of to software subroutines.

color bit planes, 8 bit planes for window management, and an additional 24-bit "Z buffer," which provides automatic hidden-surface removal. The Z-buffer determines the distance from the viewer of each Z-coordinate of the image and computes in hardware the necessary hidden-line and hidden-surface removal. The speed of the Z-buffer is really what makes real-time three-dimensional imaging possible on the Personal IRIS. Without the Z-buffer, you can still have hidden-line and hidden-surface removal, but it must be computed in software, which is considerably slower.

The workstation runs Silicon Graphics' implementation of Unix System V.3. On top of the operating system, Silicon Graphics provides an icon-based windowing system called 4SIGHT, which allows click, point, and drag operations on the Unix file structure. In addition to supporting Silicon Graphics' Graphics and Distributed Graphics Libraries, 4SIGHT supports the X-Windows and NeWS windowing environments.

The system can also run MS-DOS programs, although somewhat slowly, by using Insignia Solutions' SoftPC emulator for MS-DOS, which is available as an option. Using SoftPC, you can connect a PC to the Personal IRIS via an RS-232C port and run MS-DOS applications from the PC or attach the optional floppy drive directly to the Personal IRIS.

The Personal IRIS is an indication of one direction the industry is heading in. "The Mac III or Mac IV will eventually use this kind of man-machine interface," said Silicon Graphics CEO Ed McCracken. "We have a 2- or 3-year window before Apple jumps into [the three-dimensional graphics] marketplace. We need enough applications by 1991 to withstand the competition."

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LETTERS

Does Data Need Liberating?

The letter from Evan Provisor ("Data Liberation," August) proposed a Freedom of Information Act relating to the data structures used in proprietary software. As a consultant, I can sympathize with his dudgeon, but as a systems developer, I'd like to make a few tempering points and offer a different suggestion to purchasers of packages than that they require information about a package's data structures.

Some data structures of packages are available—there are two volumes of Jeff Walden's formats books, for example. (*File Formats*, published by John Wiley & Sons, New York, 1986, is the first.) These open up Lotus 1-2-3, MultiMate, dBASE, Multiplan, SuperCalc, and Symphony, among others. Of course, these were released for a good commercial reason: to enable the creation of add-ons that leverage sales of the original product.

But the distinction between data and program code is not as rigid as Provisor seems to think. I can imagine applications where the data structures in effect embody 75 percent of the algorithmic intelligence in a program.

This is particularly likely in the areas of sophisticated data storage software and in applications that gain speed by precrunching input (like satellite images) into an intermediate form for quicker end processing. When the program as a whole gains significantly through the ingenuity and originality of its data structures, these are respectably regarded as proprietary.

Such inventiveness is unlikely to have been used in a medical office accounting package, so I can understand Provisor's irritation. There is a better criterion for package selection, however, than availability of internal file formats. After all, cross-loading based on internal file formats requires a programmer, which should not be necessary even if consultation is.

I always check that a package can export and import its data in a standard format, such as quoted BASIC or DIF. This way, the data per se is always available, and importing it into a new package is a simple matter of shoving the ASCII data around, rather than programming export pipes right into the old package's data files.

Lindsay Gillies
New York, NY

The Last Word on BYTE

I've been a regular reader of BYTE for the past 5 years. I've watched it change over the last 18 months, and I'm happy to say that it has emerged as *the* viable source for reliable, up-to-date information about what's happening in the computer industry today.

Not only does the magazine cover a broad base of computer types and manufacturers, but the evaluations and reports are more accurate and technically sound, emanating as they do from people with a history of involvement, insight, knowledge, and training in computer sciences.

BYTE is still the last word in understanding the real truth of keyboard technology. Keep up the good work!

Wendell Anderson
Hamilton, Bermuda

Hartley vs. Fourier

We enjoyed the enthusiastic article entitled "Faster Than Fast Fourier" by Mark O'Neill (April). From the August Letters, it seems that the article has stimulated some lively correspondence.

First, regarding John C. Polasek's letter, the hazard he refers to is explained in R. N. Bracewell's *The Hartley Trans-*

continued

WE WANT TO HEAR FROM YOU. *Please double-space your letter on one side of a page and include your name and address. We can print listings and tables along with a letter if they are short and legible. Address correspondence to Letters Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.*

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form (Oxford University Press, New York, 1986) in a way that would satisfy him. The answer is that the kernel $\cos(2\pi/T) + \sin(2\pi t/T)$ preserves all the original information, just as the complex Fourier kernel does, because the first term works on the even part of the data and the second part works on the odd part. That's why the plain sine function would not serve just as well.

B. D. Ripley's letter cites a letter by Gary Bold in which the fast Hartley transform (FHT) is compared with "sophisticated FFT algorithms," also referred to as "existing FFT methods," which are found to give "the same speedup factor." In other words, Bold accepts the factor-of-2 speedup relative to the complex FFT, and he certainly does not support Ripley's notion that Bold's FFT is "considerably faster." In fact, Bold is comparing two things that, he says, have the same speedup factor.

What is being compared? Ripley gives a list of times, but he doesn't say what algorithm he used or who wrote them. He may have written the Hartley version for the numerous computers he mentions himself, which requires particular caution when one has an ax to grind.

However, Bold does say what he did. We recognize the "sophisticated FFT algorithm" as the well-known unilateral Fourier transforms. They are indeed exactly as fast as the Hartley, but they cannot retransform their own output. In other words, they should not be called Fourier transforms at all, because the Fourier transform is a reciprocal transform. The trouble is easily understood. A unilateral Fourier transform of Type I, or a right-handed Fourier, takes real input and gives out the correct complex result. After you operate on that complex Fourier transform, for example, by applying a little low-pass filtering, and wish to return to the original function domain, you cannot use that program anymore. It takes only real inputs. You must supplement it with a left-handed unilateral transform algorithm. You wind up with a combination of two unilateral Fouriers plus a management program constituting a software package. The totality is equaled by just one Hartley program. Whenever you call the Hartley, you go straight to the other domain, regardless of whether you are in the time or in the frequency domain at the moment.

The sophisticated Fourier packages, of which there are several versions, regain the factor of 2 gained by the Hartley—but at the expense of a factor of 2 in

continued


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R. N. Bracewell
John Villasenor
Dept. of Electrical Engineering
Stanford University
Stanford, CA

"Executivitis" Blues

How long has VGA been out now? A year at least, wouldn't you say? Yet, as nearly as I can determine, there is not a single programming language available to IBM clone users that supports even the lowest-resolution of the true VGA modes—not to mention the 1024-pixel by 768-pixel high-resolution mode for which Orchid, Genoa, and a number of other manufacturers now provide off-the-shelf adapter hardware (albeit for 16 colors, not 256) and for which at least a half-dozen outfits offer suitable color monitors.

Let's carry this one step further: As nearly as I can determine, not one of the major U.S. commercial software houses has yet so much as faced the perilous executive decision to attack the crushing technical problem of providing to the user a valid option of maximum-resolution, maximum-color video output from their products, to keep pace with available hardware capabilities. (I leave aside a few special-purpose programs, such as CAD and spreadsheets. And I remark that though Microsoft has an older version of Windows that supports 1024-pixel by 768-pixel resolution, its latest 80386 version apparently does not.)

Do their programs have to stop selling entirely before the executive brains in question bestir themselves to begin considering the matter? I hope I have this all wrong.

Am I doing an entire "industry" an injustice? Or are we seeing here in microcosm the same "executivitis" that sank Detroit?

Thomas E. Phipps Jr.
Urbana, IL

IBM and Licensing

Bruce F. Webster ("Macintosh Redux," August) refers to "[IBM's] subtle hints about landing with both feet on anyone cloning PS/2s without a license." But that is precisely the point. IBM is prepared to sell licenses, and at reasonable prices, too. It should be possible to pay the license fee and still undersell IBM on all but the largest orders. IBM is not using its patents, which in any case are much less dubious than visual copyright, to secure a legal monopoly on a large sector of the business of putting chips in boards and the boards in boxes and marketing the boxes. There is a difference between collecting royalties and using intellectual property rights to restrain trade, as a number of the young Turks of the personal computer industry have done.

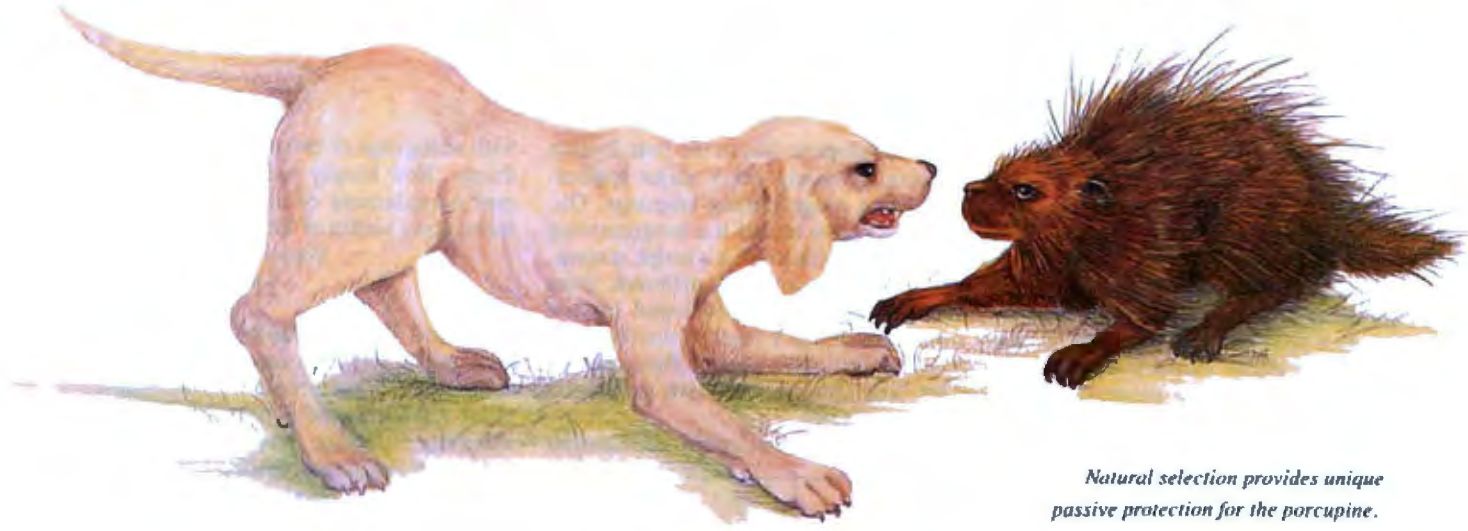
Note that this applies to separately sold software, as well. A large part of the expense of a typical program is for marketing. Cloning generally means that the original vendor has to face facts about its marketing operation.

Andrew D. Todd
Springfield, OR

YAPL: Yech!

I had gone through the article entitled "A Better C?" by Bjarne Stroustrup (August) and was reading "HyperCard: How Does It Work?" by Laurence H. Loeb (August *Macintosh Special Edition*) when a feeling of impending doom settled upon me—sensory overload from

continued



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YAPL (yet another programming language).

In the 30 years after the Mark I computer switched on in 1945, I estimate that some three dozen programming languages kept computers humming. When dBASE II introduced the microcomputer user to a programming language, it also created an entire industry to teach the hapless user the art of programming in dBASE II. Unfortunately, the power of this technique wasn't lost on other program developers. So, in the past 3 years especially, nearly every major application has a programming language. Oh, you don't have to call it a programming language, you can call it a script, a stack, or a complex macro. All different. Even having applications developed by one company doesn't lead to uniformity. Look at Borland's Sprint, Paragon, Reflex, and Quattro. All have languages; all are different.

At one time, you could get familiar with a language or two and do wonderful things. Now simply picking up the normal complement of applications will make you a victim of YAPL.

Walter J. Rottenkolber
Visalia, CA

Seek and Ye Shall Find

I am trying to find a supplier or the author of a program called FABS/86M (Fast Access B-tree Structure). It is an assembly language program to enable high-level languages, BASIC (interpreter and compiler), Pascal, FORTRAN, and COBOL to retrieve data using B-trees.

The only information I have is from the copyright notice, which reads as follows:

FABS86M Version 1.06 12-13-82 (13 Dec 82) Computer Control Systems Inc.

This program has many advantages, such as duplicate keys, multiple keys, ASCII or integer keys, fast access, and ease of use. Its main disadvantage is that it does not support path names or more than six open files at a time.

I'd appreciate any information you can provide.

Ian Sidebottom
South Humberside, UK

According to Data Sources, *you can contact Computer Control Systems, Inc. at Route 3, P.O. Box 168, Lake City, FL 32055, (904) 752-0912.*

Ackerman Exercise

I noted with interest the letters regarding recursion (August).

Your readers may be interested in the "Ackerman function," to which I was introduced in 1970 by Dr. R. S. Northcote, director of the ICL Software Development Centre in Adelaide, South Australia.

I regularly challenge my students to deliver to me the value of Ackerman(5,5).

```
Ack(m,n) = if m = 0
             then n + 1
           else
            if n = 0
             then Ack(m - 1,1)
            else
             Ack(m - 1,Ack(m,n - 1))
            endif
           endif
```

Test this by finding that 1 is Ack(0,0); 3 is Ack(1,1); and 9 is Ack(2,3).

Christopher Greaves
Islington, Ontario, Canada ■

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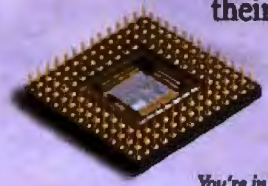

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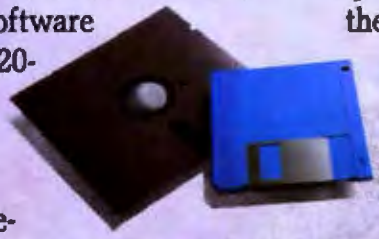

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CHAOS MANOR MAIL

Jerry Pournelle answers questions about his column and related computer topics

An "MIS Type" Speaks

Dear Jerry,

Alas, I and my profession have been defamed in that most hallowed of documents, BYTE, and by—of all folks—Jerry Pournelle!

In your June column, you twice took misguided swipes at "MIS types" as if we were some variant of power-hungry czars. By using the collective phrase, you have lumped the evil and the saintly together into one unrecognizable mass. I know that I don't fit this unwholesome description.

A number of factors are retarding the use of personal computers in the office environment. Few, if any, result from self-centered management. By far the biggest problems arise from the current state of technology (or lack thereof) and the user community itself.

Take the user (please). My experience leads me to classify users into three distinct categories: the CRT-Shy, or folks who simply won't go near a computer; the Grumblers, those who will eventually learn and use a computer only after receiving threats of physical violence; and the Office of One.

The last category includes users like you—people who have seen the potential of small systems and take the time to investigate their power. Such users are in effect becoming one-person offices, producing their own numerical analysis, graphics, and prose. Only the most malignant of managerial attitudes could keep these people from using small systems.

The other problem is technology and the historical path information has taken. When a megabyte of memory carried the same price as a new automobile, centralized systems made the greatest sense. So, for decades, information was entered into, processed by, and dumped from large centralized computers. And there lies the rub. All that current, relevant, and sometimes critical information is still there, in the centralized computer—not the micros!

The technology for making all that centralized data available to all those decentralized computers is just now developing. Local-area networks (LANs) offer a path, as do trusty serial connections, but developing a solution that pleases everyone is still a dream. Limits on data throughput, not to mention the software problems inherent in meshing microcomputer programs with a central DBMS, are nontrivial.

There lies my point. "MIS types" are still confronted with the same problem as always, just in a different form: How do we get all pertinent data to all users across existing platforms, without investing every dollar of corporate profit? The answer is, we don't. We have to wait on third-party developers and primary vendors to create the tools we need before we can give them to the user.

There is hope. The IBM PC standard went far in taking the risk out of such development. DEC and Apple have formed an alliance that is causing quite a ruckus. ANSI and OSI are clearing the way for cohesive LANs. And MIS directors are watching all of the above, carefully.

Guy Smith
Titusville, FL

P.S. BYTE is a tough market for a freelance writer like myself to break into. Do you have any advice?

I can hardly disagree with that! My quarrel, probably overstated, is with people who want centralization for its own sake and who keep insisting that only centralization can get the job done.

Your classifications aren't bad, although I don't think they are either mutually exclusive or collectively exhaustive.

P.S. I fear that BYTE, like any other magazine, requires that you have something interesting to say, that it's well said,

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, or on BIX as "jerryp."

and that you have the luck to get it in front of the editor when he is looking for it.

As to how I got into BYTE, I did just the above, but long ago, when they needed more from outsiders.

I wish you well, but I don't hold out a lot of encouragement.—Jerry

Editor's note: *Jerry's right, in that we receive a daunting number of freelance submissions each month. But you'll never know until you try: If you'd like to write for BYTE, drop a note to Editor, One Phoenix Mill Lane, Peterborough, NH 03458. Tell me what you propose to write, why it's right for BYTE, and why you're the best author for the topic. Include a writing sample, if you have one. And if you include a stamped, self-addressed envelope, I'll ship you a copy of our Writer's Guidelines.*—F.S.L.

Translating CBASIC Source Files

Dear Jerry,

Like you, I started to use CBASIC many years ago, when it was the best thing around by far for writing useful and flexible programs in BASIC, and when it had yet to be abandoned by Digital Research. I, too, have a number of useful programs that were written in this language and that are now orphans.

What we both need is a way to translate the CBASIC source files into source for QuickBASIC, so that they can be recompiled and maintained using this language. This shouldn't be too hard to do in BASIC, or even in the VEDIT macro programming language, but it would certainly take time to do and to debug.

Do you know whether anybody has done this already, and where I might find such a translation utility?

Peter R. Maggs
Cambridge, MA

I just dug out the sources of all my accounting programs—all in CBASIC. While I had no trouble getting them to compile and link on the Cheetah 386—where they run awfully fast—I did miss a lot of the features of QuickBASIC 4.0.

Minnow Bear used to do a lot of add-on functions for CBASIC, but now that Digital Research has thoroughly abandoned the language, I don't hear from them any more. Pity: They did good work.

One thing CBASIC had that I wish they'd add to QB4 is the toggle that finds all undeclared variables. The XREF *feature of CBASIC was nice, too. All in all, CBASIC had the potential to be a better language than either TURBO or QB4. What a pity it was abandoned!*

Alas, I don't know of a good program that would translate CBASIC into QB4. It wouldn't be that hard to write, of course. Maybe one of the readers knows of one.
—Jerry

Word Processor Roundup

Dear Jerry,

I have come to many of the same conclusions as you about word processors.

I gave up MultiMate long ago because it devoured chunks of text on certain kinds of document scrolling. That has probably been corrected, but I don't like it well enough to find out.

Of the command-driven programs, PC-Write is far and away my favorite. Although it is a "text-in-memory" system, it has a neat command for chopping up longer texts so they can be processed. I like to have an unlimited length option if it does not reduce speed. I'll probably be tempted back to PC-Write this spring if its promised new unlimited text-length version manages to maintain speed of operation. However, PC-Write is counterintuitive, and a little absence from it requires a good deal of refresher time.

Textra is a simple, quick, transparent, and intuitive menu text-in-memory system. For me, this makes it too awkward for long documents. Moreover, it lacks the more complex operations. However, it's neat for correspondence.

WordPerfect, to which I constantly return, is, as you say, simply too cumbersome. It takes seven operations to cut and paste a fragment of text that Textra does in three. The segmented manual is frustrating. WordPerfect was salvaged for me by Karen Acerson's *WordPerfect: The Complete Reference*. But I cannot remember to always do the requisite exiting in every file manipulation. You have to do that to keep it from autocloning text copies within a file. I find this annoying. I also don't like the bugs.

Somewhat worse is the tedium of saving a text to ASCII. Some of WordPerfect's ASCII texts seem to lose columns if the column size of the target system is shorter. On many other word processors, this is quick, effortless, and readily transitive.

I haven't tried Microsoft Word yet because of its reputation for being slow. I understand this has been corrected, and, if so, I suppose I shall have to try it. I hear that it refuses to read from any other word processor, not even in ASCII. I'll look forward to your next report on it.

But this highlights another problem. I am now semifluent in five word processors. Even though one can quickly start using the basic functions of any new word processor, real satisfaction involves a learning period of several hours. This, along with its reputation for slowness, has kept me from trying Nota Bene.

On top of this, the hypertext knowledge processors are beginning to appear. I'll probably have to try out three or four of them before settling down with one, and I am very grudging about the learning time they will steal away from me. Here's my proposal:

We are at a sufficiently sophisticated juncture to enter the QWERTY stage of word processing. QWERTY is not perfect, but the mere fact that it exists is a great boon. The product developers cannot produce standardized codes for the main command-, menu-, and icon-driven approaches to word, text, and knowledge processing.

I suspect you could pull it off. It is an ideal project. Start a "TextCode" workshop on BIX or on the USC Virtual Academy. Membership should include leading writers and developers.

The first task would be to work up a comparative survey of all the essential functions, manipulations, formats, fonts, and utilities of 10 leading word processors. Then an analytical comparative display could be made. This would produce a set of the codes for their commands, menus, and icons. Start with the command codes; they're the most basic. There will be some duplication. It shouldn't be hard to agree upon a standard set. Menuing systems can be considered as macros for commands. These also could be reduced to a single set in the same way. Icon systems can be considered as pictograms and symbols of macros. They could also be compared and reduced to a single set.

Then have all the developers, plus a few others, try it out for 6 months before certifying the final version.

It's not likely that developers will troop to such standards automatically. However, a transparent shell could be produced without much trouble. It would be a general-purpose TextCode utility, customizable for any word processor. The developers would soon write to its codes and develop programs using its features.

Harvey Wheeler
Carpinteria, CA

Sounds like a great idea; it's possible that we could do it on BIX. I completely agree: Karen Acerson's WordPerfect book is the best way to learn that one. WordPerfect is an editor that's more than good enough, and those who really get used to it don't want anything else.
—Jerry ■

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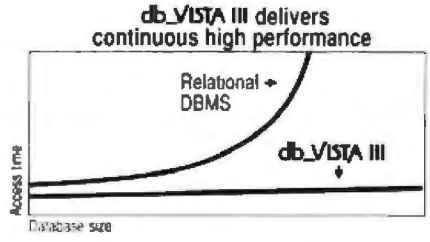

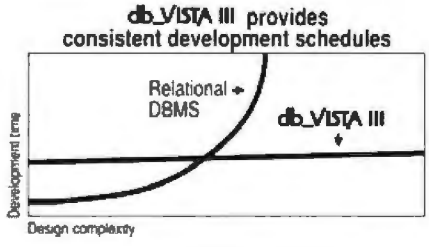

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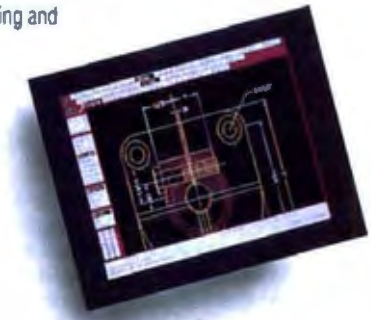

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ASK BYTE

Circuit Cellar's Steve Ciarcia answers your questions on microcomputing

The High Cost of a UPS

Dear Steve,

I have been musing for a long time about the high cost of an uninterruptible power supply (UPS) for microcomputers.

It seems that much engineering (or marketing hype) is spent on making a quick switch from AC to inverted battery power. Why switch? Why don't the manufacturers just run the inverters all the time? They already have a battery-charging circuit designed in.

I also think it would be much better to replace the original power supplies entirely. The UPS replacement supply does not have to be the same size as the original power supply, although that would be nice. The internal UPS just needs to be able to run off batteries that get charged by the AC line. Why not just have a large plug on the back for heavy cables to run to some suitable batteries?

Those who think saving their work "blind" isn't acceptable could buy an additional car-battery-driven AC inverter to be used to power CRTs.

This leads me to realize that between the rectification and regulation stage of all power supplies, even switching ones, there is always a capacitor bank. It seems to me that the proper number of gel-cell-style batteries would provide an excellent number of extra farads. Can't batteries be kept charged by the existing supply circuitry, and wouldn't their current be used instantly if the AC power went off for short periods? The batteries might also provide some protection against power spikes.

Could you publish a short article that would detail the exact kind of batteries to use and where to connect to existing IBM PC or Macintosh power-supply circuitry? Since there may be a power-up timing sequence to the multiple voltages, a delaying relay might be used to bring the batteries into the circuit after the power supply establishes the proper voltages.

A companion project could be a car-battery-to-AC inverter for a CRT. Couldn't two high-current field-effect transistors (FETs) be used to produce a modified square-wave supply?

K. Kenneth Clark
Garden Grove, CA

Complete answers to all the questions you've raised could fill at least one good-size textbook. With UPSes, there are trade-offs piled upon trade-offs in each design. Given certain goals, the engineers do the best they can with the design. There are few, if any, ideal solutions; the real world is a place of compromises, and UPS design is no exception.

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.

It is useful to divide UPSes into two types—part-time and full-time—and discuss them in that context. A part-time UPS consists essentially of a battery, a charging circuit, an inverter to convert DC to ersatz AC, and a switching circuit to detect power failure in the supply line. The battery is kept charged, and in the event of power failure on the line, it supplies backup power to the system via the inverter. A full-time UPS always powers the computer. Main power serves only to charge the batteries, which, in turn, always power the computer.

Most of the currently available UPSes are of the part-time variety. Part-time systems are more efficient than full-time systems, requiring fewer conversions in normal use. A full-time UPS also requires more robust components, better cooling, and more careful design than a part-time unit.

Your suggestion that the backup batteries supply DC power directly, without the DC-to-AC-to-DC roundabout, is a sound one, and it's by far the most efficient method, since it avoids multiple conversions. Installation and use of such a unit, however, is another story. You'd need either a special connector or cable to supply system power, or else some board surgery, and perhaps both. In a world that is dominated by appliance users who think anything more complex than a toaster is too difficult to use, a marketable UPS is one that computer users can just plug the computer into and run. That means AC power, just as if it were coming out of the wall. The January 1988 issue of Radio-Electronics *features a construction article for a 40-watt UPS of this type.*

If the capacity of the computer's built-in power supply were great enough to power the computer under worst-case conditions and charge the batteries, your proposal for a backup system could work. The biggest problems are where to put the battery or batteries, and the modifications that would need to be made to the computer. A separate small PC board might reduce the second problem.

A minimum homebrew DC-only UPS could consist of a car or motorcycle battery and float-charger, a few regulators, and a means of detecting power failure and switching on the backup battery. The switching circuit could be as simple as a few diodes and capacitors (similar to what is used in the battery backup circuits for clock/calendar circuits) or something more elaborate, such as a series-pass transistor switched by a comparator.

A simple square-wave inverter, as you suggest, should be capable of faking squared-up AC for a monitor, but the monitor should agree to the deal in advance. I'd want to heat-sink the FETs

continued

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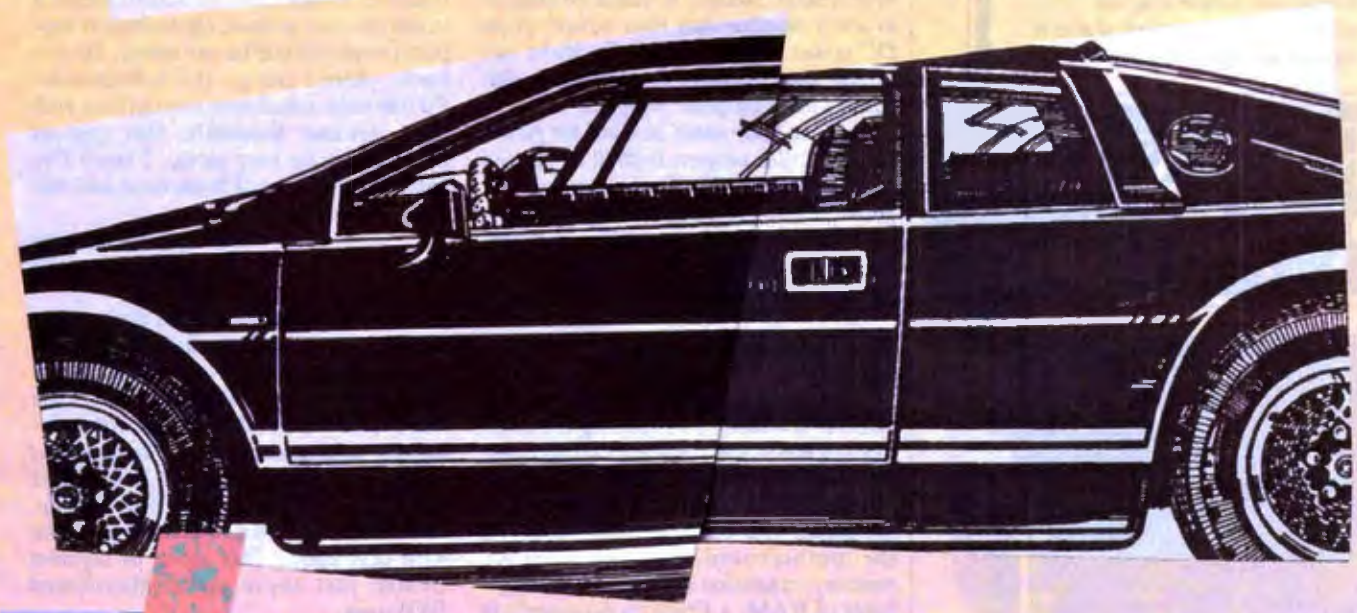

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well and have a fan blowing air across the heat sink(s), though. It would be simpler to use a monitor that runs directly from DC power. Outfits like B.G. Micro advertise such monitors regularly in publications like Computer Shopper.

I'll keep your ideas in mind for future Circuit Cellar projects both in BYTE and Circuit Cellar INK. *Over the years I've gotten much good inspiration and many interesting ideas from readers and fans such as you. If only I had the time to pursue them all!*—Steve

Acer in the Hole

Dear Steve,

I have a problem that I can't seem to resolve. It concerns addressing the 128K bytes of RAM used on the IBM bus to address ROM on the I/O boards.

My system is an Acer 1100 (an 80386 machine) with 1 megabyte of RAM on the motherboard, an Acer MFB-AT memory expansion card with 1.5 megabytes of RAM, a Franklin 60-megabyte internal tape backup, a Micro Display Systems Genius full-page display, a LaserMaster CAPCard printer card for the Hewlett-Packard LaserJet Series II printer, a Western Digital WA-2 floppy/hard disk controller card, and an HP ScanJet Scanner. As you can see, I have been trying to put together a usable desktop publishing system to run Ventura Publisher.

The problem I'm having is that the system locks up occasionally.

To date, I have verified that the power supply and cooling systems are adequate. The computer is connected to a constant-voltage conditioned power loop specifically dedicated to our data processing equipment, grounding (I'm using a 4-wire separate chassis ground system), static protection, static mats, and so on. For cooling, I've installed an external auxiliary cooling fan. Nothing has solved the problem.

At this point, Xerox says it must be the hardware; the hardware people say it must be the software. I have determined that the machine has no conflicting addresses in the I/O address area, and there are no conflicting interrupts.

As I have gotten deeper into this issue, on occasion I have noticed mention of the 128K-byte expansion ROM area. Hewlett-Packard discusses this at some length in its ScanJet Scanner manual. The MDS Genius Display manual also talks about it. Unfortunately, no one else (ACER, Franklin, etc.) has been able to tell me if they use this memory and, if so, what addresses they use. If this is an area of potential conflict between expansion devices, I would think that anyone who makes an expansion card would discuss it in the manual; at least, the technical support people should be informed. Do you know where I can get this information? I'd like to be sure I have no conflicts with these devices. Evidently, this type of problem can be very subtle. I know I've spent untold hours of frustration and still don't know what to do.

Herald S. Harrington
Jerome, AZ

I don't have any technical data on the Acer, so all I can do is make an assumption that things are put in the same places as they are in an IBM PC or AT. If you had two active ROMs installed with overlapping addresses, your problems would not be occasional; the most likely effect would be a failure to boot. Incidentally, one address you should investigate is the hard disk BIOS. This starts at segment C800h, just above the display-board BIOS area.

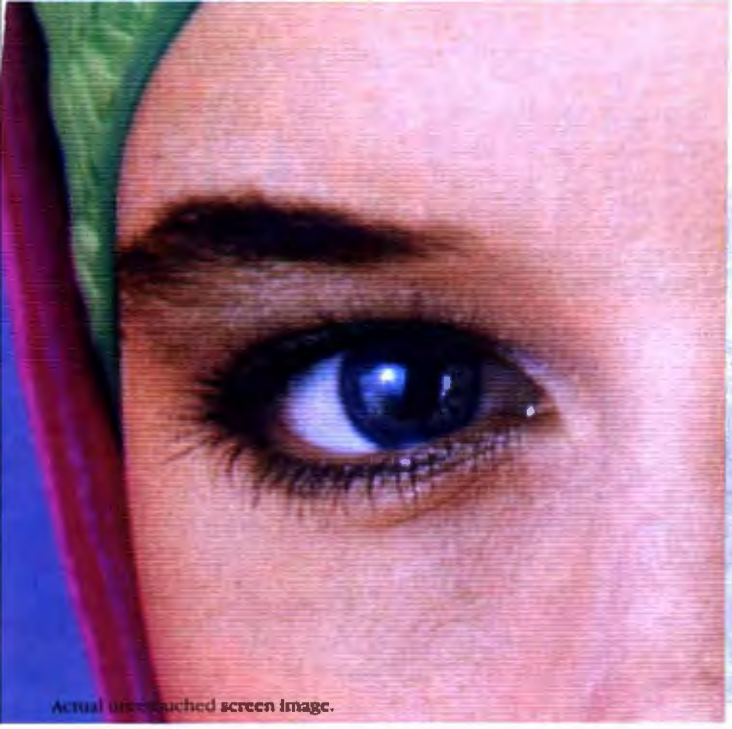
If you have a hardware problem, it could be a slow memory chip or peripheral board that occasionally gets out of sync. This can cause intermittent problems of the type you describe. Sometimes you get a parity check message with this type of problem, and sometimes you don't. The type of problem you describe could be caused by software with a bug that causes it to write to memory that is being used by DOS or other resident programs.

One thing that bothers me is your use of a 16-bit memory-expansion board in the 32-bit Acer 1100. The Acer uses an interleaved memory scheme of some type, probably for speed, and it's probably similar to that used in some models of the Compaq 386.

I suggest you perform some diagnostic tests to isolate the problem. First, temporarily delete any resident programs—SideKick, keyboard enhancers, pop-up calculators, and so on. Revise your AUTOEXEC.BAT and CONFIG.SYS files so that you boot with only the drivers and resident programs that are absolutely needed. If the problem goes away, start adding the things you removed, one at a time, until the problem reappears.

If eliminating the unnecessary software doesn't solve the problem, you'll have to start removing hardware. Start by removing the memory chips on the AT expansion card and setting the switches (if any) to indicate zero memory. The output ports on this board should not cause problems unless one is defective, so you shouldn't have to remove the board yet.

continued



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OW CONTAINS C LANGUAGE.

Listing 1: *Reading the joystick port in GWBASIC.*

```
100 'Joystick STICK function demo
110 LOCATE 9,1: PRINT "JOYSTICK A";
120 LOCATE 10,1: PRINT "XA = ";
130 LOCATE 11,1: PRINT "YA = ";
140 LOCATE 9,20: PRINT "JOYSTICK B";
150 LOCATE 10,20: PRINT "XB = ";
160 LOCATE 11,20: PRINT "YB = ";
170 TEMP = STICK(0)    'READ JOYSTICK
180 XA = TEMP          'COPY THE FOUR VALUES
190 YA = STICK(1)      'INTO FOUR VARIABLES
200 XB = STICK(2)      'AND PRINT THEM
210 YB = STICK(3)
220 LOCATE 10,15: PRINT USING "###"; XA;
230 LOCATE 11,15: PRINT USING "###"; YA;
240 LOCATE 10,35: PRINT USING "###"; XB;
250 LOCATE 11,35: PRINT USING "###"; YB;
260 A$=INKEY$          'LOOP UNTIL A KEY
270 IF A$ = INKEY$ GOTO 178 'IS PRESSED
280 END
```

The next thing to remove is the Lasermaster card. Not that you don't need it, but it is a possible source of conflict until you know more about it, and you can at least run the computer without it.

If you follow this procedure far enough, you should find the problem. It's time-consuming and not much fun, but in the absence of several kilobucks' worth of diagnostic equipment, it is usually the only way to find the culprit.—Steve

A Sticky Question

Dear Steve,

I have a question concerning programming in GWBASIC. How do you use the STICK( ) function to access the joystick? If you can, please provide me with a sample program.

Garth H. Brantley
Baltimore, MD

The program in listing 1 reads an x,y coordinate pair from each of two joysticks and prints the results in a table on the screen as the program continuously tracks the positions of both sticks. There is really only one tricky feature to this: It's in line 170, where STICK(0) *is read. This returns all four stick values to the variables* STICK(1) *for* 1 = *0 to 3, so all four values are determined simultaneously.*—Steve

Game-Playing Junkie

Dear Steve,

I'm a game-playing junkie. I want to learn how to write game programs—not to sell, but as a personal challenge. I'm also a novice programmer. The only language I own is Microsoft QuickBASIC 4.0. My interest in games ranges from Stargate (Atari public domain) to Sesame Street Pals Around Town (Hi Tech Expressions) for the kids. What can I read that will give me good information on how to write game programs?

Gail Nolf
Hellertown, PA

Get The Art of Computer Game Design *by Chris Crawford (Osborne/McGraw-Hill, 1984). It will give you insight into how to design a game, as distinct from the actual gritty details of implementing one on any particular system. You'll find that there's more to a simple game than meets the eye.*

Once you've decided what the game should do, it's time to write the code that makes it work. For that, you'll need detailed information on the particular computer system that you're using. A good game will stretch the system, particularly the video hardware, to its limits. Get all the books you can find on the system and read all of them, because knowing just one fact can often make the difference between success and failure.

IBM PCs, unfortunately, don't have good built-in support for arcade-quality video or audio. Unlike the Ataris and Amigas, the IBM has no hardware for manipulating graphics images; and unlike the Mac, it has no Toolbox routines to help you out. You'll have to do it all by hand.

If you're tackling an IBM PC, be sure to get Richard Wilton's Programmer's Guide to PC and PS/2 Video Systems *(Microsoft Press, 1987), which will tell you everything you need to know about writing serious down-and-dirty code to make the best of the video hardware. Apart from that, pick up any of the better books that delve into hardware details. You may pick the wrong ones, but if you get enough, you'll be able to glean the essentials. Skip the junk that tells you how to use DOS.*—Steve

Hi-Res on Hercules

Dear Steve,

I am involved in research that requires high-resolution graphics, so I plan to write assembly language routines for the Hercules monochrome graphics card.

What are the commands to turn on the 720-pixel by 348-pixel graphics mode? I understand the card has 32K bytes of video RAM starting at B000h. My guess is that it is divided into four banks of 8K bytes each.

I've heard that through special programming techniques, you can get a 720-pixel by 350-pixel graphics display. Is this possible?

Meng Heng
Penang, Malaysia

On a Hercules card (or compatible), these 8088/8086 I/O ports are used:

- 3B4—6845 address register
- 3B5—6845 data register
- 3B8—Display mode control port
- 3BA—Display status port
- 3BF—Configuration switch

There are other ports used for a printer interface and serial interface (if present), but they have no effect on the display.

To understand the card's operation, consider the two operating modes: text and graphics. In text mode, the video comes from the 6845 display controller, a character-generator ROM, and an attribute circuit (for controlling blinking, underlining, and normal and reverse video modes). In graphics mode, the pixels come directly from the video buffer.

There are two pages of 32K bytes each, for a total of 64K bytes of display memory. In the graphics mode, each horizontal line of 720 pixels is stored in the buffer as 90 consecutive bytes, with bit 7 as the leftmost bit on the screen. Each page is divided into one line from field 0 and then goes to fields 1, 2, and 3. This sequence continues for the entire screen, so adjacent lines from the same field are displayed four lines apart on the screen.

The offset (into the page) of the byte containing pixel x,y *in each page is expressed as follows:*

```
2000H * ( Y MOD 4 ) + 90 * INTEGER(Y/4)
 + INTEGER(X/8)
```

continued

The bit in the bytes that stores the dot is at position

```
7 - ( X MOD 8 ).
```

You select the mode by writing a 1 into bit position 1 of the display mode control port (3B8). Bit 3 gates the video on and off, bit 5 enables blinking characters in text mode, and bit 7 selects the memory page. Bits 0, 2, 4, and 6 are not used.

While you can fool some boards into displaying the last two lines (349 and 350), you can't fool them all. Therefore, I suggest that, given the marginal utility of two additional pixels in the vertical interval, it's really not worth attempting to use them.

A number of public domain packages interface to the Hercules card quite nicely, but I don't know what's available in Malaysia. If there is an IBM PC user's group nearby, you might inquire there. —Steve

Racehorse or Relic?

Dear Steve,

Recently, I was given an old computer system gratis. I received a huge 132-column printer, a Bell-compatible modem, several disks that appear to contain utilities, and the main system. The main system consists of a case containing an 8-inch green-phosphor monitor and two 8-inch disk drives. The keyboard plugs into a card inside the case, as do the modem and the printer. The name on all the equipment is Sycor, Inc., and the date stamped inside the computer case is 12/23/78.

My problem is twofold. First, I have no idea what this thing that takes up floor space is; and second, I don't have the documentation. Consequently, I can't tell whether it is junk or usable.

Matthew Lunsford
Russell Springs, KY

One of the more obvious features of a field like microcomputers is the never-ending obsolescence of otherwise useful equipment.

Older items from obscure manufacturers are especially prone to fall victim because of lack of support and software development. While you may be able to obtain information or documentation for your system by advertising in or writing letters to publications like Computer Shopper, *the system you have is likely to be hopelessly out of date.*

At best, it is probably an interesting curiosity (or a large paperweight), rather than a genuinely useful computer system. Sorry. —Steve ■

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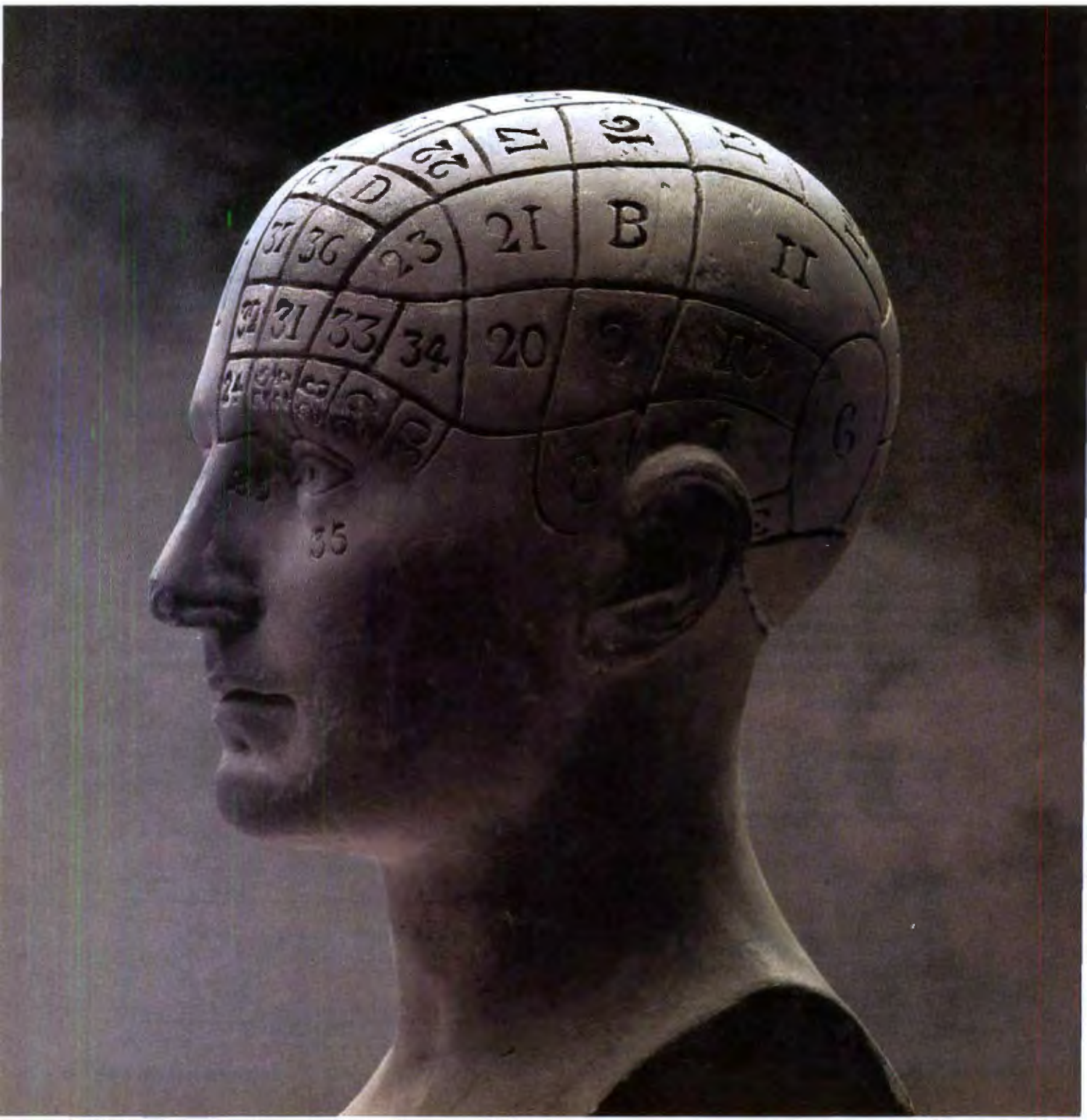

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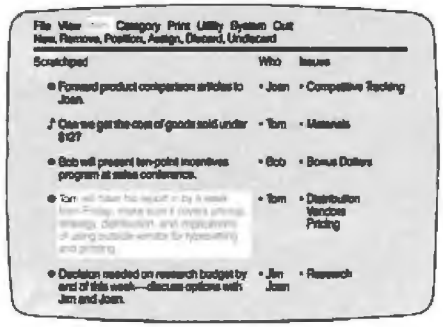

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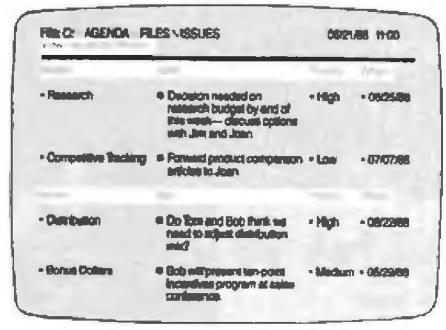

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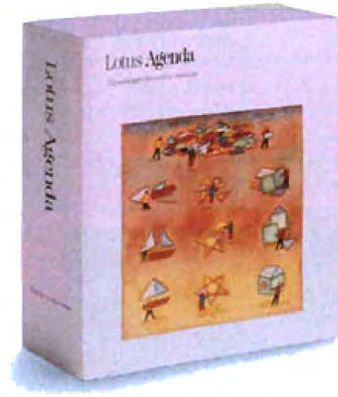

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BOOK REVIEWS

Programmer's Introduction to the Macintosh Family

Apple Computer, Inc.

Addison-Wesley, Reading, MA: 1988, 197 pages, $26.95.

Reviewed by Dong H. Kim

By now, everyone in the Macintosh programming community knows what it's like to wade through the five volumes of *Inside Macintosh*. The mind-numbing effect of thousands of pages in such official documents must have turned away many would-be programmers.

An American philosopher I knew once said that trying to read *Being and Time* by Martin Heidegger, a renowned German philosopher, is somewhat akin to trying to swim in sand. Wading through most technical computer manuals is at least that bad—perhaps closer to swimming in mud. Since official documents tend to present all information as being of equal importance, little room is left for providing an insightful perspective on a computing system or programming environment as a whole. Consequently, there is an inevitable information "overload."

I wish I'd had *Programmer's Introduction to the Macintosh Family* in my hands a couple of years ago. Certainly, my encounter with *Inside Macintosh* would have been easier and more immediately productive. A very concise introduction to the basic theories and technical operations undergirding the Macintosh computer, loaded with numerous insightful programming suggestions, this book would have saved me a lot of head-scratching and page-flipping through these earlier volumes. In short, this book greatly deepens the reader's knowledge of the Macintosh programming framework by providing an illuminating background that makes Apple's previous documentation comprehensible and easier to understand.

Written by an anonymous team of Apple programmers, this Macintosh family portrait is divided into nine well-organized chapters and three indexes. The first index takes up important issues of compatibility across Macintosh computers and gives us the latest "official" guidelines for ensuring compatibility with future systems. The second index presents the most frequently used Toolbox routines in an easy-to-find format. The information on APDA (Apple Programmer's and Developer's Association) is given in the third index.

The first chapter, "An Overview of the Macintosh," provides the answers to the question, "Why program for the Macintosh?" Here you'll find clear explanations of the key programming ideas that made the Macintosh such a revolutionary computer. A brief discussion of "event-driven" programming is also provided.

The second chapter, "The Software Anatomy of the Macintosh," deals with such vital topics as Resources, QuickDraw, Toolbox, and the Finder. After a good discussion of the hierarchical nature of Toolbox routines, we are advised: "Working around the Toolbox routines to write your own codes takes more code and more energy and introduces bugs. Because the Toolbox routines are largely in ROM and are highly optimized, you will not find yourself gaining any real execution speed. And the potential incompatibility problems you create for yourself are just not worth the effort." This is why, we are told, it's better to use the Toolbox rather than design our own ways to handle such things as menus, windows, and dialog boxes, even though it is perfectly possible to do so.

Many programmers forget to focus on the user interface design until all their routines are finalized. Then they try to glue everything together with interface design. This approach guarantees frustration

continued

ALSO REVIEWED

The C Programming Language, 2nd ed.

Advanced C Tips and Techniques

Introduction to Object-Oriented Programs and Smalltalk

What Every Engineer Should Know About Artificial Intelligence

Principles of Database Systems

and possible failure with the Macintosh, because the programs are driven by user events and the user interface is the most important part of the program. It is essential that you understand how you expect the user to interact with your program before you start coding. This timely advice is typical of the chapter.

The third chapter, "An Eventful Experience," gives a delightful account of the idea behind the main event loop, what must be in it, and how its requirements relate to application programs. It also discusses topics such as the event queue, event-masking, and ways of handling Activate, Mouse, Key, Disk-insert, and Update events.

Next, the authors move on to the very important subject of memory management on the Macintosh. They explain how and when objects stored in memory are subject to being relocated, how to know when they can be moved around, and how to keep track of such moves at all times. Insightful comments on pointers, handles, blocks, the stack, heaps, and memory fragmentation are scattered throughout this fourth chapter. For example, we learn that `UnloadSeg` does not, as its name implies it does, actually unload the segment, but that it unlocks the segment, permitting the Memory Manager to purge it or reallocate the space it occupies if necessary. Three primary causes of out-of-memory conditions are also discussed: overzealous use of nonrelocatable blocks, the use of desk accessories, and the system's own use of memory.

The key to Macintosh programming is learning how to call the correct routines provided for you in the ROM and operating system. Chapter 5 covers those routines related to QuickDraw and Color QuickDraw. Here we are told why everything is in graphics in the Macintosh. Bits and pixels as well as graphics ports are explained in detail. The section on Color QuickDraw is particularly interesting and useful, since this is still a relatively new subject.

The sixth chapter goes into a detailed account of the User Interface Toolbox and deals with the Window, Menu, Dialog, Control Managers, and TextEdit.

Regions of a window and the contents of a window record are masterfully explained in just three pages of chapter 6. Have you ever wondered how `NewWindow` and `GetNewWindow` are different? Here you'll find out. (`NewWindow` creates windows dynamically, while `GetNewWindow` loads a predefined window resource from the appropriate resource file and carries out the same function as `NewWindow`. Thus, `NewWindow` requires eight arguments, whereas `GetNewWindow` requires only three.) Other similarly helpful explanations and distinctions are scattered throughout this important chapter, regarding the Menu, Dialog, and Control managers.

Chapter 7 deals with file management: how files are organized, how we access them, and how our programs create, open, read, write, and close disk files. Such concepts as file types and creators are clearly discussed. A good example of file handling is given at the end of the chapter.

Chapter 8 gives a brief account of development tools in the form of HyperCard, the Macintosh Programmer's Workshop, and MacAPP. Object-oriented programming is also briefly touched upon here. The next chapter, "Becoming a Macintosh Developer," explains what to expect in *Inside Macintosh* and how to find your way around these volumes. The chapter also gives information on the procedure to follow to become a registered Macintosh developer.

If I have one complaint to make about this useful book, it is that Apple should have published it 2 or 3 years ago—but

continued

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better late than never. On the other hand, some readers may argue that the authors should have devoted more space to newer topics, such as Color QuickDraw and MultiFinder. Otherwise, this book provides a solid foundation for understanding the Macintosh family of computers. Throughout the book, and especially in chapters 4, 5, and 6, I found valuable nuggets that clarified the nature of code and operations I had read about elsewhere but had failed to understand.

In addition to being well-organized and informative, the book is enjoyable to read. It is written in a relaxed style; they also make appropriate and frequent use of diagrams and tables to illustrate concepts under discussion; they also follow up with fully coded examples. One example: "A Macintosh program is not, as some people have said, an amusement park ride with moving stairs you can't predict. It's more like an escalator whose stairs take you where you want to go, quickly and effortlessly. Just don't try to drive the escalator." Another example: "An event-driven environment is one in which the user gets to say to the programmer, OK, I have your program now. Don't call me, I'll call you."

In the final analysis, this is an indispensable first book for anyone who wants to program computers in the Macintosh family. It is also the long-awaited definitive introduction for those who haven't been exposed to the Macintosh philosophy of programming—a chance to find out at last what makes people so evangelical about the Mac.

BRIEFLY NOTED

The C Programming Language, 2nd ed. *by Brian W. Kernighan and Dennis M. Ritchie, Prentice-Hall, Englewood Cliffs, NJ: 1988, 272 pages, $28.* This new edition of *The C Programming Language* is a complete rewrite commemorating the tenth anniversary of the original best-seller that introduced the language. It follows the outline of the original book, but Kernighan and Ritchie have updated it to reflect the draft ANSI standard for C. The book incorporates all the so-called post-K&R extensions, including enumerations and function prototypes.

The new book talks about C in comparison to Pascal instead of PL/1. The typography is vastly improved, and the sections on declaration type precedence and separate compilation are more detailed and comprehensive than they were in the original.

Written in a terse and cryptic style faithful to the spirit of C, the new K&R will please fans of the old. The book remains an introduction to the language for experienced programmers; even with the new material, it is neither a beginner's tutorial nor a comprehensive reference.—*Joel West*

Advanced C Tips and Techniques *by Paul Anderson and Gail Anderson, Howard W. Sams, Indianapolis, IN: 1988, 464 pages, $24.95. Advanced C Tips and Techniques* starts off easy with a refresher chapter, then pops the latch and opens the hood to expose the mechanics of the C language. Here you'll get an inside look at the text area (where program code lives), the data area (for static and global variables), the stack (which manages procedure calls and local variables), and the heap (the realm of run-time storage created by alloc()).

It's nice to see good explanations of why C does some of the things it does. If you're a black-belt samurai C programmer, you may find some of the topics trivial, but it still makes interesting reading. For example, the authors point out that one reason C does not initialize automatic variables at run time is because problems would arise if a goto transferred control inside a

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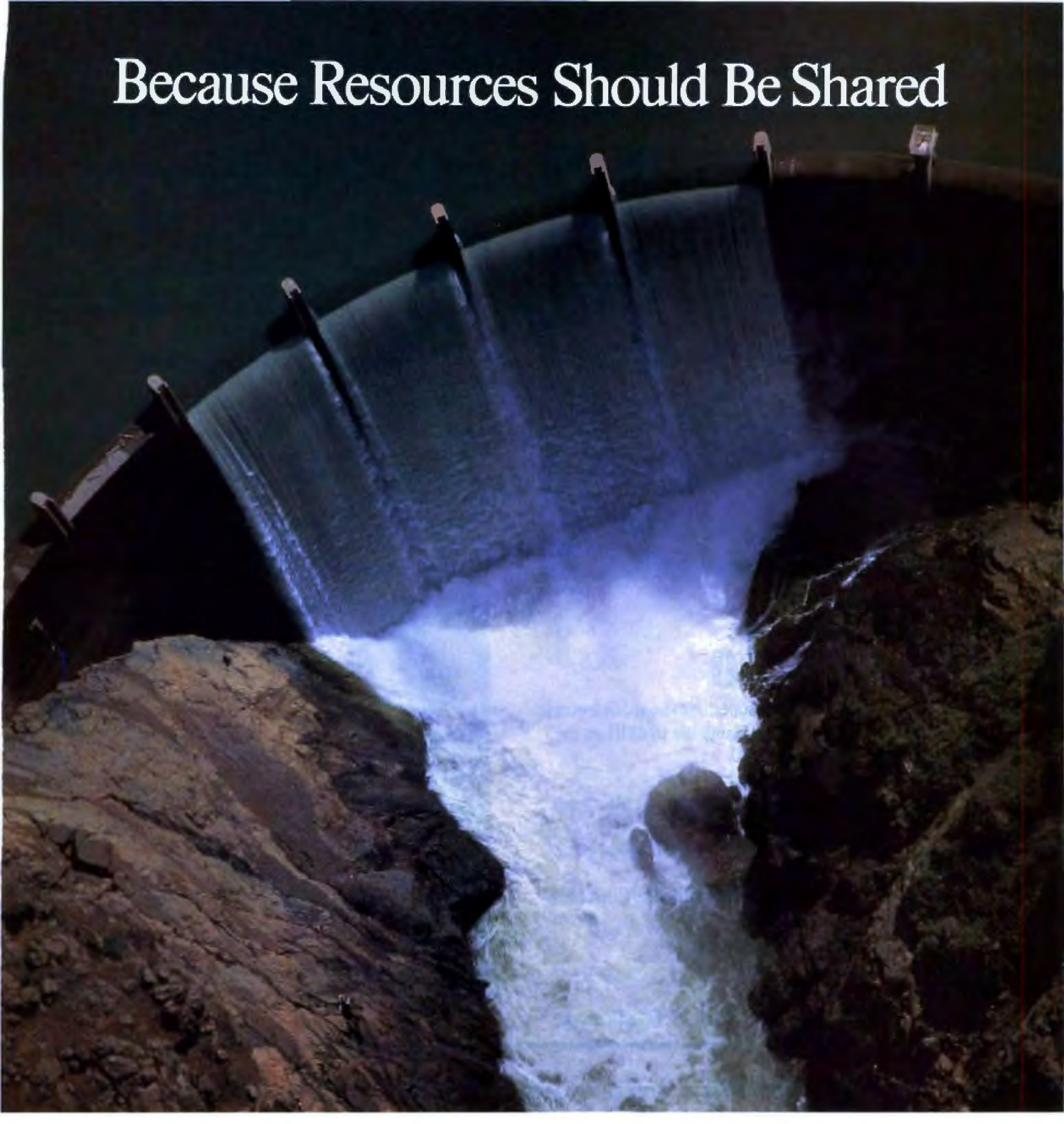

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block that contained automatic variables.

The authors explain how the C constructs operate from the point of view of the underlying system architecture. And you will find lots of source code that encourages exploration of C's internal structure.

Next comes a good guide through the confusing—even to experienced programmers—maze of arrays and pointers, though this is not so much a set of hard-and-fast rules describing proper techniques as it is a series of invitations to experiment. Some of the examples given are surprising; you'll find yourself looking at an expression with a different eye.

The section covering debugging presents an assortment of techniques, most of them basic commonsense methods. The author offers some novel suggestions for applying front-end code to the memory allocation functions (use of which is notorious for yielding cranky code); the result is a tightening up of error checking in these routines.

The appendixes of *Advanced C Tips and Techniques* really shine. Here you'll find useful minimanuals for popular C compilers, including SCO Xenix System V, Microsoft C 5.0, Turbo C, Microport's System V Unix (for the AT and 80386 machines), and, of course, the standard Unix C compiler.

If you're a serious C programmer and your work spans a variety of machines, this book belongs on your shelf right next to the high-potency vitamins.—*Richard Grehan*

An Introduction to Object-Oriented Programming and Smalltalk *by Lewis J. Pinson and Richard S. Wiener, Addison-Wesley, Reading, MA: 1988, 502 pages, $27.95.* Object-oriented programs have been around since the development of Smalltalk at the Xerox Palo Alto Research Center labs in the late 1970s, but only recently have hardware prices fallen enough to make such systems obtainable by home enthusiasts and useful to small businesses. In the 1980s, the invention of C++, an extension of the C language that includes constructs for object-oriented programming, has greatly increased interest in the object-oriented programming methodology.

With uncanny timing, Lewis J. Pinson and Richard S. Wiener, professors at the University of Colorado, have written two books to teach this methodology, using the two most prominent object-oriented languages, C++ and Smalltalk.

C++ is a superset of C that retains all the power of that language but includes object-oriented features, such as data abstraction, encapsulation, inheritance, and polymorphism. Invented at Bell Labs by Bjarne Stroustrup, the original C++ is a preprocessor that interprets C++ code and translates it into C so that compatibility with existing C compilers is guaranteed. Thus, the programmer is spared efficiency problems that often plague Smalltalk environments.

Pinson and Wiener's book assumes that the reader understands C but knows nothing about C++ or object-oriented programming. The book provides a tutorial of C++ and then continues into a more technical presentation of the topics listed above (e.g., data abstraction). The programming examples are particularly enlightening, such as the "superfast spelling checker" that effectively uses data encapsulation and inheritance. The book concludes with case studies, including the grand finale, an interactive algebraic expression evaluator.

The authors consider Smalltalk the language "most true to the object-oriented philosophy." Therefore, they devote almost twice as many pages to Smalltalk in order to delve into the methodology, the language, and the Smalltalk environment. For the

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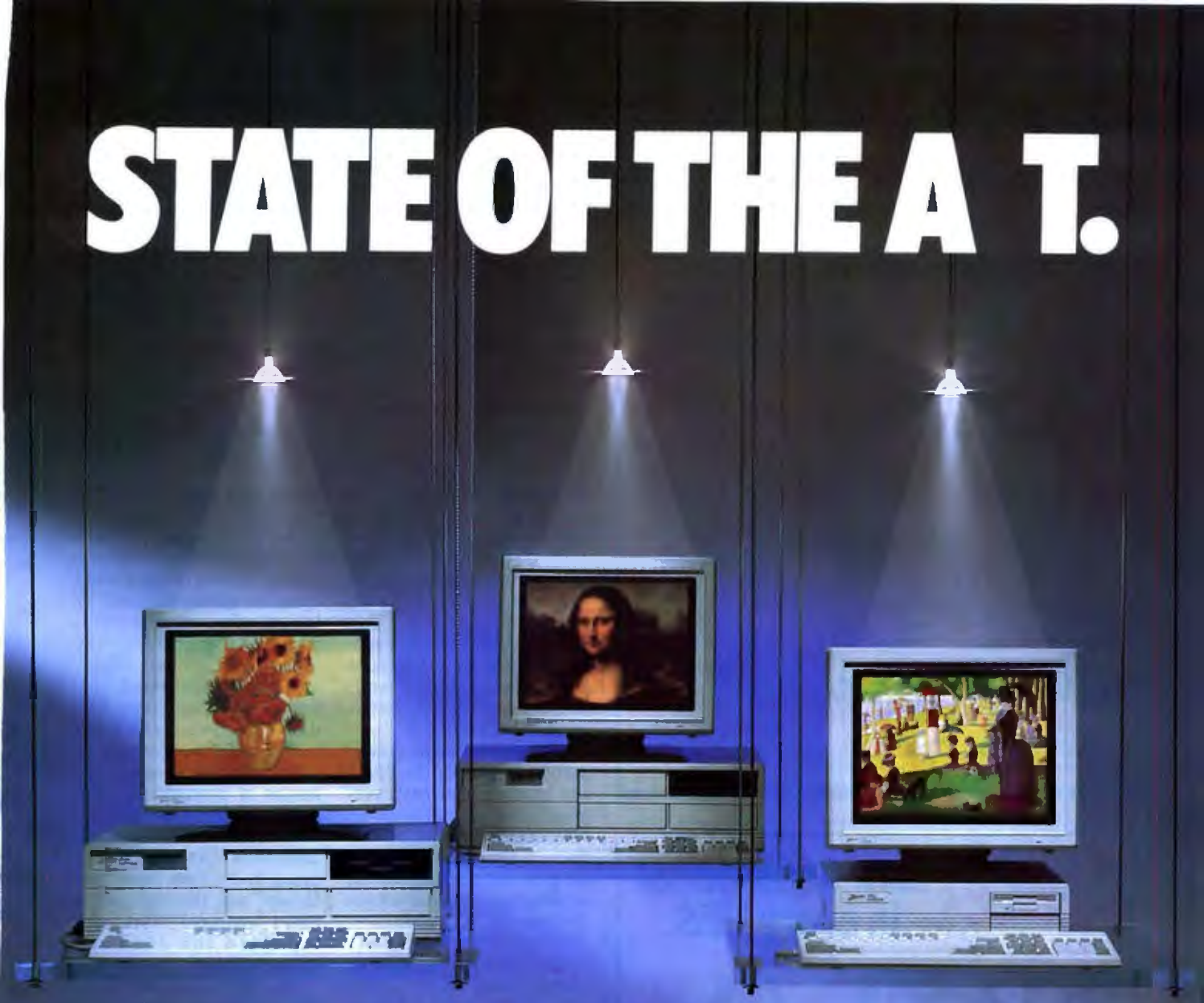

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most part, their Smalltalk book uses the perspective of this environment so that access to a Smalltalk machine is almost a necessity for using the book (screen diagrams are included, however). Given that Smalltalk environments are relatively rare and normally require a mouse, this is a small drawback to the book.

The authors present the central concepts of Smalltalk—but not the entire language—thoroughly, allowing you to explore further possibilities independently. In addition, topics are presented incrementally: on an elementary level at first, and later at a more advanced, abstract level. This eases the comprehension process considerably. Programs are generally small, well-chosen, and easy to understand and extend.

The book is designed as an introduction both to Smalltalk and to object-oriented programming. It assumes no prior knowledge of either. The discussion is squarely aimed at the professional programmer or advanced computer science student.—*Jason Levitt*

What Every Engineer Should Know About Artificial Intelligence *by William A. Taylor, MIT Press, Cambridge, MA: 1988, 331 pages, $25.* Computers already can check circuit design rules and verify the manufacturability of printed circuit boards. They can calculate part routing in machine shops and devise the best assembly procedures in many factories. In short, AI is having a profound impact on every aspect of engineering.

The book offers an insightful survey of AI and expert systems for the engineering community. The author discusses multitudes of engineering opportunities in AI research and throws light on programming approaches such as function-based, object-oriented, and rule-based orientations. He also introduces the important AI languages, Lisp and Prolog.

Taylor is an international consultant on practical applications of AI, and his experience shows in the book's hands-on details. The book concludes with a look at future trends and a fascinating discussion of the Japanese computer industry and the fifth-generation computer project.
—*Dong H. Kim*

Principles of Database Systems *by Jeffrey D. Ullman, Computer Science Press, Rockville, MD: 1988, 631 pages, $41.95.* This new volume covers mainly "classical" (relational) database systems. Knowledge-based systems, as represented by logical rules, are also introduced. After defining key terms for relational, object, and knowledge-based systems, the author shows how these methodologies are interrelated in the development of more powerful systems. Examples of programming languages used in each methodology, such as DDL (Data Definition Language), proposed by the Data Base Task Group, and the object-oriented language OPAL, are explained and discussed extensively.

The book also deals with physical storage techniques, design theories for databases, security, integrity, concurrency control, recovery in database systems, and distributed database systems. The chapter entitled "Protecting the Database Against Misuse" contains particularly valuable discussions of computer security and safety. The book includes over 200 exercises at graded levels of difficulty.
—*Dong H. Kim*

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Dong H. Kim is a researcher and consultant in artificial intelligence. He lives in Chapel Hill, North Carolina. **Joel West** is president of Palomar Software and lives in Vista, California. **Richard Grehan** is a senior technical editor at BYTE. **Jason Levitt** is a Unix consultant in Austin, Texas.

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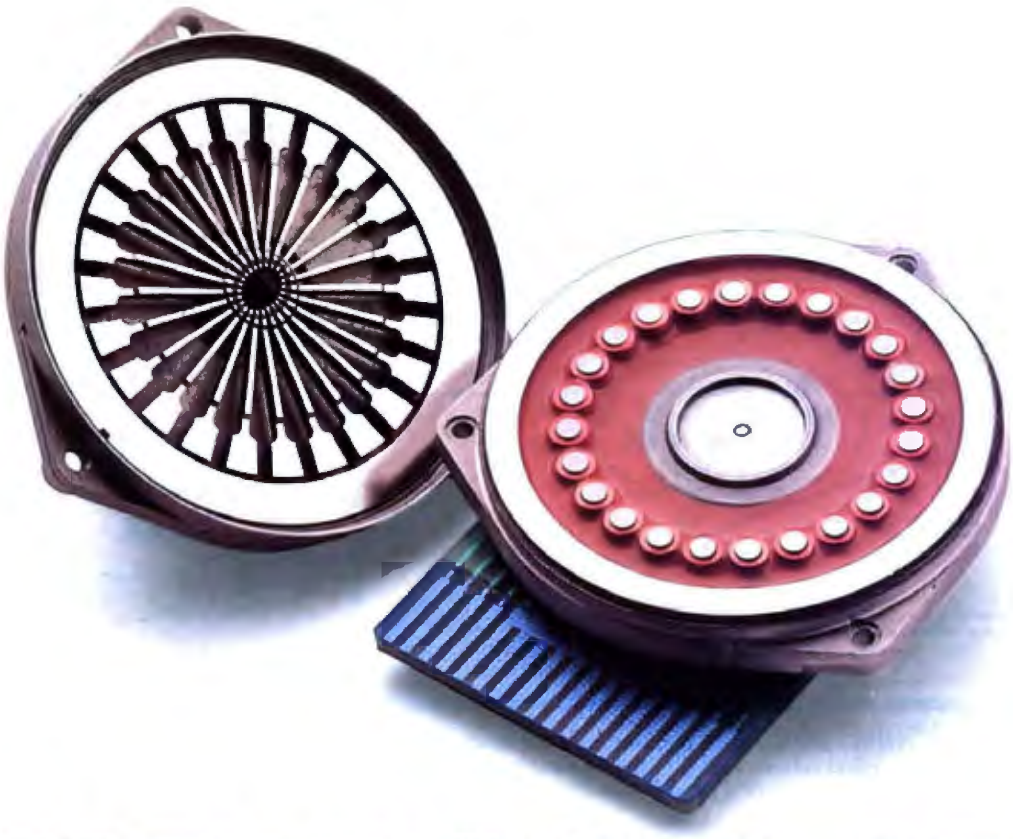

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*Infoworld, July 6, 1987

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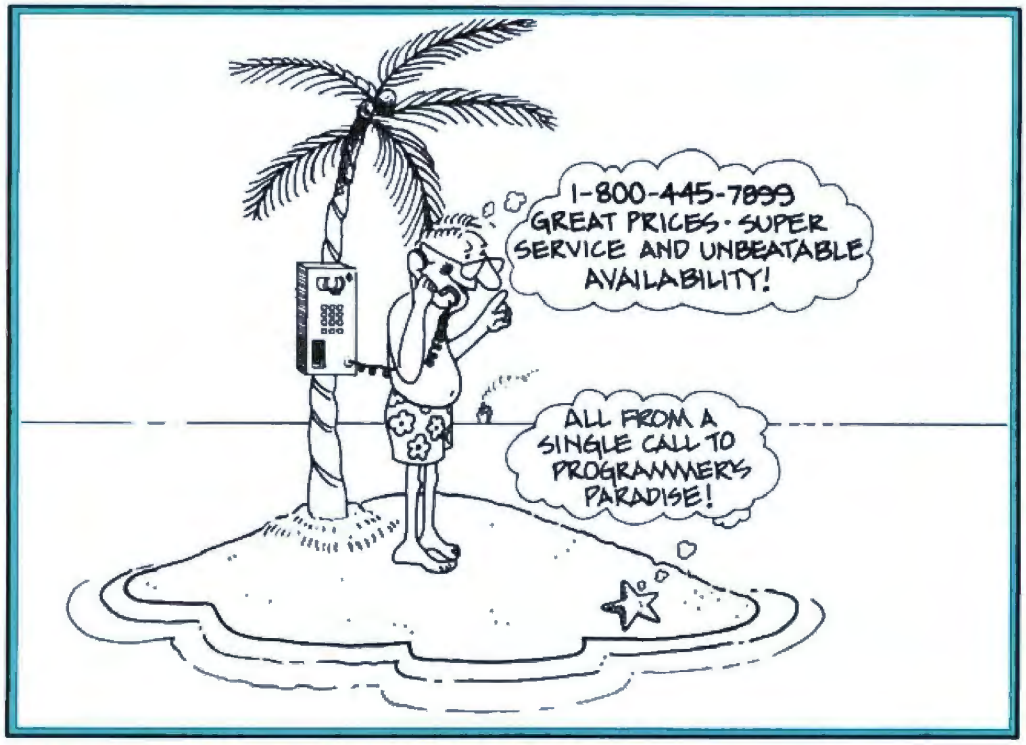

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LIST: $129
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WENDIN-DOS is the new multi-tasking, multi-user MS-DOS replacement operating system for IBM compatible Personal Computers. Version 2.5 allows users to create hard disk partitions greater than 32 MB. WENDIN-DOS uses the MS-DOS file system, and supports MS-DOS commands while providing new ones to enable multi-tasking, file protection, and command language extensions and enables you to access your files with DOS, UNIX, or VAX/VMS style file names—whichever you prefer. WENDIN-DOS supports several users on the same computer. WENDIN-DOS now includes XTC, Wendin's ULTIMATE PROGRAMMER'S EDITOR!
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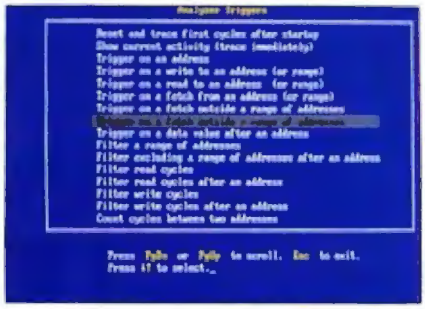

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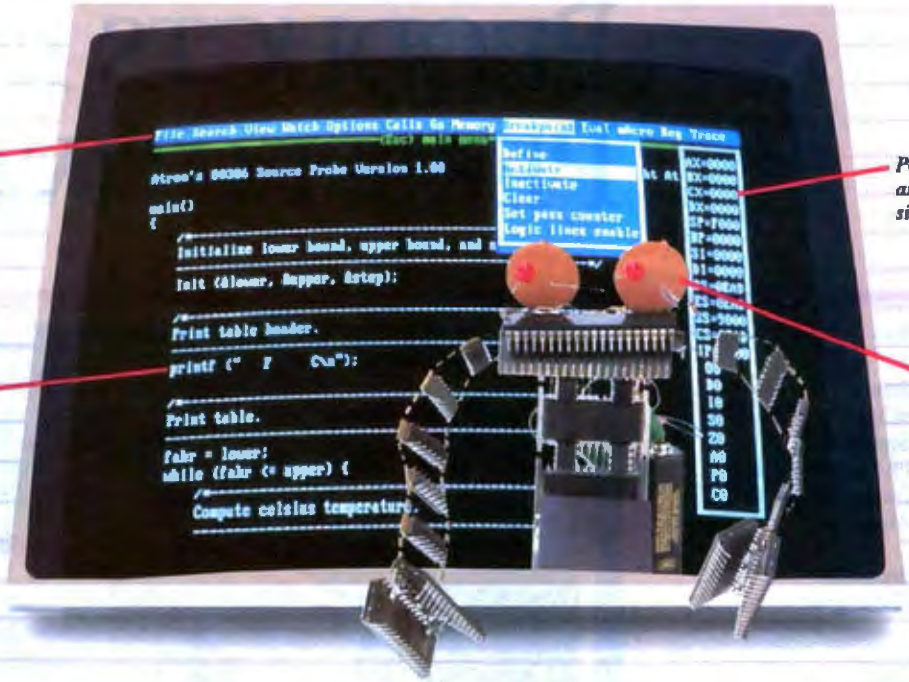
PRODUCTS IN PERSPECTIVE

IT'S TIME TO DO SOME SERIOUS 386 BUGBUSTING!



Welcome to your nightmare. Your company has bet the farm on your product. Your demonstration wowed the operating committee, and beta shipments were out on time. Then wham!

All your beta customers seemed to call on the same day. "Your software is doing some really bizarre things," they say. Your credibility is at stake. Your profits are at stake. Your sanity is at stake.

THIS BUG'S FOR YOU

You rack your brain, trying to figure something out. Is it a random memory overwrite? Or worse, an overwrite to a stack-based local variable? Is it sequence dependent? Or worse, randomly caused by interrupts? Overwritten code? Undocumented "features" in the software you're linking to? And to top it off, your program is too big. The software debugger, your program and it's symbol table can't fit into memory at the same time. Opening a bicycle shop suddenly isn't such a bad idea.

THIS DEBUGGER'S FOR YOU

Announcing the 386 PROBE™ Bugbuster.*from Atron. Nine of the top-ten software developers sleep better at night because of Atron hardware-assisted debuggers. Because they can set real-time breakpoints which instantly detect memory reads and writes.

Now, with the 386 PROBE, you have the capability to set a *qualified breakpoint*, so the breakpoint triggers only if the events are coming from the wrong procedures. So you don't have to be halted by breakpoints from legitimate areas. You can even detect obscure, sequence-dependent problems by stopping a breakpoint only after a specific chain of events has occurred in a specific order.

Then, so you can look at the cause of the problem, the 386 PROBE automatically stores the last 2K cycles of program execution. Although other debuggers may *try* to do the same thing, Atron is the only company in the world to dequeue the pipelined trace data so you can easily understand it.

Finally, 386 PROBE's megabyte of hidden, write-protected memory stores your symbol table and debugger. So your bug can't roach the debugger. And so you have room enough to debug a really big program.

COULD A GOOD NIGHT'S SLEEP PUT YOU IN THE TOP TEN?

Look at it this way. Nine of the top-ten software products in any given category were created by Atron customers. Maybe their *edge* is – a good night's sleep.

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*Versions for COMPAQ, PS/2-80s and compatibles. 386 PROBE is a trademark of Atron. Call 44-2-855-888 in the UK and 49-8-985-8020 in West Germany. TRBA

Circle 36 on Reader Service Card

MIDI Meets DOS in a Laptop

Yamaha Music introduced an MS-DOS-compatible laptop that's designed specifically for professional musicians.

At first glance, the C1 seems no different from a standard laptop.

An 8- or 10-MHz Intel 80286 microprocessor is coupled with 64K bytes of ROM, 640K bytes of RAM (upgradable to 1 or 2.5 megabytes), and two 720K-byte 3½-inch floppy disk drives (or an optional 20-megabyte hard disk drive/720K-byte floppy disk drive configuration).

The backlit digital liquid crystal display offers 640- by 400-pixel resolution, and you can connect an external monitor.

Several features, however, distinguish this machine. The first is MIDI compatibility, which you can access through the 11 MIDI ports (2 in, 1 through, and 8 out) that line the back of the 15- by 15- by 3-inch, 18-pound machine.

There's built-in tape synchronization functionality and two sliders on the side of the keyboard for pitch bend, volume, tempo, and other functions that work off music-specific software packages.

Music-specific hardware includes a chip that gives the C1 a system timer.

Also, Yamaha claims that about two dozen third-party software manufacturers are ready to deliver as many as 100 programs.

Price: $2995; $3995 with hard disk drive option.

Contact: Yamaha Music Corp., USA, P.O. Box 6600, Buena Park, CA 90622, (714) 522-9011.

Inquiry 753.

Yamaha C1 breaks the music barrier.

Apple Joins the 68030 Bandwagon

A new CPU, floating-point coprocessor, and floppy disk drive controller mark the advanced technology Apple Computer is promoting with the introduction of the Mac IIX computer.

Motorola's 16-MHz 68030 microprocessor has separate instruction and data caches and includes Paged Memory Management hardware that supports shared memory and virtual memory. It also includes the latest-generation 68882 floating-point coprocessor.

Apple says the new floppy disk drive controller and its 1.44-megabyte 3½-inch floppy disk drive, called SuperDrive, can format and read/write both 400K-byte and 800K-byte Apple floppy disks as well as MS-DOS and OS/2 720K-byte and 1.44-megabyte floppy disks.

Two drive configurations are available: one 1.44-megabyte floppy disk drive, or one 1.44-megabyte floppy disk drive and an internal 80-megabyte SCSI hard disk drive.

The Mac IIX will run Apple's operating system version 6.0. Inside the Mac II–size, 25-pound Mac IIX are 4 megabytes of on-board RAM (expandable to 8 megabytes). Monitor and keyboard are options.

Price: $7769; $9369 with 80-megabyte hard disk drive.

Contact: Apple Computer, Inc., 20525 Mariani Ave., Cupertino, CA 95014, (408) 996-1010.

Inquiry 751.

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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. These items, along with additional new product announcements, are posted regularly on BIX in the microbytes.sw and microbytes.hw conferences.

Wang Supermicro Runs Its Own VS and Unix

Three VS 5000 microprocessor chips provide the Wang VS 5000 with 25 to 33.3 MHz of no-wait-state performance. On each of these scalable CMOS chips is an entire Wang VS instruction set, which the company claims is a variant of the IBM 370 mainframe instruction set.

Wang's VS operating system comes standard, but a Unix-based system called the VS IN/ix is available as an option. All systems are shipped with a 1.2-megabyte 5¼-inch floppy disk drive. Each can also be equipped with one full-height hard disk drive, and one or two half-height hard disk drives, or half-height streaming tape drives.

Model 30 operates at 25 MHz and can handle as many as six terminals. It sports 1 or 2 megabytes of RAM and a 72-megabyte or 145-megabyte hard disk drive.

Model 40 operates at 25 MHz, but it handles up to 16 users, with each system containing 2 megabytes of RAM (upgradable to 8) and your choice of a 72-, 145-, or 326-megabyte hard disk drive.

Model 50 operates at 28.6 MHz for up to 32 terminals with 2 megabytes of RAM (upgradable to 8), and any of the three hard disk drives.

Price: Model 30, $8800 to $13,900; Model 40, $15,200 to $41,100; Model 50, $26,200 to $52,100.

Contact: Wang Laboratories, Inc., One Industrial Ave., Lowell, MA 01851, (508) 459-5000.

Inquiry 752.

continued

Erasable Technology Meets Optical Storage

DISCUS Rewritable is a magneto-optical disk subsystem that's compatible with all MS-DOS- and OS/2-based systems.

It's a 5¼-inch, 650-megabyte subsystem that's compatible with the manufacturer's WORM and CD-ROM drives. Operation of the DISCUS is the same as a hard disk drive, except that the optical cartridges are removable. The AGADrive SCSI host adapter is installed in a full-length AT or PS/2 (Micro Channel) slot.

The system reads data from the 3M-designed removable cartridges using an 800-nanometer, 20-milliwatt semiconductor laser diode. The cartridges have a polycarbonate chemical substrate that sandwiches a thin film of "earthen" elements. The laser polarizes (deflects) tiny elements on the thin film, making the writing magneto-optical. All reads are optical.
Price: $4995; $250 for cartridges.
Contact: Advanced Graphic Applications, Inc., 90 Fifth Ave., New York, NY 10011, (212) 337-4200.
Inquiry 757.

DISCUS rewrites optical disks.

PC-Based CAD Peripheral for 2½-D

Adra Systems' new PC-based CAD peripheral, Acclaim!, has roughly one-third the storage capacity of its minicomputer-based (CAD) System 3000.

Both systems have 2½-dimensional (2-D that can be viewed from multiple *x*, *y*, and *z* axes) functionality. Both have a quick response time of about 1/10 second. Both functions are perfect for the engineer designing the nuts-and-bolts-type components necessary in any manufacturing facility.

Files can be shared with other Acclaim! systems, with PCs, or with the Adra 3000 via Transmission Control Protocol/Internet Protocol (TCP/IP) Ethernet or 360K-byte floppy disks. Acclaim! can also be linked to an Adra file server for a multiple workstation environment.

Applications software is Adra's Cadra-II, version 6.0, which works with MS-DOS 3.1 or higher and with IBM PC, XT, and AT compatibles, including PS/2s.

Compatible computers must have at least 20 megabytes of hard disk capacity, a graphics display (EGA and VGA monitors with 1024- by 768-pixel resolution are supported), a keyboard, and a mouse or tablet.

Adra also sells a complete system, which includes a 10-MHz 80286-based PC (or a 16-MHz 80386-based machine), Acclaim!, a 15-inch VGA color display, and a 40-megabyte hard disk drive. Options include a 19-inch 1024- by 768-pixel display, a data tablet and stylus, and a 40-megabyte tape backup.
Price: $10,795 to add Acclaim! to your existing system; $14,995 with an 80286 package; $17,995 with an 80386 package.
Contact: Adra Systems, Inc., 59 Technology Dr., Lowell, MA 01851, (508) 937-3700.
Inquiry 758.

WORMs That Slither Faster

Maximum Storage is banking on the idea that a permanent WORM (write once, read many times) media will be used for years to come.

The 500-megabyte APX-4000 device is the company's second offering with non-erasable permanence in mind (it is conservatively estimated to last more than 10 years).

The APX-4000, a 5¼-inch unit, is coupled with the company's proprietary software for 28-millisecond access time resulting from both coarse-seek and fine-seek motors. Each drive comes standard with a controller card (XT- and AT-compatible) and an enhanced small device interface port.
Price: External version, $4450; internal version, $4250; double-sided cartridges, $175; single-sided, $125.
Contact: Maximum Storage, Inc., 5025 Centennial Blvd., Colorado Springs, CO 80919, (719) 531-6888.
Inquiry 756.

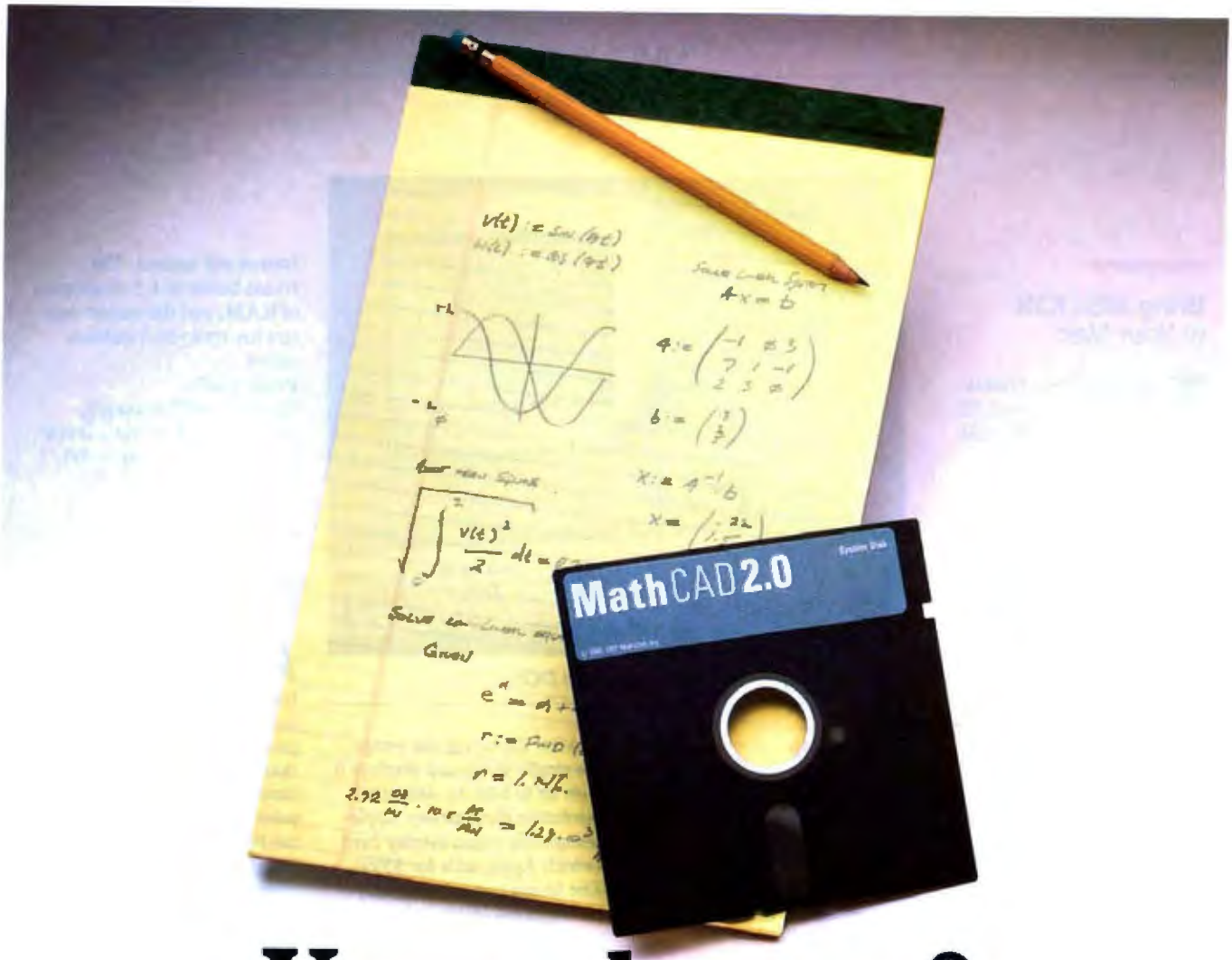
continued

RS-232C Modem Doesn't Hog Your RS-232C Port

The XE2400FT is a compact 2400-bps modem that requires no XT- or AT-compatible slots. It doesn't even use up your RS-232C port.

If your RS-232C port is already occupied, you simply unplug that device, plug the XE2400FT into your computer's RS-232C port, and plug the other peripheral into the XE2400FT's RS-232C port. This arrangement gives the Xecom-designed modem the ability to receive and transmit through the telephone lines. Or you can flip a switch and be in direct contact with a printer, a mouse, another computer, or any other serial peripheral device.

The XE2400FT includes many functions. It's compatible with the Hayes AT command set, and it features auto-answer, auto-baud, auto-dial, and redial functions. It also has a fully programmable set of S registers, for programming the number of rings or dialing time delay, for example.
Price: $349 with communications software; $477 with a serial mouse and compatible software.
Contact: Xecom, Inc., 374 Turquoise St., Milpitas, CA 95035, (408) 945-6640.
Inquiry 755.

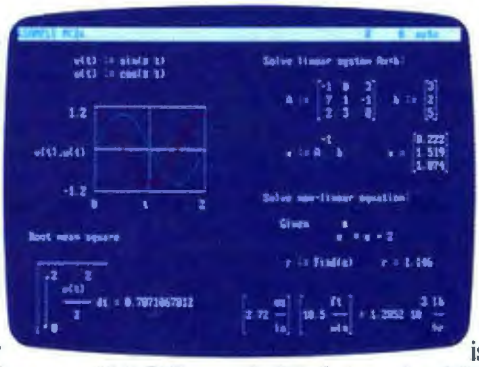


Your pad or ours?

If you perform calculations, the answer is obvious.

MathCAD 2.0.

It's everything you appreciate about working on a scratchpad – simple, free-form math – and more. More speed. More accuracy. More flexibility.



Just define your variables and enter your formulas anywhere on the screen. MathCAD formats your equations as they're typed. Instantly calculates the results. And displays them exactly as you're used to seeing them – in real math notation, as numbers, tables or graphs.

MathCAD is more than an equation solver. Like a scratchpad, it allows you to add text anywhere to support your work, and see and record every step. You can try an unlimited number of what-ifs. And print your entire calculation as an integrated document that anyone can understand.

Plus, MathCAD is loaded with powerful built-in features. In addition to the usual trigonometric and exponential functions, it includes built-in statistical functions, cubic splines, Fourier transforms, and more. It also handles complex numbers and unit conversions in a completely transparent way.

Yet, MathCAD is so easy to learn, you'll be using its full power an hour after you begin.

What more could you ask for? How about the exciting new features we've just added to MathCAD 2.0...

- Built-in equation solver
- Full matrix operations
- Two to four times increase in calculating speed
- Easier full-page text processing
- Auto-scaled plots
- Memory enhancements
- Additional printer and plotter support
- And more.

If you're tired of doing calculations by hand or writing and debugging programs, come on over to our pad. MathCAD. The Electronic Scratchpad.

Call for a detailed spec sheet and the name of a MathCAD dealer near you. **1-800-MathCAD** (In MA: 617-577-1017).

Requires IBM PC® or compatible, 512KB RAM, graphics card.

IBM PC® International Business Machines Corporation.
MathCAD® MathSoft, Inc.

MathCAD®

MathSoft, Inc., One Kendall Sq., Cambridge, MA 02139

Circle 207 on Reader Service Card

Bring MS-DOS to Your Mac

Two coprocessor boards allow the Macintosh SE and II to run MS-DOS applications easily, the manufacturer claims. Each fits in a single expansion slot and includes a parallel port for IBM PC–compatible printers and a serial port for RS-232C devices. All you need to add is the operating systems.

MAC/DOS SE, which is based on Intel's 8086, comes with disk-transfer and file-conversion utilities. These permit you to transfer files directly, without having to use an external 5¼-inch floppy disk drive. The SE board also supports Macintosh features (such as font style and size selection for desktop publishing, Multifinder and Switcher, and many Macintosh desk accessories) while operating in the DOS environment.

Memory is 128K bytes of RAM, upgradable to 512K. Macintosh disk drives are assigned and used as DOS disk drives using a logical format. The SE's hard disk drive is partition-configurable from 1 to 32 megabytes.

The MAC/DOS II coprocessing board, which is based on Intel's 80286, includes 1 megabyte of expansion memory (upgradable to 2 megabytes) you can use for the Mac when you're not using it to run MS-DOS applications. Besides the parallel and serial ports, there's an optional 80287 math coprocessor socket.

Price: MAC/DOS SE with 128K bytes of RAM, $795; with 512K, $1195; MAC/DOS II with 1 megabyte of RAM, $1495.
Contact: PerfecTek Corp., 1455 McCarthy Blvd., Milpitas, CA 95035, (408) 263-7757.
Inquiry 760.

PerfecTek coprocessing lets Macs run DOS.

NuView Images the Mac II

AST Research has an 8-, 16-, and 24-bit color image-capture card for the Mac II that digitizes and manipulates images from NTSC- and RGB-standard sources. Typical applications vary from desktop presentation and publishing to medical imaging and industrial inspection.

After capturing the image, the single-slot board displays it with up to 640- by 480-pixel resolution through any Apple-compatible video display card (which Apple sells for $599). The image can subsequently be displayed (digitized to fit within multiple windows of any size), manipulated, stored, printed, or transferred to graphics applications.

Key features include real-time hardware panning and zooming, clipping, and masking. Capture rate is 30 frames per second. The frame buffer is 1.5 megabytes of RAM, and the system palette has up to 16.7 million colors.

Price: $2099.
Contact: AST Research, Inc., 2121 Alton Ave., Irvine, CA 92714, (714) 863-9991.
Inquiry 763.

CATV-Delivered Video Meets the PC

One of the first consumer products involving data processing of cable television–delivered video is now available from CableSoft.

LiveWire allows you to keep up with your stock market portfolio through the Financial News Network while you're in an application in the DOS environment. Any time your PC, XT, AT, or compatible is tuned into FNN, delivered by your local cable television franchise, you've got the most up-to-date stock quotes available.

Coprocessor multitasking allows LiveWire to signal you from within your application to buy, sell, stop buying, or stop selling when prices reach preset levels.

Included software allows for multiple portfolio management with cash accounting. There's 64K bytes of ROM and 8K bytes of RAM for storage of historical data for securities, indexes, and portfolios. Software is included for some technical analyses of the historical data.

Price: $995.
Contact: CableSoft, Inc., 307 West Burlington Ave., Fairfield, Iowa 52556, (515) 472-8393.
Inquiry 761.

LIM/EMS 4.0 Boards from Intel

Above Board Plus and Above Board Plus I/O are Intel products supporting the Lotus/Intel/Microsoft Expanded Memory Specification (LIM/EMS) 4.0 and OS/2 hardware for multitasking capability above 640K bytes on the IBM PC, XT, AT, non-Micro Channel PS/2s, and compatibles.

LIM/EMS offers access to 32 megabytes rather than the conventional 640K-byte limit that can be accessed by applications and utilities such as RAM disks and print spoolers. Since LIM/EMS 4.0 was released, more than a dozen software packages have been revised to support the specification.

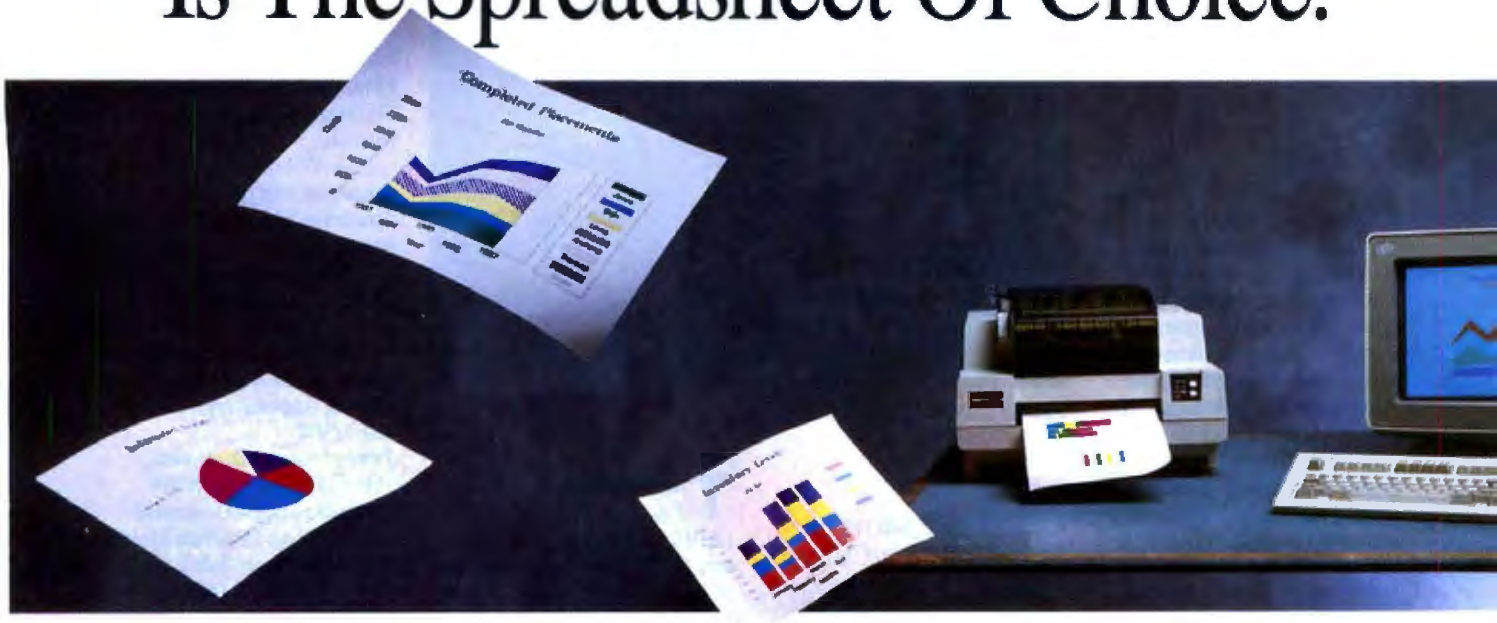
With LIM/EMS and a piggyback card, Above Board Plus offers access to 8 megabytes. Memory on Above Board Plus can also be configured to OS/2, or extended memory.

Above Board Plus I/O comes standard with one serial and one parallel port.

Price: Above Board Plus, $745; Above Board Plus I/O, $895; piggyback memory board configured with 2 megabytes, $2195.
Contact: Intel PCEO, Mail Stop C03-07, 5200 Northeast Elam Young Pkwy., Hillsboro, OR 97124, (800) 538-3373.
Inquiry 762.

continued

It's Easy To See Why Quattro Is The Spreadsheet Of Choice!



In fact, it's hard *not* to see. Because one look at Quattro* shows you a lot more for your money. More speed, more power, and the most spectacular presentation-quality graphics anywhere—built in.

Dazzling and diverse

If you went out looking, you'd be hard pressed to find spreadsheet graphics as dazzling and diverse as Quattro's. If you did, they'd be in a separate standalone package with a separate standalone price. And they still wouldn't be integrated with your spreadsheet's menu commands the way Quattro's are.

Brilliance built in

Quattro lets you choose from 10 different types of presentation-quality graphs and a huge selection of fonts, fill patterns and colors.

Quattro supports PostScript* too. So you can use today's most popular laser printers and typesetters to make your work—and yourself—look positively brilliant.

Hard copy made easy

Quattro makes it easy to get hard copies of your graphics—with a printer or plotter, directly from the spreadsheet. In fact, you don't even have to leave the spreadsheet.

Seeing is believing!

Dazzling graphics are just one of Quattro's eye-opening features; your dealer can show you the others. Quattro is easy to use and fully compatible; it even accepts familiar 1-2-3* compatible commands and uses data files created with other spreadsheets and databases. But Quattro gives you a lot more—in fact, twice the speed and power of the old standard. For only half the price.

*60-Day Money-back Guarantee**

For the dealer nearest you call (800) 543-7543

"Quattro contains the most comprehensive presentation graphics capability available in a spreadsheet . . . The graphs Quattro can produce surpass even those available through add-on products like Lotus Graphwriter or Freelance Plus. If Borland wanted to, it could certainly sell the graphics portion of the spreadsheet on its own merit as a standalone graphics application.

Robert Alonzo, Personal Computing

Quattro's presentation-quality graphics output capabilities rival those that 1-2-3 can obtain only in conjunction with separate presentation graphics software . . . For me, at least, Quattro has certainly become the character-oriented spreadsheet program of choice.

William Zachmann, Computerworld

In the few years since Lotus Development Corp. introduced 1-2-3, many companies have attempted to unseat the king of the spreadsheet hill. The latest contender, Borland International Inc.'s Quattro, succeeds where other spreadsheet packages have failed . . . Quattro is at least two steps ahead of 1-2-3.

Ricardo Birmele, PCResource"

*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.

BORLAND INTERNATIONAL

Circle 52 on Reader Service Card (DEALERS: 53)

Gateway Merges Token Ring and Ethernet

If you have PCs on both token rings and Ethernets, Harris Corp. has the SuperNet Gateway to connect both types of local-area networks together while providing you with an instant upgrade path to the minicomputer and mainframe worlds.

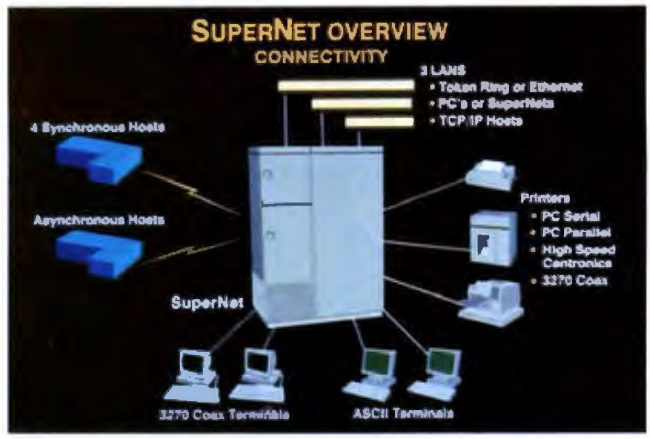
It allows you to hotkey from PC applications (through either your token ring or Ethernet) to other PC applications and in turn to mainframe applications, and vice versa, through the most standard protocols, like TCP/IP and SNA.

PCs, 3270 coaxial terminals, asynchronous terminals, it doesn't matter. IBM hosts, async hosts, Unix, MS-DOS. Same thing. A few of the issues Harris has addressed are terminal emulation, file transfer, and program-to-program communications.

In its base configuration, Model 20 is a 16-MHz, 80386-based server. Harris sells it stripped down with 4 megabytes of RAM; a 1.2-megabyte floppy disk drive; a 40-megabyte hard disk drive; a 150-megabyte tape drive; console; diagnostic modem; one 32-bit, four 16-bit, and two 8-bit slots; and a Unix license.

Model 30 is based on a 20-MHz 80386 microprocessor. It has 4 megabytes of RAM and comes standard with an 80-megabyte hard disk drive and four 32-bit, five 16-bit, and three 8-bit expansion slots.

Both models operate under Unix System V with "MS-DOS as a guest."
Price: Model 20, under $14,000; Model 30, $21,000.
Contact: Harris Corp., Data Communications Division, 16001 Dallas Pkwy., Dallas, TX 75248, (214) 386-2000.
Inquiry 764.



Harris links token rings, Ethernets, and more.

Ethernet Learns LocalTalk, and Vice Versa

FastPath 4 is designed to provide a gateway between Ethernet and Apple's LocalTalk, using either thin or standard coaxial cabling.

Compared to the previous Kinetics' Ethernet/LocalTalk gateway, memory for processing and buffers between the 10-megabit-per-second data-transfer rate and the 230-kilobit-per-second data-transfer rate has been beefed up to 256K bytes, upgradable to 512K.

Optional configuration and network-management software, called K-Star, can be loaded to FastPath 4 from any Macintosh on the network. Automatic address management is also provided with K-Star, allowing Internet Protocol (IP) addresses, which are necessary for communication with an Ethernet host speaking Transmission Control Protocol/Internet Protocol (TCP/IP).
Price: $2495.
Contact: Kinetics, Inc., 2540 Camino Diablo, Walnut Creek, CA 94596, (800) 433-4608; in California, (415) 947-0998.
Inquiry 852.

The GatorBox provides an Aperture File Protocol (AFP) to Network File System (NFS) protocol translation to a LocalTalk-to-Ethernet gateway, Cayman Systems claims.

This precludes the need to install any software on the AFP clients or the NFS servers. This functionality allows Macintoshes running Apple's AppleShare workstation software to always "see" NFS servers as AppleShare servers. NFS servers similarly see each Macintosh that uses the GatorBox as an ordinary NFS client.
Price: $3495.
Contact: Cayman Systems, Inc., University Park at MIT, 26 Lansdowne St., Cambridge, MA 02139, (617) 494-1999.
Inquiry 767.

Increase AppleTalk Beyond 230K bps

DaynaTalk, a connector box for Apple Macintoshes and IBM PC, XT, AT, PS/2s (Models 25 and 30), and compatibles, increases data rates beyond the 230,000 bps of LocalTalk.

Data rates depend on the bus structure, according to manufacturer Dayna Communications. That means that this connector box increases the data-transfer rate to 750K bps when coupled with a Mac Plus, 800K bps with the Mac SE, and 850K bps with the Mac II.

The AT bus allows the connector box to boost the data-transfer rate to 1.7 megabits per second. One connector box is required between each LocalTalk machine, or the data rate will default to 230K bps. Several network operating systems are supported, including AppleShare, NetWare, and TOPS.
Price: Macintosh version, $189; IBM version, $289.
Contact: Dayna Communications, Inc., 50 South Main St., Fifth Floor, Salt Lake City, UT 84144, (801) 531-0203.
Inquiry 766.

Token-Ring Device Adds to Number of PCs per Node

One Local Ring Hub from Madge Networks lets you add four PCs (equipped with token-ring cards) to the twisted-pair cabling between a token-ring multiple-access unit (MAU) and the PC on your desk.

Token-ring MAUs, which are generally placed in wiring closets up to 100 meters from the PCs, are standard equipment on a token-ring local-area network—the second most popular LAN.

Daisy chain up to two hubs off the first one and you can support a total of 10 PCs within that same 100 meters of cabling.
Price: $445.
Contact: Madge Networks, Inc., 534 Salem Ave. SW, Roanoke, VA 24016, (800) 876-2343; in Virginia, (703) 982-0638.
Inquiry 765.

continued

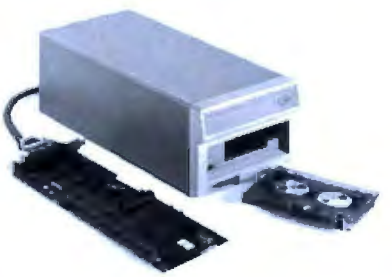
Lost Data Means Lost Opportunities

A child doesn't understand a hard disk crash. To her, lost data only means her mother won't be home until late.

At Everex, we know that lost data means more than just time and money. That's why we make a complete line of high quality tape backup products. We don't cut corners when the security of your data is at stake.

You don't get a second chance to recover what you've already lost.

Everex tape backup systems. Because little girls can't wait.



EVEREX

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1-800-821-0806
1-800-821-0807 in California
See Everex Products at Comdex
Las Vegas Hilton, Booth H8406
Circle 126 on Reader Service Card (DEALERS: 127)

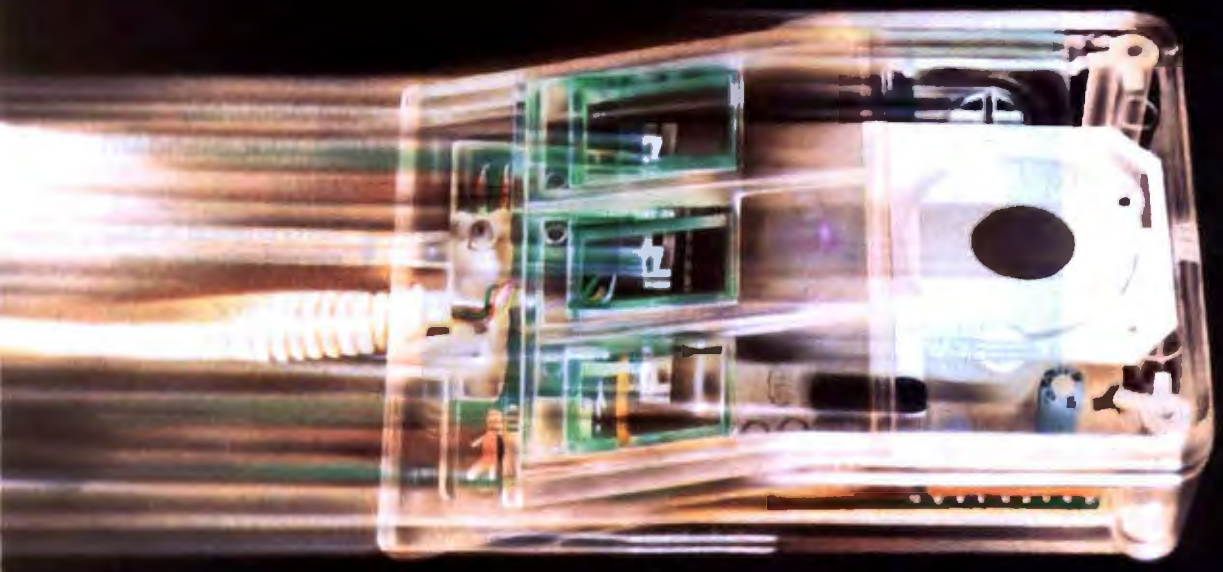
ClearCase™ Mouse—Special Edition From Logitech.

To celebrate the shipment of our two millionth mouse, we took the covers off our winning technology.

But this mouse is a lot more than just a pretty case. It's compatible with virtually all mouse-based programs, plus you can program it to "mousify" any keyboard-based application. And it doesn't need resetting when you switch programs.

High resolution, adjustable cursor control, and a programmable 9,600 baud rate let you move the cursor quickly and accurately, even on detailed graphics—perfect for applications

for Christmas.



like PaintShow™ which, it so happens, comes with your ClearCase Mouse.

You get everything for $149. The package includes: the Logitech ClearCase Mouse for IBM PC, XT, or AT and PS/2 or 100% compatibles; a 9-25 pin adapter; Plus Package™ software; and Logitech PaintShow™ (which requires a graphics card).

Pick up the ClearCase Mouse at your computer dealer, or call: ***800-231-7717.*** *(In California call* ***800-552-8885.****)*

LOGITECH
Personal Peripherals. Worldwide.

Circle 193 on Reader Service Card (DEALERS: 194)

Tablet Features Absolute Positioning

Kurta's intelligent graphics tablets, called IS/ADB input systems, plug directly into the Apple Desktop bus on the Mac II and SE (leaving serial ports free).

There are three features novel to this pointer/tablet combination (with corded pen and interface software). Each unit incorporates absolute positioning, macro commands, and keys to scale your work to fit the size of the screen or window you are using.

Absolute positioning means that every point on the tablet corresponds exactly to a point on the screen, whether you're using the 8½- by 11-inch, the 12- by 12-inch, or the 12- by 17-inch tablet. The tablet can also handle up to ½-inch-thick documents.

Along the top of the tablets are 23 programmable function keys, which can be loaded with macros such as "align, save, and print." Loading the keys with macros is a function of Apple's MacroMaker, which is designed so you don't have to pull down multiple menus every time you do a standard set of commands.

Of the five scale functions available, `Std` scales the tablet itself to an Apple-defined active screen, and `Win` scales the tablet to whatever window is active, for example.

Optional equipment includes cordless pens and corded or cordless four-button cursors, with buttons that can be programmed to execute command sequences just like the function keys.
Price: 8½- by 11-inch tablet, $395; 12- by 12-inch tablet, $595; 12- by 17-inch tablet, $965; to upgrade models purchased before August, $50. Free upgrade for models purchased in August and September.
Contact: Kurta Corp., 4610 South 35th St., Phoenix, AZ 85040, (602) 276-5533.
Inquiry 768.

Kurta's ergonomics breakthrough.

Bright Future for GW3

GW3 introduced a single board computer for industrial control problems. Motorola's 68020 and 68881 are the CPU and floating point-processor.

The SBC-20 includes 128K bytes to 2 megabytes of RAM, an EPROM socket, two asynchronous serial ports, and six interrupt levels.

Key features of the SBC-20 include the following: 32-bit data path to on-board RAM, 32-bit data path to on-board floating-point processor, and a real-time multitasking executive in EPROM that includes file management and multitasking BASIC.
Price: $764 to $1440.
Contact: GW3, Inc., 7623 Fullerton Rd., Springfield, VA 22153, (703) 451-2043.
Inquiry 771.

More Accurate Than Your Standard Rodents

Thanks to optical technology and software, nine speed settings and effective resolution of 2000 counts per inch are available through MSC Technologies' Microsoft-compatible PC Mouse II. Actual resolution is 200 counts per inch without the software.

It connects to your serial port through a 9-foot cable and includes an 11.8K-byte driver for your CONFIG.SYS file. It's compatible with the IBM PC, XT, AT, and compatibles and features an automatic install program, designer pop-up menus, and a menu compiler. Standard accessories include a mouse pad and PC Paint Plus graphics software.
Price: $149; $179 bundled with Autosketch.
Contact: MSC Technologies, Inc., 47505 Seabridge Dr., Fremont, CA 94538 (415) 656-1117.
Inquiry 769.

continued

Multiply Lab Instruments by One Macintosh

The MacAdios II Jr and MacInstruments software from GW Instruments lets your Mac II emulate oscilloscopes, scan-line recorders, chart recorders, and other types of common laboratory equipment.

This configuration gives the analog and digital I/O board the ability to record one channel at 25,000 samples per second while concurrently plotting to the screen.

The MacAdios II Jr plugs into one of the Mac II expansion slots. It is then ready to provide 16 analog input channels, 2 analog output channels, 8 digital input channels, 8 digital output channels, and three counter/timer channels.

Optional TurboDriver software is capable of digitizing waveforms at up to 833 kHz in the oscilloscope mode, 25 MHz in the chart recorder mode, 60 Hz in the scrolling strip chart recorder mode, and 16 kHz in the scan-line recorder mode.
Price: $890, not including software.
Contact: GW Instruments, Inc., 35 Medford St., Somerville, MA 02143, (617) 625-4096.
Inquiry 770.

SQL Top Gun School

$199

All the database Top Guns are flying SQL, the industry-standard data management language first delivered by Oracle. Why? Because one SQL statement replaces up to 20 lines of dBASE code. And because all the powerful multi-user and distributed databases use SQL — exclusively.

Now you can turn your PC into a SQL trainer that will make you a database top gun: Introducing SQL*Tutor from Oracle, only $199.

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Lost that Lovin' Feeling for dBASE?

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According to PC Week, Professional ORACLE is "the most versatile database management system available on the PC." It includes the ORACLE SQL database engine, utilities and Oracle's 4th-generation application development tools. Professional ORACLE is network-ready, and is the same ORACLE that runs on minis and mainframes. Use it as your standard PC workgroup database, and to provide connectivity to corporate data.

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1-800-ORACLE1, ext. 4909

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☐ $1295 for Professional ORACLE, which includes SQL*Tutor.

$_____ Please add appropriate sales tax.

$_____ **Total.** I understand Oracle pays shipping, and this offer is valid in the U.S. only.

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Finding It All On-Line

If you're the type of programmer who spends more time trying to find obscure entries in manuals (or trying to find the books themselves) than writing code, Microsoft has a new product that's designed to make your life easier and more productive. The Microsoft Programmer's Library (MPL) is a CD-ROM that gives you immediate online access to a comprehensive collection of books, technical manuals, and sample programs.

The MPL contains 48 books and technical manuals that are grouped into nine different categories: OS/2, Windows, MS-DOS, C, BASIC, Microsoft Macro Assembler, Pascal, FORTRAN, and hardware.

Each category has all the technical manuals for the languages and operating systems, as well as sample code organized into multiple files that are indexed and cross-referenced.

Also included are several books, including *Inside OS/2*, *Programming Windows*, *The MS-DOS Encyclopedia*, *Advanced MS-DOS*, *Proficient C*, and *Programmer's Guide To PC and PS/2 Video Systems*.

The MPL is memory-resident, and Microsoft says it's compatible with a wide range of text editors and word processors. You can instantly remove it from memory if you need maximum RAM space for large compiles. To use the MPL, you'll need an IBM PC, XT, AT, PS/2, or compatible with 640K bytes of RAM, a CD-ROM player, and MS-DOS 3.1 or higher. A hard disk drive is recommended.

Microsoft says a no-charge update will be available in early 1989 that will contain documentation for the OS/2 Presentation Manager and LAN Manager.

Price: $395.

Contact: Microsoft Corp., 16011 Northeast 36th Way, P.O. Box 97017, Redmond, WA 98073, (800) 426-9400; in Washington, (206) 882-8080.

Inquiry 772.

Microsoft crams 48 manuals onto a CD-ROM.

Spread a Little JAM on Your Application

JYACC says that JAM (JYACC Application Manager) is an application generator, application environment, prototyper, and (last but not least) a methodology that promotes parallel applications development. The bottom line is that if you're an applications developer, JAM lets you design and link together user-interface screens without having to do any programming.

You use JAM to create the screens, windows, and menus that make up an application and to specify the control flow among them. The result is a prototype, which the company calls an *applications shell*.

To make the prototype into a real working program, you write the transaction processing routines and link them with the applications shell. You can even have the applications shell call existing programs directly.

JAM includes full screen-painting facilities, including support for windows, menus, and color. The package is shipped with JYACC For-Maker, a context-sensitive screen and window manager. Versions of JAM are available for a wide range of systems from the PC all the way up to the VAX. They run under MS-DOS, Unix, VMS, and other operating systems.

Price: Starting at $750.

Contact: JYACC, Inc., 116 John St., New York, NY 10038, (800) 458-3313; in New York, (212) 267-7722.

Inquiry 774.

ROM Your C Programs

If you're a developer who wants to use C for developing embedded systems, the C86PLUS/ROM Development System is for you. It's a complete ROM development system for the Intel 80x86 family of processors.

The system includes the ANSI-standard C86PLUS/ROM C compiler, an Intel-compatible linker/locator, run-time library source code, and a ROM-image symbolic debugger. The package also supports math coprocessors for the Intel 80186/286/386.

The C86PLUS/ROM Development System runs under MS-DOS and lets you use both C and assembly language to produce programs for embedded systems.

Price: $1300; C compiler alone, $750.

Contact: Computer Innovations, Inc., 980 Shrewsbury Ave, Tinton Falls, NJ 07724, (201) 542-5920.

Inquiry 776.

continued

A Pop-up Programmer's Calculator

Another programmer's productivity tool comes from Texas-based Falk Data Systems. It's called PrgCalc, and it's a memory-resident programmer's calculator that works with binary, octal, decimal, and hexadecimal numbers while taking up about 50K bytes of RAM. It displays results in all four numeric formats simultaneously and supports all major bit-level manipulations, including shift-left and shift-right.

The package is shipped with PrgCalcm, a version of the calculator that you can run as a background task under DESQview or TaskView. You can also run PrgCalcm as a stand-alone program under MS-DOS.

PrgCalc requires an IBM PC, XT, AT, PS/2, or compatible and MS-DOS 2.0 or higher. It comes with a setup program and a student-oriented tutorial.

Price: $29.95.

Contact: Falk Data Systems, 5322 Rockwood Court, El Paso, TX 79932, (915) 584-7670.

Inquiry 773.

6 ways Genoa takes the gamble out of data backup.

It isn't the hardware or the software, it's the data that's the most valuable part of your personal computer. The hundreds of hours spent creating and editing data, plus its inherent value to your operation, make it priceless.

Protect that expensive data with a dependable backup system. Only Genoa's Galaxy family of tape backup systems offers 6 high-performance advantages in data protection.

1. On-Line

Galaxy software provides on-line network support. Galaxy and Galaxy/MC tape backup systems come with Genoa's Novell Advanced Netware 86 or 286 compatible software driver, a $200.00 value, *free!*

The SlimBox cassette is a space efficient way to provide tape backup for IBM PC/XT/ATs.

2. Fast

At 5MB a minute, Galaxy systems are among the fastest tape backups around. You can back up the whole data file in just a few minutes.

3. Easy

Simple command menus make Galaxy systems so easy to operate, most users can start backing up data within minutes.

4. Automatic

Never again will you worry about forgetting to back up data. Galaxy's autoscheduler feature lets you preset an exact date and time, then it *automatically* does the backup for you.

5. Reliable

Galaxy boasts one of the lowest return rates in the industry. Plus a full year warranty.

6. IBM Compatible

Galaxy works with all IBM PCs and compatibles, including the new Micro Channel. For the PC/XT/AT, there are external and internal models. Both are available in cassette and cartridge versions. We also offer a SlimBox model for the PC/XT/AT. It's an efficiently sized external cassette system.

The Galaxy Micro Channel family makes it possible to exchange data between IBM PC/XT/ATs and PS/2 models 50, 60 and 80.

For the Galaxy dealer nearest you, contact Genoa, 75 E. Trimble Rd., San Jose, CA 95131. Fax: (408) 434-0997. Telex: 172319. Phone: (408) 432-9090. Or fill out the coupon below, we'll send you more information. You've got nothing to lose—except the most valuable part of your personal computer.

Genoa SYSTEMS CORPORATION

Pictured are our internal and external cartridge backups for IBM PC/XT/ATs.

Come see us at COMDEX/FALL Booth #1078 in the LVCC

I want to protect my investment in data!

Please send me more information on Galaxy tape backup subsystems.

Name _____

Title _____

Company _____

Address _____

City _____ State _____ Zip _____

Phone (_____) _____ Ext. _____

Please check all that apply: ☐ PC ☐ XT ☐ AT
☐ PS/2, Model 50 ☐ PS/2, Model 60 ☐ PS/2, Model 80

Mail to: Geri Scheer, Genoa Systems Corporation, 75 E. Trimble Rd., San Jose, CA 95131

Circle 141 on Reader Service Card

Designs in the Real World

Though its name sounds like something out of a Saturday-morning children's television show, Mac Architrion is a serious product indeed. Running on the Mac Plus, SE, and II, it's a complete design, drafting, presentation, and quantity take-off package for architects and builders.

If you design buildings, Mac Architrion's purpose is to let you conceive and develop a project from start to finish. You can do design, delineation, and working drawings, and extract tables of data for costs.

Mac Architrion consists of three main modules: 3D, 2D, and a Quantifier. The 3D designer begins with each point in a plane existing as a perpendicular line. According to the company, this allows you to immediately create blocks of "real" space, rather than using wire diagrams.

The 2D drafting module allows for automatic and manual dimension strings and automatically linked multiple parallel lines. It has over 40 additional tools.

Finally, the Quantifier module gives you both a space-by-space breakdown and an overall breakdown of a project. You can then use the data in a word processor or a spreadsheet.

Price: $1499.
Contact: Gimeor, Inc., 1815 H St. NW, Washington, DC 20006, (202) 223-4373.
Inquiry 778.

Mac Architrion turns ideas into on-screen reality.

Simnon Explores the Nonlinear World

The company name ESC doesn't stand for "escape"; it stands for Engineering Software Concepts. And its latest product—Simnon/PC 2.11—is short for Simulation Language for Nonlinear Systems.

The package automatically compiles numerical solutions to differential and difference equations, producing 8086/8087 machine code.

Because the world we live in is essentially nonlinear, the company says that Simnon/PC is being used to study a wide range of subjects such as chaos, eye movement, and the control of pulp in paper-processing plants. It's also being used to design jet engines, perform research in robotic manipulators, study rockets and aircraft, and even track economic models.

ESC says version 2.11 of Simnon/PC is about twice as fast as version 1. It includes new functions and provides support for PostScript and HP LaserJet printers. To use Simnon/PC, you'll need an IBM PC, XT, AT, PS/2, or compatible with a math coprocessor and at least 256K bytes of RAM (640K bytes is recommended).
Price: $695.
Contact: Engineering Software Concepts, Inc., 436 Palo Alto Ave., Palo Alto, CA 94301, (415) 325-4321.
Inquiry 779.

Binary Upgrades Tech*Graph*Pad

It's the third time around for Tech*Graph*Pad, which its maker calls engineering data software. The package integrates data retrieval, data manipulation, and data output for scientists and engineers.

Tech*Graph*Pad 3.0 includes a number of new features. For instance, there's a worksheet browse mode that lets you bring up Lotus 1-2-3, Symphony, or Quattro spreadsheets for direct retrieval of data. Binary Engineering has also updated the package's user interface and added support for the HP LaserJet, PaintJet, DeskJet, and other HPGL-compatible devices.

Among the other new features of version 3.0 are that Tech*Graph*Pad now reads and plots unlimited data points per set and provides built-in error bars, superscripts, subscripts, and major/minor axis increments. The package also directly imports binary or two's complement data files generated by real-time data acquisition devices and creates .PIC graphics files.
Price: $395; upgrade from version 2.0, $99.
Contact: Binary Engineering, 100 Fifth Ave., Waltham, MA 02154, (617) 890-1812.
Inquiry 781.

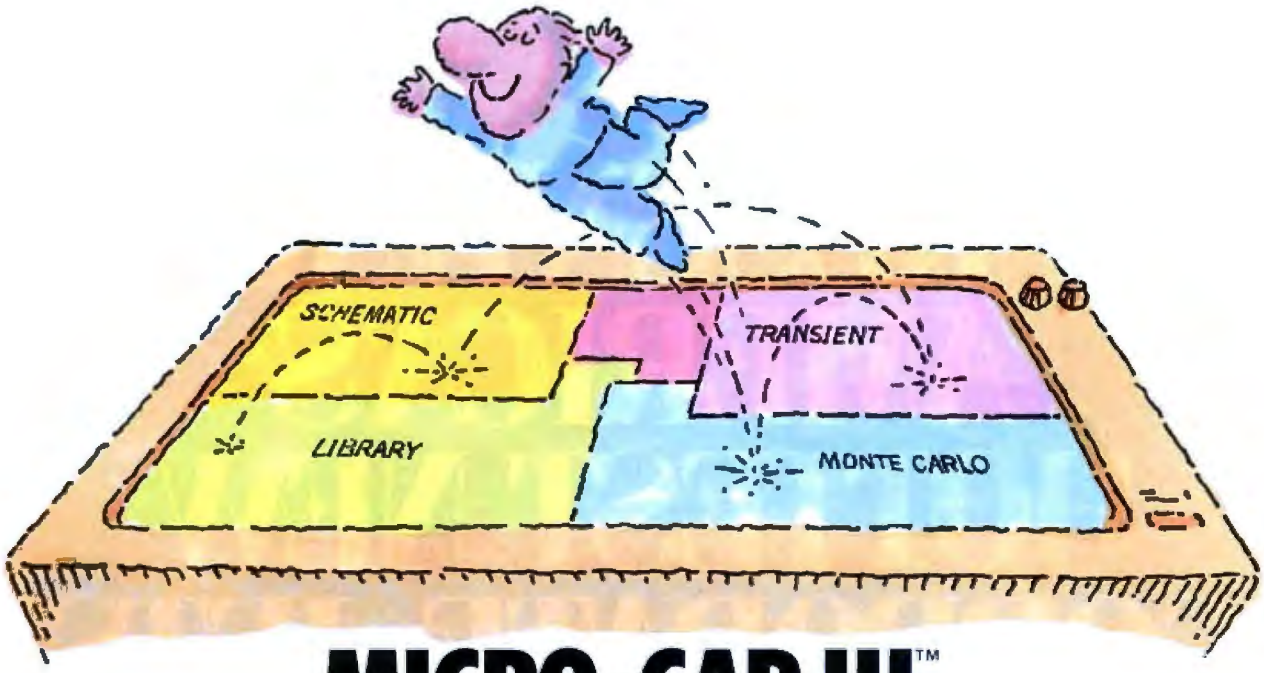
continued

MathCAD Adds Advanced Math

Those of you who use MathCAD and don't want to reinvent the wheel for solving specific computational problems might just find nirvana in MathSoft's recent release of the Advanced Math Applications Pack. The first in a series of planned applications, the Advanced Math package is a collection of mathematical models that you can load into MathCAD and immediately calculate and graphically display the results.

Packed into this first Applications Pack are software and documentation for 16 frequently performed computational tasks including differential equations, real and complex Eigenvalues and Eigenvectors, convolutions, polynomial least-square fit, digital filtering, conformal mapping, diffusion, the Laplace equation, and static equilibrium.

You can also customize any or all of the models for your specific requirements. In order to take advantage of all that the Advanced Math Applications Pack has to offer, you'll need a system running MathCAD 2.0.
Price: $40.
Contact: MathSoft, Inc., One Kendall Sq., Cambridge, MA 02139, (800) 628-4223; in Massachusetts, (617) 577-1017.
Inquiry 780.

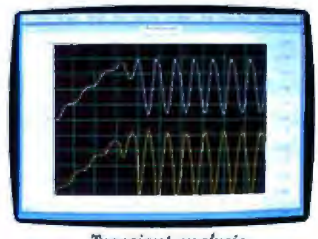


MICRO-CAP III.™
THIRD-GENERATION INTERACTIVE CIRCUIT ANALYSIS. MORE POWER. MORE SPEED. LESS WORK.

MICRO-CAP III,™ the third generation of the top selling IBM® PC-based interactive CAE tool, adds even more accuracy, speed, and simplicity to circuit design and simulation.

The program's window-based operation and schematic editor make circuit creation a breeze. And super-fast SPICE-like routines mean quick AC, DC, Fourier and transient analysis — right from schematics. You can combine simulations of digital and analog circuits via integrated switch models and macros. And, using stepped component values, rapidly generate multiple plots to fine-tune your circuits.

We've added routines for noise, impedance and conductance — even Monte Carlo routines for statistical analysis of production yield. Plus algebraic formula parsers for plotting almost any desired function.



Transient analysis

Schematic editor

Monte Carlo analysis

Modeling power leaps upward as well, to Gummel-Poon BJT and Level 3 MOS — supported, of course, by a built-in Parameter Estimation Program and extended standard parts library.

There's support for Hercules,® CGA, MCGA, EGA and VGA displays. Output for laser plotters and printers. And a lot more.

The cost? Just $1495. Evaluation versions are only $150.

Naturally, you'll want to call or write for a free brochure and demo disk.

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FIVESTAR'S fleet of powerful business computers have really taken off in the last three years. That's because they're built for corporations that want to get where they're going in a hurry.

We build a full line of high-powered performers that not only provide *total* PC compatibility and advanced business capabilities, but also offer American-made ingenuity, quality and value.

In fact, when you *really* compare, you'll find that FIVESTAR Computers leave the competition far behind.

FIVESTAR 286's.
The performance to fly through heavy workloads.

FIVESTAR 286's provide the features and performance aggressive companies need to reach higher corporate goals. In fact, they're designed to run future as well as current operating systems.

The 286/10 is powered by an Intel 80286 microprocessor that operates at a fast 10 MHz, with zero wait states. With 640KB memory and 1.2MB floppy disk drive, you'll soar through today's popular business applications. Serial, parallel and game ports, and an enhanced 101-key keyboard, provide in-flight convenience.

The 286/14 is also powered by an Intel 80286 CPU, but operates at 14 MHz (with zero wait states) for even faster performance. It, too, comes equipped with 1024KB memory, 1.2MB floppy disk drive, serial/parallel/game ports and a 101-key keyboard. No doubt about it — it's a hot machine and a dream to fly!

FIVESTAR 386's.
Don't forget to fasten your seat belt.

The incredible speed and power of FIVESTAR 386's have made them a leading choice of corporations across America for multitasking and sophisticated applications, including CAD. In fact, there's so much performance and value built into our 386's, it can take your breath away.

The 386/16 is fast. Very fast. That's because it features an Intel 80386 CPU operating at 16 MHz, with zero wait states. And its 1024KB memory and 1.2MB floppy disk drive will keep you airborne for long distances. Serial/parallel/game ports and a smooth performing 101-key keyboard are standard equipment.

Prices:
The 286/10 – from $1099.
The 286/14 – from $1499.

The 386/20. It's made for those who want to fly to the outer limits. With an Intel 80386 microprocessor operating at 20 MHz (with zero wait states) it'll move through the most complex applications with astounding ease. And you won't have to worry about running low on memory either. It not only features 1024KB of RAM and a 1.2MB floppy disk drive, it also has a 64KB cache memory. Naturally, it comes equipped with serial/parallel/game ports and a 101-key keyboard, too.

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All FIVESTAR 286 and 386 Computers are available with hard drives, from 20 to 320 MB, as well as a choice of monochrome, EGA, VGA or super-high resolution paper-white monitors. Whatever the requirement, FIVESTAR can meet it.

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The 386/20 – from $2999.

Unmatched reliability. Unbeatable ground support.

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Circle 129 on Reader Service Card

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Evolution Comes to Accounting

State of the Art calls the latest incarnation of its Master Accounting Series M·A·S 90 Evolution/2. With that imposing moniker, the company claims it's designed to take full advantage of 80286- and 80386-based computers as well as multiuser operating systems.

Evolution/2 has over 100 new features, including an integrated menu system with pull-down windows for instant navigation through the various accounting applications. The program also has high-level password security.

Modules available in the M·A·S 90 Evolution/2 series include general ledger, accounts receivable, accounts payable, payroll, inventory management, sales order processing, purchase order processing, and job cost.

Price: $195 to $995 per module.

Contact: State of the Art, Inc., 3545 Howard Way, Costa Mesa, CA 92626, (714) 850-0111.

Inquiry 787.

Evolution/2 takes accounting software a step forward.

Project Management Takes to the Skyline

Most project management packages do only one thing: schedule projects. But Applitech Software has taken the process several steps further by combining project planning, outline processing, scheduling, and graphics into an integrated package.

The package is called Skyline, and although it runs on the IBM PC and compatibles, the company has included a Macintosh-like graphical interface. Despite all its features, Skyline is still designed primarily for project planning.

Skyline also offers PERT charts, importing and exporting of generic subprojects, a variety of scheduling features, and Gantt charts. Besides a PC, you'll need a color or monochrome graphics adapter and at least 640K bytes of RAM.

Price: $295.

Contact: Applitech Software, Inc., 381 Harvard St., Cambridge, MA 02138, (617) 497-8268.

Inquiry 784.

Financial Planning for Business Owners

No, Ronstadt's Financials isn't a program for handling the cash flow of a famous singer. Lord Publishing says it's designed to help all you business owners take control of financial decision making. According to the company, it answers five "critical questions of entrepreneurial finance," namely: How much money does your business need? When does it need the money? What type of money (debt or equity) is needed? Where should you get the money? What value does this money have to you in terms of equity sold?

Ronstadt's Financials offers built-in accounting and financial expertise for a variety of specific industries, including real estate, retail, manufacturing, professional services, wholesale distribution, and contract services. These features tailor the program to your specific business.

The program also has knowledge bases with built-in formulas. You input figures only once and Ronstadt's Financials produces detailed budgets, break-evens, profitability measures, projected cash flows, income statements, balance sheets, and worst-case/best-case scenarios.

The program works with the IBM PC, XT, AT, PS/2s, and compatibles and requires 640K bytes of RAM and a hard disk drive. A color monitor is recommended. Also included is the book *Entrepreneurial Finance: Taking Control of Your Financial Decision Making*.

Price: $499.

Contact: Lord Publishing, Inc., One Apple Hill, Natick, MA 01760, (617) 651-9955.

Inquiry 788.

A Duo for Manipulating Mail

Whether you handle small mailings for a local users group or five-figure mailings for a corporation, Phoenix Phive's aptly named Mail is a low-cost package designed to add some organization to your organization.

Mail is a general-purpose address manager that handles up to 30,000 names that the fleet-fingered can enter directly or import from ASCII or dBASE files. The package also exports its data in ASCII format.

Price: $45.

Contact: Phoenix Phive Software Corp., 7830 East Gelding Dr., Suite 400, Scottsdale, AZ 85260, (602) 483-0991.

Inquiry 785.

And while we're on the subject of mailings, Paul Mace Software has brought its venerable NVelope program to the world of the Mac.

NVelope, which had been previously available in an MS-DOS version, is designed for those of us who have to abandon the computer and ferret out a typewriter every time we want to address an envelope.

NVelope is a desk accessory that uses the Mac's familiar graphical interface to grab addresses from a word processing document or its own address list. It can even add a return address or (if necessary) look up the ZIP code. NVelope works with all versions of the Mac.

Price: One 800K-byte disk, $69; two 400K-byte disks, $74.

Contact: Paul Mace Software, 400 Williamson Way, Ashland, OR 97520, (503) 488-2322.

Inquiry 786.

continued

"TOPSPEED EARNS A STANDING OVATION!"

—Kent Porter, Dr. Dobbs Journal

See us at COMDEX
Cashman A348

"...TopSpeed is surely one of the finest new products introduced to date in the PC arena...DDJ doesn't give unqualified raves very often, but there's no question about it in this case; JPI's TopSpeed Modula-2 is first-rate."

Kent Porter
Dr. Dobbs Journal

"JPI Modula-2 looks like another classic in the making. It generates code as good as or better than leading C compilers and the programming environment is a genuine pleasure to use."

Dick Pountain
BYTE Magazine

"I liked all of the hard-disk space that was recovered after I deleted my BORLAND, MICROSOFT, and LOGITECH compilers, because with TopSpeed Modula-2 all the rest are obsolete."

Robert D. Randall
Donnelley Marketing

In England and Europe contact:
Jensen & Partners UK Ltd., 63 Clerkenwell Road, London EC1M 5NP Phone (01)253-4333 Compiler Kit £59.95, TechKit £34.95, VID £34.95, 3-Pack £109.95
Handling charges:
In UK, add £2 for each product ordered. VAT will be added on software. In Europe, add £4 for up to 3 products, £2 for each add'l product.

Circle 173 on Reader Service Card

The successor of Pascal: JPI TopSpeed™ Modula-2 produces better code than Microsoft C, Turbo C, Logitech Modula-2 and Turbo Pascal 4.0.

Introducing VID: The easy-to-use, source-level debugger. Single-step and trace through source in multiple modules. Examine and modify all variables in symbolic form, including arrays, records, enumerated types and pointers. Point and shoot breakpoints including "One-shot," "Sticky," "Delayed," and "Monitor." Watch both variables and Modula-2 expressions during execution. Automatic variable trace of all variables accessed, and assembler, registers and procedure call-stack trace windows. Package includes symbolic disassembler and execution profiler. 72-page manual.

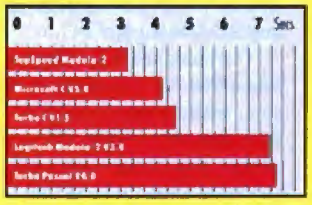
The Compiler Kit includes: High-speed optimizing compiler (3,000-5,000 lines/min. on a PC AT 8MHz), integrated menu-driven environment with multi-window/multi-file editor, automatic *make*, fast smart linker. All Modula-2 sources to libraries included. BONUS: Complete high-speed window management module included with source. 258-page User's Manual and 190-page Language Tutorial.

The TechKit™ includes: Assembler source for start-up code and run-time library, JPI TopSpeed Assembler (30,000 lines/min.), TSR module, communications driver, PROM locator, dynamic overlays, and technical information. 72-page manual.

System Requirements: IBM PC or compatible, 384K available RAM, two floppy drives (hard disk recommended).

See our OS/2 version at COMDEX.

VID (Visual Interactive Debugger): power without complexity.



Sieve benchmark measured by the British Standards Institution (BSI)—25 iterations on an 8MHz AT.

Compiler Kit $99.95
TechKit $59.95
VID $59.95

3-Pack $179.95
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Emulate the VT-240 on Your EGA

If you need to connect your PC to your corporate computer, chances are you'll need to emulate a DEC VT-240 terminal to get the most out of the connection. Poly-Star can give you full VT-240 or VT-241 emulation on any EGA-equipped PC.

The standard VT-240 provides 800- by 240-pixel resolution, while a standard EGA provides only 640 by 350 pixels. But Polygon says it's invented a way to coax the EGA into giving 800- by 350-pixel resolution, giving you a full graphics image or a 132-column display. Poly-Star also includes a utility for remapping a standard keyboard. You can map multiple characters onto a single key, making it a custom function key. You can also use the program with DEC's LK250 keyboard, as well as remap the LK250 for regular PC use.
Price: $299; EGA option, $29.
Contact: Polygon, Inc., 1024 Executive Pkwy., St. Louis, MO 63141, (314) 576-7709.
Inquiry 792.

A VT-240 screen, and Poly-Star's EGA emulation of the VT-240.

WordPerfect Makes the Network

If you're a confirmed WordPerfect 5.0 user and have a PC-based network, you can bring the two together with a network version of WordPerfect 5.0, now available from the Utah-based word processing mavens.

The network version of WordPerfect 5.0 runs on the 3Com 3+ network, 10Net, AT&T StarLAN, Banyan, IBM Networks, Novell NetWare (versions 4.6 and higher) or Advanced NetWare, TOPS, Torus Tapestry, Western Digital ViaNet, and most other network systems that support DOS file locking. For European users, it also runs on NOKIA PC-Net.

Each networking workstation using WordPerfect 5.0 requires 384K bytes of RAM and MS-DOS 2.0 or higher. If you want to use the document-locking feature, you'll need MS-DOS 3.0 or higher.
Price: File server fee, $695; each additional workstation, $150; update from non-network version, $120.
Contact: WordPerfect Corp., 288 West Center St., Orem, UT 84057, (801) 225-5000.
Inquiry 790.

Mail-Server Links Remote Locations

Mail-Server is a software package that combines communications functions with electronic mail features. It's a memory-resident program that runs in the background and offers remote-access capabilities. The package is fully automatic. You can send or receive messages or attached files from any attended or unattended IBM PC or compatible, 24 hours a day.

Mail-Server has a autoscript capability that lets you record file-transfer procedures. Then you can automatically send files at daily, prescheduled times. When you place a Mail-Server call, a window pops up on the receiving system, on top of the running application.

The Mail-Server distribution list can send E-mail to multiple mailboxes and up to 100 locations. You can also attach any number of files to a message. Other Mail-Server features include a built-in text editor and a terminal-emulation utility that emulates most asynchronous terminals. The package uses its own file-transfer protocol.

To use Mail-Server, you'll need an IBM PC, XT, AT, PS/2, or compatible and at least 384K bytes of free RAM.
Price: $195 per station.
Contact: 3X USA, One Executive Dr., Fort Lee, NJ 07024, (800) 327-9712; in New Jersey, (201) 592-6874.
Inquiry 791.

Communicate via OS/2

LogiCOMM is a general-purpose communications package designed to take advantage of OS/2's multitasking capabilities, allowing you to perform background communications and file transfers.

With the package, you can do both foreground and background data transfers with XMODEM, XMODEM 1K, YMODEM batch, YMODEM G, CompuServe Quick B, and ASCII upload/download protocols.

LogiCOMM requires an 80286- or 80386-based computer running OS/2 and supports both Hayes-compatible and other modems.
Price: $30.
Contact: Logistique LMM, 1550 Barre St., St. Laurent, PQ, Canada H4L 4M6, (514) 748-9192.
Inquiry 793.

continued

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Choose between high contrast or high detail. Import images into any best selling publishing application—PageMaker,™ Ventura™ and many more. All you need is $299, an IBM PC, XT, AT or PS/2 (or compatible) with a spare slot, and five minutes to set up.

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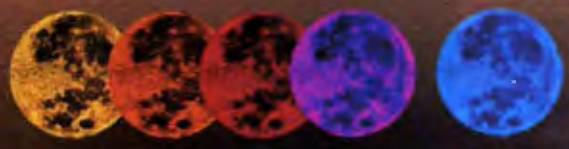

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Circle 195 on Reader Service Card (DEALERS: 196)

Professional Graphics Meet the Mac

The venerable Apple Macintosh—helped along by an enthusiastic coterie of third-party developers—is butting its way into more and more "professional" applications.

Case in point: The Avalon Development Group has unveiled a product for professional graphics designers called PhotoMac. It's an integrated graphics prepress application that lets you manipulate the Mac II's 24-bit color images, enhance them, and combine them with text from any of the popular page-layout programs to produce color publications.

PhotoMac lets you redesign, retouch, and color-correct images. You can then print color proofs, generate four-color separations, or combine images with text. The company claims you need only 2 megabytes of RAM to handle full-color full-page graphics. Using conventional techniques, you'd need about 25 megabytes of RAM.

Price: $695.
Contact: Data Translation, Inc., 100 Locke Dr., Marlborough, MA 01752, (800) 522-0265.
Inquiry 798.

PhotoMac lets you manipulate digitized photos.

Coming Soon to the Graphics Screen

Are you often the victim of one of life's greatest disappointments—namely, laser printer output that doesn't look anything at all like you thought it would? A company named Data Perceptions has a simple answer to the problem. The company's Laser Preview is a memory-resident printer utility program that redirects printer output to a full-page on-screen preview. So what you end up with is a true WYSIWYG screen image of the laser printer output.

Laser Preview can display the document page image faster than the printer, allowing you to check the page format and text before committing it to the printer.

The program takes up about 64K bytes of RAM and works with the IBM PC, XT, AT, PS/2s, or compatibles. You'll also need a CGA, EGA, VGA, Hercules, or compatible graphics card and monitor.

Price: $69.95.
Contact: Data Perceptions Corp., 9842 Hibert St., Suite 137, San Diego, CA 92131, (619) 455-9500.
Inquiry 796.

Speaking of printers, if you own a Hewlett-Packard DeskJet ink-jet printer and feel more than a little constrained by its limited selection of low-cost fonts, there's SoftFontWare's LaserJet-to-DeskJet font conversion package.

As its name implies, the package will happily convert any soft font designed for the LaserJet to work on the DeskJet. There are hundreds of widely available public domain and shareware fonts available from bulletin boards.

Besides the actual conversion program, the disk you'll receive also contains a program that corrects common errors found in public domain LaserJet soft fonts, a program to print character-width tables for any DeskJet soft font, and a program to display magnified DeskJet font characters on any EGA display.

Price: $42.
Contact: S.H. Moody & Associates, Inc., SoftFontWare, 1810 Fair Oaks Ave., South Pasadena, CA 91030, (818) 441-2260.
Inquiry 797.

Take My Computer . . . Please

On the lighter side, Responsive Software of California says it's bringing high technology to the (kind of) serious business of creating jokes. But seriously, folks, the Humor Processor is designed for speech writers, columnists, executives, or anyone who needs to say something funny.

The company says the Humor Processor is more than just a database of jokes. You can choose a joke formula, type in the joke's setup, and then enter the program's brainstorming mode to come up with joke ideas.

It runs on any IBM PC or compatible, with or without a rodent, and it needs 320K bytes of RAM.

Price: $49.95.
Contact: Responsive Software, 1901 Tunnel Rd., Berkeley, CA 94705, (415) 843-1034.
Inquiry 802.

Let's Think About It

A company called Transpower says that its program—called Expert Thinker—is the first expert system designed to bring logical-reasoning capabilities to microcomputers. Expert Thinker is a theorem prover that doesn't use old standard heuristic algorithms to find solutions.

The program is written in Prolog, but unlike Prolog, it features true negation, non-Horn clauses, occurs check, staged depth-first search, and Meson reduction and extension operations. According to the company, Expert Thinker is designed for logicians, mathematicians, scientists, engineers, artificial-intelligence gurus, philosophers, college professors and students, and even puzzle lovers.

You can add logical reasoning powers to your IBM PC, XT, AT, PS/2, or compatible. You'll also need 640K bytes of RAM. Expert Thinker comes with a 30-day money-back guarantee.

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Contact: Transpower Corp., 1 Oak Dr., Parkerford, PA 19457, (215) 495-6362.
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Send Us Your Local News

BYTE is expanding its coverage of local events in the Pacific-West Coast region. If you would like your event, conference, special project, or users group covered, please send information to: Regional Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

The Berkeley Mac Users Group

Like other supergroups, the Berkeley Macintosh Users Group (BMUG) has its special-interest groups, tutorials, bulletin board systems (BBSes), and help hotline, but the one thing that really stands out is the *BMUG Newsletter*. It's published only semiannually, and no wonder—the Fall 1988 issue is over 350 pages long.

BMUG staffers who claim the newsletter (most textbooks are thinner) is the definitive reference guide for Mac users may be hard-pressed to find a challenger to the claim. In the newsletter, you'll find product reviews, BBS tutorials, articles on telecommunications, HyperCard, connectivity, and networking, and plenty of commentary on the state of the Apple. BMUG also published a HyperCard guide that's over 200 pages long. All without any advertising.

BMUG's BBS is open 22 hours a day (the other two are spent exchanging mail with other systems). You can reach it at (415) 849-2684, but nonmembers are granted limited access only. It supports 300, 1200, and 2400 bits per second. The group also welcomes out-of-towners to drop in at its office at 2150 Kittredge St., Suite 3B.
Contact: The Berkeley Macintosh Users Group, 1442A Walnut St., #62, Berkeley, CA 94709, (415) 549-2684 or (415) 849-9114.

Seminar Trifecta

The dBASE Symposium is a 3-day seminar that features Adam Green, author of several books and articles on the database, as its chairman. The seminar will discuss the impact of dBASE IV on the status quo of dBASE-compatible products, when the new version appears. Also on the agenda is the structured query language included with dBASE IV.

Vendors of the following dBASE-compatible products will conduct sessions at the seminar: FoxBASE, Quicksilver, MultiBase, Frontrunner, Eagle, Force III, and dBXL.

David Fulton, president of Fox Software, is slated as a panelist, along with Dave Irwin, president of Irwin Ink; author, Wayne C. Ratliff; Pat Adams, president of DB Unlimited; and others.

The seminar will be held from November 2 to 4 at the Warner Center Marriot in Los Angeles.
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OS/2: Inside and Out is a 2-day seminar that, according to its sponsor, will feature live demonstrations of the operating system's multiprocessing session management, command capabilities, and multiple, simultaneous program execution.

The first day is dedicated to the fundamentals of OS/2. The second day is for advanced techniques.

Judd Robbins, president of Computer Options and author of *The Essential OS/2*, will be the seminar's chairman. The seminar will be held at the San Francisco Airport Marriot from November 17 to 18.

Price: $765.
Contact: Digital Consulting, Inc., 6 Windsor St., Andover, MA 01810, (508) 470-3880.

A seminar for programming in C is an introductory course for those who wish to program in Unix and non-Unix applications. The seminar will cover the components and characteristics of C, words of the C language, expressions, control statements, and more. Knowledge of at least one other high-level programming language is a prerequisite.

The 5-day seminar is scheduled to go from December 12 to 16 in Los Angeles.
Price: $975.
Contact: The 1st Seminar Service, 88 Middle St., Lowell, MA 01852, (508) 452-0766 or (800) 321-1990.

Network to Sponsor Third-Party Tours

The ApplAmbassadors Information Network (AAIN) is now sponsoring what its founder calls a "traveling road show" for representatives and spokespersons of third-party products for the Macintosh. According to AAIN's George Voltz, users group coordinators are always seeking vendor representatives to speak at the groups' monthly meetings, but getting in contact with them is difficult. After several third-party developers expressed a similar interest in making contact with users groups, he started a service that provides transportation and lodging for vendor representatives who want to meet with users groups.

AAIN will provide vendors contact information, transportation, and lodging for a fee. The users groups get knowledgeable speakers for their monthly meetings at no cost, and the vendors get to demo products to sophisticated audiences.

The "tours" would probably consist of five users group meetings, either in the same region or across the country. Voltz said AAIN was formed in January 1988. The network sends new product announcements and information on bugs, fixes, and updates to about 1000 Mac users groups.
Contact: ApplAmbassadors Information Network, P.O. Box 416, Mountain Rd., Raymond, NH 03077, (603) 895-3009.

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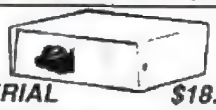

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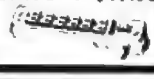

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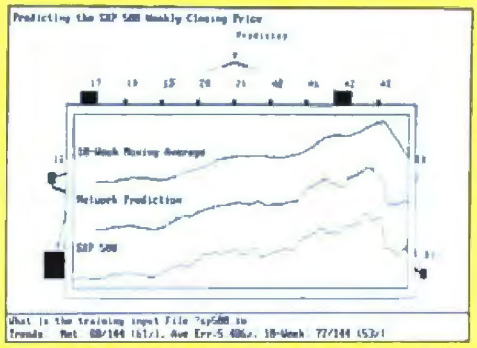

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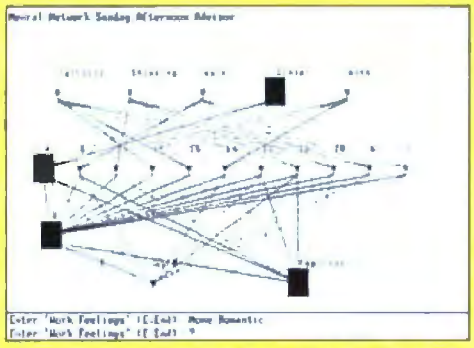

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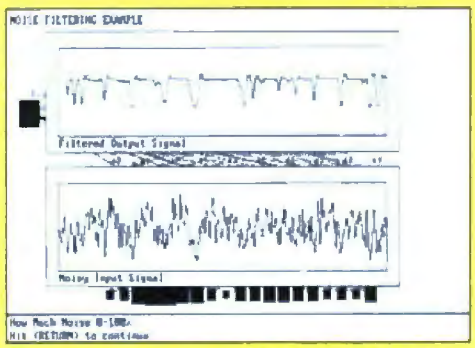

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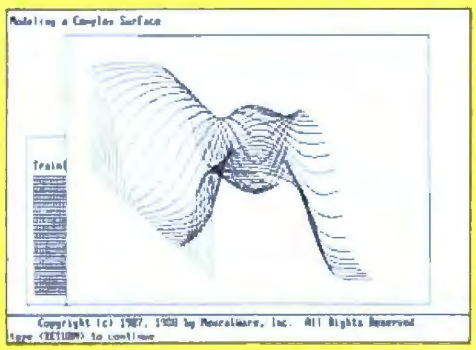

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SHORT TAKES

BYTE editors offer hands-on views of new products

NEC's Incredible Shrinking Computer

I just knew that the computer industry's quest for size reduction had to hit some limit. A display can get only so small before the characters become unreadable. Likewise, a keyboard can shrink only so far before it becomes unusable. Thus, NEC concentrated on collapsing the only remaining dimension: The **NEC Ultralite** is about as thin a computer as I've seen. With its cover closed, the Ultralite measures 8½ by 11¾ by 1⅗ inches. And at 4.4 pounds with batteries, it's one of the lightest.

The Ultralite (in above photo at right) comes standard with 640K bytes of RAM, a 1- or 2-megabyte "silicon drive" (NEC's term for a nonvolatile RAM disk), an internal ROM disk with DOS 3.3 (from which you boot the machine), and a "card drive." That's right, a card drive: a narrow slot on the right side of the machine that accepts ROM cards—measuring 3⅜ by 2⅛ inches and about ⅛ inch thick—each capable of holding between 512K bytes and 1 megabyte. The liquid crystal display is backlit (electroluminescent), so you don't have to find elusive perfect lighting.

Of course, NEC told us that it anticipates numerous applications to be converted to the ROM-card format. (The unit we received came with two ROM cards, one holding Traveling Software's LapLink, the other Microsoft Word.) The machine will also come with Microsoft's DOS Manager—a kind of window-based shell for user-friendly file management—and LapLink, the premier utility for moving files from machine to machine through serial ports.

Across the back, you'll find a 9-pin DIN-style connector for the RS-232C port, two modular phone jacks for the internal Hayes-compatible 2400-bit-per-second modem, a 7-pin DIN connector for the external power pack, and a bizarre multipin connector (it looks like a miniature Eurocard connector) for an external 3½-inch floppy disk drive (optional).

The model I reviewed was an engineering version—and how. The internal RAM drive would not work, and I couldn't get the ROM cards to behave long enough to execute any programs from them. I did manage to attach the external drive and run from the floppy there. The external drive connector carries power as well as signals, so the drive itself doesn't need a power cable or an AC adapter. The screen suffered from more ghosting (the partial activation of pixels along the same horizontal or vertical coordinate as an intense graphic) than I would have expected, though I could usually reduce the effect with the contrast slider.

I ran BYTE's low-level CPU benchmarks to get a feel for the Ultralite's performance. Though the machine is using an NEC V-30 processor (8086-compatible) running at 9.54 MHz—only twice the speed of a standard 4.77-MHz IBM PC XT—there's more going on than just a hike in the clock speed, because the Ultralite executed the benchmarks an average of 4.2 times faster than the XT. (This agrees well with the Norton SI, which awards the Ultralite a rating of 4.5.)

On the user-friendliness scale, I'll give the Ultralite high marks for portability. An MS-DOS machine with no-moving-part drives and a backlit display with dimensions as svelte as the Ultralite's is every mobile computer user's dream. But an Ultralite with a 1-megabyte silicon drive is $2999, and a 2-megabyte version runs $3699. When $700 can get me a Toshiba laptop with an 80-column display (with no backlighting, true) and a 720K-byte floppy disk drive . . . hey, to save $2300, I'll find a lamp and live with the disks.

—Rick Grehan

THE FACTS

NEC Ultralite
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Inquiry 852.

Computer Shuttlecraft

The **NEC ProSpeed 386** (in above photo at left) is a pseudoportable; it's designed to give you a home base to which you regularly return the machine. NEC calls this home

continued

base the "docking station," and I'll describe it in detail later. Not that you couldn't operate the ProSpeed 386 indefinitely without the docking station; it would make a fine portable 80386 machine all by itself.

Let me rattle off the stats: a switchable 8-MHz/16-MHz 80386; support for an 80387 math coprocessor; 2 megabytes of 32-bit 100-nanosecond memory (standard), expandable in two upgrade paths to a maximum of either 4 or 10 megabytes; a cold cathode fluorescent technology (CCFT) backlit display (11 inches diagonal) that supports EGA, double-scan CGA, or Hercules; an internal 1.44-megabyte 3½-inch floppy disk drive; and your choice of a 40- or 100-megabyte internal hard disk drive. This all fits in an 18-pound case that measures 15⅓ by 4 by 13⅗ inches.

If the CCFT display doesn't float your boat, you can pop it off, hook your favorite PS/2 color or monochrome display to a connector in the back, and run VGA graphics (the ProSpeed will also accept a multisync monitor). And if there are *still* not enough options onboard, you can slide an internal 2400-bit-per-second modem into the special modem slot and one of the hoped-to-be-released expansion boards into the LTX slot, an "IBM PC AT-like" (though not AT-compatible) connector that you access through a snap-off door on the right of the machine. (At the time of this writing, NEC said that three cards for the LTX slot were already under development: an Ethernet card, a Token Ring card, and a 3270 interface card.)

Of course, ProSpeed provides the standard I/O ports: an RS-232C serial connector (9-pin AT-style) and a PC-standard 25-pin parallel printer port, both in the rear, of course. Around back, you'll also find a connector for NEC's "battery slice," a 3-pound add-on battery pack that hooks to the rear of the machine for 2 to 3 hours of operation away from a wall outlet. (Unfortunately, there was no battery slice available for the system I tested.)

The back is also home to the 120-pin connector that hooks the machine to the docking station I mentioned earlier. The docking station, which is slightly bigger than a big shoebox, comes with accommodations for three full-size 16-bit (AT) expansion cards, one full-size 8-bit expansion card, and two half-height drive bays that you can populate with your choice of floppy disk drives, hard disk drives, tape drives, and so on.

The docking station also extends the ProSpeed's I/O ports—parallel printer, serial, VGA, and RJ-11—to its own rear and adds a second serial port, another RJ-11 connector, and a keyboard port for an external keyboard. Inside the docking station is a 200-watt power supply that runs not only the components within the station, but the docked ProSpeed as well.

The docking station is a no-muss-no-fuss expansion bay. You sit at your desk, ProSpeed mated with its docking station, using piles of megabytes, an eye-pampering VGA display, and all the special-purpose adapter boards you can stand. Then, when it's time to hit the road, simply detach the ProSpeed, reattach the CCFT display, grab a cable or the battery slice, and drive off into the sunset. When you return, just hook the ProSpeed back to the station; you don't have to worry about reattaching a nest of power cables, video cables, and is-this-a-serial-or-parallel-printer?-cables.

In preliminary tests using BYTE's 80386 Small-C benchmarks, the ProSpeed actually scored marginally poorer than a 16-MHz PS/2 Model 80 on the CPU tests. On average, the ProSpeed ran at about 85 percent of the speed of the Model 80. Also, though the low-level hard disk drive test showed the ProSpeed's

continued

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Imagine creating a complicated spreadsheet. Then while a macro is being run, open up a word processor. Type a document, open and work with a graphics program. Cut and paste between programs and even call up electronic mail. And still be able to check on the status of your spreadsheet at any time.

Considering all you can do with Microsoft Windows, you have only one question to ask yourself.

What have you been doing without it?

Microsoft®

Corporation; dBASE III PLUS by Ashton-Tate Corporation; Network Courier by Consumers Software, Incorporated; Micrografx by Micrografx, Incorporated; PackRat by Polaris Software; and CFO Advisor by Financial Feasibilities, Incorporated. PackRat is a trademark of Polaris Software. CFO Advisor is a trademark of Financial Feasibilities, Incorporated.

hard disk drive to be slightly faster than the Model 80's, the File I/O, 1-megabyte File Read, and 1-megabyte File Write benchmarks all turned in marginally poorer figures than the Model 80's (the NEC ran at about 90 percent of the Model 80's speed).

At a price of $7699, the NEC ProSpeed costs more than a Toshiba T5100, but it offers the added capabilities of VGA graphics and a larger internal hard disk drive. On the downside, the ProSpeed weighs 3 pounds more than the Toshiba, and its 80386 isn't as zippy (at the same speed as the Toshiba).

Whether or not the concept of the docking station will catch on remains to be seen. I wonder how many people actually need the kind of arrangement the ProSpeed offers. Perhaps for some computer users, the cost of an 80386-based system is still too high to permit purchasing two complete systems, a home base and a portable. But how many people must have an 80386 in their portable? Most folks I know survive with an 80286 or even an 8088 in their laptops and save the big bucks for a PS/2-style tower on the floor next to their desks. But if you have to take your 80386 with you and like the idea of expanding it at home, the ProSpeed may be your machine.

—Rick Grehan

A Promotion for Commander Norton

That puzzling `C:` prompt that stares you in the face every time you start up your MS-DOS system has sparked a bevy of companies to develop so-called DOS shells that supposedly make DOS easier to use. Over the years, I've tried and rejected most of them. With few exceptions, these shells shoehorn you into one person's view of what the DOS interface should be. I seldom agree.

I've been a regular and enthusiastic user of **The Norton Commander** since it was first released almost 3 years ago. And when the update (version 2.0) arrived on my desk, I had the envelope ripped open and the software installed on my system in a matter of minutes. Happily (and not unexpectedly), the Norton folks have made a useful product nearly indispensable.

What I've always liked about The Commander is that it can be as helpful or as nonintrusive as you wish. Although your screen is filled with useful information, the old standard `C:` prompt is still there. You can enter normal DOS commands anytime you wish, just like The Commander wasn't there. Aptly, the Norton folks like to call The Commander a "DOS extender and enhancer" instead of a DOS shell.

The program is still based on twin panels that can contain alphabetical lists of files or other information. You can turn individual panels on or off or change their information. In version 2.0, the panels have been extended downward to fill nearly the entire screen, the better to see more files at a glance. And if you have an advanced display, you can see even more: 43 lines on an EGA display and 50 on a VGA.

Peter Norton Computing has added a long list of other new features to version 2.0—in fact, too many to cover in my limited space. But for a start, there's an optional graphical tree display of your disk's subdirectory structure; switching to a different directory is a simple matter of pointing at a tree entry and pressing Enter. And I wasn't surprised to find that in addition to direct commands, almost all the new features are on those ubiquitous pull-down menus we've all grown to know and love.

What else? One of the handiest features lets you directly view the contents of Lotus 1-2-3 and dBASE data files without having to start up the respective programs. There's also a fast new file-find feature that lets you view files while The Norton Commander is still looking for additional matches.

Though the program doesn't require it, you need a mouse to get the most out of The Commander. With a modicum, it's amazing how quickly you can move around and get things done through strategic "pointing and shooting."

With source code consisting of some 32,000 lines of C and 15,000 lines of assembly language, this isn't a trivial program, and using the full-fledged memory-resident version takes up 140K bytes of your precious RAM space. If space is really tight, you can also use The Commander with a tiny 12K-byte resident kernel that calls the rest of the program when it's needed.

At $89, The Norton Commander 2.0 is fairly priced, and it's a program you'll use all day, every day. In my case, it's the only survivor of the numerous applications and utilities I had on my system 3 years ago. And version 2.0 is likely to stay there for a long time.

—Stan Miastkowski

THE FACTS

The Norton Commander 2.0
$89

Requirements:
IBM PC, XT, AT, or PS/2 with DOS 2.0 or higher.

Peter Norton Computing, Inc.
2210 Wilshire Blvd.
Suite 186
Santa Monica, CA 90403
(213) 453-2361
Inquiry 856.

Compaq's 20-MHz 386er Slims Down

The new **Compaq Deskpro 386/20E** (E for "enhanced") has the brains of a Deskpro 386/20 in the stylish new body of a Deskpro 386s (the sleek system based on Intel's 80386SX processor). And it's a nice body—taller and narrower than the original Deskpro box, with a rounded beige case that's clearly modeled after the IBM PS/2s. At just under 16 inches wide and 15 inches deep, it covers the

continued

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THE FACTS

Compaq Deskpro 386/20E
$5199 with a floppy disk drive; $6599 with a floppy disk drive and a 40-megabyte hard disk drive; $7999 with a floppy disk drive and a 110-megabyte hard disk drive

Compaq Computer Corp.
20555 FM 149
Houston, TX 77070
(713) 370-0670
Inquiry 854.

same area as a PS/2 Model 50. The power switch is on the front of the computer, and there's a 1.2-megabyte 5¼-inch floppy disk drive, with room for another floppy disk drive (either 5¼- or 3½-inch) and a tape backup unit for a hard disk drive.

Like the PS/2s, the Deskpro 386/20E has a case that opens with a turn of a few thumbscrews (though there's also a mechanical lock to secure the system), and floppy and hard disk drives come out easily with a screwdriver.

Inside the box, the computer merges the strengths of the 386s and the 386/20. From the 386/20 comes an 80386 processor running at 20 MHz and a megabyte of 100-nanosecond RAM, complete with caching—32K bytes of 35-ns static RAM run by an Intel 82385 cache memory controller. Compaq claims the cache system lets the 386/20E run with no wait states more than 90 percent of the time. There are also sockets for either a Weitek 3167 or an Intel 80387 floating-point coprocessor.

The 386/20E doesn't represent any performance breakthroughs. Compaq representatives say it runs in the same range as the older model, and BYTE's CPU benchmarks bear that out. The new machine is a little faster on the Sieve and Sort benchmarks and slightly slower on the Matrix and String Move benchmarks, but on average, there's no real change, and the 386/20E is still faster than 20-MHz PS/2s. The on-board VGA controller should improve graphics speed, though. Compaq claims its graphics run up to 50 percent faster than a standard VGA card. If you're not satisfied with VGA, a switch on the motherboard lets you use a graphics card in one of the available slots.

The 386/20E also has all the nice features that are on the 386s motherboard: VGA graphics, mouse circuitry, a parallel printer port, a serial communications port, and a floppy disk controller. A Compaq memory-expansion slot accepts the same memory card and modules as the earlier Deskpro machines; in the case of the 386/20E, you can increase RAM to 16 megabytes. And there's space for a pair of hard disk drives of capacities of 20, 40, or 110 megabytes.

Cramming the processor and support circuitry on a 386s-size motherboard was a challenge for Compaq's engineers; it's the densest board they've ever created, 10 levels deep and very tightly designed. Unfortunately, while they managed to fit in all the functionality (and more) of the old Deskpro 386/20, there was no way to include all the slots of the original.

The 386/20E has only four AT-compatible slots, one of which will typically be tied up with a hard disk controller card. As with the PS/2s, you don't need parallel, serial, floppy controller, or graphics cards; Compaq's advantage is that memory cards won't use up slots either, but some people will still be unhappy with the slot shortage.

The Deskpro 386/20E is going head-to-head with the PS/2 line. The new high-density motherboard has everything IBM added to its PS/2 motherboard—but with more slots available, particularly after memory upgrades. The 386/20E is still significantly faster than any 20-MHz PS/2. Com-

continued

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paq continues to hammer away with what it views as its biggest advantage over the PS/2: the variety and availability of AT-bus expansion cards, and the limited selection of Micro Channel cards. And now Compaq is competing on good looks, too. Although the 386/20E isn't a significantly different machine, it does say something about Compaq's response to the PS/2s.

—Frank Hayes

A Measure of Success

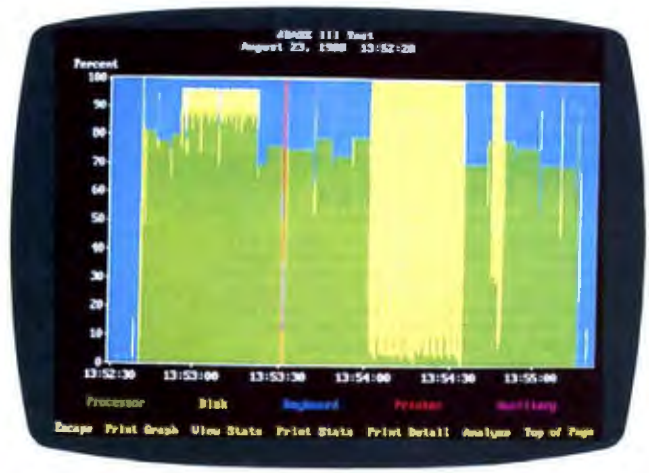
I kept seeing shadowy images of Big Brother as I put **Personal Measure**, a performance analysis package, through its paces. As you go about your work on the computer, Personal Measure monitors your every keystroke, analyzing the effectiveness of your system and the efficiency of your task.

But personal fears aside, Personal Measure performs a noble feat. It analyzes the performance of your IBM PC compatible and of your software from a real-world perspective. You need only develop repeatable scenarios based on work actually performed. Once you've settled on a scenario, just turn Personal Measure on. The terminate-and-stay-resident (TSR) program works in the background, monitoring the flow of information through the software interrupt vectors. The resulting statistical data and color graphs show how system resources are allocated for the selected task.

When you run the analysis module, you can graph an entire event, a portion of it, or the performance of a particular program. The graph displays the blend of resources employed throughout the event cycle. Personal Measure maps usage of the processor, disk drive, keyboard, printer, and auxiliary resources. Tables assign a percentage of the total time to each resource as well as clocking total time duration for each resource. A disk activity summary lists the number of file reads, file writes, programs loaded, directory accesses, and non-DOS accesses performed during the selected event.

This data is useful stuff. You can clearly see how resources are used for each application. You can determine if a particular task flogs the disk or requires heavy keyboard input. If you're looking for a new system, you should base that decision on the applications you'll be using most. Personal Measure will take some of the guesswork out of that equation. If your application employs the processor 90

continued



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percent of the time, perhaps you should consider raw processor speed above all other considerations. Or if you note heavy disk usage, a system with optimal interleave might make a better choice.

Personal Measure can also provide insight into selecting the most effective software, choosing the best upgrade path, or determining how to best allocate resources in a local-area network. You can even tailor your PC for optimum response by enhancing performance where it is most needed. For example, when the ratio of BIOS calls to DOS calls exceeds 1.2 for file reads, the program issues a message suggesting you reorganize your hard disk drive to reduce the effects of file fragmentation.

Unfortunately, some drawbacks curse this package. Because it taps the software interrupt vector to gather data, it cannot evaluate any program that bypasses the interrupt vectors in order to access devices. Such programs include Microsoft's Windows, Borland's SideKick, and Lotus's Express. And since Personal Measure stays resident, you must watch out for other TSRs running with it.

Personal Measure also balks at many low-level operations, like certain DOS activities (`CHKDSK`, `BACKUP`) and most Norton Utilities. You can even lose hard disk drive information if you run these programs with Personal Measure active. Spirit of Performance has included a disk file that lists known programs that Personal Measure will not run.

At first the program would not run properly on my Hercules-compatible AT clone. The company promptly sent a software upgrade that solved the glitch, but the ordeal exposed an inflexible installation routine. The software is easy to install, but that may be part of the problem. You can select an output port and a printer (Epson, Proprinter, or LaserJet), but that's it. If a configuration problem arises, you have precious few parameters to tweak.

I also had some problems running the program on a Dell System 310. However, the system used an early version of the Paradise VGA card, and subsequent releases of Personal Measure do run the software. In any case, you should check with Spirit of Performance to confirm that the program runs with your specific machine. I ran it successfully on a true-blue AT, Compaq, PS/2, and ALR FlexCache.

This program could use some polish, like a more comprehensive setup menu and fuller documentation. The documentation offers general tips on ways to optimize your system, and one chapter explains the benchmarking suites available. More of the 58 pages should have been devoted to practical program operation. In any case, Personal Measure includes a 30-day money-back guarantee and limited 90-day telephone support. So make sure Personal Measure is compatible with your computer and your applications. If it is, your efforts, as well as your $69.95 investment, will pay off.

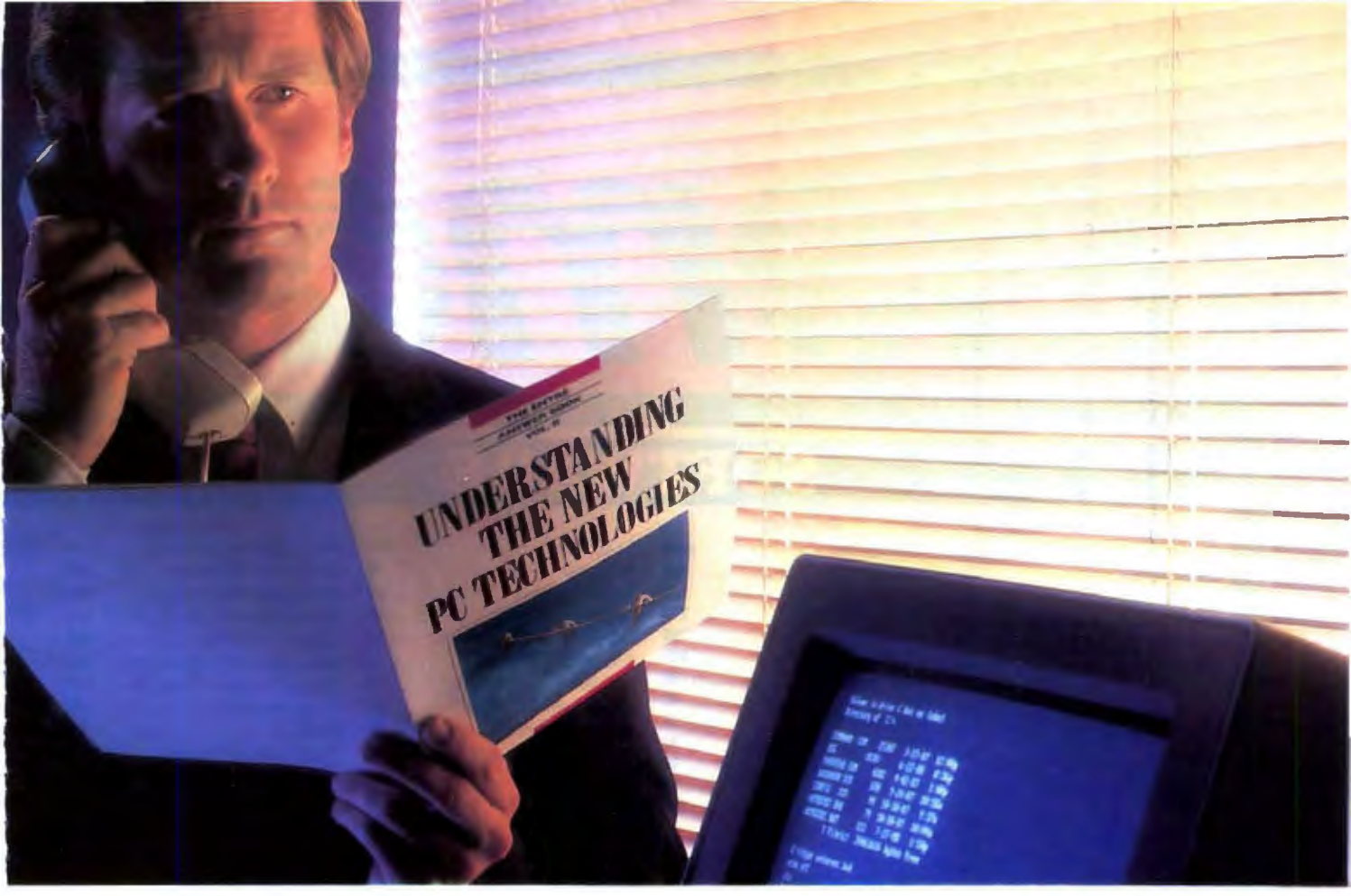
—Stanford Diehl ■

THE FACTS

Personal Measure
$69.95

Requirements:
IBM PC, XT, AT, PS/2, or true compatible with one of the following combinations of video adapter and display type: VGA color, VGA monochrome, EGA color, EGA monochrome, Hercules graphics, CGA, MCGA color, MCGA monochrome; DOS 2.0 or higher.

Spirit of Performance, Inc.
73 Westcott Rd.
Harvard, MA 01451
(508) 456-3889
Inquiry 855.



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THE REVENGE OF THE FILE FORMATS

Jerry tackles a complicated file-conversion problem, takes a look at Unix, and handles some unfinished business

It has been one frantic month. Of course, all months at Chaos Manor tend to be that way, but this one was a doozy. Not only was last month's column late, but there was the column for this fall's *IBM Special Edition*. Now this one is due early: which really means tonight, since tomorrow afternoon I catch a train for San Antonio. I'll stay there a week, then go on to New Orleans for the World Science Fiction Convention.

I'm going to San Antonio because that's where Dr. Francis X. Kane lives. Dr. Kane is one of the coauthors of *Strategy of Technology*, a book first published in 1970 and for years adopted as a textbook in the War Colleges and two of the service academies. We've been revising the book off and on for the past several years, and it's time to get it out the door.

The first step was to print a copy of what we have. That, alas, turned out to be more of a problem than I thought.

Conversions

The original *Strategy of Technology* was written on a Selectric typewriter. The manuscript has long since vanished. When we first decided—about 1984—to revise the book, there was no optical character reader capable of scanning the printed text and turning that into a machine-readable manuscript. Nowadays, I'd use Hewlett-Packard's ScanJet and Flagstaff Engineering's Spot trainable OCR program; *Strategy of Technology* was nicely typeset on good paper, and from my experience with the ScanJet and Spot, there'd be no problem at all. (See my column in the *IBM Special Edition* for a full discussion of Spot.)

Back then, though, I had no choice but to hire someone to type the entire book into CP/M-based WRITE, which was the text editor I used at the time. The result was stored on 8-inch CP/M disks.

Over the past few years, I have revised some of the key chapters of *Strategy of Technology* and included them as nonfiction in my anthology series on the future of conflict, *There Will Be War* (Tor Books). There are seven volumes in that series, and most of them contain revised chapters of *Strategy of Technology*. I do about one *There Will Be War* book a year, and over time the series has been done on a variety of word processors, beginning with WRITE and ending with the one I use at present, Q&A Write.

Worse, Dr. Kane is from the old school: he writes with a pen on lined yellow legal pads. Someone has to type all that, generally a secretary at whatever place he is working for at the time; since he retired from the Air Force as a colonel, he has been at a lot of places, and each one used a different word processor. Longtime readers of this column will recall my efforts to convert some of his text from Wang 8-inch floppy disks to CP/M.

Anyway, when the crunch came this month, I found I had text in a number of different formats. The trick was to get it all into Q&A Write, integrate all the notes and addenda, and print out a clean copy.

Much of the stuff was in WordPerfect 4.1. That presented a problem. Q&A Write doesn't read any flavor of WordPerfect. Borland's Sprint, however, says that it will read WordPerfect 4.2 files and convert them to WordStar. That sounded good, because Q&A Write says it reads WordStar files. As it happens, some of the stuff I needed to convert had been written in WordStar, so the first thing was to test Q&A Write's ability to read those files.

Voilà. Worked fine. The only hitch is that what WordStar thinks is italic comes out in Q&A Write as underlined. This wasn't a problem, because Q&A Write's search-and-replace system is extremely versatile: if you search for `@ul` and tell it to replace with `@it`, it will convert all the underlined text to italic. I could even use it to correct spelling. I had *glasnost* spelled incorrectly throughout, so I told Q&A Write to search for `\@ul glassnost\` and replace with `\@it glasnost\` before I did the global underline-to-italic conversion. That worked fine.

So. If I could get those WordPerfect 4.1 files into WordStar, I'd be all right. First thing was to try Sprint's conversion. No go. Sprint aborted with a mysterious error message. I figured there was no point in looking it up. Clearly, Sprint won't read version 4.1 files. Next thing, then, was to read each file with WordPerfect 4.2, then save the file, thus converting it to a 4.2 file. It was tedious, but it worked.

Now, I figured, I could use Sprint to convert to WordStar.

Not really. Sprint aborted with a mysterious error message: `Conversion error 37`. Fine. Look in the Sprint manuals—there are two or three of them, each as thick as a book—and see what the error is. The only problem was that nowhere in the several hundred pages of Sprint manuals does Borland tell you what the conversion error messages mean. I tried a couple of other files, with the same result. The one certain thing was that Sprint wasn't going to convert those WordPerfect files into anything at all.

As a last resort, I used WordPerfect 4.2 to read the files, then saved them as ASCII files. That was even more tedious than before, and saving as ASCII wipes out all the italics and boldface and some of the formatting, but it did work. Q&A

continued

Write read those in fine. It has a read-in option called "Special ASCII" that removes carriage returns from the ends of lines (but not paragraphs), so that I now have text that edits with word wrap enabled. I had to go through and put in all the italics—principally book titles—by hand, but even that wasn't onerous given the versatility of Q&A Write's search-and-replace capability.

I continue to be impressed by its search-and-replace function. The one thing I would add is a "surrounded by" feature—that is, the ability to search for everything framed on both ends by some character like the underbar, a control character, or some combination of those, and replace the formatting characters by another set of surrounds.

As an example, you'd be able to say "search for everything between a Control-B and a Control-D, and italicize it," or "find everything between pairs of Control-B, and replace the first Control-B with '<it>' and the second Control-B with '<rom>'." That latter would, of course, let you convert files to Atex format.

Anyway, once I had all the WordPerfect and WordStar files read in, it was time to bring in old WRITE files off 8-inch floppy disks. That was simple enough: I fired up the Golem, my trusty CompuPro 8/16. It runs Concurrent DOS, which will copy CP/M files to PC-formatted 5¼-inch floppy disks. It took a minute for me to remember how to use PIP.COM, but after that there was no problem.

Of course, there's a trick to it: WRITE marks the ends of paragraphs with a carriage return but no linefeed; Q&A Write looks for linefeeds but pays no attention to carriage returns. This is a holdover from the old days, when ASCII was devised to control Teletype machines: the linefeed character dropped the print head down a line without moving it horizontally, while the carriage return moved the head to the left side of the page without any vertical motion. ASCII has no "newline" character and has to make do with the carriage return/linefeed pair.

At my insistence, Symantec changed Q&A so that it will recognize either a carriage return or a linefeed as the paragraph marker—but, alas, while that feature was built into Q&A 3.0, it hasn't yet been retrofitted into stand-alone Q&A Write. Thus, I had to use Q&A to read in the WRITE files. That's no great hardship, since Q&A has the Q&A Write editor built into it, so I created a "strategy" subdirectory in Q&A, moved all the files from Q&A Write over to it, and did all the rest of my edits using Q&A 3.0.

Printer Blues

It took working until 6:00 a.m. three nights in a row, but I managed to collect all the notes, additions, and rewrites we'd accumulated over the years and incorporate them into the relevant parts of the book; and this morning I had six chapters complete, as far as I'm concerned. That's more than half the book.

The next thing was to print those chapters and FedEx them off to Dr. Kane so he can be working on them while I'm relaxing on the train. (Actually, I won't be relaxing, I'll be working on fiction. I have a private room on the Limited, and I'm taking the Zenith Z-286 SupersPort laptop. For two whole days the telephones can't ring, and no one will be able to find me. I expect to get a lot done, but that's next month's story.)

I figured that printing the chapters

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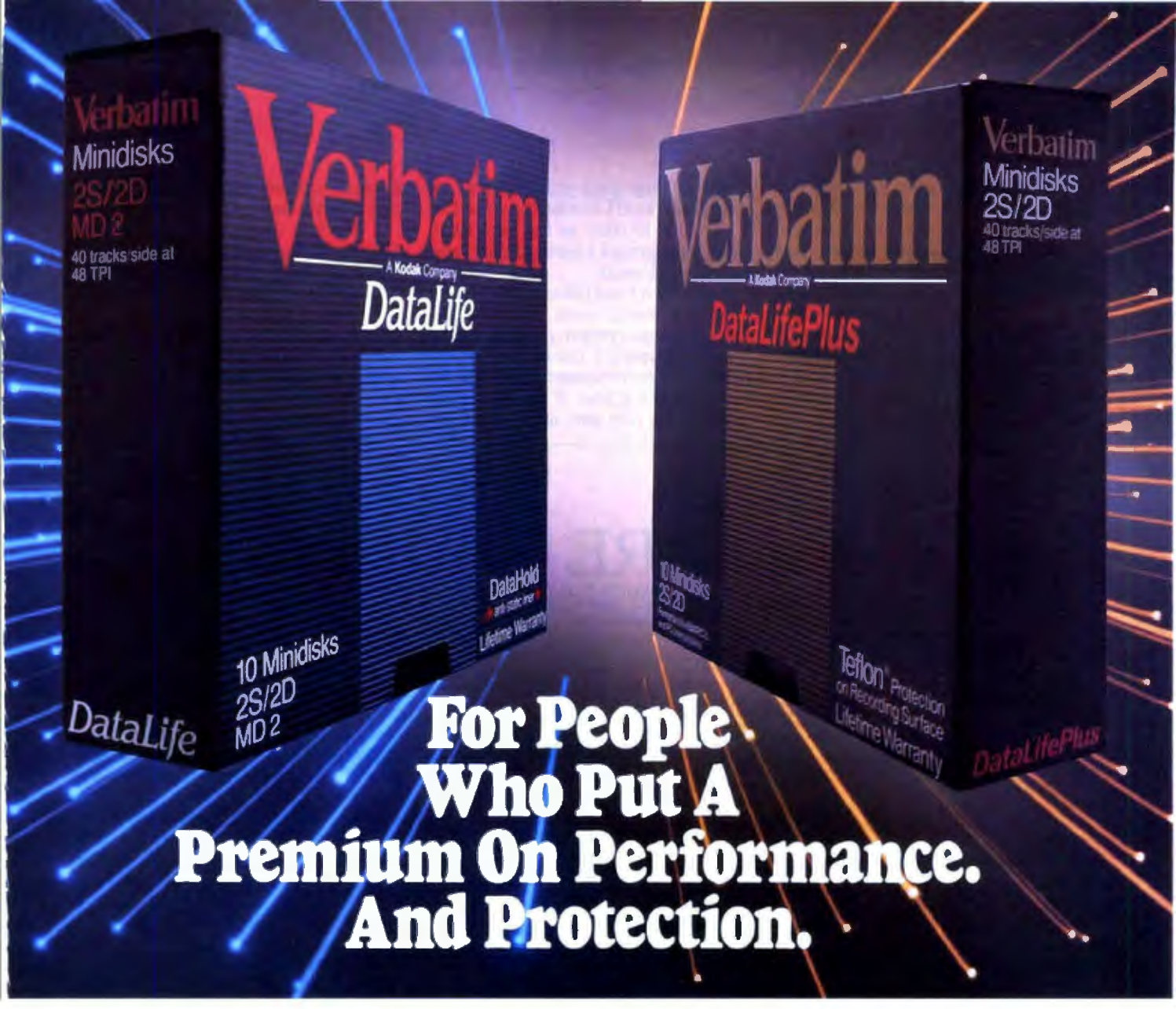

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would be straightforward. After all, I've been printing books with Q&A Write for some time now; Q&A 3.0 is a later version, and therefore should be even less trouble.

The best printer I have is the Kyocera F-3010 laser printer. I've described this jewel before. It's fast, it's reliable, and it emulates darned near any other printer in the world. The only trouble with it is that it's somewhat bigger than the printer stand. I'm getting new furniture, but until I do, my main printer is still the Hewlett-Packard LaserJet Plus. The Plus is not quite so fancy as the LaserJet II, being an upgraded LaserJet I with more memory and smarts.

Alas, when I told Q&A 3.0 to print my files, the results were all cockeyed. Q&A 3.0 wasn't properly initializing the printer; at least, I think that was the problem. The symptoms were that the header didn't appear at the top of any page but the first one; after that, it appeared to progressively move down several lines per page.

I checked the printer installation. Q&A 3.0 offered me a choice of drivers for a LaserJet I or a LaserJet II. No Plus. I selected the LaserJet I. I could, I suppose, have fooled around with Q&A and tried to make it work—I could even manually send the complicated escape sequences that initialize the LaserJet—but that seemed pointless, and besides it was getting late—and I was getting frantic.

I hadn't done all that work just to miss the FedEx deadline because the printer had developed a Critical Need Detector error! I knew I could print those files with Q&A Write, because I've been using that for months. Nothing for it, then, but to transfer all the files back from Q&A 3.0 to Q&A Write. While I was at it, I wrote everything off onto the Maximum Storage WORM (write once, read many times) drive for backup.

There was one more problem. While Q&A Write has a kind of batch file that will let you print a whole slew of chapters (you list what you want to print in one master file), there is no global "double-space" command. Each file (there are six—one for each chapter) needs to be brought into Q&A Write, told to be printed double-spaced, and saved without printing. This doesn't take all that long, but it is tedious. I've complained to Symantec, and they claim they'll fix the problem in the next release. I hope so.

Anyway, I called in each file, revised the header, declared that I wanted double-spaced text, and saved the file; after which everything worked like a charm. Q&A Write squirted the text over to the ACT Printer Optimizer (a box of memory that serves as the printer buffer); the Optimizer fed the LaserJet Plus; and paper came spewing out at about 6 pages a minute, half as fast as I could get with the Kyocera F-3010, but still fast enough.

Of course, there was one final problem. Unlike the Kyocera printer (and other printers that use the Kyocera engine), the LaserJet spits out paper face-up. That stacks it in precisely the wrong order from the way you want it. A year or so ago, I bought a gadget called the Collaser, which is a thingumby that dangles below the LaserJet's output slot. The paper falls into the Collaser, which is shaped in a way that causes it to stack itself face-down.

At least, that's what it's supposed to do. What actually happens is that about one sheet in 10 won't quite clear the LaserJet's output slot. It lacks only about

continued

A Clear View To Monitor Quality

CHAOS MANOR

¼ inch, but that's enough; the printer thinks there's a paper jam. Clearing the paper jams is simple enough, because the LaserJet, like all laser printers I'm aware of, remembers what it was doing when the jam happened and reprints the page that was spoiled; but it's still more work than I like.

However, I noticed that if you lead the paper out another ¼ inch, it falls into the Collaser just fine. All it takes is something attached to the lip of the LaserJet's output slot. After some thought, I hit upon duct-taping a long bamboo Chinese back scratcher to the LaserJet Plus. It looks silly, but it works just fine.

So. I got my six chapters—about 200 pages—printed in time for the FedEx pickup, and all's well.

When I get back from my trip, though, I'm going to hurry the installation of the Kyocera F-3010. It's not that I don't like my LaserJet Plus, but it does look a bit odd with that back scratcher taped to it.

Unfinished Business

I did get a lot done on *Strategy of Technology*, but otherwise this month has been something of a bust: everything I started seems to have just sort of died away.

For example, I was going to do a thorough test of FastTRAP, MicroSpeed's trackball substitute for a mouse. Last month, I tried FastTRAP and found it pretty good for CAD situations, but not very useful for normal mouse actions, where you have to click-and-drag. Then I discovered that I'd neglected a key feature of FastTRAP—namely, that MicroSpeed has built into the hardware a method of simulating a click-and-drag operation.

What happens is that you can set up the three buttons above the FastTRAP trackball so that when you press the middle button, it is as if you have pressed and *held* the left button. Now, moving the cursor by manipulating the trackball produces the same result as if you did click-and-drag with the left button. This continues until you press either the left or the center button again. You can use this emulation to select text, choose icons, or do anything else you might do with mouse click-and-drag.

Incidentally, I don't apologize for missing this feature. It's well documented, but I had little incentive to read the FastTRAP documents. Someone at MicroSpeed got fascinated with fonts and desktop publishing packages, and, not content with having named their product FastTRAP, they proceeded to put most of the text in a thin, light sans-serif typeface, while the word FastTRAP is always set in a larger font and boldfaced wherever it appears in the documentation. It appears quite often, a dozen times on each page. They also played other games with fonts and boldfacing. The result is so incredibly ugly that you'd have to see it to believe it. Certainly, I had no desire to read it.

If you get past the unaesthetic typography, the FastTRAP documents do tell you quite a lot. Also, once you start getting used to it, FastTRAP may very well be easier to use than a mouse.

My original intention was to disconnect the mouse and substitute FastTRAP for a month, after which I'd know which I preferred.

Alas, the test didn't get made this month. Too much work piled up; enough that I just didn't have time to learn FastTRAP—and it does take some learning. I normally use Logitech's Point editor as

my general-purpose utility editor. Point not only requires a mouse, it's not really happy unless the mouse has three buttons. There are also a fair number of click-and-drag operations.

While you can, on the fly, reprogram the FastTRAP center button from "sticky" to "same as left and right buttons pressed simultaneously," it's a bit tricky to remember to do that each time you need to change modes. My first couple of attempts to use FastTRAP with Point were near disasters; and while it was clear that I could, eventually, learn to use FastTRAP—and I might even like it—it was also clear that while learning I wasn't going to get a lot of work done. Best to wait until next month. More then.

Internal or External?

Another unfinished bit is the installation of the Supra MegaDrive, an internal hard disk drive for the Atari Mega ST. The installation itself went smoothly. The Mega ST isn't all that easy to take apart—there are too many screws by half—but, if you're at all used to mucking about with a computer, it's no great task. Supra's directions are sufficiently clear, and besides, it's pretty obvious where everything goes. It didn't take my son Alex an hour to install the drive and get the Mega ST back together.

It works, too. You can boot off the internal hard disk drive, and if there's any difference in speed between the internal and external drives, I don't know it.

Unfortunately, we have not been able to get both drives working at the same time. The Mega ST will recognize either the internal *or* the external drive and boot off it; but it won't recognize both. Since I have most of my programs stored on the external disk, this can be serious: how do I transfer those programs? One at a time with floppies? That would certainly give me a hobby.

It's probable that we're doing something wrong and there's a way to make the Mega ST see both drives at once, but if so, we can't figure it out.

I also have a Supra 10-megabyte 5¼-inch external floppy disk drive. That would certainly facilitate the transfer of programs from one hard disk to the other. Alas, we've been totally unable to make that work. I know it can be done because I've seen it in operation at shows, but I'm darned if I can do it. With any luck, we'll have all those problems taken care of by next month. Meanwhile, if you have or are getting a Mega ST, you won't have any problems installing and using your Supra MegaDrive, and it does save space.

Unix for PCompatibles

We have now spent two months experimenting with Unix on the Zenith Z-386, with mixed results.

First, it does work. You can, with considerable effort, install any of several brands of Unix—we tried Santa Cruz Operation Unix and Zenith's Xenix—on the Z-386, and they work. Plug several user terminals into the system and you'll have multiuser capability, and you can run all kinds of Unix software. Most of that software tends to be pretty vanilla compared to what's available for DOS—I'm not terribly impressed with any Unix word processor, database, or spreadsheet I've seen—but you'll be able to grep and use all the Unix utilities and system stuff. If you have special needs—multi-

continued

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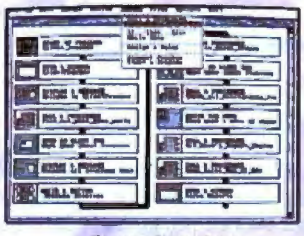

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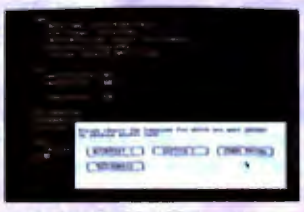

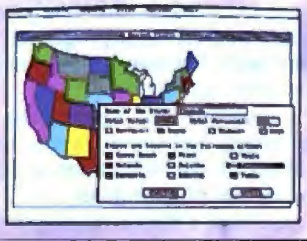

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user real-time access to a big database is the example that comes instantly to mind—Unix may well be what you need.

Of course, you may also need more than an 80386-based computer can give you. I'm told that the fastest Unix 80386 system is a Cheetah. This is because multiuser systems tend to unduly stress cache software, and with enough users making enough calls, the raw hardware governs. A 25-MHz Cheetah 386 with a Priam 330-megabyte hard disk drive is an awesome thing to behold, but if you hang enough users on it, you can overwhelm that, too. My point is that if you just like Unix, you can certainly get it in an 80386 computer; but if you have business requirements that demand Unix, you'll need better professional advice than I can give you.

Once you have Unix set up, you can install Locus Merge 386, a program that lets you run DOS under Unix. It won't be cheap, and the installation isn't simple. Alex, who studied computer science at the University of California at San Diego, tried three times, and eventually we brought in our friend David Butterfield, who wrote a good part of the Locus program. Even he had difficulties, mostly with the hardware configuration. For example, you cannot run Unix with the Zenith Z-448 video board and the ZCM-1490 Flat Technology Monitor. Unix wants a fairly vanilla EGA board if you're to have color in DOS.

However, they did get the Locus program running, and it did run most of my favorite software. We had Q&A, Quattro, Sprint, Expert 87, and some other stuff going. Most of The Norton Utilities worked. Games and graphics programs that write directly to the screen were a pain; some worked, and some didn't. Unix doesn't really like or understand color, or at least that's my conclusion.

The thing is, it did work at least as well as OS/2's compatibility box, except that you can run a number of DOS programs at once.

On the other hand, it was slow. Not painfully slow, but certainly slower than I'm used to with the Z-386. And we couldn't get it to access a CD-ROM.

We also discovered that Unix doesn't really do multitasking. Before anyone gets excited, let me explain. One complaint I have about Q&A is that while I don't often need multiple windows, I sometimes do, and Q&A doesn't have any. Under DESQview, that's no problem. I just open two Q&A DESQview windows. When I tried that with Unix, even though I was only one user, I got a message saying that I'd have to buy the network version of the program. Unix apparently thinks multitasking is only a special case of multiusing, and it networks those tasks.

My conclusion is that if you want to do it, you certainly can use Unix instead of OS/2, DESQview, or VM/386. If you have good and compelling reasons to do that, it's worth investigating.

I don't have any such reasons, and I needed the Z-386, so last week we reformatted the drive and installed DOS.

DOS 4.0

This is another unfinished project. We got a vanilla IBM DOS 4.0 to work, more or less, on the Z-386; but there are a lot of incompatibilities. As an example, The Norton Utilities don't work. Norton says they already have a patch to take care of that, but I haven't got it yet.

continued

We had glitches with mouse software. I'd hoped that DOS 4.0 would make it simpler to use a CD-ROM, but so far I haven't got a CD-ROM reader to work with it at all. I've had some troubles with the WORM drive, too.

Priam says they think 4.0 will work all right with their 330-megabyte drive, but they're not sure, and in any event they'll have a version of their enhanced-small-device-interface (ESDI) controller software tested with 4.0 by the time you read this column. Other colleagues have told me of odd glitches they've experienced.

Zenith says it will have its own brand of DOS 4.0 Real Soon Now. Meanwhile, IBM is famous for collecting all the problems experienced with a new release of DOS and putting out an update; I suspect that about the time you read this, you'll be able to get DOS 4.01. My advice is to wait for it.

Noise and Modems

Chaos Manor used to be famous for line-noise problems. We didn't know whether it was the internal wiring or our local phone connection; but when I first began logging onto BIX, I was driven half batty by noise.

All that went away when we installed a USRobotics Courier HST 9600-bit-per-second modem. Indeed, the improvement was so dramatic that I thought the OmniTel 2400-bps internal modem I'd been using had failing chips. Anyway, for months now I've had no line-noise problems, and I've gotten used to reliable communications at 2400 bps (for BIX) and up to 9600 bps to bulletin boards.

Then, suddenly, my Courier HST began to do odd things. It would turn on the phones, or the little red lights would flash—when I wasn't even using the modem. I'd get strange noises from the speaker. It would dump me out of communications, sometimes locking up the machine so I had to reset. All the problems would be cured if I turned the modem off and back on, but then they'd come back again.

It didn't take a lot of that to be intolerable. Clearly, something had to be done. The simplest thing would have been to go get Roberta's Courier HST and install that; but I've had a SupraModem 2400 sitting here unopened for some time, and this seemed a good opportunity to test it.

The SupraModem 2400 is smaller than the Courier HST. There are no set-up switches; the only control is an on/off switch. There are, of course, the usual flashing lights.

The manual is well organized and explains everything, but in fact I didn't have to use it. I didn't do anything but unplug the Courier HST's power supply—the SupraModem 2400 uses different voltages than the Courier HST—and connect the SupraModem 2400 where the Courier HST had been. Then I logged onto BIX without making any adjustments in software. Everything worked, in that I certainly was able to connect to Tymnet and thence to BIX.

The problem was that my line noise was back, in spades, with big casino. I even had trouble logging onto BIX; I kept getting line noise in my password, so I had to try three times. Once on BIX, I was able to read most messages, but there were frequent bursts of garble. Then I tried to upload something with XMODEM. I'd get started, but before the whole file could be transmitted, the

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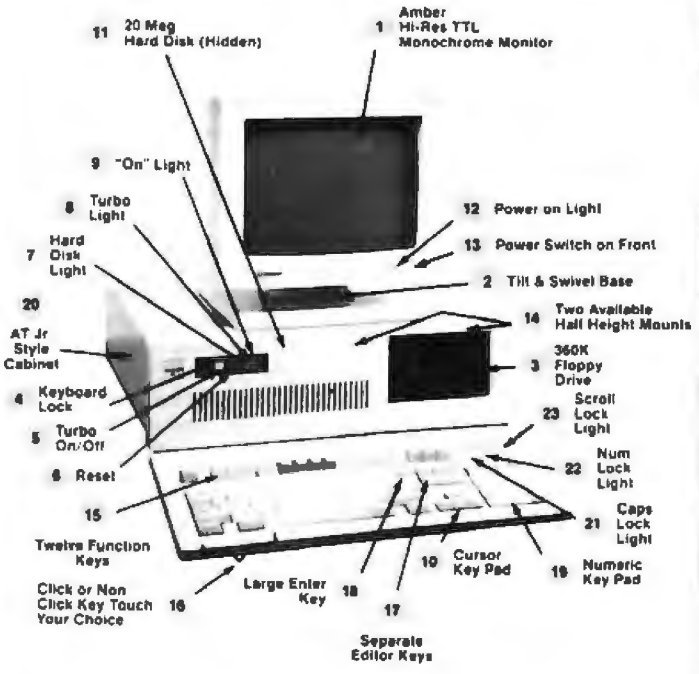

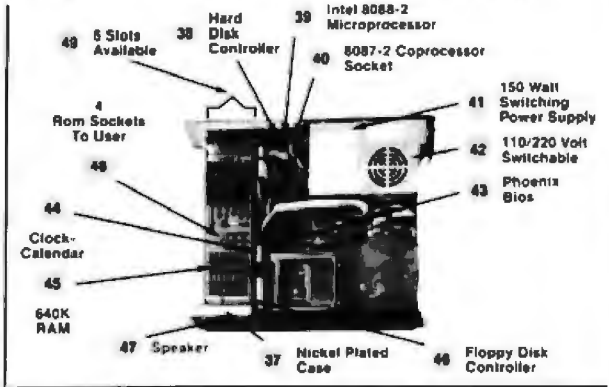

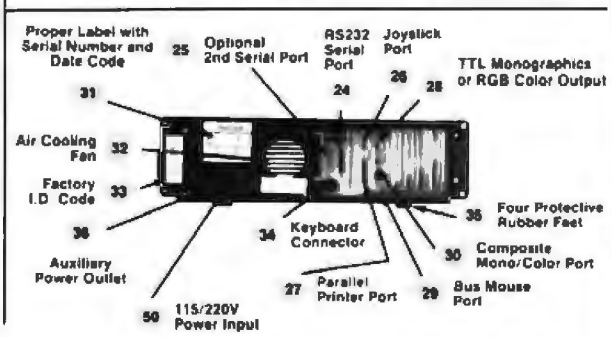

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operation would abort. This happened three times.

I tried everything. I hung up and dialed again; that sometimes cures noisy connections. Not this time. I waited for a while before trying once more. Same thing. I won't say the noise was worse than I'd had with the OmniTel modem, but it sure wasn't any better.

Nothing for it then, I thought. I went down and grabbed Roberta's Courier HST and brought it up. I plugged it in.

Lights flashed in crazy patterns. The speaker made funny noises.

Of course, you've guessed what happened. When I swapped my Courier HST for Roberta's, I didn't bother exchanging power supplies. Why should I? Nothing ever goes wrong with power supplies. Only this time that wasn't true. When I went down and got her power supply, both her and my Courier HST worked fine.

A quick call to USRobotics technical support got an expression of surprise, and an offer to send a new power supply right away. That came two days later, so now both modems are back in use. While it was coming, Roberta used the SupraModem 2400. She had line-noise problems, too. Perhaps not as bad as I had, but bad enough. When she went back to the Courier HST, the noise went away.

I took the SupraModem 2400 to a different part of the city and connected it to a portable. It worked fine; there was no noise. Back here, though, the noise overwhelms it.

The moral of the story is that if you're lucky enough to have good, quiet, and clean phone connections, you can get away with inexpensive modem equipment; but if you generally have noisy connections, you'll need something a lot better. I don't know what technology USRobotics uses to let the Courier HST deal with line noise, but I do know it works.

Highly recommended.

Internal vs. External

It's always a dilemma. When there's a choice of auxiliary systems, do you get the internal or the external version?

I used to favor internal systems, on the grounds that they don't take up room on the desk and they eliminate the clutter of cables and power cords.

Now, I'm not so sure. First, I had problems with an internal modem. Not only did it take up a slot, but sometimes the only way to reset a modem is to turn it off. Once in a while I like to change phone lines, and if your system sits on the floor in a tower configuration, as mine does, it's a lot easier to reach the back of the modem on the desk than to get down on the floor behind the computer. Finally, it's a lot easier to hear the external modem's speaker. On balance, then, external is probably better for a modem.

Then there's WORM drives. I started with Maximum Storage's APX-3200 external WORM. I really like this, so when I put my big Cheetah development system together, I built in the internal version.

Now, I'm not sure at all.

When you insert a new cartridge into a WORM drive, sometimes the drive latches aren't in the proper place. The result is that the drive rejects the cartridge. The manual says that when that happens, you should turn off the WORM drive, press and hold the eject button, and while holding down the button, turn the drive back on. This will restore the heads and latches to their proper place.

I'm sure I read that, but I forgot it. It's

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my practice to back up new work onto a WORM cartridge. I have several of them, one of which is the master backup. That isn't normally in the machine. I keep it in a desk drawer, and periodically I swap it for one that's kept in a safe-deposit box. A few days ago, I had an assistant make the swap. When I inserted the new cartridge into the drive, it wouldn't latch. The cartridge ejected. I pushed in again, and out it came again. I did this several times, and the final time I used too much force. The cartridge went in and stayed all right, but the drive made horrible mechanical grinding noises.

At this point, I had to turn off the power to my machine. It's the only way to turn off the power on an internal WORM. Alas, when I turned the machine back on, the grinding noise started again.

The upshot was that I removed the internal WORM to examine it. I couldn't see anything wrong, but clearly it wasn't working properly. I said a little prayer and used forceps to pull the cartridge out. Then I connected the external drive—Maximum Storage's controller has both internal and external connectors, so I didn't have to change controller cards—and turned things on, this time holding down the eject button when the machine powered up. Then I inserted the cartridge I'd retrieved.

The Maximum Storage WORM can be accessed through LANtastic.

It all worked fine. Nothing wrong with the cartridge. Probably what's wrong with the internal drive is something very simple. It's beyond me, though, so I've sent it back to Maximum Storage. Meanwhile, the external drive works fine.

However, the incident got me to thinking, and now I'm inclined to prefer the external drive anyway. I can get several controllers, install them in different machines, and carry the external drive—it's about the size of a shoebox—from one machine to another when it's backup time. For that matter, though, the Maximum Storage WORM can be accessed through LANtastic, and probably any other PC network.

The main thing is that if you have an external drive, it's no trouble to follow the recommended procedures for repositioning the latches and heads. With an internal drive, you have to turn off machine power. I've suggested to Maximum Storage that they might want to put a power switch on the face of the internal unit, and they're considering that.

I still say that anyone who's serious about the value of work done on a computer is insane not to get a WORM drive.

Minor Glitch

Recently, I backed up my entire Priam 330-megabyte drive to a WORM. Of course, the Priam drive wasn't full, but I did have files in drives C through I inclusive. What I did was insert a fresh car-

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tridge—fresh on one side, anyway—and create directories named C1 through I1. Then I logged onto C and reset the machine, having first brought in AUTOEXEC.BAT and CONFIG.SYS files that configure a bare system—no mouse driver, no SideKick or other memory-resident programs, nothing at all but the disk driver.

Then I ordered `XCOPY C:*.* N:\C1 /s /e`. This copies everything from the C drive onto the C1 subdirectory of N, which is what my WORM drive happens to be. The `/s` tells XCOPY to create subdirectories if they don't already exist. The `/e` tells the program to create empty subdirectories as well.

It's not strictly necessary to reset and create a bare system before you use XCOPY, but it may be wise. There's growing evidence that some memory-resident programs interfere with XCOPY in unpredictable ways. Also, XCOPY reads everything it can into memory before it starts writing; the more memory the system has available, the faster XCOPY operates.

I copied the C partition to the WORM C1 directory and D to D1 without a hitch; but when I copied the E drive, I got read errors. XCOPY lists each file as it reads it, so it was possible to see which file couldn't be read. Also, XCOPY offers you the choice of retry, ignore, or abort. I hit the *R* key for retry. That didn't work.

After a few more attempts, I wrote down the name of the file that XCOPY couldn't read and hit the *I* key for ignore. XCOPY went on down the list for a while, then it happened again. All in all, there were about nine read errors, all fairly close together. One of them was cured by retry. I told the system to ignore the others, first writing down the filenames.

After the E drive was done, I went on to the others. There weren't any more errors. When I was all done, I went back to the E drive and used the DOS COPY command to copy all the files from my list into the appropriate subdirectories. I was able to do this with all but one of them; clearly, COPY is less sensitive to minor disk defects than XCOPY.

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SpinRite

The one file I hadn't been able to copy wasn't important, so that was all right, but the incident was annoying. I recently got a copy of Steve Gibson's SpinRite. This program supposedly lifts the data off your hard disk a track at a time, reformats the track, and puts the data back where it found it. SpinRite is said to cure disk problems before they get acute. It's also supposed to significantly speed up your hard disk operations. I've heard very good things about it.

SpinRite is easy, if a bit tedious to use. I first aimed it at the C drive of my ESDI Priam hard disk drive. SpinRite trundled a while and told me there was nothing wrong with the disk. Ditto with D.

At E, it said it found problems. Since I'd just made a backup of the entire hard disk, this seemed a good time to test SpinRite, so I told it to go fix things.

SpinRite trundled for a few moments, told me I had a Priam hard disk drive, and Priam says do not use SpinRite, and I should go read the documents (which, I blush to say, I really had only glanced through). The SpinRite documents say the same thing. Don't use SpinRite with a Priam drive. That took care of that.

I did try SpinRite on a generic AT clone, and it worked fine—that is, it said it found some soft errors and corrected them. Subsequent tests showed I hadn't lost any data, and subsequent diagnostics with SpinRite didn't detect any more errors. Beyond that I couldn't say, because I hadn't had any trouble with that system in the first place.

I did try SpinRite on a generic AT clone, and it worked fine.

As to the Priam drive, I got out Golden Bow's Vopt program and ran VMARKBAD against the E drive. I've previously recommended Vopt; if you don't have it, you really ought to get it. Sure enough, VMARKBAD found about nine sectors it didn't like. I told it to mark them so they're not in use any longer.

When IBM brings out DOS 4.01 and Priam certifies it as safe, I'll probably reformat the Priam drive and start over. The WORM backup files will make that simple enough. Until then, when you have 330 megabytes to play with, what's a few kilobytes of bad sectors, anyway?

One More Conversion

Steve Stirling and I are working on a science fiction novella that takes place in Larry Niven's Man/Kzinn Wars sequence. A few minutes ago, I got a disk from Steve with a new outline and a partial draft.

Naturally, it was in WordPerfect.

I could have read it into WordPerfect and written it out as ASCII, but I'd just done that; and I remembered a program called Word Exchange.

Word Exchange works fine. There is a hitch: it translates only to or from Microsoft Word, meaning that to get a WordStar file, I had first to translate Steve's

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Our printers can make just about any PC look good, from IBMs to Apples, and they'll run on all popular software programs.

☐ **Too noisy:**
Shut your eyes, and you can't tell whether our Laserstar 6 is on or not.

☐ **Not enough fonts:**
We have 24-pin dot matrix models with 4 resident fonts, our Laserstar 6 has 9, and for each you can get additional plug-in font cards.

☐ **Too expensive:**
If you want price/value, look at our best selling dot matrix model NP 30.

☐ **No support:**
Part of our "product" is our nationwide dealer network. If you have questions about any AEG Olympia printer, the answers are only a phone call away.

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and mail it with your name and address to AEG Olympia, Dept. ADV, Box 22, Somerville, NJ 08876-0022. Or if you're in a hurry, call us at 1-800-999-6872. It's the first step to making your problems go away.

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Telephone

Company

Address

City State Zip

984

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file to Microsoft Word format, then from that to WordStar. Even on a fast 80386 computer this takes time; but it does work, and his file is now saved in Q&A Write. One fair warning: it takes Q&A Write a lot longer than you expect to read in and translate WordStar files created this way. Don't give up and reset just because nothing seems to be happening.

Word Exchange comes with a 50-page document, but you won't need to read it unless your job is pretty complex. Mostly, the document lists program limitations. The program reads and writes ASCII, all flavors of DisplayWrite, several versions of WordPerfect, Wang PC, Samna Word, WordStar, and Volkswriter. I haven't tested them all, but it sure seems to work better than Sprint did. It's painless, too.

Winding Down

I'm out of space, but there's still an enormous stack of stuff here. There's PC Pillow: a keyboard-size cloth-covered board with padding under it. You put it on your lap and the PC keyboard (or even your whole laptop PC) on top of it, making things both more secure (because it's less likely to slide off) and more comfortable. I'm taking it with me on the train.

There's a new version of DESQview, as well as new DESQview interface tools complete with a debugger. Combine DESQview with the Phar Lap DOS extensions, and you can have multitasking unbound by the 640K-byte limit, while running all your old DOS programs as well. This is a serious competitor to OS/2, and I'll have more on it next month.

There's a whole slew of stuff for the Mac II, including both a facsimile board and a scanner; maybe I'll have a fax at last.

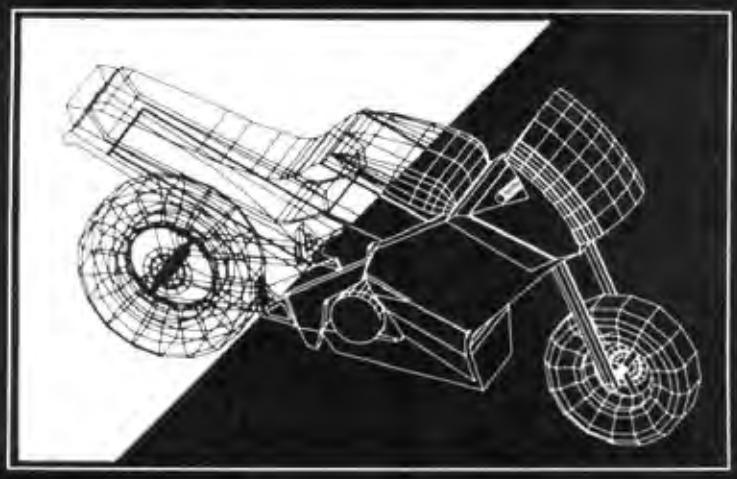
There's Symantec's GrandView, a worthy successor to Ready! and ThinkTank; GrandView is extremely powerful and easy to use; put it in a DESQview window, and you won't know how you ever got along without it.

The book of the month is Robert Wright's *Three Scientists and Their Gods* (Times Books, 1988). The title is a bit of a misnomer; the book is an account of the beliefs and work of Ed Fredkin, F. O. Wilson, and Ken Boulding. Boulding, a Quaker, is the only one close to being a traditionalist. I've known him for some years, and Wright does a pretty good job of presenting his views. The computer book of the month is by Michael Banks, *The Modem Reference* (Brady, 1988). This will tell you all you need to know to get started and keep going in computer communications.

The game of the month is Earl Weaver's Baseball for the PC. My baseball fanatic son has spent half the time he isn't actually watching baseball playing the game. Me, I'm still addicted to Empire. The PC version is all right, if a bit slow; it's better on the Atari ST. Of course, if you have an Atari ST and you haven't got Dungeon Master out of your system, nothing else counts. ■

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."

AW...WHAT THE HECK!



The first question asked by many people is, "Why is *DesignCAD 3-D* priced so low?" The answer? After developing *DesignCAD 3-D* we were unable to decide how the product should be priced. We consulted experts. We used the finest spreadsheets on the market. We took employee polls. We asked our lawyers and accountants for their opinion. We even asked our Mothers, Wives, and childhood Sweethearts! Finally in the greatest American Tradition, we said, *"Aw... What the Heck! Let's see the other guys beat this price!"* *DesignCAD 3-D* sells for $299 complete. No add-ons, nothing else to buy!

DesignCAD 3-D is a complete 3-Dimensional CAD system. It offers most, if not all, the features found on programs costing more than $3000! In fact, **PC Magazine** says, "For a low-cost, self-contained 3-D package DesignCAD's range of features steals the show. The package offers more than adequate features for a wide range of professionals and hobbyists alike."

Once again, American Small Business Computers has proved that you don't have to spend a lot of money to get quality software. *DesignCAD 3-D* provides features such as Shading, Solid Object Modeling, Hidden Line Removal, Cross Sectioning capability, ability to output shaded drawings to laser printers, dot-matrix printers, or pen plotters, extensive file transfer capability, *all for only $299!* No other 3-Dimensional CAD system can come close to providing the price/performance of *DesignCAD 3-D*.

There is a very important reason to buy *DesignCAD 3-D* other than price: PERFORMANCE! *DesignCAD 3-D* provides complete 3-Dimensional drawing capabilities. It's not a "warmed-over" 2-D program. *DesignCAD 3-D* allows you to draw any entity in 3-D space. This means, for example, that you can draw a curve in the shape of a spring. You can draw a circle or arc at ANY angle on ANY plane.

DesignCAD 3-D allows up to 4 simultaneous views - any angle or perspective - on the screen. *DesignCAD 3-D* also provides complex extrusions—linear, scalar, and circular. Extensive 3-D text capabilities and auto-dimensioning are provided, *at no extra charge, of course!*

DesignCAD 3-D almost certainly is compatible with the computer system you now own. *DesignCAD 3-D* supports more than 200 dot-matrix printers, at high resolution. *DesignCAD 3-D* supports more than 80 plotters, and most digitizers, mice, and graphics adapters available for "PC and PC Compatible" systems. Shaded and wireframe models can be output to the printer or plotter YOU own.

$299

DesignCAD 3-D provides the capability to read drawings from most other CAD systems (*DesignCAD/ProDesign II, AutoCAD's DXF, Hewlett Packard's HPGL,* and *IGES*). *DesignCAD 3-D* will also write GE, and POSTSCRIPT files. This file exchange utility is included at no extra charge, of course.

DesignCAD 3-D does not require expensive graphics adapters and monitors - even shading can be done on ordinary displays, such as the Enhanced Graphics Adapter (EGA), Color Graphics Adapter (CGA) and Hercules Monochrome Adapter. *DesignCAD* also supports many of the ultra high resolution graphics adapters, with more hardware being supported daily.

However, the best reason to buy *DesignCAD 3-D* is not the low price. It's not the outstanding performance. It's not the extensive hardware compatibility. *The best reason to buy DesignCAD 3-D is for its amazing ease of use!*

What else do you need to know about DesignCAD 3-D? Only this: "Included at No Extra Charge." What is included at no extra charge? **EVERYTHING! $299 BUYS IT ALL!**

DesignCAD 3-D

Oh yes, we also market a 2-Dimensional version of *DesignCAD 3-D* with special drafting and design functions. Can they work together? Naturally... Our Mothers, Wives, and childhood Sweethearts would see it no other way! The price?... **$299, of course!**

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Write or phone us for FREE DEMO DISK and information on DesignCAD 3-D and DesignCAD 2-D products.

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Periscope's *New* Version 4

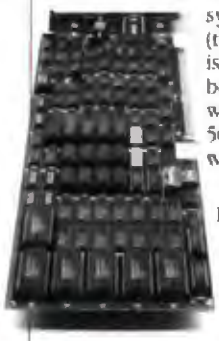
...Gives you all the right stuff for debugging! No matter which model you pick, you have the same powerful software to help you track down hard-to-find bugs fast.

Periscope's hardware adds the power to solve the really tough debugging problems.

The break-out switch lets you break into the system any time. You can track down a bug instantly, or just check what's going on, without having to reboot or power down and back up. That's really useful when your system hangs! The switch is included with Periscope I, Periscope II, and Periscope III

The **NEW** Periscope I memory board keeps all debugging information out of the lower 640K. Can be used in PCs, ATs, and 386s with both EGA/VGA and EMS boards installed. The Periscope break-out switch enables you to recover from a hung system. Included with Models I, II, and III.

Periscope I has a **NEW** board with 512K of write protected RAM, user-expandable to 1MB, for the Periscope software, symbol tables, and all related debugging information. Normal DOS memory (the lower 640K) is thus totally freed up for your application, and Periscope is protected from being overwritten by a run-away program. The new board's footprint is only 32K, so you can use it in PC, AT, and 386 systems with EGA/VGA and EMS boards installed (not possible with the previous 56K board). It can also be used with Periscope III to provide additional write-protected memory.



Periscope III has a board with 64K of write-protected RAM to store the Periscope software and as much additional information as will fit. AND..

The Periscope III board adds another powerful dimension to your debugging. Its hardware breakpoints and real-time trace buffer let you track down bugs that a software-oriented debugger would take too long to find, or can't find at all!

The Periscope III hardware-breakpoint board captures information in real-time, so you'll find bugs that can't be found with a software-based debugger

Periscope's software is solid, comprehensive, and flexible.

It helps you debug just about any kind of program you can write . . . thoroughly and efficiently.

Periscope's the answer for debugging device-drivers, memory-resident, non-DOS, and interrupt-driven programs. Periscope works with any language, and provides source and/or symbol support for programs written in high-level languages and assembler.

David Nanian, President of Underware, Inc. (of BRIEF fame) says this about the new Periscope Version 4:

"Periscope has always been an unbelievable assembler-level debugger. Version 4 has turned it into a terrific source-level debugger as well. Aside from major enhancements like the source-level improvements, all the little changes make a really big difference, too. For instance, symbol lookups and disassemblies are noticeably faster, and highlighting the registers that have changed really makes life easier. Once again, Periscope has raised the industry standard for debuggers!"

What's New in Periscope Version 4:

- View local symbols from Microsoft C (Version 5)
- Debug Microsoft windows applications
- Set breakpoints in PLINK overlays
- Improved source-level support
- Monitor variables in a Watch window
- 80386 debug register support
- Debug using a dumb terminal
- PS/2 watchdog timer support
- Use mixed case symbols
- Set breakpoints on values of Flags
- Much more!

- **Periscope I** includes a **NEW** full-length board with 512K of write-protected RAM; (user-expandable to 1MB); break-out switch; software and manual for $695
- **Periscope II** includes break-out switch; software and manual for $175
- **Periscope II-X** includes software and manual (no hardware) for $145
- **Periscope III** includes a full-length board with 64K of write-protected RAM, hardware breakpoints and real-time trace buffer, break-out switch, software and manual. Periscope III for machines running up to 10 MHz with one wait-state is $1395.

Due to the volatility of RAM costs, prices on board models are subject to change without notice.

REQUIREMENTS: IBM PC, XT, AT, PS/2, 80386 or close compatible (Periscope III requires hardware as well as software compatibility, thus will not work on PS/2 or 80386 systems); DOS 2.0 or later; 64K available memory (128K at installation time); one disk drive, an 80-column monitor.

Call us with your questions. We'll be happy to send you free information or help you decide on the model that best fits your needs.

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PORTABLE SOFTWARE

Programs packed in ROM for traveling computer users; thoughts on Spuds MacKenzie and OS/2

Are you familiar with Spuds MacKenzie? He's that wonderfully ugly bull terrier who acts as the star celebrity in television commercials and print ads for Bud Light beer. The dog has become a major sensation. Billed as "the original party animal," you can find pictures of Spuds on billboards, posters, T-shirts, and even neon signs. But without question, it's the television spots that have rocketed Spuds MacKenzie to superstardom. And television is the medium that really defines the essence of Spuds.

The scenario for each commercial is fairly similar. Spuds is wheeled to center stage wearing a ridiculous costume (a tuxedo or a Hawaiian shirt, for example). A trio of women sings, "Go, Spuds, go!" An announcer extolls the virtues of Bud Light. Dancers whirl about the set, ostensibly portraying the exciting party life. Spuds sits there and pants good-naturedly. That's really all there is to it. Why Spuds MacKenzie should have become a national culture hero is beyond me; perhaps it's because the dog is absolutely expressionless through the course of all this mayhem. Your guess is as good as mine.

Anyway, one evening while watching another 30-second Spuds spot, I suddenly realized that Spuds MacKenzie is a perfect metaphor for OS/2. Think about it for a second. Microsoft wheels OS/2 to center stage, dressed in a tuxedo or a Hawaiian shirt. Singers croon praises. The announcer extolls the virtues of the Presentation Manager, vast amounts of addressable memory, the DOS compatibility box, and suchlike. Dancers whirl around, symbolizing the computing joy we'll achieve when we switch to the operating system of the future. OS/2 just sits there and pants good-naturedly. Absolutely expressionless.

If you follow the trade press, you'll have noticed that month by month the minimum requirements for a system that can run OS/2 go up as the projections for market share go down. Microsoft has begun muttering that OS/2 will need some sort of dynamite software package to pull the public in, much as VisiCalc lured users to the Apple II way back when.

Though the list of hardware and software companies "endorsing" OS/2 and the Presentation Manager continues to grow, we're still waiting for all that fantastic software we were promised when the show began. None of the OS/2 packages released so far has been the sort of blockbuster that would cause most people to shell out the bucks to make the switch. And Unix is sitting off in a corner somewhere, sharpening its fangs, waiting to drag OS/2 into a real dogfight.

I propose that while we're waiting for OS/2 to become whatever it is that it's supposed to become, we simply refer to it as OS/Spuds, after Spuds MacKenzie. The phrase rolls off the tongue, and the similarities are hard to miss.

There is one important difference, however. Spuds MacKenzie is doing a good job of selling beer. OS/Spuds isn't selling much of anything yet.

Smallware

I've been messing around with laptops again, after giving up on my Tandy Model 100 a year ago. It had served me well as a portable terminal and a note-taking machine, but my irritation with the teeny screen finally got the better of me. In most other respects, it's a perfect computer; supplemented with Traveling Software's Ultimate ROM II, it can do

continued

Items Discussed

MemoryMate $69.95
Broderbund Software
17 Paul Dr.
San Rafael, CA 94903
(415) 492-3200
Inquiry 934.

Tornado $99.95
Micro Logic Corp.
P.O. Box 70
Hackensack, NJ 07602
(201) 342-6518
Inquiry 935.

Z88.....$549
Cambridge/North America
SSI Computer Systems, Inc.
424 Cumberland Ave.
Portland, ME 04101
(207) 761-3700
Inquiry 936.

many things well, and it weighs almost nothing. But I found myself lugging it around and rarely turning it on, and I'm not enough of a masochist to enjoy carrying dead weight.

Currently, two machines are battling for replacement duties. Note that my needs are relatively simple. I want decent word processing and some way to communicate over telephone lines—nothing more. Forget disk drives, fancy graphics, and MS-DOS. One of the things I enjoy about this approach is that I don't have to use the same software I use on the bigger machines. Yes, I know this is a heretical philosophy and that I should be drooling at Compaqs and Toshibas, but sometimes I find it refreshing to strip down to basics.

One of the contenders is the PC-8500 from NEC, a discontinued model that you can buy only from liquidators. It's a direct descendant of the Kyocera line that includes the Model 100, only this has a 24-line by 80-character screen and some serious software in ROM, including WordStar, a spreadsheet, a filer that allows either standard fields or free-form text, and a telecommunications module. It's also a CP/M machine, which means I can run dozens of little public domain utility programs. It's heavy, though. Six pounds, not including the AC adapter and the essential 128K-byte RAM add-on. And it burns C batteries at an alarming rate. But WordStar is WordStar, and I've spent some delightful hours with the PC-8500 writing on the back porch.

The competition comes in the form of a bizarre British machine from Clive Sinclair, the Cambridge Computer Z88. To begin with, it's tiny, a hair smaller than a sheet of typing paper and less than an inch thick. It weighs about 2 pounds, and that includes four AA batteries and three ROM or RAM cartridges (I've stocked mine with two 128K-byte RAMs and a ROM that contains a communications program). The display is only 8 lines deep, but it's 106 characters wide and a supertwist liquid crystal display at that. The keyboard is rubber, but the key travel is realistic and the touch is light. Someone with thin fingers like myself can really get some speed going.

On appearance, portability, and ergonomics, the Z88 beats the PC-8500 handily. I haven't decided about the software though, and that's the purpose of throwing this discussion into my column. Both machines are based on the Z80 chip, but the PC-8500 is stocked with old friends from CP/M days, while the software in the Z88 is radically different from anything I've ever seen.

The operating system and a collection of software modules are built into the Z88's ROM. This includes a calculator, clock, alarm, calendar, diary, terminal emulator, printer editor (for saving escape sequences for your output device), file maintenance system, BBC BASIC, and a word processor/spreadsheet combo called PipeDream.

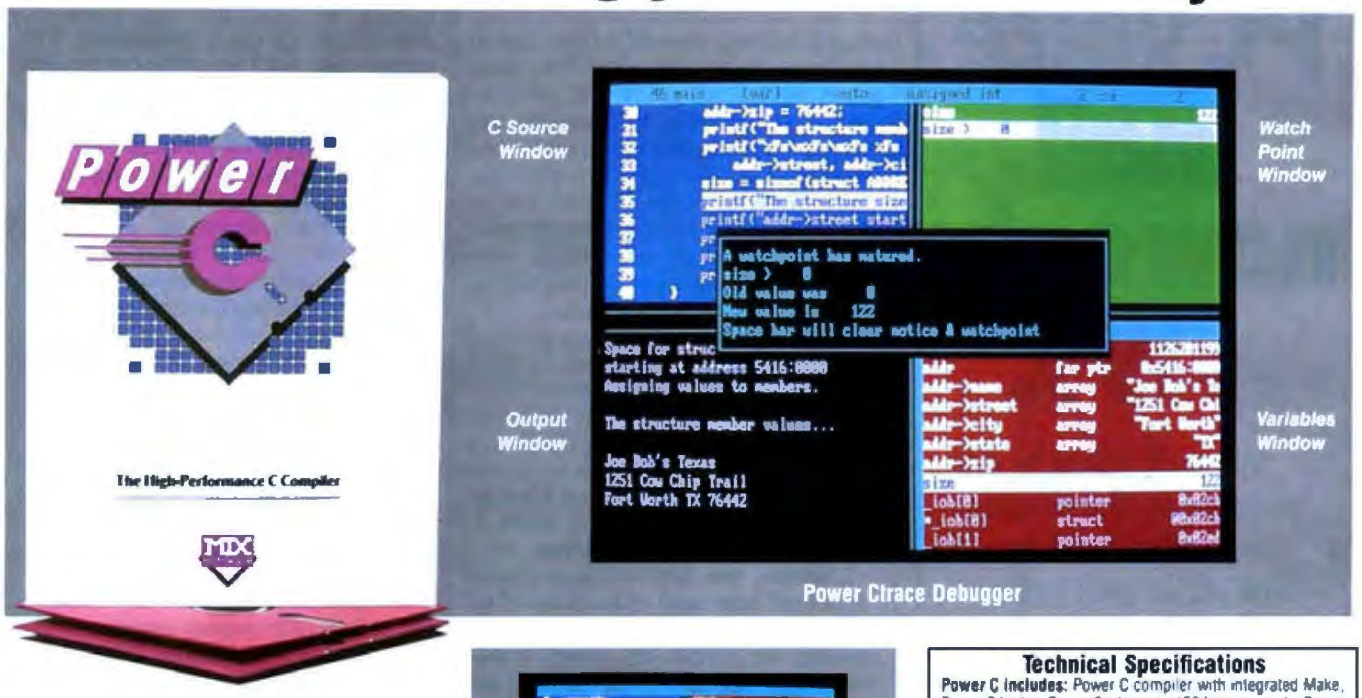
Individual modules are loaded from a main menu and remain active until you explicitly shut them down. I've heard the principle called "lazy concurrency"; although true multitasking is far beyond the capability of this machine, it saves status information in available RAM, letting you jump back and forth among applications quickly. You can even launch multiple "copies" of PipeDream for a simulation of windowing.

PipeDream itself is the major oddity. It's essentially a spreadsheet, with vertical columns labeled with letters and horizontal rows indicated with line numbers. Used as a spreadsheet, its operation is straightforward and not much different from any other spreadsheet. If you know Lotus 1-2-3 or SuperCalc, you can make the adjustment quickly.

However, the spreadsheet paradigm has been modified to allow PipeDream to operate as a fairly decent word processor as well. You can set a right margin for text, and once you begin typing, word

continued

How to create high-performance programs without wasting your time or money



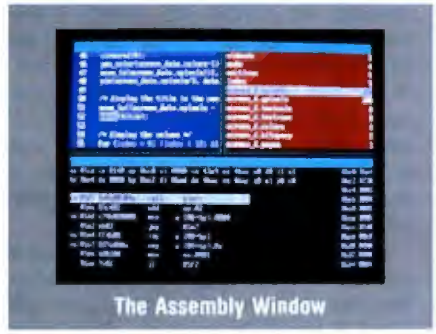
Step 1: The $19.95 Power C compiler

Power C is the new ANSI compatible C compiler that runs faster than Microsoft C and has more functions than Turbo C®. Power C combines high-performance software with superb documentation, all for less than the price of most C books alone. It's your fast route to fast programs without the fast bucks. Compare Power C to the competition and see how much time and money you'll save.

Performance/Price Chart
(execution times in seconds)

	Power C	Quick C®	Turbo C®
1) fib	23.8	53.4	26.4
2) sieve	27.6	43.2	25.5
3) tdbl	3.5	9.0	9.6
4) diskio	13.5	14.4	14.3
5) report	11.0	71.7	60.7
6) drystone	36.6	41.6	31.8
Compile/Link	73.9	113.5	81.4
EXE File Size	25120	32092	27184
Compiler Price	$19.95	$99.00	$99.95
Debugger Price	$19.95	N/C	N/A
Library Source	$10.00	$150.00	$150.00
Total Cost	$49.90	$249.00	$249.95

N/C no charge - N/A not available
Benchmarks compiled using Make utility, command-line compiler, and medium memory model


The Assembly Window

Step 2: The $19.95 Power Ctrace debugger

Power Ctrace is the new state-of-the-art C debugger that makes Microsoft's Codeview look like old technology. Power Ctrace will reduce the time you spend debugging your C programs by at least a factor of 10. With Power Ctrace, you'll be working smarter instead of harder. Actually, you'll be having so much fun that it won't even feel like work anymore.

Unlike other debuggers, Power Ctrace lets you debug graphics programs on a single monitor. You can even debug programs that write directly to video memory. However, the major advantage of Power Ctrace is simple operation. You won't waste any time trying to understand or remember cryptic commands. With Power Ctrace, a single keystroke is all it takes. Help screens show you which key to press and pop-up menus list your options. Invest just 10 minutes with Power Ctrace now and you'll save hours from now on.

Technical Specifications

Power C includes: Power C compiler with integrated Make, Power C Linker, Power C Libraries (450 functions), the Power C book (680 pages), and support for

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Optional Products:

- Power Ctrace debugger
- Library source code
- BCD business math

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1-800-333-0330

For technical support call: 1-214-783-6001

Minimum System Requirements
DOS 2.0 or later, 320K memory, 2 floppy drives or hard drive
Runs on IBM PC, XT, AT, PS/2 and compatibles

60 day money back guarantee

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State _____ Zip _____
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Computer Name _____ Disk Size ☐ 5¼" ☐ 3½"
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☐ Power Ctrace debugger ($19.95) $_____
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(includes assembler & library manager)
☐ BCD Business Math ($10.00) $_____
Add Shipping ($5 USA – $20 Foreign) $_____
Texas Residents add 8% Sales Tax $_____
Total amount of your order $_____

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B

Circle 227 on Reader Service Card

wrap takes you smoothly from line to line. Inserting text into an existing paragraph pushes following text down as needed, but deleting text requires that you issue a "reformat paragraph" command. This is a bit more automated than classic WordStar on the PC-8500, but not as slick as current MS-DOS word processors that handle all reformatting automatically. It's a minor inconvenience, though, and you quickly adjust.

More troubling, however, are traces of spreadsheet functions that have not been altered when you're in text entry mode. Though lines stretch as far as you've set the margin, they're still essentially single spreadsheet cells. The Tab key is useless for paragraph indents, as it moves you from, say, column A to column B, thereby resetting your left margin.

Likewise, you have to use a special "split line" command to insert a carriage return into the middle of an existing line; pressing the Return key merely moves you down to the next line. You can't use the left arrow key to move from the start of one line up to the end of the previous one. And block operations, oriented to cells, take whole lines only; if you want to move a sentence from the middle of one paragraph to the middle of another, you're out of luck.

I find the Z88 extremely frustrating as a result of these niggling inadequacies. Were the software only slightly more polished, it would be amazing. PipeDream lets you mix running text and columns of numbers easily, so there's no need for separate files if you're trying to generate a business report. The word-wrap and standard justification options can be used to create side-by-side narrow columns of text. Mail merge is handled easily by using a spreadsheet as a sort of database. There's even a "word count" command for writers on the go.

What's my reaction to all this? Well, even though the Z88 strikes me as overpriced at $549 without any additional memory cartridges, 2 pounds is still 2 pounds. If you need a true lightweight laptop, it's the only way to go. The Swiss-Army-knife software covers most of what you'll do on the road, barring any need for powerhouse MS-DOS programs like databases. I took the machine on a week-long trip during which I did a lot of writing, and the software never crashed.

But I do resent the small sacrifices in convenience I have to make to use PipeDream as an editor. I just wish Cambridge would spend a little more time perfecting PipeDream, making it into a more reasonable tool for text handling. And I'd love to see someone else take the concept and design a spreadsheet with margins and word wrap that can be used on other computers; it makes a lot of sense as a multipurpose tool. It's a great idea, certainly worth investigating.

What about the PC-8500? I suspect I'll keep it around for full-screen editing with WordStar, which still beats PipeDream. The Z88 will become my long-distance machine, accompanying me on trips, while the PC-8500 will live in the house, moving from room to room when I feel like abandoning my office. And with a cable, a null modem, and a gender changer, I can dump files into my bigger machines with little effort.

I refuse to take either laptop with me when I'm on vacation, though. Enough is enough.

Taking Notes

I've repeatedly expressed my affection for an MS-DOS pop-up program called MemoryMate (Broderbund, $69.95). It's a free-form text database that allows searches on any word; think of it as a stack of 120-line by 80-character cards that can be organized by issuing a search command. You can enter your data in any format you like; field names are not required.

MemoryMate will cut and paste between its records and your main application, so you can use it as a permanent text scrapbook. It's handy for note-taking, and I love the ability to enter random bits of information and retrieve them with a minimum of effort. MemoryMate works the way I do.

Things change quickly in this business, and it's now time to report on the latest batch of enhancements to MemoryMate. Although I had few quibbles with the original, I have to admit that the upgrade provides MemoryMate with several much-needed capabilities. First, the maximum size of MemoryMate's database has gone from 2 to 32 megabytes. Second, you can now switch among named databases, so you can add another level of organization to your record-keeping. Third, you can search for words using a mixture of alphabetic characters and wild-card symbols.

Fourth, MemoryMate now supports the Lotus/Intel/Microsoft Expanded Memory Specification; you have to give up only 30K bytes of main memory. Fifth, author Michael Fremont has added a linking feature, which he calls hypertext, that lets you chain related records that may not contain the same search words. It's a nice shortcut. Finally, the program is now packaged with a large se-

continued

lection of useful junk, including toll-free phone numbers, metric conversions, area codes, and, yes, DOS help.

I recommend MemoryMate to everyone, without reservation. It has been a truly great program all along, and now it's even better. However, MemoryMate is no longer alone at the top of the heap. I just received the latest version of Tornado (Micro Logic, $99.95), and I'm finding it very appealing.

The underlying philosophy is the same—both Tornado and MemoryMate are designed to keep track of odd pieces of information—but the two programs take different routes to get to the same goal. MemoryMate uses full-screen records, while Tornado employs lots and lots of windows. I once described an early version of Tornado as "looking like Framework gone mad," and the phrase is still apt.

Tornado lets you make little notes to yourself and organize them into stacks of related material. Like MemoryMate, you can search on a keyword, but Tornado also lets you flip through a stack of windows. Tornado optimizes screen appearance every time a new window is brought to the top of the stack, and occasionally things jump around a little, but this is unsettling only the first few times you use the program.

Tornado seems to be a bit quicker than MemoryMate, but its windows are generally smaller than MemoryMate records. Tornado is a much more visual program, though. And it lets you create templates, so you can enter your data into convenient forms, a feature that is lacking in MemoryMate.

On the whole, the two programs seem about equal. Both are top-notch, and I highly recommend both of them. Probably the major difference is stylistic rather than structural; I'd suggest looking at both of them before making your decision.

I think I'd prefer to use MemoryMate on a big hard disk drive–system for long-term storage; Tornado strikes me as better suited to quick reminders and a laptop environment. But whichever you choose, get one or both of them. Either program can make your life a lot easier. ■

Ezra Shapiro is a consulting editor for BYTE. You can contact him on BIX as "ezra." Because of the volume of mail he receives, Ezra, regretfully, cannot respond to each inquiry.

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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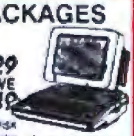

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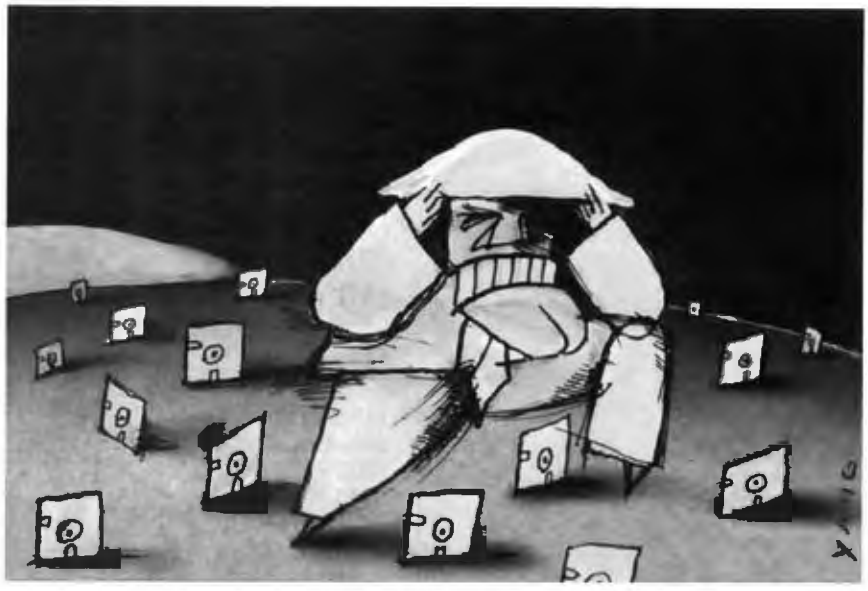
DO PRODUCTIVITY TOOLS HELP PRODUCTIVITY?

Selecting the right package is like walking through a minefield. It's easier to take the wrong step than the right.



When's the last time you made a luncheon date with someone who keeps appointments on his or her computer? You probably remember the event. "Are you free for lunch on Thursday?" you ask. Then you wait.

First you hear some beeping on the other end of the phone while the person you're talking to gets out of Lotus 1-2-3 or WordPerfect or whatever. Then he or she runs the appointment calendar program, finds the proper date, and types you in. Seems to take forever, doesn't it? It all seems like a lot of trouble, when all you had to do is take your Day-Timer out of your pocket and write in the date.

As this example illustrates, not everything that bills itself as a software productivity tool does much that's positive for productivity. On the other hand, other packages billed as productivity tools are quite helpful. How helpful depends on what the program is designed to do and how well it does it.

What Is a Productivity Tool?

Before I get too deeply into this discussion, it's not a bad idea to decide exactly what a productivity tool is. The problem is that there's little agreement among users on the exact definition. Too, the waters are muddied by those who, if they can't think of something else to call it, define their software as a "productivity tool."

The other reason for confusion about productivity tools is that there are at least two types. There are those aimed at what are essentially vertical markets. That is, they are aimed at a single specific segment of the market and are intended to accomplish work only in that field. A good example of these packages are editors for programmers, such as the SideKick editor or the Condor editor. Likewise, an on-line thesaurus such as Word Finder is a productivity tool for writers. Systems analysts might use Index Technology's Excelerator to help in system design.

Then there are the tools aimed at horizontal markets. They are intended to be used by nearly anyone in nearly any business. A good example is SideKick's appointment calendar or its phone dialer. Borland once had the field to itself. But now such packages as Prodex and Take Charge have entered the picture. On a grander scale, there's GrandView, which promises managers to improve productivity.

The Vertical Approach

If there's one area where productivity tools are really likely to shine, the vertical market is it. Generally, vertical packages are developed by people who actually use them. Programming editors are developed by programmers, for example. Provided you like the approach they use, chances are these packages will, indeed, enhance your productivity.

The secret to success of the vertical market tools is that they don't even attempt to be all things to all people. They simply take aim at a particular function, such as the programming editors mentioned above, and try to make that function easier to handle. If you're shopping for these types of tools, you've got a good chance of finding something that will help whoever's going to end up using the tool. You will need to take care, though, that the tool you select actually does what the user wants.

The Horizontal Approach

Trying to select the proper type of horizontal productivity package is like walking through a minefield. It's infinitely easier to take the wrong approach than

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the right one. The reason is simple.

These products generally attempt to perform some computer function you are already doing in another way. When you adopt the tool, you have to change your habits and your way of doing your job. This is not to say that your habits don't need changing. They might. But if you're going to change them, before you buy, you need to make sure that the new way actually works well with the way you do business.

Let's look at Borland's SideKick, for example. This was one of the first of the memory-resident productivity tools. Recently, it has been supplanted by a new version, SideKick Plus, a program that operates on the same principle as the SideKick clones that are available. They all give you access to a set of memory-resident tools that are supposed to make your job easier by running in the background so you can access them at the same time you are operating another program.

If you spend nearly all your time at your desk with your computer turned on and don't have processes running that conflict with memory-resident programs, SideKick can be a real plus. No matter what you're running at the time, you can open a window on your screen and make a note, set up an appointment, or look up a number. Under those circumstances, it's pretty handy.

But if you spend a lot of time out of the office, either in meetings or on the road, how can you use SideKick?

This situation illustrates the problem with productivity tools that depend on your computer. You have to be using the computer to make use of them. I suspect that the copies of SideKick and its clones that sit unused on hard disks number in the tens of thousands.

These packages are unused because their owners found that it was easier to use their Day-Timers to keep appointments or phone numbers than it was to use their computers. The reason may be as simple as their having to share the computer with a coworker. Or they may spend a significant amount of their day in meetings in rooms where there aren't any

computers. Despite their many advantages, IBM PCs or Macintoshes still can't be slipped into your coat pocket when you head for a meeting.

Deciding What You Need

Now that we've discussed what can go wrong with productivity tools, let's talk about what can go right. There are, after all, many such packages that are worth buying, or people wouldn't be buying so many of them. You need to see what suits your particular style of work before you can take advantage of their features, however.

The first thing you need to decide is whether you spend a lot of time at the computer. If you don't, a computer-based productivity tool will be of limited value to you. You also need to consider whether you have access to a computer when you are at your office. If you have to share a PC with six other people, it may not be handy when you need to be productive.

Once you have arrived at the conclusion that you really are at the computer most of the time and that you are the person who usually has access to it, you must explore what you need in order to be productive. Your decision depends heavily on what you actually do at the office. Are you a programmer who spends much of the day typing in code? Then one of the tools developed specifically for programmers could make a big difference to your work, but a phone dialer is probably not necessary.

On the other hand, if your Rolodex has had its 100,000-mile checkup in its second year, maybe an address list and a phone dialer really are a good idea. If so, chances are you wouldn't benefit a great deal from an editor that automatically produces the indentations for C source code.

Once you decide what functions you would actually use, you should go to the software store and try the packages yourself. Each productivity package is a little different, and since these tools have to fit your personal work habits so closely, their subjective feel is quite important. Even if a package has every feature you'd ever want, you won't use it if it feels clumsy to you.

While you're checking things, take a look at the documentation. If you're helping other users select their software, it will help a lot if you can read and understand the manual. An example of this is a package called Take Charge! from Departmental Technologies. This product has aspects of a number of other productivity tools, making the manual reasonably important, but the text is so small that it's nearly impossible to read. It looks like they photoreduced a full-size page until it was the size of a paperback book.

Analyze your job and the way you perform it to decide whether one of these tools really will help you.

Manager's Tools

While there are those who would argue that the use of the terms *productivity* and *manager* in the same sentence is an oxymoron, there are a number of tools becoming available that are aimed specifically at the manager. These tools are understandably quite different, since a manager's job can be extremely varied. GrandView (for IBM compatibles) and More (for the Macintosh) from Symantec are examples of this concept.

GrandView and More are extremely flexible outlining programs. I think they are billed as management tools because of their flexibility. You can create outlines, fill them in, turn them into memos, and arrange them by categories. If this is the way you manage, these features could be useful. On the other hand, these activities may be done by more junior-level people. You have to look at your work and decide.

Do They or Don't They Help Productivity?

It depends. You have to analyze your job and the way you perform it to decide whether one of these productivity tools really will help you get your work done easier and faster. It might be that they won't. ■

Wayne Rash Jr. is a member of the professional staff of American Management Systems, Inc. (Arlington, Virginia), where he consults with the federal government on microcomputers. You can reach him on BIX as "waynerash."

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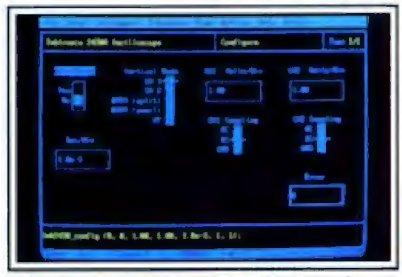

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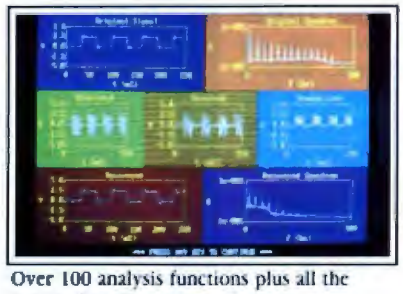

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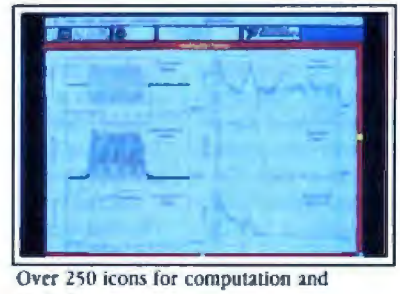

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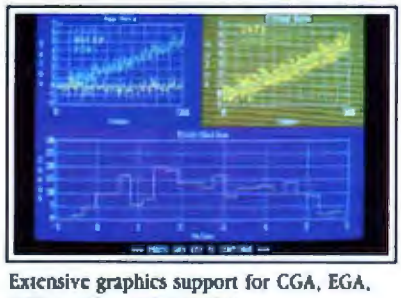

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HOT STUFF

The products that outshined the rest in the halls of MacWorld Expo

Another MacWorld Expo has come and gone, this time from a sweltering Boston locale. MacWorld Expo has become a big deal: too big, in fact, for the show organizers, Mitch Hall Associates/World Expositions. The show bridged four hot, humid days in August, and it was spread over three different locations (the World Trade Center, the Bayside Expo Center, and the Wang Center), each one inconvenient to reach through the legendary, even insane Boston traffic.

Although the show attracted more exhibitors and attendees than ever before, it was painfully evident that the facilities and conference were both being strained to their limits. As happened in August 1987, the air conditioning at the Bayside Expo failed on Thursday, and at the World Trade Center it lacked sufficient cooling power to keep the crowds comfortable. The Wang Center was cooler, but was used only for keynote speeches and panel discussions, not vendor booths.

Although attending the show was an exercise in patience and perspiration, I had a chance to try out a number of interesting new Mac products. This Expo is best characterized by the evolutionary nature of the products shown, rather than any revolutionary ones. The show finally brought home to me just how far the Mac has come in 4 years. There is no doubt that the Mac is now taken as a Serious Business Machine by vendors. Just counting the number of new Mac-to-mainframe communications products at the Expo took me the better part of an afternoon.

While it's gratifying to see the Mac recognized by business for the powerful tool it's always been, I also have a feeling of sadness. The Mac is no longer the cultural icon it had been, venerated by hobbyists, hackers, and academics. Fortunately, the Expo still had space for plenty of "small" products that don't offer every gee-whiz feature and cost a bundle. The Expo proved that Mac entrepreneurship is alive and well, thank you.

Hard Disk Salvation and Communications Products

1stAid Software's 1stAid Kit has saved my bacon on more than one occasion by recovering files from disks I had zapped by mistake. When I saw the new version (2.5) at the Expo, I was even more impressed. The application is a complete package of utilities that recovers seemingly lost files from disks that have crossed the great divide. The newest utility is called Quick Cure, and it lives up to its name. It makes fast work of scanning bad disks (hard or floppy), diagnosing problems, and recovering lost or damaged files. Like the earlier 1stAid Kit versions, 2.5 will work with any HFS version of the System and Finder, including the newest release, System Tools 6.0. At $99.95, 1stAid Kit is a bargain.

If I could point to a dominant theme at the Expo, it would be the maturation of Macintosh networking and communications products. A bunch of companies have upgraded earlier communications products that connect the Mac to corporate mainframes (IBM, DEC, etc.), using just about every communications protocol and access method known to mainframedom. These programs now offer reliability and full MultiFinder support, where they once were kludgy and flaky.

Another category of improved communications products includes those that permit customized applications. Connect, the company that offers the MacNet

continued

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Items Discussed

Acknowledge.....$495
SuperMac Software
P.O. Box 390725
295 North Bernardo Ave.
Mountain View, CA 94039
(415) 964-9694
Inquiry 841.

DaynaMail
for five Mac nodes $295
Dayna Communications, Inc.
50 South Main St., Fifth Floor
Salt Lake City, UT 84144
(801) 531-0203
Inquiry 844.

DaynaTalk
per Mac node $189
per IBM PC node $289
Dayna Communications, Inc.
50 South Main St., Fifth Floor
Salt Lake City, UT 84144
(801) 531-0203
Inquiry 845.

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Jasmine
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San Francisco, CA 94124
(800) 347-3228
Inquiry 843.

DirectTape..... $1099
when purchased with a
DirectDrive hard disk drive $899
Jasmine
1740 Army St.
San Francisco, CA 94124
(800) 347-3228
Inquiry 842.

1stAid Kit 2.5 ..... $99.95
1stAid Software, Inc.
42 Radnor Rd.
Boston, MA 02135
(617) 783-7118
Inquiry 840.

on-line service, announced a special toolkit called the Connect Protocol Manager that permits developers to write custom applications for accessing MacNet.

Another product, Acknowledge, from SuperMac Software, carries this custom communications theme even further. Acknowledge generalizes the concept of creating communications applications so you can write custom programs that run on the Mac and effect seamless connections to any remote computer or on-line service. Acknowledge is a development system for producing end-user Mac communications applications that don't require modification of the remote host's communications software or protocols.

Acknowledge includes its own programming language, TAL (Telecommunications Access Language). TAL allows you to build true Mac applications with pull-down menus, icons, dialog boxes, and so on. Acknowledge also includes some sample applications to help you get started, although TAL is straightforward enough that it doesn't present a steep learning curve for professional programmers.

The sample Acknowledge applications show that the programs you create can be made to look and work like popular single-purpose communications programs, such as DeskTop Express, CompuServe Navigator, and AppleLink.

Backing It Up

In September I reported on the very reliable and fast Tecmar QT-Mac40 DC-2000 tape drive. I'm happy to report that Tecmar has found an OEM for its drive: Jasmine. Jasmine calls the drive DirectTape, and it's virtually identical to the Tecmar-labeled unit, including similar backup/restore software. I used the tape for about an hour at the show (admittedly a poor test of reliability), and it did indeed work just like the Tecmar unit. Both Tecmar and Jasmine assured me that the drive was functionally identical to the Tecmar drive, and I'd expect it to be equally reliable. In any case, it's nice to see that a good device is being sold by another reliable vendor.

Jasmine has priced the drive at $1099, almost $300 lower than Tecmar. If you buy it in conjunction with any Jasmine hard disk drive, the price drops even farther to $899. The price includes a t-adapter with a 25-pin Mac small-computer-system-interface connector and two 50-pin standard SCSI connectors, so you can plug your DirectTape into just about any existing SCSI cabling setup. The price also includes two preformatted DC-2000 tapes, so you can use the drive as soon as you've hooked it up. Jasmine has taken the solid Tecmar drive and repackaged it as a better value. If you still haven't bought a backup device, check it out. Come to think of it, at $1099, you might want to dump your current slow backup drive (like the Apple 40SC) and buy the Jasmine.

DirectPrint

Although Jasmine introduced several other new products at the show, I was most impressed with the DirectPrint printer. The DirectPrint, which should be shipping by the time this column hits the streets, is a PostScript printer that includes 3 megabytes of RAM and 35 PostScript fonts embedded in 1 megabyte of ROM.

It's small, about 35 pounds, and takes up only a moderate amount of desk real estate (16 inches wide by 13½ inches deep). It's also fairly fast, with an average throughput of 6 pages per minute. The 4-MHz Weitek XL-8200 processor keeps the printer near its rated speed by composing pages quickly. The DirectPrint can be connected to your Mac by using AppleTalk, a Centronics parallel port, or an RS-232C serial port. It also includes an Apple Desktop Bus port for future connectivity options that Jasmine only hinted at. Jasmine says the DirectPrint will cost under $4000.

Although these are good specifications and the price is attractive, the really interesting point about the DirectPrint is that it's *not* a laser printer. Instead it uses a much newer technology: a liquid-crystal shutter-marking engine, the Casio LCS-130. This 300-dot-per-inch printing engine produces blacker blacks than the Canon LBP-SX laser engine or an Apple LaserWriter IINTX. It also lacks the rotating and swiveling imaging mirrors common to some laser printers, which should mean that the printer won't suffer from scanning distortion. This also means that long-term reliability will be high (remember the equation: fewer moving parts = higher reliability).

Putting It in the Mail and Getting It There Quicker

I've never really thought highly of the current crop of electronic mail packages available for the Mac (InBox and Microsoft Mail spring to mind). Oh sure, they work as billed, but their interconnectivity is not great (you can't use them easily across interconnected networks of machines other than Macs), and their mail-handling features are pretty basic.

Enter DaynaMail. This new mail system works on both Macs and IBM PCs. It supports network connections through AppleShare, Novell's NetWare, 3Com's 3+, and Sun's TOPS. It can also com-

continued

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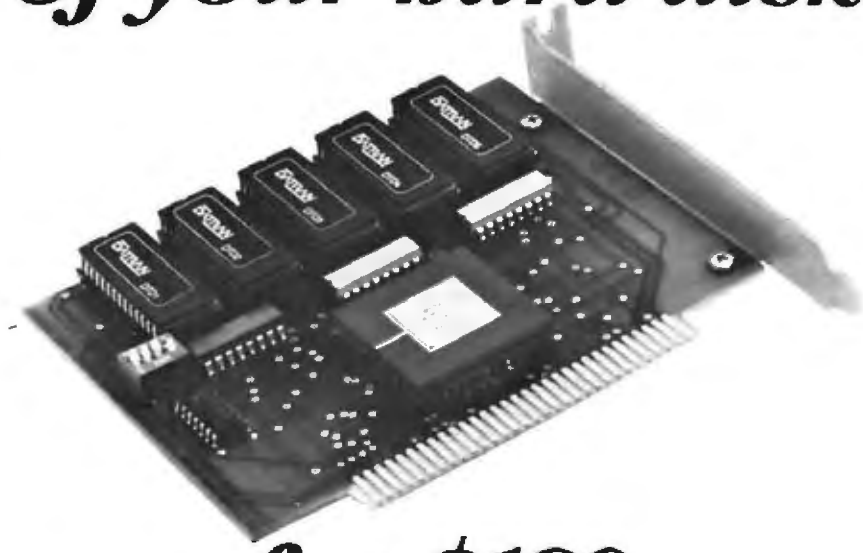

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municate with any application on remote computers that is compatible with Action Technologies' MHS communications package. MHS-compatible products include IBM's PROFS, DEC's All-in-1, and Action Technologies' The Coordinator. This connectivity gives DaynaMail serious wide-area capabilities that should be attractive to computing environments like mine, where you have to make disparate computers communicate with each other over every cabling scheme and network setup known to humanity.

DaynaMail works as an application on an IBM PC and as a desk accessory on a Mac. The program is server-based, and any machine on the network can be designated as a DaynaMail server. You can also set up multiple servers on the same net to better distribute the message load. I tested some of the mail database features at the show, and all of them worked as billed: message sorting by multiple criteria, saving and restoring unfinished draft messages, attaching any file to a message, sending blind carbon copies, message receipt and message opening notification, mail address lists, multiple address books, incoming mail alert, and several others.

In my brief time testing DaynaMail, I was hooked. I'm already set to test it in a full-blown configuration here at the university. I'll have more to say about how it works in the real world over the next couple of months.

All of you who are sick and tired of waiting for your AppleTalk network to clear so your LaserWriter job prints, raise your hands. AppleTalk is a great idea. Building a network into the Mac was a stroke of genius on Apple's part. But now that we're all hooked on this network, the fact is it's *too bloody slow!* 230K bits per second over LocalTalk or PhoneNet cabling just doesn't cut it anymore.

Sure, we can buy Mac IIs and migrate to EtherTalk and its 10-megabyte-per-second bandwidth, but that's a pretty expensive solution. Well, hold off on those EtherTalk purchases, because DaynaTalk has just been released.

DaynaTalk is a small (2- by 3- by 1-inch) hardware module that replaces your LocalTalk or PhoneNet node and plugs into your existing network. It boosts the data-transmission rate to as high as 850K bps for each Mac and as high as 1.7 megabits per second for each PC on the net. You'd be surprised at the difference between 230K bps and 850K bps.

DaynaTalk works by varying the transmission rate over the network; it takes advantage of periods of light usage to cram more AppleTalk packets down the pipe. I expect to test the devices soon in my own labs, so I'll have more to say about this magic network accelerator in a future column. For now, it's enough to know that it really works; it's completely transparent to the network; it's fully compatible with TOPS, AppleShare, and NetWare Mac; and it costs but $189 for each Mac, and $289 for a PC. ■

Don Crabb is the director of laboratories and a senior lecturer for the computer science department at the University of Chicago. He is also a consulting editor for BYTE. He can be reached on BIX as "decrabb."

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OS/2's MULTITASKING DASHBOARD

You can fine-tune OS/2's CONFIG.SYS file to give optimum performance for your particular setup

One of OS/2's two big draws is multitasking. (The other, of course, is large memory.) Multitasking is a bit of processor sleight of hand that makes a single piece of silicon seem to do more than one thing at the same time.

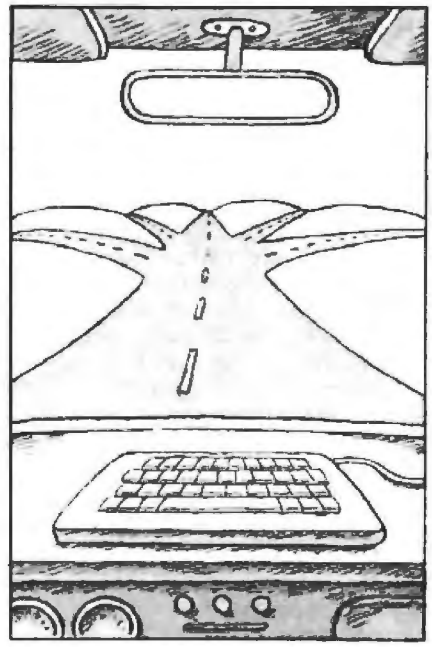
At first blush, this seems simple: If you have *n* programs in the computer, just give each program a small amount of CPU time, called a *time slice*. Program 1 gets 10 milliseconds, program 2 gets 10 ms, and so on. How tough could that possibly be?

That approach isn't tough at all. But it's also inadequate for communications programs, as they can't afford to be totally inactive for a number of time slices. It's also inefficient for I/O-bound programs, since they may end up getting an entire time slice in which all they do is wait for a keystroke.

Everyone Is a Systems Programmer

Any decent multitasker—and OS/2 falls into that category—goes beyond simple time slicing. But beyond simple time slicing, there be dragons. There's no best way to multitask, so multitasking operating systems have a wealth of *tuning parameters*, variables you adjust to get maximum performance. In the DOS world, the `buffers=` variable is one example of a tuning parameter.

The names of some new multitasking parameters are `priority`, `timeslice`, and `maxwait`. Such tuning parameters are important in multitaskers. For example, when I used to work in a large IBM-



mainframe-based DP shop, users would periodically learn that on such and such a day the system would be upgraded by the addition of more or better processors, I/O processors, or the like.

"Great," we'd say, as this would no doubt improve response time. But the day after the installation, response time would stink. Why? Because the system hadn't been tuned. There's a whole cadre of people at mainframe shops whose jobs revolve around adjusting the tuning parameters of the system to get maximum throughput: They're called systems programmers.

The other day, I had a conversation with the president of a well-known database company while flying to California (there's something strange about this, but 50 percent of the people I meet on planes seem to be in the computer business, and I do a lot of flying). He complained, "OS/2 sounds good, but I'm afraid it's going to force me to become a systems programmer in my spare time to get anything out of it."

There's no getting around it: You'll have to fool around with OS/2's multitasking parameters a bit. But here are a few results and some insight into getting the most out of OS/2 multitasking.

Schizophrenic Slicing: The Priority Parameter

Reviews of OS/2 often discuss the "OS/2 scheduling algorithm," as if there were just one. In fact, OS/2 has two algorithms. You select one or the other with the `priority=` variable in the CONFIG.SYS file. The legal values for this are `absolute`, an egalitarian algorithm, and `dynamic`, a foreground-selfish algorithm.

`Absolute` is pretty straightforward. I wrote a test program called TIME1 that does simple computations over and over again. It does no I/O except for a final performance report, so it is a compute-bound program. Then I ran eight copies of TIME1, one in the foreground and seven in the background. The programs report how many computations they got done per second. The results are shown in table 1.

Note that all tasks get equal time. The foreground doesn't get any special treatment. But if you do the same run with `priority=dynamic` in the CONFIG.SYS file, as shown in table 2, you'll see quite a difference. The `dynamic` algorithm gives a much greater share of the CPU's attention to the foreground than to the background.

Microsoft included the `dynamic` option (in fact, it's the default value for `priority=`) as part of what Gordon Letwin, the architect of OS/2, calls the "OS/2 religion." In traditional minicomputer and mainframe systems, he argues, the desire is to make each user seem to get a fair share of CPU attention. Under OS/2, however, we have a multitasking operating system without multiple users. In this case, we're not concerned with

continued

Table 1: *The results of TIME1, a simple compute-bound program run under OS/2. Eight copies of the program were run as simultaneous tasks, one in the foreground and seven in the background. The figures are the number of computations each copy performed per second. Note that all tasks got equal time.*

Task name	Computations/sec
Foreground	280
Background 1	279
Background 2	279
Background 3	279
Background 4	279
Background 5	279
Background 6	279
Background 7	279

Table 2: *The results when the test in table 1 is repeated with* `priority=dynamic` *in the CONFIG.SYS file. The foreground task now receives a much greater share of the CPU's attention.*

Task name	Computations/sec
Foreground	1338
Background 1	142
Background 2	140
Background 3	141
Background 4	141
Background 5	142
Background 6	141
Background 7	67

giving a fair shake to each program. Instead, we're interested in giving the lion's share of the CPU time to the foreground program—the one the user is interacting with at the moment.

Minute by Minute: Timeslice

The OS/2 command `timeslice` appears in the CONFIG.SYS file as

```
timeslice =
<maximum><,minimum>
```

where the minimum is optional and the maximum must be at least 32 ms, the resolution of the OS/2 clock (length of one timer tick). The ticks of the timer tell OS/2 that it's time to stop doing whatever it's doing and consider switching to another program.

What's a good value for `timeslice`? That depends on what you're doing. Think of it this way. Suppose I have two projects to work on at the same time. I could work on project 1 for 6 months, then project 2 for 6 months. This would work, but the client for project 2 might get a bit antsy knowing that I'm working only on project 1 for 6 months.

It's the same thing with OS/2. If I set `timeslice` to, say, 30,000 (30 seconds), OS/2 seems very balky. When it is paying attention to the foreground task, the system seems quick. But then it seems to die for a few minutes, as it devotes a few time slices to the background programs. The length of the time slice causes the choppy behavior. So, time slices can be too large.

Returning to my two projects, suppose I try the opposite approach. I'll spend a minute on project 1, then a minute on project 2, then a minute on project 1, and so on. Won't this seem a lot smoother to my clients?

No, again. The reason: It takes time to switch from one task to another. I've got to stuff whatever I'm doing on project 1 into a folder, then find the folder for project 2 and put the things from that onto my desk. That process may take 10 minutes. That implies that I work for a minute, switch tasks for 10 minutes, work for a minute, switch for another 10 minutes...you get the idea. Notice that the switching time has no relation to the size of the time slice. If I switched only every 6 months, I'd still require only 10 minutes.

So time slices are like the beds Goldilocks found: There's "too hard," "too soft," and "just right." For strictly CPU-bound programs, a larger time slice (about ½ second) is good. For communications programs, which can't afford to be out of commission for long, small time slices are good. Unfortunately, you just can't adjust `timeslice=` on the fly. You must change your CONFIG.SYS file, then reboot—what a pain.

To demonstrate the effect of `timeslice=`, I ran my CPU-bound TIME1 loop program in the foreground and in the background simultaneously. I ran it for different time slices, with values ranging from 32 ms to 8 seconds. The results, which are found in table 3, show the range of good time slices, but they also seem to point to some strangeness in the OS/2 `priority=dynamic` scheduling algorithm, as I'll explain.

Multitasking systems are stochastic, so rerunning the benchmarks could yield a completely different set of results. The numbers seem to show that a time slice in the range from 1024 ms to 4096 ms

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Table 3: *The results of the TIME1 test, run with two simultaneous copies, one in the foreground and one in the background. The figures are the number of computations performed per second with the* `timeslice` *parameter set from 32 ms to 8 seconds. Note that, in this case, the foreground task receives the most CPU attention with* `timeslice` *set to less than 512 ms (½ second).*

Time slice (ms)	Foreground computations/ sec	Background computations/ sec	Total computations/ sec
32	2134	86	2220
256	1622	642	2264
512	1660	648	2308
1024	1245	1246	2491
2048	1170	1213	2383
4096	1477	1181	2658
8192	1022	1295	2317

yields the best total system throughput. Given the choice, though, you should take a smaller time slice. Sometimes a larger time slice leads OS/2 to put all the background jobs on hold until the foreground task is done. But the strange part is how the allocation of time shifts from foreground to background. It seems that as the time slice gets larger, the background priority gets higher. I haven't yet figured out why this is so, but I'll let you know as soon as I do.

How Long Must I Wait?: The Maxwait Parameter

Programs in OS/2 are assigned different priorities. Higher-priority programs generally get all the CPU's time, causing lower-priority programs to suffer from "CPU starvation." The `priority=dynamic` algorithm amends this by watching how long each program has been CPU-starved. After a certain number of seconds, the CPU-starved program's priority is nudged up a bit.

This still may not be enough to get it any CPU time, so even more seconds later the program's priority is nudged up again. This process continues until the program actually gets CPU attention for a single time slice; then its priority is returned to its original low level. The whole thing then starts over, as the program makes a slow climb up the priority ladder.

The `maxwait` parameter controls the above procedure. The command looks like

`maxwait =` *<number of seconds>*

You include this line, like `priority` and `timeslice`, in the CONFIG.SYS file. The system nudges up the priority of CPU-starved programs every `maxwait` seconds. For example, say it takes four nudges to give a program sufficient priority to get some CPU time. The program ends up getting a time slice every 4 × `maxwait` seconds. If `maxwait` equals 1, the program gets a time slice every 4 seconds. If `maxwait` equals 10, the program gets a time slice only every 40 seconds.

It would be nice if we could assign a different `maxwait` for every program, but we can't. There is just one global system `maxwait` value.

This command is most important for keeping background processes alive. When `priority=dynamic`, recall that the background processes drop in priority. With a large value of `maxwait`, the background performance drops markedly. Of course, with `priority=absolute`, `maxwait` has no effect.

My Settings

OS/2's three new CONFIG.SYS commands—`priority`, `timeslice`, and `maxwait`—will all have a significant effect on your system's performance. Of the two `priority` options, `priority=dynamic` is the more interesting. I set my `timeslice` to 512 (½ second), which for me is a compromise between choppy switching and excessive overhead. I don't do OS/2 communications much—all my favorite communications programs still require DOS—but when I do, I'll no doubt have to drop this value. I leave `maxwait` at 1, or else nothing gets done in the background. ■

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Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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COM1: ■ Brock N. Meeks

YOU CAN'T GET THERE FROM HERE—OR CAN YOU?

The development of gateways could pave the way for a nationwide telecommunications network

"You can't get there from here." That's the classic comeback to the beleaguered traveler, and it usually draws a small, if weary, smile. But when you use that line in the context of the on-line community, people don't smile; they wince.

On-line networks are fractured and compartmentalized. It's a small miracle that anyone finds his or her way around. Yes, we have packet-switched networks, but these information highways resemble the state of America's highway system around the turn of the century (few signposts exist, and maps are confusing, if they exist at all) more than today's "state-of-the-art" superhighways.

The French solved this problem by installing a single information highway called Minitel. Minitel has become the world's standard on linking information services with the end user. For the French, it was a relatively easy solution. The phone system is a monopoly. One system serves the entire country, no questions asked. But such an environment doesn't exist in the U.S.

When Judge Harold Greene's Modified Final Judgment (MFJ) broke up Ma Bell's monopoly, thus creating the seven regional Bell operating companies (RBOCs), he put very rigid controls on what types of services the RBOCs could and couldn't provide. One constraint prohibited the so-called Baby Bells from providing "enhanced services, such as data networks that would allow links to information providers." This created a competitive environment wherein packet-switched networks could thrive.

But that environment changed radically last March, when Greene, during his triannual review of the MFJ, allowed the RBOCs the opportunity to create information highways, now called "gateways."

Cutting the Ribbon

Judge Greene essentially "cut the ribbon" on these new highways by allowing the RBOCs to provide such capabilities as voice store and forward, protocol conversion, gateway services, electronic white pages, and information storage. He has allowed the RBOCs to participate in everything except the origination of information content. In essence, Greene's decision has laid the groundwork for a revolutionary information infrastructure.

Greene's action isn't a simple twist of free market ideology; his decision tosses a gauntlet at the feet of the RBOCS, challenging them to prove themselves.

You see, Greene is enamored of the French Minitel system. And he makes it no secret that he'd like to see something similar spring up throughout the U.S. He now wants to see just how much intelligence and market savvy the RBOCs really have. If they pass this test, if they create a viable market from within this gateway structure, he may at some point give the RBOCs much more freedom to compete in the information industry. But that's a big "if." (And it raises disturbing questions better dealt with in another column.)

Making It Work

According to Robert Smith, president of the Videotex Information Association (VIA), the forthcoming gateways should contain the following characteristics:

- *Ease of use.* The gateways must be usable by novice or untrained users, as well as by expert users. The implication is that gateways will need to offer a variety of navigation options to allow full access to novices while not being perceived as slow or cumbersome to experienced users.
- *Affordability.* The use of the gateways must not significantly raise the cost of using information services. Ideally, they should lower information costs.
- *Ubiquity.* For information services to be accessible to the widest audience possible, gateways must be implemented across the entire North American landscape, not merely in a limited number of markets.
- *Uniformity.* Gateways should have a standard "look and feel" so that users traveling from one location to another will not be required to learn new procedures for using the gateway. There must also be a gateway-to-gateway connection.

To the user, the gateway should appear as a directory. The directory would contain a series of menus listing each information provider connected to the gateway. Standards for these directories have yet to be hammered out, but it's widely recognized that they all should be uniform in appearance.

By dialing into the gateway, you'll have hundreds, perhaps thousands, of information services to choose from. You can search the directories by keyword. Once you've located your desired information service, the gateway will connect you directly to that service. This will eliminate the need to memorize the commands for several different networks.

According to the VIA, by the year 2000, the availability of gateways will have increased sufficiently so that travelers will be able to access their "primary gateway" via a simple, standardized interconnection procedure. Each gateway will be sufficiently compatible to include the ability to gather and store information about individual users. Each gateway will match the user's terminal and navigational preferences and establish a

continued

means of payment for use of the gateway and of services reached through it.

The Four Cs

Content is perhaps the most important issue when discussing gateways. John Gunter, a Bellsouth vice president, says that the aim of his company's Transtex Universal Gateway (TUG) market trial is to supply a "market basket" rich enough to draw a wide audience of users. The critical mix of this market basket is a host of localized information services.

Gunter identifies such local information services as hospitals, schools, local governments, social services, and even small businesses. Industry observers say that the success of gateways will depend on the RBOCs' ability to recruit such "nontraditional information providers." In this way, information services available on the local gateway will be relevant to the everyday lives of the people using the gateway. Such localized services might include ticket purchases for local entertainment establishments and on-line restaurant reservations.

The cost factor cuts three ways. First, the cost of accessing information services is likely to drop. This should entice more people into using on-line information services. Costs will drop because, in most cases, users won't have to lay out subscription fees for several different services. Instead, they will pay a small fee for using the gateway to access those same services that once required costly subscriptions or minimum monthly usage fees. This will encourage more casual use of information services in a kind of "pay as you go" atmosphere.

Second, costs to the information providers themselves will drop. Currently, start-up costs for an information provider are prohibitive. This is due, in part, to capital investment in equipment, administrative overhead, and the costs of "hanging" that service on an existing packet-switched network. Because the RBOC gateways can store information, an information provider need supply only the information, not the equipment. Administrative functions, such as billing services, can be handled by the gateway, too. And the means of access is, of course, taken care of by tying into the established gateway. Most agree that the cost of "hanging" an information service on a gateway will be substantially lower than a similar setup on a packet-switched network like Telenet.

When a mass market for information services starts to materialize, many of the costly information services in existence today will have to rethink their pricing structures. The current high cost of information is due to an extremely narrow market. However, as more users begin to access the gateways, information providers should be able to lower costs, making up in volume what they lose by lower prices.

As costs are lowered, more people will access the service. This could lead to even lower costs, owing to a higher volume of users. The same "domino effect" has occurred over the past 3 years with long-distance phone rates. As the total number of long-distance telephone calls rose dramatically, the FCC ordered rates cut in direct proportion to the high usage. Each time rates were cut, usage went up, and again the FCC ordered rate cuts.

The issue of coverage was summed up by Congressman John D. Dingall when he said, "A democratic society is at risk if it allows only an elite few to reap the

benefits of the information revolution." Ubiquitous coverage is the ultimate goal of these gateways.

Last May, Bellsouth Chairman John Clendenin gave a speech during the SuperComm trade show in which he said his fond vision is the development of telecommunications to "offer the most rural community in this nation the opportunity, via a gateway network, to be a viable player in the global information marketplace."

Conflicts

There is seldom any kind of innovation that does not fall prey to conflict. Gateways are no exception. For starters, established information services, such as CompuServe, have been very vocal in opposing gateway experiments. CompuServe is afraid that gateways will dilute its user base. On the contrary, with the likelihood of casual usage by potentially millions of users, CompuServe and services like it stand only to gain from being accessible via a gateway service. Indeed, after CompuServe lost its initial appeal to the FCC to have the gateway experiment squashed, it has now signed with at least two different gateway projects.

Other conflicts came from newspapers, which fear a loss of classified advertising revenue. It's a healthy fear, because newspapers last year racked in some $32 billion in classified ads alone, according to the Newspaper Advertising Bureau. The danger is that users might turn to on-line services where they can electronically search for services, rather than thumb through the daily newspaper. If the gateways are successful at recruiting local businesses, newspapers might well see a drop in ad revenues.

Packet-switched networks also stand to lose. With cost-effective rates offered by gateways, in addition to supplementary services such as billing and information storage, information providers could easily be seduced away from the packet-switched networks. However, because an information provider cannot directly connect to a gateway service outside of its own region (for example, a Boston company cannot directly connect to Pacific Bell's gateway), packet-switched networks can be used to bring the information provider to the "door" of a remote gateway service. This arrangement will likely cause a shift in the role of packet-switched networks.

Looking Forward

Currently, three gateway experiments are under way, conducted by Bell Atlantic, Bellsouth, and NYNEX. At least two others, Pacific Bell and Ameritech, have gateways on the drawing board that should be ready for testing soon, if not already in use by press time.

Gateways, if successful, will change forever the way we think and interact with information services. If the RBOCs can truly create a ubiquitous information highway, they will create an environment of low-cost, easily accessible information that will eradicate today's information elite subset.

Now that's something to smile about. ■

Brock N. Meeks is a San Diego–based freelance writer who specializes in high technology. You can reach him on BIX as "brock."

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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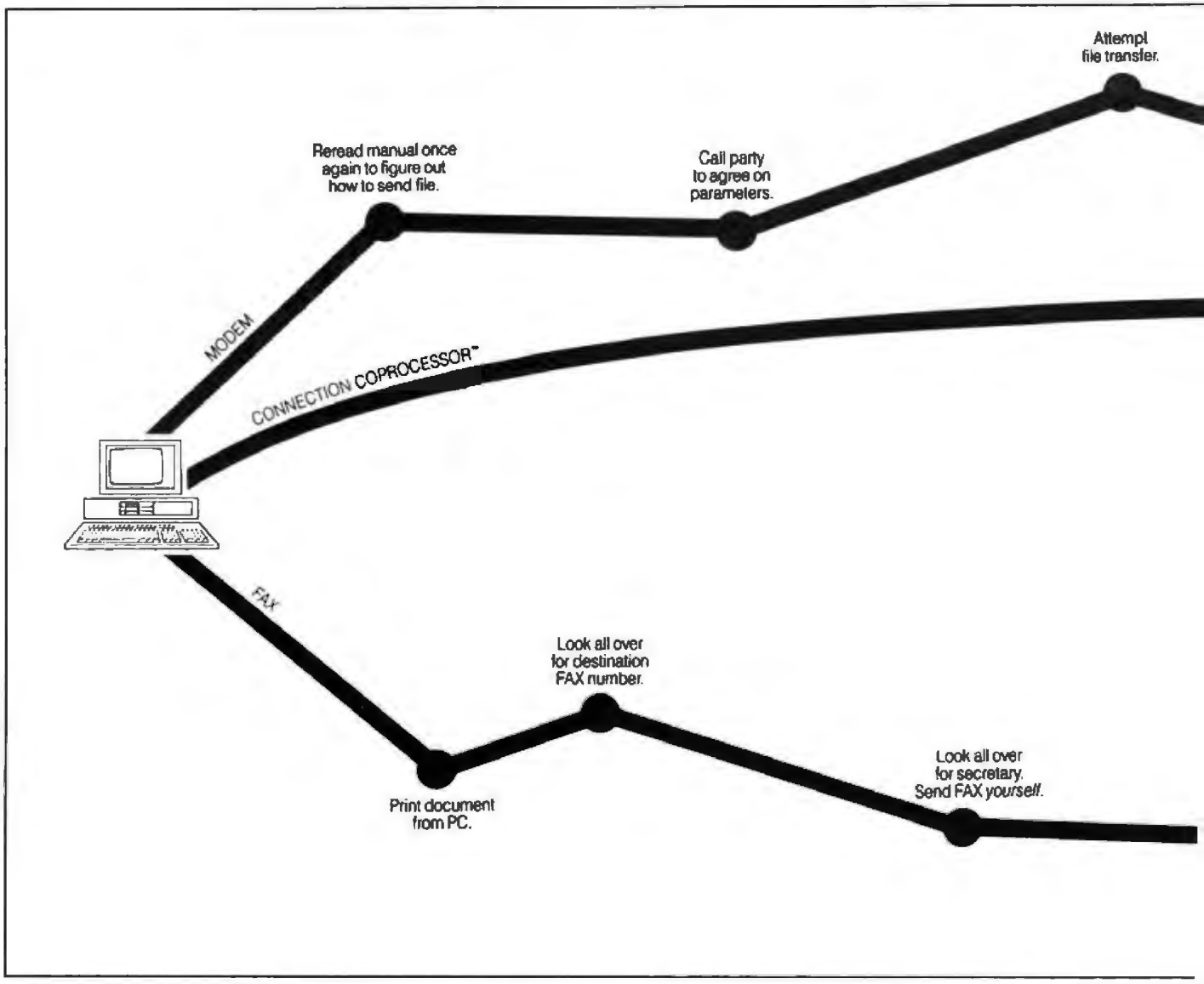

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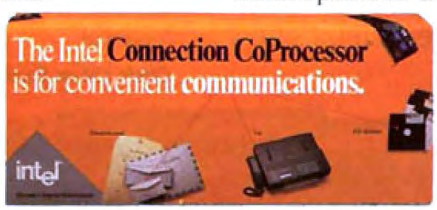

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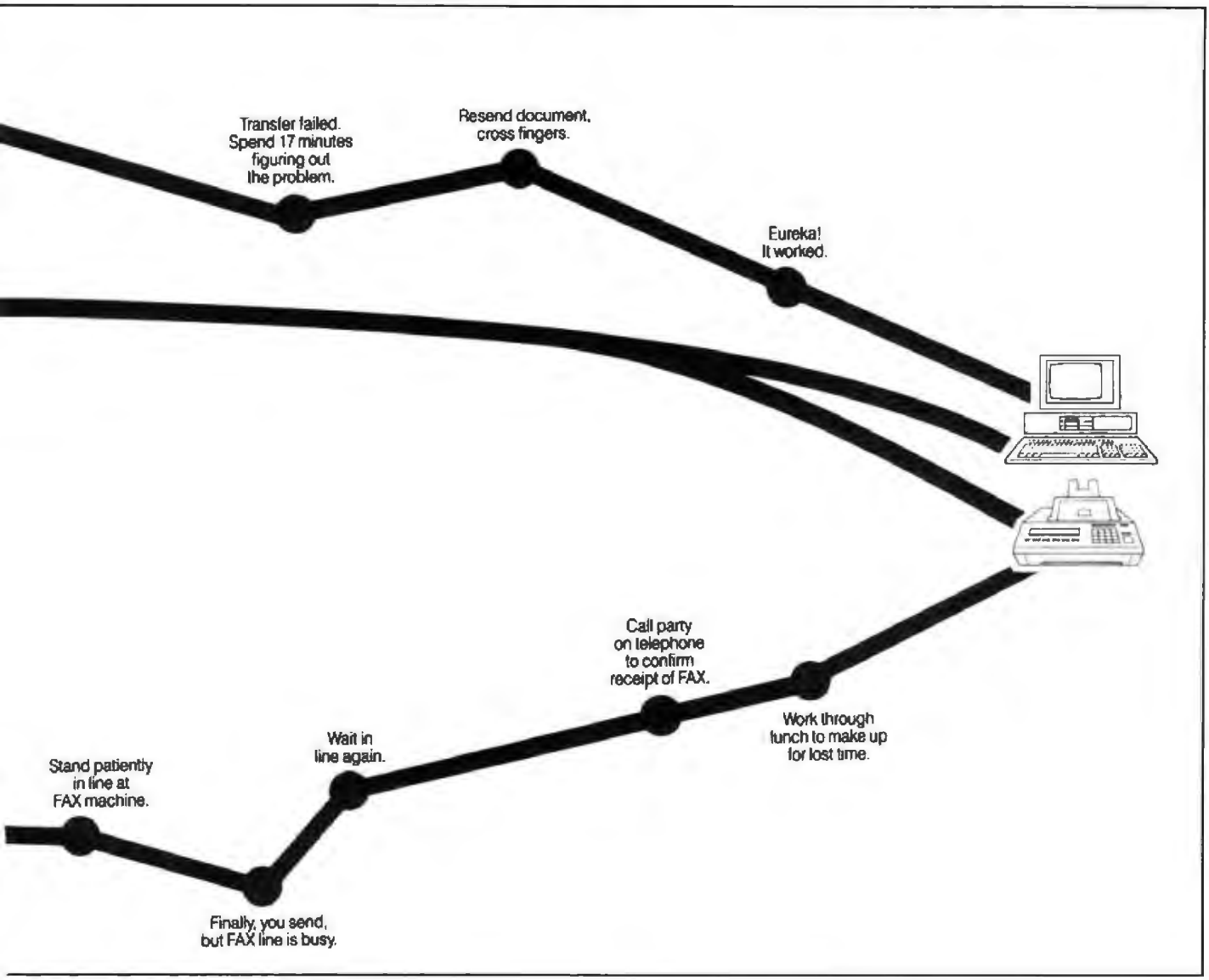

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Editor's note: *In August, Nick Baran, Tom Thompson, and I attended a marathon, all-day briefing at NeXT's headquarters in Palo Alto. It was the first time a publication was given an in-depth look at what surely is one of the most eagerly anticipated machines in recent memory: the NeXT Computer.*

On this and several follow-up visits we saw beta versions of the hardware, system software, and some early applications. We met with many of the engineers and programmers who developed the machine's hardware and software, and we spoke with the managers who are determining where NeXT is going and what role it will play in the microcomputing community.

We weren't disappointed. This is a milestone machine—one that in all likelihood will cop machine-of-the-year honors all around.

BYTE will have ongoing coverage of the NeXT Computer in upcoming issues. We'll report definitive performance figures, for example, after we receive and test a production unit. Here are our first impressions of the beta hardware and software.—FSL

It's been a long wait, but it has finally arrived. In early October, Steve Jobs's NeXT, Inc. unveiled the fruit of its creative efforts: a workstation referred to as "the cube."

NeXT asserts that the cube, having been designed to meet the computing needs of the next decade, is "the machine for the nineties." A bold statement, to be sure, but the cube goes a long way to bolster that claim: It sports the first commercially available erasable optical drive and advanced VLSI (very-large-scale integration) technology, and it comes with a built-in digital signal processor. On the software side, the Unix-based cube features an object-oriented version of C as its standard programming environment. It uses Display PostScript to present a graphical user interface that shields users from the traditionally user-hostile Unix command syntax, and it offers easy access to the cube's considerable power.

Targeted initially for the higher-education market, NeXT built the cube with the feedback of an academic advisory council that consisted of researchers and professors from schools such as Carnegie-Mellon, Stanford, and the University of Michigan.

The academic bent shows throughout. For example, the digital signal processor can be programmed for real-time laboratory work and demonstrations. The cube's large mass storage and memory capacity make it ideal for accessing substantial libraries of information. And Unix is the multitasking operating system of choice in academia.

Although the cube delivers a lot of bang for the buck, it's priced in the neighborhood of $6500 (all prices quoted are aimed at the higher-education market), which may, at least initially, limit its availability to its intended user base: students. The cube's rich features list would surely be appealing to those in nonacademic settings (engineering and science applications come to mind), but we were surprised to learn that for now, NeXT has no firm plans to pursue these markets.

Outward Appearances

The cube is starkly simple in appearance and physical layout. The main computer unit is a matte-black cube measuring 1 foot to a side. There are no switches, and no indicator lights. There are two panels covering bays that can hold two 5¼-inch full-height devices. One bay is occupied by a full-height drive with a wide slot: a magneto-optical drive. The main system unit is a power user's dream: the latest generation Motorola 68030 processor and 68882 math coprocessor, plus 8

continued

PHOTOGRAPHY: PAUL AVIS © 1988

megabytes of RAM as *standard* hardware (a 4-megabyte version of the system is available). An army of connectors (such as a SCSI [small computer system interface] connector and "thin" Ethernet connector) located along the rear of the computer can hook the cube to nearly any peripheral device (see photo 1).

The system is designed to avoid the rat's nest of wiring all too common with complex systems. The entire cube system requires just one power cable, which connects the main unit to a wall socket.

A single 10-foot-long shielded umbilical connects the black 17-inch monochrome monitor to the main unit (see photo 2). This cable carries power for the monitor, video, keyboard, mouse, sound I/O, and auxiliary input signals in a complex shielded array. The black keyboard attaches via a connector to the base of the monitor, whose housing also contains a small speaker, stereo earphone jack, two stereo channel jacks, and a microphone jack. A two-button mouse (also black) connects to the keyboard (see photo 3). The beta cubes we looked at were FCC Class A certified.

This arrangement is very convenient: Your desk need only accommodate the monitor, keyboard, and mouse, and the ample length of the umbilical gives you the freedom to place the main unit well away—say, on a shelf. A key on the keyboard switches the system's power on or off so you don't have to touch the main unit at all.

Fine-Tuned for High Throughput

The cube's internal construction mirrors the simplicity of its exterior (see photo 4). The main unit's cubic housing is made of lightweight magnesium. Inside are four 32-bit NuBus slots, one of which holds the system's main CPU board. All the cube's system electronics reside on this densely packed CPU board, which makes heavy use of surface-mount devices; the cube is essentially a single-board computer. With the exception of a bipolar array used to manage the video display and perform Manchester encoding/decoding for Ethernet communications, all the CPU board's parts use low-power CMOS components.

A power supply mounts inside the housing on two screws; the entire box is cooled by a large, quiet, low-speed fan. The nonswitching power supply can handle voltages ranging anywhere from 90 volts to 260 V, and frequencies from 50 Hz to 60 Hz. This means that you can plug in the same hardware almost anywhere in the world without having to set switches. The cube should also prove resistant to the vagaries of commercial electrical power. Its power supply generates 200 watts, of which the monitor uses 50 W, and 25 W is allocated for each slot.

NeXT's design for a workstation for the nineties used four important strategies. First, when possible, high-performance components were used. The CPU board is built around the 68030 processor and 68882 floating-point unit, both running at 25 MHz. For SCSI peripherals, the NCR 53C90 SCSI interface chip provides a maximum 4-megabyte-per-second transfer rate. That's considerably faster than the 1.5-megabyte-per-second rate of the older NCR 5380 chip. For mass storage, an optional high-speed hard disk drive using the SCSI bus is available. This hard disk holds 670 megabytes of formatted data and has an average seek time of 18 milliseconds.

However, even a high-performance processor can be slowed to a crawl if it must service every I/O call, or wait on slow peripherals. (Steve Jobs put it this way: "MIPS is only one-third of the equation; sustained system throughput is the key.") So, the second part of NeXT's design strategy was to minimize the

Photo 1: *The cube's I/O ports. Top to bottom: DSP port, two serial ports, SCSI port, laser printer port, Ethernet port, and monitor port.*

Photo 2: *The monitor I/O ports, left to right: stereo earphone jack, left and right stereo channels, umbilical connection, keyboard connector, microphone jack.*

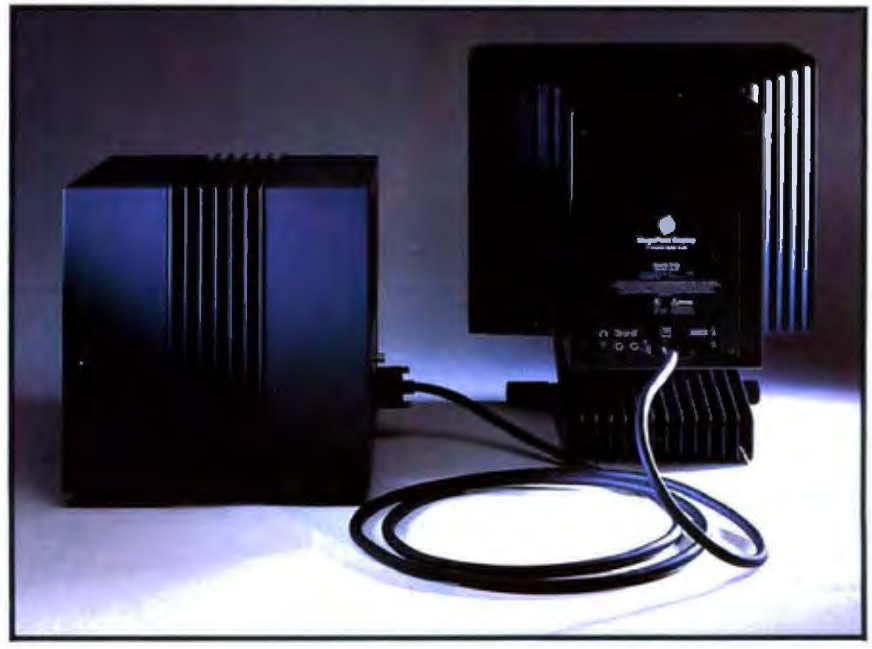

Photo 3: *The cube's keyboard. The keys above the cursor keys control the monitor's brightness, the system's power, and sound volume.*

Photo 4: *The inside of the cube. At top center is a bay for an additional full-height peripheral; at center is the magneto-optical drive. The power supply is at the bottom. To the right of center is the main CPU board.*

Photo 5: *The NeXT 17-inch monitor. The screen can be tilted forward or back; the tractor-style wheels allow it to be rolled across a table.*

overhead of communicating to the outside world by offloading as much I/O from the CPU as possible onto smart I/O processors managing each peripheral (see figure 1). This happens to be a matter of necessity given the amount of I/O the cube is doing. Consider that the cube's synthesized digital sound is handled by a Motorola DSP56001, a 20-MHz digital signal processing (DSP) chip. The DSP56001 provides the cube with its ability to synthesize compact-disk-quality stereo sound—no mean feat when you consider it must handle two channels of 16-bit data sampled at 44.1 kHz. Although the primary function of the DSP is to minimize system overhead while processing high-quality sound, you can program the DSP56001 to manipulate any sort of digital data, say, signal filtering or image processing (see the text box "The Cube's Digital Signal Processor" on page 166). The DSP makes the cube an excellent machine for laboratory and experimental work.

That's only part of the I/O traffic. Looking at the back of the cube, we counted no less than seven I/O ports. These include the following:

- *A DB-19 monitor port* carries all video signals, video data, control signals, mouse movement, stereo sound, and 12-V DC power to the NeXT monitor. Both the sound I/O data and video data (1 pixel every 10 microseconds) are managed by dedicated DMA (direct memory access) channels.
- *A "thin" coaxial Ethernet port* operates at 10 megabits per second and is driven by an AM7996 Ethernet transceiver chip.
- *A DB-9 serial printer port* drives the NeXT laser printer (see the text box "The NeXT Laser Printer" on page 168). This port transfers data at 1.8 mbps when printing at 300 dots per inch, and 3.2 mbps when printing at 400 dpi.
- *A DB-25 SCSI port*. Its signals are identical to those of the Apple Macintosh SCSI port. As mentioned earlier, the SCSI bus can transfer data to a peripheral at up to 4 megabytes per second.
- *Two serial ports* that use the Macintosh mini DIN-8 serial connectors and signals. Both serial ports can handle up to 230.4K bits per second synchronously (the same as Apple's LocalTalk), and 38.4K bps asynchronously.
- *A DB-15 DSP port* connects to both the asynchronous (SCI) and synchronous serial (SSI) channels on Port C of the digital signal processing chip. This port can be used to receive or output digital data.

continued

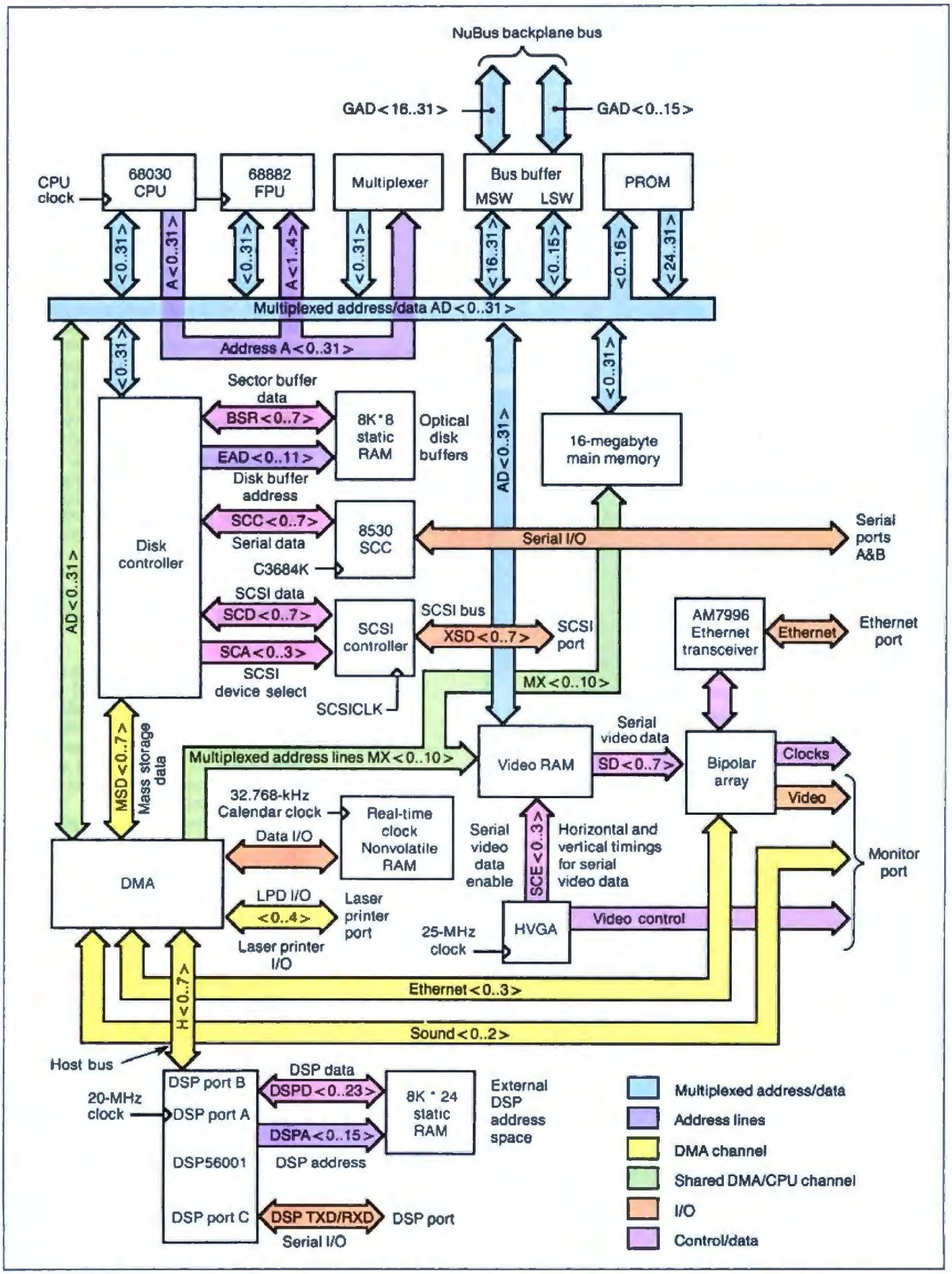

Figure 1: *Block diagram of the NeXT system. Note that the PROM is read by driving 16 bits of address onto the bus and reading bytes off the most significant address lines.*

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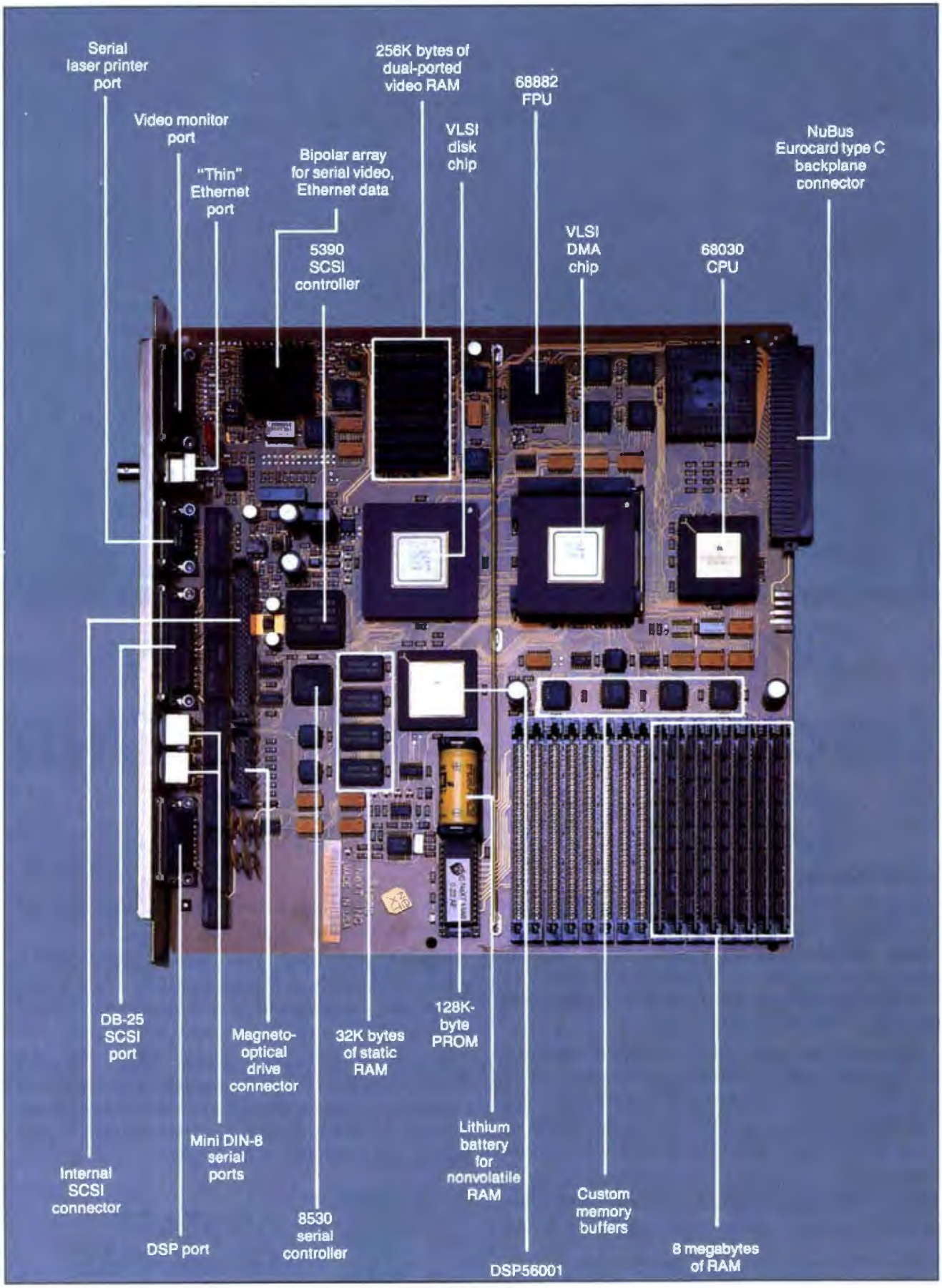

Figure 2: *The NeXT Computer's main CPU board, with its two custom VLSI chips.*

Looking inside the case, the main CPU board has two more ports: a 20-pin connector for the optical disk drive, and a 50-pin SCSI connector for a hard disk drive. Finally, inside the cube's housing are four 32-bit NuBus slots. Each slot uses a Eurocard type C connector. NeXT has implemented a CMOS NuBus with twice the data rate of the standard NuBus for its backplane bus. The CPU board assumes the ID of the slot it occupies. Although they're not used for outside communications, each of these devices can make demands on the system.

For digital sound synthesis, there happened to be an off-the-shelf component—the DSP56001—that could be assigned the job. Unfortunately, there aren't high-speed processors available that could deal with the rest of the system's I/O, and certainly none that could handle the magneto-optical drive. Two custom VLSI chips were designed to manage the cube's remaining I/O subsystems. These chips handle the SCSI interface, the magneto-optical drive (including error-correction logic), the serial ports, and Ethernet transfers.

Both these chips pack a lot of components: According to NeXT, each chip contains about *10 times* the amount of logic circuitry used by an entire Mac II.

But there's still a problem lurking here, subtly related to I/O: how to manage data to and from these I/O processors. If the CPU must periodically transfer data between memory and the various I/O processors, the system's performance is still degraded.

NeXT's third design strategy was to improve data throughput within the system itself by managing these transfers with custom DMA hardware. This DMA hardware is implemented in one of the same VLSI chips that helps manage the system I/O. There are no less than 12 DMA channels on the main CPU board. They include the following:

- two Ethernet channels (one for transmitted data, one for received data),
- one video channel,
- one serial channel (for both serial ports),
- one DSP channel,
- two disk channels (one for the magneto-optical drive, one for a SCSI hard disk drive),
- one printer channel,
- one memory-to-DMA register channel,
- one DMA register-to-memory channel, and
- two sound channels (one for input, one for output).

For the memory-to-register and register-to-memory DMA channels, "register" corresponds to a 16-byte register buffer in the DMA hardware. The contents of these registers can be copied repeatedly under DMA control to memory. An example of this would be to copy a background pattern for the video display into the DMA registers, and then use the register-to-memory DMA channel to copy the pattern into all of the video memory.

The final aspect of NeXT's overall design strategy to improve throughput is that when the 68030 processor must access memory, it attempts to do it efficiently. The 68030's *burst read cycle* is used where possible, since this mode allows four long words (128 bits) to be transferred in 9 clock cycles, instead of 16 clock cycles—roughly twice as fast.

The optical cartridges resemble overgrown 3½-inch floppy disks, but hold a whopping 256 megabytes of data.

Memory and Mass Storage

One way to improve system performance is to keep as much of the executable code in memory as possible, particularly where multitasking is concerned. The cube has no problem in this area: It comes equipped with 8 megabytes of 100-nanosecond SIMM-mounted RAM (see figure 2). The main CPU board has 16 SIMM (single in-line memory module) sockets, and 8 of these are populated with the standard RAM.

You can add additional 1-megabit-density SIMMs in 4-megabyte increments to expand system RAM to either 12 megabytes or the maximum of 16 megabytes.

Also located on the main CPU board are 32K bytes of 45-ns static RAM. 8K bytes of this SRAM are used for the magneto-optical disk buffers, and 24K bytes are allocated for the DSP56001. There are also 256K bytes of dual-ported video RAM for the video display. A 128K-byte PROM contains the bootstrap and some diagnostic code for the cube. This bootstrap code simply loads the Unix kernel and starts it. There are no special graphic or system functions similar to the Macintosh Toolbox embedded in this ROM. The operating system, drivers, and custom display software reside on the boot drive.

The most interesting peripheral on the cube is its read/write magneto-optical drive. The optical drive fits into a 5¼-inch full-height bay on the cube and has a slot to accept an optical cartridge. The cartridge is removable through a software-actuated eject mechanism using an internal motor.

The optical cartridges themselves resemble overgrown 3½-inch floppy disks, complete with a rigid shell and shutter door, but the resemblance ends there; each optical cartridge holds a whopping 256 megabytes of user data. This allows you "to take your entire world with you" since the Unix kernel, the bundled applications software, and lots of user data will fit on a single cartridge.

The optical platter is composed of the same clear rigid polycarbonate material that's used in CD-ROMs. Embedded within the platter is a layer of reflective aluminum backing that's overlaid with a magneto-optical substrate. The platter rotates inside the cartridge at 3000 revolutions per minute, 10 times the rotation speed of a CD-ROM, and almost as fast as a hard disk drive.

How does the magneto-optical drive work? A single laser performs both read and write operations. To write data to the disk, the drive first applies a magnetic field to the platter. The orientation of the magnetic field determines the data to be written to the platter—either a 0 or a 1. The magnetic field is first oriented to write 0s at the start of what's called the *erase pass*.

The laser uses a high-power beam to heat a sector on the platter's substrate to its *Curie point*—the temperature at which the crystals in the substrate "forget" their previous orientation and reorient themselves to the surrounding magnetic field. All the data in the target sector is thus erased to 0s.

Next, the magnetic field is oriented to write 1s in the *write pass*, and at every spot in the sector where a bit must be set to a 1, the laser again heats the substrate to the Curie point. Finally, the sector is read in a *verify pass* to check the accuracy of the data.

To read data off the platter, the drive removes the magnetic field, and the laser directs a low-intensity beam at the plat-

continued

The Cube's Digital Signal Processor

The Cube comes equipped with a Motorola DSP56001, an 88-pin CMOS chip designed for data-intensive real-time signal processing applications. At the core of the chip are three execution units—data arithmetic logic unit (ALU), address-generation unit, and program-control unit—that operate in parallel to provide the necessary throughput.

The DSP works with 24-bit digital data, providing 144 decibels of dynamic range. Two internal 56-bit accumulators provide 336 dB of dynamic range during arithmetic operations so the precision of the intermediate results is retained during data processing.

The DSP56001 is programmable, allowing it to be tailored for a specific purpose. The 16-bit address-generation unit, combined with hardware select lines for program code or data, can access three separate 64K words of an external memory space (192K words total, where a word is 24 bits of data).

The DSP56001 has on-chip program memory composed of 512- by 24-bit-wide RAM cells, of which the bottom 64 cells are used for interrupt vectors. DSP programs can occupy the remaining memory, or if they're large, they can reside in the external program space. In the latter case, the on-chip program memory can serve as a fixed cache. Program instructions are 24 bits wide, and each bit is significant.

On the cube, the DSP56001 is clocked at 20 MHz, and instructions execute every two clock cycles to give the chip a 10-MIPS (millions of instructions per second) rating. The DSP instruction set consists of 62 mnemonics that include math, logical, bit-manipulation, loop, and program-control instructions. The math instructions encompass such operations as absolute value, add, subtract, shift left/right, shift left/right and add (useful for implementing the butterfly computation in certain fast Fourier transforms), compare, signed multiply, signed multiply and accumulate, and signed multiply accumulate and round (MACR).

All these instructions—notably some of the math instructions just mentioned—are not pipelined and execute in one instruction cycle (two clock cycles). For example, as the MACR instruction executes, an instruction prefetch, 24- by 24-bit multiply, 56-bit add with convergent rounding, two data moves, and two pointer updates are performed, and all within one instruction cycle. Such powerful instructions are possible because of the parallel operation of the three execution units. These powerful arithmetic instructions, coupled with its high throughput, allows the DSP56001 to literally process data on the fly.

Inside the DSP56001 are four 24-bit bidirectional data buses: X, Y, program, and global. Digital data is split into X and Y components and can be treated as such in two separate 64K-word external memory spaces. On the cube, 24K bytes of static RAM provides 8K words of contiguous scalar data, or 4K words of X and Y data. How this data is ordered in SRAM on the cube is determined by what range of addresses you write into in the chip's external memory space.

The two 56-bit accumulators in the data ALU can operate on the X and Y data sets in parallel. Breaking the data into X and Y components provides certain advantages. For example, the data can be treated as X and Y coordinate data for image processing or graphics, or as real and imaginary components for complex math, or as coefficients and data for digital filtering. Each X and Y data bus has an on-chip memory composed of 256- by 24-bit cells that is used to improve performance. The program bus prefetches DSP program instructions into the on-chip program memory. The global bus is used for internal data routing within the DSP.

The DSP56001 has three I/O ports: A, B, and C. Port A has a 24-bit bidirectional data bus, and the address unit can access external memory for off-chip program code or data. Various control lines determine operations such as whether to access program or data memory, X and Y data, and if the operation is a read or a write.

Port B handles 8-bit data to and from a host processor that could be a CPU, DMA (direct memory access) hardware, or even another DSP. Control signals for this bus permit interrupt-driven or DMA transfers of data.

Port C consists of two full-duplex serial ports. The first port is the serial communication interface (SCI) that provides standard asynchronous rates up to 312.5K bits per second, and up to 2.5 megabits per second for synchronous data transmission. Although these signal timings are RS-232C-compatible, the voltage levels range from 0 volts to 5 V, so a line driver is required to produce a true RS-232C signal.

The second port is the synchronous serial interface (SSI) and is a programmable serial interface. You can set the number of bits per word, protocol, clock rate, and mode as required to transfer data at up to 5 megabits per second to and from a variety of peripheral devices.

An example of the DSP56001's processing capability is given by one of Motorola's application notes, where the chip is used as a 10-band graphic equalizer for a digital stereo system. In this document, a compact-disk digital stereo signal (two channels of 16-bit data sampled at 44.1 kHz or 88,200 16-bit digital samples a second) goes through the DSP56001's SSI on port C. Next, real-time digital filtering is performed on 20 bands (10 bands per channel), and the filtered data returns to the stereo system, again via the C port's SSI. This admittedly down-to-earth example shows the processing power that the DSP56001 can bring to bear on a problem. The sampling rate of the DSP56001 depends on the amount of data processing going on at the same time, but it can reach a maximum of 1.66 megawords per second.

As a computer peripheral, you could use the chip in any number of applications: speech synthesis, voice recognition, high-speed modems, image processing, two-dimensional graphics, and real-time filtering of digital data. Although the signed 24-bit resolution may seem limiting for some scientific and engineering applications, you can always use the cube's math coprocessor. But for those problems that do fall within this range, the DSP56001 will be more than adequate.

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The NeXT Laser Printer

Let's face it: There are certain situations in your computer work where you must have printed output. NeXT's answer to this problem is a low-cost 400-dot-per-inch laser printer. There's no entry-level dot-matrix printer offered; NeXT is banking on users preferring laser-printed output. Since the cube handles screen imaging with Display PostScript, it also makes sense to take advantage of a high-resolution PostScript-compatible printer. The printer costs $1995.

The NeXT printer is built around a custom-designed laser engine based on the Canon LBP-SX laser engine. It can print eight pages per minute and uses the same toner cartridge as the Apple LaserWriter II printers. A user-selectable printing mode lets the printer produce pages at either 300 or 400 dpi. The printer has its own power cord, and the power supply is set for 110 volts or 220 V levels with a switch.

The printing process involves imaging the page inside the cube using Display PostScript, and then bit-blasting it to the printer. This is similar to the method used by Apple's LaserWriter IISC, except that the cube uses Display PostScript, and the Mac uses QuickDraw. Since massive amounts of data must be transferred to the printer to produce a page, the printer port has its own direct-memory-access channel.

One limitation of the printer is that it will only work with the cube. Also, you cannot network it like PostScript printers that use Apple's LocalTalk, although you could use a cube with a NeXT laser printer to act as a print server on a network. The cube can print to non-NeXT PostScript printers using its serial ports and Unix printer drivers.

ter. The beam travels through the substrate and is reflected off the aluminum backing. However, in a phenomenon known as the Kerr effect, the crystal alignment in the magneto-optical substrate alters the polarization of the reflected beam. The amount of beam polarization determines its intensity as it passes through a polarizing filter to a photodetector. The beam intensity indicates whether a 1 or a 0 was read at the spot on the platter.

The optical drive's I/O processor uses a robust error-correction coding to protect the integrity of the data read from the platter. (In addition to the 256 megabytes of user data, each cartridge carries a 30 percent overhead just for the error-correction code.) Data and its associated ECC information is read from the disk and fed into one of two 1296-byte buffers located in high-speed SRAM. As the data is checked and corrected for errors, it is transferred to the second buffer. It's the contents of this second buffer that is actually used by the system.

While the operation of the magneto-optical drive seems simple in principle, the new technology needed to make this storage device possible was considerable. NeXT admitted that it had literally "gambled the company" on this technology becoming available for use in the cube.

But it did work, and one magneto-optical drive comes standard on the cube. While the drive is designed to boot and run the operating system, its 96-ms average seek time may prove a bottleneck in some applications. For the beta software, if you were using the magneto-optical drive as the system disk, you could not remove the cartridge without rebooting the system. However, NeXT plans to modify the software so you can copy files to another optical cartridge with a single magneto-optical drive.

Optical cartridges are expected to cost $50 initially, although the price may fall as they are produced in volume. Since the cube has room for an extra 5¼-inch full-height device, you can purchase either a second optical drive for $1495, or the 670-megabyte hard disk drive for $3995.

Getting the Picture

As we used the cube, we couldn't help being impressed by the crisp quality of its display. This is no accident: The 17-inch NeXT monochrome monitor has an ample 1120- by 832-pixel display that contains more pixels than most 19-inch monitors (which usually have 1024 by 768 pixels). The monitor has a 94-dpi screen, as compared to the Macintosh's 72-dpi screen. However, this display is only 2 bits (four gray levels) deep. The graphic interface looks very good and makes effective use of the four gray levels.

A 17-inch monitor was chosen for the video display as a compromise between display size and weight. On the monitor's base are two small tractor-style wheels that let you move the monitor easily across a table surface (see photo 5).

The video display has a bandwidth of 100 MHz, with a vertical refresh rate of 68.3 Hz. The monitor uses the positive and negative 12 V DC supplied by the cube's monitor port for power. Inside the monitor's housing are two boards. A step-up transformer on the first board generates the high voltages required to drive the video tube. The second board handles the rest of the I/O managed by the monitor: keyboard, mouse, and sound.

The 84-key keyboard connects to a port located on the monitor's base. The keyboard also has cursor keys, a numeric

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Display PostScript

Display PostScript is an extension of Adobe's PostScript page-description language (PDL) and is designed as an imaging model for graphics displays. In theory, software developers could write the display portions of their applications just once using Display PostScript: These applications would run without modification on any computer and operating system that supports Display PostScript. Another major benefit is that the image on the screen would reproduce identically on a printer supporting the PostScript PDL.

Display PostScript is device-independent, an important feature when you consider that specific dimensional sizing is display-dependent in most graphics handlers. For example, if you write a Display PostScript routine to draw a 2-inch square on the screen, the routine will always draw a 2-inch square on any display supporting Display PostScript, regardless of the resolution, color capability, or size of the output device. In other words, Display PostScript permits a "non-unitized" description of an image until it is interpreted for a particular display.

This non-unitized approach is in contrast to pixel-based graphics handlers that can only handle proportional sizing. Of course, you can also specify proportional sizing in Display PostScript. Additionally, Display PostScript automatically uses the maximum color capabilities of the host display, whether it has just black and white, or 16 million colors. The programmer does not have to worry about the characteristics of the output device while writing the application.

The core of Display PostScript is called the DPS Kernel. The DPS Kernel is an interpreter that translates PostScript routines into the images on the screen and is designed to be machine-independent. The DPS Kernel is supplied precompiled in object format to the OEM.

In addition to the Kernel, Adobe supplies the OEM with "front- and back-end" adapters that consist of source code for interfacing to the display devices, the operating system, and the windowing system. The Display PostScript adapters become part of the host computer manufacturer's system software. Of course, modifying these adapters for the host computer system is not a trivial task, and it is usually undertaken by the OEM as a joint or cooperative effort with Adobe Systems. Again, the important point here is that the software developer need not worry about these "adapters."

The main underlying concept of Display PostScript is to isolate the display operation from not only the host computer's operating system but also from its windowing system. The core of Display PostScript fits inside the host windowing system, which in this case is the NeXT windowing system, although it could be anything from Microsoft Windows to X-Windows to QuickDraw.

While the windowing system handles functions such as cut, paste, and copy, and manages the window boxes on the screen, Display PostScript handles the actual painting of the window's contents. Thus, routines for displaying icons, text fonts, and graphics images have to be written only once using Display PostScript. However, the software developer still has to write separate window calls for each windowing system.

Programmers can use the Display PostScript language directly, or they can use a library of C procedures called PSWrap, which is recognized and interpreted by the DPS Kernel.

NeXT fully supports the PSWrap library, but has added many of its own procedures. Some of these are used by the Application Kit to create and manage windows; other procedures handle events, mouse, and cursor operations; and still others support "compositing."

The compositing procedures are multibit pixel operators designed by NeXT's sister company, PIXAR. Each pixel has two values associated with it: its data value (or color), and its alpha value (the data's transparency or opacity). On the cube's 2-bit display, compositing makes an icon transparent as it moves over another object on the screen. These compositing operators are easily extendable and will allow the NeXT software to migrate to color displays when the time comes.

From brief glimpses of alpha versions of Display PostScript, several industry observers have concluded that Display PostScript has serious performance problems—it is too slow. Adobe Systems vehemently denies this and says critics have jumped to conclusions based on these preliminary demonstrations. Adobe says Display PostScript is very fast provided the code is written properly.

A number of techniques have been developed to improve Display PostScript's performance, including a binary preprocessor (described below), graphic state objects (multiple PostScript graphic states that can be switched quickly by changing a pointer), and user paths (an aggregate of PostScript drawing commands that represent a PostScript path). NeXT uses these techniques and its own compositing functions to boost the speed of the display.

keypad, a power-on/power-off key, and pairs of keys that control the volume and screen brightness (pressing one key increases the chosen output; pressing the other decreases it). There are two Command keys and two Alt keys (located on opposite sides of the keyboard) that are mapped separately. There are no PC-style function keys. A two-button optomechanical mouse also connects to a port on the keyboard.

There are also left- and right-channel analog stereo jacks, and a jack for stereo headphones on the monitor's base. There's also a jack for a microphone so you can record sounds through the monitor, say, for voice mail. This port uses a telephone codec input that's sampled at 8 kHz, and it uses 8-bit Mu-law scaling for the digitized data. The data is saved within a Sound object that can be utilized by the NeXT Unix mail facility or by NeXT applications.

The Software

As much as the NeXT hardware represents an impressive step forward in areas

As an example of how binary encoding works, say we want to issue the PostScript operator `72 426 moveto`. Normally the DPS kernel would have to translate the ASCII digits 72 and 426 into a floating-point format, and the ASCII `moveto` operator into a binary code. A lookup table uses this binary code in the DPS Kernel to steer execution to the routine that implements the `moveto` operation. A NeXT application normally calls a PSWrap function, `PSmoveto()`, that passes the IEEE 754 floating-point values of the numbers to the DPS Kernel, along with the corresponding binary code for `moveto`. This effectively eliminates the overhead of the ASCII translation stage for the DPS Kernel. The NeXT DPS Kernel can process ASCII PostScript commands if required.

Display PostScript has one major limitation in that it does not support three-dimensional imaging. It is therefore not suitable for CAD software. Adobe admits that Display PostScript is not intended for high-end mechanical design applications. (Steve Jobs said that NeXT will support the Renderman Standard, which he called "the PostScript of three-dimensional graphics.")

Display PostScript has some very compelling features for software designers and for end users. It could greatly facilitate the porting of software applications across incompatible hardware systems.

But the various competitors for display standards—such as IBM and Apple—will have to make some compromises before Display PostScript can succeed. Until these compromises are made, both the end user and the software developer will continue to be plagued by an incompatible world of competing display standards.

such as digital signal processing, optical disk storage, and VLSI technology, the NeXT system software is a step forward for software technology. The system offers an easy-to-use graphical interface to Unix and an object-oriented programming environment for programmers and software developers.

It's an understatement to say that NeXT expects Unix to catch on. Steve Jobs told us, "I believe this with every bone of my body: Unix will be the prime operating system of every major company in the 1990s."

So it's not surprising that the cube is a Unix-based system. It features a proprietary windowing system that is designed to shield the Unix command-line interface (CLI) from the user, substituting simple point-and-click mouse operations to manage files and execute applications. NeXT also uses Adobe Systems' PostScript imaging model (often referred to as Display PostScript) for displaying all text and graphics on the screen. Display PostScript is an extension of the PostScript page-description language (see the text box "Display PostScript" at left).

The NeXT system software also includes development tools for building application interfaces and integrating objects into application programs. These tools are called the Interface Builder and Application Kit, respectively.

The Operating System

NeXT uses the Mach Unix kernel developed at Carnegie-Mellon University. The Mach kernel is compatible with BSD (Berkeley Standard Distribution) Unix version 4.3, but provides major enhancements such as shared memory, fast interprocess communication, and potential multiprocessing support through the use of threads. Shared memory allows multiple processes to share common segments of memory. IPC allows processes to communicate with other processes and to transmit messages and data between them. Threads are "lightweight processes" that have their own execution stack, but within the context of a the task that created it (i.e., the thread has access to all the resources made available to the parent task such as memory, and opened files).

Multiprocessing support is possible by assigning threads to particular processors. However, multiprocessing is not supported in the initial release of the NeXT operating system. Since you can add multiple CPU boards to the cube's backplane, we can expect to see multiprocessing support in later releases of the operating system.

In NeXT's first release, the operating system consists of a single kernel with the Mach implementation of IPC, scheduling, and virtual memory operating as a layer within the BSD Unix kernel. However, the ultimate goal of the Mach implementation is to provide a modular architecture for Unix that would allow for a much smaller kernel with separate processes dedicated to file handling, networking, and Transmission Control Protocol/Internet Protocol (TCP/IP).

Like most Unix-based systems, the cube implements virtual memory using a paged-memory system to allow applications to run even if their memory requirements exceed the available physical memory. Idle portions of a running application are "paged" (i.e., written to disk) in 8K-byte blocks, called pages. However, as in all virtual-memory systems, it is possible to overload the system with too many applications, causing excessive paging or "thrashing," which can bring the system to a crawl. While NeXT was not ready to provide numbers for the amount of memory consumed by the system software, the 8-megabyte base memory configuration is designed to allow "three or four" applications to run simultaneously in addition to the system software.

It's an understatement to say that NeXT expects Unix to catch on: The cube is a Unix-based system.

For networking, NeXT uses TCP/IP and Sun's Network File System, which has become the standard Unix file-sharing system. Since the cube comes with an Ethernet interface, it is "network-ready" for TCP/IP-based networks. The thin Ethernet cabling allows up to 600 feet of cabling and connection of up to 30 machines without gateways or repeaters. While NFS does not require one, a dedicated server is preferable in networks of more than a few machines, due to performance degradation. In other words, if you're planning to network a bunch of cubes, you'll need a dedicated NFS server, or a cube to serve that purpose.

User Interface and Window Server

NeXT provides a graphical windowing interface to Unix that hides the laborious Unix commands from the user. While veteran Unix users still have the option of

continued

issuing those intuitive commands (like grep and ls) within a Unix CLI window called the Console, most cube users should never have to deal with Unix. The windowing interface, called the Workspace Manager, provides all the necessary functions for file management, opening and closing applications, and communicating with other resources on the system such as peripherals or nodes on the network.

The main interface screen is called the Workspace (see photo 6). Noticeably absent from the screen is the ever-present menu bar found on the Macintosh screen, or on a PC running Windows. Unlike the Macintosh Desktop, menus can be moved anywhere on the Workspace and float above any open windows.

Menus are hierarchical, and you can split off subhierarchies from their parent menus. Windows have scroll bars located on the left and bottom, and there are small boxes on the window frame for resizing or closing the window. It also has a "miniworld" function that collapses the window and its menus into an icon while the process owned by the window continues to run.

Icons become transparent when they overlay other icons, allowing you to always see everything that's currently available on the Workspace. The icons of frequently used applications can be "docked" along the right side of the Workspace for easy recall.

The Workspace is similar to the Desktop metaphor on the Macintosh, and the Workspace Manager is analogous to the Mac's Finder. However, no one will accuse NeXT of copying Apple's look and feel.

The Workspace resembles the Desktop, but no one will accuse NeXT of copying Apple.

File management operations are similar to those used by the Mac Finder. When you click on a directory in the Workspace, you can examine the directory in a number of ways. There is a "browser window," which displays the directory tree in a window with the directory hierarchy ordered from left to right on the screen. This browser window normally lets you see three levels deep, but you can position the point in the hierarchy where you wish to view files, or resize the window to examine additional levels.

You can also choose to view the directory as icons with subdirectories represented by folders, or as a conventional text-only Unix directory listing.

The version we saw was definitely beta, so the final word on the Workspace will have to wait. Nevertheless, it seems very intuitive and easy to learn. Its performance seems good, and the display quality is excellent.

Rather than use an existing Unix window server such as X-Windows, NeXT designed its own proprietary Window Server. The Window Server manages all interactions between the windows, keyboard, and mouse for all applications attached to it. The Window Server obtains events from the operating system and handles the ones it can (e.g., resizing a window or moving it to another part of the screen). If it's not an event that it can service, the Window Server determines which application can and dispatches it to that application.

Embedded inside the Window Server is the Display PostScript interpreter, which acts on the PostScript commands passed to it. This embedded interpreter executes the PostScript commands it receives and writes the results into the cube's video RAM, making it appear on the monitor.

The Window Server supports Mach IPC connections as well as connections through TCP/IP, allowing other cubes on a network to access another machine's Workspace. The proprietary Window

continued

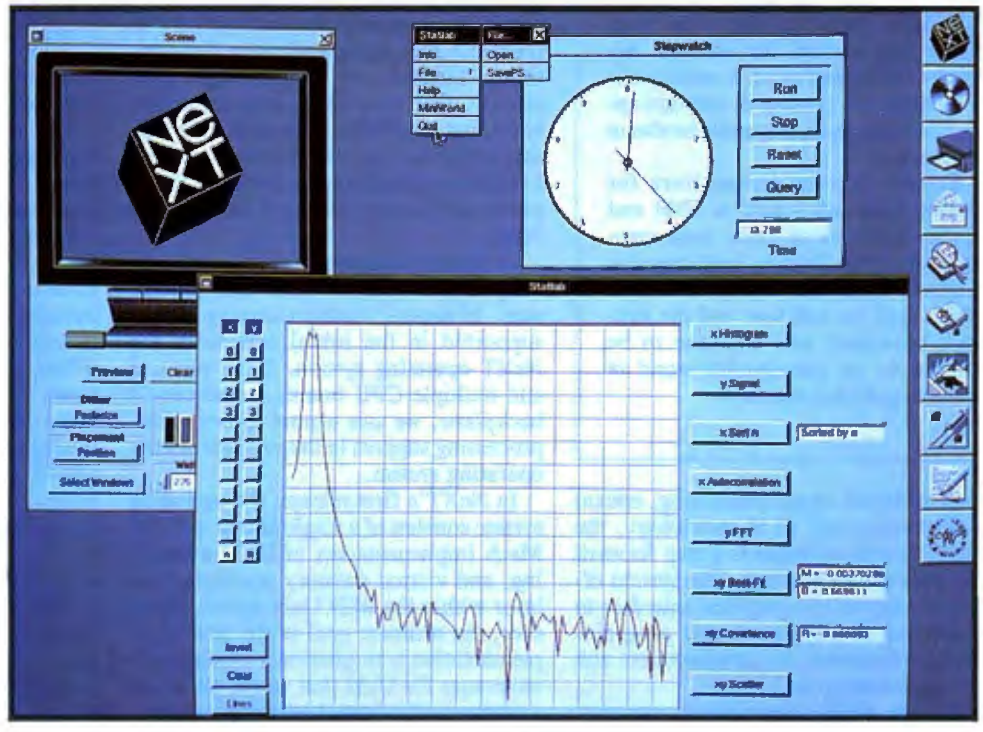

Photo 6: *The cube's Workspace. Each window represents a running application. Note that the menu has its own Close box. The icons at the right represent "docked" applications.*

In 1988, $3.5 billion in microcomputer software will be sold worldwide. During that same time, another

$3.0 billion in sales will be lost to free distribution — better known as software piracy. And right now, Rainbow Technologies' Software Sentinel™ is protecting close to $1.0 billion in software for developers who never wanted to be part of the free software distribution network in the first place. ( ) The Software Sentinel hardware key is "execution control" software protection. It ships with the software and simply plugs into the PC's parallel port

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Bundled Software

Here is a list of the software that is scheduled to be bundled with the NeXT Computer. It includes the Mach operating system and its development software. Also included are the works of Shakespeare, a dictionary, and a thesaurus.

You can call up quotations or the dictionary entry for a specific word at any time by using the cube's Find function. This capability would be valuable not only to college students and faculty members, but to anyone who has to write frequently—whether it's a business proposal or a technical document.

System software:
Mach operating system
PostScript Window Server and fonts
System administration tools

Development tools:
GNU C compiler
GNU debugger
GNU EMACS
Objective-C 4.0
Berkeley Unix utilities
Terminal emulator
Window-based text editor
Interface Builder

Object-oriented software kits:
Application Kit
Sound Kit
Music Kit

High-speed text-retrieval application (called "Find") for
Standard reference works:
Merriam-Webster's Ninth New Collegiate Dictionary
Merriam-Webster's Collegiate Thesaurus
The Oxford Dictionary of Quotations
Documentation for all bundled software: user's manuals and programmer's manuals
Literature:
Oxford University Press' William Shakespeare: The Complete Works
User-created text files, such as mail or documents

Applications:
Personal text database
Electronic mail application with graphical interface and ability to attach voice messages
Word processor
Window-based file manager
Mathematica (Wolfram Research, Inc.)

Server means that existing applications that run on other Unix windowing systems will have to be modified to run under the NeXT windowing system. However, a Unix application that uses conventional console I/O will run inside the Console window without modification.

The Development Environment

The primary objectives of the NeXT programming environment are to simplify the development of interactive user interfaces and to simplify the creation of new applications through the use of object-oriented programming.

Other systems employing graphical interfaces—like the Macintosh, for example—are great for the end user but extremely complex for programmers, particularly in developing a working user interface. To ease the burden of this task for the developer, the NeXT system includes tools for building interfaces to the NeXT windowing system, and also tools for object-oriented programming.

The NeXT system software includes an ANSI C compiler and an object-oriented preprocessor called Objective-C, developed by Stepstone Technologies. Objective-C allows you to define objects as groups of C procedures.

NeXT provides several libraries of ready-to-use objects, calles *kits*, for integration into Objective-C programs. These kits provide a library of around 34 objects for implementing the core functionality of a NeXT application, although a programmer would normally use only a small subset of these objects. This library is known as the Application Toolkit, and the Objective-C interface can access it directly.

Object-oriented programming allows a one-to-one correspondence between objects on the screen and objects in your program. An object consists of data (called instance variables) and executable code. If the object is to be visible on the screen (a window, for example), the code also contains an entity called `drawSelf::` that's composed of C code, Objective-C code, and PostScript code, which is used to describe the appearance of the object to the Window Server.

Probably the key concept with respect to user interfaces is that objects can respond directly to messages generated by user actions. Rather than having to write lines of conditional statements in C code to respond to user actions, the user actions are interpreted as messages other objects can understand. For example, you might have an object in your program called "Window," which can understand the "Close" message sent by a user response.

NeXT provides a program called Interface Builder that allows you to interactively build user interfaces for your programs. Interface Builder lets you design the layout of a graphical user interface by selecting buttons, menus, and other objects from an object library to include in your application.

This function is somewhat similar to `ResEdit` on the Macintosh. However, Interface Builder goes further—it allows you to define connections between objects. That is, Interface Builder lets you specify actions for the objects to perform in response to user actions on other objects. For example, you could build a Beeper button object into your program interface simply by selecting a prototype button from Interface Builder's on-screen inventory, moving it to where you want on the screen, giving it a label, and assigning an action (say, emit a beep) to be performed when a user clicks on the button.

This is similar to the function of HyperTalk in Apple's HyperCard program. The big difference, however, is that Interface Builder generates the binary description of the object that you can integrate into programs.

You can also create custom objects by selecting an object that most closely resembles what you want and customizing its appearance and behavior. NeXT's goal is to supply enough objects so that a programmer could select objects and define their connections, making it possible to built an application from scratch writing little or no code.

In addition to the Application Kit and Interface Builder, the NeXT system software includes kits for working with music and sound. The Music and Sound Kits provide objects for integrating these

features into your programs. There is also a number of library functions (not objects) that allow you to tap into the processing capabilities of the DSP. These libraries provide some 50 functions for performing tasks like fast Fourier transforms, and spectral filtering.

NeXT supports the concept of "shared libraries" in its development environment. This means that multiple applications and processes can share a single copy of executable code from the object library. Although library sharing was not implemented when we saw the cube, it should improve performance and reduce the memory and storage requirements of applications.

Applications

NeXT will bundle several applications with the machine. These include the word processor, WriteNow, that is owned by NeXT and is currently distributed by T/Maker for the Macintosh. The system software also includes the standard Unix Mail program equipped with a graphical front end that can attach voice messages to mail files, a file-searching program called Find, C and Objective-C, a symbolic debugger, and on-line documentation. It also has educational and reference tools such as *Webster's Dictionary*, the complete works of Shakespeare, and Mathematica from Wolfram Research (see the text box "Bundled Software" at left). A personal text database allows you to automatically index all your word processing and electronic mail communications so you can recall documents or memos based on keywords instantly.

An important goal of the NeXT software environment is the development of "digital libraries." With its erasable 256-megabyte magneto-optical disk, NeXT hopes to promote the idea of easily accessible text databases. In the educational market, these databases will include encyclopedias, dictionaries, textbooks, and other reference works.

NeXT's first software release lays the groundwork for the company's plans for the nineties. The DSP and the kits for programming it offer exciting possibilities for new real-time applications. It will be interesting to see how the software will be used and what new applications will be developed.

One Giant Step Forward?

The cube is an impressive technical achievement. We liked the carefully thought-out design that didn't just use fast components, but covered every aspect of moving information through the system. The choice of NuBus for the backplane bus is an excellent one; it goes a long way toward providing the hardware support for the cube's planned multiprocessing capability.

Considering the amount of information that the machine is expected to use, the high-capacity magneto-optical drive is a good design choice. The graphical interface uses the well-documented PostScript imaging language and goes a long way toward hiding the uglier side of Unix from the user. The facility with which NeXT's object-oriented programming environment reduces the work needed to write an event-driven program is also impressive.

Considering the machine's capabilities, we can't help but wonder if NeXT is being too conservative in its marketing plans.

It is indeed a machine for the nineties. It represents a bold step forward both in hardware and software design and effectively redefines what constitutes "standard equipment."

However, as we go to press, some big questions remain unanswered. One relates to the performance of the machine. In our limited time with several beta cubes, it was difficult to judge the overall performance. Display PostScript operations were very fast, putting to rest the controversy of Display PostScript's performance, at least as far as the cube is concerned.

However, disk read/write operations seemed pretty slow—perhaps because so much beta debugging code was being carried along as baggage, and because library sharing was not yet implemented. We saw the magneto-optical disk drive in operation, but it still had some operating bugs, and its 96-ms access time might be a source of frustration if it's used as the main system drive. At this point, we cannot comment on its reliability.

Another question is whether software developers will support NeXT. The primary obstacle to the acceptance of Unix in the general marketplace has been the lack of software applications. Software developers are faced with choosing between Macintosh, OS/2, DOS, and now a new version of Unix with a proprietary windowing system. To be successful, NeXT will need substantial support from software developers; at the time of our visit, only about 10 developers had signed on, and NeXT would not release their identities.

The concern about outside development is perhaps tempered by two facts. First, the object-oriented environment should simplify moving existing Unix programs to the machine. Second, each cube is a complete development system, since all the development tools—compilers, object libraries, and Interface Builder, are bundled with the machine.

Then there's the question of NeXT's target market—higher education. While the machine is certainly a perfect fit for the university community, universities are not known for being big spenders. Certainly, many students will have a hard time coming up with $6500 or more for a computer, let alone another $1995 or so for the laser printer, and perhaps $1495 for a second magneto-optical drive for backups.

Of the cube's design, Jobs told us, "If you want to make a revolution, you have to raise the lowest common denominator." That's true, but you also have to get the product into the hands of enough revolutionaries to make a difference. Yet it's clear NeXT is thinking small, at least in terms of initial marketing.

Dan'l Lewin (NeXT's vice president of marketing and sales) told us, "We built the company not to need huge numbers." And Jobs said, "We'll focus on other markets in the future, but we're not going to do it today. There's no reason why we can't do very well in [the educational] market alone."

Perhaps. But considering the machine's capabilities, we can't help but wonder if NeXT is being too conservative in its marketing plans. If so, it seems that NeXT may have to be able to endure some lean years until the machine catches on in the early nineties. ■

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The Promise of

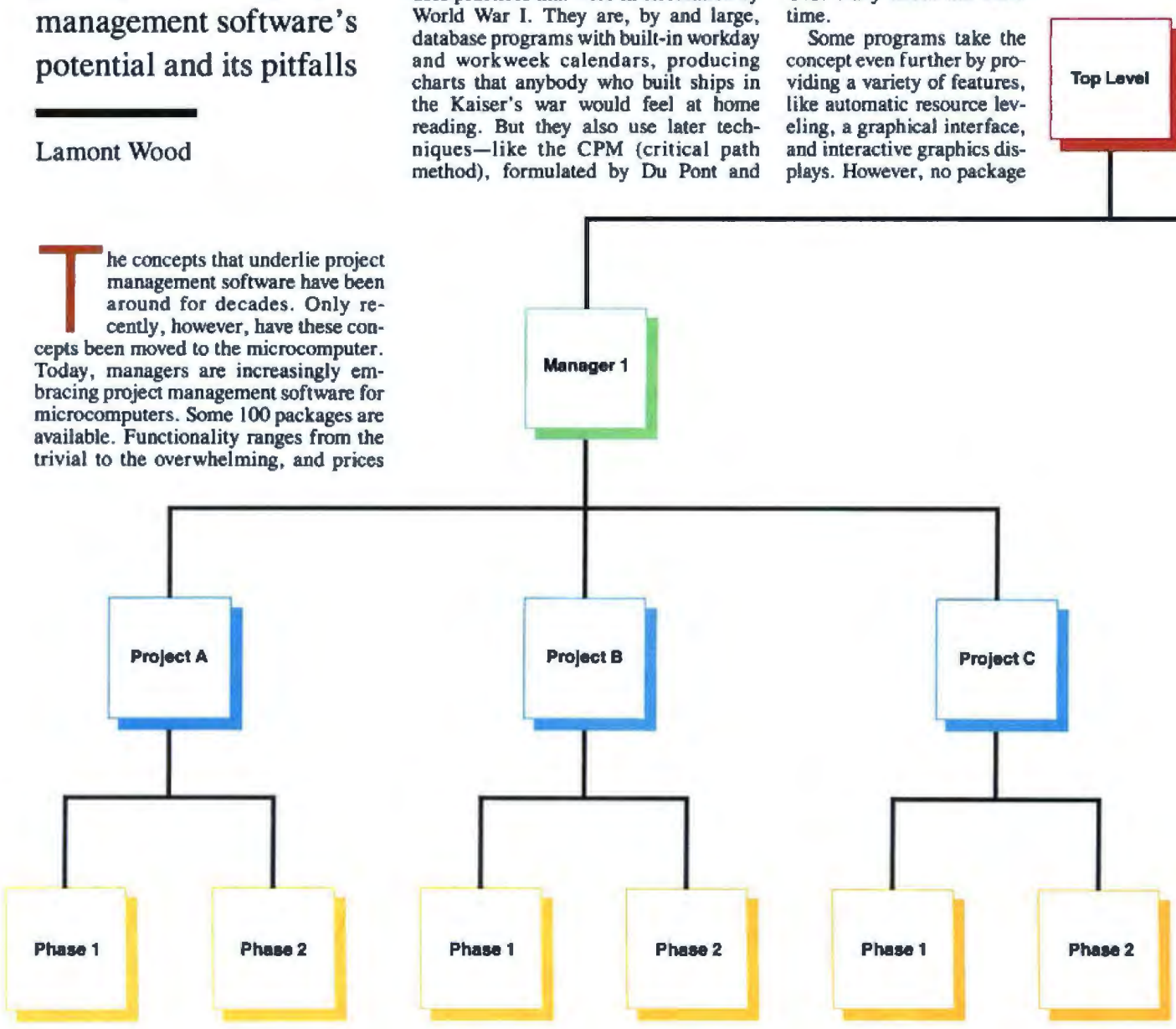
A roundup of 10 packages reveals project management software's potential and its pitfalls

Lamont Wood

The concepts that underlie project management software have been around for decades. Only recently, however, have these concepts been moved to the microcomputer. Today, managers are increasingly embracing project management software for microcomputers. Some 100 packages are available. Functionality ranges from the trivial to the overwhelming, and prices range from inexpensive shareware to products priced up to $10,000.

Most project management software uses practices that were in circulation by World War I. They are, by and large, database programs with built-in workday and workweek calendars, producing charts that anybody who built ships in the Kaiser's war would feel at home reading. But they also use later techniques—like the CPM (critical path method), formulated by Du Pont and Remington Rand Univac in the 1950s, and PERT (program evaluation and review technique) charts, developed by the U.S. Navy about the same time.

Some programs take the concept even further by providing a variety of features, like automatic resource leveling, a graphical interface, and interactive graphics displays. However, no package



Project Management

now available offers an ideal mix of such features.

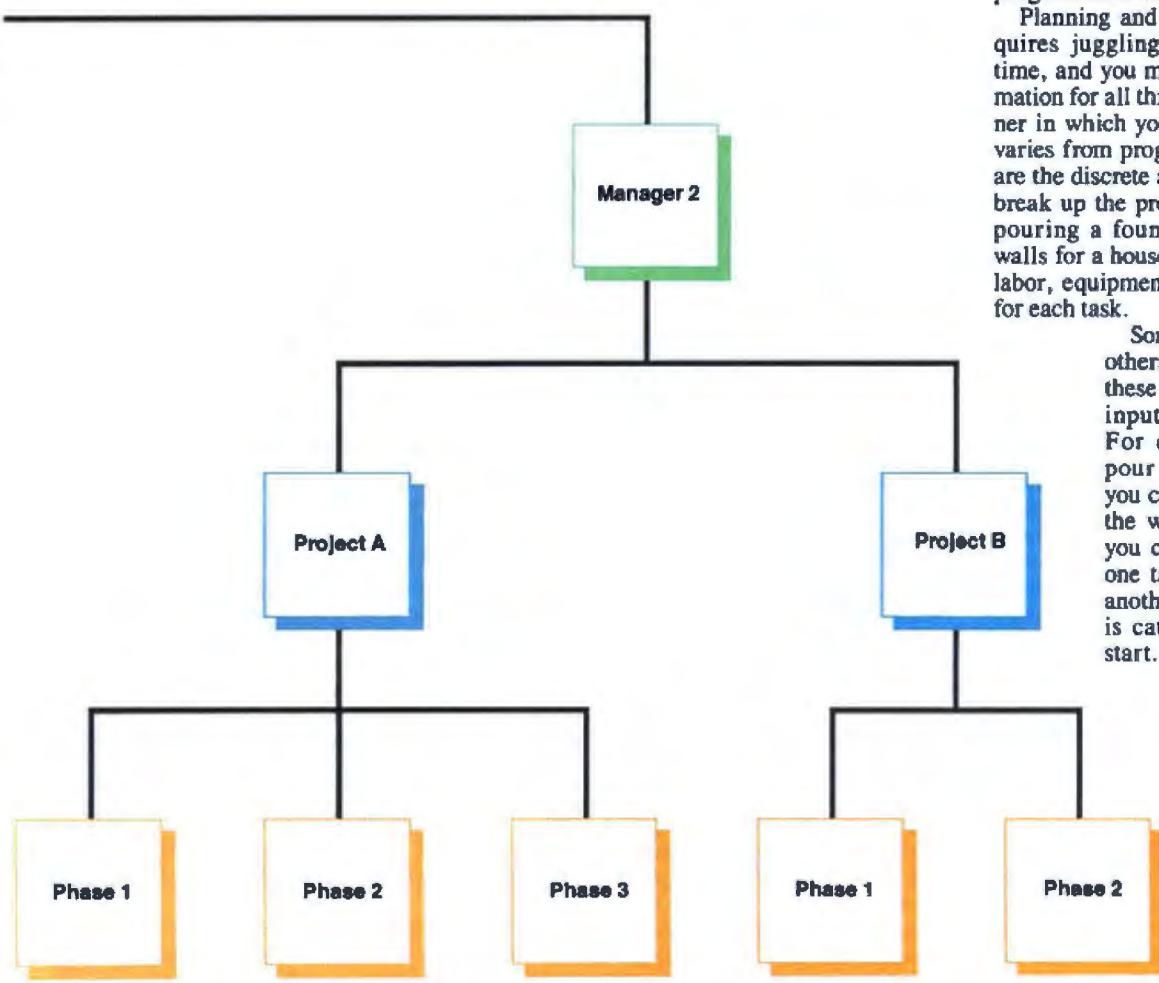
I examined a representative sampling of popular project management packages available for under $2000. I tested 10 such packages. Due to the idiosyncratic nature of projects and the different techniques with which the packages input and manage information, across-the-board performance benchmarks would not provide meaningful results, and I didn't attempt any.

Major Considerations

Project management software isn't for everyone. The types of projects that these packages handle best are long-range group efforts with a definable beginning and end. Project management software is not designed for scheduling the coverage of daily chores, although you could probably trick some of these packages into doing so. An example of a suitable project commonly used by project management software vendors is the construction of a house. The construction of a nuclear submarine is a commonly used example of a complex project.

The advantage to using project management software is that it makes planning and updating easier as a project progresses. By contrast, with traditional paper tracking, you would need to log everything in and then redraw related charts and recalculate schedules. With project management software, you simply log in the update information and the program handles the rest automatically.

Planning and managing a project requires juggling tasks, resources, and time, and you must input relevant information for all three categories. The manner in which you enter this information varies from program to program. Tasks are the discrete activities into which you break up the project. Examples include pouring a foundation or framing the walls for a house. Resources include the labor, equipment, and materials needed for each task.



Some tasks must precede others, and you must define these relationships when you input project information. For example, you have to pour the foundation before you can frame the walls, and the walls must be up before you can start the roofing. If one task can start only after another ends, the relationship is categorized as finish-to-start. If both must start at the same time, then it's called start-to-start.

Once you've determined all the tasks involved to complete the project, it becomes obvious that the tasks follow in succession and that inter-

continued

Table 1: *Capabilities, features, and pricing vary widely among the 10 project management programs reviewed.*

Product	Price	Disk format	Language	Minimum system requirements					Manual
				DOS version	Display	RAM	Disk drives	Hard disk space	
InstaPlan 1.03B	$99	4 5¼-inch or 2 3½-inch	C	2.11	Mono	512K	2 floppy or hard	1.2 M	162-page manual; 36-page PERT option guide
MicroTrak 1.6	$595	2 5¼-inch or 2 3½-inch	C	2.0	Mono	256K[3]	1 floppy or hard	0.4 M	295 pages
Pertmaster Advance 2.0	$1495	7 5¼-inch	C	2.0	Mono	320K	2 floppy or hard	2.1 M	372-page manual; 82-page tutorial
PMS-II 8.1	$1295	4 5¼-inch or 2 3½-inch	BASIC, C, assembly	2.1	Mono	512K	1 floppy, 1 hard	1 M	147-page user's guide; 90-page tutorial
Pro Path Plus 1.0 Level 26	$495	3 5¼-inch	BASIC, assembly	2.1	Mono	384K	2 floppy or hard	1.1 M	267 pages
SuperProject Expert 1.0	$695	4 5¼-inch or 2 3½-inch	C	2.0	Mono	512K	2 floppy or hard	1.4 M	495-page manual; 36-page 10-minute guide
Time Line 3.0	$595	4 5¼-inch	Modula-2	2.0	Mono	470K	Hard	1.9 M	300-page manual; 8-page getting started booklet
Timepiece 1.3	$495	7 5¼-inch	C	2.0	CGA or Hercules mono	512K	1 floppy, 1 hard	0.7 M	276-page user's guide; 76-page tutorial; 15-page installation guide; 14-page product update
Topdown Project Planner 1.01	$99	4 5¼-inch and 2 3½-inch	C	2.11	CGA or Hercules mono[5]	384K	2 floppy or hard	0.6 M	150 pages
ViewPoint 3.0	$1995	6 5¼-inch	C	3.0	CGA	512K	1 floppy, 1 hard	0.8 M	408 pages

[1] T = time-scaled network diagram, G = Gantt, H = resource-distribution histogram, P = PERT, W = work breakdown structure.
[2] With no resources defined.
[3] Additional 384K bytes needed with PlotTrak option.
[4] With no tasks defined.
[5] Requires optional $40 driver software.

task relationships must be determined. The delay of one task may create a domino effect that delays the entire project. Such tasks form what is called the critical path. Other tasks are noncritical—unless they get excessively delayed. A 1-day delay in pouring the foundation will delay the project by 1 day. A 1-day delay in landscaping will not delay the project (although a 2-month delay might). The amount of delay a task can experience before it delays the whole project is called its float.

Resource planning, meanwhile, is complicated because resources come in discrete, finite quantities and also cost money. A carpenter, for instance, can work only 8 hours a day. To hold costs down, you'll want to schedule the carpentry work efficiently.

As you enter the resource information, some packages ask you to show whether each item has a fixed cost or a variable cost. For example, labor is a variable cost, since you can reduce the overall cost of it with efficient scheduling. But with fixed-cost items, like lumber, scheduling only changes the delivery date.

Then there's time scheduling. Project management software usually lets you define your own calendar, taking holidays and weekends into account. The software then uses this calendar for scheduling and plotting purposes, automatically working around days that aren't workdays. Simpler packages assume one calendar for the whole project. Others let you define a calendar for each resource, and they let you figure in individual vacations and even downtime expected due to bad weather, for example.

Once you've input task, resource, and cost considerations, the software should schedule tasks and calculate project costs automatically. All the programs in this review have this capability. As the project proceeds, all these programs provide a way to update the information to show how long tasks really took and how much they actually cost. Most of the programs also let you show variances—the difference between the plan and what actually happened. Some packages also let you specify multiple time estimates (i.e., optimistic, pessimistic, and most likely time scenarios) and make projections for each.

Surprisingly, one thing you don't always get is automatic resource leveling—the ability to schedule a project to make

Maximum capabilities				Time scale	Task prioritizing	Automatic resource leveling	Variance tracking	Printer graphics	Charts supported[1]	User interface
Tasks	Resources	Calendars	Intertask relationships							
1400[2]	Limited by memory	1 per resource	Unlimited	Hours to years	○	●	Option	●	T, G, H, and others; P optional	Lotus-type menus
5000	Limited by disk space	1 per project	100 preceding, unlimited succeeding	Days to months	○	○	●	Option	T and G (optional)	Menu
1800	Limited by disk space	1 per resource, task, and project	1800	1/80 day to months	●	●	●	○	T, G, P, H, W, others	Lotus-type menus
3000	192	1 per project	1500	Days to months	●	○	●	Option	T, G, P, H, others	Menu
500	60	1 per project	10 preceding, unlimited succeeding	Quarter hours to years	○	●	●	○	G, P, H	Menu
1560[2]	1500[4]	1 per resource	Unlimited	Hours to years	●	●	●	●	T, G, P, H, W, calendars	Lotus-type menus
1000	300	1 per project	Unlimited	Minutes to months	●	●	●	Option	G, H, network diagram	Lotus-type menus
500	Limited by disk space	2 per project	Unlimited	Hours to years	○	○	●	●	T, G, H	Graphical
1500[2]	3000[4]	1 per resource	Unlimited	Hours to years	●	●	○	●	T, G, P, H, others	Graphical
Limited by disk space	Limited by disk space	10 per project	Unlimited	Days to years	●	●	●	Option	T, G, P, H, W	Graphical

●=Yes ○=No

tasks fit available resources and time. Some packages with automatic resource leveling also let you prioritize each task and use that information during automatic resource leveling.

While most of the programs require entering task relationships by typing in an ID number or a task name, some offer a graphical, point-and-shoot type of interface, which lets you draw connections on the screen using the arrow keys or a mouse. These packages tend to be more expensive, however.

Producing Charts

Whether scheduling is automatic or manual, the interaction of tasks, resources, and time gets complicated fast and is best tracked visually. A key feature of project management software is its ability to generate a variety of printouts for this purpose. Each program generates a variety of charts that fall into the following broad categories:

- Gantt charts: Designed to help manage shipbuilding during World War I, Gantt charts represent tasks as horizontal shaded bars that are drawn to a common time scale (see photo 1). Usually, there's one task per row, and simultaneous tasks appear as bars stacked on top of one another. The course of events, when sorted by date, flows from the top left to the lower right. The method is named for its inventor, Henry Laurence Gantt.
- PERT charts: Created by the U.S. Navy to help in the design of the *Polaris* nuclear submarine, PERT is actually a technique incorporating the CPM. PERT charts are project network diagrams that put each task in a box, with lines between boxes showing task relationships (see photo 2). Relationships, not scheduling, are the main concern here.
- Time-scaled network diagrams: These charts differ from vendor to vendor, but they are often the ultimate product of project management software, combining the concepts of PERT and Gantt. Tasks are shown in boxes laid out according to a time scale and connected by relationship lines. A heavy or double line usually denotes the critical path line.
- Resource-distribution histograms: These graphically show the demand for a particular resource over time (see photo 3). For example, you might plan to hire three carpenters on Wednesday, but the

continued

histogram may reveal that on Wednesday you'll need five carpenters to handle all the tasks scheduled for that day.

• Other plots: One example is a work breakdown structure (WBS), which arranges tasks graphically to present the structure of activities or cost accounts (see photo 4). These usually look like an organization chart.

What follows is an evaluation of the 10 project management programs I examined (see table 1). I ran them on an IBM PC AT clone using a 16-MHz 80386 CPU and Hercules monochrome graphics (except where color was mandatory) and running under MS-DOS 3.3. I tested printing capability with a Quadram QuadLaser emulating a Hewlett-Packard LaserJet, a Qume daisy-wheel printer, or an Epson dot-matrix printer, as each package required.

InstaPlan 1.03B

This $99 package from InstaPlan Corp. requires two 5¼- or 3½-inch floppy disk drives and 512K bytes of RAM. Three options are available: a $70 set of notepad utilities, a $70 facility for tracking with variance reporting, and an $80 PERT-chart generator. The review copy had the latter two options. While InstaPlan's base price seems low, many of the other packages include InstaPlan's optional functions. A fully configured version, at $320, moves the program closer to the prices of other low-end packages.

InstaPlan uses a command interface reminiscent of Lotus 1-2-3 (e.g., pressing the Slash key brings up a command menu). Aside from the commands used for filling and editing the lists of tasks and resources, you can view the data as a PERT chart, a Gantt chart, and a "load chart," or resource-distribution histogram.

The on-screen PERT chart is actually a three-tiered vertical WBS in a screen window (see photo 5). The task currently highlighted in the task list is in the middle of the window, with its predecessors boxed above it and its successors boxed below it. Critical path connections appear as double lines, and you can see more of the chart by scrolling through the list. The histogram highlights overload situations, where resource demand exceeds supply, and you can assign separate calendars to each resource.

After you've defined tasks and resources, the program assigns them to each other through what appears to be a spreadsheet—resources are displayed along the top, and tasks along the left side of the screen. At the cell where a resource and a task intersect, you can define the relationship. For example, where a carpenter resource and a framing task intersect, you might enter 8h/d for 8 hours daily. Costs for each task group and the project total are also shown on this screen, and these change as you define relationships.

InstaPlan includes automatic resource leveling, but you should use it only when you don't mind changing the completion date. You can tell this function not to change tasks on the critical path, or you can have it schedule a specified percent of available resources (using more than 100 percent lets you see what adding people would do to the schedule).

The optional tracking module lets you save your initial plan as a "reference plan," and then you can update the working version of the plan with ongoing completion data, using the spreadsheet view. Subsequent Gantt charts will then show the current plot and the baseline plot of each task, so that problem areas will stand out.

The PERT-module option prints beautiful charts, complete with a symbol key and even a "sign-off block," as is normally included in the corners of blueprints for an approval signature. The charts come out lengthwise on multiple sheets, which you reassemble.

The Gantt charts are equally handsome, although the bars are so large that only eight tasks fit on a page. Relationship lines also connect the bars in the Gantt chart. InstaPlan covers the basics, but it doesn't have task prioritizing and it doesn't support plotters. It also doesn't let you specify multiple time estimates, but neither do most packages in this price range. InstaPlan's low price and its high-quality printer graphics make it an excellent choice for those who can live without more advanced features.

MicroTrak 1.6

This $595 package from SofTrak Systems requires a 5¼-inch or 3½-inch floppy disk drive and 256K bytes of RAM. To print network diagrams, however, you must buy a $295 companion product called PlotTrak, which requires an additional 384K bytes of RAM.

High-priced multiuser versions of MicroTrak are also offered for Unix-based systems and for DEC minicomputers. The user interface shows the mark of the mainframe world—it's less flexible than InstaPlan and other programs. You fill in "fields" on the screen, and when you've filled all of them, the program asks if you want to edit the screen or go

Photo 1: *A Gantt chart generated by SuperProject Expert.*

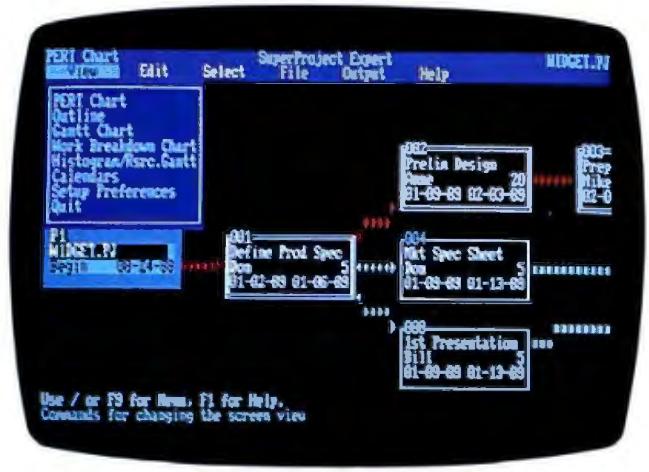


Photo 2: *A typical PERT chart created with SuperProject Expert.*

on to the next one.

MicroTrak doesn't support ASCII character graphics, and the time scale network diagrams that it produces are based on typewriter-style graphics that aren't terribly edifying. Likewise, the Logic Diagram Report, a PERT chart, is created with equal signs, minus signs, and periods. Printer graphics are available in the optional PlotTrak module.

Most of the output was in the form of tabular reports, with rows and columns of information and a variety of options as to what subject and how much detail to include. The Overuse/Underuse tabular report seemed to fill the niche usually filled by a resource-distribution histogram.

MicroTrak does not support automatic resource leveling. There is only one calendar for the whole project, and it's modified by simply listing the holidays. By contrast, other packages let you maneuver through an on-screen calendar grid.

PlotTrak lets you plot Gantt and PERT charts using a MicroTrak schedule, and it supports Hewlett-Packard, Ioline, Houston Instrument, CalComp, and Roland plotters.

MicroTrak is a program done by and for people who are at home in the mainframe world. Its interface, its price, and its all-or-nothing approach to graphics all reflect this. As a project management package, it provides bare-bones functionality. It has no automatic resource leveling, you can create only one calendar, and the user interface is crude.

Timepiece 1.3

The interface in Timepiece is more accommodating. It provides menus and input fields that change as you go along. This package from Communications Dynamics, which costs $495, requires a 5¼-inch floppy disk drive, a hard disk drive, a CGA or Hercules graphics display, and 512K bytes of RAM. It supports on-screen graphics and graphics printers, and it produced handsome graphs on my laser printer.

When inputting resource data in Timepiece, you update the default setting, which says, for example, "cost type: variable. $500 per day. hours available per day: 8." If you change "variable" to "fixed," the rest of the field disappears, since it no longer applies. When defining tasks, you can assign resources to them as you go along, selecting them from a pop-up menu that shows which resources you previously listed.

Alternately, you can define the project by drawing a network chart on-screen, instead of listing the factors and having the computer draw the chart. You start with a chart on the screen showing Start, End, and a task box in between them. You can name and define multiple tasks, listing precedence relationships as you proceed, and Timepiece draws them in as you go along. While Timepiece adds tasks from left to right, you can nudge them up and down if the screen gets cluttered.

Timepiece supports only two calendars per project and has no automatic resource leveling. It can do variance reporting, but it won't allow multiple time estimates. For project reporting, there are 19 canned report formats, with various options and levels of detail. You also can update the plan with percentages, completion dates, and actual costs, so you can track an ongoing project.

Timepiece is undemanding—you don't have to know much about the software to use it, and for that matter, you don't have to know much about project management. It seems aimed at middle managers who need to spend time where the actual work is happening rather than learning software and fiddling with schedules, and its graphical user interface makes Timepiece easy to use.

Pertmaster Advance 2.0

If Timepiece provides a good user interface, Pertmaster Advance raises project management nearly to the level of a video game. This British package from Projectronix demonstrates many things a project management package should do. Not only does it support automatic resource leveling, it also has a "nudging" feature.

At $1495, Pertmaster Advance is a serious system for serious users—at a serious price. The program requires 320K bytes of RAM and two 5¼-inch floppy disk drives, although a hard disk drive is preferable.

Pertmaster Advance supports up to two graphs at once in half-screen windows (see photo 6). If you have, say, a resource-distribution histogram showing some overload, you can place it at the bottom of the screen. At the top of the screen, you open a Gantt chart showing only those tasks involving the overloaded resource. Then you set the two graphs to the same time scale with the same starting point, so that they track each other.

Next you can go into the Gantt chart and move one of the bars. This capability is unique among these packages—the software usually arranges the bars in response to your scheduling data. The tasks linked to that task rearrange them-

continued

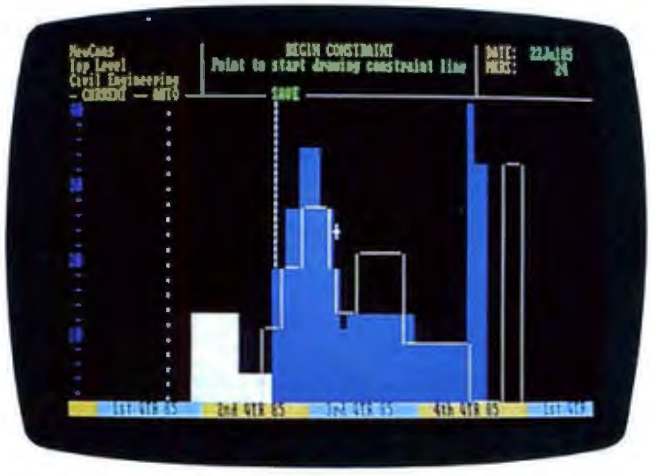


Photo 3: *A resource-distribution histogram display in ViewPoint.*

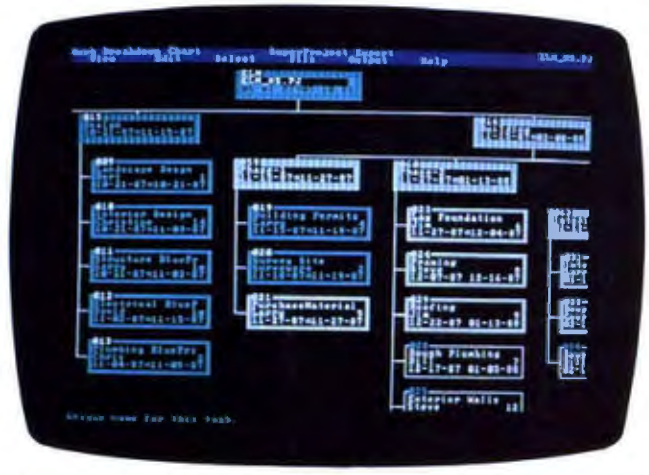


Photo 4: *A work breakdown structure created with SuperProject Expert.*

selves, and if you've affected the resource demand, the histogram changes. So you can move bars on the Gantt chart back and forth until the histogram no longer shows a problem.

An alternative is to trust Pertmaster Advance's resource-leveling "plan fit" command. If there is no required finish date, it can make everything fit. Otherwise, the program may leave some resources overcommitted.

You can assign separate calendars to each task and resource, and you can have resources and subresources. Examples include assigning workers to crews, trucks to crews, and drivers to trucks.

Pertmaster Advance can track ongoing projects and show variances. It also offers a mix of standard reports, including one numerical table that shows the demand for each resource on each day. But it doesn't let you create multiple time estimates.

The program is also rather weak when it comes to printing. Its reports are well organized, but charts are limited to typewriter-style graphics unless you have a CalComp, Hewlett-Packard, or Houston Instrument plotter.

PMS-II 8.1

If Pertmaster Advance is for the more serious user, PMS-II from North American MICA is for the full-time, dedicated user—the person who sits in a shipyard office and does nothing but scheduling. This orientation is reflected in the manual, which assumes some training with the software and familiarity with the world of project management. It limits itself to a general prose discussion of what needs to be done and how PMS-II accomplishes it. There is, however, a separate on-line manual with specific directions on using the software.

PMS-II requires a 5¼-inch or 3½-inch floppy disk drive, a hard disk drive, and 512K bytes of RAM. By itself, PMS-II does task and resource scheduling only, and it costs $1295. However, I also looked at six submodules, and the price for the entire combination is $3695.

PMS-II's manual is refreshingly jargon-free, with discussions on "loading your hard disk" instead of "installation procedures." Even the on-screen messages are less stilted, like `Please be patient while we figure this out.`

The six submodules define the resource database, material delivery scheduling, graphics printer support, color plotter support, a report generator, and batch-processing macros for unattended operation.

The material-scheduling submodule—unique among the packages I reviewed—is designed not only to let you know when to order things, but to help pool orders to get the best quantity discounts.

You can define only one calendar per project. Each activity on the network diagram can have a text note appended to it recording your planning assumptions, interactions with contractors, or whatever you want. The report generator includes a database-type language with IF...THEN...ELSE logic to define report parameters. You can divide resource costs between general and administrative budgets.

Amid all its features, PMS-II makes no effort to achieve a sophisticated user interface—PMS-II worries about your data, not about you. And for a system with its price tag, you'd expect automatic resource leveling, but it's not there.

Pro Path Plus 1.0 Level 26

The main thrust of Pro Path Plus, a $495 program from SoftCorp, seems to be to provide nicely formatted reports for use at morning progress meetings at an on-site construction office. It supplies the usual Gantt and PERT charts, but it also has reports that might be useful in a world inhabited by people more interested in precise pieces of information than in pretty charts.

Pro Path Plus uses a pop-up menu user interface, and it can produce reports on cash flow, project milestones, and expected completion dates. It also generates to-do lists and Gantt charts. You can reduce the time scale of the Gantt charts from yearly down to quarter-hour increments, with each character representing 15 minutes. On-screen, you can change the time scale by pressing the Plus or Minus key.

You can also create Gantt charts with one of three different time lengths for each task: the expected time, an optimistic time, and a pessimistic time. From these three values, it predicts a fourth, the duration you can expect within 50 percent accuracy, and produces a Gantt chart. It then prints a report with a list of possible completion dates for each task and the chance of finishing by that date. Printouts are limited to typewriter-style graphics, however.

Pro Path Plus does automatic resource leveling by delaying one or more tasks associated with an overloaded resource. On the Gantt chart, it marks the tasks it delays with one "r" symbol for each unit of time that it has delayed the task. If what you see on the chart confuses you, pressing F1 brings up a symbol legend.

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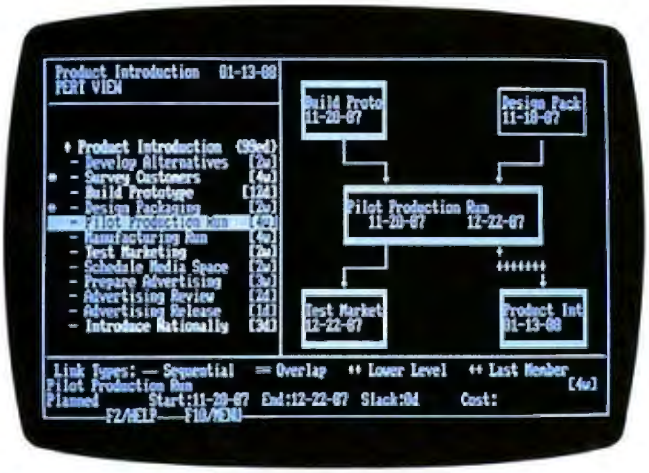

Photo 5: *InstaPlan is less sophisticated than some other packages, but it's also one of the least expensive.*

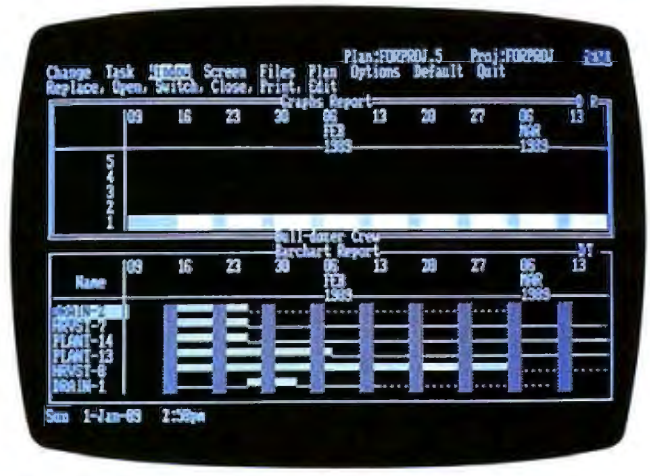

Photo 6: *Pertmaster Advance lets you combine PERT charts and resource-distribution histograms on one screen.*

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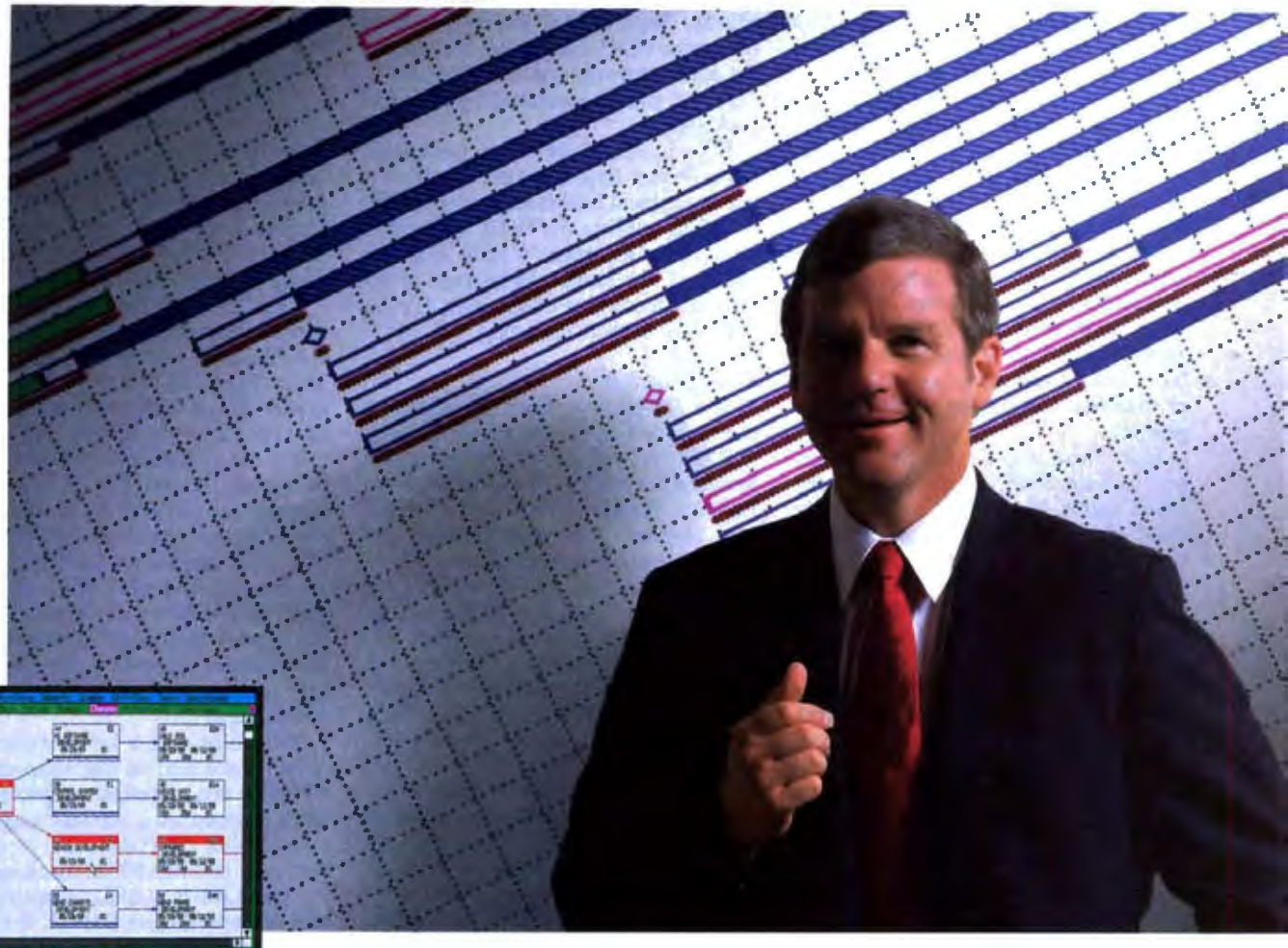

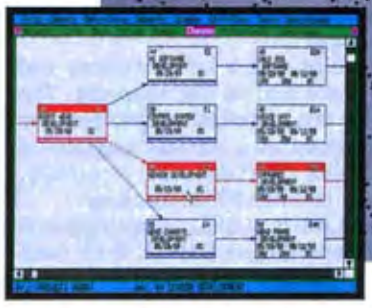

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Playing what-if games with resources is difficult because there is no central list of them—resources exist only by being listed under a particular task.

Pro Path Plus is a limited package designed for middle-level managers, for whom fiddling with charts and computers is a secondary concern.

SuperProject Expert 1.0

SuperProject from Computer Associates International is available in high-end Expert ($695) and low-end Plus ($395) versions. I reviewed SuperProject Expert; SuperProject Plus is similar to Expert, but it lacks automatic resource leveling, probability scheduling, and graphics printing.

Like Lotus 1-2-3, SuperProject Expert uses the Slash key to invoke a command menu. You select options, like what chart to display, from pop-up menus. You can also compile project information in an "outline" screen, and you can switch from there to a Gantt chart, PERT chart, WBS, or resource-distribution histogram. The PERT-chart screen is somewhat interactive—you can "scroll" from one task to another with the arrow keys, and pertinent information for that task appears in a pop-up box. You can also change this information on the fly and thus edit the chart as you go along.

Each chart's scale is changeable. This includes changing not only the time scale in a Gantt chart, but also the size of each task box in a PERT chart. You can reduce the size of the boxes until there is only enough room for the task ID number, making more of the project visible on the display.

You can also specify optimistic, pessimistic, and likely durations and output them in Gantt-chart format. With this option, the software calculates the expected duration (i.e., the optimistic, the pessimistic, and four times the likely duration, divided by 6), which it then uses for most other calculations.

When tracking a project's progress, each task can have six different conditions: scheduled for the future, started late, in progress, interrupted, completed, and finished late. The program does automatic resource leveling and can report variances. Also, you can have a separate calendar for the project and one for each resource. SuperProject Expert also includes a macro language that automates repetitive tasks or lets you set up unattended batch processing.

Printer facilities include Sideways, a utility that outputs charts in landscape mode. Charts generated using Sideways support graphics printing. On a laser printer, SuperProject Expert produced handsome PERT charts, but they lacked the accompanying symbols, legends, titles, and frames produced by the other packages.

Like most of the other packages, SuperProject Expert makes no effort to use a graphical interface. You enter data by filling out lists and fields. Other than that, however, there's little else you could ask for amidst its barrage of options and features. For the price, it's one of the best deals in the group.

Time Line 3.0

This $595 package from Symantec requires a hard disk drive and 470K bytes of RAM. A $195 graphics option makes presentation-quality charts on Hewlett-Packard, Houston Instrument, and Roland plotters. The basic package produces typewriter-style graphics.

Time Line's eye-appealing packaging gives it away: This is product management software for the mass market. The documentation is lucid and stocked with examples, the user interface is polished, and great attention has been paid to some carefully selected features, to the exclusion of some others.

The program displays a network diagram that is a variation on the standard PERT chart. Time Line organizes tasks as "summary tasks" composed of subtasks. Each summary task is in a large box that contains subtask boxes, and the summary task boxes are connected by precedence lines. Each subtask can also have tasks under it, and charts quickly become complicated. Projects can end up looking like a complicated nest of boxes that's bothersome to decipher.

Also, while Time Line does calculate the critical path, you can highlight only the boxes, not the precedence lines, on the critical path. To do so, you must use a "filter."

Time Line does not have a time-scaled network diagram, but it does have a Gantt chart that includes coded information to the right of each task name, indicating whether a task is on the critical path or has an overscheduling problem. You can scroll around in the chart by using the arrow keys, but you can't nudge the bars—they are placed according to the information you give in various data input screens.

Time Line can also display resource-distribution histograms, but only in combination with a Gantt chart. You can show up to five histograms on the bottom of a Gantt chart, set to the same time scale, and you can print out these combined charts. Resources that are overscheduled are highlighted. Time Line can also perform automatic resource leveling.

The number of reports available is not extensive. It can do status reports, showing what tasks occur in a specified week or month; cross tab reports, showing expenses involved in a particular task (or resource) in a specified time frame; and resource reports, whose columns contain whatever data fields you specify.

The Lotus 1-2-3–like user interface includes numerous shortcuts using the function keys. You can conveniently select items (like when you assign a resource to a task) using a variation of the point-and-shoot method from pop-up screens.

The manual assumes the reader has no background knowledge of project management, and it carefully introduces new concepts like critical path and fixed cost. There is a lengthy on-line tutorial that's too simple. And when you run the program for the first time, Time Line gives you special "First Aid" screens that help you create a schedule. Also, contextual help screens that you can invoke with F1 are thorough.

Time Line uses a lot of memory and relies a great deal on disk swapping. The only time this proved to be a problem was when it produced a network diagram—a project with 50 tasks took 3 minutes, even on a 16-MHz 80386 machine.

Time Line is a slick, simplified version of SuperProject Expert. Both work from an outline task list, but Time Line adds a comforting cocoon of help screens and tutorials. It lacks some extras, like multiple time estimates, a time-scaled network diagram, multiple calendars, and more extensive report formats.

On the other hand, because of its copious help features and plain-language documentation, it can be safely placed in the hands of someone who is approaching computer-aided software management for the first time.

Topdown Project Planner 1.01

Topdown Project Planner from Ajida Technologies is a $99 package that requires 384K bytes of RAM, two floppy disk drives, and a color graphics display. The program is based on a descending hierarchy of PERT charts, each covering one screen. You define the main tasks by placing, defining, and connecting PERT boxes on the initial screen, using the program's graphical interface. Then you go into each box, where you start over with a blank screen and define the tasks that go into the main task. This continues for

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as deep as you want to go, within ordinary memory limitations.

You can go into a screen mode that shows the boxes without any text. In this mode, you can see, drawn in miniature within the boxes, the charts for the next level. Perhaps mercifully, you can't see to the third level.

You can assign tasks priorities, and automatic resource leveling is available, although you can't perform variance tracking. The latter works by delaying tasks with lower priorities. The manual suggests resolving obvious conflicts by assigning priorities and then letting the computer take over, but it warns that resource leveling should be used with care because it can cause major rescheduling for noncritical tasks. In the real world, such changes can make a schedule difficult to implement. Automatic resource leveling is still useful, however, as long as you make provisions for making some manual adjustments.

Topdown Project Planner can combine two graphs on one page, like a Gantt chart on top of a cumulative cost chart, and can set both to the same time scale. You could also have a Gantt chart with a daily cost projection below it, for budgeting purposes, or a Gantt chart with a histogram below it, so you could spot overloads and immediately see the source. Printouts are essentially screen displays scaled to fit a page, and they require a graphics printer.

The program also lets you track progress on a project, and the Gantt charts reflect what has been done. You also can assign a calendar to each resource and append text notes to each task on-screen. The only thing I didn't like is that Topdown Project Planner limits each PERT chart to one screen. By contrast, other programs let you create charts that are bigger than your display.

ViewPoint 3.0

ViewPoint from Computer Aided Management is one of the higher-priced packages in the group, but it also offers the most features. It costs $1995, but I also tested its graphics printing and plotting option, which costs $995. The program requires a floppy disk drive, a hard disk drive, and a color monitor.

When you start defining a project in ViewPoint, you see a screen with a blank work area and a cross-hair cursor that you can move with a mouse or cursor movement keys. The date counter in the corner moves forward as the cursor moves right, and backward as it moves left. You move the cursor to a likely date, press the Plus key on the numeric keypad, and up pops a window. Press T, for task, and a "task description window" pops up. You fill in the information, and a box representing that task appears on-screen.

After entering a few tasks, you assign precedences by drawing lines between the boxes. To establish a finish-to-start relation, you draw from the right (finish side) of the first box to the left (start side) of the other. If the new line is part of the critical path, the line appears in red.

If the precedence relations (and duration of the preceding tasks) indicate that a task should start at some time different than its original placement, ViewPoint may relocate the box after you draw the lines. You can also change the time scale to view more of the project on-screen. The larger the time scale, however, the smaller the boxes get; task names may be truncated beyond recognition.

You can play with the layout of the network and with the task data until you get what you want. After you define a list of resources, you can assign them to tasks by a simple point-and-shoot method: You highlight the task, call up the pop-up resource list, and highlight the resource.

You can also "constrain" resources graphically. On the resource-distribution histogram, you can draw a line at whatever level you want to limit the resource to. You can move the line up and down as you go left to right, reflecting any changes you expect. ViewPoint then does resource leveling, changing the end date or eating up the available float to push tasks to a point on the time line where they can get the resource they need.

The new schedule is labeled "pending" until you decide to accept it. "Negative float" may appear on the new schedule—meaning the software has moved the start of some tasks forward to level resources.

The program's constrain function also

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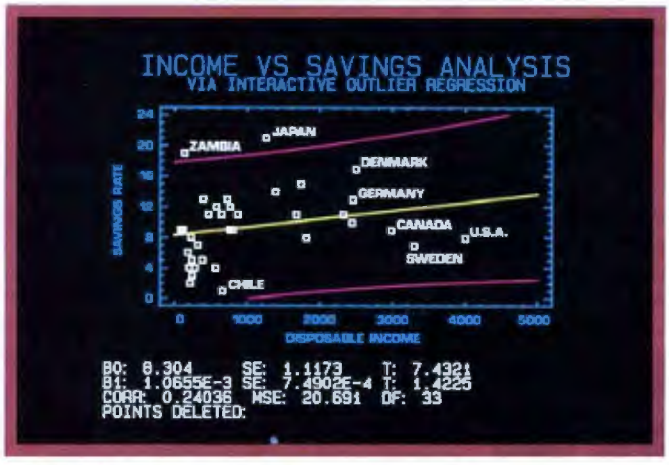

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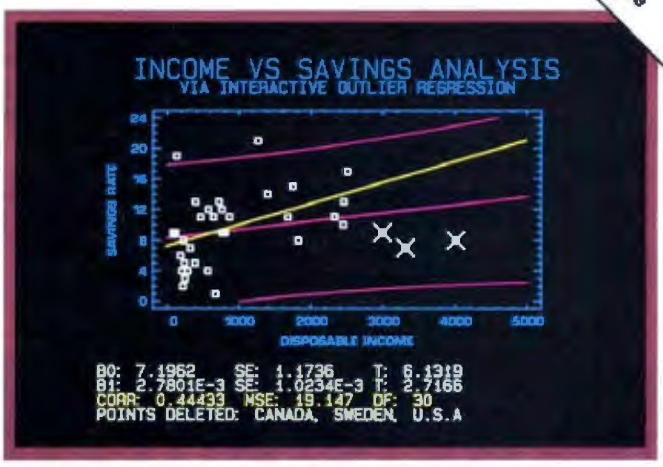

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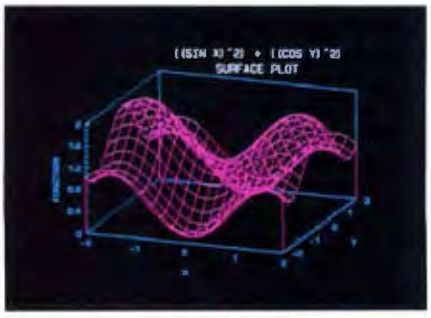

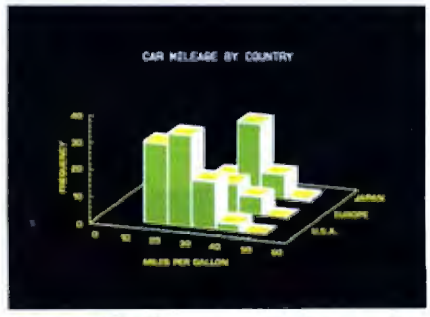

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prevents expenses from rising above a specified daily level, since you can draw a constraint line on the cost histogram.

To measure a project's progress, you make a "snapshot" of your original "reference plan," which thereafter appears as pale blue lines placed over white bars that represent progress. ViewPoint offers a full range of report options, and the printer-graphics option generates Gantt, PERT, WBS, and other project network charts.

ViewPoint comes across as both fun and powerful—a rare combination. Unfortunately, it's also expensive. Many other packages provide most of the functionality for substantially less money.

Overview

All the packages reviewed here could help you manage a project with varying degrees of depth and sophistication. But many of them lack a good user interface, and some offer only basic project management capabilities. MicroTrak, for example, does little more than the on-screen equivalent of paper modeling, although it's faster than manual methods once you've entered the data. Most of the others make an effort to break with the past and make use of the computer's power, like Pertmaster Advance, with its nudging function, and ViewPoint, with its ability to let you graphically build and interact with a network diagram on the screen. Topdown Project Planner and Timepiece have similar functions, but they aren't so sophisticated.

Another consideration is whether you need project management software at all. Ultimately, a project must be of a large enough scale to benefit from project management software. How many tasks should you have before project management software becomes worthwhile? The answer depends on the manager and the project. You may find the software helpful for tracking as few as 20 tasks, if frequent updates are required; others may find manual methods easier until a project requires tracking 100 or more tasks.

While many of these packages have one or two attractive features, none has all of them in one package. The optimal package would be a combination of Pertmaster Advance and ViewPoint, which would involve a graphical point-and-shoot interface, automatic resource leveling, and manual editing capability using the graphics interface. Unfortunately, such a program doesn't exist.

Of these 10 programs, which is best depends on your needs. If you want support tools for managers who would otherwise keep everything in their heads, something like InstaPlan will do the job for a reasonable price. If you're trying to ease the burden for someone who spends many long hours trying to squeeze the last bit of fat out of a high-cost project, Pertmaster Advance or ViewPoint would be desirable. Good compromises are SuperProject Expert and Topdown Project Planner, which offer much of the capability of the high-end packages at more reasonable prices. ■

ACKNOWLEDGMENT

I wish to thank Daniel Yahdav, president of the consulting firm I Soft Decision, Inc., who provided input for this review. His firm publishes PM Solutions, *a comprehensive report on project management software.*

Lamont Wood is a freelance writer in the computer and electronics fields who lives in San Antonio, Texas. You can reach him on BIX as "lwood."

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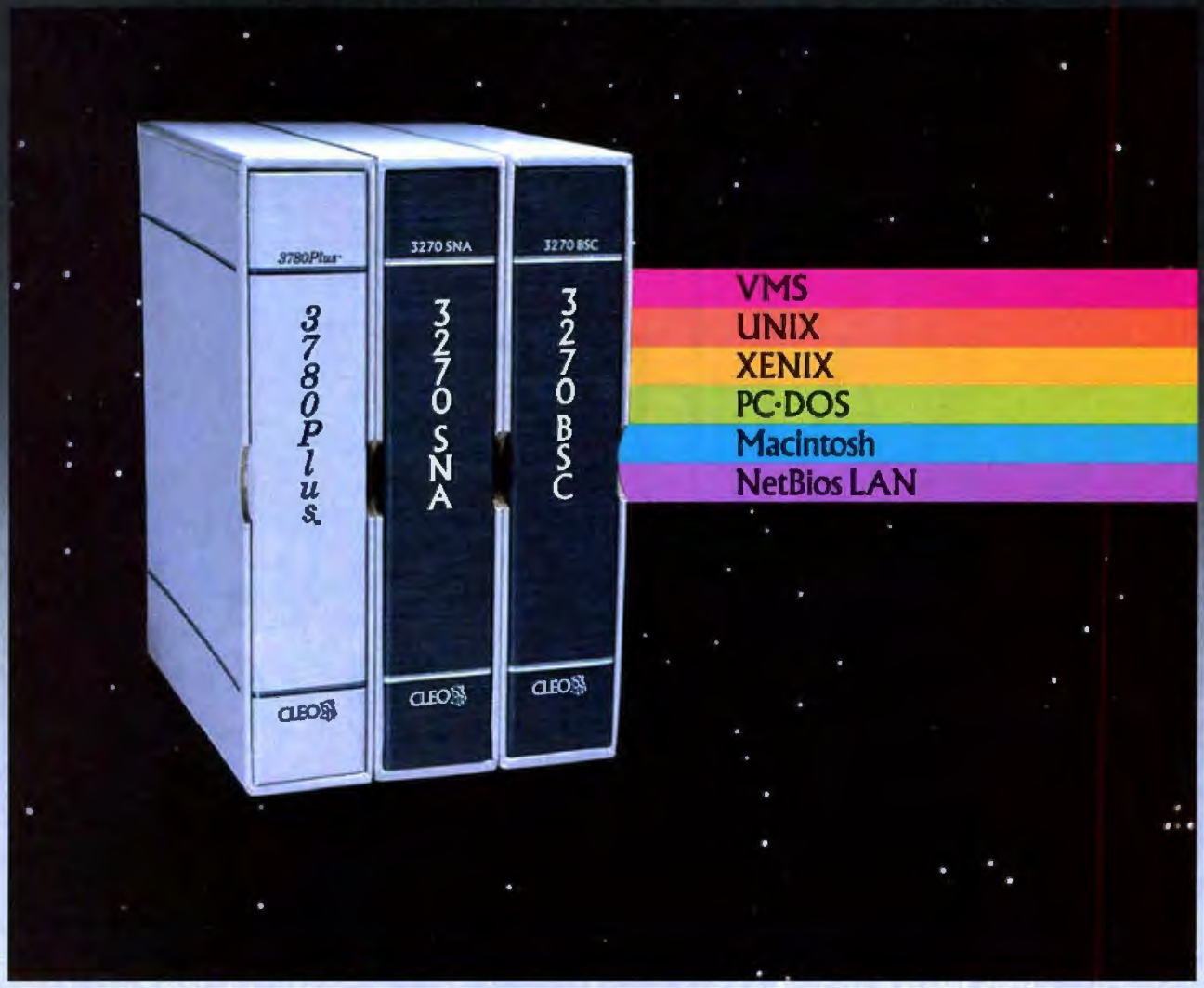

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SX Appeal

Compaq's 386s is the first of a new generation of microcomputers that implement Intel's low-cost 80386SX

Jeff Holtzman

One of the most exciting developments in microcomputers this year has been the introduction of the 80386SX microprocessor, which promises 80386 performance and software compatibility at AT prices. Compaq's 386s is the first personal computer built around this new chip. It's the harbinger of a new class of machines that's destined to become the entry point for 80386-level computing and eventually replace the AT as the mid-range microcomputer of choice.

The Compaq 386s has a small footprint, is lightweight, and packs a lot of power. But while the 386s's design takes full advantage of the SX chip's potential, the machine's relatively high price puts it in competition with more powerful 80386 systems.

Compaq offers the 386s in three configurations. The Model 1 ($3799) has 1 megabyte of memory, a 5¼-inch floppy disk drive, a 101-key enhanced keyboard, and a 140-watt power supply. The Model 20 ($4499) adds a 20-megabyte, 29-millisecond, 3-to-1 interleave enhanced-small-device-interface hard disk drive. The Model 40 ($5199) offers a 40-megabyte, 29-ms, 1-to-1 interleave ESDI hard disk drive.

All models come with hard/floppy disk controllers, serial and parallel ports, a mouse port, and a 16-bit VGA-compatible video adapter on the motherboard. The 386s also includes Compaq's Expanded Memory Management software (CEMM), a disk cache, a RAM disk, and other utility programs. DOS (version 3.31) and OS/2 (version 1.0) are extra-cost options, however.

The motherboard has four 16-bit AT expansion slots and one proprietary 16-bit memory-expansion slot that holds up to 13 megabytes of RAM. Color and monochrome analog VGA monitors, tape backups, and a multitude of other options are also available. All models come with a 1-year warranty and carry FCC Class B certification.

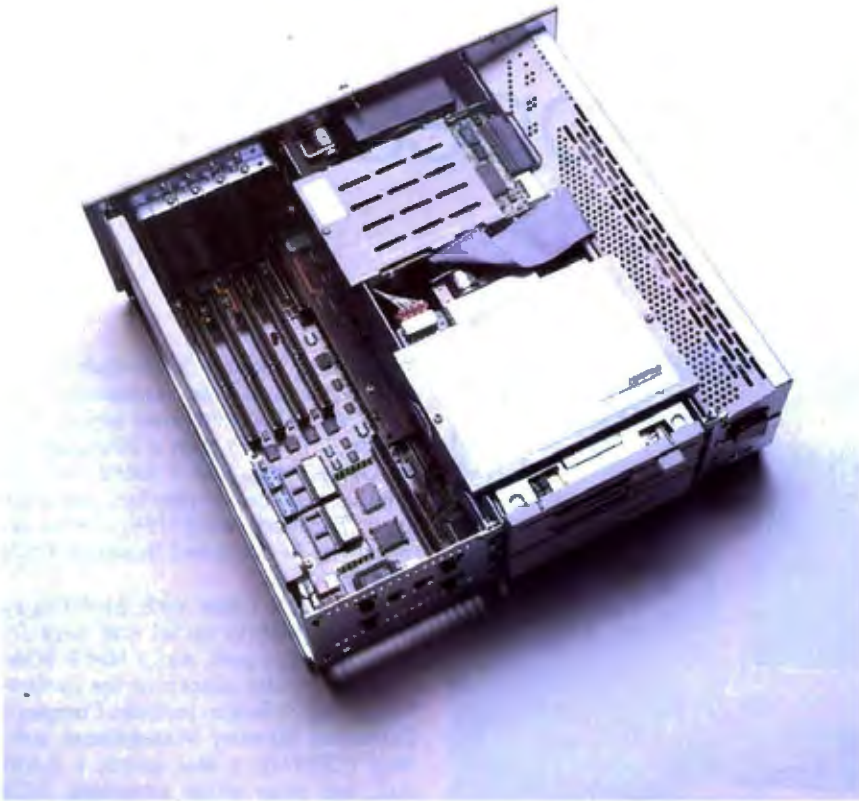
I tested a Model 40 with 1.2-megabyte 5¼-inch and 1.44-megabyte 3½-inch floppy disk drives, a 40-megabyte hard disk drive, a 40-megabyte Irwin Magnetics tape backup with backup software that runs under both DOS and OS/2, 5 megabytes of RAM, an 80387SX math coprocessor, and a color VGA monitor. This brought the cost of my system to $10,740.

Internal Affairs

Getting inside the 386s is easy; the cover is held on with three thumbscrews. It must have been a challenge for Compaq's engineers to fit everything into the narrow (15-inch) chassis. As the photo on page 198 shows, they did so by using some unusually shaped components and by arranging them efficiently.

The front of the chassis provides open-

continued



Internally, the 386s has a clean, compact design that fits neatly into a 15-inch-wide chassis.

ings for two one-third-height drives and one half-height storage device. Directly behind these are spaces for two 3½-inch internal drives. All drives mount in a separate subchassis; together, the power supply and the drive chassis occupy about 60 percent of the width of the case. Unfortunately, there is no reset switch. An LED lights up when power is on; another indicates hard disk drive activity.

Next to the drive chassis is a slot for Compaq's proprietary memory card, which also contains a VGA feature connector. There's no video circuitry on the memory card, however; it merely provides a path for signals from the motherboard and an additional sandwich card mounted above it.

As with Compaq's 80386-based machines, the memory slot operates at microprocessor speed (16 MHz), not expansion-bus speed (8 MHz). Both 1-megabyte and 4-megabyte expansion boards are available. Each is expandable by adding 1- or 4-megabyte modules, to a maximum of 13 megabytes of memory. You can add even more memory by using the regular expansion slots, but this will decrease system performance.

The motherboard, which measures 11 inches wide by 13 inches deep, is built almost entirely from surface-mount components and has an extremely clean look. More than half of it is obscured by the drive-bay subchassis, but most important things are easy to get at, including the CPU, ROM, and math coprocessor sockets and two system-configuration DIP switches. Unfortunately, a third DIP switch that specifies the amount of installed memory is partially obscured by the drive bays and memory card; they have to be removed to access the switch.

A chassis lock on the rear of the chassis doesn't provide an electrical keyboard interlock, as most AT compatibles do. However, an optional password feature performs the same function.

Run Time

The 386s's high-caliber documentation makes getting up and running easy, and the best part of Compaq's documentation is affixed to the chassis: two metallic labels that show the location of the major system components and the DIP-switch settings. If your machine gets separated from its manuals, you'll still have no trouble setting it up.

The 386s also comes with an operations guide that contains Getting Started, Technical Overview, and User Program Reference booklets. The latter includes information on CEMM, CACHE, and VDISK. Compaq also sells two technical reference guides—one for the VGA subsystem and one for the 386s itself. Both contain in-depth descriptions of topics such as block diagrams, timing diagrams, and BIOS functions.

The setup process involves a bit more switch-flipping than do AT compatibles. Three DIP switches indicate the presence of the math coprocessor, boot speed, monitor type, optional power-on password, amount of memory, and so on. The switches also let you disable the onboard controllers (e.g., video, disk, and I/O ports) in case a fault develops on the motherboard or an expansion board requires it.

A conventional RAM-based setup program lets you specify items such as time and date, hard disk type, NumLock key boot state, the power-on password, and network server mode. In the network server mode, the machine boots only from the hard disk, and the keyboard remains inactive until you enter a password. The machine stores the password in CMOS RAM.

Compaq has taken an innovative approach to providing compatibility with software designed to run at slower speeds. You can use MODE.COM to set the machine's speed to any value between 1 (slow) and 50 (fast). The values that correspond to different PC speeds are listed in the technical reference guide.

Actual clock speed doesn't change; the expansion bus continues to operate at 8 MHz with one wait state. But the machine's refresh timing changes, increasing as the speed selected decreases to effectively lengthen the time each instruction takes to execute.

The 386s keyboard has an excellent feel and is the best I've tested. It provides the "clicky" tactile feedback of the IBM Enhanced keyboard, but it's not so noisy.

Compatibility Testing

I had no trouble installing and using a Hayes 2400-bit-per-second internal modem (Model 2400b) and a Microsoft Serial mouse. I also had no trouble installing and running DESQview 2.01 (with QEMM), 386MAX 2.36, WordStar Professional 4.0, a beta version of WordStar Professional 5.0, Turbo Pascal

continued

Compaq 386s

APPLICATION-LEVEL PERFORMANCE

Compaq 386s **11.5***

WORD PROCESSING	Med/Large
XyWrite III+ 3.52	
Load (large)	:13
Word count	:04/:27
Search/replace	:06/:26
End of document	:02/:15
Block moves	:10/:10
Spelling check	:11/1:22
Microsoft Word 4.0	
Forward delete	:18
Aldus PageMaker 1.0a	
Load document	:10
Change/Bold	:32
Align right	:24
Cut 10 pages	:21
Place graphic	:04
Print to file	2:29
Index:	**2.24**

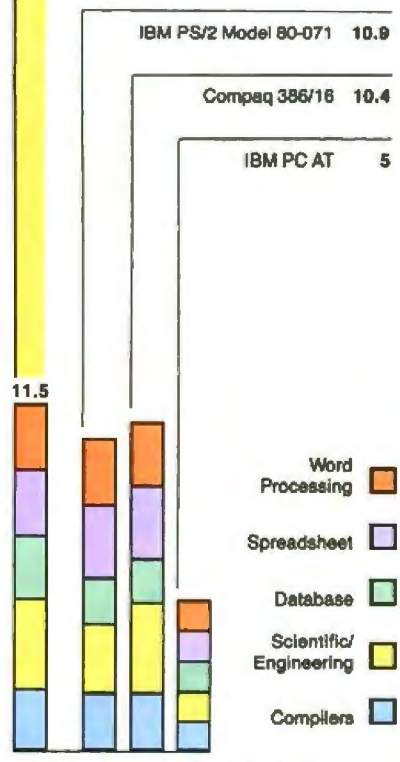
SPREADSHEET	
Lotus 1-2-3 2.01	
Block copy	:04
Recalc	:02
Load Monte Carlo	:15
Recalc Monte Carlo	:06
Load rlarge3	:04
Recalc rlarge3	:01
Recalc Goal-seek	:04
Microsoft Excel 2.0	
Fill right	:07
Undo fill	2:34
Recalc	:02
Load rlarge3	:26
Recalc rlarge3	:02
Index:	**2.15**

DATABASE	
dBASE III+ 1.1	
Copy	1:17
Index	:06
List	1:00
Append	2:11
Delete	:02
Pack	1:41
Count	:05
Sort	1:01
Index:	**2.06**

SCIENTIFIC/ENGINEERING	
AutoCAD 2.52	
Load SoftWest	:57
Regen SoftWest	:45
Load StPauls	:12
Regen StPauls	:07
Hide/redraw	14:56
STATA 1.5	
Graphics	:32
ANOVA	:13
MathCAD 2.0	
IFS 800 pts.	:19
FFT/IFFT 1024 pts.	:20
Index:	**3.01**

COMPILERS	
Microsoft C 5.0	
XLisp compile	5:01
Turbo Pascal 4.0	
Pascal S compile	:05
Index:	**2.05**

All times are in minutes:seconds. Indexes show relative performance; for all indexes, an 8-MHz IBM PC AT = 1



*Cumulative applications index. Graphs are based on indexes at left and show relative performance.

LOW-LEVEL PERFORMANCE[1]

Compaq 386s

CPU	
Matrix	6.69
String Move	
Byte-wide	52.48
Word-wide:	
Odd-bnd.	44.27
Even-bnd.	26.25
Doubleword-wide:	
Odd-bnd.	29.41
Even-bnd.	19.7
Sieve	36.10
Sort	30.79
Index:	**1.86**

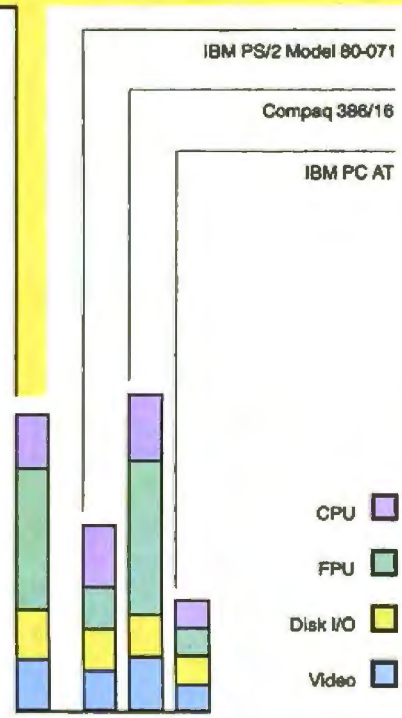
FLOATING POINT	
Math	11.17
Error[2]	0.00E+00
Sine(x)	3.23
Error	2.00E−09
e^x	3.49
Error	1.00E−09
Index:	**5.03**

DISK I/O	
Hard Seek[3]	
Outer track	3.32
Inner track	3.33
Half platter	9.92
Full platter	9.97
Average	6.63
DOS Seek	
1-sector	14.37
32-sector	24.61
File I/O[4]	
Seek	0.13
Read	0.64
Write	0.99
1-megabyte	
Write	4.70
Read	3.59
Index:	**1.78**

VIDEO	
Text	
Mode 0	4.63
Mode 1	4.63
Mode 2	4.61
Mode 3	4.61
Mode 7	N/A
Graphics	
CGA:	
Mode 4	2.47
Mode 5	2.49
Mode 6	2.62
EGA:	
Mode 13	4.36
Mode 14	4.76
Mode 15	N/A
Mode 16	4.74
VGA:	
Mode 18	4.98
Mode 19	2.69
Index:	**1.87**

CONVENTIONAL BENCHMARKS	
LINPACK	242.66
Livermore Loops[5] (MFLOPS)	0.12
Dhrystone (MS C 5.0) (Dhry/sec)	3553.00

[1] All times are in seconds. Figures were generated using the 8088/8086 and 80386 versions (1.1) of Small-C.
[2] The errors for Floating Point indicate the difference between expected and actual values, correct to 10 digits or rounded to 2 digits.
[3] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100).
[4] Read and write times for File I/O are in seconds per 64K bytes.
[5] 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

Compaq Deskpro 386s Model 40

Company
Compaq Computer Corp.
20555 FM 149
Houston, TX 77070
(713) 370-0670

Components
Processor: 16-MHz 80386SX; optional 80387SX math coprocessor
Memory: 1 megabyte of static-column RAM, expandable to 13 megabytes in proprietary slot
Mass storage: 1.2-megabyte 5¼-inch floppy disk drive; 40-megabyte ESDI hard disk drive
Display: On-board VGA adapter; optional monitors
Keyboard: 101-key enhanced
I/O interfaces: RS-232C (9-pin), parallel (25-pin), and mouse (PS/2-style DIN) ports; four 16-bit AT expansion slots; one 16-bit proprietary memory slot

Size
6 × 15 × 16 inches; 28 pounds

Software
Diagnostics test; system setup; ROM version; disk cache; RAM disk; CEMM software

Options
16-MHz 80387SX: $799
1-megabyte memory-expansion board: $799
4-megabyte memory-expansion board: $2999
1-megabyte memory module: $799
4-megabyte memory module: $2999
1.2-megabyte 5¼-inch floppy disk drive: $275
360K-byte 5¼-inch floppy disk drive: $225
1.44-megabyte 3½-inch floppy disk drive: $245
110-megabyte hard disk drive: $3499
135-megabyte tape backup: $1999
40-megabyte tape backup: $799
Serial/parallel adapter: $149
VGA color monitor: $699
VGA monochrome monitor: $255
MS-DOS 3.3 and BASIC: $120
OS/2 1.0: $325
Technical Reference Guide: $149

Documentation
40-page Getting Started; 60-page Technical Overview; 80-page User Program Reference

Price
Model 40: $5199
System as reviewed: $10,740

Inquiry 883.

4.0, Microsoft BASIC 6.0, Lotus 1-2-3 version 2.01, VP-Planner 1.0, Professional CED 1.01a, Brooklyn Bridge 1.30, DeskLink 2.21, AutoCAD 9.0, AutoSketch enhanced version 1.01, Excel 2.0, PageMaker 3.0, and Smartcom III.

I did experience a problem with Compaq's OS/2 version 1.0B rev. B and the internal modem I'd installed. After installing OS/2, I received an error message stating that `COM1 did not install because The device adapter could not be located`. I removed the modem and reinstalled OS/2 without any problems. And when I also reinstalled the modem, I was unable to reproduce the problem.

Unlike some non-IBM versions of OS/2, you see the Program Selector screen when you boot the installation disk; this lets you choose either a DOS prompt, an OS/2 prompt, or a separate installation program. This program copies files from the floppy disk to the hard disk and lets you create a custom configuration for your system.

Also, Compaq's OS/2 puts about three dozen files in your root directory and divides the remainder among two subdirectories: \OS2 and \OS2.000. Unfortunately, like IBM's version of OS/2, Compaq's OS/2 doesn't include a dual-boot option. After installing the operating system on your hard disk, you must boot from a floppy disk to run DOS.

The only other distinguishing feature of Compaq's OS/2 is a configuration program that gives you a menu-based means of setting up the CONFIG.SYS file. The advantage is that you needn't switch into real mode to edit the file. (OS/2 does not come with a protected-mode editor—not even a protected-mode version of EDLIN.)

I also installed version 2.1 of Windows/386. Windows itself ran fine, as did applications including Excel 2.0 and PageMaker 3.0. However, I couldn't get Microsoft's extended memory driver, HIMEM.SYS, to run. According to Microsoft, the driver incorrectly identified the 386s as using the PS/2 method of switching address line A20; consequently, it detected no extended memory.

A version of HIMEM.SYS provided with an updated version of Windows/286 ran fine, providing an extra 58K bytes of memory. Microsoft is working to correct the fault with Windows/386, and a fix should be available by the time you read this review.

Architectural Details

Compaq built most of the 386s around AT standards, including the expansion bus, direct-memory-access controllers, real-time clock, memory refresh, interrupt control, and keyboard controller. One interesting addition is a fail-safe timer that an advanced operating system (OS/2 or Unix, for example) can use to generate regular interrupts that prevent an errant program from hogging or locking up the system. Another timer is used in a one-shot mode to extend the refresh-request signal. This decreases system throughput, as discussed in conjunction with the mode speed command above. A BIOS function also allows programmed speed setting.

The memory system uses Compaq's page-mode architecture with no static RAM cache. Access to locations in a single 2K-byte page occurs with zero wait states; access to a location outside the current page occurs with two wait states. On the average, approximately 60 percent of memory accesses in the 386s occur outside the current page, resulting in an average of 0.8 wait states per memory access, according to Compaq.

The motherboard contains 1 megabyte of memory, of which 640K bytes is normally mapped to the first 640K bytes of CPU address space and the remaining 384K bytes is mapped to the top of the 16-megabyte address space. You can also configure the system to allocate only 256K or 512K bytes of memory beginning at 0000 hexadecimal; in each case, the remainder (768K and 512K bytes, respectively) is mapped to the top of the address space.

Whatever the base memory (256K, 512K, or 640K bytes), you can map down the upper 128K bytes of unused memory from F0E000h to 00E000h (i.e., 0000:E000), where it can run a write-protected copy of the ROM BIOS, the VGA BIOS, or both. Compaq also provides a special BIOS function for moving ROM contents. In addition, the location of the 128K-byte block of memory depends on the state of a special register that's accessible at I/O port address 878h or at memory address 80C00000h. Two bits in that register specify where the RAM is to reside and whether it's write-protected.

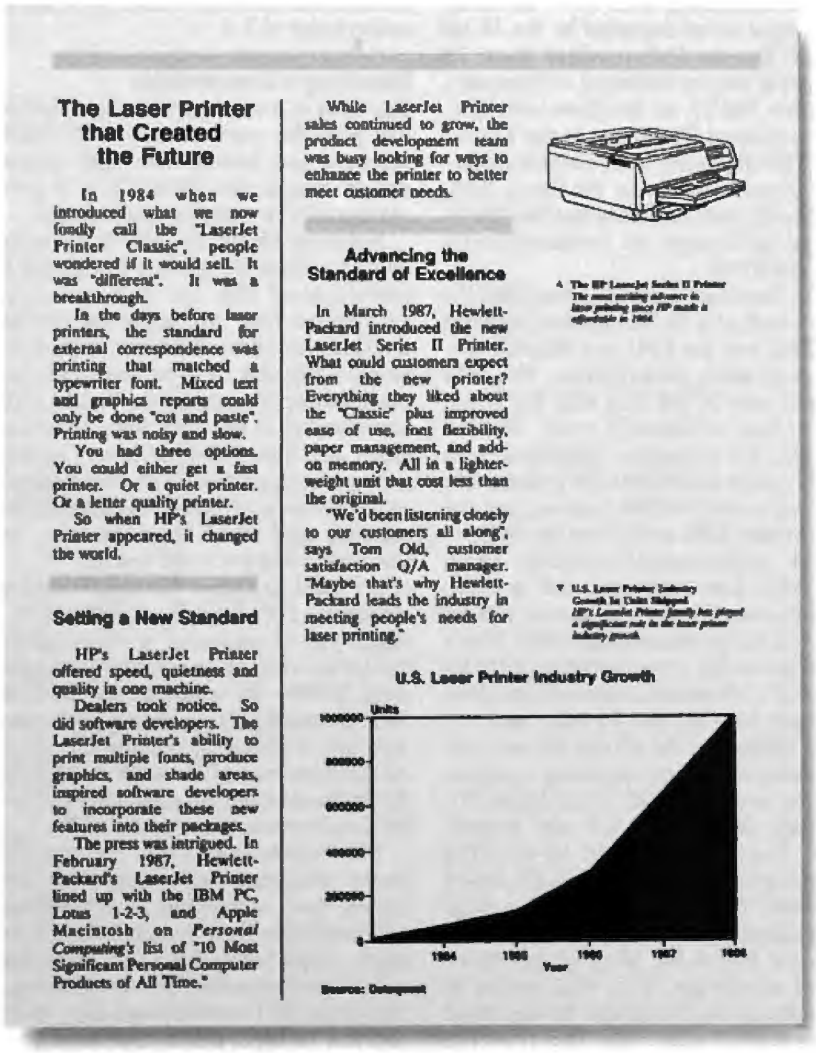
A Promise Fulfilled?

Does the 386s meet the promise of high performance at low cost? The answer, unfortunately, is not simple.

In terms of raw CPU performance, the 386s simply doesn't hold up to the performance attained by most of the 16-MHz 80386-based machines that BYTE has tested. Overall, the Deskpro 386/16

continued

The most influential laser printer in history.



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While LaserJet Printer sales continued to grow, the product development team was busy looking for ways to enhance the printer to better meet customer needs.

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In March 1987, Hewlett-Packard introduced the new LaserJet Series II Printer. What could customers expect from the new printer? Everything they liked about the "Classic" plus improved ease of use, font flexibility, paper management, and add-on memory. All in a lighter-weight unit that cost less than the original.

"We'd been listening closely to our customers all along", says Tom Old, customer satisfaction Q/A manager. "Maybe that's why Hewlett-Packard leads the industry in meeting people's needs for laser printing."

4 The HP LaserJet Series II Printer

5 U.S. Laser Printer Industry Growth

U.S. Laser Printer Industry Growth

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The HP LaserJet Series II Printer.

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attains a CPU index of 2.20; the 386s, at 1.86, attains about 85 percent of the 386/16's raw computing horsepower.

The two machines performed nearly identically in the String Move tests, which indicates that raw memory throughput is not degraded by the 16-bit 386SX. But the 386s provided about 73 percent of the performance of Compaq's DeskPro 386/16 in the Sieve and Sort tests and about 79 percent in the Matrix test. The 20 percent to 25 percent difference in performance in the Sieve, Sort, and Matrix tests indicates that the 386SX simply can't keep up computationally with the 80386.

The Floating Point tests reveal that the 386s's lack of a 32-bit interface between the CPU and the FPU is a definite hindrance to math performance. The 386s exceeds only 80386 PCs with 80287 coprocessors—Compaq's early 386/16 models, for example. Machines with 80387s (such as the IBM PS/2 Model 80, Compaq's other 80386 systems, and the Dell System 310) easily beat the 386s.

Disk performance is another story. The 386s does well here and in video performance because the lack of a 32-bit data bus isn't a disadvantage. The 386s's ESDI hard disk drive achieved a BYTE index of 1.78, which easily surpassed the Deskpro 386/16, the 16-MHz and 20-MHz versions of the Model 80, and several other machines, including a preproduction version of IBM's PS/2 Model 70.

Video performance was also impressive. The unit's built-in 16-bit VGA adapter achieves an index of 1.87, which surpasses Compaq's 386/16 by a large margin and is just slightly slower than the 16-MHz Model 80. Most of the 386s's speed advantage is in text mode; in graphics mode, the Model 80 was about 15 percent faster, and the Deskpro 386/16 was about 2 percent faster.

Faster 80386 machines leave the 386s in the dust. The 25-MHz Deskpro, for example, achieves nearly twice the video performance. Because the width and speed of the two machines' expansion buses are identical, the raw speed with which the CPU processes video data is the determining factor here.

The real test, of course, is applications, and in this area the 386s is well above AT levels and solidly in the running with the 16-MHz 80386 machines. At 11.51, the 386s has an overall application index that's more than twice that of an AT, and it edges out Compaq's Deskpro 386/16 and the 16-MHz Model 80. The 20-MHz 80286-based Dell 220 with 2 megabytes of RAM and the 20-MHz Model 80 came in just above the 386s.

The 386s's application index is also well above that of high-performance ATs, such as the five machines reviewed in the July BYTE. The highest-performing member of that group, the Amdek System 286/A, achieved an overall application index of 9.8.

Reaching a Compromise

The 386s is a solid-performing machine that provides compatibility with 80386 software and proves that, with proper system design, the 80386SX is a good platform for demanding applications.

Not surprisingly, the 386s is not a machine for those demanding the utmost in performance. The fast disk and video subsystems help overcome the limitations of the 16-bit data bus, which restricts CPU and FPU performance, but the 386s doesn't support the Weitek math coprocessor, it has only four expansion slots, and the 140-watt power supply seems underpowered. The power supply in my review unit, which included only a memory card and a Hayes modem, ran uncomfortably hot to the touch.

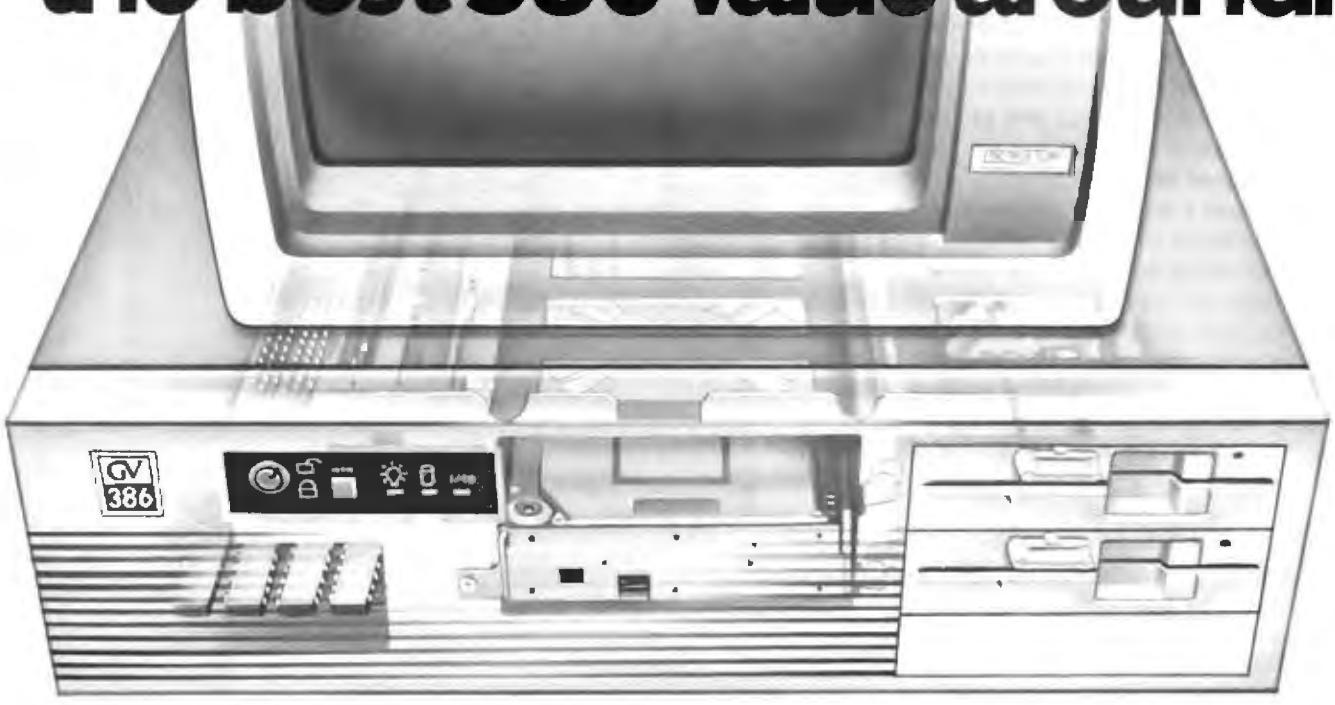
It's hard to figure Compaq's pricing structure. For example, a 386s with 1 megabyte of memory, a 40-megabyte hard disk drive, and a color VGA monitor costs $5898. By contrast, the Deskpro 386/16 costs $7797—almost $2000 more, although it performs roughly the same. At the other end of the scale, a 12-MHz 80286-based Compaq costs $5497. For a $400 difference, why buy the 80286?

The bottom line is that you can buy faster machines for considerably less money from competing manufacturers. A comparable Dell System 310, for example, costs $4299, has a full 32-bit bus, and outperforms the 386s in all categories. Even Dell's new System 220, which sports a 20-MHz 80286, performs comparably. And while the Dell System 220 can't run 80386 software, at $3199 it costs about half as much as the 386s.

The 386s is important: It's the first machine to use the 80386SX chip, and it proves that the 80386SX is a viable computing engine. It's the first entry in a new class of machines and a new category of computing power. Unfortunately, the 386s costs too much. The company that can build a quality 80386SX system and sell it at a competitive price will walk away with the market. ■

Jeff Holtzman owns Publishing Concepts, a firm that specializes in evaluation, verification, and documentation of high-technology products. He lives in Ann Arbor, Michigan. You can reach him on BIX c/o "editors."

An inside look at the best 386 value around.



The more you look into 386 compatibles, the more you realize that well thought-out design innovations (that really work) are few and far between.

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ALR Improves on a Winner

The FlexCache 25386 breaks the speed record with its 25-MHz 80386 and enhanced caching system

Mark L. Van Name

Advanced Logic Research has once again claimed the PC performance lead with its FlexCache 25386. The new machine is based on the same proprietary FlexCache architecture that ALR used in its top-performing FlexCache 20386 (June BYTE). This architecture combines a high-speed cache of static RAM (SRAM) with dual memory and I/O buses to let the 80386 CPU run without wait states 95 percent of the time.

The 25386 differs from the earlier 20386, however, in the size, speed, and management of its cache. The 20386 uses the Intel 82385 cache controller chip to manage a 32K-byte cache of 35-nanosecond SRAM. The 25386 has a larger 64K-byte cache of faster 25-ns SRAM. It also replaces the 82385 with ALR's proprietary Extended Emulation 82385 cache system, which provides several performance improvements. The 25386 also uses faster 60-ns dynamic RAM in place of the 80-ns DRAM in the 20386.

All this adds up to record-breaking performance for the FlexCache 25386. But the 25386's high performance does not come cheap. It is available in two versions, the $9499 Model 150 and the $12,499 Model 300, which differ only in the size (150 and 300 megabytes, respectively) and speed of their hard disk drives. Both models include the 25-MHz 80386, the 64K-byte cache, 2 megabytes of memory, a socket for either a 25-MHz or a 20-MHz Intel 80387 math coprocessor, a 1.2-megabyte 5¼-inch floppy disk drive, ALR's 16-bit VGA card, an enhanced-small-device-interface (ESDI) controller and hard disk drive, one parallel port, one RS-232C serial port, and a keyboard that follows the layout of the IBM Enhanced AT layout. The only software that I received was ALR's FlexCache 386 Setup Utilities disk.

Of course, to use the 25386 you also need a monitor and some operating-system software. My evaluation unit came with MS-DOS/GWBASIC 3.3, as well as a 25-MHz 80387 and a 1.44-megabyte 3½-inch floppy disk drive. ALR does not currently sell a monitor, so I used an IBM 8514 analog VGA monitor with the system.

Not counting the price of the monitor, the evaluation unit cost $14,798. Toss in another $600—the street price for a reasonable VGA monitor—and you end up with a healthy $15,398.

As high as that is, it is still not as expensive as a comparable Compaq 386/25. The Compaq 386/25 Model 300 costs $13,299, which is $800 more than the 25386 Model 300; the 386/25 also has only 1 megabyte of slower DRAM and a smaller and slower cache.

ALR also offers two 25-MHz systems with almost the same performance as the FlexCache 25386 and at much cheaper prices: its desktop 25386 DT Model R66

continued

ALR FlexCache 25386

Company
Advanced Logic Research, Inc.
9401 Jeronimo
Irvine, CA 92718
(800) 444-4257

Components
Processor: 25-MHz 32-bit Intel 80386; socket for 25-MHz or 20-MHz Intel 80387 coprocessor
Memory: 2 megabytes of 32-bit, 60-ns DRAM, expandable on the FlexMem card to 14 megabytes; 64K bytes of 25-ns SRAM; 128K bytes of BIOS ROM
Mass storage: 1.2-megabyte 5¼-inch floppy disk drive; 1.44-megabyte 3½-inch floppy disk drive; 150-megabyte hard disk drive (Model 150) or 300-megabyte hard disk drive (Model 300)
Display: ALR 16-bit VGA board; no monitors currently available from ALR
Keyboard: 101 keys in IBM Enhanced keyboard layout
I/O interfaces: One RS-232C serial port with DB-9 connector; one DB-25 parallel port; one VGA monitor port with DB-15 connector; one 32-bit expansion slot for the FlexMem memory-expansion card; one 8-bit expansion slot; six 8-/16-bit expansion slots

Size
7½ × 17 × 26 inches; 80–100 pounds

Software
FlexCache 386 Setup Utilities disk, version 4.2, with diagnostics tests, system setup, SETSPEED program, and other utilities; VGA Card Utilities disk

Options
1-megabyte memory module: $1049
4-megabyte memory module: $2995
360K-byte 5¼-inch floppy disk drive: $205
1.2-megabyte 5¼-inch floppy disk drive: $225
1.44-megabyte 3½-inch floppy disk drive: $225
20-MHz 80387 coprocessor: $1199
25-MHz 80387 coprocessor: $1899
150-megabyte hard disk drive: $2499
300-megabyte hard disk drive: $3999
ALR EGA card: $349
ALR 16-bit VGA card: $399
MS-DOS/GWBASIC 3.3: $175
SCO Xenix 386 V.3: $695

Documentation
FlexCache 25386 User's Manual; VGA Card User's Guide; VGA Card Software Manual

Price
Model 150: $9499
Model 300: $12,499
System as reviewed: $14,798

Inquiry 885.

and Model 100. These systems have only 1 megabyte of DRAM and smaller, slower hard disk drives, but at $6490 and $6990, respectively, they're in a price range that more of us can handle.

Improving the FlexCache Architecture

Nearly all of today's fastest 80386-based systems use the Intel 82385 cache controller. The 25386 breaks from this group by using ALR's new proprietary cache controller, the Extended Emulation 82385 cache system.

ALR based this new cache system on the Intel 82385 cache controller, but it has added several improvements and has implemented the whole thing with a group of chips on the 25386's motherboard. Many of these improvements are very small, but a few are worth mentioning here.

One improvement affects how the 25386's cache system maintains cache "coherency"—the consistency of cache data with the corresponding DRAM locations. When a direct-memory-access (DMA) write changes a memory location whose contents are in the cache, the Intel 82385 cache controller marks that cache data as invalid, so that subsequent accesses to it will force the system to read the data from the DRAM. The 25386's cache system, on the other hand, updates the cache data on DMA writes, thereby maintaining cache coherency.

Another big improvement is that the 25386's cache system runs parallel with main memory, so that it does not add a wait state when there is a cache miss. The 82385 imposes an additional wait-state penalty for each cache miss.

The 25386 hedges its performance bet further by using expensive but fast 60-ns main memory, in contrast to Compaq's 100-ns memory.

All this DRAM sits on a proprietary 32-bit bus. The 25386 also contains a standard 8-MHz AT-style bus that supports standard AT expansion cards.

Tops in Performance

The result of these architectural improvements? The 25386 flat-out beat every other 80386-based system that BYTE has benchmarked, including a preproduction Compaq Deskpro 386/25. Of course, the 25386 beat Compaq's 386/20 by a 40 percent margin in the CPU low-level test, as well as by smaller margins in the Floating Point and Disk I/O low-level tests. It also had a slight edge overall in the application performance tests.

The only deficiency appears in the Video Text and Database test results. The original benchmark tests were run with the IBM 8514 monitor. In those tests, the 25386 was over 2½ times slower than the Compaq 386/20. When BYTE reran the tests with the 25386 using the Compaq Video Graphics Color Monitor Model 420, the 25386 was only 20 percent slower than the Compaq 386/20. I attribute this change in performance to the interaction between the ALR VGA card and the IBM 8514 monitor. The ALR VGA card also appears to be optimized for graphics display rather than for text. An ALR spokesperson said that the company would investigate this discrepancy.

A Few Glitches

Speed is no good, of course, if you can't run your favorite programs and install your favorite expansion cards.

The 25386 is very good about hardware compatibility. While the 20386 runs its AT-style expansion bus at 10 MHz, a speed that could cause problems for older expansion boards, the 25386 uses a standard 8-MHz AT-style bus. I installed an Everex Evercom II 2400-bit-per-second internal modem and an Intel Above Board/AT expanded-memory board, as well as a Microsoft Serial Mouse, and all ran without a hitch.

The news is not quite so good on the software side. The 25386 ran almost all the software I tried, including Borland's Quattro 1.0, Reflex 1.14, SideKick Plus 1.00A, SuperKey 1.16A, Turbo C 1.0, and Turbo Pascal 4.0; Digitalk's Smalltalk/V 1.2; Kermit 2.30; MicroPro's WordStar 3.3 and 4.0; Microsoft's PC Paintbrush 2.0, Windows/386 version 2.0, and Word 4.0; Norton Utilities 3.00; Quarterdeck Office Systems' DESQview 2.0, with its Quarterdeck Expanded Memory Manager 386 version 1.10; and Symantec's Q&A 1.1.

During my software tests, however, I ran into three problems. The first involved a copy-protected Lotus 1-2-3 version 2.0. I could not get 1-2-3 to recognize the key disk, even when I slowed the system to its 8-MHz-equivalent compatibility speed. It is no surprise that 1-2-3 did not recognize the key disk when the 25386 was at full speed, for the 80386's high speed messes up 1-2-3's copy-protection scheme. Most 80386-based systems handle this problem either by slowing the system automatically when a program reads data from a floppy disk or by letting you slow the system manually from the keyboard.

An ALR spokesperson said that the

continued

ALR FlexCache 25386

APPLICATION-LEVEL PERFORMANCE

ALR FlexCache 25386 **21.2***

WORD PROCESSING	Med./Large
XyWrite III+ 3.52	
Load (large)	:11
Word count	:02/:12
Search/replace	:03/:13
End of document	:01/:08
Block moves	:08/:08
Spelling check	:05/:37
Microsoft Word 4.0	
Forward delete	:10
Aldus PageMaker 1.0a	
Load document	:02
Change/bold	:15
Align right	:12
Cut 10 pages	:11
Place graphic	:02
Print to file	1:11
Index:	**4.41**

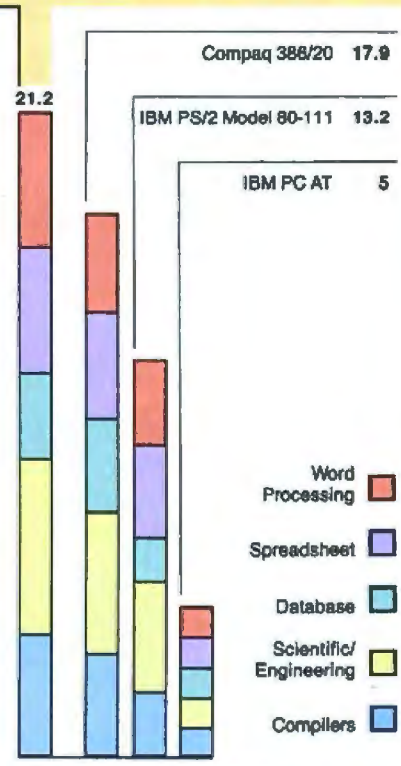
SPREADSHEET	
Lotus 1-2-3 2.01	
Block copy	:02
Recalc	:01
Load Monte Carlo	:08
Recalc Monte Carlo	:03
Load rlarge3	:02
Recalc rlarge3	:01
Recalc Goal-seek	:02
Microsoft Excel 2.0	
Fill right	:03
Undo fill	1:08
Recalc	:01
Load rlarge3	:13
Recalc rlarge3	:01
Index:	**4.13**

DATABASE	
dBASE III+ 1.1	
Copy	:33
Index	:05
List	1:08
Append	1:19
Delete	:02
Pack	1:11
Count	:03
Sort	:46
Index:	**2.83**

ENGINEERING/SCIENTIFIC	
AutoCAD 2.52	
Load SoftWest	:27
Regen SoftWest	:21
Load StPauls	:06
Regen StPauls	:04
Hide/redraw	7:02
STATA 1.5	
Graphics	:19
ANOVA	:09
MathCAD 2.0	
IFS 800 pts.	:09
FFT/IFFT 1024 pts.	:09
Index:	**5.80**

COMPILERS	
Microsoft C 5.0	
XLisp compile	2:29
Turbo Pascal 4.0	
Pascal S compile	:03
Index:	**4.08**

All times are in minutes:seconds. Indexes show relative performance; for all indexes, an 8-MHz IBM PC AT = 1



*Cumulative applications index. Graphs are based on indexes at left and show relative performance.

LOW-LEVEL PERFORMANCE[1]

ALR FlexCache 25386

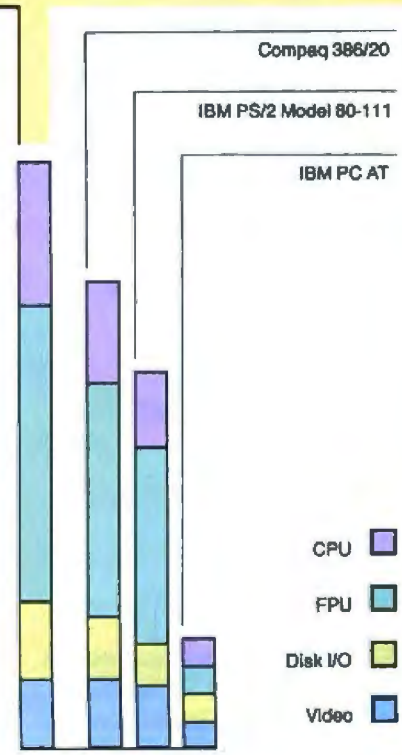
CPU	
Matrix	2.80
String Move	
Byte-wide	16.20
Word-wide:	
Odd-bnd.	21.97
Even-bnd.	8.13
Doubleword-wide:	
Odd-bnd.	15.93
Even-bnd.	4.03
Sieve	14.02
Sort	10.50
Index:	**5.07**

FLOATING POINT	
Math	4.90
Error[2]	
Sine(x)	1.54
Error	
e^x	1.81
Error	
Index:	**10.55**

DISK I/O	
Hard Seek[3]	
Outer track	1.64
Inner track	3.33
Half platter	6.67
Full platter	8.35
Average	5.00
DOS Seek	
1-sector	6.93
32-sector	15.35
File I/O[4]	
Seek	0.06
Read	0.49
Write	0.78
1-megabyte	
Write	2.91
Read	2.92
Index:	**2.74**

VIDEO	
Text	
Mode 0	4.67
Mode 1	4.63
Mode 2	4.56
Mode 3	4.56
Mode 7	N/A
Graphics	
CGA:	
Mode 4	1.12
Mode 5	1.12
Mode 6	1.19
EGA:	
Mode 13	2.58
Mode 14	2.75
Mode 15	N/A
Mode 16	2.75
VGA:	
Mode 18	2.86
Mode 19	1.17
Hercules	N/A
Index:	**2.57**

CONVENTIONAL BENCHMARKS	
LINPACK	135.01
Livermore Loops[5] (MFLOPS)	0.19
Dhrystone (MS C 5.0) (Dhry/sec)	8417.00



N/A = Not supported by graphics adapter.
[1] All times are in seconds. Figures were generated using the 8088/8086 and 80386 versions (1.1) of Small-C.
[2] The errors for Floating Point indicate the difference between expected and actual values, correct to 10 digits or rounded to 2 digits.
[3] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100).
[4] Read and write times for File I/O are in seconds per 64K bytes.
[5] 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

problem was probably due to the way the system implemented the compatibility speed, and that ALR uses a different technique in the current production machines to slow the 25386 automatically any time it uses a floppy disk drive. The spokesperson said that the same version of 1-2-3 ran without flaws on those systems.

My other two problems were subtle ones involving the interaction of the MS-DOS FDISK program and my system's 300-megabyte hard disk drive. I hung the system every time I tried to create a 32-megabyte logical drive in the last 48 megabytes of the disk. Also, every time I created logical drives and left FDISK, the system would reboot to the C>: prompt and then hang while it continuously tried to read drive A. At that point I had to shut the system down and then turn it back on.

I was able to work around the first problem by dividing the remaining disk space into two partitions that were both smaller than 32 megabytes, but I had no solution to the second difficulty. An ALR spokesperson said that the company would investigate these problems.

Disk Space to Burn

A 300-megabyte hard disk drive like the one on my evaluation unit really makes you aware of the MS-DOS 32-megabyte logical drive limit: I had logical drives C through L.

My evaluation unit's hard disk drive was a Maxtor Model XT-4380E, which has 380 megabytes of unformatted space that reduces to 300.7 megabytes when you format it. It had an average access time of 16 milliseconds. The hard disk controller was a Western Digital ESDI board that runs with 1-to-1 interleaving and includes a 16K-byte buffer for full-track buffering.

The 25386 contains another drive bay that can handle one full-height or two half-height 5¼-inch devices. For example, you could put a second 300-megabyte drive in that bay, bringing the system up to 600 megabytes of hard disk space.

Even with the Toshiba 1.2-megabyte 5¼-inch floppy disk drive and the TEAC 1.44-megabyte 3½-inch floppy disk drive in my unit, there was room for one more half-height 5¼-inch storage device. ALR offers a 150-megabyte ¼-inch streaming tape drive that would fit nicely into that slot.

The Box Itself

As you might imagine, any machine that can handle all these storage devices has to be big, and the 25386 certainly is. It is over an inch thicker, 5 inches longer, and an inch deeper than a standard IBM PC AT. It is also heavy; my unit weighed nearly 80 pounds, and it can run to almost 100 pounds when it's fully loaded. Fortunately, the 25386 is not intended to sit on your desk. It stands upright on the floor.

While its size and weight may at first be daunting, the 25386 is easy to open. You just loosen two thumbscrews on the rear of the system to remove a side panel.

Once you're inside, you can see the 25386's eight full-length expansion slots: one 32-bit, one 8-bit, and six 8-/16-bit slots. The 32-bit slot looks like two AT-style slots, one in front of the other, and you can use the two connectors only for ALR's FlexMem 32-bit expansion card.

In my evaluation unit, the FlexMem card filled the 32-bit slot, and the VGA, ESDI controller, and multifunction floppy disk drive controller and serial/parallel port card were in three of the 8-/16-bit slots. There were still four empty slots, so the system has plenty of room for growth.

The 16-bit VGA card is a Western Digital ¾-length card based on Paradise's PVGA chips. It is hardware-compatible with IBM's VGA standard. It also offers an extended graphics mode with 800- by 600-pixel graphics resolution that will work on a multifrequency monitor—but not on a standard analog VGA monitor. There was a slight problem with this card: During the video benchmarks, the screen display had a light pattern of speckles. Replacing the video card and BIOS ROMs did not correct the problem. An ALR spokesperson could not explain why the problem occurred but said the company would investigate.

The motherboard is ALR's own. It measures about 13¾ by 12 inches. It is not the same motherboard that ALR used in the 20386; the company has redesigned and improved it since that earlier system. The motherboard in the review unit contained 154 chips, including the 80386, an 80387, and 1 megabyte of DRAM in 36 256K-bit chips. Many of the chips are fairly standard parts, such as the Chips & Technologies DMA controller and Phoenix's keyboard controller and ROM BIOS (version 1.10 03). A large group of new chips in the upper front of the board provides the Extended Emulation cache system.

The system's standard 2 megabytes of memory is split between the 1 megabyte that is standard on the motherboard and

continued

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Peter Norton COMPUTING

Circle 254 on Reader Service Card (DEALERS: 255)

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the basic 1-megabyte FlexMem card. You can expand the 25386's memory to a maximum of 14 megabytes by adding up to three 1-megabyte or 4-megabyte daughtercard memory modules to the FlexMem card.

You can install either a 20-MHz or a 25-MHz 80387 by setting a a DIP switch. There is no socket for a Weitek math coprocessor, but ALR left solder positions around the 80387 socket to support a Weitek socket in the future.

Also, while all the DRAM in my evaluation unit was in 256K-bit chips, ALR has left enough room and solder positions around all the memory chips to support 1-megabit DRAM chips in the future.

The Rest of the System

The 25386's keyboard is an ME 101 Maxi-Switch model from EECO. It uses the basic IBM Enhanced keyboard layout, but it differs from that standard by having the backslash key next to a reduced Backspace key, in the older AT style. It has the nice feature that you can swap the functions of the Control and Caps Lock keys by changing a DIP switch on its back. ALR even includes an alternate set of correctly sized Control and Caps Lock keys.

The only standard software that I received with the 25386 was ALR's Setup Utilities disk. It contains such things as a system setup program, a speed change program, a low-level disk formatter, and system diagnostics, as well as several other utilities.

The standard documentation is the FlexCache 25386's User's Manual. This manual is full of useful technical detail, but once you leave the first two chapters you need to know a fair amount of computer terminology to keep reading. It's great for the experienced user, but not too useful for the novice. Of course, not a lot of novices are likely to start out on a $15,000 system.

When You Need Help

The 25386, like other ALR systems, comes with a 1-year parts and labor warranty. You can also buy from 1 to 3 years of extended warranty service, but it's not cheap; one extra year costs $725 for the Model 150 and $935 for the Model 300. An ALR spokesperson said that ALR is now finalizing its plans to offer on-site service nationwide through another company.

You also get unlimited telephone support from ALR. The support people with whom I spoke were still learning the details of the recently announced 25386, but they were all knowledgeable and eager to help. My only complaints about ALR's support are that you have to make a toll call and, in my experience, sit on hold for about 5 minutes before you get to talk to a support technician.

Top of the Heap

ALR still needs to wring out a few compatibility problems, which it seems to be doing. Otherwise, the 25386 is a solid system that offers plenty of expansion space and more disk storage than most of us will need for some time.

It's the fastest 80386-based system available today, so if you want the top performer, shop no further. As a bonus, it's not even the most expensive 25-MHz system—nevertheless, it is only for those willing to pay for top performance. ■

Mark L. Van Name is a freelance writer and computer consultant living in Durham, North Carolina. He can be reached on BIX c/o "editors."

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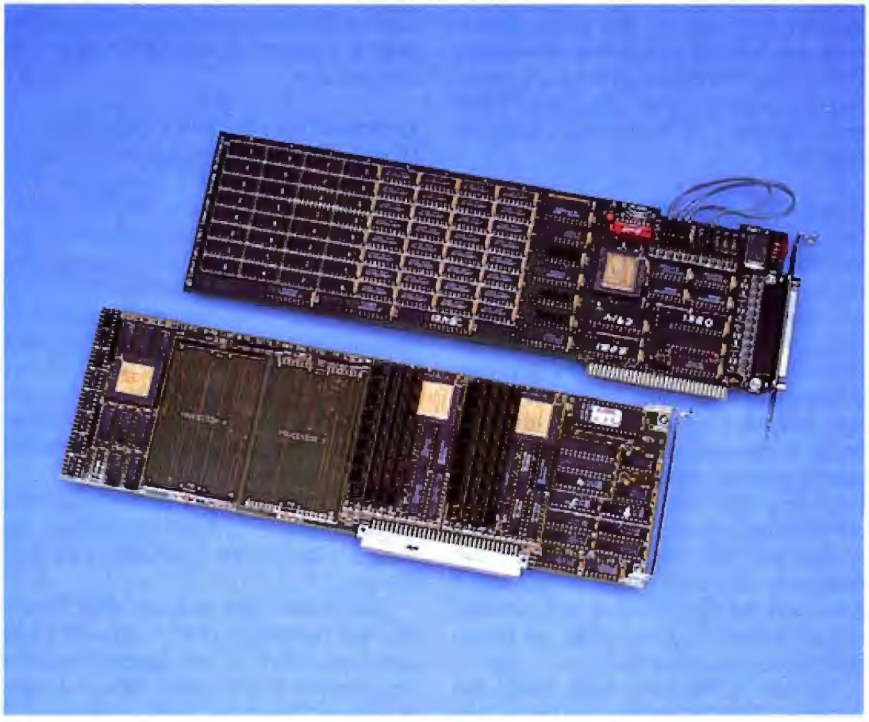
Parallel Processing Comes to PCs



Parallel-processing boards: CSA (top) and Levco (bottom).

Transputer boards boost the power of your PC or Mac

Pete Wilson

It's the Holy Grail of computing: a system that gains computational power as you add processors and memory. And it's here today.

I reviewed two parallel-processing add-on products based on the INMOS transputer—one for IBM PC AT compatibles and one for the Macintosh II. These boards outperform the best available coprocessors, but that's almost beside the point. You can link transputers to create parallel—and expandable—networks and so boost the power of your favorite personal computer as a linear function of the dollars you invest.

These boards run few shrink-wrapped applications; in general, you have to port or develop software for them. So both companies—Computer System Architects (transputers for AT compatibles) and Levco (for the Mac II)—provide tools you need to develop parallel applications, and I'll look at those as well.

Computer System Architects (CSA) makes a series of boards based on transputers. I examined two boards based on the INMOS 20-MHz T800—one with 256K bytes of memory, and one with a megabyte—and a C-oriented development Toolset licensed from Logical Systems. Levco supplied a NuBus-compatible TransLink II card, two 20-MHz 1-megabyte T800 modules that plug into the TransLink II, the Logical Systems Toolset, and INMOS's TDS (Transputer Development System). The TDS comprises the tools you need to program concurrent systems in occam, the transputer's native parallel-programming language; though CSA doesn't provide the TDS, INMOS does, and you can use it with the CSA boards. It costs $1750 to attach a CSA 1-megabyte T800 to an AT compatible, and nearly $3000 to hook a Levco 1-megabyte T800 to a Mac II. Both CSA and Levco sell the Logical Systems Toolset for around $400.

The Nature of the Beast

INMOS coined the word *transputer*. It refers to a device that integrates a reduced-instruction-set-computer processor, some memory, and a set of interprocessor communication links. INMOS manufactures a family of transputers. The T800 features a 32-bit integer processor roughly equivalent to a fast 80386 or a 68030, a 32-/64-bit IEEE floating-point unit (FPU) that's about twice as fast as a 68882 or an 80387, and four full-duplex serial I/O links driven by a dedicated eight-channel direct-memory-access (DMA) engine that can sustain 20 megabits per second in each direction on each link. Other components include a pair of timers (one ticking every microsecond, the other every 64 μs), 4K bytes of fast (50-nanosecond) memory mapped to the bottom of the processor's 4-gigabyte address space, and a multitasking kernel in microcode.

continued

CSA PART.2, PART.4A, PART.S3

Type
Multiprocessor hardware and software for PC, XT, and AT compatibles

Company
Computer System Architects
950 North University Ave.
Provo, Utah 84604
(801) 374-2300

Features
PART.2-820: T800-20 with PC DMA and 256K bytes of memory
PART.4A-820: T800-20 with PC DMA and 1 megabyte of memory
PART.S3: C compiler package (Transputer Toolset)

Hardware Needed
IBM PC, XT, AT, or compatible with a spare half-length slot (for the PART.2) or full-length slot (for the PART.4A), a hard disk drive, and 512K bytes of memory; Hercules, EGA, or CGA monitor needed for demonstration programs

Software Needed
MS-DOS 2.0 or higher

Documentation
1-page hardware installation guide; 220-page Transputer Toolset manual; 44-page Introduction to CSA PARTs and the Transputer

Price
PART.2-820: $1225
PART.4A-820: $1750
PART.S3: $400
PART.2-820 and PART.S3: $1295

Inquiry 886.

The T414 is a close cousin to the T800; it lacks the FPU and has just 2K bytes of on-chip memory.

To make a multiprocessor system, you configure transputer nodes into the topology of your choice. Then, of course, you have to program the collection. How easy is that? It depends. Some computing problems decompose naturally into concurrent subsystems; others don't.

Many graphical applications can benefit from the speed of an individual transputer and, when the elements of a display can be computed independently, from the ability to use transputers in parallel. Genigraphics uses CSA boards to enhance its illustration and video-animation software; Digital Arts demonstrated similar transputer-enhanced products at this year's SIGGRAPH. Levco supplies a demonstration program that computes the Mandelbrot set in parallel.

Modeling and simulation also lend themselves to parallel processing. Neuronics markets a neural-net modeler called MacBrain; the transputer-based version of this product will have been released by the time you read this. Deutsch Research lent me a prerelease copy of its port of Spice 3.0, an industry-standard circuit simulator, in versions for a standard Mac II and a CSA T800. The T800 version simulated a small circuit nearly 12 times faster than the Mac II version. Since this circuit simulator isn't a true parallel application, the performance boost reflects the raw power of a single T800. (For more background on transputers and their capabilities, see "T800 and Counting" by Richard M. Stein on page 287.)

Using CSA Hardware with an MS-DOS Machine

The transputer boards need to talk to one another and to the host PC. Interprocessor communication is straightforward: CSA provides connections along the top edge of the boards, as well as a set of interconnect wires. You create the topology you want by attaching connecting cables to transputer links. (The links are clearly labeled on the board.) For electrical integrity, CSA uses differential buffers and receivers between the connectors and the transputers; that's unnecessary for short cable runs, but it gives you the flexibility to run substantial distances—for example, to transputers in another chassis.

To talk to the host, each board has another INMOS device called a link adapter. On one side, it resembles a parallel I/O port; on the other, it supports the INMOS link interface. Additional hardware makes the byte-wide side of the link adapter look to the PC as a DMA-accessible I/O port on the PC's bus; the link side connects to any of the transputer's links.

Using a simple protocol to communicate with a server program running on the PC, the transputer can share the host's screen, keyboard, and file resources. There's plenty of bandwidth between host and transputer. The CSA boards include DMA hardware that supports data transfer at 100K bytes per second (on an AT); that's somewhat faster than the best hard disk drives fitted to such machines.

Each board also has a switch you use to set the link adapter's bus address. In general, only one transputer needs a bus address; additional boards draw power from the bus but communicate with each other and the host by means of the link hardware.

I installed the 1-megabyte board in a spare slot on my Tandy 3000 and ran the three test programs. One of the tests looks for link adapters on the bus; it found the correct single adapter at the default address 150 hexadecimal. Another test runs on the T800 and exercises its ability to read and write its own memory. A third checks the ability of the DMA machine in the link hardware (under control of messages sent through the links) to read and write the memory of a transputer module independently of the transputer's processor. All three tests ran successfully.

Transputing with the Tandy 3000

I decided to use the Transputer Toolset to port two nonparallel C programs that I've been working on—a SPARC assembler and a program that simulates the integer portion of a SPARC-based machine—to my transputer-equipped Tandy 3000. The Toolset includes the usual things: preprocessor and compiler (mostly compatible with ANSI C but with some private extensions), assembler, linker, and librarian. The preprocessor and compiler extensions are called `intrinsics`—constructs that look like function calls but that the compiler can convert into in-line T800 instructions for things like string handling and bit-blitting.

The Toolset also includes some things you don't normally find: two loaders and a server. One of the loaders puts a nonparallel C program onto a single transputer; the other loads a collection of C programs onto a network of transputers; the collection of programs constitutes a parallel program. The server, which runs on the host, executes the protocol that enables programs running on the transputer to access the host's screen, keyboard, and file system. The transputer program issues standard C I/O calls that the library implements as calls to the server via the link adapter.

The command `install a c` worked as advertised; it copied files from the Toolset's three disks to directories on my hard disk. One subdirectory contained the obligatory "Hello, world" program along with a batch file that would preprocess, compile, assemble, and link the single source file. I ran the batch file; it produced a transputer-loadable (.TLD) file. To run that, I issued the command `ld_b004 chello c1o`, which loaded "Hello, world" onto the transputer and loaded the server program onto the host.

Everything worked, and the transputer used the host's screen to announce its presence.

The Toolset provides two sets of library routines that you can use to parallelize C programs. These routines create processes and manage interprocess communication. One set implements the occam model, and the other supports the Unix fork/join model. I've programmed in occam, and I prefer it to the Unix model. If you don't already know occam, you may choose to avoid it, but be forewarned: The C constructs that support interprocess communication are not as intuitive as their occam counterparts.

A parallel program is really a collection of programs intended for a collection of computers. To run it, you have to supply the loader with a description of the network of processors. The Toolset's multitransputer loader operates on such a description, written as a .NIF (network information file) containing lines (one per node) of the form:

```
1, spice, R0, 2, 0, 2[1], 2[3];
```

In this example, the preamble `1, spice, R0` specifies that node 1 in the network will be loaded with the program `spice` and will be reset by node 0, the host. The remainder of the line describes how node 1's links are connected. Link 0 connects to node 2, link 1 to the host, link 2 to node 2's link 1, and link 3 to node 2's link 3.

Loading proceeds in phases. First, the loader distributes code to all the nodes, and it bootstraps the nodes with that code. Then the loader interprets the .NIF description and sends programs to the root node; from there, they percolate through the link hardware to their destinations. Normally, network problems turn up during the boot phase. If all else fails, CSA supplies an INMOS-written program called WORM that can wriggle its way around any collection of transputers and tell you what's connected to what.

My C programs, written in Megamax Laser C on an Atari Mega ST2 and an ST4, ported to the CSA system with no unusual difficulty. Of course, there were the normal problems you encounter when porting software. I had to remove some ST BIOS calls, substitute the Toolset `Time()` intrinsic for the equivalent Atari routine, take care of byte ordering (the 68000 is big-endian and views byte 0 of a word as most significant, but the T800 is little-endian), and change a compiler option to get sign propagation on arithmetic right shifts. Once I fixed those things, both the SPARC assembler and the simulator ran correctly on the transputer.

On the ST, with an 8-MHz 68000, the simulator ran at about 90 simulated clock ticks per second; on the 20-MHz T800, it ran at about 450 clock ticks. That's five times faster, but since the 68000 is at best a 1-million-instruction-per-second machine and transputers are rated at 10 MIPS, you might wonder why the T800 version wasn't faster still. I think there are two reasons. First, the simulator uses lots of global variables, but the transputer's instruction set is optimized for local variables. Second, my simulator performs only integer operations, so it doesn't take advantage of the T800's floating-point capabilities.

To check that, I ported another program that analyzes simple linear circuits and is rich in floating-point work. On this test, the T800 ran 30 times faster than the Atari ST.

Using Levco Hardware with a Mac II

Levco handles multiple transputers in a different way than do the CSA products I reviewed. Instead of adding multiple boards to the host, it uses a single NuBus-compatible motherboard to which you can add plug-in modules. (Although I didn't review them, CSA offers multitransputer boards, too.) The modules are small printed circuit boards (about 2 inches by 4 inches) with a standard pinout that supports intermodule communication. Levco offers both T414- and T800-style modules; each comes in 256K-byte, 1-megabyte, and 4-megabyte flavors. Since Levco's modules follow the INMOS pin assignments, you should be able to mix the different styles and flavors on the motherboard; I couldn't check that since I was working with two identical 1-megabyte T800 modules.

The motherboard holds four modules. Levco uses a link crossbar switch (another INMOS part, the C004) to control the topological arrangement of modules on a board. Levco's Macintosh driver can find out the number and type of modules on a board, and it supports a protocol that applications can use to configure the links on each module. The crossbar switch doesn't work across motherboards, though, so you have to interconnect multiple motherboards yourself.

I installed a motherboard into a spare NuBus slot on my Mac II. It took some pressure to seat the two transputer modules, which plug into surface-mount sockets on the motherboard. Levco supplies a test program that exercises all the transputers found on a motherboard. The company suggests running the test for a while to make sure that all is well. I ran the test for a couple of hours; no problems appeared.

Like CSA, Levco offered a beta release of the Transputer Toolset. Levco's was an earlier version (88.2 rather than CSA's 88.3); however, by the time you read this, both companies will be offering the same final version. Because of the Toolset's command-line format, you need some sort of shell to use it on a Mac. Levco requires you to use the Macintosh Programmer's Workshop as that shell.

Levco has enhanced the Toolset with the facilities you need to build transputer-based programs that look on the host like standard Macintosh applications. To demonstrate this, the company includes a parallelized version of a pro-

continued

Levco TransLink

Type
Multiprocessor hardware and software for Macintosh II

Company
Levco
6160 Lusk Blvd., Suite C100
San Diego, CA 92121
(619) 457-2011

Features
TransLink II: NuBus-compatible Transputer motherboard
Module: T800-20 with 1 megabyte of memory
Transputer Toolset: C compiler package
TDS: Occam Transputer Development System

Hardware Needed
Macintosh II with spare NuBus slot; hard disk drive

Software Needed
System 4.2/Finder 5.5 or higher; Macintosh Programmer's Workshop

Documentation
16-page TransLink Installation Guide; 250-page Transputer Toolset manual; 650-page TDS manual

Price
Motherboard: $799
Module: $2199
Toolset: $399 (purchased with hardware; $499 separately)
TDS: $1200
Macintosh Programmer's Workshop: $225

Inquiry 887.

Table 1: *Transputer add-ons really make the PC fly.*

	CSA 1-megabyte T800	Compaq 386/20	Macintosh II
Sieve*	6.31	23.18	40.2
Dhrystone*	9433	6321	2861
Whetstone**	4,005,000	1,759,199	606,060

* BYTE Small-C compiler was used for Compaq and Macintosh tests.
** MetaWare High C was used for the Compaq. Consular Mac C was used for the Macintosh.

Note: Times for Sieve (100 iterations) are given in seconds; Dhrystones are in Dhrystones per second; Whetstones are in Whetstones per second

Table 2: *Allowing for differences in Toolset versions, the CSA and Levco boards exhibit similar performance.*

	CSA/Toolset (88.3)*	Levco/Toolset (88.2)
Dhrystone	6310	5780
Whetstone	3,117,000	2,780,000

* Optimizations disabled

Table 3: *The penalty for multitasking on a single transputer is small, and it gets smaller as tasks get larger.*

	Task duration			
Number of tasks	**10**	**100**	**1000**	**10,000**
Sequential				
100	2486	20,416	198,873	1,984,256
1000	24,876	203,203	1,988,636	19,842,524
10,000	247,796	2,032,946	19,886,994	198,425,216
Parallel				
100	3006	20,847	199,379	1,985,169
1000	29,387	208,228	1,993,347	19,851,050
10,000	300,054	2,084,401	19,936,349	198,513,081

Note: Task durations are in loop iterations; times are in microseconds.

gram to compute the Mandelbrot set. Commendably, Levco supplies two versions of source for this program—one in C and one in occam. The C version illustrates, among other things, how an application can use the Macintosh driver to configure transputer modules into a topology; the occam version shows how much simpler and prettier parallel programming is in a language designed for it. And when I ran the program on two modules, it did indeed run twice as fast as it did on one module.

Levco also supplies INMOS's occam-oriented Transputer Development System. Like the Transputer Toolset, Levco's TDS has extensions that you can use to create standard Macintosh interfaces to parallel applications.

The TDS is an integrated environment, like Megamax Laser C and Lightspeed C. You've always got the editor handy; you compile from within the editor and it points out your errors; and there's built-in project management. TDS differs from the others in that it is essentially a programmer's outliner based on the notion of a *fold*. You can hide a chunk of code in a fold, and you can nest folds in other folds. For example, a procedure might live in a fold; inside that, all the declarations might be in one fold, and all the code in another. To do this, you mark the extent of the text you want to enclose in a fold and select `create fold` from the menu; an ellipsis—which you can annotate—replaces the text.

Folds are more than just textual conveniences. You wrap separately compilable procedures in SC folds, single-transputer programs in EXE folds, and multitransputer programs in PROGRAM folds. The system uses the types of the folds to control compilation and linking.

The TDS comes with some sample programs—one that measures the time required to execute various programming constructs, and another that uses multiple processes to model diffusion. Both ran happily, though it was a bit of a shock to see the Macintosh report execution times in nanoseconds.

Unlike the Toolset, which runs on the host machine, the TDS runs on a transputer. It needs at least 1 megabyte of memory and prefers more. Given the horsepower, you might expect blinding speed. But an occam compiler has to work a lot harder than a C compiler; for example, it has to check that no variable is shared among parallel processes. It does the job, but don't expect Turbo C–like performance.

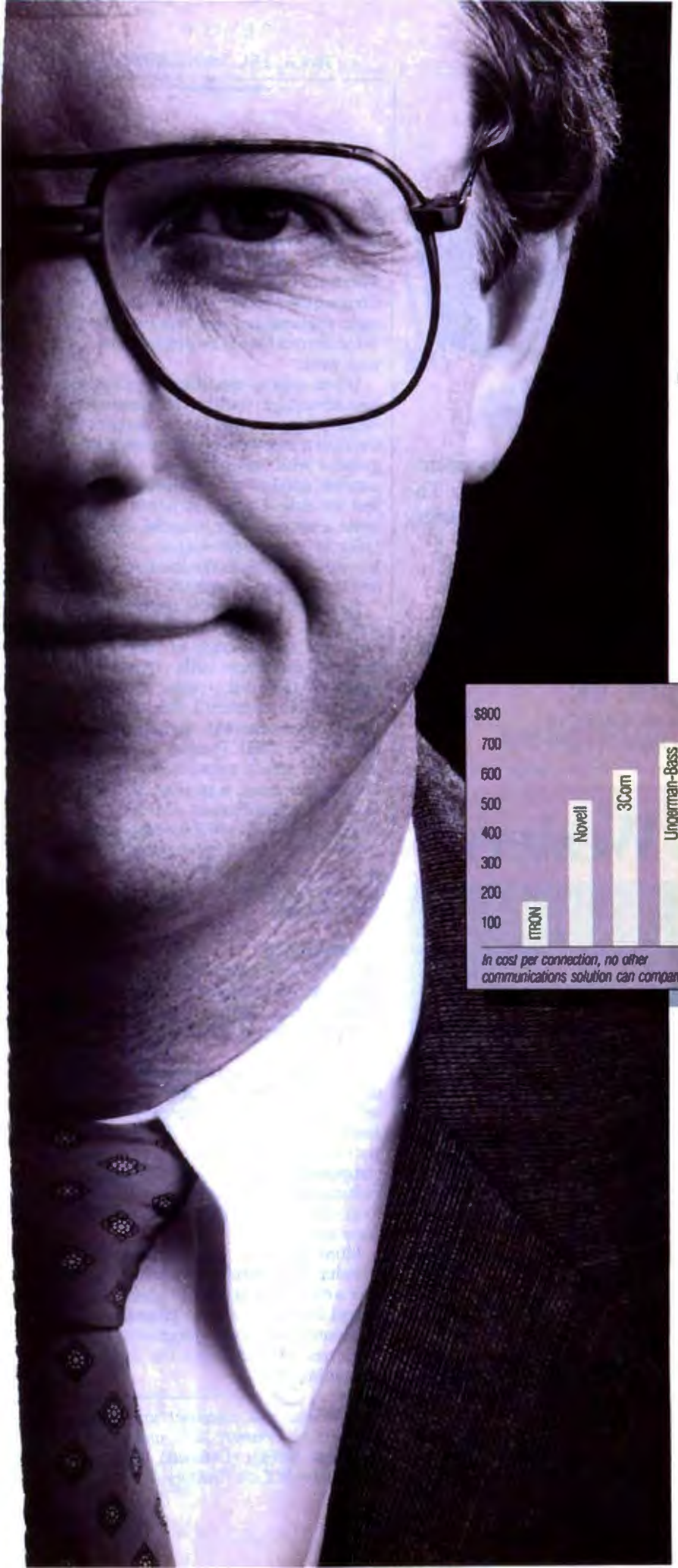
The TDS documentation includes Dick Pountain's excellent introduction to occam. Pountain assumes you know something about programming in a high-level language but nothing about programming parallel systems or about programming in occam, and he shows you how to do both.

Benchmarks

There's no BYTE Small-C compiler for the transputer (volunteers welcome), so I used the Toolset C compiler to compile and run the Sieve, Dhrystone, and Whetstone benchmarks on both of CSA's boards and on Levco's module. Because I was working with two different versions of the Toolset, (88.3 from CSA and 88.2 from Levco), I ran the tests twice. Table 1 shows the transputer in its best form—but only for the CSA hardware—relative to a Compaq 386/20 equipped with a 20-MHz 80387 and to a 16-MHz 68020 Mac II with a 68882. Table 2 supplements that with a CSA/Levco comparison that forfeits some of the optimizations available in version 88.3 to make for a fair matchup. Again, by the time you read this, both CSA and Levco will offer the latest version of the Toolset.

What do these figures mean? Taken at face value, they suggest that a single T800 can have four times the performance of a 20-MHz 80386 and six times that of a 16-MHz 68020 for integer work, or two to three times that of an 80386/80387 and six to seven times that of a 68020/68881 for floating-point work. A better way of looking at the ratios is to say that a single CSA board or

continued



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Levco module is twice as fast as a Compaq 386/20 for floating-point work, while with the BYTE Small-C compiler, the integer ratios are as shown. I suspect that with a good 80386 compiler—say, Metaware's—the T800 and a 20-MHz Compaq are about equal on a range of integer applications, and that each would outperform a Mac II by perhaps 2 to 1 on such work.

If you want to use transputers to their best advantage, you'll write process-oriented programs that run in parallel on multiple transputers but that multitask on systems with fewer than the maximum possible number of transputers. To get a feel for this, I used the Levco TDS to write a short occam program that runs tasks in two modes—serial and parallel—and varied both the number of tasks and the duration of each task.

Everybody knows that multitasking is inefficient. Creating and running a process can cost as much as several hundreds of procedure calls. (And try to create 10,000 tasks under OS/2 in a megabyte of memory!) But as table 3 shows, conventional wisdom doesn't hold for the T800. Parallel tasks on one transputer aren't much more expensive than serial ones, and that difference fades to insignificance as tasks grow larger. So you can afford to program in a parallel style, creating programs that can port to multitransputer configurations with the likelihood of a near-linear performance gain.

Summing Up

Both CSA and Levco offer full-fledged transputer development systems at a reasonable price. Should you buy one of these products to enhance your PC or Mac?

If you just want to run existing applications faster, then the answer is clearly no—transputers don't run most off-the-shelf programs yet. But if you develop your own software and you find yourself compute-bound (people in this category include scientists, engineers, and animators), then you should look very hard at these systems.

More generally, anyone interested in learning about parallel processing should take a close look at these products. What Pascal did for structured programming, transputers and occam promise to do for concurrency—and that's the future of computing. ■

Pete Wilson is a computer architecture engineer at Prisma, Inc., and lives in Colorado Springs, Colorado. He can be reached on BIX c/o "editors."

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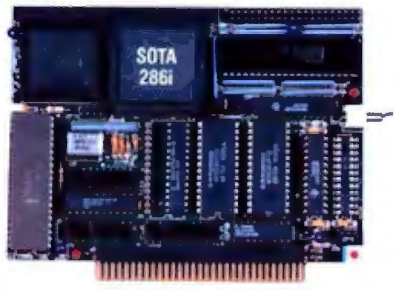

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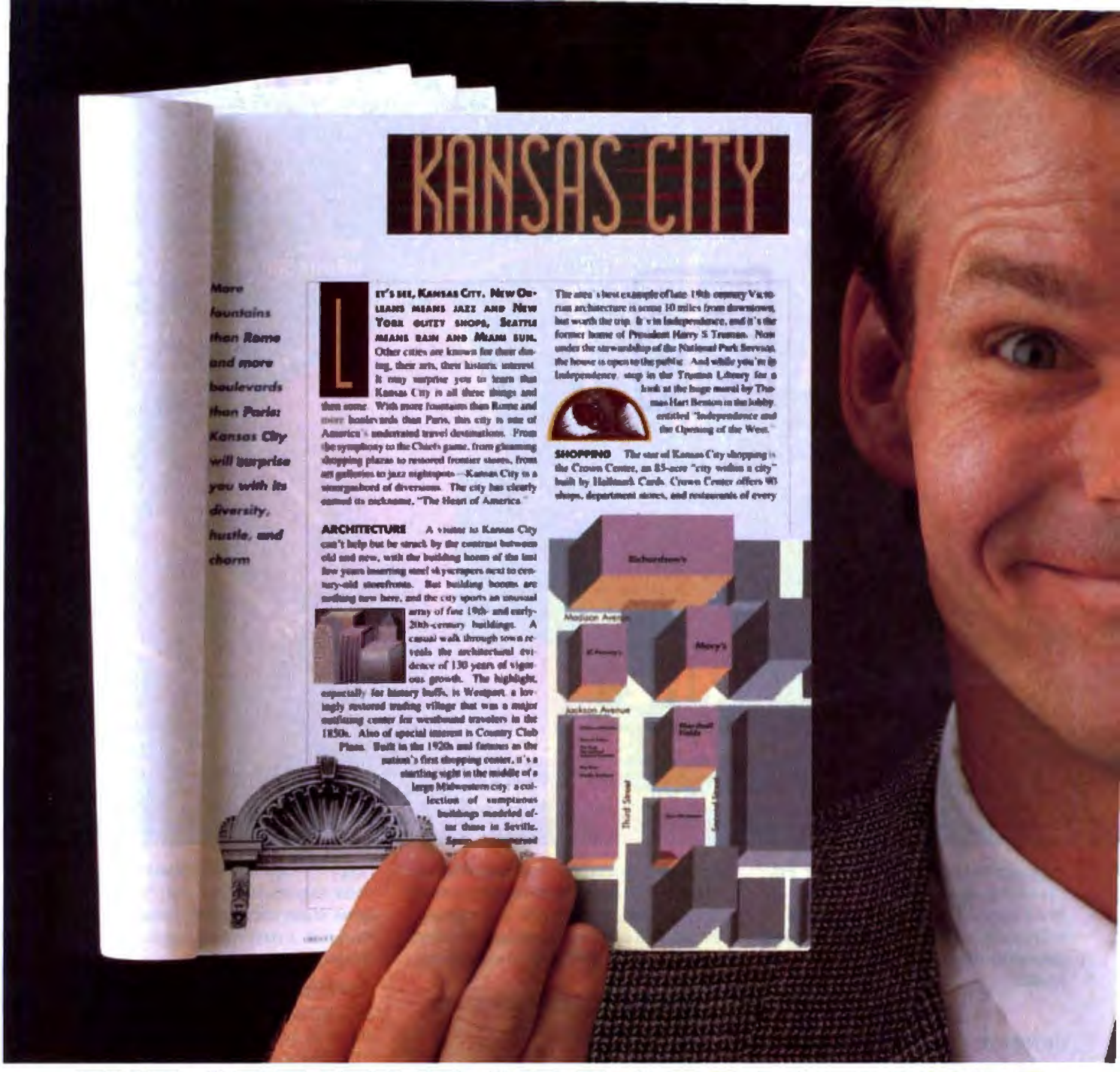
SOTA 286i benchmark was run on IBM PS/2 Model 30.

Circle 313 on Reader Service Card



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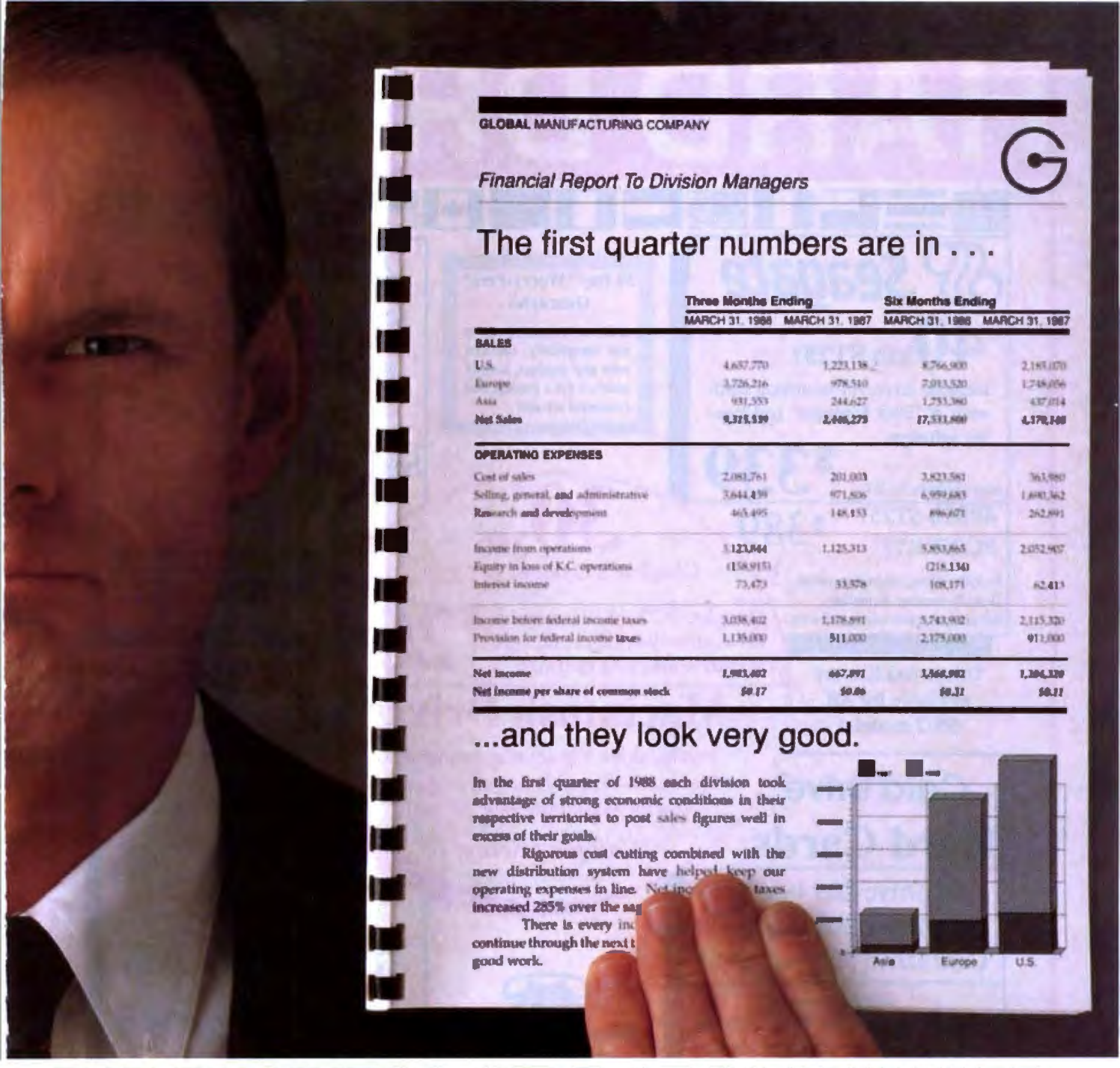

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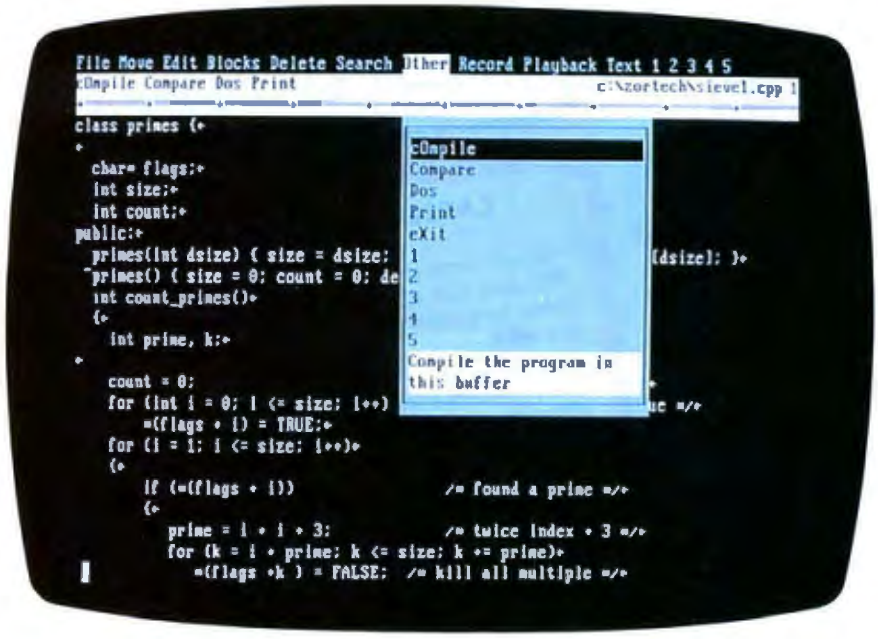
A C++ Toolkit



Everything you need to get started with C++

Jon Udell

Though it's 5 years old now, the C++ programming language has yet to achieve truly widespread acceptance within the microcomputing community. Zortech's C++ 1.0 compiler for IBM PCs ($99.95) may soon change that. Note that it is a compiler, not (as is usually the case) a translator that you use in conjunction with a C compiler. Zortech's C++ conforms closely to the definition of AT&T C++ as set forth in Bjarne Stroustrup's *The C++ Programming Language*. In addition to the compiler, the package includes an impressive collection of programming tools: an optimizer, a linker, a librarian, a disassembler, an editor, a make facility, a help system, a set of ANSI C libraries, and a graphics library.

The installation program is easy to use, but inflexible. Hard-wired to copy the contents of eight distribution disks to a directory tree at the root of drive C, it won't let you install to a subdirectory of drive C or to another drive. That was particularly annoying in my case, because I have two hard disks, drive C and drive D, and I wanted to install the package on drive D. I ended up doing it the hard way—I installed on drive C first, then moved everything to drive D. I hope Zortech corrects this in the next release. Commendably, Zortech makes available two additional disks containing source code in assembly, C, and C++ for the Zortech run-time libraries (excluding the graphics library); the library source code costs another $50.

Tools of the Trade

There are so many tools here that it takes a while to just sort them out—there are seven compilation tools and two linking tools. The organization of the compiler accounts for some of this complexity. It runs in two passes—ZTCPP1.EXE produces an intermediate representation, and ZTC2.EXE converts that into object code. If you choose to optimize, compilation becomes a three-pass affair; you run ZTG.EXE on the intermediate representation before feeding it to the code generator. Zortech's decision to provide a stand-alone C compiler adds more complexity. The C and C++ compilers share the same optimizer and code generator. But for C-only compilations, you can use ZTC1.EXE as the front end instead of ZTCPP1.EXE.

ZTG performs an extensive set of optimizations. It propagates constants; eliminates dead assignments, dead code, and dead variables; hoists loop-invariant expressions; and merges common subexpressions. You can choose to optimize for speed or size. By default, ZTG attempts all optimizations (favoring speed over size); you can selectively disable particular ones.

Zortech's manual, which compares the performance of Zortech C++ to that of Turbo C 1.5 and QuickC 1.0 on standard C benchmarks, cites the results of

continued

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Zortech C++ 1.0

Type
C++ compiler

Company
Zortech, Inc.
366 Massachusetts Ave.
Suite 303
Arlington, MA 02174
(800) 848-8408
(617) 646-6703

Format
Eight 360K-byte floppy disks

Language
C

Hardware Needed
IBM PC or compatible with 512K bytes of memory, a floppy disk drive, and a hard disk drive

Software Needed
MS-DOS 2.0 or higher

Options
Library: $50

Documentation
572-page bound manual

Price
$99.95

Inquiry 884.

an unoptimized run of the floating-point test, because the optimized run wasn't a fair comparison—Zortech's optimizer simply eliminated the computations. I compiled the floating-point test with Zortech's tools, with and without optimization, and disassembled the object files. The optimized version simply loads and prints a floating-point constant, which the optimizer determined to be computable at compile time. Oddly, it retains an enclosing loop; the Microsoft C 5.1 compiler eliminates that too.

Zortech provides a linker, LINK-.EXE, but doesn't require that you use it. And if you want to debug C++ programs with CodeView, you can't use Zortech's linker. You have to use the Microsoft linker and then run a curious utility called BUNCH.EXE, which patches your .EXE so that constructors and destructors will work properly.

You can use .BAT files to control the invocation of the compilation and linking tools, or you can use the master control program ZTC.COM. Given a mixture of .C, .CPP (C++), .ASM, .OBJ, and .LIB files, ZTC selects the right tools in the right order, distributing its command-line arguments to the right places. Through ZTC, you can turn off prototyping, define macros, generate in-line 8087 or 80287 instructions, request insertion of line numbers into the object file, specify the memory model you want, specify stack size, request optimization, link for CodeView, and run BUNCH. If you alternate between two linkers—Zortech's and Microsoft's—you'll run into a minor problem. Since the two linkers share the same name, ZTC grabs the first one on the path; you may need to fiddle with your path to ensure that you use one or the other.

Finally, you can use make to control ZTC, or to control the compile and link tools directly. It operates on a text file (make file) that specifies a set of outputs, the inputs on which those outputs depend, and the actions required to convert the inputs to outputs. Zortech's make supports standard syntax and features.

Shades of Borland

In many respects, the Zortech package invites comparison with Borland's language products. It's an inexpensive and fast compiler that aims to popularize C++ in much the same way that Borland popularized Pascal and Prolog. Zortech's editor, in particular, strongly resembles the one that comes with Borland products. Like Borland's editor, Zortech's integrates with the compiler so that when you compile from within an edit buffer, the compiler halts when it encounters an error, and the editor displays the error message and positions you on the offending line of code. And like Borland's editor, it uses a WordStar-like command set. Zortech also mimics the reconfiguration capability of the Borland editor (i.e., the ability to map edit functions to alternate keys, in case you prefer something other than the WordStar key mapping). But the Zortech editor is less reconfigurable than Borland's; you can't attach commands to multikey combinations, so you can't emulate editors that use such combinations. You can use your own editor instead of Zortech's.

Zortech's C++ comes with a graphics library that's similar to the Borland Graphics Interface, though less comprehensive. Both support basic operations like drawing lines (in varying thicknesses and styles), arcs, and boxes, and writing text in graphics mode; both can adapt their use of color to the palette at hand. But Zortech's graphics library doesn't support advanced features of the BGI, such as viewports, polygons, fill

continued

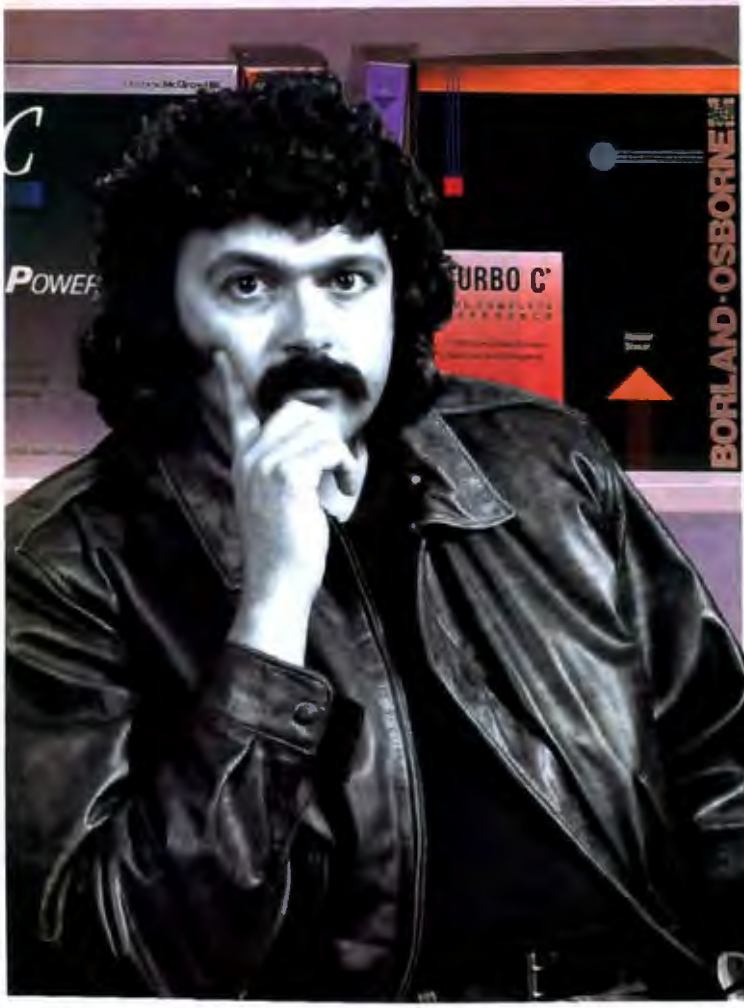

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Table 1: *Zortech C++ compiles and links faster than the combination of Advantage C++ and Microsoft C 5.1, but Advantage has a slight edge at run time. File sizes are in bytes; times are in seconds.*

Test	Compiler	Source	.OBJ	.EXE	Comp+Link	Run time
Sieve	Zortech	1219	672	11,057	5	7
	Advantage	1219	643	7457	8	6
Complex	Zortech	1645	1440	11,699	6	8
	Advantage	1645	19,579	15,148	12	6

patterns, flood filling, and scalable stroked-character fonts, and its documentation is inferior to Borland's. On the other hand, although Zortech's graphics library is C-oriented, you can embed those routines in object-oriented C++ code of your own devising; that should be quite useful if you're developing complex graphical applications.

Zortech would do well to imitate another Borland tradition. Borland's language products always come with at least one substantial piece of working code that beginners can use to get up to speed. Zortech provides a few C examples (e.g., a word counter, a file dumper, and a graphics demo), and, if you buy the library source code, you can see how Zortech has used C++ to implement the classes `istream` and `ostream`. But the basic package provides nothing in C++.

The Zortech context-sensitive help system has no counterpart in the Borland products. It's a terminate-and-stay-resident program that retrieves information about Zortech tools, and about C++ generally, from within Zortech's (or another) editor. You position the cursor on the word you want described and press the hot key (Alt-H by default); up pops a screen containing a description. Unfortunately, it's a pretty simpleminded system. If the word is *class*, you'll see a description of what a class is in C++ and how to declare one. But if the word is *istream* (the predefined C++ class that implements the concept of an input stream), you'll see the declaration for the C library function `islower`—worse than no response at all.

Fast Compilation

The BYTE Lab compared Zortech C++ to Lifeboat's Advantage C++, using C++ versions of the Sieve and complex math benchmarks. Since Advantage C++ is a translator, we ran its output through the Microsoft C 5.1 compiler. The benchmarks were run on a Dell 310 with an 80386 processor, 640K bytes of memory, a hard disk drive, and an 80387 coprocessor. We configured both Advantage and Zortech to optimize and to use the 80387.

The C++ version of the Sieve program embeds its array of flags in a class definition, defines a constructor to allocate it and a destructor to free it, and defines a member function to traverse the array and count primes. The complex math program defines a complex-number class and uses the operator-overloading capability of C++ to associate complex assignment, multiplication, and division functions with the symbols =, *, and /.

Not surprisingly, Zortech's integrated compiler works faster than the Lifeboat/Microsoft hybrid (see table 1). Once compiled, though, the Lifeboat/Microsoft programs have a slight performance edge over the Zortech versions.

Programmers who write in C for IBM PC and compatible hardware and who want to learn and apply object-oriented techniques will find Zortech's C++ compiler very attractive. There is room for improvement: The installation program lacks flexibility, the graphics routines are poorly documented, the help system frequently gives erroneous results, and the package provides few examples of working C++ code.

But Zortech C++ compiles in a hurry; it produces efficient object files; you can use it in conjunction with a third-party debugger like CodeView; it is compatible with both the draft ANSI C standard and AT&T C++; it provides a complete development environment; and it doesn't cost a lot of money. Those are powerful incentives to jump on the C++ bandwagon.

Editor's note: *The C++ source code for the benchmarks is available in a variety of formats. See page 3 for details.* ■

Jon Udell is a BYTE technical editor. He can be reached on BIX as "judell."

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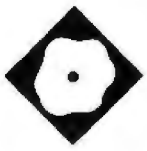

Lint for the PC

```
PC-Lint Vers. 2.15, Copyright Gimpel Software 1985-1988

---- Module module1.c
   return (x-32) * 5.0 / 9.0$;
module1.c  9  Warning 524: Loss of precision
module1.c  9  Warning 533: function cent -- return mode inconsistent
          with line 7
   x  =  cent( $atoi( argv[1] ) );
module1.c  24  Informational 718: atoi undeclared this module, assumed to return
 int
module1.c  24  Warning 516: function cent: arg. type conflict (Arg. no. 1)
          with line 8
module1.c  24  Warning 534: function cent -- return mode inconsistent
          with line 7
   $printf( "centigrade = %f\n", x );
module1.c  25  Informational 718: printf undeclared this module, assumed to retu
rn int
module1.c  25  Warning 559: size of argument no. 2 inconsistent with format
   $)
module1.c  26  Informational 715: argc (line 19) not referenced
Warning 526: printf (line 25) not defined
Warning 526: atoi (line 24) not defined
Informational 714: main (line 19) not referenced

C:\LINT)_
```

An MS-DOS version of the Unix tool

Alex Lane

The C programming language enjoys tremendous popularity these days. Tools associated with programming in C, like `make` and `lint`, have accompanied the language in its migration from Unix to MS-DOS. PC-Lint 2.15 ($139) is one PC-based implementation of Unix `lint`—a program that reads C source code before you compile it in search of what PC-Lint's manual describes as "quirks, idiosyncrasies, glitches, and bugs."

C derives its power, in large measure, from the uniformity of its rules for forming expressions; programmers like to refer to this property as orthogonality. But C's orthogonality is a double-edged sword. It supports nearly unlimited flexibility and elegance of expression; it also lets programmers make silly mistakes. Here's one kind of mistake that C compilers don't prevent and that `lint` was designed to catch:

```
int dumb_function( ) {
    return (3.1415);
    }
```

This function's declaration announces a return type of `int`, but its body returns a value of type `float`. The `lint` programs guard against these and other kinds of errors that invalidate programs, hinder portability, or simply waste resources.

PC-Lint isn't the only version of `lint` for the PC market. Phoenix Technologies, for example, offers a `lint` program called Pre-C. All the PC-based `lint`s find themselves in competition with C compilers that provide `lint` (e.g., Wizard C) or warning (e.g., Microsoft C) features. I'll compare PC-Lint to Microsoft C 5.0.

Out of the Box

PC-Lint requires a relatively minimal setup: an IBM PC (or compatible) with MS-DOS 2.0 or higher and 128K bytes of memory (though the manual notes that you might need 192K bytes for "satisfactory operation"). I tested the program on a 16-MHz ARC 386i equipped with 512K bytes of memory and a hard disk drive.

There's nothing fancy about installing PC-Lint. You can run it directly from a backup floppy (saving about 100K bytes on your hard disk), or copy all the files from the distribution disk to your hard disk and run it from there. In addition to `LINT.EXE`, the package includes a number of test files, a selection of standard library definition files that work with different compilers, and a print utility that paginates and prints one or more files with or without headers, footers, and line numbers.

Getting Started

You can use PC-Lint right out of the box even if you haven't a byte of C source code available. It comes with two sample source files that you can use to test the program. Other sample files include indirection files (`.LNT` files containing PC-Lint options), redirected outputs from PC-Lint, and a library definition file containing function declarations. These demonstration files are small but well thought-out; the first chapter of the manual does an excellent job of describing them. Another chapter of the manual introduces `lint` beginners to a philosophy (presumably that of the PC-Lint's author) regarding the use of the tool. It's called "Living with Lint (or Don't Kill the Messenger)."

The program's primary interface is

continued

PC-Lint 2.15

Type
PC-based `lint` programming tool

Company
Gimpel Software
3207 Hogarth Lane
Collegeville, PA 19426
(215) 584-4261

Format
One 360K-byte floppy disk

Language
C

Hardware Needed
IBM PC or compatible with 128K bytes of memory

Software Needed
MS-DOS 2.0 or higher

Documentation
96-page reference manual

Price
$139

Inquiry 890.

the DOS command line. You can type the entire command line directly—`LINT` plus options (if any) plus the names of the C source files that PC-Lint reads—or you can put arguments and names of source files into a `.LNT` file and supply its name as an argument to PC-Lint. You can also store arguments in the environment variable `LINT`. If `LINT` is defined, PC-Lint inserts its value at the head of the list of arguments. This serves as a convenient way to specify a standard set of options.

The C source files that PC-Lint reads constitute a secondary interface. The program recognizes and acts on commands that you can embed inside comments; for example, the comment

```
/* lint -e711 */
```

disables error 711, the loss-of-precision warning.

You can send the program's output to a file by using the DOS redirection operator (>). When PC-Lint finishes, it returns an exit code corresponding to the number of errors it detected. Control programs written in DOS command language (`.BAT` files) can use the DOS `errorlevel` facility to examine and act on the exit code.

The sample files that come with PC-Lint generate few errors. Real programs aren't usually so cooperative; they can cause PC-Lint to spew a torrent of syntax-error messages (alerting you to things like an unclosed comment), warnings (e.g., noting an unexpected use of a Boolean), and informational messages (e.g., indicating that a signed value will be shifted). The art to using `lint` lies in adjusting its verbosity to suppress extraneous messages while retaining those that warn of real trouble.

Have It Your Way

PC-Lint's many options will appeal to `lint` devotees, though the effort required to learn about all of them might be too much for occasional users. You specify these options by means of the primary interface (the DOS command line) or the secondary interface (PC-Lint commands embedded in comments inside C source files).

You can fine-tune PC-Lint's verbosity by means of the e (error) options, which

continued

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enable or disable individual messages or entire classes of messages. For example, -e501 forces PC-Lint to ignore error 501; -e7?? turns off all 700-series (informational) messages. When you've written a piece of code that you know PC-Lint won't like, you can build a detour around it like this:

```
float f;
int i;

...

/* lint -e711 disable loss-of-precision warning */

i = (int)f;

/* lint +e711 enable loss-of-precision warning */
```

This prevents PC-Lint from complaining about an intentional coercion of a `float` to an `int`, while retaining protection against unintentional coercions elsewhere in the program. It's a nifty feature, although if you use it often, you'll find yourself typing a lot of extra comments as you `lint` your way through program development.

You can also disable three general classes of error related to function arguments—arguments of unlike type (one signed, one unsigned), arguments of unlike type (yet the same size), and pointer arguments having different indirect types. These error classes are a bit obscure for my taste, and the options (e.g., -eau, -eas, and -epp) aren't easy to remember, despite the manual's attempt to present mnemonic aids.

Size options simplify life if you port code between machines that have different scalar sizes. The -si2 option, for example, specifies that integers are in 2-byte quantities.

The `f` (flag) options enable or disable global condition flags. For example, `+fnc` permits code to have nested comments, and `-fum` disallows duplicate member names in different structures.

The height options govern the style of PC-Lint's output and are good candidates for inclusion in the `LINT` environment variable. I preferred compact two-line error messages to the default four-line style, so I specified -h$2 (the dollar sign appears in the source line at the location of the error).

Miscellaneous options enable you to specify preprocessor variables (as with the Microsoft C Compiler's /D switch), restrict the acceptable keywords to those included in the current ANSI standard, specify a particular memory model, and force PC-Lint to return a zero exit code.

Listing 1: *The file* `test.c` *contains subtle and not-so-subtle bugs.*

```
 1 #include <stdio.h>
 2
 3 #define ZIP 5
 4 #define ZAP -1
 5
 6 main(){
 7 int h=50;
 8 int i=10;
 9 int *j = &i;
10 int k,m,n,q,r=20;
11 static char (*hah)[20];
12 char **p;
13
14 printf("Beginning of program\n");
15
16 n = ZIP-ZAP;
17 q = product( 3.0 );
18 printf("n = %d; q = %d; r = %d\n",n,q);
19
20 k = h/*j;
21
22 for (m=-3;m<k;printf("The value of m is %d\n",m++))
23      /* don't do anything */ ;
24
25 if ( r = 5 )
26     printf("The value of r is 5.\n");
27 else
28     if ( r = 20 )
29          printf("This'll never get printed.\n");
30
31 printf("End of program\n");
32
33 }
34
35
36 double product( x, y )
37 int x,y;
38 {
39 return ( x * y );
40 }
```

C Compilers and C Versions

In theory, C compilers are functionally identical. In practice they aren't, because they use different libraries and sets of preprocessor variables. PC-Lint helps smooth out the differences. It provides a selection of library definition files for more than a dozen C compilers. In a library definition file, declarations like

```
void printf(char *,...);
```

tell PC-Lint that functions so declared are defined in a library. If you work with a single C compiler, the easiest thing to do is erase all the library definition files except for the one you need. If you work with several compilers, you can use the c (compiler) option to tell PC-Lint to select the appropriate one.

C itself has evolved considerably since Kernighan and Ritchie published *The C Programming Language* in 1978. (C programmers refer to this book, and to the language it describes, as K&R.) Although ANSI hasn't yet released the new standard for C, many C products—including PC-Lint—have incorporated some generally accepted non-K&R extensions to C. PC-Lint supports many of these extensions, including the void type, function prototypes, enumerated data types, and the ## token-pasting operator.

On the Firing Line

In search of linty source code, I looked back through several years' worth of notes from real C programming projects. From the pages marked "Bug of the Week" and "Aaaarrgghhh of the Month," I pieced together a nonsense source file (`test.c`) containing some classic quirks (see listing 1).

First, I ran the file through the Micro-

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soft C 5.0 Compiler with the command `cl /c /DLINT_ARGS /WO test.c`, which compiles `test.c` at warning level 0 (the most permissive). I repeated the test at warning levels 1, 2, and 3 (the most stringent). Then I submitted the same file to PC-Lint.

The only problem that the Microsoft compiler caught at all warning levels was the redefinition of `product()`. PC-Lint caught it, too, and it also noted the conflict between the number of arguments in the definition (two) and in the function call (one). At level 3, the Microsoft compiler notes that the symbols `p`, `hah`, and `m` are not referenced, and, sure enough, that turned out to be true. PC-Lint notes the same thing; it also shows that `j` isn't referenced and that both `r` and `k` aren't accessed. The problem is the statement `k = h/*j;` at line 20. The `/*` characters parse as the beginning of a comment, so `k` gets the value of `h`, and the compiler ignores everything until it sees the terminating `*/` in the comment on line 23.

Unlike the Microsoft compiler, PC-Lint found the mismatch between format string and arguments in the `printf()` statement at line 18 and caught the classic misuse of the assignment operator (`=`) for the equality operator (`==`) at line 25. Neither the compiler nor PC-Lint found the bug in line 16. After the preprocessor replaces `ZIP` with `5` and `ZAP` with `-1`, the statement becomes `n = 5--1;`, which is clearly illegal.

A Good Tool

PC-Lint should appeal to a variety of users. It can help novice C programmers with the tricky aspects of the language. Experienced programmers—even those intimately familiar with C compilers that provide `lint`-like capabilities—can still benefit from its stringent analysis of source code. In a sense, you get out of PC-Lint what you put into it.

Typically, I just let the program run and redirected its output to a file for examination. I learned to ignore certain types of complaints; in time, I'm sure I'd get around to using the appropriate options to suppress them. PC-Lint does its job well and belongs in the C programmer's toolbox.

Editor's note: *Listing 1 is available in a variety of formats. See page 3 for details.* ■

Alex Lane is a knowledge engineer for Technology Applications, Inc., of Jacksonville, Florida. He can be reached on BIX as "a.lane."

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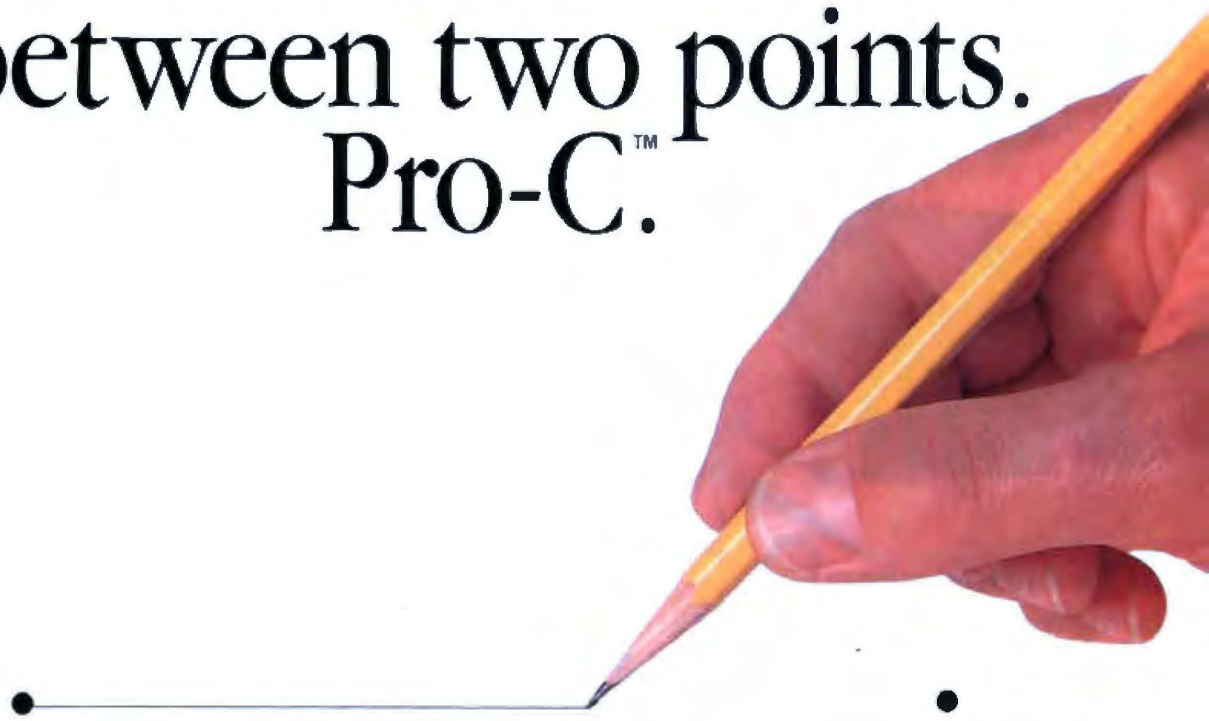

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SpinRite

Recover bad sectors and change the interleave ratio on your hard disk

Richard Grehan

SpinRite is one of those products that generate immediate suspicion. The claim that a piece of software can repair what many have been led to believe is entirely a hardware problem—bad sectors on your hard disk drive—does prompt people to inch away. Tack on the additional claim that the program can perform a low-level format on your hard disk drive and leave your data intact, and inching away becomes noisy backpedaling. I'll admit I was skeptical; when asked to review SpinRite, the first thing I had to find was a sacrificial hard disk drive.

SpinRite ($59) from Gibson Research is a powerful, low-level diagnostic and maintenance program for hard disks in IBM PCs and compatibles. I say "low-level" because SpinRite does not concern itself with file structure on the disk; it works with sectors and tracks of data, not directories and files. SpinRite also performs diagnostics on other aspects of your system: It tests system RAM, verifies that your controller is working properly, and checks the disk controller's RAM.

SpinRite also determines your hard disk's track-to-track (adjacent tracks) and average seek times. I compared SpinRite's results with the results from the Core test. Both tests showed that the Everex drive's average seek time was about 23 milliseconds, but SpinRite calculated the track-to-track seek time as 3.73 ms while the Core test found it to be 5.49 ms. But beyond diagnostics, SpinRite can actually recover sectors marked as bad by the hard disk drive controller; and it can modify the interleave pattern on your hard disk drive to guarantee the maximum possible throughput.

Taking It for a Spin

I ran SpinRite on an Everex 386/20's internal 30-megabyte hard disk drive, and it informed me that I had 51,200 bytes' worth of bad sectors. I already knew this, because I had just executed FORMAT on the drive, which reports how many bytes' worth of bad data the drive is infected with. What I wasn't ready for was that SpinRite was raring to go fix the data; all I had to do was turn it loose on the hard disk drive to do a low-level reformat with the program's extremely thorough pattern testing activated.

SpinRite's low-level reformat is unique in its own right, since it does its job while leaving the hard disk's data intact. I am not suggesting that you try it without performing a backup; the SpinRite documentation urges you to back up the contents of the hard disk prior to reformatting as a safeguard. But if the low-level format goes well—and it usually does—you don't have to spend the rest of the day reloading your files. However, SpinRite's real claim to fame is its ability to recover bad sectors, and even though the pattern testing took over 2 hours, I got my 51,200 bytes back. I wrote files on the hard disk and everything—I even

continued

SpinRite 1.02

Type
Hard disk utility

Company
Gibson Research Corp.
22991 La Cadena
Laguna Hills, CA 92653
(714) 830-2200

Format
One 5¼-inch floppy disk

Language
Machine

Hardware Needed
IBM PC or compatible with a hard disk drive

Documentation
40-page user's manual

Price
$59

Inquiry 888.

ran the Norton Disk Test utility a half-dozen times just to make sure all was OK.

SpinRite also boasted that it could determine the proper interleave for a given drive and controller configuration and change the interleave—ostensibly to its optimum—leaving the hard disk's data intact. For the Everex I mentioned above, the interleave was set to 1-to-1, and SpinRite showed that the Everex couldn't do any better than that. So I decided to set the Everex to a 2-to-1 interleave to determine how much worse its performance would be. This meant that I had to send SpinRite off for another round of its pattern testing. Here's where more of SpinRite's user-friendliness showed through. The reformat takes a long time. I started it late in the afternoon, and it happened that power would be shut off so that BYTE could install its new uninterruptible power supply that evening. Could I interrupt SpinRite's low-level formatting and restart it the next day, where I left off? You bet. The next morning, when I booted the machine and started SpinRite, it asked if I wanted to resume the current operation. The program finished the interleave change in about an hour.

With a 2-to-1 interleave, SpinRite reported that I could expect a maximum throughput of 261,120 bytes per second. For a 1-to-1 interleave, SpinRite promised a maximum throughput of 522,240 bytes per second. Table 1 shows the results of the BYTE low-level disk benchmarks for both interleave patterns. As you can see, a 1-to-1 interleave provided an overall performance improvement, though not as much as I would have expected. The DOS Seek benchmark gains the most; the File I/O test showed little gains, if any (I would have expected little gain from this benchmark anyway, since it performs lots of random reads and writes); and the 1-megabyte File Read and Write benchmarks are split on gain and loss.

The final figures are most surprising; optimizing interleave should improve throughput for those operations that read and write logically contiguous sectors (assuming that logically contiguous sectors are also physically contiguous on a track)—which is exactly what the 1-megabyte File benchmarks were de-

Table 1: *As expected, a 1-to-1 interleave provides an overall performance improvement compared to a 2-to-1 interleave. However, the performance gains are somewhat overshadowed by the seeks to and from the file access table.*

Benchmark	1-to-1 Interleave	2-to-1 Interleave
DOS Seek		
1-sector	5.35	10.83
32-sector	38.58	41.49
File I/O		
Seek	.15	.05
Read	1.41	1.58
Write	1.14	1.24
1-megabyte File		
Write	6.26	6.00
Read	7.03	7.21

Notes: All times are in seconds, except the File I/O read and write times, which are in seconds per 64K bytes. The seek time for File I/O is approaching the resolution of the timing routine. For intervals that small, the signal-to-noise ratio is getting dangerously low.

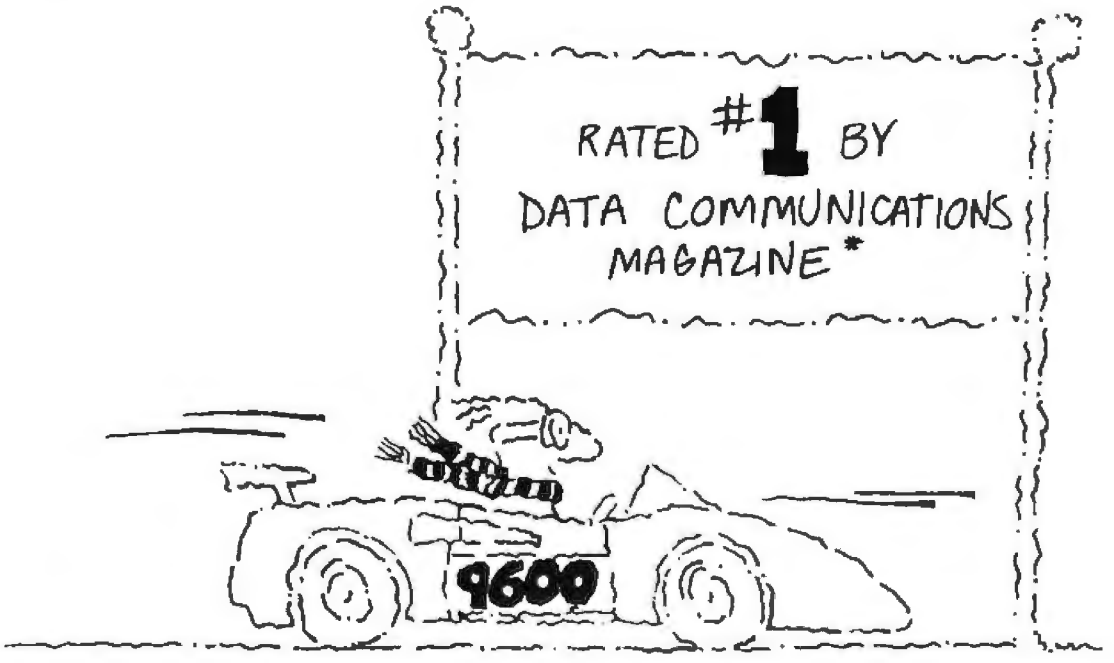
signed to do. An engineer from Gibson Research pointed out that I should be careful about what I was testing—what I was testing *exactly*. Simply reading a file involves seeks to and from the system's file access table, and the time required for those seeks might overshadow the sector I/O time. In all fairness, SpinRite did report the maximum *possible* throughput for each interleave factor; how the operating system performs its hard disk I/O could reduce any performance differences between different interleave factors.

A Must-Use Utility

All I can say about the Gibson Research people is that they did their homework. The user interface is well thought-out and easy to use; all interaction is via an easy-to-navigate window system. The package comes with a hard disk and a 40-page user's manual that is more interesting for its historical content (how the authors of the package made all their discoveries about hard disks) than any other information. The program is so well put together, I found I seldom referred to the manual, anyway.

SpinRite is no 14-disk grand-slam C compiler, but you shouldn't underestimate its usefulness. If you have a PC with a hard disk drive that you spend most of your day relating to, and your heart sinks every time you see the drive's bad sector list, SpinRite is what the word "must" was invented for. ■

Richard Grehan is a BYTE senior technical editor at large. He can be reached on BIX as "rick_g."



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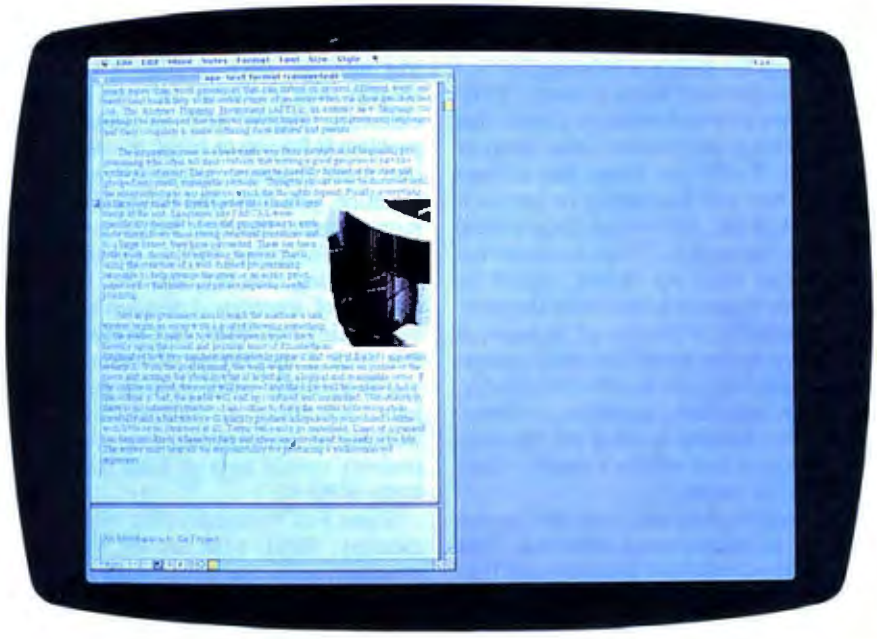

FullWrite takes the feature-rich approach to word processing

Diana Gabaldon

Calling FullWrite Professional 1.0 "full-featured" is an understatement. It's a word processor for the Macintosh with all the attendant ruffles and flourishes, but it also has many capabilities commonly found only in desktop publishing packages. For example, it can wrap text around graphics, it mingles graphics, notes, outlines, and text, and it even has a MacDraw-like facility that lets you create simple drawings without leaving the program. For all its functionality, however, FullWrite also has some significant performance disadvantages that you may find limiting.

FullWrite ($395) is produced by Ashton-Tate, and it runs on any Mac Plus, SE, or II with at least 1 megabyte of memory, one 800K-byte floppy disk drive, and a hard disk drive.

FullWrite lets you choose from four displays: the icon bar, the outline bar, the change bar, and WYSIWYG. The icon bar displays symbols indicating the position of embedded notes, rulers, sidebars, and other formatting in a vertical bar to the left of your text. The 15 symbols aren't all intuitive, however, so it takes some time to distinguish between them. The outline display lets you view your document in outline format and can collapse the outline to display only headers or only body. The change bar flags all changes that you've made to a document since the last session or the last save.

The program includes an undo key, spelling checking with a 100,000-word dictionary and optional in-context checking capability, and a 15,000-root-word (220,000-synonym) thesaurus. Formatting functions include automatic hyphenation (with soft hyphens available), adjustable-height headers and footers, and automatic table of contents and hierarchical index generation.

FullWrite also has features that you don't see in many other word processors. For example, FullWrite lets you break a document file up into chapters and keeps only the chapter you're currently editing in memory. And while Microsoft Word and other word processors have outliners, FullWrite's outliner not only expands, collapses, and adjusts, but it also can outline over multiple chapters of a document. Most word processors let you footnote a document, but FullWrite gives you footnotes (floating or fixed), endnotes, posted notes (the electronic equivalent of 3M's yellow Post-it Notes), content notes, index entry notes, and bibliography entry notes, and it lets you browse through them from any point in a document.

The search-and-replace function is also quite sophisticated. In addition to text string and wild-card searches, you can search for text with specific style attributes and even for invisible characters such as tabs, spaces, and carriage returns. In contrast, Word lets you search for text and some attributes, but not for invisible characters.

In some cases, the program also anticipates things you want to do and makes automatic adjustments. For example, whenever you enter specifications for an option in the layout box, FullWrite automatically adjusts related options. If you change the number of columns, the column width changes automatically.

And, as with Word, you can express things such as margins in terms of multiple units of measure: inches, centimeters, picas, and points. But FullWrite

continued

FullWrite Professional 1.0

Type
Word processor

Company
Ashton-Tate
20101 Hamilton Ave.
Torrance, CA 90502
(213) 329-8000

Format
Three 3½-inch 800K-byte floppy disks

Language
Pascal

Hardware Needed
Mac Plus, SE, or II with a minimum of 1 megabyte of memory (2 megabytes recommended), one 800K-byte floppy disk drive, and a hard disk drive

Software Needed
System 4.1 or higher, Finder 5.5 or MultiFinder 1.0, Font/DA Mover 3.6, and LaserWriter Driver 5.0

Documentation
250-page spiral-bound Learning Guide
300-page Professional Reference Guide
Keyboard Shortcuts card

Price
$395

Inquiry 891.

also adds pixels to the list.

In addition, FullWrite lets you zoom in to display a full-page or even a two-page layout on a single screen. And if the available fonts and type sizes are insufficient for your needs, FullWrite lets you specify a nonstandard-size font and kern existing fonts (two characters at a time) to improve spacing.

FullWrite's MacDraw-like facility lets you create simple line drawings, and you can paste irregularly shaped images from the Clipboard directly into your document and wrap text around them. The latter is a fairly complicated process, however, and involves putting the graphic into a sidebar to position it.

Under the Get Info selection, summary information is available for the document you're currently editing. Data includes the author, the revision date, and the time and number of keystrokes you've made. Word has a similar capability, but FullWrite also gives you character, word, line, paragraph, and page counts. The summary screen also includes a readability index that indicates the complexity of writing on a scale of 1 to 13, with the numbers 1 through 12 corresponding to grade levels and the number 13 indicating college level.

Juggling Documents

FullWrite lets you open and alternate between multiple windows containing chapters or documents. The maximum number of windows you can open is limited only by available system memory. On a 1-megabyte system, you might find using windows to be impractical because you run out of memory quickly. There are also multiple save and print functions that let you check off a list of documents for saving or printing.

For document management, FullWrite uses a virtual memory system that breaks long documents into smaller chapters. FullWrite keeps the current chapter text and formatting in memory. The rest of the file resides in a virtual memory file on disk. When a chapter becomes too large for RAM, FullWrite warns you to break it into more chapters.

Technically, a chapter of 30 pages is about as much as a machine with 1 megabyte of memory can handle. Practically, however, sidebars, graphics, indexes, and other elements quickly eat up available memory and whittle a chapter down to just a few pages.

An Auto-Save option saves the current chapter at user-selected intervals. This feature can be more of an annoyance than a convenience, as chapter saves can interrupt your work for several seconds, depending on the extent of the changes you've made since the last save. You can also set an auto-backup function to automatically create an archival copy of the entire document, but this process hangs up your system for about 5 seconds.

FullWrite can read a variety of document formats in addition to its own. These include Word 1.05, 3.01, and 3.02; MacWrite 2.2, 4.5, and 5.0; MultiMate 3.31; MultiMate Advantage; MultiMate Advantage II 1.0; and ASCII text files. However, FullWrite can write only to FullWrite, MacWrite 4.5, and ASCII text formats.

Slow Performance

The BYTE editors and I ran FullWrite on several machines, including a Mac SE with 1 megabyte of RAM and an 800K-byte floppy disk drive that I had networked to an 80-megabyte file server; a Mac SE with 4 megabytes of memory, one 800K-byte floppy disk drive, and a 20-megabyte hard disk drive; a Mac II with 5 megabytes of RAM, a 68851 paged-memory-management-unit chip, a video board with a 256K-byte color upgrade, an 80-megabyte hard disk drive, and one 800K-byte floppy disk drive; and a Mac Plus with 1 megabyte of RAM, an 800K-byte floppy disk drive, and a 20-megabyte Super Mac DataFrame small-computer-system-interface hard disk drive.

FullWrite's minimum requirement is 1 megabyte of memory, but you'll need more than that to make full use of the program. FullWrite was slow to respond on the Plus, and I quickly ran out of memory on the 1-megabyte Plus and SE when creating even small documents. My machine returned a `Document is too big` message after creating a five-page chapter with a sidebar and two graphics elements. FullWrite's solution to this problem is for you to break the document into more chapters, but on a 1-megabyte machine, you may find yourself creating more chapters than you bargained for.

Other functions, such as the thesaurus and spelling checker, are also quick to run out of memory. I wouldn't recommend using FullWrite on a machine with less than 2 megabytes of memory, and you'll probably need even more for big jobs. According to Ashton-Tate, users working on documentation or other large projects should have at least 2.5 megabytes of RAM.

Since FullWrite runs best with lots of memory, BYTE's lab ran the word processing tests on the 4-megabyte Mac SE. In the keystroke count, search-and-replace, ASCII file conversion, and scrolling benchmarks, FullWrite fell behind MacWrite 5.0 and Word 3.01 (see table 1). In the search-and-replace test in particular, FullWrite lagged far behind Word and MacWrite. This function, on a 4K-byte test file, took 94 seconds—nearly four times longer than Word and three times longer than MacWrite. On the Mac II, this number dropped to a more tolerable 35 seconds.

FullWrite also fell behind when converting from ASCII to FullWrite format. Not surprisingly, these times improved substantially on the Mac II, taking 13 seconds to convert the 4K-byte test file from ASCII and just 4 seconds to convert it to ASCII.

During the scroll test, FullWrite paused to update the document at some page breaks while passing by others. These pauses occurred at different places each time I ran the test, and they accounted for a 20-second spread in the resulting test times. Ashton-Tate attributes the poor performance to FullWrite's inter-

continued

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REVIEW

FEATURES VS. SPEED

nal updating of the document; the company could not explain why the program's scroll performance varies with each test run. The number in the benchmark table (74 seconds) is an average, but even the fastest time—64 seconds—was substantially slower than MacWrite or Word. The Mac II, at 69 seconds, was only slightly better.

A related area where FullWrite falls down is during cursor movement using the arrow keys on Mac SE and II keyboards. Text cursor movement works normally when you're using the mouse. But when you press one of the arrow keys, the text cursor moves even more slowly, and it disappears completely during the movement and doesn't reappear until a second or two after you've released the cursor-move key. This is aggravating, since you can't keep track of the cursor during moves.

Table 1: *FullWrite's performance was lacking in several of the benchmarks.*

	FullWrite 1.0	MacWrite 5.0	Microsoft Word 3.01
Keystroke count	203	177	185
Scroll	74	60	43
Search and replace	94	29	26
Reformat	2	8	<1
Save	3	5	2
Load	5	5	2
Word processing to ASCII	10	5	14
ASCII to word processing	25	15	16

Note: All tests were performed on a Mac SE using a mouse. File saves in Word were executed using the Fast Save option. All times are in seconds.

An alternative is to use the Move menu, but this, too, is slow. The way around this is to use the keyboard shortcut keys, which instantly move the cursor to virtually any point in the document.

Professional writers and other heavy-duty text dumpers often sneer at Mac word processors because they claim it's a nuisance to keep taking your hands off the keyboard to steer a mouse. However, FullWrite provides a full complement of other keyboard shortcuts that range from text format and style selection to windowing and saving a document.

Minor Distractions

It's difficult to think of many features that Ashton-Tate left out of this package. One drawback is that columns are serpentine only; there's no easy way to do side-by-side columns. Anyone wanting to do two-column manuscripts can still manage; you have to define the second column as a sidebar and use the page-layout function to set it beside the main column of text. This requires some extra effort, however, and is a bit of a kludge.

FullWrite's WYSIWYG display mode

continued

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displays fonts using fractional pixels. But the program may have a problem displaying some fonts if you're using a version of Font/DA Mover lower than version 3.6, because earlier versions corrupt fractional font measurement information. I used version 3.6, which worked fine, and version 3.4, which made some fonts appear rough or jagged-edged on-screen. But aside from the screen display, performance was unaffected; document layout, text processing, and font printing worked fine.

Other than my problems on the Mac Plus, no significant errors occurred while I was using FullWrite, and warning messages helped to prevent potential problems.

FullWrite is easy to learn and use, and the documentation is well designed and organized. The package includes a spiral-bound Learning Guide, a Reference Guide, and a Keyboard Shortcuts card. Notes, tips, and warnings are liberally sprinkled throughout both manuals.

If you get into trouble, Ashton-Tate includes 90 days of free technical support, provided you send in the registration card. The company also offers extended support, which entitles you to 15 calls for $50 a year. A monthly graphics newsletter, *Random Lines*, is also available, as is electronic support via forums on CompuServe, The Source, and an Ashton-Tate bulletin board.

Bone of Contention

FullWrite is hard to beat on features, providing elements of MacDraw, PageMaker, and a sophisticated word processor in one package. Unless you're doing book-size projects, this package would probably suit your needs for both general word processing and desktop publishing functions. PageMaker is more powerful than FullWrite in terms of special effects and page layout, but FullWrite is more than adequate for most desktop publishing needs.

On the other hand, FullWrite has a ravenous appetite for memory, and it is a slow performer—especially during search-and-replace functions. It's best suited for Mac SE and II users with at least 2 megabytes of memory on-board. If you've got the resources and you're not looking for speed, however, FullWrite is worth a look. ■

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 c/o "editors."*

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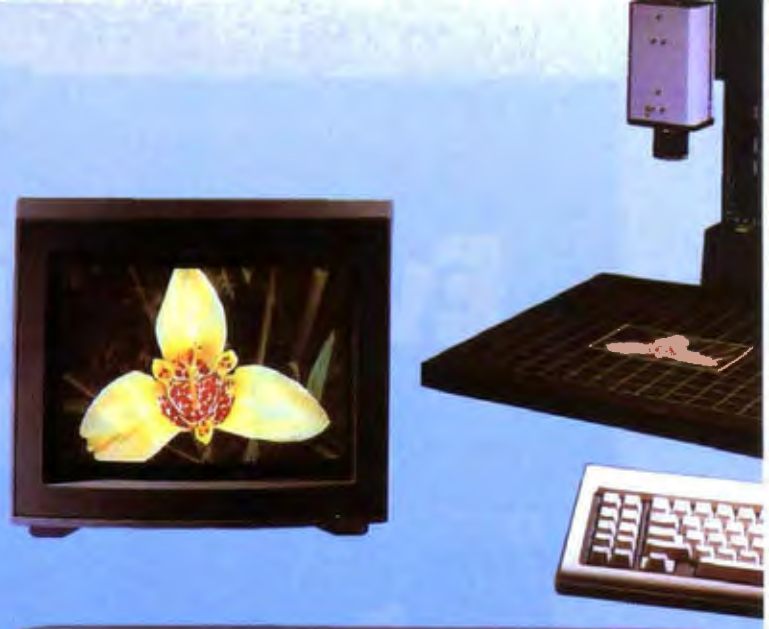

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Remote-Control Communications

Crosstalk's Remote² lets you control another computer via your modem

Rick Cook and Paul Schauble

A remote-control communications program is indispensable for anyone doing software support over the telephone. It lets you use a modem to look over the user's shoulder to examine the system as it runs, enter commands, and check screen displays. The program is an enormous asset if you do software maintenance or support, and it is ideal for walking a user through a sequence of instructions.

One such remote-control program is Remote² 1.0 ($195) from the Crosstalk division of DCA in Roswell, Georgia. It consists of a program called R2Host, which runs on the user's machine, and R2Call, which calls into the remote computer. The programs run on MS-DOS systems in as little as 36K bytes of RAM.

Remote-control programs are definitely useful, but they are very difficult to write. In essence, they are the ultimate terminate-and-stay-resident (TSR) programs in that they go far beyond anything MS-DOS was ever intended to do. They must wedge themselves invisibly between the applications and the operating system and transmit every keystroke and every pixel through a communications port to another computer.

The remote caller needs to be able to do everything the user can do from the keyboard, as well as see everything on a remote display. Ideally, the remote program should be absolutely invisible to the user's system. Everything should operate exactly as it does when the remote-control program is not loaded.

Unfortunately, no remote-control program is that good. Like all remote programs, the R2Call/R2Host system has inherent drawbacks; however, it also has some problems all its own, especially in the way it handles screen displays.

In addition to running a computer remotely, R2Call/R2Host also provides a number of other features, such as file compression and error-corrected transmission, password and callback features for security, and a simple but useful session management function that includes maintaining a comprehensive call log.

R2Call/R2Host works over a modem or over a direct serial link. It handles both Hayes-compatible and non-Hayes-compatible modems. R2Host can handle calls from systems without R2Call, but it must run DCA's Crosstalk XV communications package. The program includes a reference card for the key combinations used to simulate control, escape, and other key combinations when running with Crosstalk. R2Host will even accept calls generated by about a dozen types of terminals, including the ADM-3A, the VT-220, and the IBM 3161.

We tested R2Call/R2Host on an Everex 386 PC running at 16 MHz with a USRobotics 2400-bit-per-second modem, and on an IBM PC switchable between 4.7 MHz and 8 MHz with a DataFox 2400-bps modem. For the CGA tests, we used a Leading Edge Model M with the DataFox modem instead of the IBM PC. We also tested the programs using a serial cable and a null modem connection between the computers' serial ports running at 19,200 bps. We had no problems with either the modems or the cables that could be attributable to the software.

Installation

One of the best things about R2Call/R2Host is the installation program. In-

continued

Remote² 1.0

Type
Communications program

Company
Crosstalk Communications/DCA
1000 Holcomb Woods Pkwy.
Suite 440
Roswell, GA 30076
(404) 998-3998

Format
Two 5¼-inch floppy disks

Language
Assembly

Hardware Needed
IBM PC or compatible with at least 36K bytes of memory above that needed for the application software

Documentation
131-page R2Host manual; 107-page R2Call manual; quick reference card

Price
System (combined host and caller): $195
Host only: $129
Caller only: $89

Inquiry 889.

stead of presenting a series of cryptic questions, it gives a screenful of text at each decision point that fully explains your choices and their consequences.

For example, if you install the program to run over a serial link, the modem test step in the installation process naturally fails. The program not only tells you it failed, it also tells you this is normal and then warns you that it can't be sure everything is connected properly.

Best of all, R2Call/R2Host asks your permission before adding something to your AUTOEXEC.BAT file. People with painstakingly crafted scripts in their AUTOEXEC.BAT files can tell the program not to mess with them, while average users don't have to make manual changes to the file.

The documentation that comes with the program is very good. It is clear, concise, and effective at explaining the basic features of both programs.

For all its ease of installation, though, you can't expect an inexperienced user to successfully install R2Host without some hand-holding. There are just too many parameters that have to be set. This is inherent in programs of this type, which is unfortunate, because R2Host is the program that has to run on the machine to be accessed (i.e., the one that will be out in the field).

One peculiarity developed when we set up our test systems. The 80386 machine was running an EGA-compatible Sigma Color 400 card and a color monitor, but it also had a monochrome card installed. Although we told the installation program we wanted a color display on that system and a monochrome display on the other system, R2Call/R2Host insisted on displaying through the monochrome card on the color system. And it wasn't until we plugged a monochrome monitor into the monochrome card that we got a screen display.

This is deliberate, according to Crosstalk. However, there's no message telling the user what is going on. If you don't have your monochrome monitor hooked up and turned on, you have no idea what is happening.

Graphics Drawbacks

Most of the problems we encountered with R2Call/R2Host were related to the screen display, especially trying to work with anything other than monochrome monitors.

The program does not claim to support EGA or VGA graphics. It doesn't support Hercules-style high-resolution monochrome graphics, and it treats cards that display CGA on monochrome monitors as simple monochrome displays.

R2Call/R2Host does support CGA-to-CGA connections in character and graphics modes, albeit with some limitations. When we tried running Lotus 1-2-3 graphics, the system running R2Call locked up, and the screen of the system with R2Host had its foreground color set to 0, leaving a completely blank screen. Both systems had to be reset.

Once again, this is a severe test. Lotus is notorious for handling graphics in a nonstandard and hardware-specific way, so failure was likely. The manual does warn that programs that do direct hardware calls for graphics may not work.

In practice, there were more limits than the ones the manual warned against. The program handles CGA all right, but only CGA to CGA, at least in character mode. (You can use an EGA card in CGA-emulation mode.) R2Call/R2Host had no problem with spreadsheets and text between CGA systems.

Although the program is supposed to handle CGA-to-CGA graphics, we found that they didn't always work. We attempted to run some of the demonstra-

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tion programs supplied with QuickBASIC 4.0. Some of them ran, and some of them didn't. Animation programs produced screen snapshots rather than moving objects. However, programs that drew a Mandelbrot set and a sine wave worked.

We also tested a character-based game on a CGA host and a monochrome remote; it didn't work. What we got was pieces of the command-line text scattered throughout the remote's display. Given the proliferation of color displays, the requirement that the displays match is a fairly serious limitation. It makes it difficult to use the product to communicate with remote computers, and that is, after all, the reason it exists.

This is further complicated by the way R2Call/R2Host behaves when things do go wrong. Don't expect warning messages or simple refusals to function here. When R2Call/R2Host fails, it almost always fails hard, locking up one or both machines. Since failures are so likely, it would have been nice if they were cushioned in some way—at least with a warning message for when the user is about to try something chancy or, preferably, by refusing to run dangerous programs.

Crosstalk says it is addressing this problem in the next version of the product (1.1), which should be out by the end of the year. But don't expect the problem to go away entirely.

Unsettling Screens

The display incompatibilities weren't the only problem with R2Call/R2Host displays. The screen updating is an invitation to a migraine.

You can see what is going on with the remote system, but don't plan on looking at it for very long. The display updating is an annoying, eye-straining mess.

Screen updates are slow, of course. Even over a 19,200-bps serial link, the display can't be expected to match the speed of a memory-mapped PC display. This means that if you are typing text into a word processor, for example, the screen will lag by several characters.

But that doesn't excuse the jerky, crazy way the display is updated on R2Call/R2Host. When you enter text, the screen does nothing for the better part of a second, and then the display jerks ahead with a burst of characters. The effect is extremely unsettling and makes it hard for even a moderately fast typist to work at the system.

Worse, entering commands on the command line is difficult. If you make a lot of mistakes, you don't catch them because you can't see them until you've reached the end of a command. If you've already hit Enter out of reflex, you get an error and have to reenter the command.

Still worse, the cursor position bears little or no relationship to where the screen is updating. When typing in text, sometimes the cursor is behind the characters as they flash on the screen and sometimes it is ahead. The effect is extremely distracting.

To top things off, in a screen redraw, parts of the screen appear seemingly at random while the old screen remains visible. In running QuickBASIC demonstration programs, for instance, often the bottom third of the screen would show up first, followed by the top, and then the middle. Usually there would be parts of both screens visible at the same time for several seconds. Using, say, WordPerfect 4.2 to type half a screen of text could drive you nuts.

According to Crosstalk, programs that use the BIOS routines to move the cursor should be smoother, though few of the most powerful application programs work that way. Crosstalk also says that the revised version should be better with all kinds of programs.

Remote Applications

With the exception of the screen update problem, when R2Call/R2Host works, it works well.

R2Call/R2Host maps the keyboard of the calling machine exactly onto the host computer: An Escape on the host is an Escape on the calling machine, and so on. The caller doesn't have to remember a separate set of keycodes for the host, and this makes things more intuitive for the caller. For callers using Crosstalk rather than R2Call, there is a set of alternate key combinations for the various special keys, all spelled out in a reference card that comes with the package.

Also on the plus side, R2Call/R2Host ran perfectly with our local-area network, an ARCnet running Novell NetWare. We had no problems manipulating the network with either program.

However, some application programs did not work. Once again, some of this is to be expected. TSR programs, or programs that write directly to the hardware, make odd function calls, or otherwise behave badly, are always chancy on systems where MS-DOS has been pushed beyond its design limits. The manual specifically warns about several potential problem areas.

However, in some cases, we could not figure out why a program failed. FinalWord 2.0, for example, would not run. It would load, and the screen would come up, but neither system could move the cursor off the command line or produce any other response. The calling system finally had to be rebooted for us to get out of it.

FinalWord is a solid word processor that does not have a reputation for doing odd things to computers. Neither we nor Crosstalk have an explanation for its failure to run. Therefore, we recommend that before buying Remote², you check the compatibility of the applications you intend to run.

In contrast, WordPerfect 4.2 worked normally—given the irritating display. Microsoft's QuickBASIC also ran without a problem.

Except for the graphics, Lotus 1-2-3 also worked normally over R2Call/R2Host. We could load 1-2-3 over the network, create or call up spreadsheets, and then manipulate them from either computer.

File transfers were trouble-free. Both archived (compressed) and text files moved both ways quickly and smoothly. There was a small difference in transferring from the 80386 to the PC versus from the PC to the 80386, but not much.

There is a real need for a program like R2Call/R2Host. If you are doing software support for remote locations, it is a great time saver.

R2Call/R2Host gets very high marks for its installation program and for its manuals. Its functionality, however, is less satisfactory. Generally, it can be recommended only if you don't have to stare at the screen for a long time and if you are thoroughly familiar with both the host and target systems, as well as the software you are running and how it interacts with R2Call/R2Host. Otherwise, you will waste a lot of time trying to decide what is a problem with the application and what is an artifact of the R2Call/R2Host connection.

At the very least, Crosstalk needs to do something about the horrible screen updates and install some kind of warning or interrupt system to keep incompatible programs from crashing the systems. It would be nice if the company could add better support for mixed-mode and nonmonochrome displays as well. ■

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80386 Clones Revisited

Northgate's Affordable 80386

Our October Product Focus uncovered some outstanding machines among the 20 low-cost 80386 clones we reviewed. But few of those receive the kind of publicity generated by Northgate's offering, a 16-MHz system retailing for an even $3000. Among our requirements for inclusion in that review were that the system come in complete usable configuration, with a monitor, a keyboard, at least one floppy disk drive, and at least a 40-megabyte hard disk drive. Although the Northgate system arrived too late for that review, it eventually came equipped with all that we asked for, and more.

Like many of the top-performing systems we reviewed, the Northgate 386 is built around the AMI/Mylex 386 motherboard. The board comes with 1 megabyte of 120-nanosecond DRAM and a 64K-byte SRAM cache. Caching allows performance at 16 MHz with zero wait states. The design earned the system a 2.61 CPU index on our benchmarks, tying it with the Zeos 386 Tower and the Spear Mono-386A for one of the highest ratings among the 16-MHz systems.

Unfortunately, all this processing power comes at a price: The board's layout limits future expansion. The system supports only an 80287 coprocessor (an 80387 can be added using a daughterboard), the 32-bit memory ceiling is set at a low 4 megabytes, and memory upgrades must be done by the manufacturer.

Northgate's most highly touted feature is its 65-megabyte MiniScribe 3650R hard disk drive, coupled with an Adaptec 2372 controller that allows run-length-limited encoding at a 1-to-1 interleave. Only Zeos, using the same controller, was able to match Northgate's hard disk capacity.

The drive's actual access time specs are not outstanding at 40 milliseconds, but Northgate claims that its drive/controller subsystem attains high throughput. Our disk benchmarks, which consider both access time and throughput, gave the combination a disk index of 1.38, about average for 40-ms drives. Application benchmark results were mixed, with the drive scoring well on the relatively disk-intensive Spreadsheet tests (2.75) but giving a poor showing of 1.34 on the most disk-intensive Database benchmarks. Zeos's 386 system, using the Adaptec with a Seagate ST277R drive, turned in a better disk performance overall.

It's hard to rate qualitative features like monitor clarity and keyboard feel, but the most outstanding part of the Northgate design may well be the ergonomics. The 102-key keyboard has an excellent tactile response, and the keys are generally positioned for comfortable typing. The 14-inch white-phosphor flat-screen monitor looks and acts like the fine Everex model.

On the whole, the system was a solid performer. Its combined application index of 10.05 put it right beside the Spear machine and ranked it seventh out of the 21 reviewed clones. The whole Northgate package, which includes DOS 3.30 and GWBASIC, is well put together and a good buy for $3000. In terms of sheer performance, though, there's little to distinguish it from the rest of the high-speed crowd.—*Steve Apiki*

Apple's Scanner

Since the October review of low-cost Mac scanners, Apple has introduced its own Apple scanner, priced at $1799. Like the competing scanners, it closely resembles a flatbed copier. The Apple Scanner requires no external power supply or SCSI adapter box; a power cord (supplied), SCSI terminator, and SCSI adapter cable (*not* supplied) get you set up. You can change the scanner's SCSI ID with a push-button selector dial if it conflicts with another SCSI peripheral.

The scanner can handle an 8½- by 14-inch document scanned in as line art, as a halftone, or as a 4-bit-per-pixel gray-scale image, for 16 gray levels. Scanning resolution (from 75 to 300 dots per inch) is user selectable, and you can save the image as PICT2, Tagged Image File Format, or MacPaint files. However, you can't open files saved as TIFF or MacPaint. I can understand this limitation for MacPaint files, since information is lost saving the image as a 72-dpi black-and-white MacPaint image, but the inability to open TIFF files doesn't make much sense.

Three disks of software are supplied. The first contains a VideoWorks II tutorial. The second disk has the AppleScan application, Scanner INIT, and LaserPrep/LaserWriter 5.2 driver files. The third disk holds the Scanner INIT and HyperScan, a HyperCard version of AppleScan for use with HyperCard 1.2.

I tried the AppleScan application on a Mac II with 5 megabytes of memory, an AppleColor monitor, and a Mac II video board. Scanning times were slow (about 47 seconds for an 8½- by 14-inch line scan, and nearly 2 minutes for a gray-scale scan of the same image), but the quality is very good. The application is reliable—no system bombs. The manual doesn't tell you that you must first convert gray-scale images to halftone images before you can print them. But printing to a LaserWriter IINTX worked fine, and the quality of the images is excellent.

I also tried Caere Corp.'s OmniPage optical-character-recognition application, priced at $795, with the Apple Scanner. It requires 4 megabytes of RAM and a 68020 processor (either a Mac II or a Mac SE with a 68020 accelerator board). The OmniScan OCR application drives the Apple Scanner directly. You can select either image scan (200, 240, and 300 dpi) or text scan (300 dpi).

I let OmniScan do a text scan on several pages from BYTE. The application automatically recognized the columns of imaged text, even when the font changed, and converted them to ASCII text. Alignment, as the manual points out, is critical. If the page is misaligned even a few degrees, the character-recognition software generates spurious characters. As you might expect, OmniPage does a better job on large-size text with a simple typeface (such as Helvetica). While by no means perfect, OmniPage goes a long way toward automating document scanning.—*Tom Thompson*

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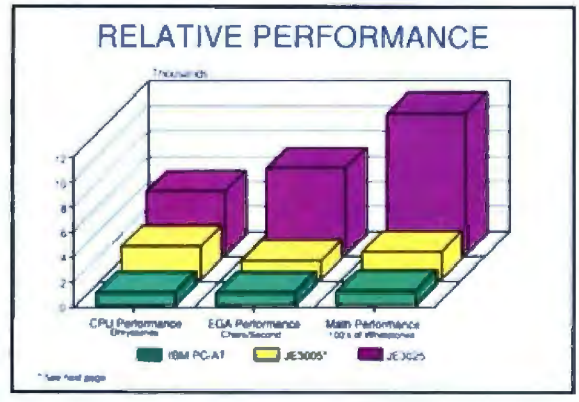

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AMBER. $99.95

CTX 14" RGB Color Monitor for IBM PC/XT/AT and Compatible Computers

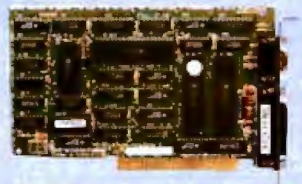
• Input: DB9 (RGB) • Horizontal scanning frequency: 14.5kHz to 17.8kHz • Video bandwidth: 18MHz • Display area: 13.1" diagonally • Resolution: 640 x 200 • Controls: (Front) Brightness, Contrast, V-Hold; (Rear) H-Phase, H-Hold, V-Lin., V-Size • 70W • Switch for Amber, Green or Color Screen • Size: 14.6"W x 15.5"D x 13.6"H • Weight: 27 lbs. • Compatible with JE1052 and the JE1055 (see below) • Cable and manual included

CTX2410. . . . . $279.95

Jameco ELECTRONICS IBM PC/XT/AT Compatible Display Cards

1-Year Warranty!

Monochrome Graphics Adapter for IBM PC/XT/AT

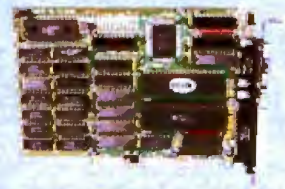


Compatible with IBM Monochrome and Hercules Graphics Standards

The JE1050 is a monochrome graphics card with parallel printer port and features the following: • Text mode: 80 x 25; Graphics mode: 720 x 348 • Compact half-card • Parallel printer interface with transfer rate up to 1000 characters per second • Manual included

JE1050. . . . . $59.95

Color Graphics Adapter for IBM PC/XT/AT



Compatible with IBM Color Graphics Standard

The JE1052 is a color graphics adapter card capable of operating with either IBM RGB or composite monochrome monitors and features the following: • Parallel printer port • Text modes: 40 x 25 or 80 x 25; Graphic modes: 320 x 200 or 640 x 200 • Light pen interface • Includes composite video monitor adapter • Manual included

JE1052. . . . . $49.95

Enhanced Graphics Adapter for IBM PC/XT/AT

Compatible with IBM Enhanced Graphics Standard

The JE1055 is an IBM EGA/CGA/MDA/HGA compatible card featuring the following: • Text mode: 80 x 25; Graphics mode: 720 x 348 • Reserved video jacks and feature connectors • Light pen interface • 256K Video RAM • Dip-switch on back of card allows changing of switch settings without opening case • Displays 16 out of 64 colors • Manual included

JE1055. . . . . $159.95

Multi I/O with Controller and Graphics for IBM PC/XT

Compatible with IBM Monochrome and Hercules Graphics Standards

The JE1071 is a multi I/O card with six add-on functions, uses only one slot and features the following: • Text mode: 80x25; Graphics mode: 720x348 • One RS232C serial communication port (expandable to two — see page 263 for 2nd Serial Port Kit) selectable for COM1 thru COM4 • Game port • Real-time clock/calendar with replaceable battery back-up • 5.25" floppy disk drive controller capable of handling up to two 360K drives • Parallel printer port • Print spooler software • Manual and cables included

JE1071. . . . . $119.95

260 ***For complete product line, request Jameco's new 74 page 1989 Catalog***

NEW! 3.5" AND 5.25" FLOPPY DISK DRIVES NEW!

Mitsubishi 720KB 3.5" Internal Floppy Disk Drive
for the IBM PC/XT/AT and Compatible Computers

Includes 5.25" mounting frame for IBM PC/XT/AT and compatible computers. May require DOS 3.2 or higher for operation. The MF353B is compatible with the JE1043 and JE1049 Interface Cards (see page 259).

Specifications: • 720KB formatted storage • Double-sided, double-density • 135TPI • 160 tracks • Rotation speed: 300rpm • Track to track access time: 3ms • Full installation documentation included • Size: 5.75"W x 8.25"D x 1.75"H • Weight: 1.7 lbs.

MF353B. $109.95

Mitsubishi 1.44MB 3.5" Internal Floppy Disk Drive
for the IBM PC/XT/AT and Compatible Computers

Includes 5.25" mounting frame for IBM PC/XT/AT and compatible computers. May require DOS 3.3 for operation. Also compatible with 720KB floppy disks. The MF355B is compatible with the JE1043 and JE1049 Interface Cards (see page 259).

Specifications: • 1.44MB formatted storage • Double-sided, high density • 135TPI • 160 tracks • Rotation speed: 300rpm • Track to track access time: 3ms • Full installation documentation included • Size: 5.75"W x 8.25"D x 1.75"H • Weight: 1.7 lbs.

MF355B. $129.95

Jameco 5.25" Half Height Drives
for IBM PC/XT/AT and Compatible Computers

JE1020 — IBM PC/XT/AT Compatible • 360KB, double-sided, double density • 48 TPI • 80 tracks • Spec included • Color (bezel): Black • Size: 5.75"W x 8.13"D x 1.63"H • Weight: 2.7 lbs.

JE1020. . . . . $89.95

JE1021 — IBM PC/XT/AT Compat. • Same specs as JE1020 except comes with beige color bezel.

JE1021. . . . . $89.95

JE1022 — IBM AT Compatible (Also compatible with IBM PC/XT when used w/JE1043 and JE1049, see page 259) • 1.2MB, double-sided, high density • 96 TPI • 160 tracks • Spec included • Color (bezel): Beige • Size: 5.75"W x 8.13"D x 1.63"H • Weight: 2.7 lbs.

JE1022. . . . . $109.95

TEAC 5.25" Half Height Drives
for IBM PC/XT/AT and Compatible Computers

FD55B — IBM PC/XT/AT Compatible • 360KB, double-sided, double density • 48 TPI • 80 tracks • Spec included • Color (bezel): Black • Size: 5.75"W x 8.13"D x 1.63"H • Weight: 3.3 lbs.

FD55B. $99.95

FD55GFV — IBM AT Compatible (Also compatible with IBM PC/XT when used with JE1043 and JE1049, see page 259) • 1.2MB, double-sided, high density • 96 TPI • 160 tracks • Spec included • Color (bezel): Black • Size: 5.75"W x 8.13"D x 1.63"H • Weight: 3.3 lbs.

FD55GFV. $119.95

Tandon 5.25" Full Height Drive
for IBM PC/XT and Compatible Computers

IBM PC/XT Compatible!

TM100-2 — IBM PC/XT Compatible • 360KB, double-sided, double density • Full height drive • 48 TPI • 80 tracks (40 tracks per side) • Rotation speed: 300rpm • Track to track access time: 5ms • Documentation included • Color (bezel): Black • Size: 5.75"W x 8.00"D x 3.38"H • Weight: 5 lbs.

***TM100-2 . . . . . $99.95**

The JE1020, JE1021, JE1022, FD55B, FD55GFV and TM100-2 *DO NOT* include case, power supply, cables, mounting hardware or manuals. All disk drive manuals are $5.00.

See page 66 for Diskettes and Accessories

JMR FLOPPY DISK DRIVE ENCLOSURES JMR

3.5" Floppy Disk Drive Enclosure

NEW

Houses One Half-Height 3.5" Disk Drive

(Horizontal Mount) • Power: +12V @ 1.2A, +5V @ 1.0A • Textured beige paint • Slot for data cable • Complete with power supply, switch, power cord, fuse holder and connectors • Size: 5.87"W x 2.25"H x 11.5"D • Weight: 6 lbs.

DDE3HH. $59.95

5.25" Floppy Disk Drive Enclosure

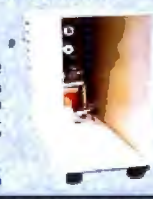
Houses One Full-Height 5.25" Disk Drive

(Horizontal Mount) • Power: +5V @ 1.0A, +12V @ 1.2A • Textured beige paint • Slot for data cable • Unit comes complete with power supply, switch, power cord, fuse holder and connectors • Size: 5.87"W x 3.25"H x 11.5"D • Weight: 6 lbs.

DDE1FH. $59.95

Dual 5.25" Floppy Disk Drive Enclosure

Houses Two Half-Height 5.25" Disk Drives



(Vertical Mount) • Power: 2 x +5V @ 1.0A*, 2 x +12V @ 1.2A* (*not simultaneously) • Textured beige paint • Data cable strain relief for operation safety • Complete with power supply, switch, power cord, fuse holder and connectors • Size: 3.5"W x 5.78"-6.19"H (slope) x 12.87" (bottom) – 13.13"D (top) • Weight: 6.5 lbs.

DDE2HH. $69.95

5.25" Floppy Disk Drive Enclosure

Houses One Half-Height 5.25" Disk Drive

(Horizontal Mount) • Power: +12V @ 1.2A, +5V @ 1.0A • Textured beige paint • Slot for data cable • Complete with power supply, switch, power cord, fuse holder and connectors • Size: 5.87"W x 2.25"H x 11.5"D • Weight: 6 lbs.

DDE1HH. $59.95

***CLOSE-OUT PRICING — PART NUMBER WILL BE DISCONTINUED WHEN STOCK IS DEPLETED!**

• Quality Components • Competitive Pricing • Prompt Delivery • (415) 592-8097

261

Seagate

HARD DISK DRIVES

Seagate

Seagate

20, 30, 40 and 60 Megabyte Half-Height Hard Disk Drives for the IBM PC/XT/AT and Compatible Computers

Seagate Hard Disk Drives provide the IBM PC/XT/AT or compatible computers with 20, 30, 40 or 60 Megabytes of formatted capacity in a shock resistant, half-height package. These drives are easily installed and ideal for applications ranging from rugged industrial use to quiet office and home environments. High reliability is assured through the use of LSI and a single circuit board. The drives may be purchased with or without controller cards. Controller cards are capable of controlling two hard drives. Cables provided for connecting one hard drive only. 90-Day Warranty. Documentation included.

ST225 (20 Megabyte): • Available for PC/XT or AT • Track to track access time: 20 msec. max. • Average access time: 65 msec. • Data transfer rate: 5.0 Megabits/sec. • Tracks: 2,460 • Bytes per track (formatted): 8,704 • Read/Write Heads: 4 • Cylinders: 615 • Size: 5.75"W x 8"D x 1.63"H • Weight: 5 lbs.

Part No.	Description	Price
ST225	20MB Hard Disk Drive Only for IBM PC/XT/AT and compatibles (MFM Controller needed)	$224.95
ST225XT	20MB Hard Disk Drive, MFM Controller and Cables for IBM PC/XT and compatibles	$269.95
ST225AT	20MB Hard Disk Drive, MFM Controller, Software and Cables for IBM AT and compatibles	$339.95

20 Mega-byte!

Seagate ST225XT 20MB Hard Disk Drive Kit

ST238 (30 Megabyte): • Available for PC/XT or AT • Track to track access time: 20 msec. max. • Average access time: 65 msec. • Data transfer rate: 7.5 Megabits/sec. • Tracks: 2,460 • Bytes per track (formatted): 13,312 • Read/Write Heads: 4 • Cylinders: 615 • Size: 5.75"W x 8"D x 1.63"H • Weight: 5 lbs.

Part No.	Description	Price
ST238	30MB Hard Disk Drive Only for IBM PC/XT/AT and compatibles (RLL Controller needed for operation)	$249.95
ST238XT	30MB Hard Disk Drive, RLL Controller and Cables for IBM PC/XT and compatibles	$299.95
ST238AT	30MB Hard Disk Drive, RLL Controller and Cables for IBM AT and compatibles	$389.95

30 Mega-byte!

Seagate ST238XT 30MB Hard Disk Drive Kit

ST251 (40 Megabyte): • Available for PC/XT or AT • Track to track access time: 8 msec. max. • Average access time: 40 msec. • Data transfer rate: 5.0 Megabits/sec. • Tracks: 4,920 • Bytes per track (formatted): 8,704 • Read/Write Heads: 6 • Cylinders: 820 • Size: 5.77"W x 8"D x 1.63"H • Weight: 5 lbs.

Part No.	Description	Price
ST251	40MB Hard Disk Drive and Software Only for IBM PC/XT/AT and compatibles (MFM controller needed)	$429.95
ST251XT	40MB Hard Disk Drive, MFM Controller and Cables for IBM PC/XT and compatibles	$469.95
ST251AT	40MB Hard Disk Drive, MFM Controller, Software and Cables for IBM AT and compatibles	$539.95
ST251-1	***NEW!*** *Fast 28ms 40MB Hard Disk Drive and Software Only for IBM PC/XT/AT and compatibles (MFM controller needed)*	$499.95

40 Mega-byte!

Seagate ST251AT 40MB Hard Disk Drive Kit

ST277 (60 Megabyte): • Available for PC/XT or AT • Track to track access time: 8 msec. max. • Average access time: 40msec. • Data transfer rate: 7.5 Megabits/sec. • Tracks: 4,920 • Bytes per track (formatted): 13,312 • Read/Write Heads: 6 • Cylinders: 820 • Size: 5.77"W x 8"D x 1.63"H • Weight: 5 lbs.

Part No.	Description	Price
ST277	60MB Hard Disk Drive & Software Only for IBM PC/XT/AT & compatibles (RLL Controller needed for operation)	$499.95
ST277XT	60MB Hard Disk Drive, RLL Controller and Cables for IBM PC/XT and compatibles	$549.95
ST277AT	60MB Hard Disk Drive, RLL Controller and Cables for IBM AT and compatibles	$639.95

60 Mega-byte!

Seagate ST277AT 60MB Hard Disk Drive Kit

See Next Page for Hard Disk Drive Controller Cards

262 ***For complete product line, request Jameco's new 74 page 1989 Catalog***

Jameco ELECTRONICS MULTIFUNCTION INPUT/OUTPUT CARDS

1-YEAR WARRANTY!

RS232 Half Card
for IBM PC/XT/AT and Compatible Computers


JE1061

• Fits the difficult to use half card slot or any long slot • RS232 card comes with one ready-to-go serial port • Expandable to 2 ports by user (parts for expansion not included – see below for 2nd Serial Port Kit) • Selectable for COM1 thru COM4 • The user is able to select addresses for ports A and B as well as interrupt requests • Manual included

JE1061 RS232 Card for XT. **$29.95**
JE1062 RS232 Card for AT. **$34.95**

Input/Output Cards
for IBM PC/XT/AT and Compatible Computers

Four Functions on One Card!


JE1060

The JE1060 and JE1065 Input/Output cards for the IBM PC/XT/AT feature the following: • Parallel printer port • RS232C serial communication port (expandable to two by user - see below for 2nd Serial Port Kit) • Selectable for COM1 thru COM4 • Ability to change interrupt requests on all ports • Game port • Cables and manual included • JE1060 (Only): Real-time clock/calendar with replaceable battery back-up and print spooler software included

JE1060 I/O Card for XT. **$59.95**
JE1065 I/O Card for AT. **$59.95**

Multifunction Card
for IBM PC/XT and Compatible Computers

Five Functions on One Card!

The JE1078 features: • Add up to 384K (zero-K on-board) using (54) 4164's • Parallel printer port • RAM disk and print spooler software • One RS232C serial communication port • Selectable for COM1 or COM2 • Game port • Real-time clock/calendar with replaceable battery back-up • 4.77MHz operation • Manual and cables included

JE1078. . . . . **$69.95**

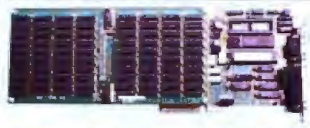
Multi I/O with Floppy Controller
for IBM PC/XT/AT and Compatible Computers


JE1079

The JE1077/1079 are multi I/O cards with up to 5 additional features • One RS232C serial communication port (expandable to two — see below for 2nd Serial Port Kit) • Selectable for COM1 thru COM4 • Game port • Real-time clock calendar (JE1079 only) • 3.5" 5.25" floppy disk drive controller capable of handling up to two 360K, 720K, 1.2MB or 1.44MB drives • Parallel printer port • Print spooler software • Manual and cables included

JE1079 Multi I/O and Controller for XT. **$79.95**
JE1077 Multi I/O and Controller for AT. **$79.95**

3Mbyte Memory Expansion and Multifunction Card
for IBM AT and Compatible Computers



The JE1082 is a 3MB Multifunction Memory Expansion card for the IBM AT and compatible computers. Expandable to 3MB (zero-K on-board) with (108) 41256-120 chips. Can be used as expanded (up to 2MB) or extended memory (up to 3MB). Also included is one Serial port (selectable for COM1 thru COM4) expandable to two (see right for 2nd Serial Port Kit), parallel port and game port. Piggyback board for expansion to 3MB. RAM Disk/Print Spooler Software and manual included.

JE1082. . . . . **$169.95**

Second Serial Port Kits
for JE1060, JE1061, JE1062, JE1065, JE1071, JE1077, JE1079 and JE1082

• Kits contain all components and instructions for adding a 2nd Serial Port to the above cards • The new SSP4 is a high-speed version for the JE1062, JE1065, JE1077 and JE1082 — *Some soldering required.*

SSP3 2nd Serial Port Kit for JE1060, JE1061, JE1071 & JE1079. . . . . **$9.95**
SSP4 Hi-Speed 2nd Serial Port Kit for JE1062, JE1065, JE1077 & JE1082 **$14.95**

Jameco ELECTRONICS HARD/FLOPPY CONTROLLER CARDS

NEW!

Hard Disk/Floppy Controller
for IBM PC/XT and Compatible Computers

NEW

The JE1044 is an 8-bit floppy and MFM hard disk controller for the IBM PC/XT and compatible computers. The JE1044 will allow connection of up to two hard disks and two floppy 360KB drives. Cables are included to allow connection of one hard disk and two floppy disk drives. To connect a second hard disk drive, an additional cable will be required.

JE1044. . . . . **$129.95**

Hard Disk/Floppy Controller
for IBM AT and Compatible Computers

The JE1045 is a 16-bit floppy and MFM hard disk controller for the IBM AT and compatible computers. The JE1045 will allow connection of up to two hard disk drives and any combination of two floppy disk drives (360KB, 720KB, 1.2MB and 1.44MB). Cables are included to allow connection of one hard disk and two floppy disk drives. To connect a second hard disk drive, an additional cable will be required.

JE1045. . . . . **$149.95**

RLL Hard Disk Controller Cards
for IBM PC/XT/AT and Compatible Computers


JE1047

The JE1042 is an 8-bit RLL hard disk controller card for the IBM PC/XT and compatible computers. The JE1042 should be used with hard disks designed for RLL formatting such as the Seagate 30MB ST238 and 60MB ST277. Cables and documentation included.

JE1042 RLL PC/XT Hard Disk Controller Card. **$99.95**

The JE1047 is a 16-bit RLL hard disk controller for the IBM AT and compatible computers. The JE1047 should be used with hard disks designed for RLL formatting such as the Seagate 30MB ST238 and 60MB ST277. Cables and documentation included.

JE1047 RLL AT Hard Disk Controller Card. **$189.95**

MFM Hard Disk Controller Cards
for IBM PC/XT/AT and Compatible Computers


JE1041

The JE1041 is an 8-bit MFM hard disk controller card for the IBM PC/XT and compatible computers. The JE1041 can be used with many types of hard disk drives including the Seagate 20MB ST225 and 40MB ST251/ST251-1. Cables and documentation included.

JE1041 MFM PC/XT Hard Disk Controller Card. **$79.95**

The JE1046 is a 16-bit MFM hard disk controller for the IBM AT and compatible computers. The JE1046 can be used with many hard disk drives including the Seagate 20MB ST225 and 40MB ST251/ST251-1. Cables and documentation included.

JE1046 MFM AT Hard Disk Controller Card. **$129.95**

• Quality Components • Competitive Pricing • Prompt Delivery • (415) 592-8097 263

LOGITECH MICE, MOUSE PAD AND SCANNER LOGITECH

Logitech M8 Mouse
for IBM PC/XT/AT and Compatible Computers

AD925 (not included)

The LOGITECH M8 mouse features opto-mechanical technology at a competitive price. This new two-button mouse requires one male DB25-pin serial port and comes with a female DB25 cable assembly. A DB25 to DB9 adapter (AD925, see below) may be needed if the serial port you plan to use has a male DB9 connector. The mouse comes standard with a six foot cord and features 200 dpi resolution. • Color: Light Gray • Size: 3.8"L x 2.7"W x 1.06"H • One-Year Warranty

Part No.	Description	1-9	10-99
M8	M8 Mouse with Driver Software.	$49.95	$44.95
AD925	DB25-pin male to DB9-pin female adapter for Serial applications.	$4.95	$3.95

Logitech HiREZ Bus Mouse
for IBM PC/XT/AT & PS/2 (Model 25, 30) and Compatible Computers

NEW

Lifetime Warranty!

The new LOGITECH High Resolution Mouse is the only mouse designed expressly for today's new generation of high resolution displays, such as EGA, super EGA and VGA. The mouse is ideal for desktop publishing as well as CAD applications. With 320 dots per inch (dpi) resolution (compared with 100 or 200 dpi mice), the LOGITECH HiREZ covers the same area on your screen, but uses 62% less desk space to do it. This saves 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. Includes Plus Package software with mouse drivers, text editor, menu building and point-click software (Lotus 1-2-3) • Size: 3.8"L x 2.7"W x 1.06"H • Color: Light Gray • Lifetime Warranty

Part No.	Description	1-9	10-99
HIREZ	High Resolution Mouse, Bus Board and Plus Package Software.	$99.95	$94.95

Logitech Desktop Publishing Mouse and Software
for IBM PC/XT/AT & PS/2 (Model 30) and Compatible Computers

This sophisticated yet easy to use desktop publishing package includes the Logitech Serial (C7PLUS mouse — right) or BUS Mouse (right), PLUS Package Software and Publisher desktop publishing software. The package is the complete solution for people who want to produce great looking, attention-getting documents without having to master a lot of complex commands and typographical jargon. It's easy to learn, fast to use, and it gets you the results you need right now. • Lifetime Warranty: C7PLUS and BUS Mouse only

Page Layout Made Easy . . . You don't have to be a graphic designer to get professional-quality results. Create and edit text right on the page. The package offers design templates, automatic layout in 1-4 columns, automatic flow of text around graphics, and vertical and horizontal rulers to guide you.

Typography Made Easy . . . Select from over 61 fonts representing 14 typefaces, in sizes suitable for headlines, subheads and text.

Graphics Made Easy . . . using our ClipArt. You can shrink or expand your graphic images, modify, rotate or copy them to fit the area you desire.

LPP7	C7PLUS Mouse & Publisher Package Software. . . .	$129.95
LPBUS	BUS Mouse and Publisher Package Software.	$129.95

Logitech Serial and Bus Mouse
for IBM PC/XT/AT & PS/2 (Model 25, 30) and Compatible Computers

PC MAGAZINE EDITORS' CHOICE

BUS

PC/XT/AT & PS/2 (Model 25, 30) Compatible!

The LOGIMOUSE C7 features opto-mechanical technology, programmable baud rate up to 9600 baud, and excellent tracking. LOGIMOUSE is fully compatible with all mouse-based application programs (e.g. AutoCad, MS Windows, etc.). Logitech PLUS package software features drivers, LOGIMENU (Programmable Pop-up Menu System), CLICK (sets mouse to predefined settings), POINT-AND-CLICK SHELL (for Lotus 1-2-3), and POINT EDITOR (Mouse Based Program Editor). The C7PLUS requires one serial port. • Size: 3.8"L x 2.7"W x 1.06"H • Color: Light gray • Lifetime Warranty

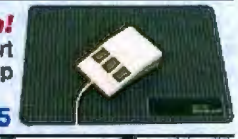
Part No.	Description	1-9	10-99
C7PLUS	C7 Mouse and Logitech PLUS Package Software.	$79.95	$74.95

BUS MOUSE frees your serial port. The Bus Board installs easily in a half slot in your computer and leaves your system's serial port free for other peripherals.

Part No.	Description	1-9	10-99
BUS	Logitech Mouse, Bus Board and Logitech PLUS Package Software.	$79.95	$74.95

NEW! Mouse Pad

Prevents Dirt Contamination!



Cleans, protects and prevents wear on your mouse's roller ball. Sensitive, accurate and prevents dirt contamination. Tough non-skid neoprene backing with smooth gliding anti-static plastic coating on top surface. Size: 11"L x 8.5"W

MP Mouse Pad. $5.95

Logitech ScanMan Hand-Held Scanner
for IBM PC/XT/AT & PS/2 and Compatible Computers

NEW

The Logitech ScanMan Portable Scanner makes adding graphic images to computer documents affordable!

The ScanMan offers the largest handheld scanning window available — a full four inches at 200 dpi resolution (most scanners only offer 2.5 inches). Graphics are scanned directly to the powerful ScanWare™ Graphics editor where a full range of paint utilities and tools are available for editing the scanned image.

ScanMan combines power and flexibility in one neat package. Scan directly to the powerful graphics editor, directly to a file, or to an MS Windows™ clipboard using the Logitech WinScan™ utility.

You can scan photographs, newspaper and magazine articles, books, drawings, logos and business cards. Scanned images may be stored and used in many of the most popular applications, including: LOGITECH Publisher, Aldus PageMaker™, Ventura Publisher™, PFS: First Publisher™, ZSoft PC Paintbrush™ and many, many more. Includes driver controller card and cable. • Size: 5.25"W x 3.5"D x 1.25"H • Color: Light Gray • One-Year Warranty

SCAN ScanMan Hand-Held Scanner, Software and Driver Board. $199.95

264 ***For complete product line, request Jameco's new 74 page 1989 Catalog***

NEW! **MODEMS** SALE!

DATATRONICS 2400/1200/300 Baud Internal Modems
for IBM PC/XT/AT and Compatible Computers


1200H

Internal Card Frees Your Serial Port! • Hayes command compatible • Bell 103/212A compatible • Auto-dial and auto-answer • Tone or pulse dialing capability • Call progress detection • Easy access DIP switch • Supports COM1, COM2, COM3 and COM4 • Two modular phone jacks • Built-in speaker with adjustable volume control • FCC approved • Includes MaxiMite communication software by Mycroft Labs • One-year warranty

Includes MaxiMite Software!

1200H	1200/300 Baud Internal Modem (½ Card)	$69.95
2400S	2400/1200/300 Baud Internal Modem (¾ Card)	~~$139.95~~ $129.95

DATATRONICS 1200/300 Baud Pocket Modem for IBM PC/XT/AT and Compatible Computers

Also compatible with other computer systems that have an RS232 port.

This shirt pocket-sized, lightweight miniature modem is perfect for the computer user on the move. Features the following: • Hayes command compatible • Bell 103/212A compatible • LED status lights for: Battery, High Speed and Carrier Detect • Auto-dial and auto-answer • Tone, pulse or adaptive dialing • Call progress detection • On-board speaker • Two modular telephone jacks • Uses standard 9VDC battery or 9VDC transformer (not included) for power • Includes: 9V battery, carrying case, telephone connector cable and manual • Size: 4"L x 2.375"W x .875"H • Weight: 0.25 lb. • One-year warranty

1200P 1200/300 Baud Pocket Modem. . . . ~~$109.95~~ **$99.95**

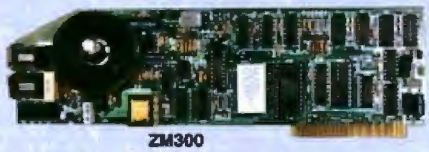
DATATRONICS 2400/1200/300 Baud External Modems for IBM PC/XT/AT & Compatible Computers


2400E

Also compatible with other computer systems which have an RS232 port • Hayes command compatible • Bell 103/212A compatible • Auto-dial and auto-answer • Tone, pulse or adaptive dialing capability • Call progress detection • Two modular phone jacks • Built-in speaker with adjustable volume control • FCC approved • Includes MaxiMite communication software • Size: 5.75"W x 10"D x 1.6"H • Weight: 3.25 lbs. • One-year warranty

Part No.	Description	Price
1200C	1200/300 Baud External Modem.	~~$119.95~~ **$ 99.95**
2400E	2400/1200/300 Baud External Modem . . .	~~$179.95~~ **$169.95**

ZOOM 300 Baud Modems
for Apple II, II+ and *IIe*


ZM300

Two versions available: (NM300) Manual dial, manual answer or (ZM300) Auto-dial, auto-answer • Hayes compatible • Includes call progress monitor, speaker, Zoom Communications Software and manual • Made in the USA • Two year warranty • Also available is the NMS software enhancement for the NM300 and ZM300 which allows Xmodem file transfer, storage, editing and printing of files

Part No.	Description	Price
NM300	300 Baud Manual Dial/Answer Modem (II, II+ and *IIe*)	~~$29.95~~ $19.95
ZM300	300 Baud Auto Dial/Answer Modem (II, II+ and *IIe*).	$49.95
NMS	Software Enhancement for NM300 and ZM300.	$19.95

APROTEK 1200/300 Baud External Modem
for Commodore C-64 and C-128

Hayes and Commodore 1670 Compatible!

• Plugs directly into the Commodore user port • Runs at either 1200 or 300 baud • Full Hayes compatibility including terminal emulation and file transfer • Auto-dial and auto-answer • Touch tone or rotary dialing capabilities • Seven LED status indicators for send data, off hook, 1200 baud, carrier detect, receive data, auto answer and ready • FCC approved • Includes Multiterm communication software for Commodore 64 and 128 • Size: 4.75"L x 2.75"W x .7"H • Weight: 0.25 lb. • 1-year warranty

MMC 1200/300 Baud External Modem (C64/128). **$79.95**

Jameco ELECTRONICS COMPUTER POWER PROTECTION


JE1191

Jameco Power Base with 6 Control Switches and 6-Outlet Power Strip

The JE1190 Power Base utilizes solid state line conditioning circuitry and fully shielded sockets to protect your computer from harmful power surges and EMI noise. Each device within your computer system can be turned on or off by individual illuminated rocker switches or the entire system can be turned on by the master switch. The Power Base eliminates the maze of power cords normally found behind most computer systems. • **JE1190 Specifications:** • 5 outlets • 15A, 125VAC, 1875 Watts, 60Hz • Max. spike: 80 joules one time • Energy dissipation: 25 joules repeated, self-restoring • Max. spike volts: 6,000V • Max. spike current: 4,500A • Clamp volts: 175V • Clamping response time: 10ns • Color: Beige • Size: 12"W x 12.75"D x 2.25"H • Weight: 5.25 lbs.


JE1190

The JE1191 Power Strip with built-in circuit breaker gives you continuous spike protection. **JE1191 Specifications:** • Master switch with pilot light • Built-in safety circuit breaker (15 amp) • UL listed • Durable enamel finished housing • Three-prong, 6-foot power cord • Color: Beige • Size: 12"L x 2.25"W x 1.5"H • Weight: 2 lbs.

Part No.	Description	Price
JE1190	Power Base with 6 Control Switches and Surge Protection.	$29.95
JE1191	Power Strip with 6 Outlets and Circuit Breaker.	$11.95

See opposite page for tilt/swivel Monitor Base with Power Center

NEW! TrippLite Isobar Command Console Plus

Lifetime Warranty!

Complete Isobar protection with fingertip control for all your systems' components plus new Modem and FAX protection outlets

• Each outlet offers Isobar surge suppression and filter isolation • Mounts conveniently between your CPU and CRT • Command console provides one main on/off switch and five individual component switches • 6 outlets total • Two New RJ11 receptacles for modem/FAX/telephone line spike protection • Built-in static guard • 15 amps on one receptacle • Color: Beige • Size: 12.5"L x 13.5"W x 2"H • Weight: 8 lbs.

CCI6P Command Console Plus with Modem and FAX Protection. **$99.95**

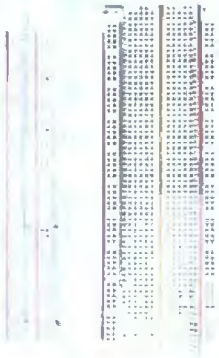
• Quality Components • Competitive Pricing • Prompt Delivery • (415) 592-8097

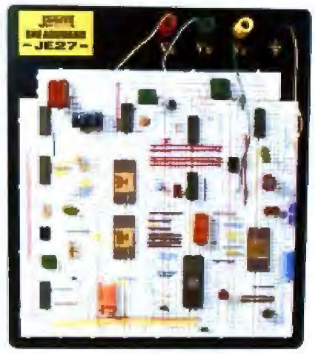
265

Jameco ELECTRONICS SOLDERLESS BREADBOARDS & ACCESSORIES

- Low static, plastic body — CMOS safe
- Nickel plated clips designed to withstand up to 5,000 insertion cycles
- Breadboard strips easily connect together to form larger working areas
- Screen printed color coordinates make circuit design easier
- Larger models come with heavy duty aluminum backing and grounding posts for long life and durability
- Components are easily interconnected using 20-29 AWG wire (see JE10 and JE11, below)
- The JE31 offers all the advantages of the JE26 plus a wire jumper kit containing 140 assorted wire jumpers

Breadboarding Versatility!

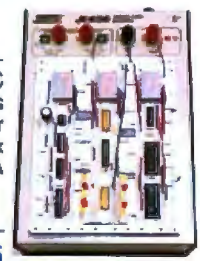




JE20 JE23 JE24 JE27 JE31

Part No.	Terminal Strips	Bus Strips	Contact Points	Binding Posts	Jumper Wires	Component Case	Size L x W (Inches)	1-9	10-99
JE20	0	2	200	0	0	0	6½ x ¾	$ 2.95	$ 2.49
JE21	1	2	400	0	0	0	3¼ x 2⅛	$ 4.95	$ 4.49
JE22	1	0	630	0	0	0	6½ x 1⅜	$ 5.95	$ 4.95
JE23	1	2	830	0	0	0	6½ x 2⅛	$ 7.95	$ 6.95
JE24	2	1	1,360	2	0	0	6½ x 3⅛	$14.95	$12.95
JE25	2	4	1,660	3	0	0	6½ x 4¼	$22.95	$19.95
JE26	3	5	2,390	4	0	0	6⅞ x 5¾	$27.95	$24.95
JE27	4	7	3,220	4	0	0	7¼ x 7½	$37.95	$34.95
JE31	3	5	2,390	4	140	Stores Wire Jumpers	6⅞ x 5¾	$31.95	$28.95

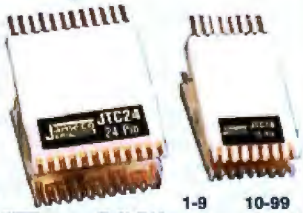
Jameco ELECTRONICS JE450 Solderless Prototype Builder



The JE450 Solderless Prototype Builder provides the user with a quick and efficient system for breadboarding electronic circuits without soldering. Configured with 3 power supplies, the JE450 is ideal for IC breadboarding of TTLs, CMOS, ECLs, microprocessors and op-amp circuits. Components and wire leads can be quickly inserted, removed and changed without the need for soldering or desoldering. The 3 power supplies incorporated in the JE450 provide the user unlimited use in prototyping circuits. • Size: 9¾"L x 6¾"W x 3¼"H • Weight: 6 lbs. • Power supplies, regulated: 5V @ 1A, +5V to +15V @ .5A, −5V to −15V @ .5A • Power: 120VAC, 60Hz fused • For recommended wire jumpers see JE10 and JE11, below

	1-9	10-99
JE450 Solderless Prototype Builder.	$119.95	$109.95

Jameco ELECTRONICS IC Test Clips



Jameco's IC Test Clips are designed to facilitate temporary connections to DIP package components. A heavy-duty spring-loaded hinge provides positive contact even after thousands of uses.

Part No.	Description	1-9	10-99
JTC16	16-pin (used for 8, 14 and 16-pin IC's). . . .	$4.49	$3.95
JTC20	20-pin (used for 18 and 20-pin IC's).	$5.95	$5.49
JTC24	24-pin.	$6.95	$5.95
JTC28	28-pin.	$7.95	$6.95
JTC40	40-pin (used for 36 and 40-pin IC's).	$9.95	$8.95

Jameco ELECTRONICS Wire Jumpers

• The JE10 Wire Jumper Kit comes with 350 assorted lengths and colors of pre-stripped and pre-formed 22AWG solid wire jumpers all in a handy, durable plastic case. The kit includes 25 each of the following lengths: .1", .2", .3", .4", .5", .6", .7", .8", .9", 1.0", 2.0", 3.0", 4.0" and 5.0" • The JE11 contains all of the same wire jumpers included in the JE10 and makes a convenient refill package.

Part No.	Description	1-9	10-99
JE10	Wire Jumper Kit 350 ea. (includes case).	$7.95	$7.49
JE11	Same as JE10 except case not included.	$6.95	$5.95

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Kingdom MULTIMETERS METEX

Kingdom Handheld Analog Multimeters Kingdom

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• Mirrored Scale for Accuracy • Audible Continuity Test • Fuse/Diode Overload Protection

Both units come complete with probes, batteries and manual. Size: 6"H x 4.125"W x 1.75"D

ET207 Specifications: • AC Voltage: 10-1000VAC • DC Voltage: 0.25-1000VDC • DC Current: 50μA-10A • Resistance: 1Ω to 10MΩ • Decibels: −10 to +62dB at ACV ranges • Accuracy: ±3 to ±4% on all ranges • Sensitivity: 9KΩ/VAC, 20KΩ/VDC • Audible continuity test • Battery Tester

***ET207** 20KΩ/Volt Analog Multimeter w/DC Current Measurement and Battery Tester . . . **$15.95**

ET302 Specifications: • AC Voltage: 2.5-1000VAC • DC Voltage: 0.25-1000VDC • AC Current: 12A • DC Current: 50μA-12A • Resistance: 1Ω to 5MΩ • Decibels: −20 to +64dB at ACV ranges • Accuracy: ±3 to ±4% on all ranges • Sensitivity: 10KΩ/VAC, 30KΩ/VDC • Audible continuity test

***ET302** 30KΩ/Volt Analog Multimeter with AC and DC Current Measurement. **$22.95**

ET302

METEX Handheld Digital Multimeter METEX

The Economical Choice for a High Quality, High Accuracy Digital Multimeter

• 3.5 Digit (.5" High) LCD Readout • Audible Continuity Test • 1-Year Warranty

RANGE	ACCURACY	RESOLUTION
AC VOLTAGE		
200mV	±1.2% of reading	100μV
2V	±0.8% of reading	1mV
20V		10mV
200V		100mV
700V	±1.2% of reading	1V
DC VOLTAGE		
200mV	±0.5% of reading	100μV
2V		1mV
20V		10mV
200V		100mV
1000V		1V

RANGE	ACCURACY	RESOLUTION
AC CURRENT		
20μA	±1.0% of reading	10nA
200μA		100nA
2mA		1μA
20mA		10μA
200mA	±1.8% of reading	100μA
2A		1mA
20A	±3.0% of reading	10mA
DC CURRENT		
20μA	±0.5% of reading	10nA
200μA		100nA
2mA		1μA
20mA		10μA
200mA	±1.2% of reading	100μA
2A		1mA
20A	±2.0% of reading	10mA

NEW

RANGE	ACCURACY	RESOLUTION
RESISTANCE		
200Ω	±0.5% of reading	0.1Ω
2KΩ	±0.5% of reading	1Ω
20KΩ		10Ω
200KΩ		100Ω
2MΩ		1KΩ
20MΩ	±1.0% of reading	10KΩ

Unit comes complete with probes, batteries, carrying case and manual. Size: 6.75"H x 3.5"W x 1.25"D

Measures: AC/DC Voltage, AC/DC Current, Resistance, Diodes, Transistor hFE, Audible Continuity Test • Auto Zeroing • Input Impedance: 10MΩ • Overload Protection: 1000VAC/VDC • One-Year Warranty

M3800 3.5 Digit Multimeter. **$39.95**

METEX Handheld Digital Multimeters METEX

• Jumbo 3.5 and 4.5 Digit (.7" High) LCD • Audible Continuity Test • Overload Protection • 1 Year Warranty • Ruggedized Case

AC Voltage (for M3610, M3650 and M4650)

Range	ACCURACY		RESOLUTION	
	M3610/M3650	M4650	M3610/M3650	M4650
200mV	±1.2% of reading	±0.5% of reading	100μV	10μV
2V	±0.8% of reading		1mV	100μV
20V			10mV	1mV
200V			100mV	10mV
750V	±1.2% of reading	±0.8% of reading	1V	100mV

Resistance (for M3610, M3650 and M4650)

Range	ACCURACY		RESOLUTION	
	M3610/M3650	M4650	M3610/M3650	M4650
200Ω	±0.5% of reading	±0.2% of reading	0.1Ω	.01Ω
2KΩ	±0.8% of reading	±0.15% of reading	1Ω	0.1Ω
20KΩ			10Ω	1Ω
200KΩ			100Ω	10Ω
2MΩ			1KΩ	100Ω
20MΩ	±1% of reading	±0.5% of reading	10KΩ	1KΩ

DC Voltage (for M3610, M3650 and M4650)

Range	ACCURACY		RESOLUTION	
	M3610/M3650	M4650	M3610/M3650	M4650
200mV	±0.3% of reading	±.05% of reading	100μV	10μV
2V			1mV	100μV
20V			10mV	1mV
200V			100mV	10mV
1000V	±0.3% of reading	±0.1% of reading	1V	100mV

Capacitance (for M3650 and M4650 only)

Range	ACCURACY	RESOLUTION	
	M3650/M4650	M3650	M4650
2000pf	±2% of reading	1pf	0.1pf
200nf		100pf	10pf
20μf	±3% of reading	10nf	1nf

Frequency (for M3650 and M4650 only)

Range	ACCURACY	RESOLUTION	
	M3650/M4650	M3650	M4650
20KHz	±2% of reading	10Hz	1Hz
200KHz		100Hz	10Hz

M3610

M4650

All units come complete with probes, batteries, carrying case & manual. Size: 7"H x 3.5"W x 1.5"D

M3610: • Measures: AC/DC Voltage, AC Current (200μA to 20A), DC Current (200μA to 20A), Resistance, Diodes, Transistor hFE, Audible Continuity Test • Auto-Zeroing • Input Impedance: 10MΩ • Overload Protection: 1000VAC/VDC

M3610 3.5 Digit Multimeter. **$49.95**

M3650: • Measures: AC/DC Voltage, AC Curr. (2mA to 20A), DC Curr. (200μA to 20A), Resistance, Diodes, Transistor hFE, Audible Continuity Test, Freq. & Capacitance • Auto-Zeroing • Input Imped.: 10MΩ • Overload Protection: 1000VAC/VDC

M3650 3.5 Digit Multimeter with Frequency and Capacitance Measurement. **$69.95**

M4650: • Measures: AC/DC Voltage, AC Current (2mA to 20A), DC Current (200μA to 20A), Resistance, Diodes, Transistor hFE, Audible Continuity Test, Frequency and Capacitance • Auto-Zeroing • Data Hold Switch • Input Impedance: 10MΩ • Overload Protection: 1000VAC/VDC

M4650 4.5 Digit Multimeter with Freq./Cap. Measurement and Data Hold Switch. **$99.95**

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JE680 UNIVERSAL IC PROGRAMMER

Programs 16K to 512K EPROMs, EEPROMs and PROMs, PALs, GALs, EPLs and PLDs

One-Year Warranty!

JE680 Features:

- Universal IC Programmer: memory *and* logic devices
- Stand-alone or computer-controlled modes
- Parallel printer port and RS232C port
- Automatic self-test on power up
- Auto-Sense
- Pin Check
- Split/Shuffle
- Full functional test on logic devices
- Patented design for programming reliability
- No personality modules needed
- Variable baud rates — up to 9600bps

JE680 Universal IC Programmer

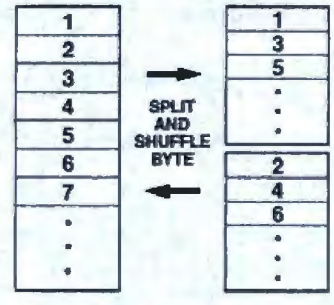
NEW!

JE680 Description of Operations:

The new JE680 Universal IC Programmer supports and programs virtually all devices from 16K to 512K and with up to 28 pins. The JE680 will program memory-type ICs such as MOS and CMOS EPROMs, EEPROMs and PROMs as well as logic-type ICs such as PALs, GALs, RALs, PLDs, EPLDs, EEPLDs and FLPDs. The JE680 programming algorithms meet all manufacturers' specifications and support STANDARD, INTELLIGENT and QUICK PULSE methods.

The JE680 supports 18 data formats, such as JEDEC, INTEL HEX, ASCII HEX, Motorola S and Binary. It is compatible with virtually all software package programs including: PALASM, PLAN, CUPL, ABEL, AMAZE and SGAPL. The RAM buffer EDIT function allows you to LIST, SET, INSERT, MOVE, DELETE and SWAP data.

SPLIT BYTE EXAMPLE



Incorporated with the JE680 is a full array of TEST functions including Automatic Self-Test, Insertion and Backward-Device Check. The Auto-Sense allows the user to insert and remove ICs sequentially to automatically repeat an operation; no other action is required. The Pin Check examines individual pin continuity using pulse-reflection techniques; displays bad pin numbers. The Split/Shuffle function allows you to split your data up into even (high) and odd (low) bytes (8-bit), words (16-bit) or long words (32-bit). The Shuffle function allows you to reverse the procedure (see diagram, right). After programming your logic device, a full functional test ensures that your device has been programmed in accordance with your design. In addition to the loop test, the JE680 will perform consecutive test cycles to simulate worst-possible conditions so as to weed out logic devices with intermittent or other performance problems.

While the JE680 can be operated as a stand-alone unit, it can also be linked to an IBM PC/XT/AT or other compatible computer or to a data terminal. The user may output fuse-pattern and vector-table data or memory data to a printer. Specifications: • Input: 115VAC, 60Hz • Size: 15.6"L x 12"D x 3.7"H • Weight: 12.8 lbs. • One-Year Warranty

Part No.	Description	Price
JE680	Universal IC Programmer (Includes MS-DOS Menu-Driven Software, DB25 male to female cable and Centronics 36-pin male to female printer cable)	**$1799.95**
JE680AP	Software option package for logic design applications (assembler package) — provides Boolean conversion, auto compiling and fuse map generation.	**$29.95**

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2						
3						
4						
5						
6						
7						
8						
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Parallel Processing

Parallel processing could be described as the ultimate in teamwork. In fact, the kind of teamwork involved is not unlike that found in the football stadium on an autumn Sunday afternoon. The quarterback has his job to do, the center has his, the ends and backs have theirs, and the guards and tackles have theirs. All these jobs are under way at the same time, but they're all different and being done by a different player—parallel processing.

Similarly, when a group of people are raking leaves, different people are doing the same job, at the same time, with the result of significantly cutting down on the time required—also parallel processing. Not all jobs, however, can be done in parallel. That Thanksgiving turkey we look forward to at the end of the month can't be rushed—microwaves aside.

The same basic concepts apply in computing. Multiple processors operating in parallel can perform many, but not all, jobs faster than uniprocessors. A logically sequential program must still run sequentially. However, a modular program, or one that can be made modular, can run different sections on different processors and improve its speed.

Last summer, NASA's Jet Propulsion Laboratory introduced the Mark 3 Hypercube parallel supercomputer. Parallel processing has long been the exclusive realm of very large systems; however, it is now becoming available at the microcomputer level. For example, Zenith has announced the Z-1000 with its parallel 80386s (see Microbytes on page 11), and Cogent has come out with the XTM (see the text box "The Crossbar Connection" on page 278).

This month, we look at the world of parallel processing from the microcomputer view. In "Side by Side," Klaus K. Obermeier looks at the field as a whole: the appropriate algorithms and applications; the programming languages, including old favorites and new ones with special parallel-processing functionality; and the hardware and operating-system architectures involved.

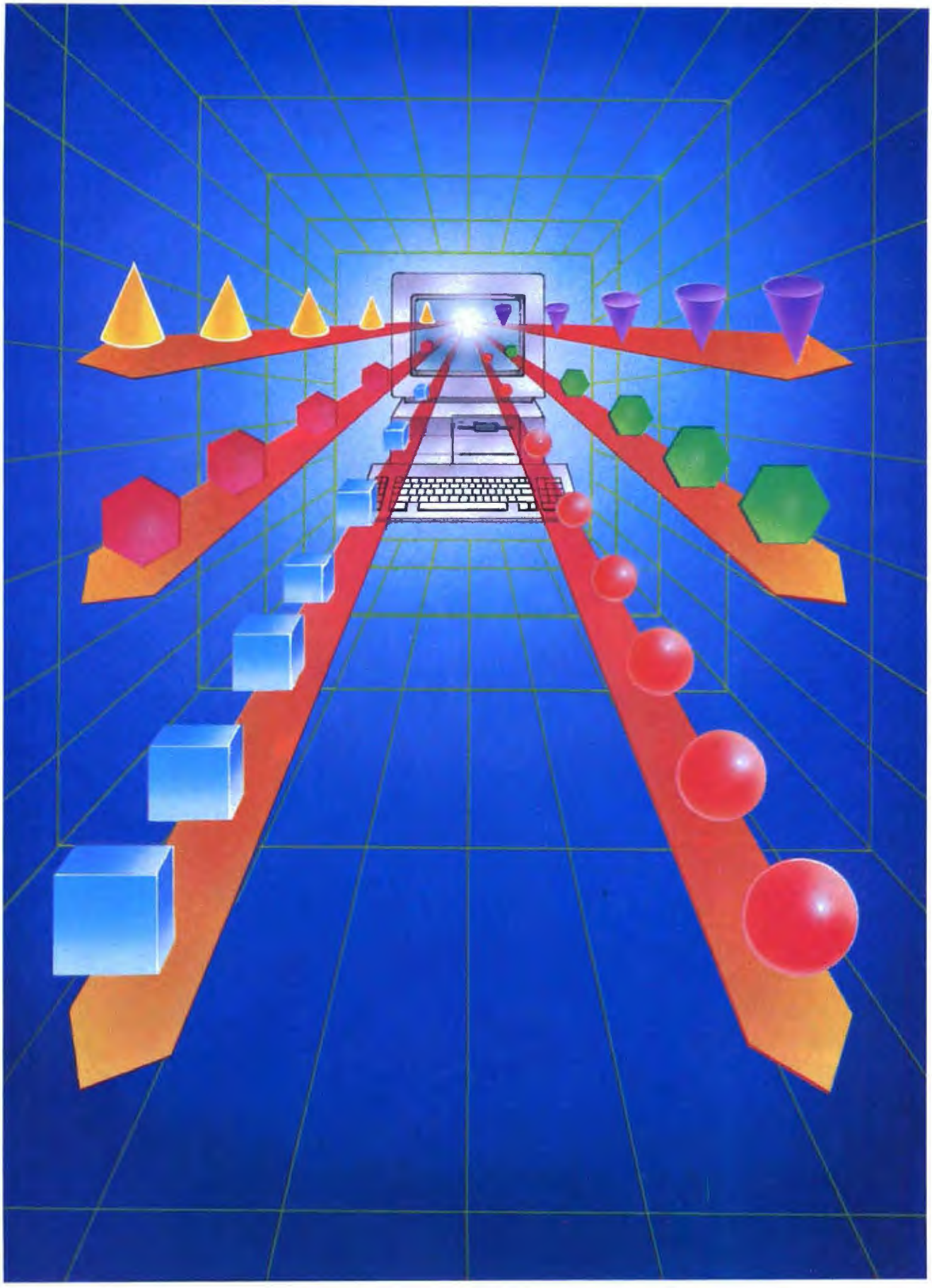
One particularly applicable piece of hardware is the transputer board. In "T800 and Counting," Richard M. Stein looks at the T800 transputer board from INMOS, discussing both the hardware aspects of the transputer and the related software aspects of the occam language—the two were designed to work together.

Another language designed for parallel processing on the transputer is Yale University's Linda. In "Getting the Job Done," David Gelernter, one of the language's designers, gives us the inside scoop on the current state of Linda, what it does, how it does it, and its specifically parallel features.

Finally, we have an article on a different way of making computers. In "The Third Dimension," Michael J. Little and Jan Grinberg describe the inner workings of Hughes Research Lab's 3-D Computer. It's an innately parallel computer built not of chips but of *wafers—stacks* of wafers. It's a fascinating technology.

While the concept and practice of parallel processing have a history in the large-computer arena, the idea of putting parallel-processing power on a desktop is still very new. The Mark 3 Hypercube is intended for simulations for the Strategic Defense Initiative. Can *that* kind of power really exist on a desktop?

—Jane Morrill Tazelaar
Senior Technical Editor, In Depth



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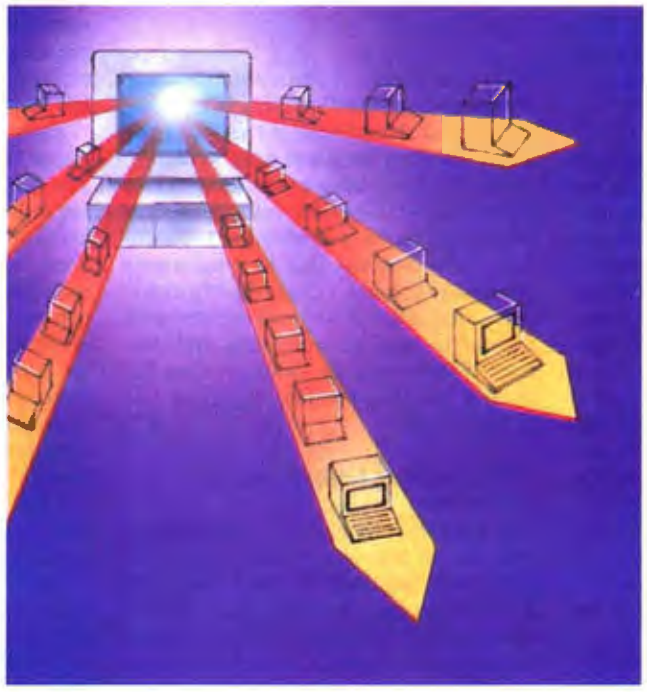
Side by Side

You can only simulate true parallelism on your personal computer today, but tomorrow will be another story

Klaus K. Obermeier

A parallel-processing computer, simply defined, is one that can perform operations using more than one processor simultaneously. You can generally divide parallel processing into three major areas of research: algorithms and applications; programming languages; and architecture, including hardware and operating systems.



Where to Start

The conventional serial computer suffers from one serious drawback: the way the CPU accesses memory. While data is being retrieved from memory, it is actually written into a processor register, and after the register is incremented, the new value is put back into memory. During this period, the CPU remains idle. This phenomenon, known as the von Neumann bottleneck, accounts for the sometimes slow and inefficient use of conventional serial-processor resources.

But parallel processing has been around longer than the von Neumann bottleneck. As early as 1840, Charles Babbage conceived of a way to perform multiplication and indexing arithmetic simultaneously. The first operating parallel processor was the ILLIAC IV. This machine, developed by Dan Slotnick in 1966 at the University of Illinois, featured 64 processors.

Although the first commercial parallel-processing system flopped—the $7 million Heterogeneous Element Processor, developed in 1985 by Denelcor—by 1986 more than a dozen companies were either selling or in the process of building parallel processors, including Bolt Beranek and Newman, Cray Research, DEC, IBM, Intel, Alliant, Encore, and Thinking Machines.

Today, parallel-processing systems, such as the Connection Machine from Thinking Machines, can execute a few billion operations per second using up to 65,536 processors simultaneously. Searching a database of over 30,000 documents (18 megabytes) on a 16,384-element Connection Machine takes about 0.004 seconds for a Boolean query with 25 terms. Dow Jones recently purchased two 32,000-processor, 256-megabyte Connection Machines for use with its information-retrieval services.

The Parallel Approach

The central problem parallel-processing systems face is how to effectively and efficiently use more than one processor at the same time. A system's effectiveness depends on whether you can identify a problem that lends itself to parallelism, determine the algorithm, and map it onto a suitable architecture.

As you can imagine, problems arise if more than one processor requires access

continued

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to the same memory location or if more than one processor tries to increment data in the same memory location. Therefore, the common argument that more processors are always faster than one holds true for systems that can cope with problems such as contention and have appropriate synchronization mechanisms in place.

Another factor that can prevent successful use of parallelism is the bottom-up approach parallel-processing-system architects often take to hardware design. Simply put, they sometimes don't consider the needs of the application designer when they configure the hardware. People who write parallel applications should always keep in mind the target architecture so they can be sure their application-design algorithm will be suitable (e.g., whether they will use message passing or shared memory).

The use of parallelizing compilers is no answer to this problem. Parallelizing compilers are most suitable when past investment does not warrant rewriting the existing software. The programmer has to consider the problem from two sometimes opposing points of view: top-down for the design of the algorithm and bottom-up for the actual implementation.

Algorithms and Applications

Parallel processing's most common applications are simulation, modeling, and optimization programs for commercial use. Airline scheduling is among the potential applications—calculating seat assignments and about 200,000 to 250,000 necessary changes in routing daily takes United Airlines' current aircraft assignment model 15 hours of CPU time. If you were a programmer faced with such a task, you would first break down the task into sizable chunks that could be processed in parallel and then worry about synchronization between the processors. Unfortunately, your creativity for designing a solution would be hampered by the existing operating system and the idiosyncratic architecture of the target hardware.

What you should first do in such a situation is decide the necessary *granularity* of the application. Granularity refers to the amount of time being spent on communicating versus computing in a parallel program. In a coarse-grained application, the parallel-processing system consists of large independent chunks with little time—on the order of hundreds of communications per second between processors—spent on communicating between the individual processors. In a fine-grained application, more time—millions of communications per second—is spent on communicating and synchronizing between the processors. In any case, you have to leverage your solution with the encountered architecture. In the example of the aircraft assignment task, a processor may be assigned to one flight in a fine-grained system and to an entire aircraft in a coarse-grained system.

Once you determine the application's granularity, consider what form the communication between processors should take, via shared memory or message passing in distributed systems. While processors in a shared-memory system communicate via a common data structure, message passing takes place between two processors. Ultimately, atomic operations (e.g., locks, semaphores, and monitors) take over the task to synchronize processors properly. Once the algorithm is in place, it has to be synchronized with a specific parallel-processing architecture. What role do the programming languages play in matching algorithms to architectures?

People who write parallel applications should always keep in mind the target architecture.

Programming Languages vs. Compilers

For parallel processing, programmers can choose between parallelizing compilers and genuinely parallel programming languages. Parallelizing compilers are often used because of the high investment in existing application software or in bringing the programmers up to speed. As with digitizing old recordings, parallelizing serial algorithms doesn't work as well as algorithms genuinely conceived for parallel implementations. And as for the alleged complexity of writing programs in parallel, according to Chuck Seitz, chief designer of Cal-Tech's Cosmic Cube, the precursor to Hypercube, all other things being equal, "Programming experimental computers like the Cosmic Cube is not much harder than programming sequential computers, if the problem lends itself to a concurrent solution."

According to David Gelernter of Yale University, parallel-programming languages can be classified into three categories: Algol-based languages (e.g., Ada, Linda); parallel Lisps and logic languages (e.g., Multilisp, Concurrent Prolog); and parallel functional languages (e.g., Parafl).

Algol-based languages span the spectrum from Ada, originally designed for systems that execute sequentially, to Linda, especially conceived for parallel processing. Whereas Ada includes tools to support parallel processing, a parallel program written in Linda is, according to an article by S. Ahuja, a "spatially and temporally unordered bag of processes, not a process graph."

The Linda system consists of operators that can turn any host language (e.g., FORTRAN or C) into a parallel-programming language. However, it is an autonomous language consisting of a run-time kernel for synchronization and a compiler. Furthermore, it allows for parallelism both in the form of partitioning simultaneous processes and in replicating identical ones. (See "Getting the Job Done" on page 301.)

Parallel Lisps focus on symbolic rather than numeric parallel processing. The difference between the two, according to Robert Halstead, is that "numerical programs may be described as delivering numbers to an arithmetic unit to calculate a result," whereas "symbolic computation emphasizes rearrangement of data." Consequently, parallel Lisps are prime candidates for artificial-intelligence applications with an emphasis on operations such as recursion on trees and lists, rather than iterations in the form of loops for numerical computations.

Parallel functional programming includes a methodology that allows mapping programs to parallel-processing topologies. According to Paul Hudak, the most important aspect of this methodology is that "it treats the multiprocessor as a single autonomous computer onto which a program is mapped, rather than as a group of independent processors that carry out complex communications and require complex synchronization." Rather than having side effects from assignment statements, functional languages guarantee that a program will have the same result regardless of the order in which it has been executed. Therefore, in functional languages the parallelism is implicit and supported by

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The Crossbar Connection

Frank Hayes

Two processors should be twice as fast as one, and a thousand processors should be a thousand times as fast—at least in theory. But that depends on getting those thousand processors talking to each other, and that's not an easy task. In a fully connected network, interconnecting only 30 processors requires 435 separate connections; 1000 processors would require 499,500 connections.

A fixed network structure (such as a Hypercube) avoids that problem by connecting each processor to only a few neighbors, but then data must be passed from processor to processor through the network for distant processors to communicate. Alternatively, all the processors can share a common communications bus, but that risks tying up the bus if two processors have lots of data to exchange, bringing communications for the rest of the system to a screeching halt.

Cogent Research in Beaverton, Oregon, thinks there's a better solution. Cogent's new desktop supercomputer, the XTM (see photo A), can connect any number of parallel processors, without passing data hand-to-hand through a network or tying up a common bus when there's lots of data to exchange. Instead, the Cogent machine has a hybrid communications architecture that has both a common bus and a unique network system.

The Cogent XTM

The XTM's processors are INMOS T800 transputers. Each transputer has 4 megabytes of RAM, as well as four high-speed serial-communications channels specifically designed for exchanging data with other transputers.

Photo A: *Cogent Research's XTM parallel desktop supercomputer, based on the INMOS T800 transputer and Yale University's Linda programming language. (Photo courtesy of Cogent Research, Inc.)*

In the XTM, the transputers all share an ordinary parallel-communications bus, through which messages can be sent. Separately, the four serial-communications channels from each transputer are connected to an intelligent switching system. Inside the intelligent switch, the serial-communications channels from all the transputers in the system are arranged in a network—but with no permanent connections. Upon request, the intelligent crossbar switch can directly connect any two transputers in the network. Consequently, any two transputers can talk either through the shared bus or through a temporary "private" direct connection (see figure A).

For example, suppose processor A wants to send a large collection of data to processor B. If A sent the data through the common bus, it would tie up the bus—a classic communications bottleneck. Instead, A sends a message through the bus to the crossbar-switch controller, asking for a direct connection to B.

Once the connection is made, A can send data to B at high speed without interfering with any other processor's communications. Once the data transfer is complete, A sends another message to the switch controller, asking it to disconnect A from B, and the two processors are free to make new connections.

Meanwhile, every other pair of processors in the system can be connected in the same way. While A and B are exchanging data, C and D can make their own connection. At least in theory, in a 1000-processor system, 500 serial connections could be transferring messages at high speed.

It takes the XTM's intelligent crossbar switch less than 40 microseconds to link any two processors, and only 200 to 400 μs to completely reconfigure the entire computer. (The XTM can even be reconfigured to mimic a Hypercube or another fixed network.)

Because the communications network is dynamically reconfigurable, all the processors can communicate directly through a relatively small number of communications channels. One thousand processors can communicate using only 4000 serial lines—less than 1 per-

cent of the number required for a fully connected network. As a result, the number of processors in the system is almost unlimited. Cogent has designed a system for Sandia National Laboratory that contains 1900 processors and has roughly the same computing power as a Cray X-MP.

A more typical Cogent XTM system sits on a desktop and has two processors in a workstation cabinet that's slightly smaller than an IBM PC (14 by 14 by 6 inches). Along with the processors, the workstation contains a 90- or 190-megabyte hard disk drive, an 800K-byte 3½-inch floppy disk drive, and three NuBus slots.

There are also an external 1024- by 808-pixel display, a keyboard, and a mouse. The least expensive XTM system (with a 90-megabyte hard disk drive and a monochrome display) costs $19,800.

To add processors to this basic system, you first need to add a resource server (a 14 by 18 by 6 cabinet with 16 slots and the intelligent crossbar switch) and a communications card to connect it to the XTM.

As a result, going from two processors to four adds another $35,000 to the price. After that, you can add computation cards (each one contains two transputers) for $12,000 each—until you run out of slots in the resource server, at which time you can add another resource server. Additional disk storage comes in the form of a disk server (1.9 gigabytes, plus an 810-megabyte optical drive for backup, for $60,000). The workstation, resource servers, and disk servers all communicate through fiber-optic cable at 100 megabits per second.

An Easy Growth Path

The price on a desktop supercomputer can rise quickly. A workstation with a single resource server packed full of processors fits easily on a desktop—and costs over $200,000. The Cray-class system Cogent designed for Sandia will cost $15 million to build.

But the XTM is unique among supercomputers in that both the two-processor minimal system and the 1900-processor Sandia machine use exactly the same hardware. And with enough time and money, you can build any system into a colossus—without changing the software. The XTM's operating system is based on the Linda parallel-programming concept, which is effectively blind to the number of processors in the computer. A program written in FORTRAN or C using the Linda extensions will run on a minimal XTM system. Add two (or a dozen) more processors, and the program will run in exactly the same way—but nearly twice (or a dozen times) as fast.

And how fast is fast? Each of the XTM's transputers adds 3 million floating-point operations per second of processing power. Cogent's designers believe that because the XTM can be so easily tailored to match computational problems—adding more number-crunching capability as it's needed—the new machine will open up a completely new range of problems that were previously inaccessible from desktop workstations.

Frank Hayes is an associate news editor for BYTE in San Francisco. He can be reached on BIX as "frankhayes."

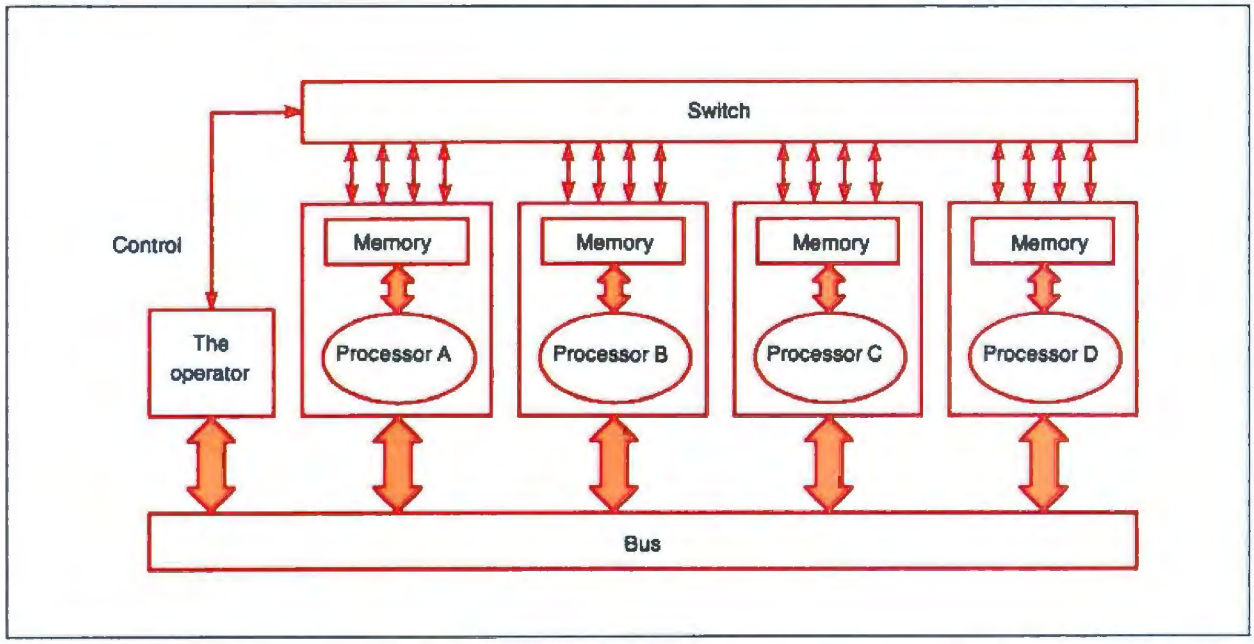

Figure A: *The Cogent XTM's communications system. For A to exchange data with B, A notifies the switch controller via the communications bus. The controller then orders the intelligent switch to make a direct connection between A and B.*

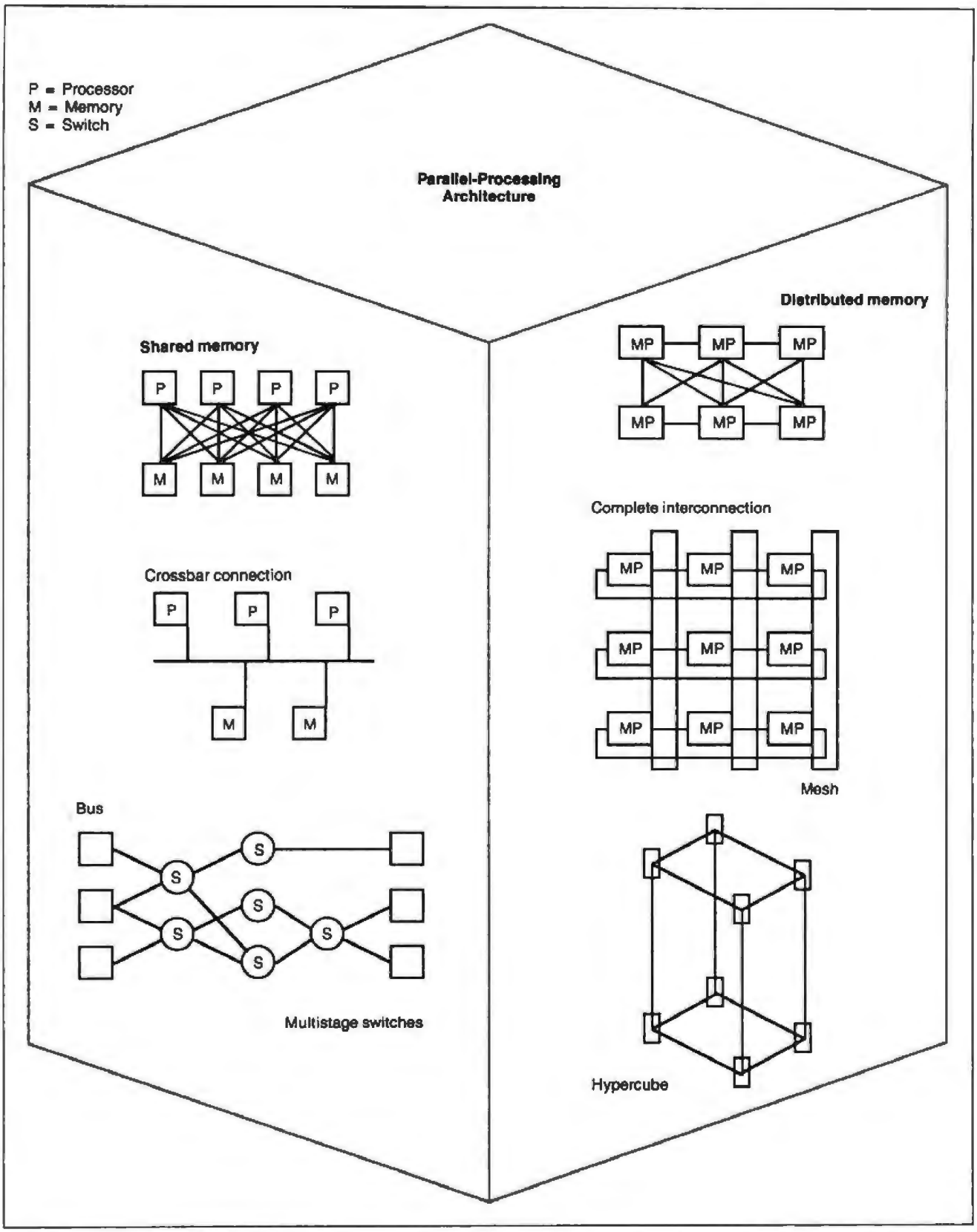

Figure 1: *Shared memory architectures allow parallel systems to access a common shared memory, as opposed to distributed memory systems, which provide memory to each processor.*

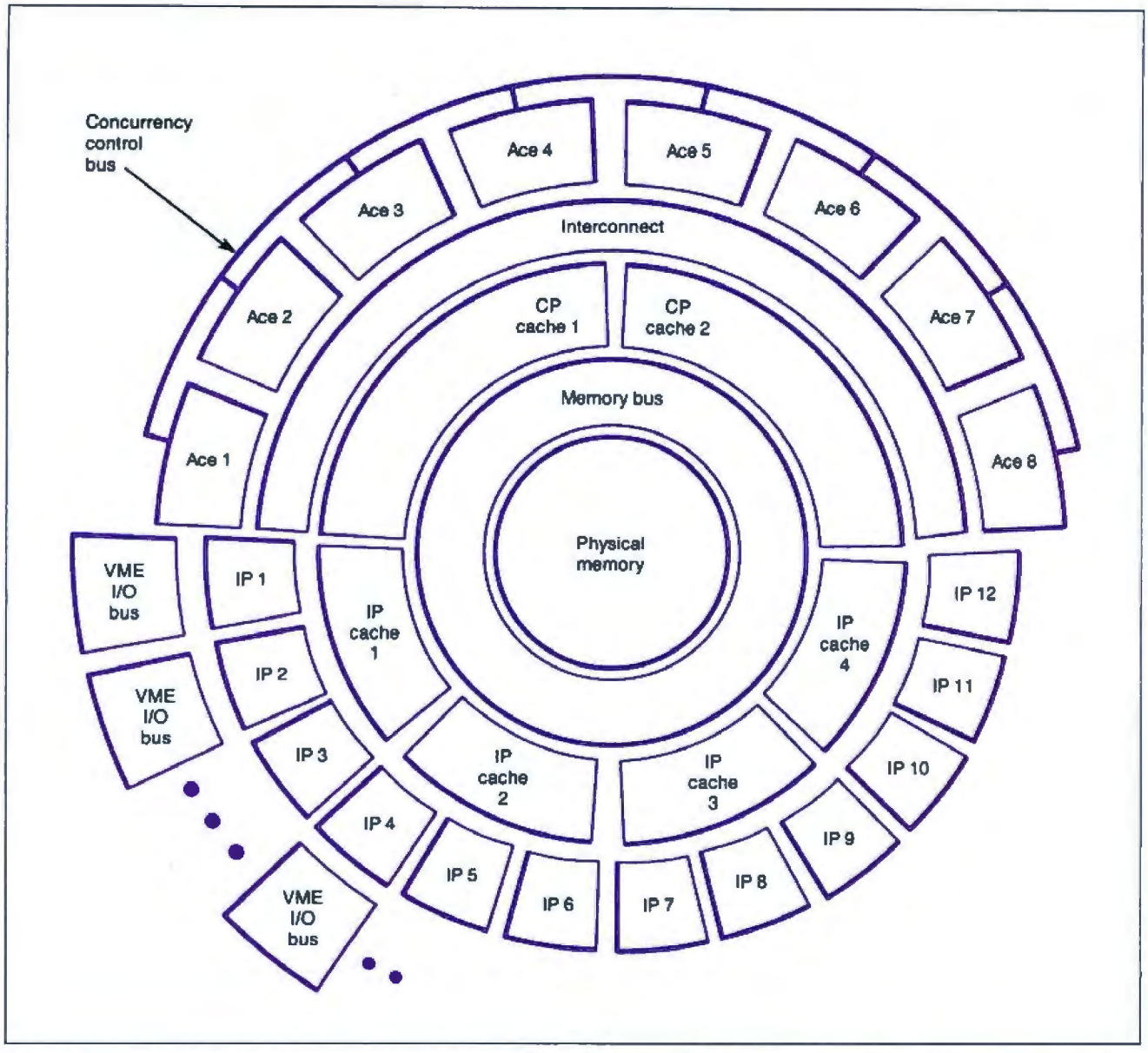

Figure 2a: *The FX/8 system's common-bus architecture. The ACE processors (Advanced Computational Elements) function as application processors. I/O and operating-system jobs are performed by the interactive processors, which are 68020-based.*

underlying semantics. In brief, functional languages are prime candidates for programming parallel machines.

All about Architecture

A dichotomy exists between shared-memory architectures and distributed-memory architectures. The former allow parallel systems to have access to a common, shared memory, while the latter give each processor its own memory. As shown in figure 1, a multitude of configurations is possible and has been used for building parallel-processing systems.

The most widely used architectures are bus-based systems, the Hypercube, and a design using special-purpose switches, as shown in figures 2a, 2b, and 2c. A less widely known architecture is found in wafer technology. (See "The Third Dimension" on page 311.)

Bus-based systems (e.g., the FX/8, from Alliant Computer Systems, Littleton, Massachusetts) provide the simplest form of parallelism, having a set of processors connected to a set of memory boards via a common bus. Although these systems are attractive for their simplicity, problems arise in the form of limited scalability, contention for accessing the same memory location, and rising costs for overall speed gain. In applications dominated by scalar code, like older mechanical CAD applications, you'll find good speed increases with from one to four processors, but after that, adding processors won't increase speed.

Hypercube (e.g., the Connection Machine from Thinking Machines, Cambridge, Massachusetts), based on CalTech's Cosmic Cube, allows multidimensional connections between processors, thus connecting every processor at least indirectly. Although it's attractive for its capability to interconnect thousands of individual processors, communication speed between processors may

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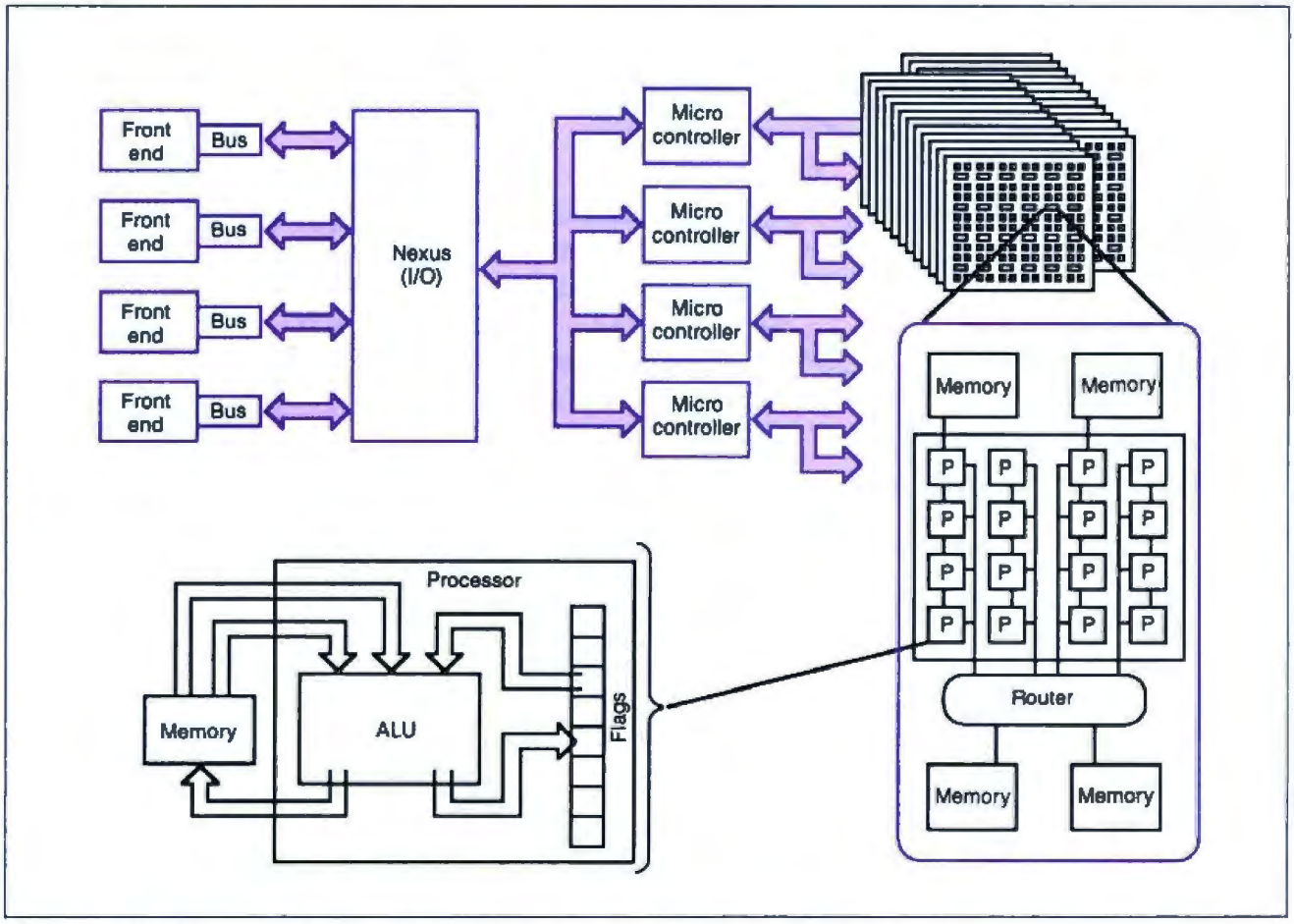

Figure 2b: *The Connection Machine's Hypercube architecture and blowup of individual processor.*

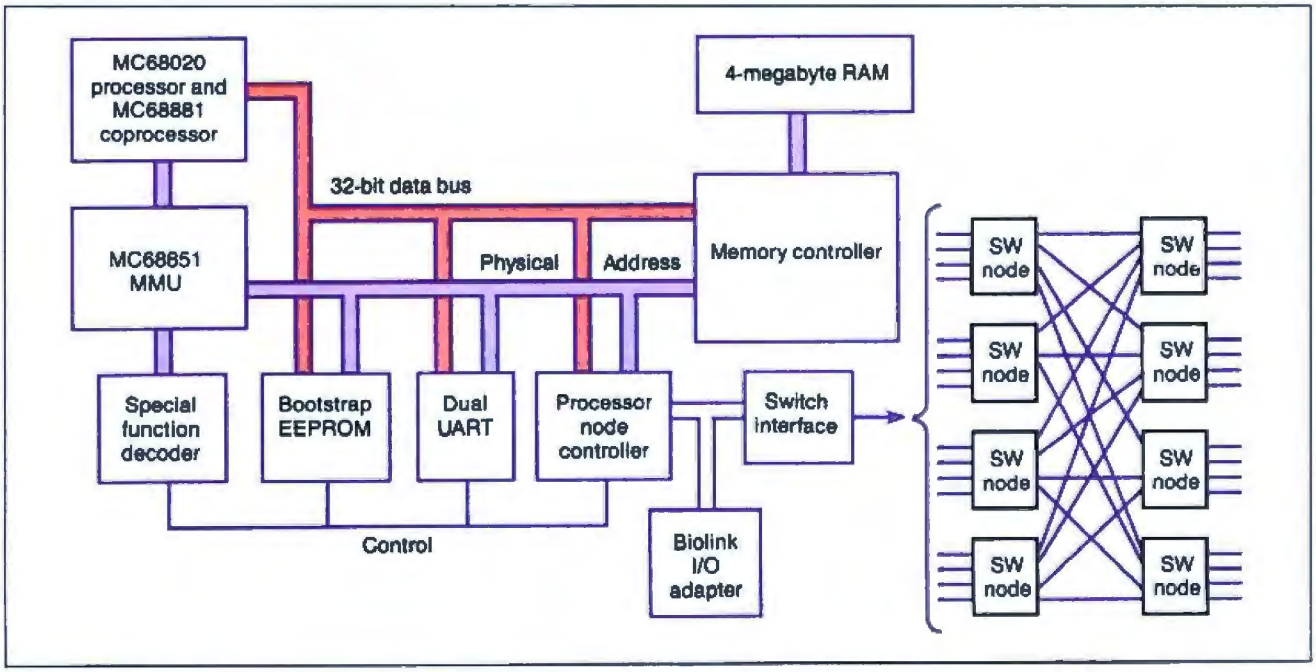

Figure 2c: *A Butterfly processor node block diagram and blowup of the Butterfly switch design.*

vary depending on the number of intervening processor nodes. Ultimately, programming a Hypercube architecture may require treating it as a loosely coupled multiprocessor with explicit data placement and task assignment per node under certain memory size limitations.

Multistage switch architectures (e.g., the Butterfly from Bolt Beranek and Newman, Cambridge) are closely modeled around crossbar switching connections that use separate buses for each processor. Whereas crossbar architecture has a serious contention problem, if two processors want to communicate with the same memory location at the same time, special-purpose switches allowing multiple paths to the same memory node alleviate the contention problem. (See the text box "The Crossbar Connection" on page 278.)

The Problem with Benchmarking

In general, benchmarking parallel-processing systems is a formidable, if not impossible, task. While you can use MIPS (million instructions per second) and MFLOPS (million floating-point operations per second) to compare parallel-processing machines, their ratings may be skewed by I/O-intensive programs or the types of programs themselves. Moreover, transporting code between parallel-processing machines of different types is not possible.

A popular dichotomy between right-wing and left-wing machines points to the important role of the operating system. Just as ideological differences set conservatives apart from liberals when it comes to the role of the government, right-wing machines (e.g., Hypercube-based) offer little control or support through their operating systems. With these machines, programmers are required to code more low-level operations themselves. Left-wing machines (e.g., Butterfly) provide more generous support by the operating system.

The Personal Computer Connection

While parallel processing has reached the minicomputer market, parallel-processing capabilities for personal computers are slowly emerging and usually come in two forms: expansion boards and software simulation. (See "T800 and Counting" on page 287.) The INMOS D700 Card and T414 CPU offer IBM PC users parallel-processing capabilities as part of the D701 Transputer Development System. The package comes with the Algol-based programming language occam. The T414 CPU, a 32-bit microprocessor, is able to pass information to multiple processors while at the same time operating on a problem.

Another expansion board that offers parallel-processing capability is the PCturbo 286e from Orchid Technology. The board connects to the IBM PC AT or XT and lets you run simultaneous applications in the computer's standard memory and the 286e's RAM. If you choose to run two programs in parallel that try to access the same data or write to the same disk sector, the data may be compromised.

Parallel-processing capabilities for personal computers are slowly emerging.

The complexity and cost of commercial parallel-processing machines available today make them prohibitively expensive for mass use. The available expansion boards that may allow some parallel processing on personal computers are primarily for the programmer exploring the flavor of this technology. Integration into existing infrastructures makes personal computers probable candidates for host or front-end vehicles.

Where We Are Going?

Parallel processing, despite its commercial impact over the past 5 years and its academic endeavors over the past 20 years, is still in an embryonic state. The three most significant issues standing in the way of necessary commercial breakthroughs are standardization of parallel-processing languages and architectures, integration of parallel processing into the existing computing infrastructure, and design of solid interfaces required by the complexity of the programming tasks.

Standardization of parallel-processing languages and architectures is important because there is currently no standardization of parallel-processing techniques in sight. One reason for this is that parallel-processing technologies are still mostly in R&D laboratories, an environment that promotes individualism. Another reason is the potential for diverse applications that makes it impossible to predict what such standards should look like. Finally, the design of hardware is so far ahead of the state of the art in software development that both disciplines have to be brought to the same level before standardization of either software or hardware becomes possible.

Integration of parallel processing into the existing computing infrastructure is important because drastic changes are slow to be implemented, especially in an investment-intensive area like software development and hardware purchases. Although projects like the one that involves Dow Jones and Thinking Machines show some promise, many more successful applications have to come about before parallel processing becomes a major force in the commercial computing market. As with any other innovation, commercial evolution has to follow the revolution in the laboratories. Integration is the key.

Last but not least, the design of solid interfaces required by the complexity of programming tasks is a necessity. As we are beginning to imagine programming parallel systems of multiple gigabytes in size, debugging and maintaining such programs, much more than actually using them, will be delegated to the user interface. Ultimately, programs may come about through the intelligent interaction in English between the user and the interface.

For these reasons, personal computer users will have to limit themselves to simulating parallelism in the near future—that is, until commercial parallel-processing technology matures. ■

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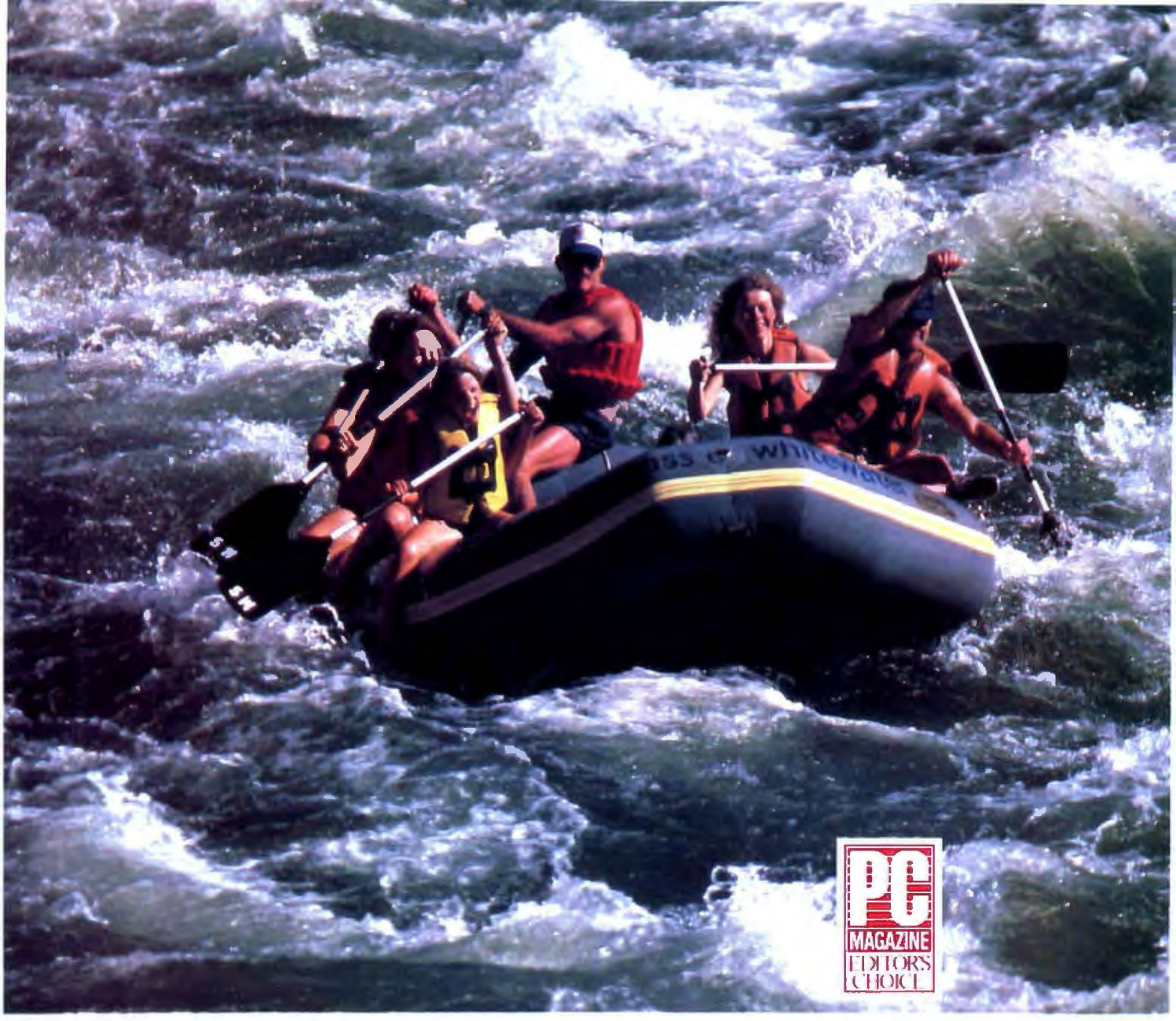

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T800 and Counting

The T800 transputer and the Occam language are a hardware/software team designed to work together

Richard M. Stein

Mankind constantly seeks ways to solve the technological challenges found by observing the natural universe. Today, our understanding of nature is increasingly dependent on computer-based simulation of theories, suppositions, and curiosity.

Such complex operations as verifying the fluid flow of air around the wing section of an airplane to determine drag and stability, studying chemical reactions in the preparation of a new drug, and studying weather patterns require the increases in performance provided by parallel-processing computers. In fact, many problems are beginning to require that increase in speed to quench our growing thirst for immediate responses. As parallel-processing computers become more and more available, these workhorses of science and industry are emerging as a key to continued technological growth.

Multiprocessors vs. Multicomputers

Parallel-processing computers can be divided into two basic architectures: the shared-memory multiprocessor (see figure 1a) and the multicomputer (see figure 1b). The shared-memory multiprocessor comprises a collection of CPUs connected by a bus to a common pool of memory.

A multiprocessor performs parallel computations in several ways. One is to dedicate a complete processor to each active process; this is called *control parallelism*. Each process is free to operate on memory without appreciable interference from the others. Why not add more processors and keep partitioning the problem, one process to each processor, to gain more speed? A problem arises as you add CPUs to the bus: When one CPU tries to access an address in memory, it must first get permission from the others. Arbitration among the CPUs leads to contention. Each CPU requires a finite amount of time to fetch something from memory, and while this is going on, the other CPUs must wait if they need data as well. Adding more CPUs simply makes the problem worse, and a bottleneck results.

This is the so-called von Neumann bottleneck. It's the reason multiprocessors seldom have more than four CPUs simultaneously operating on a common pool of memory. The bus bandwidth is saturated by simultaneous requests from the CPUs. The shared resource leads to a form of inflation, where the cost of performing an operation becomes increasingly expensive and therefore less efficient. This is the key limitation to multiprocessor architectures: Finite bus bandwidth means that only a fixed num-

continued

ber of instructions can be carried out each second. While this may be appreciable—more than 500 million floating-point operations per second (MFLOPS) is possible—the growth rate in the bandwidth is limited by technology.

The multicomputer differs from the multiprocessor in several ways. Processors are not connected to a common bus. Instead, each processor has a small (64K-byte to 4-megabyte) RAM connected to a local bus—the processor and RAM are called a *node*—and communication between processors occurs through high-speed serial links. There is no bottleneck. Since a node doesn't share a common bus with any other node and communication occurs through serial links, the multicomputer's bandwidth rises linearly with the number of nodes.

The multicomputer has other advantages as well. The most notable is cost. Multicomputers require less glue logic and fewer support chips on a per-node basis than do multiprocessors. A multicomputer typically runs between one-tenth and one-hundredth the cost of a comparable multiprocessor.

The Transputer

About 4 years ago, INMOS introduced the transputer, a multicomputer building block. It has a great cost-performance ratio: A T800 transputer with 4 megabytes of RAM costs about $1000, and a 30-MHz T800 delivers 2.25 IEEE 32-bit MFLOPS and 15 million instructions per second, well under $100 per MIPS. In addition, the transputer requires little support circuitry: You can build a fully functional multicomputer node (a transputer, a 5-MHz crystal, a few pull-up resistors and diodes, four F373 parts [octal latches], some RAM, and a wire-wrap tool) in a few hours. The most costly part of the hardware is the RAM.

Figure 2 shows the internal structure of the T800 transputer. This architecture is unique when compared with conventional CPUs. The T800 incorporates 4K bytes of on-chip static RAM. A program that fits into this on-chip reservoir will execute instructions in the transputer's cycle time—that is, in the 33-nanosecond cycle for the 30-MHz version. The internal RAM is not cache memory per se, as many conventional reduced-instruction-set-computer processors have, but it does serve an important role as stack space.

The internal RAM is used by compilers to hold the base addresses of arrays and local procedure variables. The base address of an array is used far more often than a single array-element address during program execution. The size and type of an array element are fixed at compile time, so a simple calculation can determine the address of any array element. The internal RAM serves as a register stack, an area where variables used repeatedly are held to speed access and program execution. A register variable is accessed in a single cycle, but variables held in external RAM require a handful of cycles to latch and read.

Using the transputer's internal RAM in this way does have one side effect, and it shows up in the language specification for Occam, the transputer's native language. By definition, the Occam language is not recursive. If it were, the repeated stacking of the local variables would generate confusion at each level of recursion during program execution. Stack frame building requires dynamic memory allocation, which Occam does not support. Implementing recursion on the transputer is a bit tricky in Occam, since the application must maintain the stack and you must explicitly manage stack traversal.

The T800 integer-register set is sparse but highly functional (see figure 3). The three accumulators are arranged as a stack and serve as expression evaluators. The workspace pointer tracks the address of the data that the active process is using. The instruction pointer is similar to the program counter found in conventional CPUs and points to the current instruction.

The transputer's operand register serves as the focal point for instruction processing. All transputer instructions are 1 byte long and typically execute in one to two cycles. The transputer forms an operand by loading the instruction data field into the 4 least significant bits of the operand register. The instruction uses the contents of the entire operand register as its operand; it clears the operand register to 0 on completion.

The transputer also performs instruction prefetch. Since each instruction is 1 byte, four will fit into one word on the

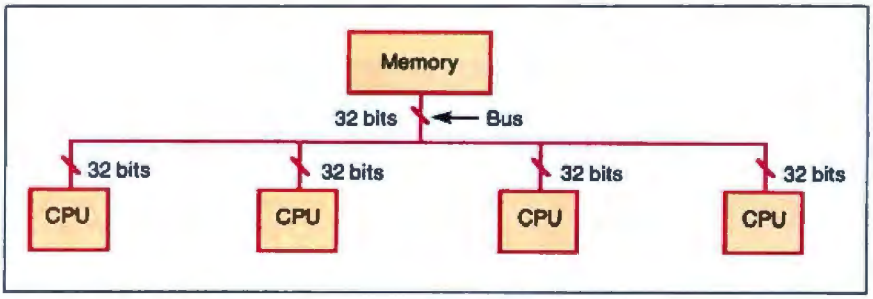

Figure 1a: *A typical shared-memory multiprocessor (without contention memory cache). The bus is a common resource among all CPUs; as more CPUs are added, bus contention can lead to the von Neumann bottleneck.*

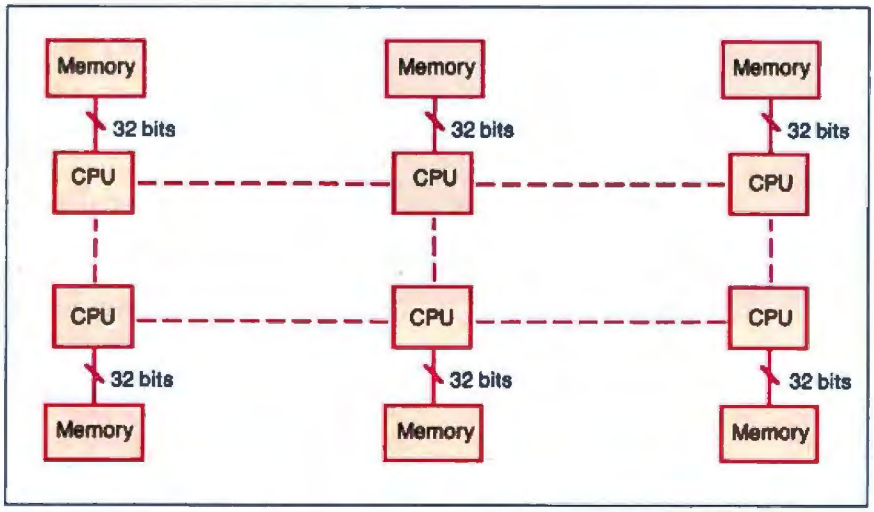

Figure 1b: *A typical multicomputer system. Each node consists of a CPU and memory. Processes communicate with each other through bidirectional serial links (dotted lines).*

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T800. Each instruction fetch retrieves four instructions simultaneously; this requires less frequent accesses to memory. The transputer maintains a double-buffered instruction queue. The prefetch-and-buffering scheme delivers most of the performance benefits of an instruction cache, but without the silicon's cost. The prefetch-and-buffering sequence almost completely decouples instruction execution time from memory speed.

The transputer is designed to execute concurrent processes under direct hardware control. A by-product of hardware process scheduling is realized in the extraordinarily short context switches. Due to a hardware stack maintained by transputer microcode, most context switches require only between 1 and 2.5 microseconds (μs). A transputer process consists of a local workspace and a small reserved area for linkage information, which holds the pointers used to maintain multitasking and I/O protocols.

The hardware scheduler supports two process priorities: high and low. It gives the high-priority process unconditional control over the CPU and prevents the low-priority processes from executing until the high-priority one relinquishes the CPU. You use a high-priority process for very short—less than one time slice—sequences of instructions that are not to be interrupted by external events or bumped by other processes. The time-slice period is approximately 1 millisecond for a low-priority process. All low-priority processes execute asynchronously. This asynchronous execution scheme is an important concept for multicomputer software systems.

The transputer has an on-board hardware timer, which can be used to obtain synchronous interrupts for time-critical processes. The timer derives its signals from the externally connected 5-MHz crystal. The crystal supplies the transputer's phase-lock loop with the synchronization signal coordinating all the internal mechanisms. The timer is accessed through a channel assignment, and it has either 1-μs or 64-μs resolution. With these clock intervals, you can schedule processes tightly to execute at precise intervals.

The T800's floating-point unit conforms to IEEE standard 754-1985. At 30 MHz, it is 50 percent faster than a 16-MHz 80386/80387 combination. The T800 performs 32-bit floating-point multiplication, addition, and subtraction in less than 1 μs, and it requires just over 1 μs for division. The transputer's FPU can run in parallel with the integer CPU,

continued

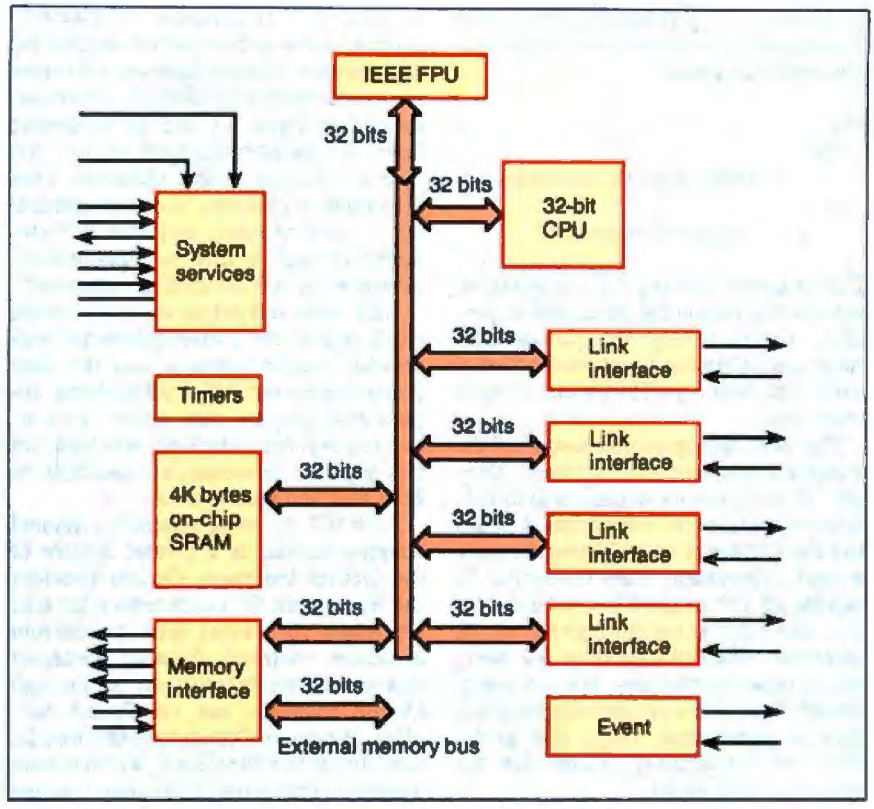

Figure 2: *The INMOS T800 transputer. The CPU and FPU can execute in parallel by organizing Occam to exploit both processors simultaneously. The chip is designed for concurrency.*

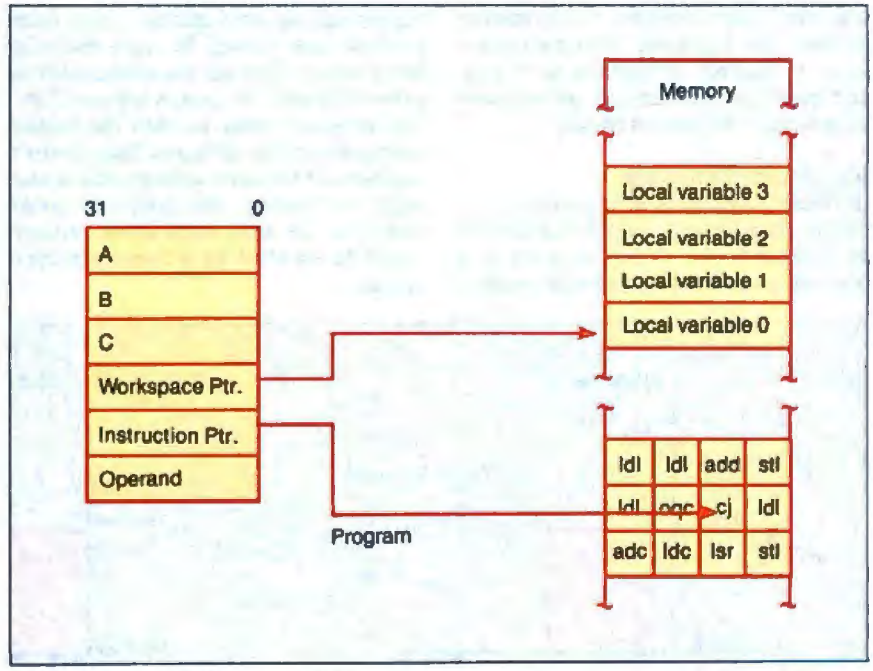

Figure 3: *The T800 integer CPU has three accumulators, registers A, B, and C, arranged as a stack for expression evaluation. Zero-address instructions operate on values in the stack; single-address instructions load values from memory into the stack, and so on.*

programmatically separating integer and floating-point computations. In Occam, you can write this as

```
PAR
  SEQ
    . . .do floating-point calculations
  SEQ
    . . .do integer calculations
```

This fragment directs the transputer to execute two sequential processes in parallel, or concurrently: One process executes only floating-point instructions, while the other performs the integer arithmetic.

The most distinguishing feature of the transputer is its four link interfaces. They are direct-memory-access-controlled, bidirectional, serial-transmission links and can operate at up to 30 megabits per second. Therefore, each transputer is capable of 120-megabit-per-second link I/O, the equivalent throughput of 12 Ethernets. The links serve as the interface to other transputers. You can easily connect them into a variety of topologies, such as hypercubes, rings, and grids. They are the primary reason that the transputer is so linear.

The transputer is linear in the sense that if you execute a program on a single transputer, gather some performance data, and then partition the software to run on two transputers, the performance will have nearly doubled. In ray-tracing studies, the transputer's improvement factor is typically 98 percent to 99 percent linear (multiprocessors are typically 70 percent to 80 percent linear).

The Occam Language

In Occam, communicating processes exchange data through a construct known as a *channel*. An Occam channel is a one-way point-to-point pathway resident in memory; it is termed a *soft channel*. Channel input and output are special for two reasons: Communicating processes are synchronized by channel communication (see figure 4), and the transputer links are memory-mapped so you can "place" channels at link addresses. This placement transforms the soft channel into a *hard channel*, and data is transferred through a link to a process attached to the link on another transputer.

Link input and output share a common clock signal (not a prerequisite for successful communication), and the data transmissions are self-synchronizing. Inputs and outputs can occur simultaneously over the same link, provided that two separate processes are available to both send and receive data.

Link I/O, or, more generally, channel communication, is a pivotal feature of the Occam language. Occam provides the framework for constructing parallel processes (processes with concurrent execution contexts). Parallel processes that communicate must do so through Occam channels, not via shared variables. Why does Occam have this restriction? Because of deadlock, which occurs when two processes fail to communicate correctly as a result of improper coding or design.

Listing 1 illustrates deadlock. The two SEQ processes execute simultaneously; the first requests input on chan2, while the second requests input on chan1. Both processes are waiting for input that will never occur, since no output executes in either SEQ until the inputs are satisfied. The program never reaches the output statements in the SEQs and thus doesn't complete. If you reversed the order of one input and output, the program would complete, because each input request would be satisfied by a complementary output.

Attempting to share a variable among parallel processes gives rise to a similar conflict: One process may try to write the variable at the same time another one is trying to read it. Since parallel processes run asynchronously (at their own rate), reading a variable that has been modified by another process means the value would be uncertain. Since you can't know when the variable will be modified, you could be trying to read it when another process is writing it. To prevent this collision, Occam precludes parallel processes from sharing variables. But Occam variables can and do store data, and channels are available for interprocess communication.

The point-to-point nature of the Occam channel discourages the design of a program dependent on routing data through intermediate nodes. While "through-routing" is typically implemented on the transputer as a separate software process that enqueues and dequeues packets, the hardware provides an easier approach. (Second-generation transputers are likely to have this feature.) You can't always achieve a logically concurrent description that isolates communication dependency to a nearest neighbor. Through-routing circumvents this design limitation, and it's much faster in hardware than in software.

Several manufacturers have developed transputer plug-in boards for both the IBM PC and the Macintosh. CSA, MicroWay, and Definicon Systems all build plug-in PC boards with varying amounts of RAM, transputers, crossbar switches, and price. Nth Graphics manufactures a transputer-based PC plug-in graphics engine running the Hoops graphics package from Ithaca Software. A typical single transputer board with a 20-MHz T800 and 2 megabytes of exter-

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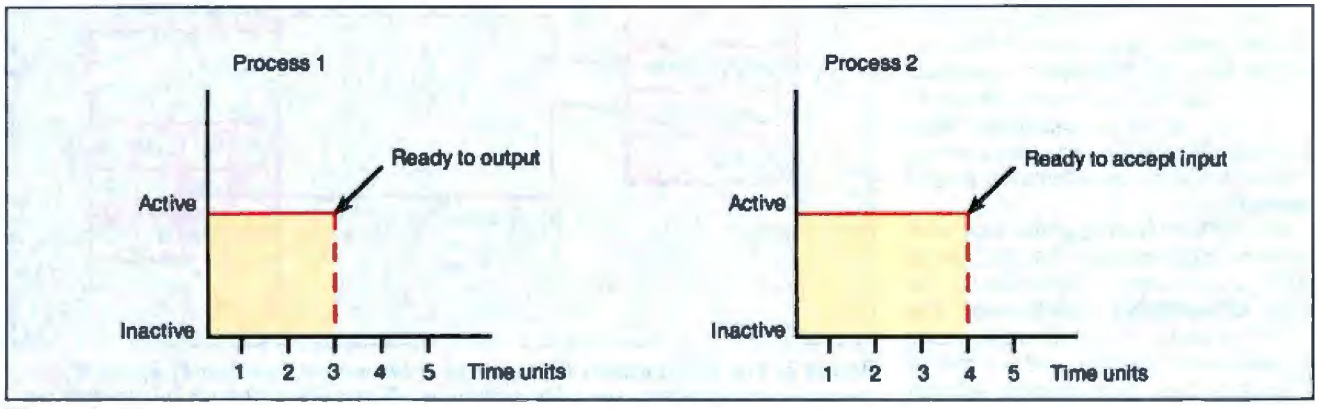
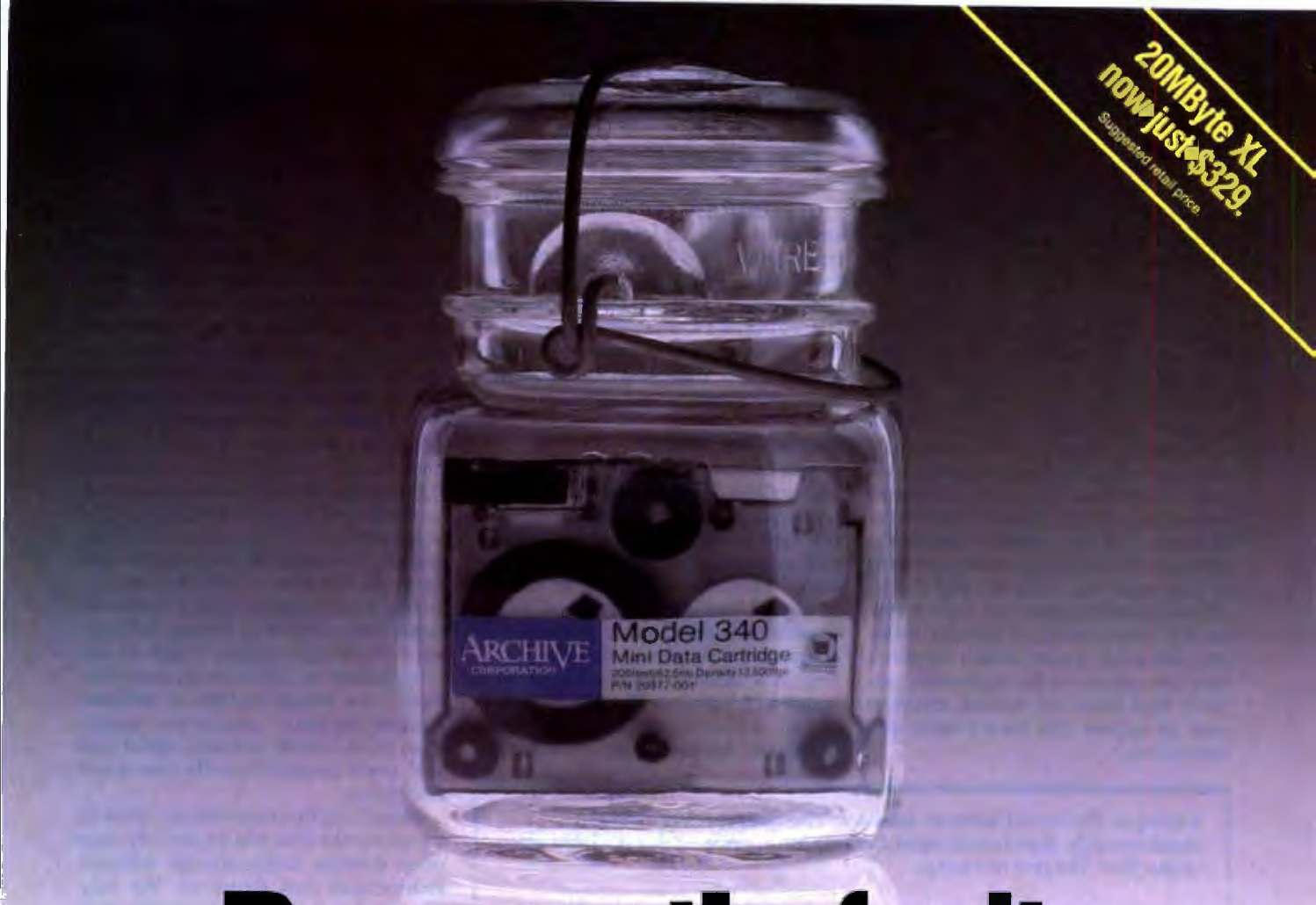


Figure 4: *When process 1 must wait for one time unit before process 2 is ready to accept its data, it is said to be "blocked." Processes synchronize only when they communicate via Occam channels.*



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nal dynamic RAM costs about $3000, including an Occam compiler, documentation, and some utilities. Levco makes a plug-in transputer board for the Mac.

Occam is a secure language with a robust and efficient compiler, but it does have some shortcomings. For one, Occam fails to provide hierarchical data-structure typing, an essential for object-oriented programming. You need to have a means of abstracting the problem domain into more than just assignments, inputs, and outputs. The success of a computer model is often characterized by the correctness of the problem-domain abstraction; this is far more easily achieved in languages like Ada, C, and C++. Occam doesn't support the `struct` syntax of C, enumeration, or dynamic memory allocation. It also doesn't support a recursive syntax, so the application program must stack and unstack recursive data structures like binary trees and linked lists.

C, FORTRAN, and Pascal compilers are available for the transputer. An Ada language compiler from Alsys is planned for August 1989, and rumor has it that Glockenspiel, Ltd., in Dublin, Ireland, is working on a C++ compiler based on the 3L Parallel C compiler. Software tools for the transputer are becoming more widespread.

Logical Concurrency

Logical concurrency is a natural part of any problem domain composed of multiple degrees of freedom. Any system you can view as a collection of processes is said to possess logical concurrency. A formal definition states that the amount of logical concurrency is equal to the number of simultaneous processes or composite coincidental actions occurring in a closed system modeled by a computer program or simulation.

This definition applies to multicomputers. In multicomputer systems, you gain speed by partitioning the processes among different processors that perform work concurrently. Multicomputers excel in applications where the problem domain possesses data parallelism. You can process a large quantity of data when many nodes simultaneously operate on small, independent parts of the database.

It's customary to classify logical concurrency in terms of granularity. For instance, say a balloon filled with a gas contains 10^{23} molecules. If you attempt to model the equations of motion for each molecule—no small undertaking—you would need a fine-grained logically concurrent description of the problem (see figure 5). However, if you treat the balloon as a composite of 1024 volume elements (and compute an average value for some observable quantity, such as the temperature or pressure in each element), you would consider a medium-grained logically concurrent model. Even fewer volume elements would lead to a coarse-grained logically concurrent description.

Identifying the composite processes of a system is the first, but not the only, step when deriving multicomputer software architectures (see figure 6). Not only must we know *what* the composite processes are, but more important, we must know *how* they interact. Determining the interfaces between the processes is the next most important step.

The interfaces between the processes define the precise format for information exchange. Process A needs input from process B, which might consist of a stream of real numbers, an interrupt, or a binary-encoded number. The interfaces between processes resemble somewhat the argument specifications for a subroutine, function, or procedure.

The inputs and outputs mark the entry and exit points for intermediate results generated by a simulation. They are point-to-point communication paths between processes. If the inputs and outputs are defined, the processes are isolated from each other, and the logically concurrent description of the system is complete. A concise interface definition between communicating processes is essential to executing the transformation from logical to physical concurrency.

The process of designing a multicomputer system begins with the idea to be studied, the environment to be simulated, or the problem to be analyzed, not with the selection of a hardware host. This somewhat radical idea—organizing the software through a logically concurrent description without considering a

continued

Listing 1: *This code illustrates deadlock. Two SEQ processes execute simultaneously. Both request input and wait for it, while neither performs any output first. The program hangs.*

```
CHAN OF INT chan1, chan2 :-- channel declarations
PAR
INT A :                     -- local variable scope is
                            -- the first SEQ
SEQ
chan2 ?                     -- input into A on chan2
chan1 ! 6                   -- output 6 on chan1
INT B :                     -- local variable scope is
                            -- the second SEQ (not shared)
SEQ
chan1 ? B                   -- input on chan1 into B
chan2 ! 9                   -- output a 9 on chan2
```

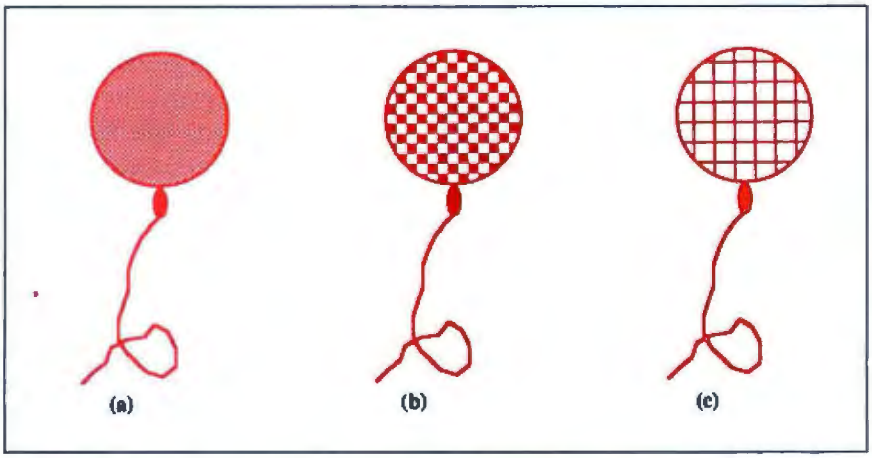

Figure 5: *Treating the molecules in a gas as individual and unique leads to a fine-grained logically concurrent description* (a), *while grouping the gas into small but finite volumes leads to successively coarser descriptions* (b) *and* (c).

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The end of the design process leads to the construction of a special-purpose computer explicitly organized to execute the software. "Special-purpose" means that the logically concurrent software description, including inputs, outputs, and processes, can now be ported to the physical concurrency of the multicomputer without affecting the software's design or the schedule.

Logical concurrency is used to abstract problem domains into software multicomputer solutions in conjunction with the transputer and Occam: a hardware-and-software team created to facilitate the logical-to-physical transformation.

Transformation Revealed

The transformation from logical concurrency to physical concurrency is the crux of multicomputer development. The speed increase in the algorithms and software is a direct result of this transformation. The entire process of designing transputer-based multicomputer software begins with this assumption: Once you have a logically concurrent description, you can evaluate the software's behavior on a single transputer using soft channels to transfer data between cooperating processes.

This single-transputer implementation is necessary for two reasons: It is unlikely that a "shotgunned" multicomputer software-development cycle (where you "hack" the software out and distribute it among all the nodes) will be successful, and debugging a single-transputer implementation, or any uniprocessor implementation, is easier than debugging software on several processors at once.

The path to physical concurrency starts with observing the logical behavior of the simulation running on a single transputer. The CHAN declarations are the key to performing the mapping. The logical software model, composed of several communicating processes, uses the channels to pass messages. Occam places these channels into the single transputer's address space.

The desire, however, is to achieve physical concurrency, which is accomplished when the logical software model is distributed among the processors according to the software design. With the Occam PLACE construct, you can map the channel addresses to the link addresses. The PLACE construct instructs the compiler to set the address of the predicate at a specific address. For example, the statements

```
INT abcd :
PLACE abcd at #4 :
```

cause the integer variable abcd to be placed at address 4 (hexadecimal).

Likewise, the PLACE construct applies to channels. The transputer's address space has eight specific addresses for the links, and once you PLACE a channel there, it's called a hard channel, instead of a soft channel for memory-to-memory channel I/O. This hard channel then writes or reads information from another process resident on another transputer. There are eight link addresses, four for input links and four for output links, designated link.in0, link.out0, link.in1, link.out1, and so on.

To complete the logical-to-physical transformation, you must also direct the processes to the appropriate transputer. This task is handled by the INMOS configurer, a postcompilation operation that determines a boot path, along which all the processes will flow toward their target destinations. An example of a tem-

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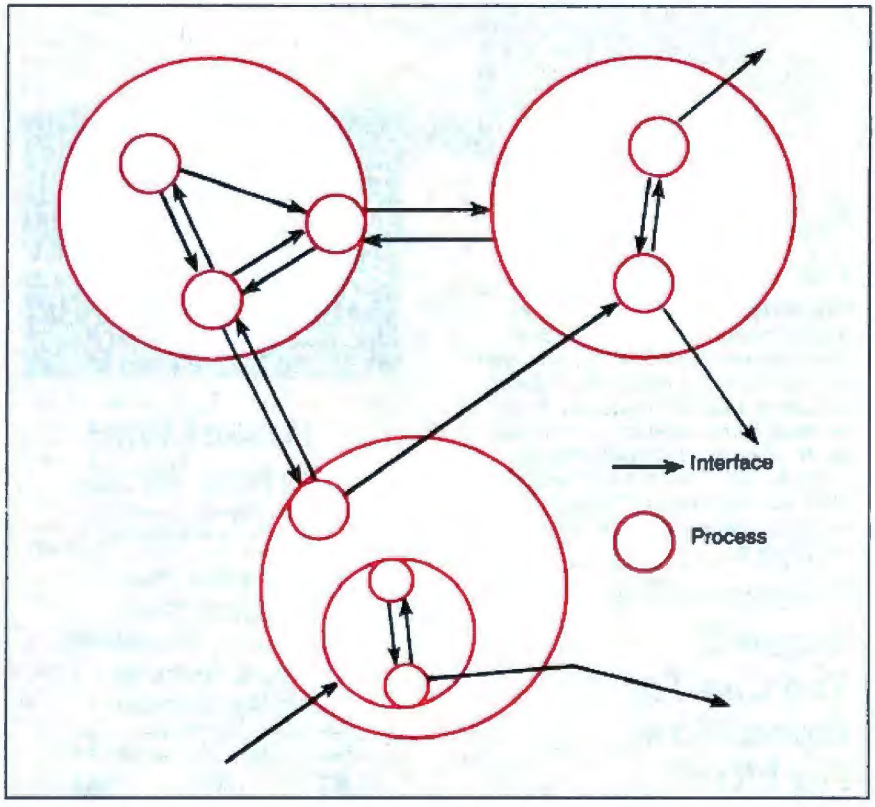

Figure 6: *A process-structure graph. Identifying the composite processes in a multicomputer system is important, but so is isolating the interfaces between processes.*

Listing 2: *A template program. This can serve as input to the configurer.*

```
PLACE chan0.out AT link0.out :
                    -- put chan0.out at hard link0.out
PLACE chan0.in AT link0.in :
                    -- put chan1.in at hard link0.in
PAR                 -- do these processes simultaneously
PROCESSOR 0 T8      -- processor 1 is a T800
navier.stokes()     -- solve the Navier-Stokes equations
PROCESSOR 1 T8      -- processor 2 is also a T800
graphics.output()   -- dump the output (in real time)
:
```

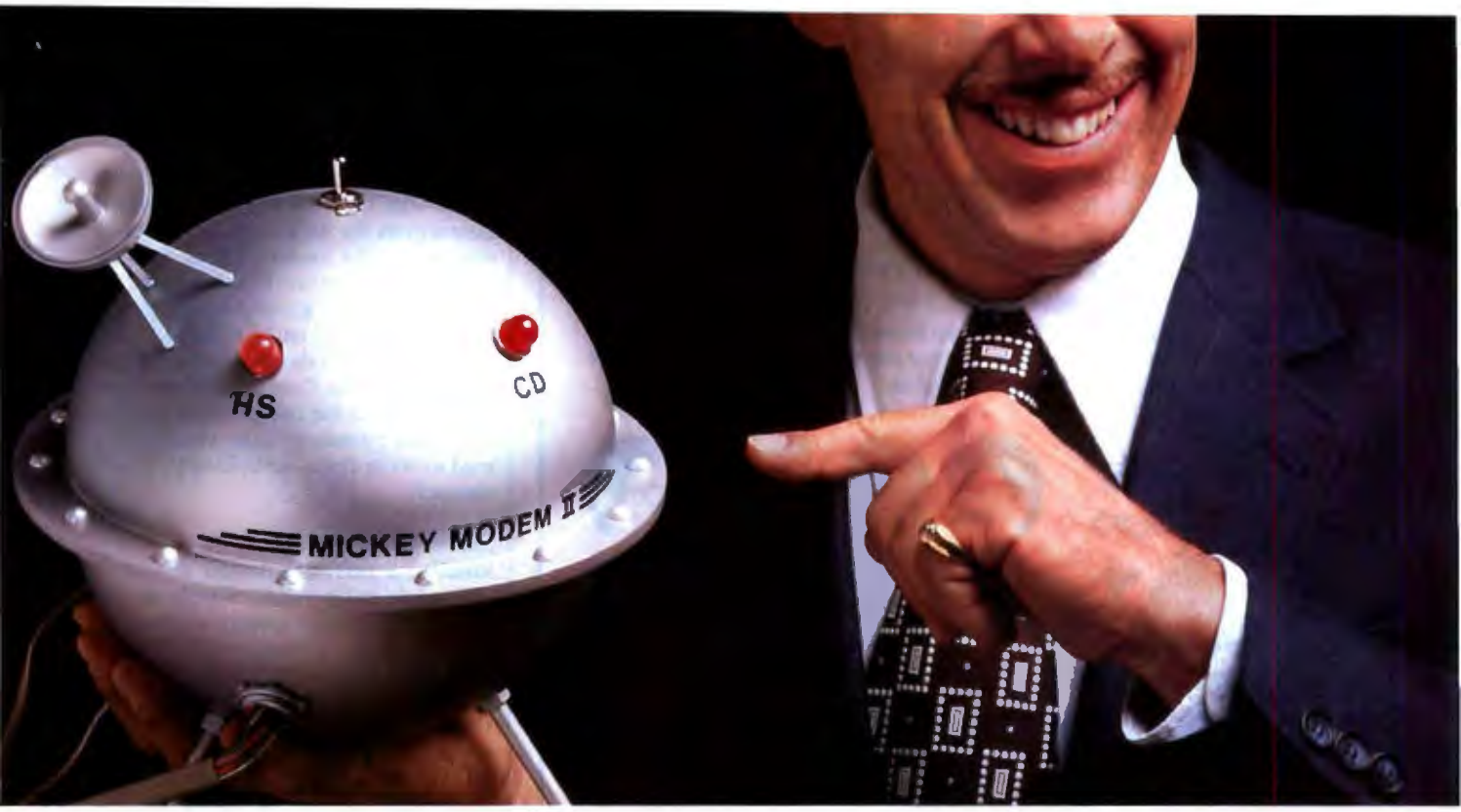

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plate program that can serve as input to the configurer is shown in listing 2.

The configurer generates a complete image with the boot path and bootstrap instructions for each node in the multicomputer. The loader PLACEs the processes called `navier.stokes()` on PROCESSOR 0. The `graphics.output()` process is PLACEd on PROCESSOR 1. The loader downloads the processes and then begins execution. Communication is synchronized, for the two processes in listing 2 don't know or care whether they read or write from hard channels or soft channels.

Software-Driven

Ideally, a software design should be completely independent of the hardware. The multicomputer system is driven by software, not hardware requirements. However, its success depends on the existence of a suitable hardware host. The INMOS transputer is designed to serve as a multicomputer node.

The innovators and pioneers who elect to invest and pursue multicomputer systems will find an increasing marketplace for this technology. The skills you need to design multicomputer software systems are not radically different from those used in sequential software design. Understanding the Occam language, transputer architecture, and, most of all, logical concurrency are the major requirements. Mostly, however, designing multicomputer software systems depends on creativity, intelligence, and desire. ■

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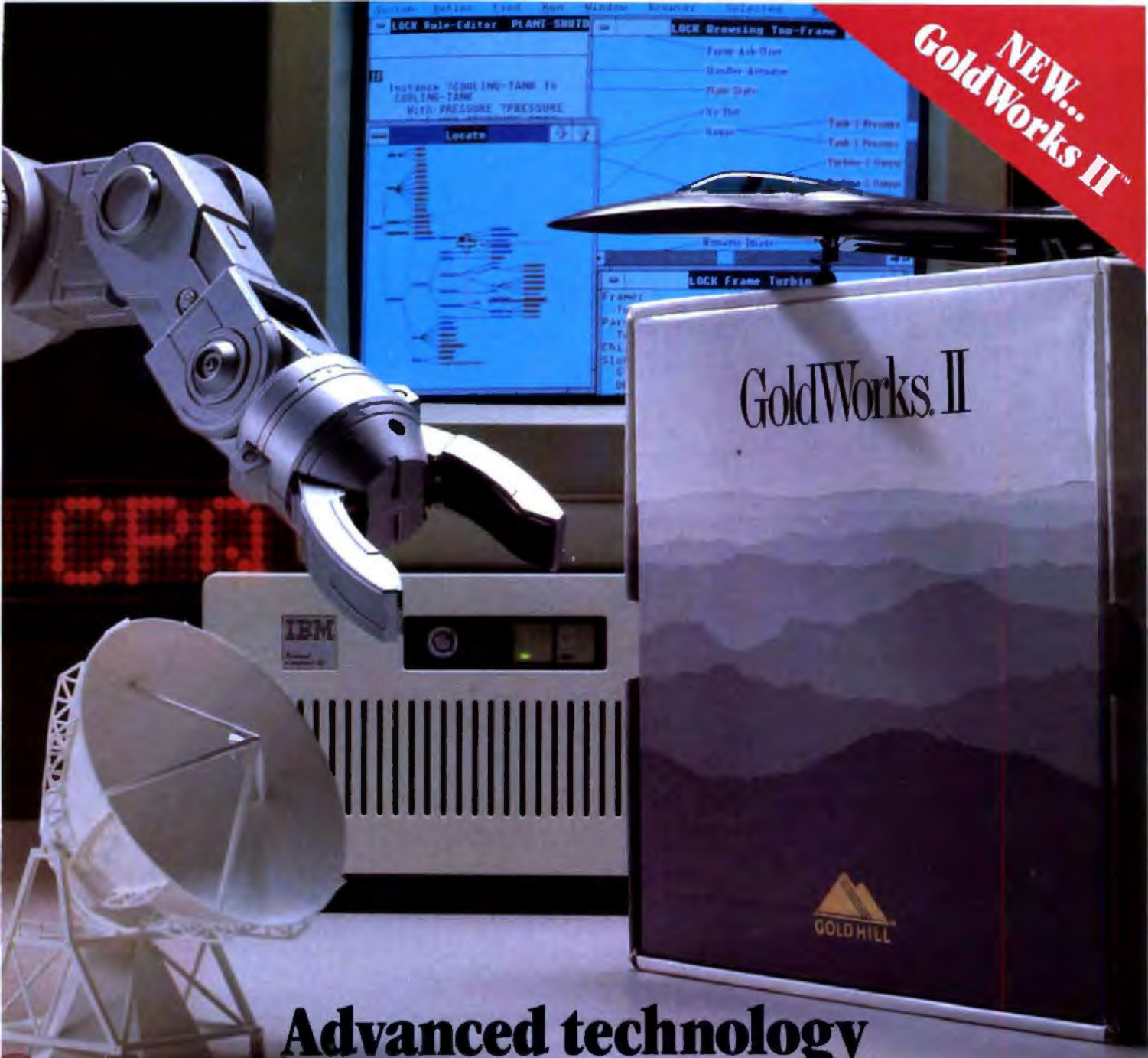
Richard M. Stein is a software engineer and writer from Irvine, California. He has worked with INMOS transputers for more than 3 years. He can be reached on BIX as "rstein."



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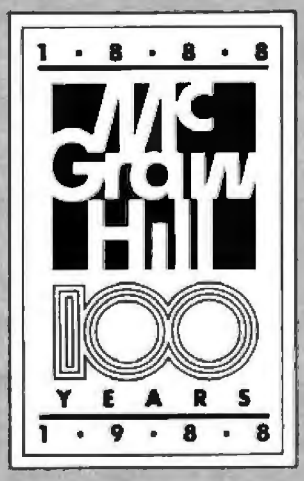

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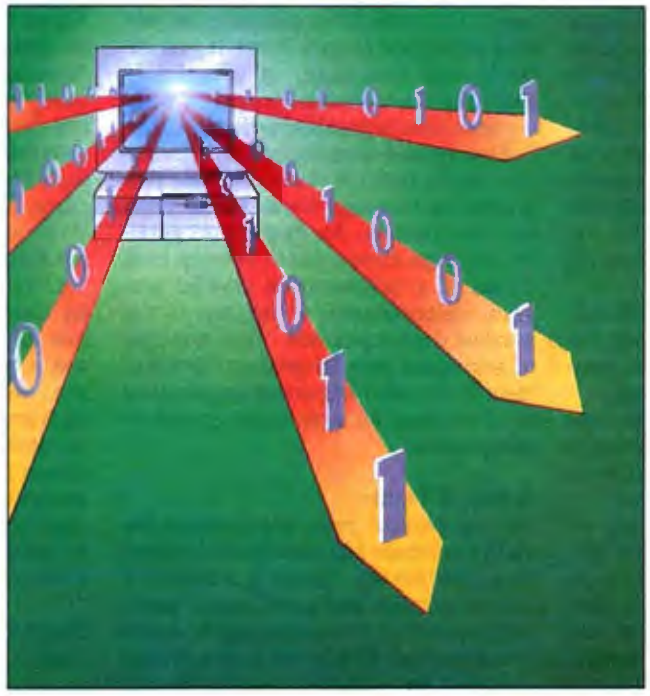
Getting the Job Done

"Linda," a parallel-programming language, is easy, efficient, and portable

David Gelernter

Parallelism is a demonstrated success at making programs run faster. It is a conceptual model of tantalizing potential. Parallel machines are rolling off more company assembly lines all the time. Parallelism, most observers agree, can revolutionize computing, from supercomputers to workstations. At the workstation level, the implications might be even more exciting than they are for supercomputing. But there is a problem.



What's the Problem?

How do you program a parallel machine? If the industry can't come up with an answer that works for lots of programmers and lots of applications on lots of machines, parallelism will survive only at the supercomputer level, and it won't thrive even there.

A parallel machine consists of many subcomputers that can focus simultaneously on the same problem. To use a parallel machine, we need programs that do many things at once. It's usually not difficult to understand how to break a program down into a collection of parallel tasks. A simple analogy: If you understand how to build a house, you can imagine attempting the job all by yourself, but you can also picture 2 people working on it simultaneously, or 10, or 100. Parallelism in such cases is a simple and obvious strategy for getting the job done. The software problem is similar. If you understand what a program does, it's usually not hard to imagine how a group of "workers" (a parallel machine) could do the job faster than one.

In software development, breaking a program into tasks isn't usually difficult. The hard part is putting them back together again into a coherent whole. Although I may understand, abstractly, that a certain group of tasks can be performed simultaneously, C, Lisp, FORTRAN, BASIC, Pascal, Prolog, and other conventional "sequential" languages provide no tools for creating parallel tasks and coordinating their activities. Sequential languages lack the necessary adjectives and verbs. Programmers need new tools—either new programming languages, new dialects of old languages, or run-time libraries of system-level routines—to write parallel programs.

In my research group at Yale, we believe that settling on and delivering the right set of new programming tools is the central bottleneck in parallel software development. The right set, we believe, will meet three major requirements: *portability*, *efficiency*, and above all, *ease of use*.

We have developed a system called Linda that demonstrably meets these requirements. It has been implemented on a wide range of parallel machines and

continued

used to program a diverse set of applications, including numerical problems like matrix multiplication, LU decomposition and linear programming, parallel string comparison, database search, circuit simulation, ray tracing, expert monitors, parameter-sensitivity analysis, charged-particle transport, and others.

Linda meets our abstract requirements and seems to be working out in practice. Another aspect to the system, harder to explain but still important, moves Professor Kenneth Birman, a distributed-systems expert at Cornell, to call Linda "the most elegant piece of work in the area." Linda is a practical system; it is also an attractive and evocative thought tool. We're using it to parallelize existing software and to develop new program structures in which parallelism plays a central *conceptual* role in making complex, heterogeneous tasks manageable.

Nonnegotiable Demands

• *Portability*. An enormous range of parallel machines is available. You can't be expected to rewrite your applications whenever you move from one to another. In addition, any network of autonomous computers is itself, potentially, a parallel machine. For example, I may choose to port my program from a parallel workstation to a large, shared parallel computer and then to an entire network of machines. Allowing for some inevitable tuning when moving between grossly different hardware setups, we insist that *one* parallel language be appropriate at all three levels.

• *Efficiency*. A parallel language should perform well, not just on theoretical future machines but on the parallel computers that are bought and sold today.

• *Ease of use*. Like so many other construction tasks, parallel programming is straightforward if you have good tools and tedious or impossible if you don't.

Ease of use requires, first, that we support parallel applications with a programming language and not merely an operating system. An operating system might let you invoke directly, in raw form, the services you need in using parallelism—task creation and intertask communication. But an operating system doesn't supply a compiler or interpreter to recognize and process these service requests.

The compiler or interpreter that a parallel *language* provides is essential for convenient programming, because it supports clear syntax, generates compile-time warnings and error messages, collects information that can be used for debugging and tracing, and in some cases (Linda is an example) performs compile-time optimizations that dramatically improve the system's performance. This kind of compile-time optimization is one reason parallel languages can support far more sophisticated, higher-level programming abstractions than distributed operating systems can.

Ease of use requires, too, that a parallel language depart as little as possible from some convenient, conventional base language. Parallel programming does *not* necessitate doing *everything* differently. The move from sequential to parallel should not require mastering an entirely new language, or completely rewriting old sequential programs when it comes time to parallelize them.

Tuples don't have addresses; to find one, you match field values.

Finally, and most important, parallelism can be tricky to handle if your programming language forces you to think in simultaneities. An easy-to-use parallel language allows you to develop each thread of a multistranded parallel program independently of the rest to the greatest degree possible. This principle of *uncoupled* parallel-program development is the most important requirement in developing an easy-to-use programming system.

A Bag of Tuples

Writing parallel programs requires the ability to create and coordinate multiple execution threads. Linda is a model of process creation and coordination that is *orthogonal* to the base language in which it's embedded. The Linda model doesn't care how the multiple execution threads in a Linda program compute what they compute; it deals only with how these threads are created and how they can be organized into a coherent program.

Linda consists of a few simple operations that embody the "tuple space" (TS) model of parallel programming. A base language with the addition of these TS operations equals a parallel-programming dialect. We've implemented C-based and FORTRAN-based Linda systems; work is proceeding on a Lisp-based system, and other groups have implemented other flavors: For example, PostScript Linda (at Cogent Research in Beaverton, Oregon) and Modula-2 Linda (see reference 1).

TS is Linda's mechanism for creating and coordinating multiple execution threads. TS is a bag of tuples, where a tuple is simply a sequence of typed fields; for example, `("new stuff", 0, 16.01)` is a three-tuple that consists of a string, an integer, and a real number. Linda provides operators for dropping tuples into the bag, hauling tuples out, and reading them without removing them. To find a particular tuple, we use *associative lookup*: Tuples don't have addresses, so to locate the one we want, we search on any combination of field values. These simple mechanisms take care of all communication and coordination needs. Basically, if task *R* has some data for task *S*, *R* puts the data in a tuple and drops the tuple into TS. *S* can either read the tuple or haul it out, depending on circumstances.

Linda also supports "live tuples," whose fields aren't evaluated until *after* the tuple enters TS. When a live tuple is dropped into TS, it is evaluated independently of, and in parallel with, the task that dropped it in. When its evaluation is complete, it turns into an ordinary data tuple that can be read or removed like any other. This takes care of *task creation*. To create 100 parallel processes or tasks, you simply drop 100 live tuples into TS.

I first described Linda in 1982; Nicholas Carriero built the first implementation for Bell Lab's S/Net in 1984. (This was a major milestone, because it had been widely alleged that Linda was too high-level to be implemented effectively, particularly on distributed-memory machines like the S/Net.) Of the many implementations that followed, the most significant is Jerrold Leichter's system for autonomous VAX/VMS machines on a network.

Tuple Commands

There are four basic TS operations, `out`, `in`, `rd`, and `eval`, and two variant forms, `inp` and `rdp`. First, `out(t)` causes the tuple *t* to be added to TS (see figure 1); the executing process continues immediately.

Second, `in(s)` causes some tuple *t* that matches the template *s* to be withdrawn from TS; the values of the actuals in *t* are assigned to the formals in *s*, and the executing process continues. If no matching *t* is available when `in(s)` executes, the

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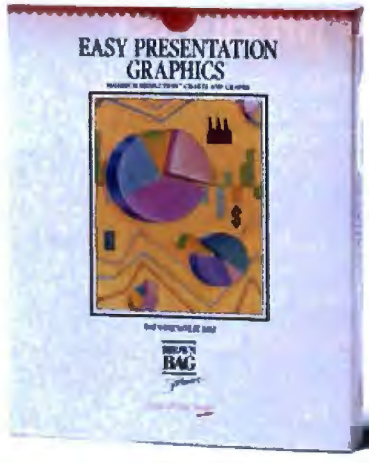

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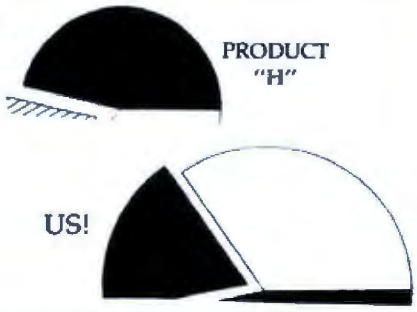

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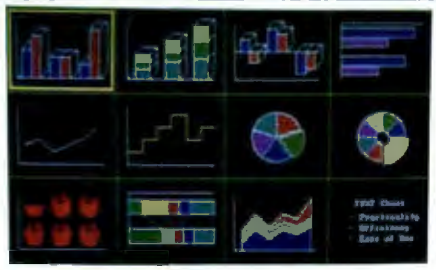

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executing process suspends until one is available, then proceeds as before. If many matching *t*s are available, one is chosen arbitrarily.

Third, `rd(s)` is the same as `in(s)`, with actuals assigned to formals as before, except that the matched tuple remains in TS. Predicate versions of `in` and `rd`, `inp` and `rdp`, attempt to locate a matching tuple and return a 0 if they fail; otherwise, they return a 1 and perform actual-to-formal assignment.

And fourth, `eval(t)` is the same as `out(t)`, except that *t* is evaluated after rather than before it enters TS; `eval` implicitly forks a new process to perform the evaluation.

TS is an associative memory. Tuples have no addresses; they are selected by `in` or `rd` on the basis of any combination of their field values. Thus the five-element tuple (A, B, C, D, E) may be referenced as "the five-element tuple whose first element is A," "the five-element tuple whose second element is B and fifth is E," or any other combination of appropriate element values.

To read a tuple using the first description, we would write `rd(A, ?w, ?x, ?y, ?z)`. This makes A an actual parameter—it must be matched against—and *w* through *z* formals, whose values will be filled in from the matched tuple. To read using the second description, we write `rd(?v, B, ?x, ?y, E)`, and so on. Associative matching is actually more general than this: Formal parameters (or "wild cards") may appear in tuples as well as match templates, and matching is sensitive to both the types and the values of tuple fields.

The Parallel Solution

The following problem may sound esoteric, but it's a good example, not only because the parallel solution is very simple and effective, but because the problem isn't really esoteric at all. It's a portent of parallelism's future role at the workstation level.

When new DNA sequences are discovered, geneticists often need to determine which previously known sequences they resemble. *Resemblance* is a qualitative measure that can be approximated using string-matching-like algorithms. Known sequences are kept on file in a database called GenBank; GenBank is large, and with progress in the widely touted "sequencing the human genome" project, it will grow much larger.

Skipping over some subtleties, one simple but effective approach to a parallel GenBank searcher is to create a col-

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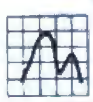

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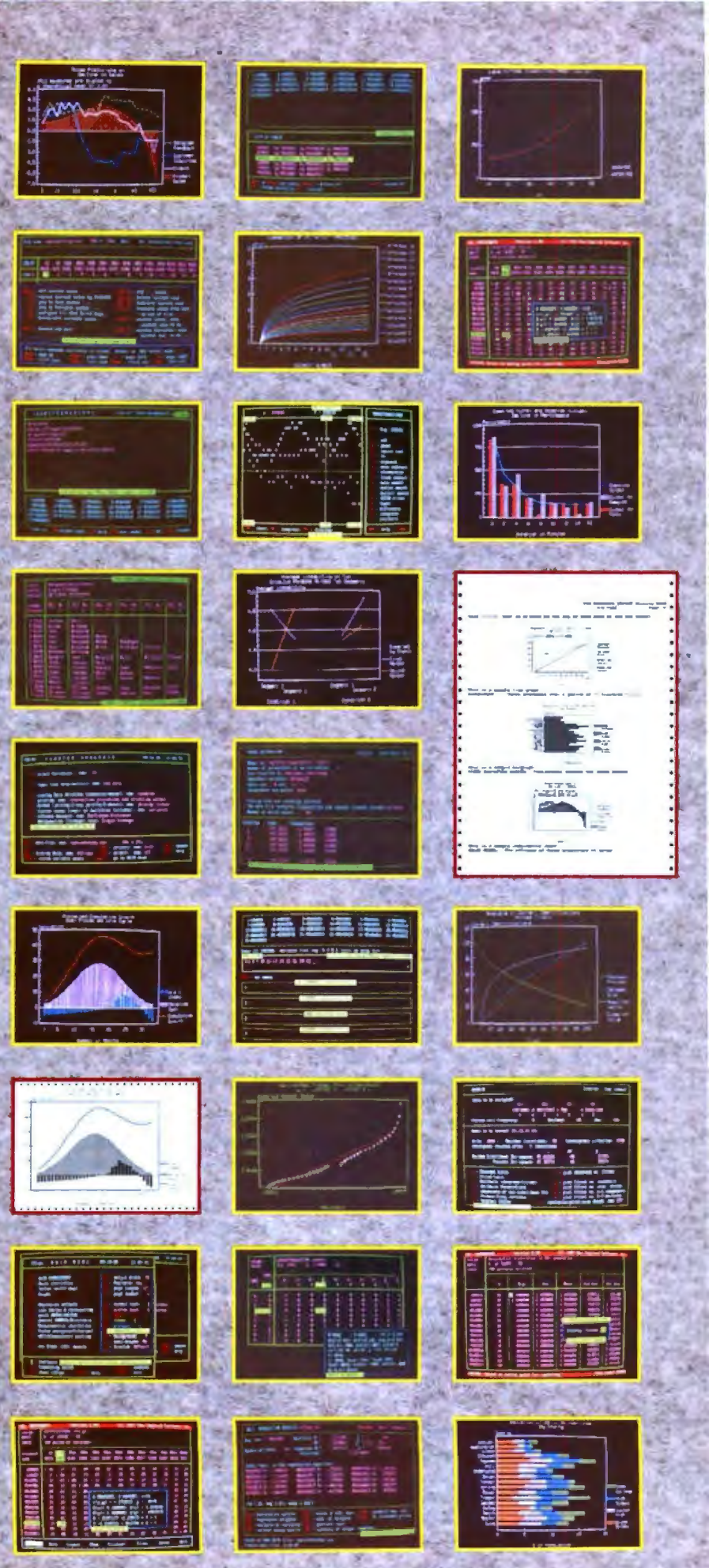

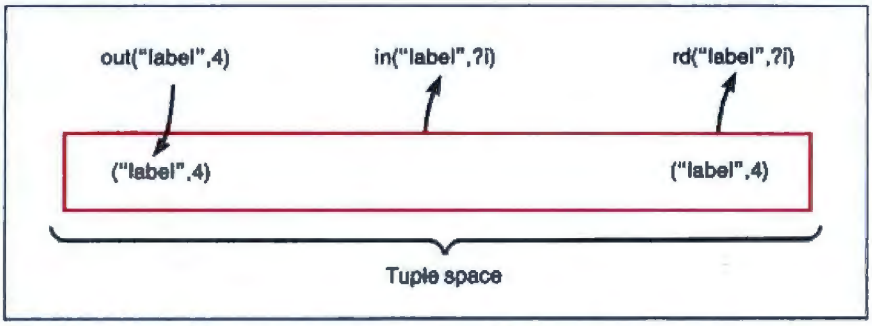

Figure 1: *The instruction* `out("label", 4)` *adds this tuple to tuple space while* `in("label", ?i)` *withdraws a matching tuple from tuple space;* `rd("label", ?i)` *simply reads a matching tuple without removing it.*

lection of identical search workers and one master task (on a 64-node hypercube, that's 63 searchers and one master). The master hands each searcher a copy of the target sequence; then it passes out sequences from the database. Searchers grab a sequence, compare it to the target, return the result to the master, and then grab another sequence.

It's easy to see how a Linda program might accomplish this. The master puts the target in a tuple, and each worker reads it. The master then scans the database, putting each sequence in a tuple; workers repeatedly reach into TS, grab a sequence tuple, compare it to the target, and put the result in another tuple.

A few important details: The sequences vary greatly in length; load balancing is better if searchers look at the long sequences first and work their way down to the short ones. (This prevents a run ending with the last active worker holding everything up while it performs a comparison against a very long sequence.) It's easy to implement this task ordering using Linda; you simply arrange the sequence tuples in a stream by using one field of each tuple as a stream index (the technique is described in reference 2). Searchers disassemble the stream from the front end, while the master adds sequences to the tail. Any database is potentially larger than available RAM, and so the master gradually plays out the database into TS, using a watermark algorithm (again, easy to implement in Linda) to avoid flooding it. (This program was designed and written by Nicholas Carriero of the Yale Research Faculty.)

How Well Does it Work?

The central issues in parallel programming are communication and coordination: moving data and results among the various worker tasks and ensuring that all workers have what they need when they need it. Linda makes communication and coordination easy because of the simple physical model on which it's based—merely a bag of objects, with new objects tossed in and old ones consulted or removed as needed. Linda is an *uncoupled* programming model—no worker task deals directly with any other; all transactions go through TS.

For example, when a worker has produced some intermediate result, it needn't know or care which other workers will need it. Labeled with any descriptive tag that seems appropriate, the new result is simply tossed into TS, and anyone who wants it can come and get it. Of course, Linda programming isn't merely a matter of tossing isolated tuples into the bag; TS is a form of distributed, associative, object *memory*, and programmers can build any kind of data structure they need out of tuples.

Linda has been implemented on shared-memory parallel computers like the Encore Multimax, Sequent Balance and Symmetry, and Alliant FX/8; on distributed-memory computers like the Intel iPSC-2 hypercube; on a VAX/VMS local-area network; and on several custom architectures, among them AT&T Bell Labs' S/Net and the Tadpole at the Vrije Universiteit in Amsterdam. Krishnaswamy of Yale and Ahuja of Bell Labs are building the Linda Machine, which supports Linda operations in hardware; the first boards have just become operational. Other groups have ports under way or planned to systems like transputer processors running the Trollius operating system, the BBN Butterfly running the Mach operating system, and the NCUBE hypercube machine.

Portability is good, but real availability is even better. Scientific Computing Associates of New Haven, Connecticut, is the current leader in the infant field of commercial Linda systems. It has systems available for the Encore and Sequent parallel machines. Our group at Yale distributes a simulator for Sun workstations. The VAX/VMS network system and the Intel system are each available through Yale to research sites; neither is "commercial" yet.

Several companies are working on their own Linda systems. Among them are Cogent Research of Beaverton, Oregon, producers of transputer-based parallel workstations; Topologix of Denver, Colorado, producing transputer-based add-on boards for Sun workstations; Human Devices of New York, producing computation servers for Macintosh networks; and AOX of Waltham, Massachusetts, which produces add-on boards for IBM PS/2s.

A quick summary of the run-time data for the DNA database program on two different machines, an 18-processor Encore Multimax and a 64-processor Intel iPSC-2 hypercube, shows that performance is excellent. A database search that would have taken about 5 hours on a single iPSC-2 processor (each processor is an Intel 80386) takes about 5 *minutes* running in Linda on the 64-node cube. While the Encore and Intel machines differ radically, the same Linda program runs, and performs well, on both.

The DNA parallel database program doesn't stress the efficiency of the Linda system much. There are Linda programs that are considerably more fine-grained than this one—they do less computing and more intertask communicating—that also perform well. Some are discussed in reference 3.

Finally, running Linda on 14 VAXes, some in California and some in New Mexico, Robert Whiteside of Sandia National Labs has handily beaten a Cray (both a Cray 1S and one processor of a Cray X-MP) on production code for parameter-sensitivity analysis (see reference 4). How he did it is the software equivalent of powering a city on recycled garbage: Whiteside built his "virtual supercomputer" out of nighttime VAX cycles that no one else wanted.

Coming Attractions

The DNA example is significant in pondering the future of the parallel workstation. There are lots of databases in the world. Most current-generation machines search them slowly, particularly if the search involves complex or dynamic search criteria. A parallel workstation that can search a large database quickly holds potential for a qualitative change. It lets the average information consumer tap into large knowledge reserves rou-

continued

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tinely, and in a sophisticated way.

Most of our current research focuses on new and better Linda systems and on scientific applications in Linda. But parallel workstations, and networks of conventional workstations, have enormous potential as well. Linda is a good tool for graphics applications: Ken Musgrave of Benoit Mandelbrot's group at Yale uses a Linda program to produce ray-traced images of fractal landscapes. Linda is also a good tool for building simulators: A circuit-level very-large-scale-integration simulator and a Monte Carlo radiation-damage simulation at Sandia are two examples.

Linda seems to be a good development tool for fast database-access and expert-database systems; for expert monitors that scan and analyze collections of incoming data streams (current work involves an ICU monitor system, but there may be applications ranging from automobile traffic control to financial monitoring); for "daemon databases"—databases with embedded expert daemons that examine and comment on the evolution of the objects modeled; and for distributed information services that can run on dynamic collections of autonomous microcomputers.

Some of these applications are well-developed research efforts, and some are only in the planning stage. But these systems and others like them will eventually contribute to a new era of parallel software—the age of software microcosms, knowledge filters, and information reservoirs—that is just around the corner. ■

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David Gelernter of the Yale University department of computer science in New Haven, Connecticut, is one of Linda's developers. He can be reached on BIX c/o "editors."

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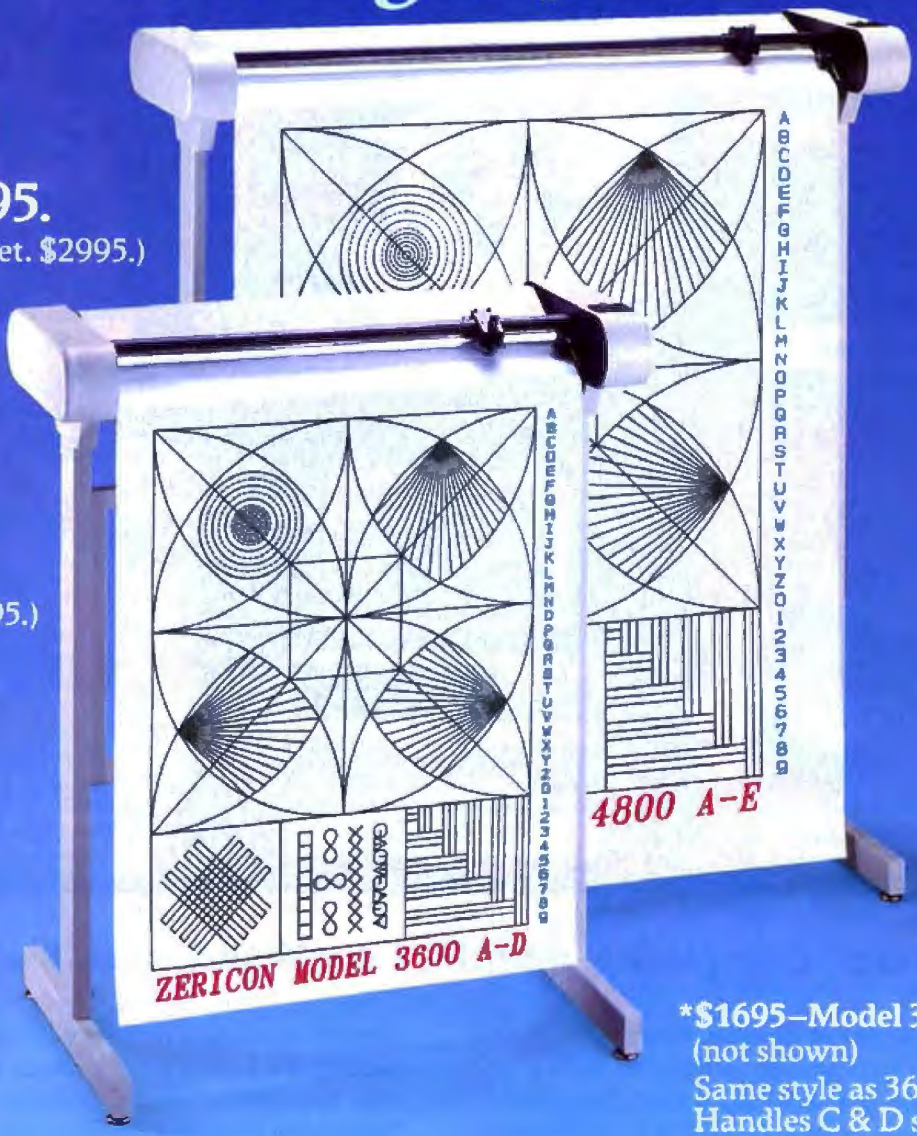

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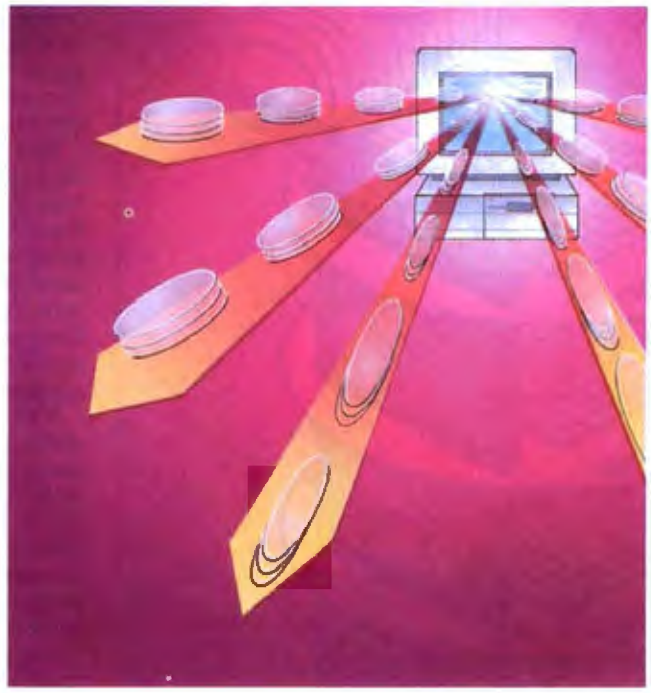
The Third Dimension

The 3-D Computer demonstrates the feasibility of the wafer approach

Michael J. Little and Jan Grinberg



Real-time image processing, and two-dimensional data processing in general, require enormously high data-throughput capabilities. Image and signal processing systems currently on the drawing boards have requirements for processors capable of between 10^{11} and 10^{12} operations per second. Parallel processing appears to be the only route available to achieve these extraordinary processing rates.

While there are several robust taxonomies for the various parallel-processing approaches, we have divided the field into two segments: multiple instruction–multiple data (MIMD) types, and single instruction–multiple data (SIMD) types.

The MIMD approach breaks a (large) processing task into subtasks and assigns each subtask to a separate processor. Each processor executes the necessary series of operations on its data values. The major difficulty with this approach comes from a frequent need for one processor to communicate with another processor so it can complete its task. This requires precise scheduling of the exchanges between otherwise independently running programs. As the number of processors gets larger, the interdependencies among programs become more complex. Load balancing—keeping each of the processors fully occupied—is another difficulty.

The SIMD approach assigns data values to each of the processors and then executes the same series of operations on each of the data values in *lockstep*. Thus, there is a single instruction stream, similar to that used in a uniprocessor except that the operations are being performed on all the data values simultaneously. For this reason, we have decided on an SIMD type of architecture.

A number of SIMD array processors have been successfully demonstrated in conventional two-dimensional IC technology. These include the ILLIAC IV, the Distributed Array Processor (DAP), the Cellular Logic Image Processor (CLIP-4), and the Massively Parallel Processor (MPP) (see references 1 to 4). In conventional technology, an array processor is built from an array of IC chips, each containing one or more processors, which are then linked together.

If we consider each chip in the array as a set of subfunctional units—A, B, C, and so on—then an alternative approach exists with three-dimensional integration. With this technology, the complexity of each processor in the array is determined by the depth of the 3-D stack, not just by the lateral dimensions of the circuitry. At Hughes Research Labs, we have built a 3-D Computer that demonstrates the feasibility of this approach.

continued

A number of extremely important system benefits result from 3-D partitioning: small size, low power consumption, high yield of WSI circuits, high reliability, and low cost. The massively parallel architecture ensures high throughput.

A Different Architecture

The basic structure of the 3-D Computer is an array of $N \times N$ identical elements contained on a stack of silicon *wafers* (see figure 1). The layout consists of an array of processors arranged horizontally, with the elements of each processor in the array connected vertically. If you look down the stack, you see an array of primitive computers, the individual elements of which are assembled underneath each other. Signals pass vertically through the stack along bus lines composed of *feedthroughs* (signal paths through the wafers) and microbridge *interconnects* (signal paths between the wafers).

Each wafer in the stack contains a complete $N \times N$ array of one particular type of processing element, such as an array of Shifters or Accumulators. All processors in a 3-D Computer are therefore identical, composed of the same vertical combination of computing elements.

A more schematic view of the 3-D structure depicts the stack edge-on and shows the control processor used to exercise the array hardware as a separate unit (see figure 2). The architecture is *word parallel* and *bit serial*; in other words, while the individual processors in the array employ serial arithmetic, they all operate simultaneously, in word-parallel fashion. Thus, the circuitry of the individual computing elements can be extremely simple, achieving the high densities necessary for its anticipated applications. The massive parallelism at the processor level more than compensates for the loss of speed incurred by using serial arithmetic.

In this architecture, data flows in a parallel fashion from the elements of one wafer to the corresponding elements of another; bit-serial processing occurs during the transfer. The functional elements are linked together vertically with a bus; thus, data can pass between *any* two wafers in the stack, not just between adjacent wafers.

For data-dependent processing, the transfer of arrays of data from one wafer to another can be mediated by one or more additional wafers. Statistics gathered from extensive simulations of a wide variety of algorithms indicate that each data transfer involves an average of 2.5 wafers. Pipeline registers in each wafer's control path let you configure wafers for the next operation while the stack is executing the current operation.

The normal word length (the length of the shift registers in each cell) is 16 bits. Consequently, the overhead associated with sequentially configuring the individual wafers is roughly 6 percent, which corresponds to using 1 clock cycle out of 16 to transfer the contents of the pipeline registers to the control drivers. Thus, an average of 1 out of 17 cycles is lost to control operations.

Five elemental wafer types are sufficient to perform all the algorithms we have studied to date (arithmetic operations, logical operations, matrix operations, image-analysis algorithms, and radar processing). Of the five—Accumulator, Shifter, Replicator, Counter, and Comparator—only the first two are essential; the other three enhance performance on certain common operations.

This modularity of functionality at the wafer level lets us assemble 3-D Computers optimized for particular applications. For example, an efficient radar-signal processor can be created from these five wafer types, as can a high-throughput linear algebraic processor; however, a slightly different combination of the wafer types would be used.

Partitioning the circuits into these five small modules has a dramatic effect on programmability. Each wafer type has an array of fairly simple, identical functional units (roughly 200 gates). Each of these units is controlled by roughly 10 control lines common to each array element. Thus, the ratio of logic to control lines—roughly 20—is 10^2 to 10^3 times higher than is found in current conventional two-dimensional implementations, providing you with control virtually down to the AND and OR gate level.

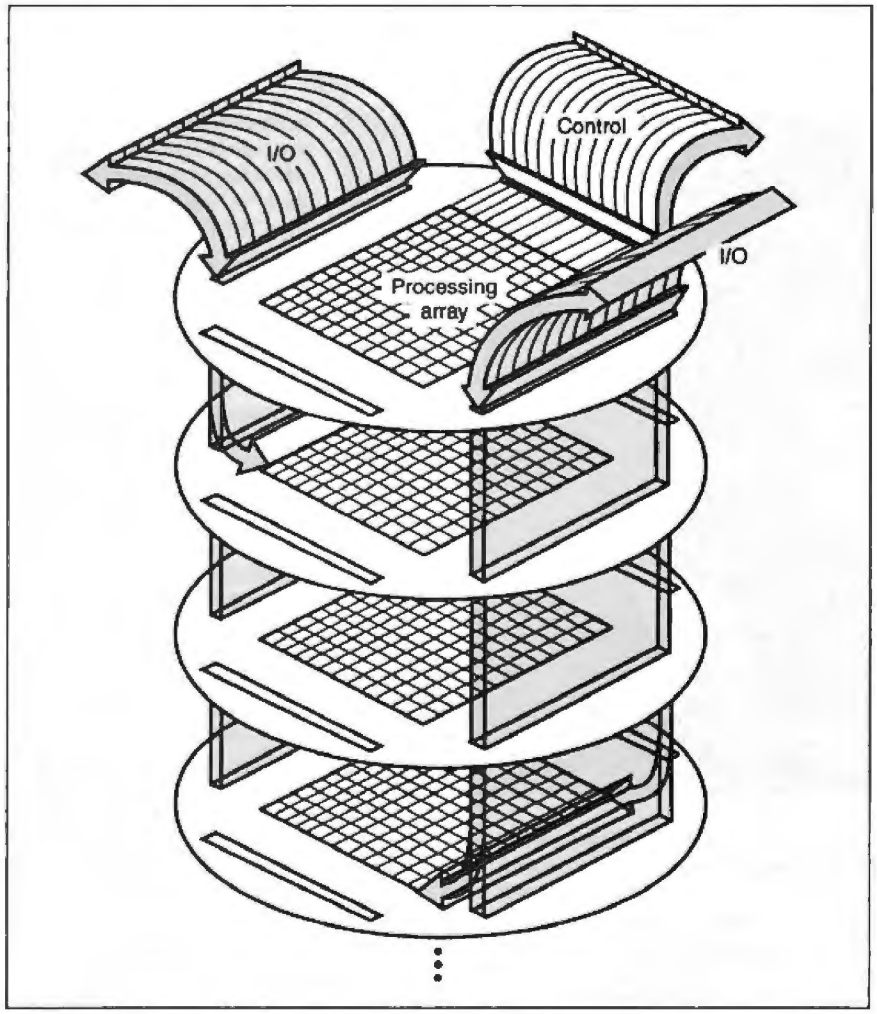


Figure 1: *The 128- by 128-element 3-D Computer. Notice the literal stack of array-processing wafers.*

Technical Necessities

Three underlying technologies make possible the creation of the 3-D Computer: feedthroughs, interconnects, and wafer stacking. Feedthroughs make communication between the opposing faces of a silicon wafer possible by routing signals through the wafer. Interconnects make electrical communication between adjacent wafers stacked one on top of another practical. And wafer stacking enables the circuits on each of the wafers to precisely register with one another.

With these three revolutionary technologies, it's feasible to assemble a stack of circuit-bearing wafers, each of which can communicate directly with any other circuit above or below it.

Feedthroughs

We evaluated several possibilities for communicating through a silicon wafer, including optical communication in the near-infrared range where silicon is transparent, creating holes through the wafer and filling them with a conductor, and thermomigration. Each approach has its merits and its drawbacks.

The first approach, optical communication through a silicon wafer, is possible with near-infrared radiation. Silicon is transparent to radiation beyond approximately 1.1 micrometers (μm), so you can simply transmit through it in unmetalized areas. This approach has three difficulties: avoiding crosstalk between closely spaced communications channels (diffraction, reflection, and scattering mix the separate communication beams together); the complexity resulting from hybridizing the emitters and detectors onto the silicon wafers (generating optical beams would require light-emitting or laser diodes at each circuit node); and, most difficult, power dissipation and thermal management. In complex systems with large numbers of communication paths, the poor efficiency of LEDs and laser diodes—the ratio of electrical power in to optical power out—puts an enormous burden on the power-distribution and heat-dissipation systems.

The second approach, small-diameter holes through a silicon wafer, can be produced by several techniques, including laser drilling and chemical (anisotropic) etching. The main pitfall with through-the-wafer holes is the drastic reduction in the wafer's mechanical integrity. It appears most practical to produce through-the-wafer holes prior to circuit fabrication; doing it afterward introduces grave risks to the circuits because of the destructive nature of the two processes. If the wafers are perforated with tiny holes, handling them becomes a nightmare. Stress concentration around each of the holes and the crystalline structure of the wafer encourage crack propagation and shattering if stressed by tweezers as in normal handling.

The third approach is thermomigration. In the early 1950s, Pfann of Bell Telephone Laboratories showed that the phenomenon of temperature-gradient zone melting (thermomigration) could be used to dope semiconductors and to produce p-n junctions in semiconductor materials. For the thermomigration of aluminum in silicon, the surface of an n-type silicon wafer is coated with a layer of aluminum metal patterned into an array of small dots using conventional semiconductor processing. The silicon wafer, with its array of aluminum dots, is mounted in a specially designed furnace capable of producing the requisite vertical thermal gradients at the desired operational temperature, typically 1100°C. When the temperature of the wafer exceeds 660°C, each aluminum dot melts and begins to dissolve the underlying silicon.

When the aluminum dot is saturated with silicon, the thermal gradient established across the wafer becomes the dominating effect. The dissolving and precipitating of silicon at the interface between the molten silicon and aluminum in the droplet is in dynamic equilibrium. But because the bottom side of the droplet is slightly warmer than the top side, in effect, silicon is dissolved on the warmer (bottom) side and precipitated on the cooler (top) side. Thus, the molten aluminum-silicon droplet "eats" its way through the silicon wafer. The precipitated single-crystal silicon contains a high concentration of aluminum, which is a p-type dopant. When the process is completed, you have highly conductive p-type channels penetrating through the silicon wafer, each one diode-isolated from the others.

The advantages of thermomigration are that the wafers don't require hybridizing with additional materials with distinct thermal and mechanical properties, and that they aren't perforated. At first glance, they are indistinguishable from ordinary wafers without any through-the-wafer communication channels.

Interconnects

The 3-D Computer also requires wafer-to-wafer interconnections. The antici-

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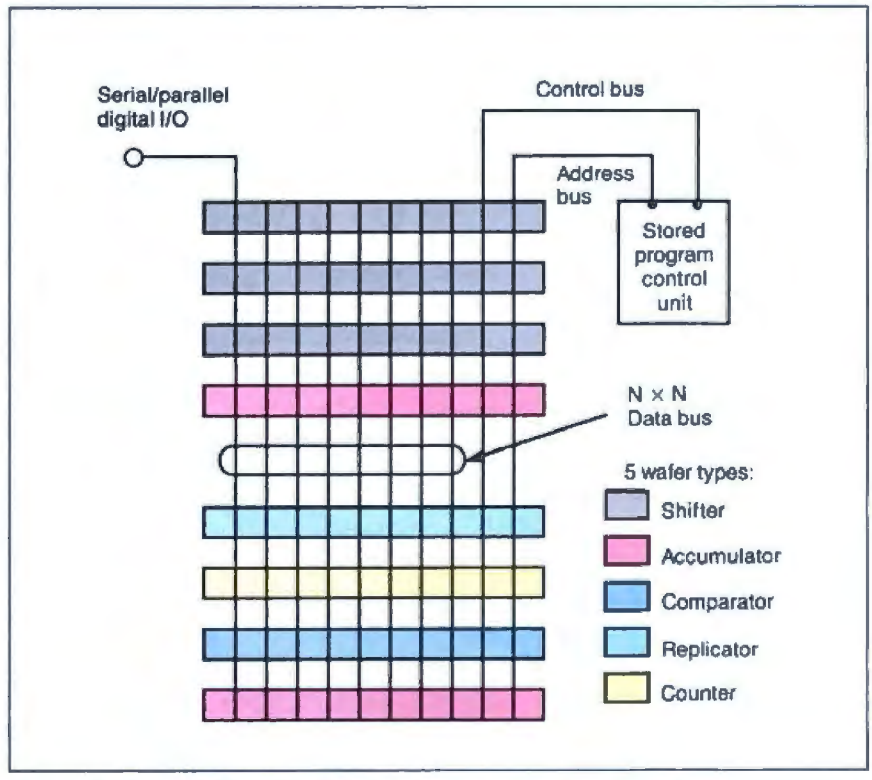

Figure 2: *Schematic of the system organization. The silicon wafers are represented by horizontal rectangles, and the vertical lines running through the stack depict the data, control, and I/O buses.*

pated need for a large number of contacts (10^4 to 10^8) means you need extremely high reliability and small contact dimensions. Also, any proposed interconnection technique must be compatible with somewhat distorted (nonflat) wafers. Having a bus that passes through all wafers in the stack requires that the contacts be electrically fast, of low capacitance, and of low resistivity. These are very stringent requirements, and they limit the number of feasible approaches.

Spring contacts (see figure 3) are fabricated so the height of the tunnel underneath them is enough to compensate for the distortion across a wafer; thus, you can reliably achieve complete interconnection of all contacts. They are batch-fabricated by vacuum evaporation, a process compatible with silicon technology.

Contacts on adjacent wafers are rotated 90 degrees with respect to each other when mated. Thus, the springs make contact at right angles, forming a cross. An important advantage of the bridge-type spring is that it can be as long as the computing cell and still occupy only a small amount of valuable silicon real estate. This ensures a more secure interconnection and is very tolerant of wafer-to-wafer lateral displacements. The stack can be disassembled and the individual wafers demounted. In addition, the spring remains flexible when the assembled stack is thermally cycled.

The principal fabrication steps for the spring contact are these: A spacer about 50 μm or thicker is evaporated or deposited on the circuit wafer; the spring contact metal is evaporated on top of the spacer; then the spacer is etched away, leaving a freestanding flexible microbridge (see photo A).

To secure the contact between two microsprings, each has an outer coating of indium-tin solder that is vacuum-deposited at the same time as the structural layer of the microbridge. After the stack is assembled, the stack is heated to the melting point of the solder, and each mated pair of microsprings is fused together, resulting in a permanent, reliable connection.

Getting Bigger Every Day

While the 3-D technologies represent an unprecedented level of 3-D integration, the ability they provide to communicate vertically, between wafers, is still nearly two orders of magnitude lower than standard two-dimensional communications. Thus, partitioning hardware across the various levels of the wafer stack is a very important consideration.

The overall structure of a cellular array is that of an $N \times N$ array of identical computing elements, working in lockstep, executing a common program. We had to decide how to distribute this array's circuitry across a stack of wafers. Since we chose serial logic for the cell circuitry, only a single primary data line would be associated with each computing element. Thus, it was natural to run this array of single data lines vertically through the stack, spreading the functional units of each computing element vertically across multiple wafers.

The detailed partitioning of the processing elements across the wafers is determined by a variety of factors. For one, the cells on all the wafers need to be approximately the same size. If they are not, the largest cell determines the cell areas on other levels, resulting in a waste of silicon.

Overall constraints on the cell size are imposed by the size of the array, the minimum feature size of the circuit technology, and the overall size of the wafers. In general, the trade-off is to use more layers in the stack rather than larger cells in each layer. Current and projected application requirements call for processing arrays of 128 by 128 elements and 512 by 512 elements, respectively. Since the horizontal dimensions are limited by the size of the wafers available, the cell circuitry on each wafer must be strictly limited.

On the other hand, several factors argue for larger cells. An absolute lower limit is set by the requirement that the circuitry on each level pass some minimum meaningful level of functionality. Beyond that, some overhead is associated with the cells themselves and with getting information off-chip.

One component of this overhead is the area consumed by the 3-D feedthroughs themselves, about 2 by 2 mils each. In addition, between 5 and 10 transistors would be required to implement the necessary interface between the cell circuitry and the data bus. This overhead would be the same regardless of the size of the rest of the cell. Thus, efficient use of silicon indicates the use of larger cells.

Balancing these constraints means having cells of roughly 200 gates each on each of the functional planes of the 3-D Computer. This design enabled us to fabricate four 32 by 32 arrays on a 4-inch wafer; it will let us put a 128 by 128 array

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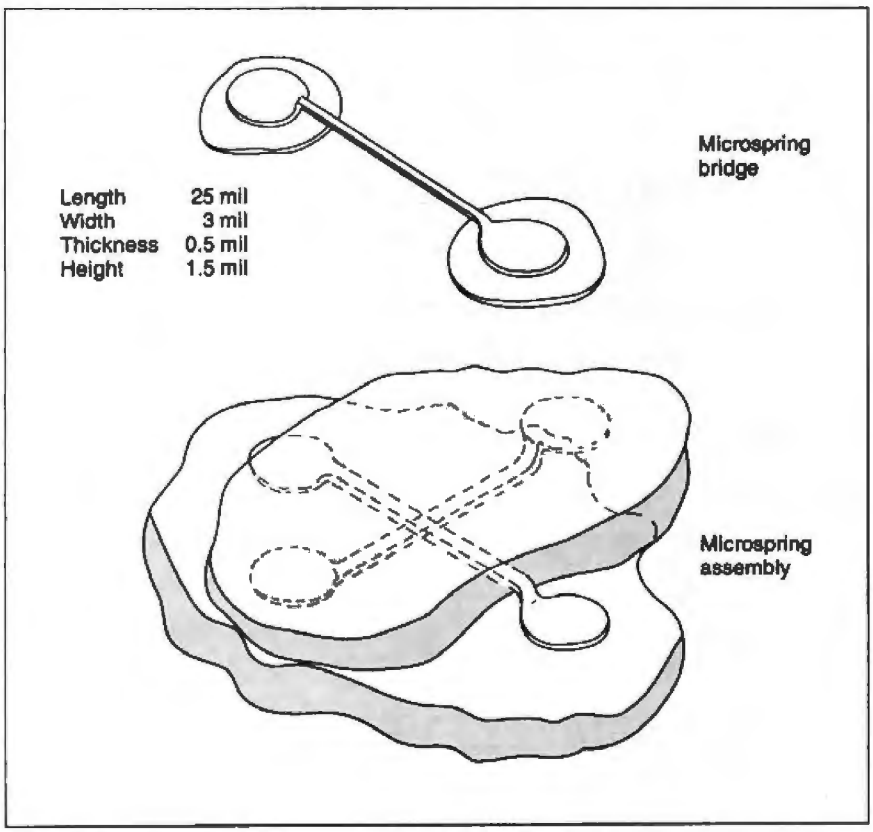

Figure 3: *The microspring interconnects. Notice how adjoining microspring bridges are assembled at 90-degree angles from each other.*

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The concept of improving yield by adding redundant circuitry is simple. You include a number of "spare" circuit elements in the system and provide some means of substituting them for other elements that may fail. It would seem that this process could be extended indefinitely to virtually guarantee perfect yield; however, this is not the case.

Both the redundant elements and the substitution means are also affected by processes that may introduce defects. Thus, the overhead associated with interconnecting the substituted redundant elements into the primary system is unavoidable. The more redundant circuitry you add, the greater this overhead becomes. Eventually, the yield of the primary/redundant interconnect wiring becomes the dominant factor in the yield of the system as a whole.

Another parameter you must consider in evaluating redundancy schemes is the resolution that they permit in selecting "good" material. This may be restated in terms of the module size of the substituted components. Very large modules require that you discard a great deal of otherwise functional components as the result of a single malfunctioning element. This is inefficient, since a much larger amount of circuitry will be required to obtain a given yield level than would be needed in a system with smaller modules. On the other hand, systems with larger modules generally require less circuitry and wiring devoted to the primary/redundant interconnect function.

Thus, we can see that there is a tradeoff involved in designing a redundancy scheme. It's desirable to choose a small module size for primary/redundant substitution, to minimize the amount of good circuitry that must be thrown away with the bad. However, it's also important to minimize the amount of interconnect wiring required to effect the substitution of redundant circuitry into the system, to avoid yield loss from that wiring.

In 3-D

In designing the yield policy for the 3-D Computer, we considered both of these factors. The small size and relative independence of the circuitry in the functional cells make it natural to introduce redundancy at the cell level. Furthermore, the machine's physical structure requires the redundant elements to be located close to the units they are intended to replace. Finally, the large array size requires a substantial amount of redundancy.

These factors led us to adopt a 2-to-1 redundancy approach for our 32- by 32-element machine, in which every functional cell on each wafer contains two identical circuits.

The primary and redundant circuits have separate I/O pads to make defect detection easy at wafer-level testing. If both primary and redundant circuits are functioning correctly, no action is nec-

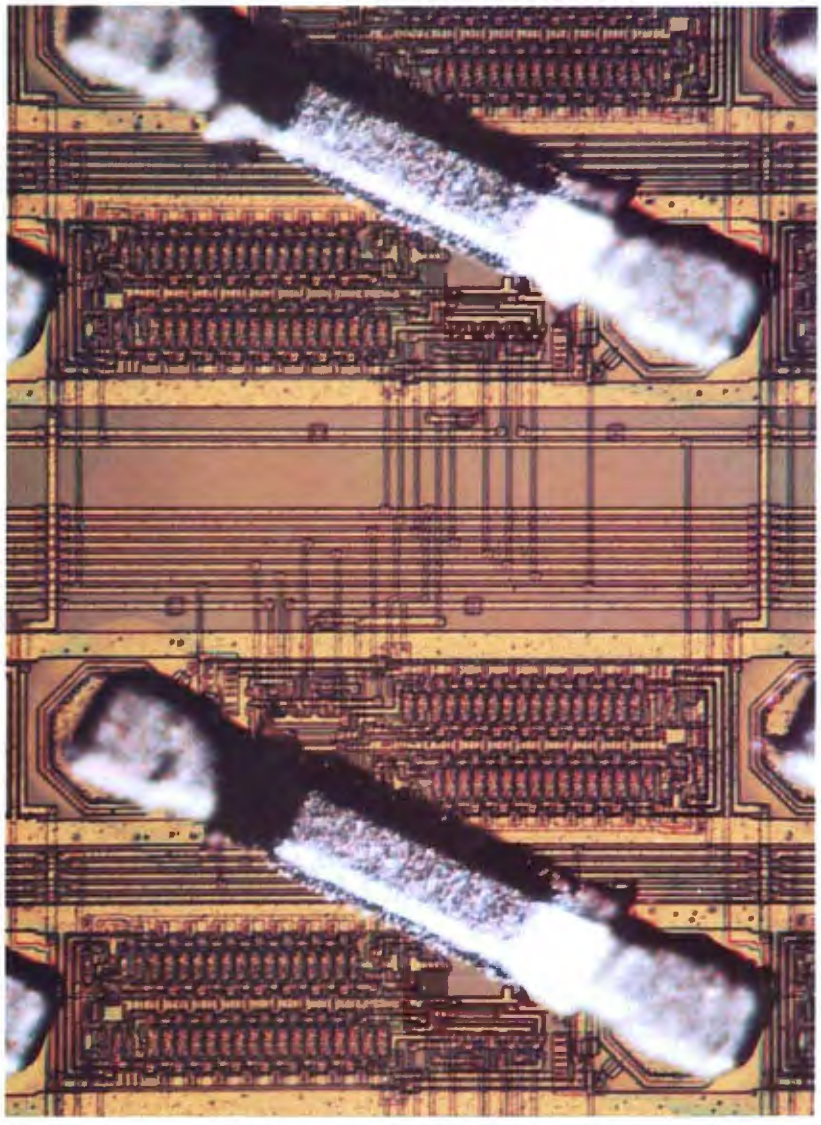

Photo A: *A 3-D circuit with microbridge interconnects. The microbridge connects the primary circuit to its redundant counterpart.*

essary. If one of the two circuits is faulty, however, it's manually disconnected from its microbridge footpad with the aid of an ultrasonic cutter. The remaining circuit supplies the functionality for that node. If both circuits in any given cell are bad, then the entire wafer is discarded.

This particular scheme, coupled with the microbridges, has subtle benefits. Normally, disconnected redundant circuits are easy to test but require more elaborate steps for repair (need connect capability), while normally connected circuits are easy to repair (cut only) but faults can't be easily diagnosed.

In 3-D circuitry, the primary/redundant circuit pair is connected by a microbridge after the testing is complete (see photo A). Thus, testing is relatively easy because you can test the two circuits independently.

The control circuitry at the periphery of the processor array also needs redundancy to be able to tolerate processing defects. Each row of circuits in a 3-D array is controlled by two identical peripheral-control drivers: one to the east and one to the west, providing 100 percent redundancy to the control circuitry and affording tolerance for at most one open line defect per row. The control signals are distributed over the array with tristate drivers, which can be independently disabled when testing at the wafer level or if the circuitry or tristate driver on one side is faulty.

Although the 100 percent redundancy scheme was proven to be adequate for the 32 by 32 arrays—67 percent of circuits received from the silicon foundry were brought to 100 percent functionality—it's not enough for the larger arrays under development. However, by adding the possibility for primary cells to *share* the redundant circuits, the yields improve dramatically.

Local sharing is also of considerable importance in dealing with clustered defects. For our 128 by 128 and larger arrays, we will use a 50 percent redundancy approach, but allow each spare to be connected to two primary circuits and each primary circuit to be connected to four spare circuits. The expected yield of 100 percent functional circuit arrays using this approach for both the 128 by 128 and 512 by 512 arrays is more than 90 percent.

on a 4-inch wafer. The 512 by 512 arrays will require 6-inch wafers.

The main factor determining the maximum practical size of microelectronic circuits is the decline of yield with increasing chip area. The large array sizes planned for the 3-D Computer make yield a primary concern. (See the text box "The Yield Problem" at left.)

Working Wafers

By far the majority of the processing occurring in the 3-D Computer takes place in the Accumulator and Shifter wafers. Each cell of these wafers has a 16-bit serial-memory register for data storage, and CMOS circuitry to provide the required logic functions. The cells of the Shifter wafer (see figure 4) not only store data but also perform lateral data transfer between adjacent processors in the array. Each Shifter cell has direct nearest-neighbor communications with others on the same plane and can pass data values north, south, east, or west on the array. Under software control, data within each Shifter cell can pass to any one of its four nearest neighbors in the array independent of the vertical data buses. Thus, multiple planes of data can shift laterally while processing is executing on the stack data buses. These independent neighbor-communications paths enable stack I/O during processing.

The Accumulator circuitry (see figure 5) is similar in complexity to that of the Shifter. The main features of the Accumulator are full adder and a bidirectional shift register. The Accumulator provides the functionality for arithmetic and basic logic. It also participates in normalizing floating-point numbers. For example, two's-complement subtraction is accomplished by allowing a "carry" to be introduced into the least significant bit of the word prior to executing the arithmetic operation. (The bitwise inversion of the subtrahend required by two's-complement subtraction is provided at the output of the Shifter cell circuitry.)

The other three wafer types, while not absolutely essential to the operation of the 3-D Computer, serve to speed up the execution of various algorithms. The Replicator wafer can rapidly propagate data values across an entire array.

The Counter wafer can count the number of occurrences of a single-bit piece of data in a single clock cycle. A normal Accumulator cell could be used for this purpose, but it would require a full 16 clock cycles to tally each single-bit occurrence. This capability is very useful in calculating histogram distributions of

continued

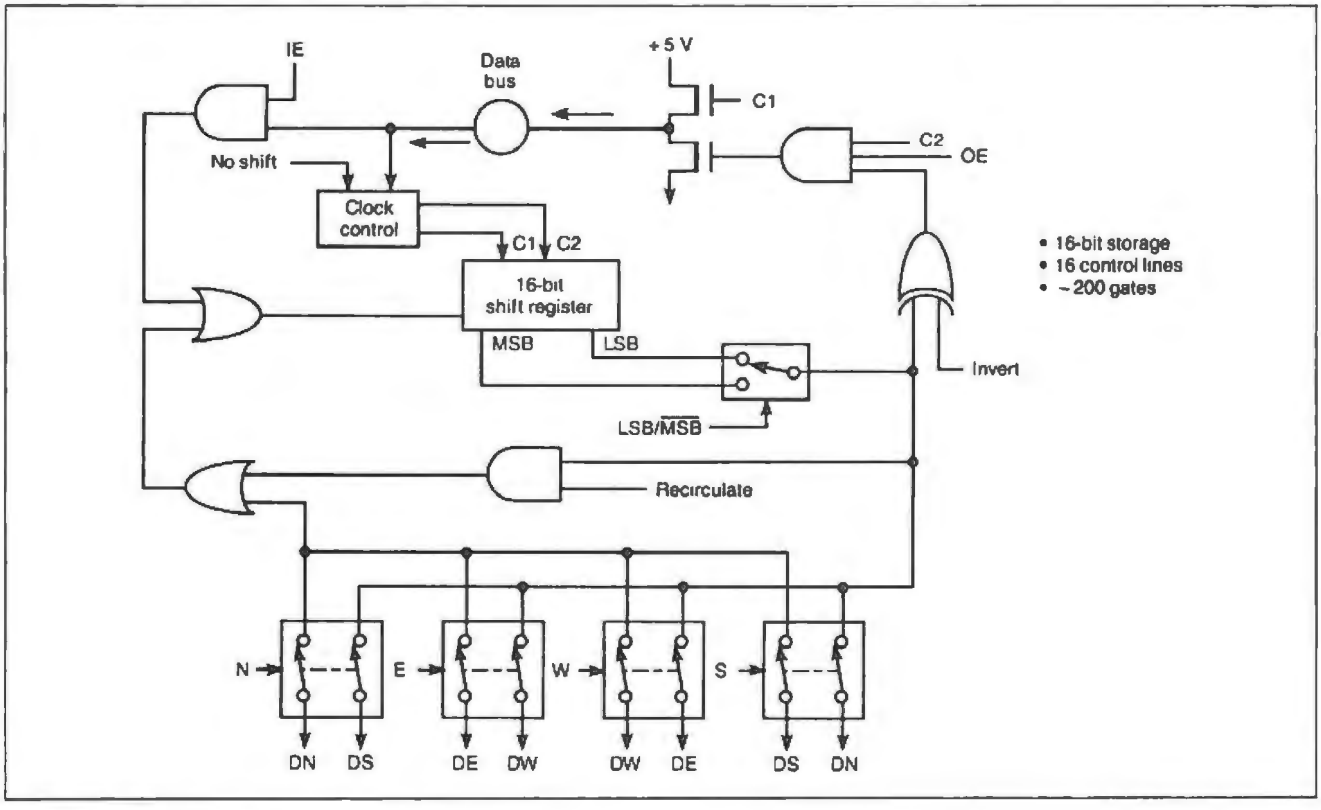

Figure 4: *The Shifter wafer type (formerly memory).*

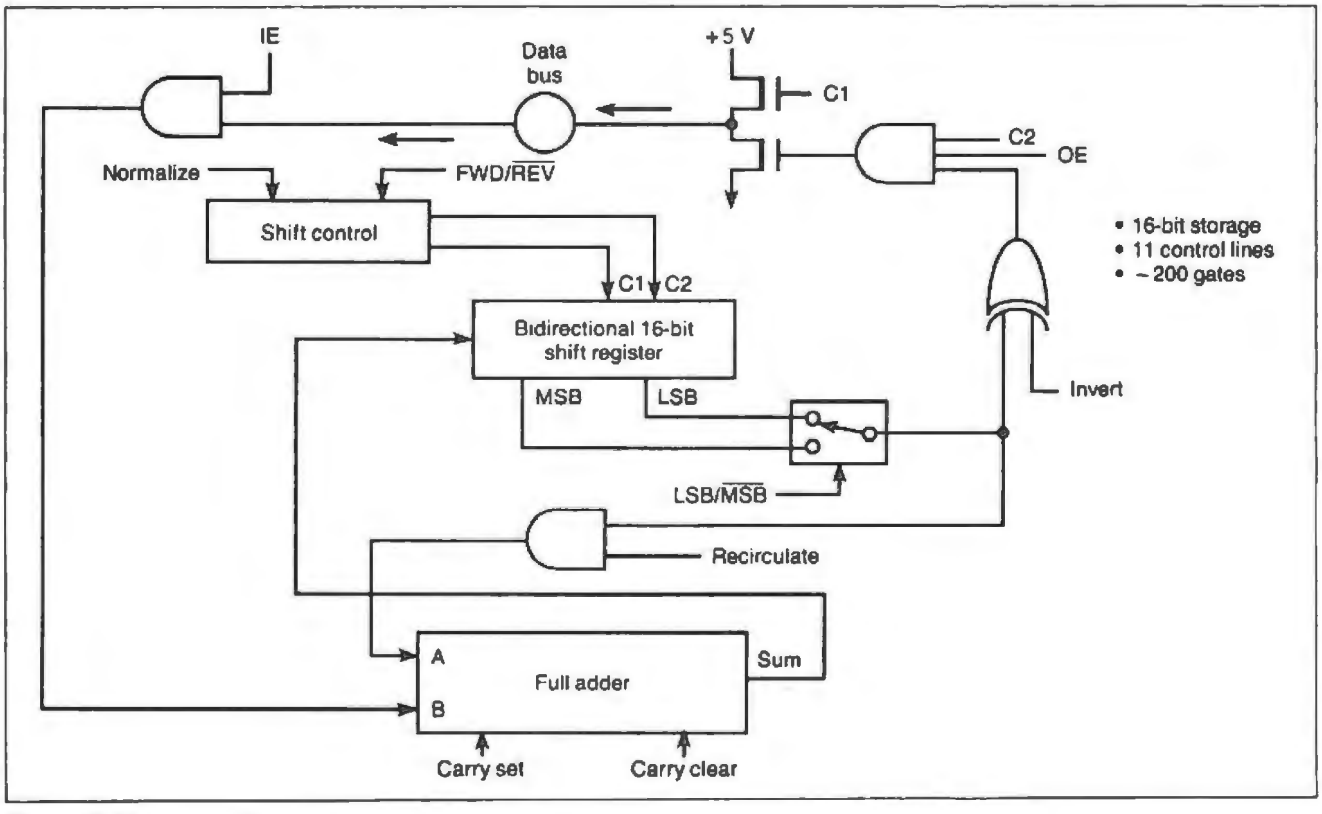

Figure 5: *The Accumulator wafer type.*

Table 1: *Processing times for various operations on a 10-MHz 32- by 32-element 3-D Computer. All times are in microseconds.*

Operation	Time
Data move (SHFT 1 → SHFT 2)	1.8
ADD (ACC + SHFT → ACC)	1.8
MULTIPLY (ACC × SHFT → SHFT)	42.2
DIVIDE (ACC + SHFT → ACC)	127.1
SQUARE ROOT (ACC → ACC)	152.6
Sobel edge operator	54.3
256 × 256 matrix multiply	12.0
256 × 256 8-bit histogram	1.7
256 × 256 matrix inversion	10.2

Table 2: *Characteristics of existing and future-generation 3-D Computers.*

Processor array size	32 × 32 (current)	128 × 128 (under development)	512 × 512 (future)
Circuit size	1" × 1"	2.5" × 2.5"	4" × 4"
Circuit technology (CMOS)	3 μm	2 μm	1 μm
Clock frequency	10 MHz	10 MHz	10 MHz
Processing throughput	600 × 10^8 OPS	10 × 10^9 OPS (390 MFLOPS)	160 × 10^9 OPS (6.2 BFLOPS)
System volume	1.3 cubic inches	2.5 cubic inches	7.5 cubic inches
System weight	170 g.	225 g.	470 g.
System power	1.5 W	500-100 W	100-150 W

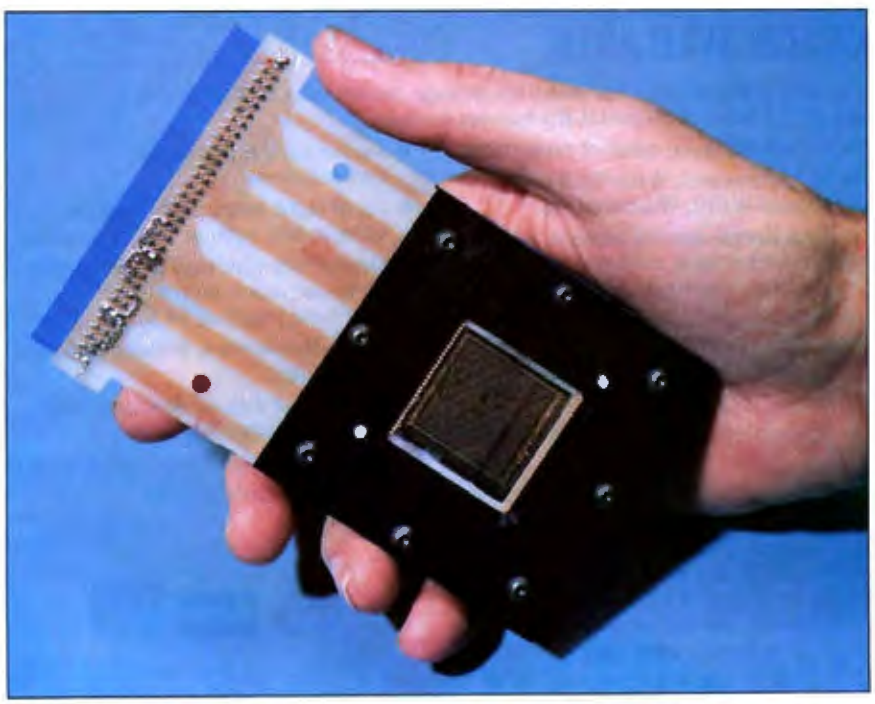

Photo 1: *A "hand-held" computer. The 1-inch square in the black section is the 32- by 32-element 3-D Computer.*

image data, an operation important in vision processing for image segmentation.

Comparator hardware also exists mainly to speed up operations that could be performed more slowly by the Accumulator circuits. Each cell of a Comparator wafer contains a 16-bit register into which a reference value can be loaded, together with circuitry for performing serial-magnitude comparisons.

It Works!

Additional constraints apply if wafer scale systems are to find widespread use: They must be moderate in cost and size. While state-of-the-art general-purpose supercomputers such as the Cray X-MP can approach the lower end of the processing speeds required—from 10^{11} to 10^{12} operations per second—they fall far short of the size and cost constraints.

Table 1 summarizes performance for several primitive operations, as well as for some algorithms frequently encountered in image processing. Note that the indicated operations are completed everywhere on the array in the indicated time. Consequently, while some operations, such as multiplication, appear to occur relatively slowly, the aggregate throughput of the array as a whole is enormous.

The 3-D Computer (see photo 1) demonstrates the feasibility of the wafer approach. The operational characteristics of the 32- by 32-element machine and the projected characteristics of the 128- by 128-element 3-D Computer currently under construction are summarized in table 2. We hope to have the 128- by 128-element machine running by mid-1990. The projected characteristics of a 512- by 512-element 3-D Computer (planned for mid-1994) are also included. ■

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TAIWAN'S HIGH TECH TAKE-OFF

A dynamic information industry offers quality, innovation and value.

A dynamic information industry offers quality, innovation and value.

Once the made in Taiwan label usually went with low cost garments and simple electrical appliances. Not any more. Taiwan has moved aggressively into the information industry -- in everything from computers and peripherals to software and advanced telecommunications equipment. From nowhere just a few years ago, Taiwan today ranks as one of the world's largest producers of information equipment.

Much of this gain has been homegrown. Although big name computer and peripheral manufacturers find the island a remarkably congenial production base, the exciting fact about Taiwan's emergence as a major player in this industry has been the development of a large number of local manufacturers and suppliers. Unlike countries like Singapore, which mainly assemble components, the information industry in Taiwan has been built from the ground up -- beginning with such basics as petrochemicals, plastics and fine chemicals.

Local entrepreneurship and innovation, with a strong assist from foreign investors and expatriate Chinese returning with their experience in the U.S., have added to the industry's market driven dynamism and innovative flair. The government of the Republic of China has helped with incentives and R&D support, recognizing early that computers and related products would be a mainstay of the economy in the '90s.

New Boy On The Block

Taiwan's information industry is of recent vintage, really getting underway only around 1980. By 1987, however, with over fifty thousand workers the hardware side alone was producing $3.8 billion in goods -- up 79% over 1986.

(highlighted quote)

By the end of 1988 Taiwan is expected to be the world's sixth largest hardware producer.

These gains have been matched by an increasing share of the world market. In 1987 Taiwan's hardware producers captured 2.4% of the world market, almost double the 1.45% share in 1986. This made Taiwan the world's seventh largest manufacturer. By the end of 1988 Taiwan is expected to be the world's sixth largest hardware producer.

Taiwan's Hardware Production Surges

Strong Export Growth

Almost all of Taiwan's hardware production is exported - $3.7 billion in 1987. Here agein the 79% growth rate is far higher than the 10% world average. Expectations are for Taiwan to maintain its fast track pace for at least, the next three to five years, based or current investment, high productivity and industry competitiveness. Information industry products now account for more then a third of all Taiwan's electronics exports

Exports Pace Information Industry Gains (TABLE 2.)

TABLE 2. Annual ROC Export of Information Products and Components

Value Unit: US$ 1 Million
Volume Unit: 1,000 Units

	1984 Export Value	1985 Export Value	1986		1987		Growth Rate (%)
			Export Volume	Export Value	Export Valume	Export Value	
Mini Computer	—	—	—	—	0 2	1 8	—
Micro Computer	152	240	1,113	393	1,958	759	93
Disk Drive	86	42	715	71	655	97	37
Printer	23	45	84	41	73	44	7
Terminal	207	225	1,318	317	1,530	414	31
Monitor	319	303	4,852	500	7,022	847	69
Other Peripherals	104	256	—	44	—	80	82
Information Product (%)	891 (88.7%)	1,111 (91%)		1,366 (66%)		2,243 (60 6%)	64
Computer Component (%)	113 (11.3%)	109 (91%)		697 (34%)		1,458 (39.4%)	109
TOTAL (%)	1,005 (100%)	1,220 (100%)		2,063 (100%)		3,701 (100%)	79%

Sources: MIC, Institute for Information Industry, ROC

Looking at the 1987 totals, four clear trends are apparent. The first is the continued importance of peripherals to Taiwan s export profile. In particular, the island remains one of the world's most important suppliers of video display monitors.

A second trend is the enormous growth in exports of microcomputers and related peripherals. These are rapidly becoming the mainstay of the Taiwan industry. Between 1984 and 1987 the number of microcomputer markers almost doubled, increasing from 19 to 35, This has brought a broadening of the marketplace.

Boom In Microcomputers And Color Monitors (TABLE 3.)

A third key trend is the boom in computer component exports. In 1987 these totalled almost 40% of all information industry exports compared to 34% in 1986.

Finally, there is the role of foreign companies, both as manufacturers and purchasers. From the outset, foreign investors have been an important part of Taiwan's information industry. But with the rapid expansion of reliable, innovative home-grown companies, able to meet international quality standards, opportunities for OEM sourcing in Taiwan have greatly expanded. As a result, last year for the first time OEM exports surpassed foreign investor shipments. Foreign company output and OEM now account for 80% of Taiwan's hardware production, highlighted quote

TABLE 1. Information Industry Production Value of Major World Producers

1987 RANK	1986 RANK	Country	Production Value (US$100 Million)	Growth Rate
1	1	USA	454	7%
2	2	Japan	212	8%
3	3	W. Germany	81	5%
4	4	Britian	59	9%
5	5	France	53	5%
6	6	Italy	42	4%
7	7	ROC	38	79%
8	10	Singapore	23	71%
9	8	Ireland	20	8%
10	9	Holland	18	5%
11	13	S. Korea	15	63%
12	11	Canada	13	10%
13	12	Hong Kong	8	15%

Sources: MIC, Institute for Information Industry, ROC

TAIPEI

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Taiwan has emerged as one of the world's most dynamic commercial centers for microcomputers, a wide range of peripherals, and other computer products. The latest offerings to stimulate worldwide buyer interest are newly developed personal computers that represent an outstanding market value.

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TABLE 3. Annual Growth of ROC Information Product Market Share Unit: %

ITEM \ YEAR		1984	1985	1986	1987
Micro Computer		19	28	30	35
Disk Drive		11	5	5	5
Printer		3	5	3	2
Terminal		26	26	24	19
Monitors	Monochrome	33	22	19	15
	Color	8	14	19	24
Total		100	100	100	100

Sources: MIC, Institute for Information Industry, ROC

Last year for the first time OEM exports surpassed foreign investor shipments

The Rise Of OEM (TABLE 4:)

Increasing Software Production

Software production in recent years has also demonstrated significant growth, with the annual gain averaging almost 50%. Software production in 1986 was valued at $120 million. This involved some 265 firms -- three times the number in 1981. This reflects the impact of the expanding microcomputer market.

Import Opportunities Open Up

Information products are imported either for local consumers or for manufacturers who re-export the products once installed in assembled units. Because of strong internal and external demand the value of imports climbed 39% in 1987 to $813 million.

Historically Japan has been Taiwan's major supplier, eapecially of printers, with the U.S. second. In 1986 the respective market shares were 45% and 33%. In 1987, however, the U.S. began to narrow the gap slightly.

The local Taiwan information market today is worth more than $500 million for hardware and over $600 million if software is included. In 1987 more than 70% of the microcomputers sold in the market were produced domestically.

By contrast, although the island produces a wide variety of general purpose monitors, in value Lerms some 60% of the video moniters were imported mainly high resolution color monitors. Similarly, while Taiwan makes Chinese and 3270 terminals, the latter for IBM host mainframes, 70% of all terminals were imported.

TABLE 4: Type of Production of ROC Information Products Unit: %

Type of Business / Production	1985			1986				1987			
	Foreign Business	Local Business		Foreign Business		Local Business		Foreign Business		Local Business	
		Self Brand	OEM	Self Brand	OEM	Self Brand	OEM	Self Brand	OEM	Self Brand	OEM
Microcomputer	64	9	27	40	10	28	22	32	9	36	23
Disk Drive	65	6	29	62	30	0	8	56	16	5	23
Printer	91	0	9	98	0	0	2	76	0	3	21
Terminal	63	2	35	69	0	7	24	65	6	7	22
Monitor	40	4	56	27	15	17	41	18	22	23	37
Other Peripherals	62	6	32	66	4	5	25	67	4	10	19
Computer Components	—	—	—	18	2	20	60	21	2	16	61
TOTAL	58	5	37	36	8	17	39	30	9	20	41

Source: MIC, Institute for Information Industry, ROC

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Chien Hou believes quality control and R & D are basic to the company's pent success. The R & D effort is now concentrating on a 19" CAD/CAM monitor in color and monochrome that should be ready by early 1989.

For its display datas Chien Hou has bypassed developing a multi-sync monitor, opting instead to offer a VGA Plus monitor that incorporates multi-sync resolution with the firm's DATAS VGA Plus Card. This allows the user to have VGA functions at a cost less than that of a multi-sync monitor.

Chien Hou's CGA units will display 64 colors beside green and amber. The EGA version's interfaced resolutions are 640 × 200 and 640 × 350, with a dot pitch of 0.31mm.

Datacomp has twenty engineers for product R & D. The turn around time for customer-designed (or assisted) products averages four to eight weeks. The company also has its own designs and innovations. For example, it has managed to reduce the size of a standard IBM keyboard by over 80%. Membrane keyboards have also been developed and will go into production this month.

Only four years old. Datatronics Technology is already one of Taiwan's leading manufacturers of computer peripherals and data communications products. The company employees 80 staff, of whom 30 hold Masters and B.S. degrees in computer science and data communications. A factory twice the size of the company's present facility is now under construction.

Datatronics is especially strong in modems, producing 250,000 annually. Most of Datatronics modems are sold under the Discovery brandname, although the company welcomes private labels and customer designs.

The auto-dial, auto-answer modems available from Datatronics are in a series of standalone, pocketsize and card version models, meeting Bell standards and CCITT recommendations for dial-up and leased-time operations in both synchronous and asynchronous modes, having been granted FCC regsitration and certification, as well as PTT homologation in several other countries, the modems are permitted for direct connection on telephone lines and networks.

Besides modems, Datatronics also produces pocket-sized acoustic couplers. The size of a cigarette package, these couplers are suitable for use with portable computers for data communication in hotel rooms or public telephone booths, where direct connection to the telephone line is not possible.

Digitech Computer is also only four years old. It is part of the $300 million diversified Chia Ho group, whose activities include chemicals, textiles and financial services, as well as computer products.

Digitech produces fax cards, handy scanners, terminals, emulation cards and printer converters. For example, the company's new Digifax CWS-18GF is a personal computer-based, CCITT Group III compatible fax card. It consists of software, a special board and an auton box to be installed on IBM PC/XT or compatibles. It has passed FCC part 15 and 68 testing and has been approved by Taiwan's PTT.

Digifax's CSW-18GF is a powerful computerized faosimile system. It supports high speed communication fax, image processing, data processing, file transfer and electronic mail box. Instant-timing multi-message and multi-address transmission allows a maximum of 16,000 messages to be stored and transmitted simultaneously.

Godspeed — data missing/data to come

By comparison Goodway is one of the Taiwan industry's older data communications equipment manufacturers. Established in 1974 it has sales on the order of $6-8 million a year.

The company's product range includes computer cable data switches, APP-NET and plus (phone net compatible), SCSI terminators, and Apple Talk compatible for the last two years kits.

User-friendly, reliable, competitively priced products are the keys the six-year old Guis's success. This approach is reflected in the company's sales staff — mainly drawn from the computer science and business administration fields, most with MBA or MIS degrees from the U.S. This allows has sales staff to react quickly to the needs of the marketplace and feed that information intelligently to the company's R & D staff.

Guis has two main product ranges. The first is telecommunications products including intelligent telex terminals, PCFax systems, fax/scanner/copiers, plain paper fax machines and personal fax machines. The second line involves such image processing equipment as desktop scanners for mid-range applications; a flat-bed, book-type professional scanner and a Microsoft Window-based software package for image processing and editing.

Guis's intelligent telex (Telewriter 841) incorporates the functions of telex, TUX DDD, word processor and electronic mail into a desktop unit. The WINNER Microsoft Window-based package can support the image file formats of Windows Paint, Paint brush and other popular graphics programs. Scanned images may be merged with images in memory and freely mixed with text on the screen.

GVC is one of Taiwan's more important telecommunications and desk-top publishing device manufacturers. Established in 1979, the company has achieved strong growth by concentrating on the development and integrated design of original and state-of-the-art computer peripherals. The company has 200 highly-trained technical staff as well as advanced design, testing and production equipment.

GVC currently offers a line a Hayes-compatible 1200 and 2400 baud modems in external, stand-alone models, including a pocket-size model; as well as internal plug in models, for both PC and PS/2 systems. All are compatible with Bell and CCITT standards. It also has a new 9600 baud stand-alone modem with V.32 compatibility and the full Hayes-AT command set.

In addition to modems, GVC has developed desktop publishing peripherals. The company's first entry is an optical mouse, with a high resolution of 250 dots-per-inch. By the end of this year, GVC will also introduce a handy scanner and a PostScript Laser Printer controller.

GVC is particularly interested in meeting the needs of OEM customers who need to cut production costs to remain competitive. GVC believes it is the best possible off shore partner for design as well as production, especially for companies that need to come out with innovative new products.

It welcomes customer-designed products, because its engineering team is experienced with all phases of microcomputer R & D. This gives it the flexibility to cope with design changes and engineering changes on

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Circle 419 on Reader Service Card

the production line, preventing costly delays.

Honotron is a peripherals manufacturer. This month, the company will announce a new Key-Mouse at the Comdex show. The Key-Mouse offers the advantage that it can be connected directly to the keyboard, without the need of any additional port. Honotron also offers computer keyboards for IBM PC/XT/AT and PS/2 and compatibles. These are of the membrane type and have a real two-step tactile feeling.

Labway is just a year old, but already has sales pushing the million dollar mark. Its products include 5.25" external FDDs for the entire PS/2 family; mouses (two-button, Din connector) again for the whole PS/2 family; RAM cards for PS/2 model 50/60; mouses (tree-button, BS-232 connector) for PC-XT and AT; NEAT Motherboards; and NEAT BIOS.

Labway's external FDDs can read/write and format both 360kb and 1.2 mb; and require no expansion slots, interface card or power supply. The mouses offer high tracking speed; provide a test program and menu creater; and are 100% IBM mouse compatible.

Lyi-Cheng Enterprise is a good example of the way Taiwan companies grow and adapt to changing market conditions, acquiring new skills and technology along the way. Founded in 1877, the company began as a producer of radios, TVs, and arcade game machines.

Since then, Lyi-Cheng has grown 75-fold in terms of capital, built a new modern production facility and shifted to XT/AT (8088, 80286, 80386) personal computers and peripherals. Total production capacity now is 16,250 PCs a month.

Maxas Industrial began operations two years ago as a sourcing agent for companies located in Singapore and the United States. Soon thereafter, the company moved into manufacturing itself. Today Maxan is an integrated company with the resources to engineer, manufacture and market technically advanced, high quality, electronic computer equipment.

Maxan views its main strengths lie in strong P & D and manufacturing divisions. It focus is in data communications, but it also has experience designing other products for OEM clients.

In product development the company is oriented towards non-systems hardware. It emphasizes data transmission and PC-related add-on products. It has in-house electronic circuit and mechanical design capability, as well as some ability in software and firmware development.

On the manufacturing side Maxan's strengths include: manual assembly of electronic board level and basic box products; quality control and assurance; production process design and engineering; non-temperature cycling burn-in; functional testing and diagnostic tests; and parts procurement.

Products developed and carried by Maxan include dial-up 2400 BPS Hayes-compatible modems; group 3 compatible 9600 BPS fax cards; ethermax control cards IEEE 802.3 compatible control cards for ethernet LAN; and IEEE 802.3 compatible ethernet local repeaters.

Founded in 1981, RCS Technology Corporation is a well-estabished manufacturer and exporter of anti-static, anti-radiation (VLF) products. It is a subsidiary of Taiwan's Daikyo Petrochemical Company.

RCS Technology's VDT filters eliminate glare and reflection; enhance picture contrast; block VLF radiation 98.9%; and dissipate static electricity 100%. The filters provide the highest resolution screen available, virtually and dust accumulation, are effective on both color and monochrome VDTs and are available for curved and flat monitors.

Real Time Industrial's RTA-03E Multi RS-422 serial adapter (4 porte) is designed for IBM PC AT or compatible computers. It offers an asynchronous communication protocol and can use an EIA 422 industrial standard interface. The communication distance is up to 3000 feet, with a baud rate of up to 58K BFS.

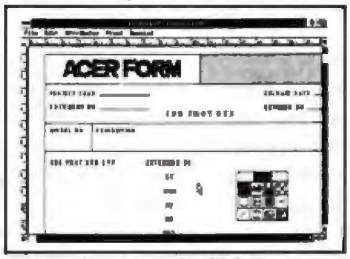
Real Time's fax card is compatible with PC/XT/AT/386 or PS/2 model 10. FCC approved, it is compatible with CCITT V.29 and V.27, TER, T4 and T30.

Real Time also offers the RTX-02B B255 plus card, a programmable input/output interface for PC/XT and PC/AT. It is suitable for design and experimentation. It contains 96 I/O lines; six independent 16 bit counters, each with a count rate of up to 5 MHz; and two programmable interrupt chips.

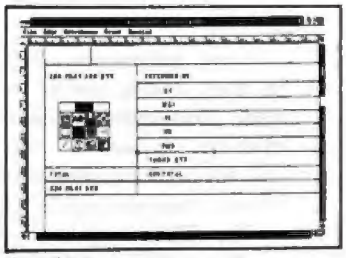
This advertisement was designed using ACERFORM.

1. Start with clean page at 1:10 p.m.

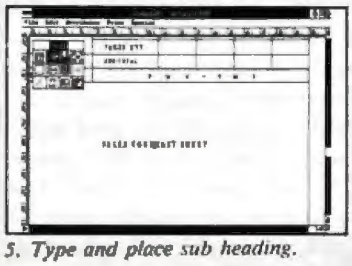
2. Type in text through Edit window.



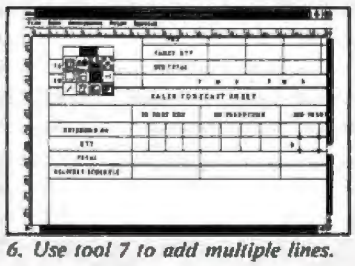
3. Load image and add lines.



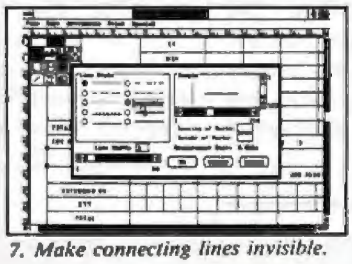
4. Add lines to form table.



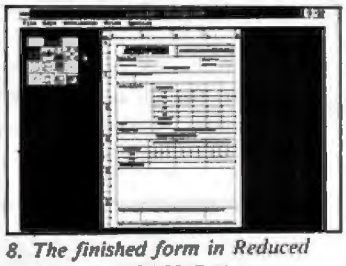
5. Type and place sub heading.



6. Use tool 7 to add multiple lines.



7. Make connecting lines invisible.



8. The finished form in Reduced View at 1:24:32 p.m.

Create a professional form in less than 15 minutes!!!

ACERFORM is an MS-Windows application. All the advantages you enjoy and rely on from Windows, like ease-of-use and excellent graphics, are at your fingertips when you use ACERFORM. With ACERFORM, lines can be as thin as a strand of hair or as thick as your pencil. For frame and text backgrounds you have 16 patterns to choose from.

Corporate logos and other images are easily loaded and sized. With SoftFont, character styles come in a wide variety of shapes and sizes -- and the fonts you select are shown right on the screen, just as they appear on your printed form.

Selectable line widths range from 0.5 cm to .01 cm.

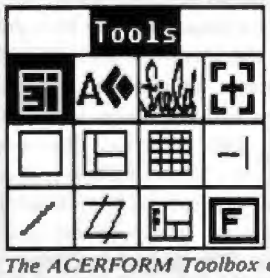
ACER FORM

Actual loaded image.

ACER FORM

Loaded, resized image.

ACERFORM offers a comprehensive toolbox with 12 tools to aid you in drawing lines, loading and cropping images, and typing or loading text. There's also a tool especially for block operations, such as saving a part of your form for loading into another form or uniformly editing parts of your form.



The ACERFORM Toolbox offers an unprecedented range of form tools.

ACERFORM's text editing feature allows you to utilize data from several sources. You can key in directly from your keyboard or load data stored in WordStar, dBase III Plus and Lotus 1-2-3.

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Worldwide inquiries, contact:

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ACERFORM enables both mouse and keyboard users to develop a form efficiently without dealing with complicated screens and strange codes. The command menus and form tools complement one another to make form building a logical and simple process.

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- Easily draw lines and frames and place them on your form accurately.
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- Fill out the form partially, or not at all.

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The Third Wave is a member of the ACER Group

Royal Information Electronics (TRL) has been making quality monitors for ten years. Emphasizing product quality and reliability, as well as after-sales support TRL has twenty quality control and quality assurance engineers in its 300-man workforce.

The TRL monitor series features a streamlined, elegant design and offers complete IBM PC/XT/AT/PS2 compatibility. The enhanced high resolution, high contrast, dark tint, non-glare screen gives sharper images. The tilt and swivel base allows easy adjustment, with readily accessible control switches.

Taiwan First Line Computer & Cable Corporation is another comparatively young company. With an up-to-date, fully integrated production facility and a corporate culture emphasizing quality control, the company seeks to offer customers better quality at competitive prices, with on-time delivery. Founded in 1985, it now has sales in the $4 million range, from cables, data switch-boxes, gender changers and similar products.

Specific products include PS/2 serial cables; Appletalk/MacIntosh cables; phonenet; Appletalk adapter bits; and SCSI terminators.

Founded in 1983, Team Technology helped pioneer the U.S. market for Taiwan high tech products, introducing its modems at the 1984 Comdex show. The response from this initial foray was so overwhelmingly positive the company immediately drew up a world marketing plan. In subsequent years Team modems were subjected to extensive product testing all over the world. Current production is 10,000 units a month.

In Team's product range are 2400 and 9600 BPS with MNP protocol modems. The "Micro 1200" is a specially designed pocket modem without battery or AC adaptor required. Its size is only 2cm × 7cm × 11cm. All Team modems are provided with Ball and CCITT protocols and are Hayes command compatible.

Quality control is taken seriously by Tean. From IQC, ICT (in aircuit text with HP-3065), burn-in test (48-hours), function test, AQL test to QA test, every step is performed thoroughly. the company has no minimum orders and welcomes private label and custom designed orders.

Sixteen of Team's 65 staff are in R&D. Products under development include a PS/2 modem (2400 BPS) to be announced this month; a V.32 modem including V.21 to V.32 and Bell 103/212A, which will be announced in early 1988; and a LAN card, a Teamnet/Ethernet interface card available next month, which will be able to run directly Novell's Netware/86, /286 or ELS by selecting the NE1000 software driver.

The Taipei Computer Association is one of the major driving forces behind Taiwan's emergence as a major player in the world information industry. Founded in 1974 with less than 30 members, today the association has more than 1700 members, including a number of major foreign companies. Corrently chaired by Stan C. J. Shih, president of Acer, the association's activities range from software development and market research to anti-counterfeiting and international cooperation.

Part of the association's mandate is to expand worldwide recognition of the Taiwan information industry. This involves both encouraging foreign firms to locate offices and production facilities on the island; and helping gain approval for Taiwan-made products.

In order to encourage foreign investors, the association actively works with the ROC government and the Institute for the Information Industry to improve the overall investment environment. It also helps foreign firms identify local product-makers for sourcing.

The association sponsors two trade shows annually. Each June it organizes Computer Taipei, the largest computer products show in Taiwan. This year the show was attended by 4,000 foreign buyers and logged more than $7.2 million in sales.

In April the association stages Softex Taipei as a venue for software developers and buyers. The show includes seminars and displays of the latest software designs.

The association has been a major force in Taiwan's anti-counterfeiting effort. Recognizing the cultural aspects of the problem where imitation traditionally has been regarded as a form of preise — the association has sought to raise public awareness of the importance of intellectual property rights.

Tatung is not only Taiwan's oldest electronics and computer company, it is also the biggest, with a true worldwide capability. It operates under its own brandname as well as on an OEM or subcontract manufacturing basis. Total sales, including home applicanes and industrial equipment, came to $1.4 billion in 1987.

Tatung's product range is enormous, by Taiwan standards. For example, it produces 8088/8086, 80286 and 80386 based micro-computers and workstations; as well as disk control, graphic control, memory expansion and LAN add-on cards. In terminals, Tatung makes ANSI, ASCII, and ANSI/ASCII/PC terminal emulations; VT-220, DG 200, ADM SA/31, and Wyse 50/60 emulations.

In monitors Tatung produces monochrome (MDA, MGA and MCGA compatible), color (CGA, EGA and PGA compatible) and plasma display units. It manufactures dot matrix printers; as well as engines and controllers for laser beam printers. Tatung also manufactures FDDs, HDDs, keyboards and mouses, power supply units (linear and switching mode), CRTs and telecommunications equipment.

Looking ahead, Tatung is working toward more high end systems products. It seeks further integration of Tatung's system design and ASIC design technology. It wants continued broadening of CAD/CAM applications and an increase in productivity and quality in design, engineering and manufacturing electromechanics. It aims at the further integration of computer and communications technology, as well as increased application of surface mounting technology.

A subsidiary of Acer, one of Taiwan's largest and best-known computer and peripheral manufacturers, the Third Wave Publishing Corporation is the island's biggest software, peripheral and publications company. Sales last year were $5.8 million and should exceed $10 million this year.

Third Wave's product line up includes the Generation Adaption Products (GAP) series of peripherals, designed to provide the computer user with the means to bridge the technology gap between different technology systems — for example in system upgrades and the transport of data between incompatible systems. Initial products on the market are a line of external drives consisting of six models covering all major types of PS/2, PC, laptops, portables and Commodore applications, for both 3.5" and 5.25" floppy disk media.

The automation industry represents the next area where computer technology finds increasing applications. Third Wave has its

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- Compatible with Hayes AT command.
- ASYN/SYN operation.

SmarTEAM 9600 PLUS
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(10M)
V.32 MODEM

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Keyless Data Collection Series to facilitate the processing of information at all levels of computerization. The series provides the user with a time-saving and cost-effective method of data input in a manner that is virtually error free. The company's bar-code reader liner under this series presently consists of four models: a keyboard emulator, an RS232/422 interface reader, a portable, hand-held reader and an on-line reader expendable to a 128-unit network.

Most recently, Third Wave released ACERFORM, a desktop form-composition software using the Microsoft Windows format. Feature for feature, it offers the best software of its kind in the market, but is remarkably easy to learn and convenient to use.

Founded in 1984, within a year Ostempor Electric's name appeared in Byte in connection with Taiwan computer manufacturing. Ostempor's president and chief engineer, Johnny Chen, takes credit for creating the first legal IBM PC-AT compatible computer in Taiwan.

Since the Ostempor has gone on to other achievements. In 1986 it produced a 12MHz AT-compatible motherboard with built in I/O ports (Model 2000 A/B), anticipating the IBM PS/2 system. In 1987 Ostempor introduced a 16 MHz AT-compatible all-function motherboard.

This year Ostempor's successes have included its model 5000X cabinet. This sleet, slim, newly designed cabinet is only 37.5 × 11.5 × 9 cm. The 5000X can be fitted with one 5.25" and three 3.5" drives, for a total of four. It is also fitted with six horizontal expansion slots. Users will especially appreciate the triangular front panel, which is inclined for easy viewing.

Four year-old P & C Shiten Enterprise concentrates on computer R & D and manufacturing, while sister company, Paoku P & C, focuses on marketing and sales. Together the two are pushing toward a $21 million turnover this year.

P & C Shiten is currently active in IBM-compatible PC/XT/AT computers and peripherals as well as laptop computers with a CGA function. By the end of the year they will also be producing laptops with EGA and VGA functions.

Paoku is the exclusive distributor for a number of European companies, including Svenska Micro Data of Sweden; Erni-Compro and Panatronic Fareast of Switzerland; C. S. E. D. of Belgium; ACM World Trade Center of Holland; I. E. E. E. of France; and Ediconsult SRL and Comprel of Italy.

Together the two companies also supply a number of major information industry giants, such as Mataushita.

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  (SINGLE, DUAL, VGA)
- 15" MONO
  (SINGLE, DUAL, VGA, MULTISYNC)
- 19" MONO
  (SINGLE, DUAL, VGA,
  MULTISYNC)

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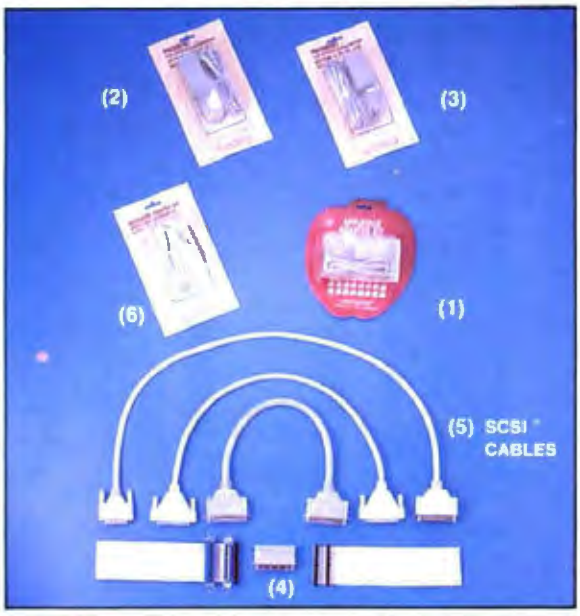

APPLETALK/MACINTOSH NETWORK HARDWARE

FIGURE (1) APPLETALK ADAPTER KIT

KS-A-001 *APPLETALK ADAPTER FOR MACINTOSH*
KS-A-001P *APPLETALK ADAPTER FOR MACINTOSH PLUS*
PATENT IN TAIWAN

FIGURE (2) & (3) PHONENET® KIT

KS-A-002 *PHONENET KIT FOR MACINTOSH*
KS-A-003 *PHONENET KIT FOR MACINTOSH PLUS*
PATENT IN TAIWAN

FIGURE (4) SCSI® TERMINATERS

KS-S-004 *MALE TERMINATER FOR MACINTOSH NETWORK*
KS-S-005 *MALE TO FEMALE TERMINATER FOR MACINTOSH NETWORK*
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FIGURE (5) SCSI® CABLES

EXTENSION CABLE, HARD DISC CONTROL CABLE, FLOOY DISC CONTROL CABLE, INTERFACE DATA CABLE — ETC.

PS/2 KEYBOARD ADAPTER KIT

FIGURE (6) PS/2 KEYBOARD ADAPTER KIT

KS-I-005 *PS/2 KEYBOARD ADAPTER FOR PC AT/XT KEYBOARD TO FULLY COMPATIBLE WITH PS/2 SERIES*
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Auto power off for cost saving
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LCD for clear display of all essential information.

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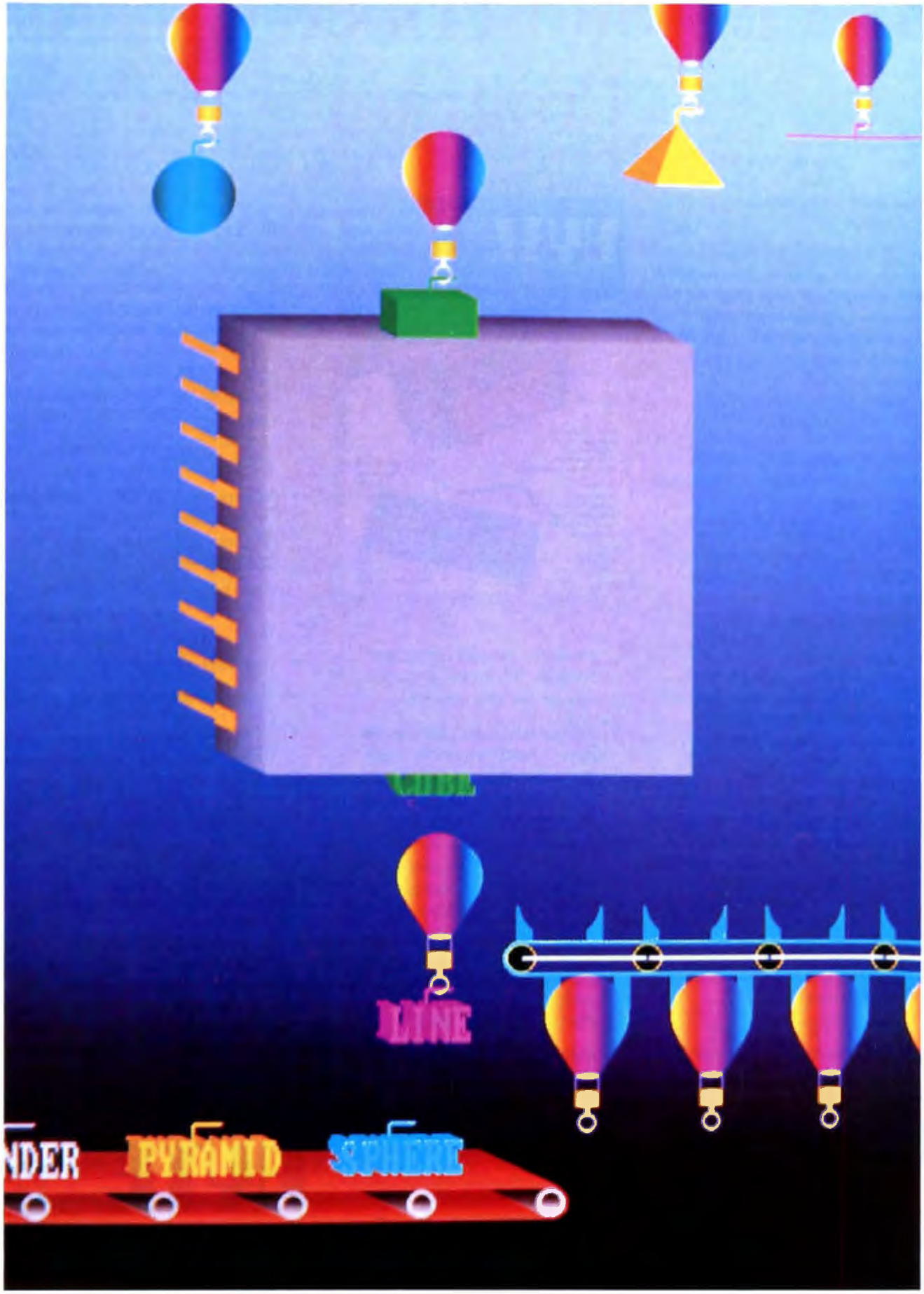

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REKURSIV: AN OBJECT-ORIENTED CPU

The Linn Rekursiv is a new microprocessor designed to run object-oriented languages

Dick Pountain

Linn Products, a hi-fi firm based in the electronics manufacturing belt that surrounds Glasgow, Scotland, has a worldwide reputation in the audio marketplace. In the early 1970s, Linn was one of the first firms to spot the market for uncompromising audiophile sound equipment, and the Linn Sondek is still regarded by its many fans as the finest record turntable ever made.

A Linn subsidiary, Linn Smart Computing, recently announced the Rekursiv, an innovative new computer architecture designed around principles of object-oriented programming. How Linn came to design a new microprocessor is an interesting story in itself.

Something Better

Linn's founder, Ivor Tiefenbrun, is a strong believer in computerization, which, until now, the firm had implemented with a series of minicomputers. Starting with PDP-11s in the 1970s, Linn now employs two DEC VAX-11/750s, two 11/780s, and a host of assorted micros. These machines are used for accounting, stock control, word processing, and the other typical business-administration tasks, together with a limited amount of production control over the cranes and conveyor belts. As a man noted both for technophilia and iconoclasm, Tiefenbrun soon became deeply dissatisfied with the software available for these machines and, in particular, with the lack of functional integration and ability to be modified.

By the early 1980s, Tiefenbrun's surveys of current computer research trends had convinced him that an object-oriented programming system would allow Linn to integrate all the factory's functions with flexibility. Since few, if any, such systems were commercially available, and since Glasgow is surrounded by some of Britain's finest university computer science departments, Tiefenbrun decided to have such a system designed.

In 1981, programmers and a compiler writer were hired, a Glasgow computer science lecturer was taken on as a consultant, and a language system called LINGO, with many of the features of Smalltalk, was written. However, the performance of LINGO on the VAX proved to be far from adequate for the task of automating a whole factory. Instead of giving up or going in for a long cycle of software optimization, Tiefenbrun characteristically decided to finance the development of a new processor architecture optimized to run object-oriented languages orders of magnitude faster than conventional hardware can. Thus was born the Rekursiv project. (Tiefenbrun seems to be inordinately fond of the letter *K*; Linn has hi-fi products called Sondek, Basik, Ittok, and Asak.)

In 1984, Linn Smart Computing Ltd. was set up and Dr. David Harland joined as technical director, a job he combines with being visiting professor of computer architectures at the University of Strathclyde. He and his team have designed a chip set with which to implement a persistent-store, object-oriented processor.

Object-Oriented Programming

An object-oriented programming system is one where programs are executed by sending messages to packages of data called objects. Each type or class of object has a set of operations that may be performed on its members, and you can apply these operations only by sending a message. The internal structure of an object is hidden from the programmer, who must manipulate it only with the allowed operations.

This type of system provides a high degree of security and modularity as application programs are isolated from the implementation details of the objects and their operations. Program modifications are very localized and, hence, easy to perform and more likely to be correct. The best known example of such a system is Smalltalk-80 (see "Smalltalk/V Release 1.2" by Mat Davis, June 1987 BYTE, and the section on object-oriented languages in the August 1986 BYTE).

An added attraction of the object-oriented style of programming is that you can make program objects correspond to objects in the real world in a more concrete way than do the vari-

continued

ables and procedures of a conventional programming language like C or Pascal. The data contained in an object can represent its attributes (e.g., size, color, and age) while the allowed operations represent its behavior. You can alter the program's behavior by sending it messages. Object-oriented languages are a natural for writing simulations of all kinds.

A very prominent property of real-world objects is that they *persist*; that is, they tend not to disappear without good reason (with odd exceptions like car keys and left socks). In most computer systems this is not the case. When you switch off the power, everything contained in the computer's RAM disappears. Program variables are more volatile still. They will disappear when you terminate the program to run another one, or even (in the case of local variables) when a procedure within the program terminates.

Imagine a world where people are flown to the moon to sleep every night and then flown back the next morning to work; that's how incongruous explicit I/O is in an object-oriented program universe.

The only way to preserve information from one session to another is to write it onto a permanent storage device of some sort, usually a floppy disk. However, the information always has to be translated into a different format to be stored, and the actual acts of storage and retrieval involve special I/O operations. These functions are invariably complicated and have different semantics from storage operations within a program such as assignment to a variable.

Persistent programming is a research avenue being explored at several universities, including Glasgow. In a persistent programming environment, the concept of I/O is abandoned altogether, and the values of program entities are preserved from one invocation of a program to the next until you explicitly deallocate them. There is no distinction between long-term data and short-term data, and the same operations are used for both. No separate filing system is needed, since ordinary program entities such as arrays and lists can serve for long-term storage.

In terms of implementation, though, you need to underlie the persistence with some kind of disk-based virtual memory that is automatic and transparent to the programmer. In a normal programming environment, to store the value of a variable on disk, you would have to create a file, open it, copy the value of the variable into the file, close the file, and so on. In a persistent programming environment, variable values still get written to disk, but you won't know when, you don't need to explicitly request them, and the format of the data doesn't need to be explicitly altered to do so.

Persistence and object orientation are natural partners, because if your program is a simulation built from objects, then you might expect these objects to live for as long as their real-world counterparts. Imagine a world where people are flown to the moon to sleep every night and then flown back the next morning to work; that's how incongruous explicit I/O is in an object-oriented program universe.

The sort of data-processing system Linn hopes to build is one where every object in the factory has an equivalent object in the computer system. When workers build a product, say a turntable, the product gets allocated its own object. This object simulates the product, reflecting its progress through the production process. The object accumulates information as the product goes through testing and quality control, even to after-sales, where the object can contain the service records. The Rekursiv processor is designed to support this model of computing in hardware.

The Rekursiv Architecture

To say that the Rekursiv departs from the mainstream of current processor design would be a gross understatement. Reduced-instruction-set-computer technology has become the new orthodoxy in high-performance processor design, and Rekursiv is not a RISC. Instead, it supports microcodable, ultra-high-level instruction sets and could be better described as a WISC (writable-instruction-set computer; see "The WISC Concept" by Phil Koopman, April 1987 BYTE).

Professor Harland's prime concern is with bridging the "semantic gap" between the operations required in a high-level language to simulate real-world activities, and the operations that a digital computer can handle. RISC designs actually increase the semantic gap (by having only simple instructions) for the sake of higher throughput, the idea being that you employ the extra performance to close the gap in software.

Rekursiv takes the opposite tack and allows you to design very high-level instructions. The very name *Rekursiv* suggests that machine instructions can be made arbitrarily complex, including recursive calls and even calls to other programs; for example, a tree-walking routine can be microcoded as a single instruction.

The Rekursiv achieves high performance by having multiple internal memory buses so that many operations can occur in parallel, instead of a highly optimized serial instruction pipeline like a RISC. Built from three custom gate arrays and several megabytes of fast static RAM, the Rekursiv is a single-board rather than a single-chip microprocessor (see photo 1).

This SRAM holds the microcode and the pager tables used to keep track of objects; it exists inside the processor like a conventional processor's register set. The SRAM is organized into six different functional memory spaces, each with its own data and address buses, a side effect being that the gate arrays require the largest packages ever: 299 pins to handle all the lines. Since there is also a dynamic RAM (DRAM) interface for the main object store memory, the Rekursiv could be labeled a seven-memory architecture. Even this is an underestimate since the pager tables employ separate buses for each field.

Figure 1 shows a block diagram of the main functional units of Rekursiv, where the three gate arrays are the blocks called Objekt, Numerik, and Logik. The six blocks that are implemented in SRAM are the two stacks (control and evaluation), control store and control store map, the pager tables, and the block marked NAM (more on NAM later). Most of Rekursiv's internal data paths are 40 bits wide, though the DRAM address bus is only 24 bits wide. Objects are stored both in DRAM and

continued

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on hard disk, in what could be thought of as equivalent to the external memory of a conventional processor, but since the microcode can access this memory, too, the distinction between inside and outside is blurred.

The Rekursiv's sole purpose in life is to create objects, to page them back and forth between memory and hard disk, and to perform arithmetical and logical operations on the data in their fields. You can think of it as combining the functions of a CPU, memory manager, database manager, and operating system all in one. An object is just a chunk of memory divided into fields that hold its data and represent the *instance variables*, in

continued

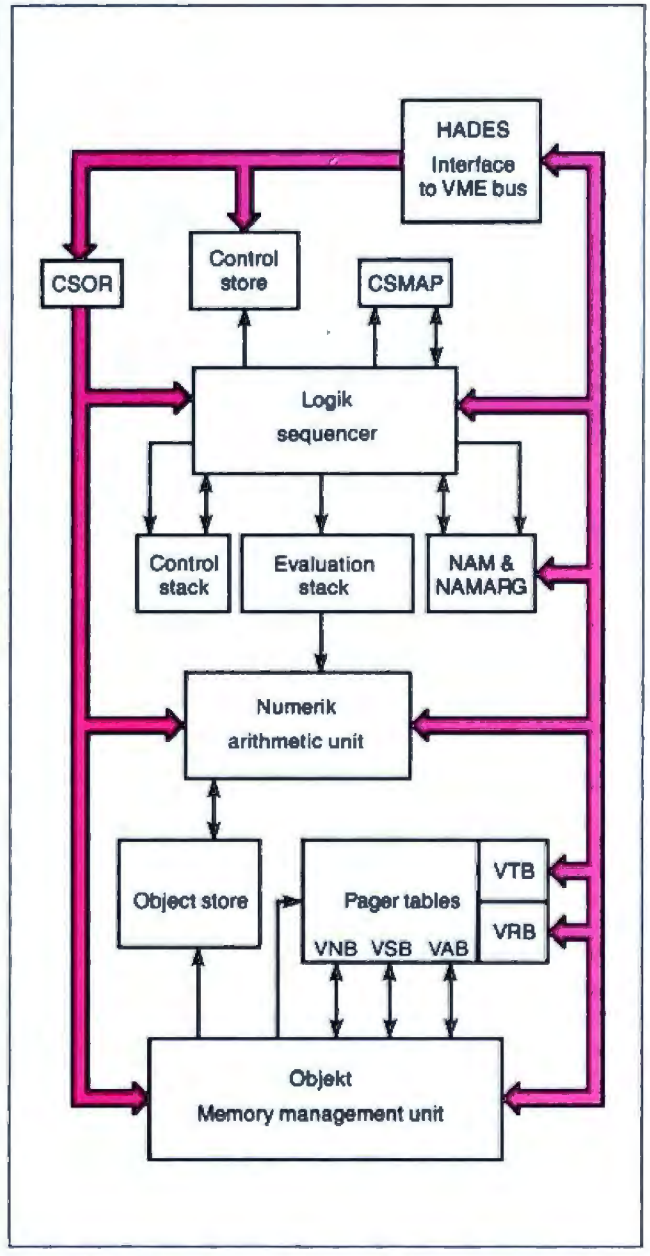

Figure 1: *A block diagram of the main functional units of Rekursiv, a persistent-store, object-oriented processor that, in effect, combines the functions of a CPU, memory manager, database manager, and operating system all in one.*

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Smalltalk parlance. Every Recursiv object is identified by a unique 40-bit number that is assigned to it at its creation (from a counter called the allocator) and that remains with it for its life. This number is the only way you can refer to the object, because only the processor knows its real address.

When they are stored on disk, objects are prefixed by a header holding the object's number, size, and type (a 40-bit value that the software must interpret in some meaningful way). Types are objects, too, so the type field contains a 40-bit object number. When an object is transferred into memory, only the data fields are written into object store; the header is stripped off and written to a slot in the pager table along with the new address of the data in main memory. The pager table contains 65,536 (i.e., 64K) slots that you can address very quickly by hashing on the object number.

If the pager table slot for a requested object is occupied, then the object's address is retrieved from the slot along with the offsets to index its fields, and the requested operation is performed on its data. During this table lookup, the hardware also checks the type field, refuses to perform operations that are not allowed on the type, and performs range checks so you can't index a field that lies outside the object.

If the slot for the requested object is empty, that means it is not currently in main memory and there is a page fault. The Rekursiv is stopped dead while a signal is sent to an external disk processor to fetch the object into memory.

This disk processor has its own B-tree directory structure, which allows it to find an object's image on disk through its number. When the object has been fetched to memory and its header put in the pager table, the Rekursiv resumes processing as if nothing had happened, without any need to restart the current instruction, as there would be with a conventional processor. Page fault recovery occurs "below" the level of instruction execution, rather than being an external operating-system task. It is this property that enables Rekursiv's microcoded instructions to be of arbitrary complexity and to include recursive calls that are forbidden to normal CPUs.

The programmer's view of Rekursiv is of a truly object-oriented processor in which there is no concept of an address, only of object numbers, and where objects persist until you destroy them. Programs can be executed only by requesting an operation on a numbered object. In a network of workstations, the object universe can be extended to cover the whole network, and object numbers can be made to indicate in which processor an object was born.

Memory Management

Memory management, especially garbage collection, has always been a problem for object-oriented systems. In the real world, dead objects get eaten by crows or bacteria or consumed by rust or whatever, but in a computer simulation, they just hang around and clog up the all-too-finite memory space.

Rekursiv has been designed with a brutal, but fast, garbage-collection strategy. The DRAM object store memory is divided into halves, only one of which is used at any time. The last address in this active half is called `EndMem`, and the "grabspace" operation that creates new objects contains a hardware test that stops it from allocating object addresses that would exceed

EndMem. When this test fails, more memory is required and the Objekt chip invokes hardware garbage collection.

The Objekt chip initiates a tree-search of all the object dependencies in the processor, taking in both the stacks and a handful of registers. The chip then inspects each object by paging it with disk fetches disabled, and it tags those that do not exist on disk—these must be objects that are either newly created, or old but modified (i.e., they have been read from disk, altered, and not yet written back). Then it undertakes a linear scan of the pager table, copies only the tagged objects into contiguous addresses in the other half of DRAM, updates the pager tables, and resumes execution in the new memory space. In effect, this is a heap compaction performed in hardware.

This hardware compaction is low-level and completely transparent, dealing as it does with physical rather than logical memory. Its speed is largely independent of the content of the memory or its degree of fragmentation. As with page faults, the processor is unaware of its occurrence and can resume execution where it left off.

If this process still does not free enough memory, a second level of garbage collection progessively squeezes out other objects to disk to free up space. If even this fails (i.e., a new object wants all the memory), then a last resort is to use the spare half of DRAM to accommodate it directly. These fall-back strategies ensure that garbage collector performance degrades gracefully rather than failing with a bang. The sweeping of unwanted objects from disk is a software housekeeping problem that should take place off-line.

The finite limit on object numbers raises a potential problem (even though 2^{38} numbers is quite a lot) because they are allocated sequentially by a counter. When you kill an object you theoretically free up its number, but you can't just reset the counter to reflect the fact. What happens when you run out of numbers? Rekursiv tackles this problem in two different ways.

One solution is conservative: Don't squander precious object numbers on very common data items that tend to be consumed and forgotten. The top 2 bits of a 40-bit object number are used as flags, so the real object number is only 38 bits long.

The top bit says that this is an object number to distinguish it from an untyped binary value (these are permitted in Rekursiv but can only exist embedded inside objects; they help to conserve object memory). The next bit distinguishes between normal and "compact" objects whose remaining 38 bits hold a 5-bit type identifier and 32 bits of actual data rather than an object number. Such compact objects ought to be used to hold numbers, characters, strings, pixels, and so on. Compacts are reminiscent of the way Smalltalk handles SmallIntegers. The Rekursiv hardware knows about compact objects and extracts their data directly so they consume no object memory and can be accessed quickly.

The other solution is radical: Rekursiv garbage-collects object numbers in an operation totally distinct from garbage-collecting the objects themselves. This operation needs to be performed only infrequently, and it could be done during an off-line period such as a maintenance break when all objects are resident on disk. A compaction utility writes a new disk image of all the objects, renumbering them with consecutive numbers, and then

continued

Listing 1: *A Lisp function that copies a tree structure.*

```
(DEFUN Copytree (Item)
  (COND ((ATOM Item) Item)
    (T (CONS (Copytree (CDR Item))
             (Copytree (CAR Item))))))
```

Listing 2: *A Rekursiv instruction equivalent to the Lisp function shown in listing 1.*

```
MICRO$COPYTREE: entf 1 pagebus d=ustack
  crtf IDXBADTYPES  newtrbr _CONS
  incmsp m.sp' newmptr
  jf MICRO$COPYTREE ldustk d=pgrorr
                          // the CDR branch
  m.fp 1 uaddbr newmptr
  readustk
  pagebus d=ustack
  idx2 newsr newbr loadaddr
  idxget nocheck incmsp m.sp' newmptr
  jf MICRO$COPYTREE ldustk d=memout
                        // the CAR branch
  js RTN$CONS
  rtf
```

resets the allocator's counter to the next available number.

One implication is that no references to object numbers can be allowed to exist outside the Rekursiv universe, since these would escape renumbering and become corrupt. Since Rekursiv is meant to be programmed only at the symbolic level (e.g., as in Smalltalk), this prohibition doesn't prevent you from storing program code outside the machine; but it is a symptom of a more profound philosophical problem that all those who build distributed databases (e.g., the hypertext movement) will eventually face.

The size of the pager table raises another theoretical problem: If you have a program with more than 65,536 objects, then hash collisions are possible (though pretty unlikely). In the case of a table collision, Rekursiv just squeezes the old object from that slot out to disk.

The Microcode

The Rekursiv is an object-oriented database engine for creating and managing persistent objects and, with strict type-checking, performing just about any operation on them you can think of. Since the Rekursiv has a writable instruction store, it will come out of the box absolutely empty and is incapable of doing anything at all until the microcode for an instruction set is loaded into the control store part of the SRAM. Of course, Linn does not expect potential users to dive headfirst into microcode programming, and so the production machines will be supplied with at least one instruction set.

A standard instruction set that supports C, together with the

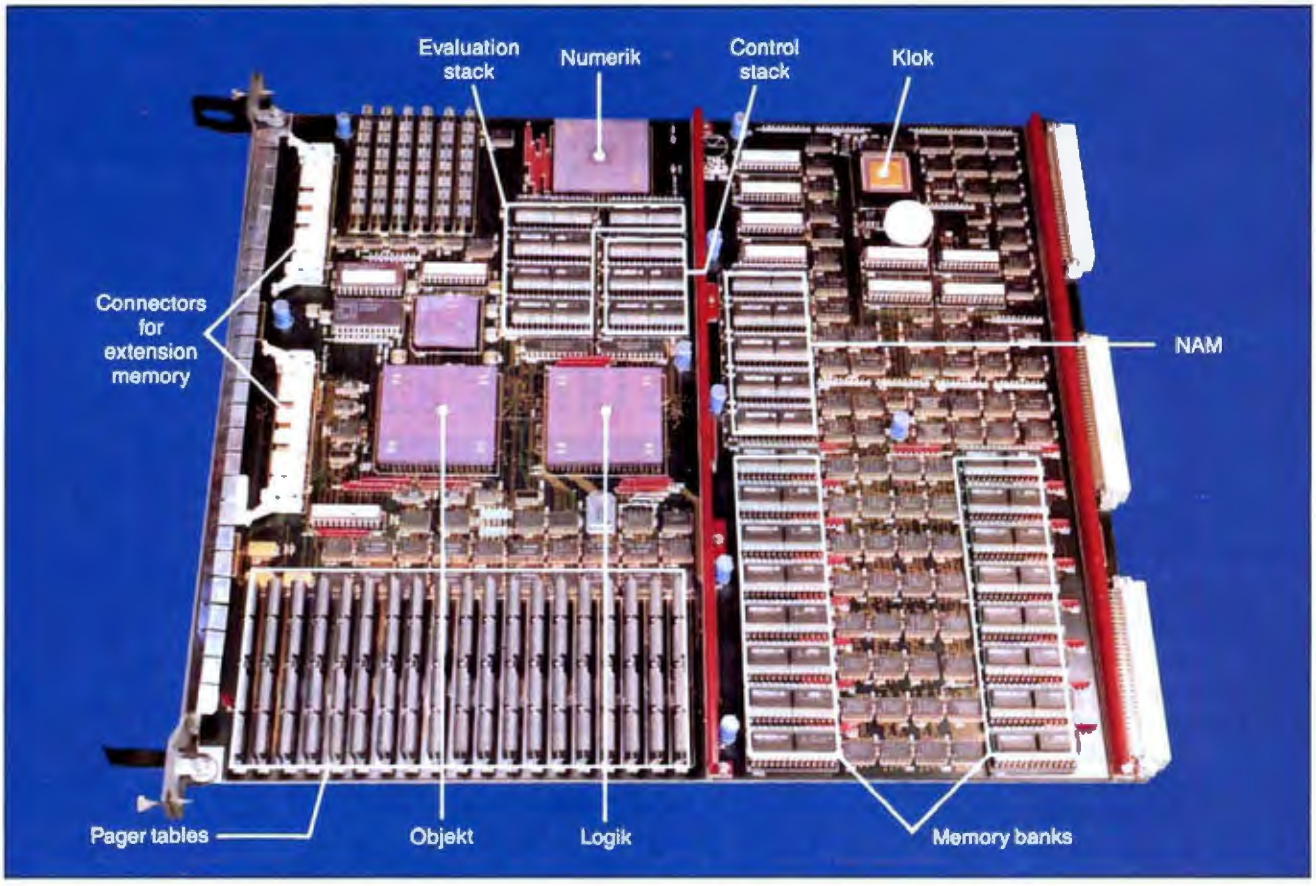

Photo 1: *This VME board, called HADES, is the first working Rekursiv system. The main units are three gate arrays called Numerik (the ALU), Logik (the sequencer/stack unit), and Objekt (the object memory manager).*

corresponding C compiler, will be supplied for writing application programs. Far more interesting, though, is a second instruction set, a microcoded Smalltalk interpreter, that makes far better use of the Rekursiv's unique features.

The microcode is stored in the control store, an SRAM area with its own 16-bit bus, where there is room for 16,384 control words of 128 bits each. Another separate memory space, called the control store map, holds a table of 2048 microcode start addresses, and maps 10-bit op codes onto the microcode that implements them. This function is equivalent to the instruction decoder of a conventional processor that would normally be hardwired logic. The control store and map can be thought of as a Smalltalk-style bytecode interpreter implemented in hardware.

Where does the processor keep its program code? So far, we have only seen object store memory, which, in conventional terms, might be thought of as data memory. In fact, op codes can be contained in objects and thus can be stored in the main object store, from which they must be fetched as in a conventional processor. For frequently performed operations, though, there is an alternative that offers much higher performance.

The block called NAM & NAMARG in figure 1 is the New language Abstract Memory that stores up to 524,288 words of 10-bit op codes and their 30-bit arguments that form abstract or high-level instructions. Since the NAM is inside the processor, it behaves like a fast instruction cache and creates a two-tiered system for language implementation.

First, you choose the set of primitive instructions best suited to supporting the specific language and write them in microcode. Now you have a customized assembly language, and you could write a compiler that generates these primitive instructions directly as its output; this is how C will work. But for advanced languages like Smalltalk, Lisp, or Prolog, you would use this abstract assembly language to write a set of interpreter subroutines and make them resident in the NAM. In the case of a Smalltalk implementation, the abstract code in the NAM would be the *methods* of the most important system classes.

Methods for user-defined classes would be contained in objects in the main memory and would thus incur a memory fetch, though you might be able to "freeze" important code into NAM. This two-tiered structure should allow Rekursiv to support these artificial intelligence languages that are traditionally interpreted almost as efficiently as a fully compiled language.

As a sample of what Rekursiv microcode looks like, the fragment in listing 2 is a recursive instruction that copies a tree structure, equivalent to the Lisp function shown in listing 1.

The microcode for `MICRO$COPYTREE` calls an auxiliary instruction, named `CONS`, as well as calling itself in two places. Simulations of this code suggest that when running on a 10-MHz Rekursiv, it will create a new `CONS` node every 2 microseconds, some 20 times faster than Lisp on a Symbolics 3675 workstation. In the course of writing a Prolog interpreter, Linn's programmers have also implemented Prolog unification as a single instruction.

HADES and the Real World

Linn has plans to use the Rekursiv architecture in several products: an accelerator board for existing engineering workstations like those from Sun, Apollo, or MicroVAX; a networked Rekursiv-based workstation; and the full multistation control system for flexible manufacturing that was the original goal of the project. The Rekursiv chip set will also be sold to OEMs.

The three custom chips are all fabricated in a 1.5-micron CMOS process and packaged as 299-pin ceramic pin-grid arrays. Numerik is a fairly conventional 32-bit ALU compatible with the AMD 29203. It has a full 32-bit multiply with a 64-bit result and a built-in 32-bit barrel shifter. Logik is the sequencer/stack unit; it controls the control store and map, the stacks, and the NAM. Objekt is the object memory manager that controls the pager tables to get the addresses of objects and performs range- and type-checking. In addition to these three, there is a programmable timer chip called Klok.

So far, Rekursiv has only existed as a microcode-level simulation, but the three main application-specific IC chips have now been fabricated by LSI Logic Ltd. and, as this article is being written, only the circuit board remains to be made. The first working Rekursiv system will be a VME board called HADES (Hardware Accelerator for Dynamic Expert Systems) that plugs into the back of a Sun-3 or Sun-4 workstation (see photo 1). HADES is built from the three custom chips, 2 megabytes of 45-nanosecond SRAM, and 5 megabytes of 100-ns DRAM object store on a quadruple extended Eurocard (a longer-and-wider-than-standard printed circuit board). HADES will employ a partition on the Sun host's hard disk to page the object memory, and this setup will cramp performance considerably due to the limited bandwidth of the VME bus. Later versions will incorporate their own close-coupled hard disks with fast direct-memory-access transfer into object memory. A 10-MHz Rekursiv reading consecutive words from object memory in one cycle each reads 50 megabytes per second. You would need to use a disk capable of a transfer rate of this order to avoid a paging bottleneck.

HADES acts as a VME bus slave and interrupter, which means it is completely controlled in two ways by the Sun host to which it is interfaced. The control store is memory-mapped into 2 megabytes of Sun/VME memory space so an instruction set can be written into it. Reading from a control store address executes the microcode at that address. Four 32-bit registers, two for reading and two for writing, are used to communicate with the Rekursiv's main data bus. A typical way to program HADES from the Sun would be to load the Smalltalk instruction set and then send a stream of ASCII codes representing a Smalltalk program to these registers, whereupon the Rekursiv acts as a hardware interpreter and executes them. It's very desirable to program the Rekursiv in such a high-level, symbolic fashion to avoid having to refer to absolute object numbers in the program code. Otherwise, object number references could be removed from the machine (e.g., in a program stored on a backup streamer tape), and these numbers could escape the periodic object number compactions and so become invalid. When using Smalltalk as the programming language, symbolic object names would be mapped to Rekursiv object numbers only by a dictionary that exists *inside* the Rekursiv itself.

A Rekursiv Future?

I find the Linn Rekursiv an interesting development for several reasons. Its sheer originality offers some relief from the flood of "me-too" RISC chips that threaten to drown the industry.

If Rekursiv delivers its promised performance, we may, at last, see Smalltalk becoming a viable production language. What interests me most is that Rekursiv could be a powerful testbed for developing new object-oriented languages. The foundations of Smalltalk were laid in the 1970s, and it represents the infancy, not necessarily the pinnacle, of object-oriented programming. Object-oriented databases could be the next hot commercial product. Since Rekursiv does most of the work for you in hardware, I expect it to do well. ■

Dick Pountain is a BYTE contributing editor, a technical author, and a software consultant living in London, England. You can contact him on BIX as "dickp."

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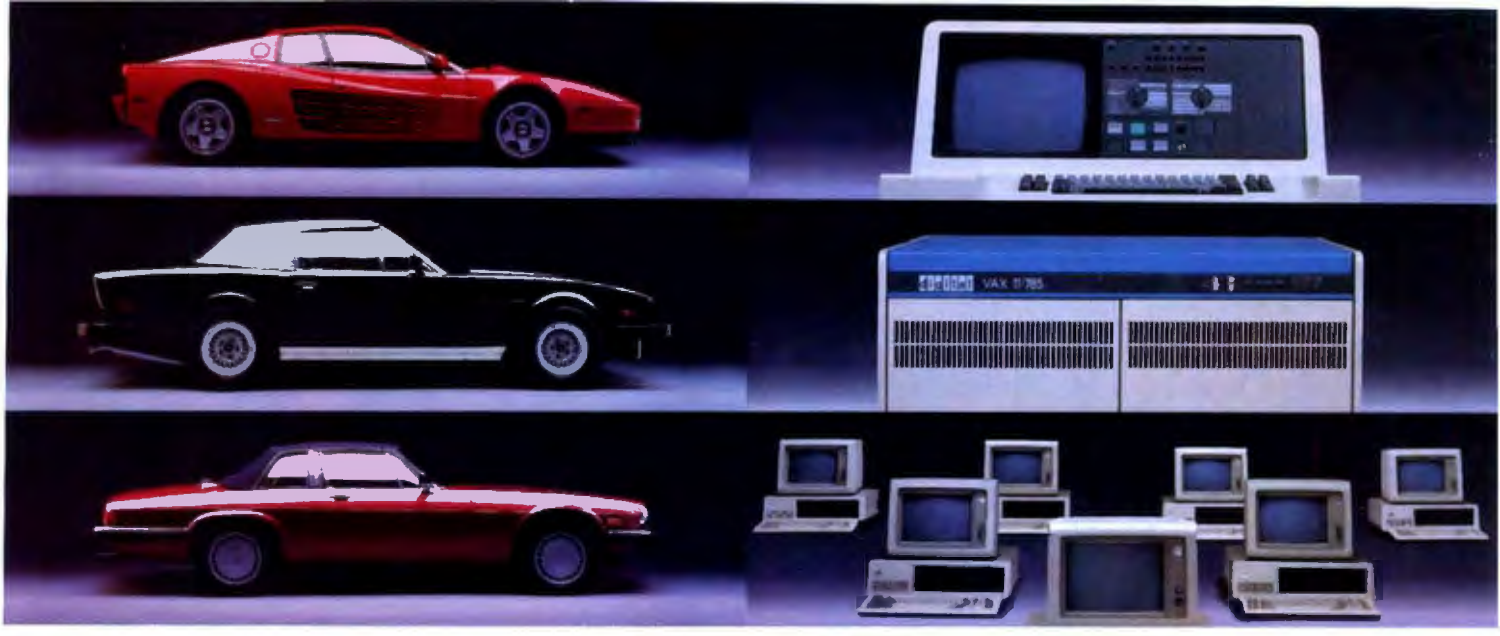

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PC Power, Part 2:

BACKUP POWER

How do you provide reliable backup power for your computer without creating new electrical problems—and how much will that cost you?

Mark Waller

When the utility power fails, your computer won't work. You may think the solution to this problem is an uninterruptible power supply. A UPS device supplies continuous power to the computer whether the utility power is flowing or not. However, in the world of personal computers, backup power systems are generally standby power systems, or SPSes. These devices switch on when utility power fails. This distinction of switching or not switching is the basic functional difference between a UPS and an SPS.

The main task of these products is to keep your computer running when utility power fails, as opposed to surge suppressors or power conditioners whose main task is to protect your computer. Backup power and power protection are areas of vital importance—especially if your investment in computing includes a local area network (LAN) or desktop publishing system. It is vital that you know the difference between backup power and power protection. Since SPSes are not all alike, you must be vigilant; otherwise, not only will you waste your money, you may end up with additional power problems.

ILLUSTRATION: MIKE HODGES © 1988

Standing by . . .

The building blocks of an SPS include the battery, the battery charger, the transfer switch, and the inverter (see figure 1). Most of the time, raw utility power is fed into the computer. All the while, though, the battery charger keeps the battery ready in case the power should fail. If power does go out, the transfer switch senses the outage and turns on the inverter, which provides AC power by drawing energy stored in the battery. After power is restored, the switch turns off the inverter and transfers the computer back to utility power.

That process sounds simple. Theoretically, it is. But different brands of SPSes handle this situation with varying degrees of efficiency. There are many functions that an SPS must provide during this simple-sounding process. It must, for instance, recognize at what point the utility power has failed and whether or not the voltage must drop out completely before it makes the transfer. It must also decide how fast it will make the transfer once the process is initiated. The way an SPS deals with these tasks determines the effectiveness of the product.

A better SPS will switch over to battery any time the utility voltage drops below a certain preprogrammed level; say, 103 volts. Low-budget units often have less-expensive sensing circuits that may not transfer to battery until the power drops significantly. Since every manufacturer

continued

rates its SPS in terms of transfer time, how they calculate this time is critical.

Your computer's power supply has some capability to store electrical energy so it can ride-through extremely short-term outages. The term *ride-through* refers to the power supply's ability to deliver stored energy to the computer even when its power supply has lost incoming power. As a general rule, your computer can tolerate outages from 20 to 30 milliseconds before it goes down. If your SPS can transfer to battery power within that time frame, you should be able to stay operational. Generally speaking, the less-expensively constructed your power supply, the less time it will be able to sustain the computer through an outage.

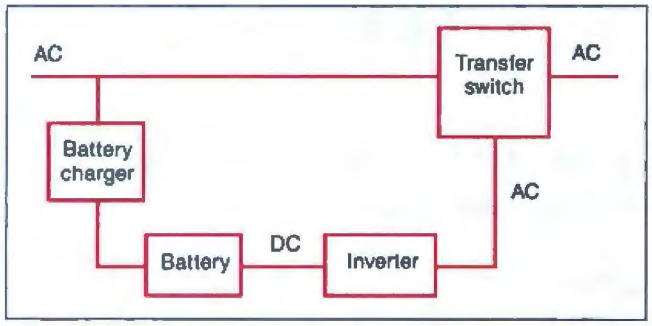

Figure 1: *The building blocks of an SPS are the battery and the inverter. The battery powers the inverter, which converts DC into AC. Notice that these blocks only operate when the transfer switch senses that utility power has failed.*

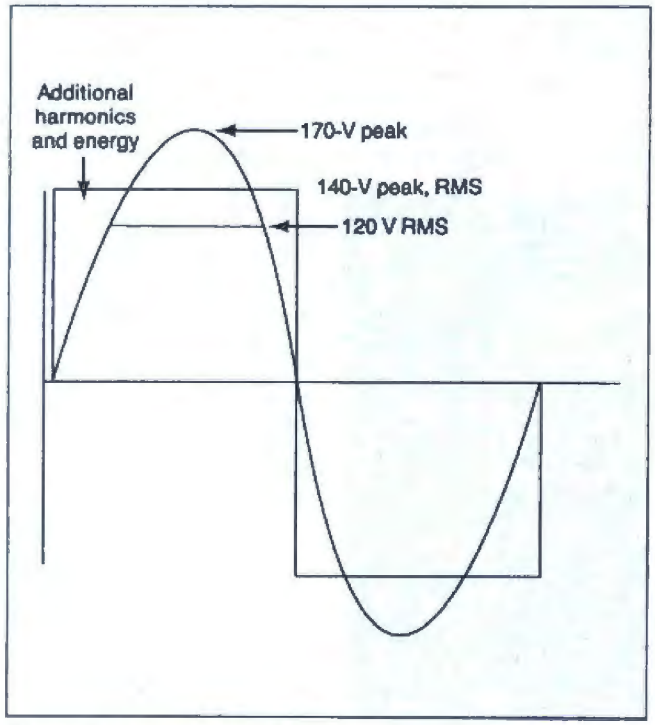

Figure 2: *A comparison of the sine wave generated by utility power and the square wave produced by many SPSes. At any given point along the graph, a square wave contains more energy than a sine wave. Its peak voltage is equal to its RMS voltage.*

Most manufacturers claim their devices have from 4- to 10-ms transfer times, which is within the ride-through time of the computer's power supply, and you should have no problems keeping your system up when the power goes down. If, however, the voltage drops for several milliseconds before the unit senses the outage and this time increment is not taken into account, the stated transfer time may be well under the actual transfer time. Reputable companies include the time it takes to sense an outage in their total transfer-time calculation.

If 4 to 10 ms is good, wouldn't 2 ms be better? Some companies boast that their devices have transfer times of 2 ms or less. Reaction times as fast as these can cause the inverter to kick in and out, constantly draining the battery every time a short-term drop in voltage occurs. The point here is that you don't need your SPS continually reacting to events that are not outages but simply fast fluctuations on the line.

Thus, transfer time is a trade-off between the computer's ability to ride through small power glitches and the need to provide quick backup power in case of a real outage. The fact that computers will tolerate such a long time without power leads most manufacturers to advertise their products as UPSes instead of SPSes—a questionable practice, and you should know the difference before you buy.

Riding the Wave

Utility power is a 60-Hz sine wave. You might just assume that your shiny new SPS will generate just such a sine wave. But, if you look at the fine print in the specifications, you may very well see terms such as *square wave*, *rectangular wave*, or *modified square wave*. Sometimes the literature will even show a picture of a great-looking square wave. Of course, you won't know if, when the picture was taken, the SPS was under load, or if the load was a switching power supply such as that inside your computer, or simply a plain old light bulb.

Figure 2 shows a comparison between a sine wave and a square wave. A square wave is a compromise between cost and quality. Since an inverter incorporates digital switches that turn on and off, it is less expensive to design an inverter to produce a square wave. But since a square wave's peak voltage is equal to its root-mean-square voltage, designers must compromise on a level somewhere between the normal 170-V peak of the utility sine wave and its RMS voltage of 120 V—usually around 140 V.

A 140-V square wave provides too little voltage with too much energy for the standard computer loads. A square wave at any given point along its curve contains more energy than a sine wave. Some engineers claim that your computer's power supply needs a minimum of 148 V RMS. The additional energy in a square wave will cause power-supply overheating and stress.

One school of thought preaches that a well-designed square wave is the best waveshape for switching power supplies since the switching power supply draws current in a nonlinear fashion. Engineers may argue, but you must be able to determine if the product is well designed, or it may produce the kind of waveshape shown in photo 1. This is the "modified" square wave generated by dozens of SPSes on the market. This waveshape will change as the load increases in order to keep the RMS voltage at the proper level, and it may even look more like a square or a rectangle.

On the other hand, when manufacturers go to the trouble of producing a sine wave, the output will likely be electrically cleaner than the average square wave.

A potential problem with an SPS inverter's waveform output is its high-frequency noise content. This noise can damage your computer components or interfere with your processing. Many

inverters use pulse-width modulation. PWM is a means of producing a desired waveform using high-frequency switching. The SPS filters out high-frequency components of the resultant signal, and the effect is a sine wave of low harmonic content with relatively little noise output. (Harmonic content refers to multiples of the fundamental frequency of the intended waveform. These multiples may cause distortion of the waveform, or high-frequency harmonics may appear as noise.)

In spite of this filtering, some of the switching noise will leak through and appear on the output. Square and rectangular waveshapes have a greater tendency to produce noise, since the waveshapes contain harmonics of the fundamental 60-Hz power signal and are created by large switching pulses.

Photo 2 shows the high-frequency content of the modified square wave in photo 1. You may think this looks harmless. Consider the fact, however, that these noise impulses occur about three times every cycle and are about 350 V in magnitude. If you buy this model, you may save around $50 over a better-engineered model, but you may put your computer in danger every time your utility power fails.

Synchronicity

After the SPS has been operating off the battery and utility power returns, two things must happen. First, the sine-wave output of the SPS must synchronize with the incoming utility power. This process is sometimes called *phase matching*. Then the unit must switch from battery power to utility power.

These operations sound fairly simple; the term describing them is *retransfer*. Most inexpensive units do not synchronize, however, and synchronization is important. Your computer's power supply is designed to expect the peak voltage of the sine wave to occur at regular intervals. If the peak of the sine wave is missing for very long, your computer may crash. When the SPS is on battery power, it generates its own sine wave or square wave according to its own internal clock. When utility power is restored, the sine wave's phase may not match that of the SPS. In order to prevent a mismatch, and perhaps a system crash, the SPS must slip sideways: *slew* its sine wave to match the phase of the utility wave before retransferring.

The SPS must also decide at what voltage level it should initiate retransfer. Normally, this level is a different, higher voltage than the transfer voltage. For instance, if the SPS transfers when the voltage falls below 103 V, it may wait until the voltage rises to 108 V to retransfer. This process avoids "dancing" on and off the inverter if the voltage hovers at a level near the transfer point.

Many SPSes provide selectable transfer points for site-specific considerations. If your location has periodic brownouts, you may want to set your SPS to a low transfer point, such as 90 V, to avoid constantly draining its batteries.

Battery Basics

The concept behind providing backup power for your computer is to give you enough time to save your work in volatile memory and bring your system down safely. SPSes are not designed to give more than a few minutes of backup power. If you need much more backup time than that, you may have to modify an existing unit to accommodate a larger number of batteries. There are some models that allow for this option.

The amount of battery time you need is a function of the kind of processing you do. You may, for instance, have an accounting package that needs several minutes to complete a task. Many manufacturers gamble that you are only going to load your SPS to about 60 percent of capacity, and in order to achieve smaller, sleeker packages, they may undersize the battery. If your actual load is 300 watts, you may want to give yourself additional capacity and buy a 500-W SPS. Compare one manufacturer's cabinet to another's. All things being equal, the size of the cabinet itself will tell you which unit will give you every minute you need.

Another battery-related feature you should consider is called automatic shutdown. If your SPS's battery completely drains, it may fail prematurely and not last nearly as long. And, short of total drainage, there is a point, called the end voltage, beyond which additional discharge will cause damage to the battery's cells.

SPSes that come with a built-in automatic shutdown function will probably cost a bit more, but this type of device may prove to be a bargain if your batteries last twice as long as those in a less expensive model.

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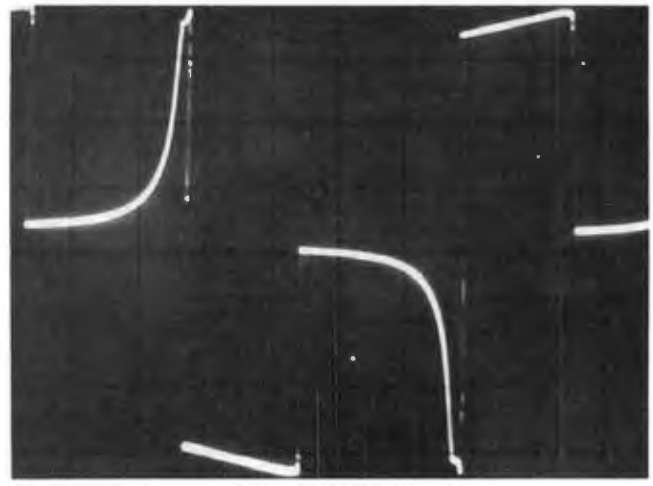

Photo 1: *The modified square wave produced by many inexpensive SPSes. This waveshape changes to correspond with the increasing demands of the load in order to maintain the designed RMS voltage.*

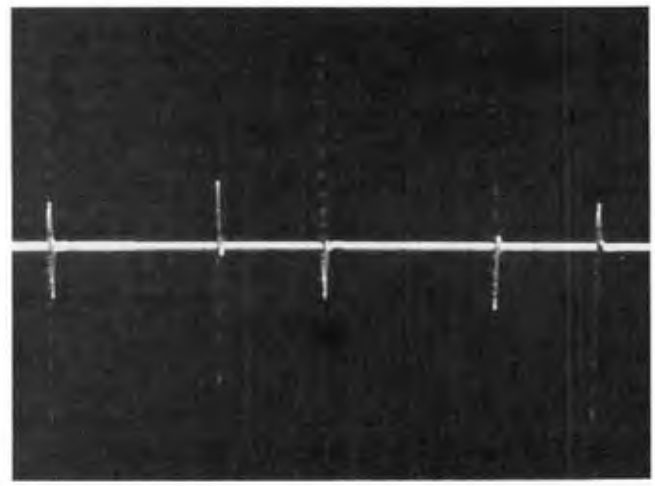

Photo 2: *These innocuous-looking spikes are the output of the typical inexpensive SPS. They are actually 350 V in magnitude and can be the source of stress on your computer's power supply; they may even cause processing errors or damage to your computer's ICs.*

Spike Those Rumors

Many manufacturers advertise that their SPSes are also power conditioners, which might make you think that you are protected from noise and spikes as well as blackouts. But SPSes are not cure-alls. This "conditioning" usually means placing one or more metal-oxide varistors deep inside the SPS (see "PC Power, Part 1: Power Protection," October BYTE). This is an inexpensive way for manufacturers to claim they have provided you with a surge suppressor. But a surge suppressor is an inferior form of power conditioning. To expect this conditioning to be much more than window dressing is wishful thinking.

The Ideal Product

You might think that the ideal product would be an on-line UPS. This concept is partially correct. The difference between a true UPS and an SPS is that in the UPS, the inverter powers the computer at all times. The incoming utility power is converted to DC by a rectifier/charger that transfers power to the inverter over a DC bus. The batteries are connected to this DC bus and, if the utility supply should fail, can provide instantaneous power to the computer—there is no switching time to worry about.

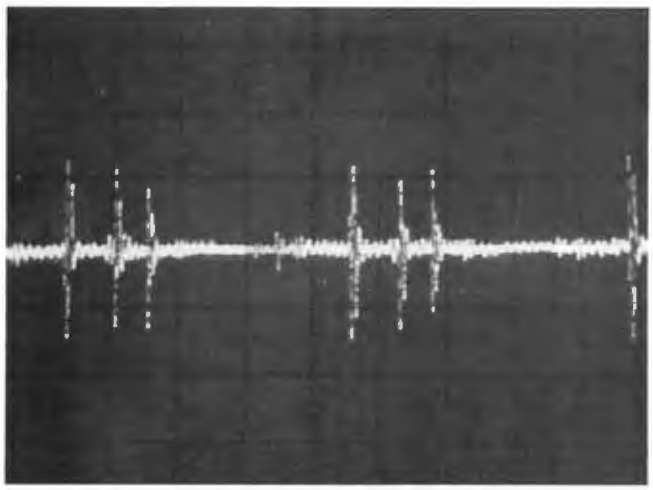

Photo 3: *This photo shows common-mode noise present on the line before insertion of an on-line UPS. Common-mode noise can be the most damaging form of noise.*

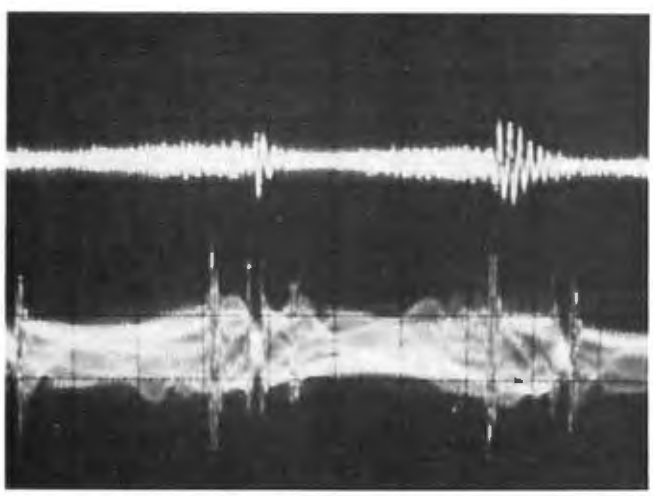

Photo 4: *Normal-mode noise (top trace) and common-mode noise (bottom trace) after the insertion of an on-line UPS. The top trace contains a small amount of noise from the UPS's inverter. The bottom trace shows inverter noise superimposed over the common-mode noise present in photo 3. As you can see, the UPS has contributed to, rather than eliminated, common-mode noise.*

In a UPS, the inverter and rectifier/charger are on-line all the time. Thus, they are larger and more substantial than those found in an SPS. This fact makes the cost of a comparable UPS three to five times that of an SPS. Specialized peripherals such as some large external hard disk drives might not be able to tolerate the switching times of an SPS.

Because of the AC to DC to AC conversion, the on-line UPS provides an excellent barrier to normal-mode noise (again, see last month's article). But the on-line design does little to suppress common-mode noise.

Photo 3 shows the common-mode noise present on the power line. Photo 4 shows the common-mode and normal-mode noise present after the insertion of an on-line UPS. Notice that the PWM inverter inside the UPS produces only a few volts of normal-mode noise (top trace). But the inverter generates about 30 V of common-mode noise, which you can see superimposed on the noise already present in photo 3.

In my previous article, I concluded that a power-line conditioner is the best product to protect your computer. The heart of this device is an isolation transformer with the neutral to ground bonded on the secondary. On the other hand, if you are concerned with blackouts, a properly designed SPS will carry you through outages. But, since it is not on-line all the time, there is no ongoing power protection.

The ideal product would seem to be a combination of power conditioner and SPS. In fact, one company recently announced a product that combines the two in one cabinet. But at $1500 for approximately 500 W, it is out of reach for most of us—although this price is less than that of many on-line UPSes of the same size.

A marriage between a power-line conditioner and an SPS is the best solution. The most effective way to connect the products is to plug the SPS into the wall, and the power conditioner into the SPS. This way, you are conditioning your power even when it is provided by the battery and inverter. The conditioner takes care of any SPS-generated noise.

Protect your LAN

The industry is just beginning to see the results of the computing revolution that networking has brought about. The economic value of data being handled via LANs is greater than ever before because there are multiple users who depend on the data. Networked data is often constantly updated by a file server and a large hard disk drive. They must be protected at all costs. In addition to mere protection, you must also be concerned with outages because they are the source of head crashes, downtime, and lost data.

Therefore, it is essential that you obtain an SPS to back up the file server and associated hard disk drive. Backup power is a necessary element in the success of a LAN because the network will not work for you if you don't learn to rely on and trust its performance.

Not only should you use an SPS for backup power, you should also use its external alarms, which will trigger LAN software to alert other users that they are on battery power and have only minutes to close their files and shut down. Remote users, whose power may be coming from a source that hasn't

continued

failed, especially need this feature.

Local users should also have backup power, or the file server should be able to use battery time to bring users back to their files gracefully.

Of course, you should use a power-line conditioner to protect your hard disk drive and its valuable data from destruction. Essentially, a LAN is just one big ground loop with several power sources and cables running all over. You should make every effort to provide a noise-free power environment so you will avoid degradation of your data.

With an expensive computer, you shouldn't scrimp on power products.

Publish or Perish

A desktop publishing system is usually a state-of-the-art computer with a high-speed processor, a large hard disk drive, a tape backup, and a laser printer. With an investment of this magnitude, you shouldn't scrimp on protection; what comes down the power line can seriously damage your system.

The typical laser printer draws as much as 1000 W, and this can be a problem. Thousand-watt power conditioners are expensive. Your only less-expensive option is a surge suppressor. If it is properly designed, a surge surpressor should protect the printer well enough to prevent any major damage. A laser printer, after all, is a lot more like a copier than a computer on the inside.

In a desktop publishing environment, backup power is essential for the computer, but not necessarily for the printer. If a printing function is disrupted by an outage, it may be a nuisance, but the job can be done again. The computer, on the other hand, has large and rather lengthy processing chores. It makes sense to provide it with an SPS to ensure that jobs finish and files are closed before power shuts down.

Buy Safe, Not Sorry

Many people spend thousands of dollars on hardware and software, only to dash out and buy the least-expensive protective and backup power products they can find. You will waste your money on this strategy and leave your system vulnerable, and you may even introduce undesirable noise into the electrical environment.

To obtain devices that provide you with a safe personal computing system, you should invest the same amount of thought and evaluation as when you selected your computer to begin with. The process will vary depending on your needs and your particular system configuration.

Armed with the facts, you can make informed buying decisions and then relax and let your investment in computing work for you. ■

Mark Waller is a computer facilities consultant and the author of Computer Electrical Power Requirements *and* Mastering PC Electrical Power, *both published by Howard W. Sams. He can be reached on BIX c/o "editors."*


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Circle 84 on Reader Service Card (DEALERS: 85)

MULTIPLE REGRESSION WITH EXCEL

A little-known feature of Microsoft Excel lets you do powerful multiple regression analysis

Charles W. Kyd

Microsoft Excel contains a powerful feature that's new to spreadsheet technology. It's also a hidden feature, largely overlooked by users and the computer press.

The new feature is array processing within spreadsheet formulas. It includes functions that multiply, invert, transpose, and find the determinant of arrays or matrices. It lets you generate a temporary array, modify it, and summarize it, all within the same formula. It allows range definitions to change as the result of calculated values in the spreadsheet. It even brings certain characteristics of a relational database to spreadsheets.

Most important, it lets you perform sophisticated applications, such as multiple regression analysis.

Array Processing in Excel

In Excel, an array is a rectangular area of data that can exist in spreadsheet cells, in range definitions, or as a temporary work area within a formula. By using arrays, you can largely eliminate the columns of intermediate calculations that clutter many spreadsheets.

For example, figure 1 presents a simple purchase history file containing the month of purchase, part number, quantity, and price of each purchased item. To calculate total purchases for this figure, most spreadsheets would require that you create a column that subtotals purchases for each row. Figure 2, however, summarizes figure 1 directly.

To create the formulas in figure 2, you first define in figure 1 the range name `Quantity` as `=$C$6:$C$14` and `Price` as `=$D$6:$D$14`. So far, there are no surprises; you could define similar ranges in most other spreadsheets. But in Excel, you can also define the range name `Subtotals` as `=Quantity *Price`. This definition sets up `Subtotals` as an array that consists of each cell of the `Quantity` array multiplied by the corresponding cell of the `Price` array.

Notice that, unlike other spreadsheets, Excel allows the new array to exist in memory, independent of the rows and columns in the spreadsheet. To prove this point, if you press the F5 (GOTO) key in PC Excel and enter `Subtotals`, Excel returns an error message because there's no place within the spreadsheet for the cell pointer to go.

The formula in cell E21 of figure 2, which depends on Excel's array-processing ability to return the amount of total purchases, could be replaced with a different formula:

1. It could contain `=SUM(Subtotals)`. Because you've defined `Subtotals` as an array that contains the subtotal of each purchase, you can simply find the sum of this array.

2. It could contain `=SUM(Quantity*Price)`. When you enter this formula, it first creates a temporary array containing each subtotal, which the `SUM` function totals. For this formula to work properly, however, you must enter it as an array formula. To do so, first type it in as you normally would. Then, in PC Excel, hold down Control-Shift and press Enter. (In Mac Excel, hold down the Command key and press Enter.) When you do so, the spreadsheet shows that you've created an array formula by enclosing it in braces in the formula bar, like this: `{=SUM(Quantity*Price)}`.

3. It could contain `=MMULT(TRANSPOSE(Quantity),Price)`. Using the techniques of traditional matrix algebra, this formula calculates the dot product of the two arrays. To do so, the formula transposes the 4-by-1 `Quantity` array to produce a 1-by-4 array, and then premultiplies it by the 4-by-1 `Price` array, producing a 1-by-1 array that contains the grand total.

These formulas generate the same result, and they do so more quickly and with a less-cluttered worksheet than other spreadsheet programs require. But because of the way you've defined the `Quantity` and `Price` ranges, all three of the formulas rest on shaky ground. Remember, these ranges begin and end with data in figure 1, not with the top and bottom borders. This approach is dangerous because if you insert additional rows of data above the first row or below the last row of data, you don't expand the two ranges as you should to include the new data.

continued

The common way to deal with this problem is to define range names to include the top and bottom borders. This way, range names always include any rows of data inserted between the borders. Unfortunately, this approach fails in this instance because many array operations would attempt to treat the empty border cells as legitimate data, thereby returning error messages.

To solve this problem, you must define dynamic range names, names that expand or contract as the shape of the data expands or contracts. To do so, you first define the range Input as =$A$5:$D$15. This range, which surrounds the data in figure 1, serves as a reference for the dynamic range name definitions.

Once you've defined Input, you can define these four ranges:

```
Month=INDEX(Input,2,1):INDEX(Input,ROWS
    (Input)-1,1)
PartNum=INDEX(Input,2,2):INDEX(Input,ROWS
    (Input)-1,2)
Quantity=INDEX(Input,2,3):INDEX(Input,ROWS
    (Input)-1,3)
Price=INDEX(Input,2,4):INDEX(Input,ROWS
    (Input)-1,4)
```

These dynamic-range definitions allow the number of rows of data to expand and contract while allowing the defined ranges to do likewise and still reference only the actual data. The INDEX function provides the key to this process. This function takes the form =INDEX(array,row_num,column_num) and returns either data or a cell reference, depending on how it's used in a formula. Here, because two INDEX functions are joined by a colon, Excel correctly assumes that you want it to return a cell reference.

Therefore, the first cell in the Quantity range is defined by the cell in the second row and third column of the Input range, which is cell C6. The last cell in the Quantity range is defined as one row above the last row of the Input range and in the third column of that range, which is cell C14. (The ROWS function returns the number of rows in a range and therefore specifies the last row of the Input range.)

This approach, therefore, defines Quantity as the range C6:C14. This is the same area that the original definition of Quantity specified, but unlike the first definition, this one is dynamic.

With these four ranges defined, you can quickly calculate the remaining summary information in figure 2. Cell E22 in this figure counts the number of purchases made in February. Its formula, which you must enter in the form of an array, is as follows:

```
=COUNT(IF(Month=2,Month))
```

This formula creates a temporary array that contains the month value whenever the value equals 2, and then the formula returns the count of this array.

Alternatively, you could use the following formula to produce the same result:

```
=SUM(IF(Month=2,1))
```

This formula creates a temporary array that contains the value of 1 whenever a value in the Month range equals 2; the sum of this array returns a count of the number of occurrences.

Cell E23 returns the sum of all purchases made in February for part number 110. Its formula, which must also be entered as an array, is

```
=SUM(IF(PartNum=110,IF(Month=2,Subtotals)))
```

continued

	A	B	C	D	E
1					
2					
3	Purchase History File				
4	Month	PartNum	Quantity	Price	
5					
6	1	101	12	3.00	
7	1	105	50	41.00	
8	1	105	20	42.30	
9	2	101	100	2.95	
10	2	110	10	18.00	
11	2	105	10	40.85	
12	2	101	100	3.10	
13	3	110	50	18.00	
14	3	112	5	7.50	
15					
16					

Figure 1: *This purchase history file contains transaction data that Excel's array formulas summarize in figure 2.*

This formula creates a temporary array that contains a subtotal value whenever the month of a purchase equals 2 and the part number equals 110, and then the formula returns the sum of these subtotals.

Notice that instead of the AND operator, this formula uses nested IF statements to join the two conditions. (PC Excel allows a maximum of eight IF statements to be nested in this manner; Mac Excel allows seven.) Also notice that only the final IF statement in the nest must specify the THEN portion of the argument.

The table at the bottom of figure 2 uses a similar formula to generate a summary of purchases by part number and month. The general format of this table is one that I've used for years for analyzing purchases, sales, operating expenses, and other transaction data.

To generate this table using most other spreadsheets, you would need to define a Criteria range and then set up a two-way data table that depends on a DSUM calculation. Not only does this approach require a complex setup, it calculates slowly because the entire spreadsheet must recalculate once for every cell in the data table.

However, Excel lets you create this table easily. To do so, first enter the data in the ranges A29:A32 and B27:D27, and then enter the following array formula in cell B29:

```
=SUM(IF(PartNum=$A29,IF(Month=B$27,Subtotals)))
```

To complete the table, simply copy the formula in cell B29 to the range B29:D32, and then enter the SUM formulas in row 34 and in the range E29:E32. Using this approach to generate the summary table requires that the spreadsheet recalculate only once—just as with any other formula that does not require iteration.

Multiple Regression Analysis with Arrays

One effective way to illustrate the power of array processing is to apply it to a challenging but useful application, such as multiple regression analysis. This statistical technique offers three challenges: It depends on sophisticated formulas generally hidden in dusty statistics books; it uses calculations that are beyond the ability of most spreadsheets to directly perform; and it produces results that many users find difficult to interpret.

Nevertheless, multiple regression serves as a valuable tool in many business applications. Suppose, for example, that the controller of a company that manufactures printed circuit boards for personal computers wants to improve her company's sales forecasts. To bring a note of reality to the overenthusiastic estimates of her marketing department, she decides to forecast company sales by using general economic indicators. If she can find a relationship between the economic indicators and her sales, she can base her own forecasts on the economic forecasts of outside experts.

Multiple regression analysis is a standard statistical technique that can find this relationship between a dependent variable (sales) and several independent variables (economic indicators). To begin the analysis, the controller decides to test an assumption that her sales vary with changes in total corporate profits, disposable consumer income, and the nationwide sales of personal computers. She therefore assembles the data shown in figure 3.

Figure 4 shows a spreadsheet that contains the results of her analysis. These are the statistics commonly produced by software designed for statistical analysis, but not by spreadsheet programs. (The Data Regression command in Lotus 1-2-3 generates about half of these statistics—those found in rows 7, 9, 10, and 19, in the range C20:E20, and in cell A21.)

continued

	A	B	C	D	E	F
18						
19						
20	**Purchase Summary**					
21	Total Purchases				5,063.00	
22	Number of Purchases In February				4	
23	Sum of February Purchases for Part # 110				180.00	
24						
25	**Summary by Part Number by Month**					
26		Month				
27	PartNum	1	2	3	Total	
28						
29	101	36.00	605.00	0.00	641.00	
30	105	2,896.00	408.50	0.00	3,304.50	
31	110	0.00	180.00	900.00	1,080.00	
32	112	0.00	0.00	37.50	37.50	
33						
34	Total	2,932.00	1,193.50	937.50	5,063.00	
35						

Figure 2: *Array formulas in this figure summarize the transaction data from figure 1. They do so without using columns of intermediate calculations, criteria ranges,* DSUM *functions, or data tables.*

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The correlation matrix helps uncover a potential problem; the forecast may be unreliable if two or more independent variables are closely correlated.

To cut to the heart of the application, I've included tables that explain both the range names (see table 1) and formulas (see table 2) used in figure 4. This approach lets you refer to the information easily when you create the application. But before you refer to these formulas, let's take a closer look at what their results mean.

Interpreting the Results

How might the corporate controller interpret the results in figure 4? Overall, the analysis shows a strong association between changes in sales and changes in the economic indicators that she's selected. The R-squared value in cell C10 is the easiest value to interpret. It tells the controller that 90.1 percent of the variations in sales can be explained by variations in the independent variables.

When the controller looks up the F value (cell C11) in a table at the back of nearly any introductory statistics book, she learns that she's identified a statistically significant relationship in her analysis. When she checks the standard error of the estimate (cell C9), she learns that actual sales generally fall within $.922 of their estimated value. This value represents a relatively accurate estimate, considering that her sales range from $10 to $17 in figure 3.

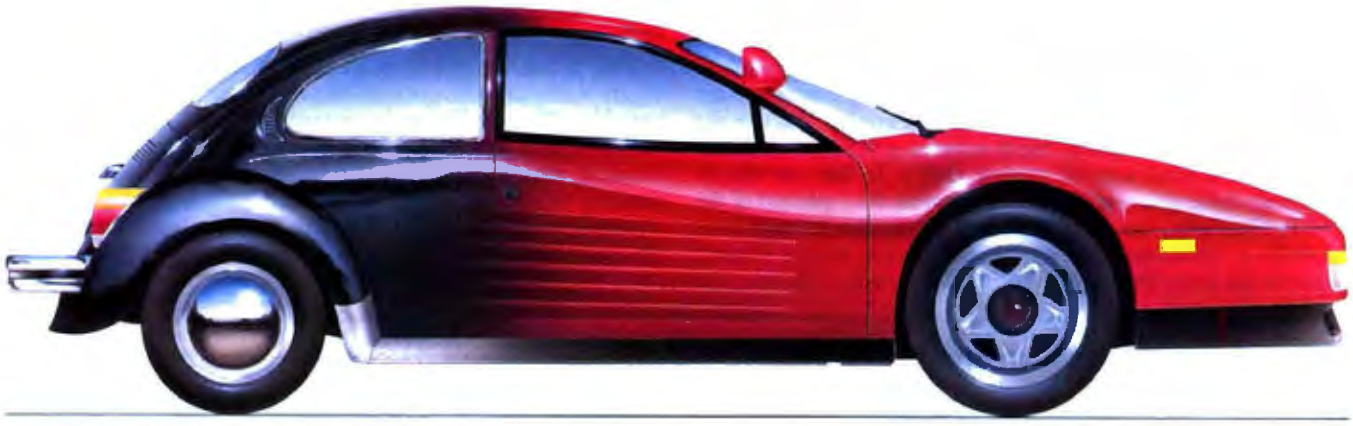
Row 19 of figure 4 shows the regression formula, which estimates that monthly sales equal $48.646, plus 0.704 times corporate profits in the month, plus 0.318 times disposable income, plus 0.714 times computer sales. Rows 20 and 21 help her evaluate the significance of these coefficients. Row 20 contains a measure of variability of each coefficient, and row 21 contains a ratio that shows how many times greater each coefficient is than its measure of variability. When she looks up each of these t-statistics ratios in her statistics book, she finds that each coefficient is significant at the 95 percent confidence level.

Rows 28 and 29 help the controller to estimate future sales. She enters economic forecasts of corporate profits, disposable income, and computer sales in row 28. When she recalculates the spreadsheet, it combines the coefficients in row 19 and the estimates in row 28. The result, which appears in cell B29, predicts the sales of her own printed circuit boards.

continued

	A	B	C	D	E	F
1						
2						
3	Data for Multiple Regression Analysis					
4			Corp	Disposable	Computer	Board
5			Profits	Income	Sales	Sales
6	Month		1	2	3	Y
7						
8	January	1	35	49	33	17
9	February	1	30	48	30	10
10	March	1	34	50	32	14
11	April	1	35	50	28	12
12	May	1	34	51	29	12
13	June	1	39	49	30	16
14	July	1	34	55	33	16
15	August	1	36	47	33	14
16	September	1	35	50	31	14
17	October	1	34	47	31	12
18	November	1	36	50	34	17
19	December	1	31	49	31	10
20						

Figure 3: *A record of economic data by month and a record of printed circuit board sales for a hypothetical company. Figure 4 performs a multiple regression analysis of this data.*



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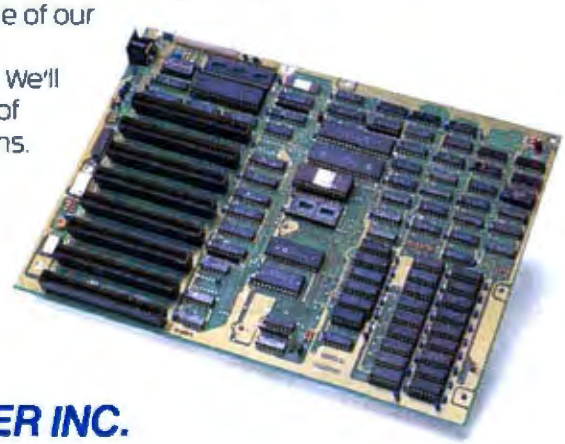

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The spreadsheet includes an analysis of variance (ANOVA) table for two reasons. First, it generates certain values required by other formulas in the spreadsheet. Second, it summarizes the regression results from yet another viewpoint. You can see that the sum of the squares due to regression (SSR) is almost as large as the total sum of squares (SST). In fact, as the R-squared value tells you, the SSR represents 90.1 percent of the SST. Similarly, the mean sum of squares due to regression (MSR) is significantly greater than the mean sum of squares due to the error (MSE). In fact, as the F value tells you, the MSR value is 24.28 times the MSE value.

The correlation matrix at the bottom of the spreadsheet in figure 4 displays the correlation coefficients for each pair of variables. This coefficient is a measure of the linear association between each pair. If the variables have a perfect linear relationship, the correlation coefficient equals either 1 or −1, depending on whether the variables both rise and fall together or whether one rises as the other falls. (Of course, each variable in the matrix is perfectly correlated with itself.) The correlation

continued

	A	B	C	D	E	F	G
1							
2							
3	Multiple Regression Analysis						
4							
5							
6	Regression Results						
7	Number of Observations (n)		12				
8	Number of Ind. Variables (k)		3				
9	Std Error of Estimate		.922				
10	R-Squared		90.10%				
11	F Value (df= 3,8)		24.28				
12							
13							
14	Variable Number		1	2	3	Y	
15							
16							
17	Individual Variables						
18		Constant					
19	Coefficients	-48.646	.704	.318	.714		
20	Std Error of Coef	8.471	.121	.132	.156		
21	T Statistic (df=8)	-5.742	5.803	2.398	4.594		
22							
23	Average Value		34.417	49.583	31.250	13.667	
24	Standard Deviation		2.314	2.109	1.815	2.498	
25							
26							
27	Point Estimate						
28	Enter Values:		35	49	33		
29	Est. Y Value	15.142					
30							
31							
32	Analysis of Variance (ANOVA)						
33		SS		df		MS	
34	Regression	SSR	61.87	3	20.62	MSR	
35	Error	SSE	6.80	8	0.85	MSE	
36	Total	SST	68.67	11			
37							
38							
39	Correlation Matrix						
40		1	2	3	Y		
41	1	1.0000	.0202	.1461	.7337		
42	2	.0202	1.0000	.1009	.3336		
43	3	.1461	.1009	1.0000	.6414		
44	Y	.7337	.3336	.6414	1.0000		
45							
46							
47							

Figure 4: *This spreadsheet uses Excel's array processing abilities to present the statistics common to statistical software.*

Table 1: *The range names used to create the spreadsheet in figure 4.*

Input=MR_DATA.XLS!Input
This range name refers to figure 3.

Data=INDEX(Input,2,2):
INDEX(Input,ROWS(Input) – 1,COLUMNS(Input))
The Data matrix contains all the data and only the data. It excludes borders and the column of 1s from the Input matrix.

Xi=INDEX(Input,2,1):
INDEX(Input,ROWS(Input) – 1, COLUMNS(Input) – 1)
X=INDEX(Input,2,2):
INDEX(Input,ROWS(Input) – 1, COLUMNS(Input) – 1)
These two arrays of X data differ in only one way: The Xi matrix includes the column of 1s; the X matrix excludes this column.

Y=INDEX(Input,2,COLUMNS(Input)):
INDEX(Input, ROWS(Input) – 1,COLUMNS(Input))
The Y column contains the data in the rightmost column of the Data matrix.

These four ranges are defined using dynamic range definitions, as described in the text.

n=$C$7
This name defines the cell that contains the number of observations (in this example, the number of months of data).

k=$C$8
Authorities are divided between whether the k notation should represent the number of independent variables—the *X*s—or the number of all variables—the *X*s and the *Y*. Here, k represents the number of *X* variables.

b=$B$19:$E$19
This name contains all coefficients of the regression equation.

Avg=$C$23:$F$23
AvgY=$F$23
The Avg name contains the averages of the *X* and *Y* variables. The AvgY range contains only the average for the *Y* variable.

Std=$C$24:$F$24
This name contains the standard deviation of each of the *X* and *Y* variables.

Est=$B$28:$E$28
The Point Estimate section of figure 4 forecasts a value of Y when you enter estimated values of X. This range contains the estimated values of X. Notice, however, that the range includes cell B28, which contains the hidden value of 1. To hide this value, select Format Number and then enter ";;;" (two semicolons) as a custom format.

SSR=$C$34
SSE=$C$35
SST=$C$36
These names contain the respective values for the sum of the squares due to regression (SSR), attributed to errors (SSE), and the total sum of squares (SST).

MSR=$E$34
MSE=$E$35
These two names label values from the ANOVA table. MSR represents the regression mean square; MSE represents the error mean square.

Table 2: *The formulas used to create the spreadsheet in figure 4. They should be entered in the order they're listed here.*

C7=COUNT(Y)
The number of Y values equals the total number of observations.

C8=COLUMNS(X)
The number of X columns equals the number of independent variables, range name k.

A11="F Value (df= "&k&","&n – k – 1&")"
This formula returns the two values of F's degrees of freedom (k and n – k – 1) as a label.

C14 1
D14=1+C14
Copy this formula to the right as needed.

B19(PC)=INDEX(LINEST(Y,X),1,k – B14+1)
In PC Excel, the LINEST function returns a 1-by-4 array that contains the coefficients of a multiple regression equation in the order of X3, X2, X1, and the constant. The INDEX function displays a value from this array. Copy this formula to the right as needed.

B19(Mac)=INDEX(MMULT(MMULT(MINVERSE(MMULT (TRANSPOSE(XI),XI)), TRANSPOSE(XI)),Y),B14+1,1)
Because Mac Excel (through version 1.5) doesn't have the LINEST function, you must use arrays to generate the coefficients of the multiple regression equation. This array formula returns the coefficients in a 4-by-1 array in the order of the constant, X1, X2, and X3, and then the INDEX function displays the appropriate value. Copy this formula to the right as needed.

A21="T Statistic (df="&n – k – 1&")"
This formula returns the value of the t-statistic's degrees of freedom (n – k – 1) as a label.

C23=AVERAGE(INDEX(Data,1,C$14): INDEX(Data,ROWS(Data),C$14))
C24=STDEV(INDEX(Data,1,C$14): INDEX(Data,ROWS(Data),C$14))
Copy these formulas to the right as needed. However, because the Y column contains a *Y* in row 14 rather than a number, this formula won't work for the Y values.

F23=AVERAGE(INDEX(Data,1,COLUMNS(Data)): INDEX(Data,ROWS(Data),COLUMNS(Data)))
F24=STDEV(INDEX(Data,1,COLUMNS(Data)): INDEX(Data,ROWS(Data),COLUMNS(Data)))
Use these two formulas to calculate the average and standard deviation of the Y value.

B28 1
This cell contains the value of 1 but is hidden by its number format of ";;".

C28 35
The remaining cells in this row contain the forecasted values for the independent variables (the X values).

B29=MMULT(Est,TRANSPOSE(b))
This array formula calculates the Y value by multiplying the estimated values of the independent variables by the coefficients of the regression equation.

C34=SUM((AvgY – MMULT(XI,TRANSPOSE(b)))^2)
To find the sum of the squared deviations due to regression (SSR) in this array formula, subtract the column of predicted Ys (generated here by the MMULT section of the formula) from the mean of the Ys (AvgY), square the results, and then sum the squares.

C35=SUM((Y – MMULT(XI,TRANSPOSE(b)))^2)
To find the sum of the squared deviations caused by errors (SSE) in this array formula, subtract the column of predicted Ys (generated here by the MMULT section of the formula) from each value of Y, square the results, and then sum the squares.

C36=SUM((Y – AvgY)^2)
To find the total sum of the squared deviations (SST) in this array formula, subtract the average Y from each value of Y, square the results, and then sum the squares.

D34=k
The SSR degrees of freedom equals the number of independent variables.

D35=n – k – 1
The SSE degrees of freedom equals the total number of observations less the number of both the dependent and independent variables.

D36=n – 1
The SST degrees of freedom equals the total number of observations less the number of dependent variables. It also equals the sum of the previous 2 degrees of freedom.

E34=SSR/D34
The mean squared deviation due to regression (MSR) equals the sum of the squares due to regression divided by the SSR degrees of freedom.

E35=SSE/D35
The mean squared deviation caused by the error (MSE) equals the sum of the squares caused by the error divided by the SSE degrees of freedom.

A42=1+A41
C40=1+B40
Copy these formulas down or to the right as needed.

B41=(MMULT(TRANSPOSE(Data – Avg),DataAvg)/ (TRANSPOSE(Std)*Std))/(n – 1)
If you let *U* and *W* be any variables in the Data range, and you let *u* and *w* equal the value of the deviations from their means, their correlation coefficient is equal to **Sum(u*w)/Sqrt(Sum(u^2)*Sum(w^2))**. This formula generates an array that contains all such combinations of correlations. To enter this formula, first highlight the range B41:E44, type the formula as shown, and then enter it by pressing Control-Shift and Enter. (In Mac Excel, hold down the Command key and then press Enter.)

C9=(SSE/(n – k – 1))^0.5
The standard error of the estimate equals the standard deviation of the error values. To find the standard deviation, divide the sum of the squares of the error terms by (n – k – 1) and then take the square root of the result.

C10=SSR/SST
The R-squared represents the proportion of all squared deviations that have been explained by the regression equation. That is, it's the simple ratio shown.

continued

C11=MSR/MSE
The F value compares the mean sum from regression to the mean sum from errors.

B20=SQRT(INDEX(MINVERSE(MMULT(TRANSPOSE(XI), XI)),B$14+1,B$14+1)*$C$9^2)
Multiplying the MINVERSE portion of this array formula by the square of the standard error of the estimate ("sigma squared") returns the variance-covariance matrix. Taking the square roots of the diagonal elements of this matrix returns the standard deviations of each of the coefficients of the regression equation, which are more commonly referred to as the standard errors of the coefficients. When you've entered this formula in the one cell shown, copy it to the right as necessary.

C21=C19/C20
The t-statistic equals each coefficient divided by its standard error.

coefficient equals 0 if there is no linear relationship between the variables.

This correlation matrix helps the controller uncover a potential problem with her regression analysis: Her forecast may be unreliable if two or more independent variables are closely correlated, a condition that statisticians call *multicolinearity*. In the spreadsheet, however, the correlation matrix shows that none of the independent variables have a correlation coefficient greater than 0.1461. Therefore, multicolinearity isn't a problem for her because, as a rule of thumb, these problems arise only when correlation coefficients are greater than 0.70 or less than −0.70.

Suppose, however, that the controller had included two additional independent variables in her analysis: sales of monitors for personal computers, and corporate bankruptcies. If she had, she probably would have found that sales of personal computers show a high and positive correlation with the sales of monitors for personal computers and that business profits show a high and negative correlation with corporate bankruptcies (as profits go up, bankruptcies go down). She would therefore eliminate these variables, for two reasons. From a statistical standpoint, they create multicolinearity problems. From a practical standpoint, these two variables add little to the analysis, and there is no need to go to the work and expense of including them.

Creating the Worksheet

To create figure 3, first open a new worksheet. Turn off its gridlines and set the manual calculation mode. This figure contains no formulas. Enter the labels, data, and formatting as shown. Notice that column B contains a column of 1s. The matrix formulas used in figure 4 won't work properly if this column is missing. If you want to hide this column after you've entered it, do so by assigning the number format ";;" to the column.

The current version of Mac Excel (1.5) cannot draw the shaded borders in figure 3. Instead, I suggest Mac Excel users substitute a row of Xs for the shading. To do so, highlight the shaded area, select `Format Alignment`, choose `Fill`, and then enter `X` in the leftmost cell.

Define the range `Input` as `=$B$7:$F$20`. This range extends from the borders above and below the data and from the column of 1s to the last column of data. After you've assigned the range name, save your spreadsheet using the name `MR_DATA.XLS`.

To create figure 4, first open a new worksheet and turn off its gridlines. Enter all labels and borders shown in the figure before entering its names and formulas. Enter all range-name definitions shown in table 1 for the figure. Of course, many of these ranges have no values associated with them yet, but this will cause no problem.

I've arranged the spreadsheet in figure 4 in a logical sequence for reading the results of a regression analysis, not in a sequence convenient for entering the formulas. Table 2 shows the sequence to follow when you enter the figure's formulas. When you follow this sequence, each formula you enter builds on formulas entered previously.

Cell B19 of figure 4 contains the only instance where the Mac and PC versions of Excel use different formulas. As table 2 shows for this cell, the PC version uses the `LINEST` function, which returns the coefficients of a multiple regression equation. But because the current version of Mac Excel lacks this function, you must substitute an array formula. Using matrix notation, this formula is as follows:

$$b = (X1'X1)^{-1}X1'Y$$

In this formula, `b` is the 4-by-1 array of the coefficients of a multiple regression equation, `X1` and `Y` are ranges defined in table 1, the apostrophe means to transpose the array, and $^{-1}$ means to find the inverse of the array.

When you've completed figure 4, save it using the name `MR_3`. This name stands for multiple regression using three independent variables.

Roll Your Own

To enter your own data into figure 3, you will probably need to modify its size. When you do, be sure to adjust both figures 3 and 4, if necessary, so each has the same number of independent variables.

When you adjust figure 4, the correlation matrix will give you a problem initially, because when you try to add rows or columns to the matrix, you get an error message that says "Can't change part of an array." To work around this problem, highlight the matrix, click on the formula in the formula bar, and press Control-Enter (Option-Enter in Mac Excel). The correlation matrix will then return a `#VALUE!` error. Insert the additional row and column and add the new headings.

To change the error values into a working matrix, highlight the matrix that now contains five rows and columns, click on the formula in the formula bar, and press Control-Enter (Command-Enter in Mac Excel).

When you recalculate, the matrix should return the correct values. But if it still returns a `#VALUE!` error, check that all numbered headings are correct and that you have five columns of data in your version of figure 3.

When you first try to create and modify figures 3 and 4, you'll probably see that `#VALUE!` error more than once—I certainly did. But as you use arrays, you'll quickly learn that they're easy to use and correct. Soon, you'll wonder how you ever got along without their incredible power. ■

Charles W. Kyd spent 10 years as a chief financial officer of high-tech companies, and he is now a writer and consultant. This article has been adapted from his new book, The Microsoft Excel Business Sourcebook *(Microsoft Press, 1988). He can be reached on BIX c/o "editors."*

IT'S APT TO WRITE

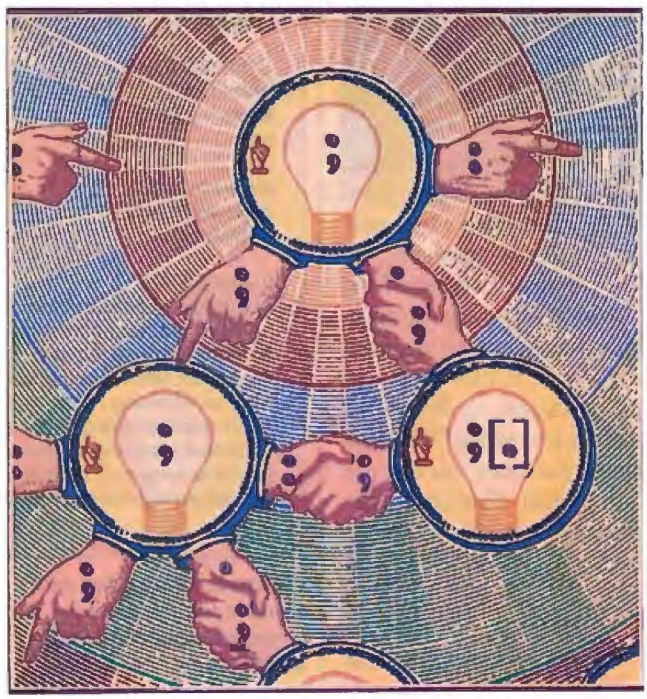
The Abstract Planning Tool is an intelligent outliner that makes logical connections from your thoughts and ideas

Peter Wayner

If you don't want people to fall asleep while they're reading what you've written, there's plenty of careful planning to be done before you begin writing.

Most people organize their material with either an outline or index-card system. Many different outlining programs can help you handle this part of your writing process, but generally they are not much more than word processors that let you format your material in various ways. They rarely help you sketch out your ideas in the initial writing stages.

To make outlining more natural and precise, I have developed the Abstract Planning Tool (APT), a new system for writing that borrows many techniques from programming languages and their compilers. One significant difference between APT and other outlining programs is that this system understands logical connections. This feature is unique in that it allows you to think about the relationships between your ideas.



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Birth of a Notion

Instructors of beginning programmers often tell their students that writing a good program is like writing a good essay. This advice was the inspiration for creating APT. To write a good essay, you must carefully define your topic at the beginning and group the material into small, manageable sections. You should discuss subjects only after you have introduced the ideas on which the subjects depend. Finally, you must draw everything in your material together into a single cogent treatise at the end.

Languages like Pascal were specifically designed to force the programmer to write code that follows these strong structural guidelines. To a large extent, they have succeeded. There has been little focus, however, on using the structure of a well-defined programming language to help arrange the ideas for writing any type of material that requires logical organization.

Just as programmers aim to teach the machine a task, you begin a writing project by wanting to impart some information to the reader. The subject might be how Shakespeare drew heavily on the social and political tenor of Elizabethan England or how two numbers are relatively prime if, and only if, Euclid's algorithm returns a 1.

With this goal in mind, then, you outline your ideas and arrange them in a logical and reasonable order. If the outline is good, the piece will succeed and the reader will understand the topic. But if the outline is bad, the resulting material will be bad and the reader will end up confused and unsatisfied.

Unfortunately, there is no set outline pattern to require you to develop your ideas

continued

carefully. Thus, when you spontaneously create an outline, you may end up with one that is hopelessly convoluted and has little or no structure. In this situation, you may overlook defining terms that need definition or you may turn lines of argument into loops by introducing facts and ideas too early or too late. As the writer, you must bear the burden and responsibility for producing a well-conceived argument.

APT is an attempt to provide writers with the power to generate structurally sound outlines by casting ideas in a quasi-mathematical or quasi-logical form. The APT compiler takes these abstractions and converts them into a simple, sound outline just as a Pascal compiler converts a list of code words into a working program. The APT compiler requires you to define all your ideas at the beginning and carefully connect them in equations. You can still produce a bad outline, just as a programmer can inadvertently generate code that will loop forever, but the structure of APT makes you think through many of the potential problems in advance.

continued

```
IDEAS
Slavery; {The use of slaves on southern plantations.}
Southern farming; {Economy of the South depends on
   large-scale plantation farming.}
Plantation labor; {Plantation farming of tobacco and sugar
   is labor-intensive. Automation for these processes is un-
   available.}
Northern factories; {The northern economy is dominated by
   factories and high-technology manufacturing.}
Automation; {Automation of northern factories reduces the
   need for labor.}
Northern farming; {The northern soil is more suited to
   grains and other crops easily harvested by new automated
   machines.}
Economic differences; {The North has a factory economy
   while the South relies on labor-intensive farming.}
Tariff; {Hawley-Smoot bill raises tariffs on imported goods.}
Civil War; {War between northern and southern United
   States (1861–1865).}
Farming differences; {The differences between the two
   systems.}

CONNECTORS
helps:LEFT;
leads to:LEFT;
and;
or;
does not help;
requires:RIGHT;
different than.

CONNECTIONS
Automation helps northern farming;
Automation helps northern factories;
Automation does not help plantation labor;
Plantation labor requires slavery;
Southern farming requires plantation labor;
Tariff helps northern factories; (farming differences =
   northern farming different from southern farming)
Leads to economic differences; (farming differences and
   economic differences) leads to Civil War.
```

Figure 1: *Using a text editor or word processor, you can create a text file to be fed into APT. The statements must be arranged under the headings Ideas, Connectors, and Connections.*

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An APT Example

Assume you are writing an essay on the economic causes of the American Civil War. APT helps you handle this by getting you to organize your thoughts into three segments: Ideas, Connectors, and Connections (see figure 1).

In the Ideas segment, you list the principal ideas of your paper, each followed by a semicolon. The compiler considers the words between semicolons as a token, a separate entity that represents each idea or connector. The same word can appear in different tokens, and one token can be a prefix of another. You can include additional thoughts and explanations between brackets, and the program will ignore these words.

The Connectors segment defines various words that will join two ideas. They are stored as separate tokens that may contain words from other tokens and other connectors as prefixes. In figure 1, for example, "helps" and "different from" are connectors. "Helps greatly" is also a perfectly acceptable connector. The compiler treats it differently than "helps." The parser's current design limits you from using the same word in both an idea and a connector. You should not find this situation too much trouble, though, because ideas will generally consist of nouns, and connectors will generally consist of verbs.

There are three different types of connectors. Ordinary ones (also called symmetric) place no restrictions on the order the two ideas will take in the outline, while left and right connectors force the compiler to develop either the left or the right side of the equation first.

In figure 1, the program defines the verb "helps" to be a left connector. When the compiler reaches the clause "automation helps northern factories," it places the left side of the equation, "automation," first in the outline. The link "helps" forces the topic of "automation" to be developed before "northern factories." If the connector is a right one, the right side comes first. "Requires" is a right connector, so in the phrase "plantation labor requires slavery," in the final outline, "slavery" will come first.

You specify whether a connector is left or right by placing a colon immediately after it and writing the word left or right in capital letters. Unspecified tokens are assumed to be symmetric. In figure 1, "or" is a symmetric token.

In the Connections segment, you draw together your ideas in pairs with connectors. Each of these new idea-connector-idea clauses forms a new idea, and you can link these clauses with nested parentheses in patterns such as "(idea-connector-idea) connector-idea." The first connector idea in parentheses now acts as a new idea. If you plan carefully, then when the ideas and connections are defined, the resultant clauses may come close to being grammatically correct. In figure 1, I defined "does not help" as a connector so it could join two ideas together in an English-like sentence.

The program takes a text file for input. You can create the file with any editor or word processor that stores the words in a simple text-file format with no control characters or escape sequences. You need to make the files look exactly like figure 1, using the words IDEAS, CONNECTORS, CONNECTIONS, LEFT, and RIGHT.

Semicolons must separate the different ideas, connectors, and phrases, but a period must come after the last item in each segment. The program asks for the names of the input and output files. The output file will contain all the error messages.

The compiler encourages free-form thinking by accepting Ideas, Connectors, or Connections segments in practically any order. It only requires that the ideas and connectors used in a clause be defined in a previous section. Two outlines can easily be combined by cutting and pasting complete segments from

continued

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Describe: slavery

Describe: plantation labor

Show how: plantation labor requires slavery

Describe: southern farming

Show how: southern farming requires plantation labor

Describe: northern farming

Show how: farming differences = northern farming different from southern farming

Describe: economic differences

Show how: farming differences lead to economic differences

Describe: automation

Show how: automation does not help plantation labor

Describe: northern factories

Show how: automation helps northern factories

Describe: tariff

Show how: tariff helps northern factories

Show how: automation helps northern farming

Show how: farming differences and economic differences

Describe: Civil War

Show how: (farming differences and economic differences) leads to Civil War

Figure 2: *The outline produced by APT from the text in figure 1.*

```
IDEAS
Definition of right triangle; [a triangle with one right angle.]
Pythagorean theorem; [a squared plus b squared equals c
  squared.]
Definition of sine; [sine is the ratio between the opposite
  side and the hypotenuse]
Definition of cosine; [cosine is the ratio between the adja-
  cent side and the hypotenuse]
Transcendental identity. [sine(x) squared + cosine(x)
  squared = 1]

CONNECTORS
and;
implies:LEFT.

CONNECTIONS
Definition of right triangle implies Pythagorean theorem;
(Pythagorean theorem and (definition of sine and definition of
  cosine)) implies transcendental identity.
```

Figure 3: *You can use APT for outlining material that needs to be precisely organized, such as mathematical proofs. The outline shown here is a proof of a trigonometric identity.*

one into another. You just need to make sure all the necessary ideas and connectors are carried along into the new outline.

How the Outliner Organizes

When the APT compiler finishes reading the tokens, it tries to create an outline using the basic ideas and the connections that must be made between them. It starts by selecting one of the clauses in the Connections segment and stepping through the ideas in it one by one. The ideas that should be joined together are placed one after the other. Then the connection between two ideas is inserted into the outline immediately after the ideas are defined.

Figure 2 shows the results of running the outline in figure 1 through APT. When the compiler develops the clause "plantation labor requires slavery," it asks you to describe first slavery, then plantation labor. Right after these two ideas are introduced, it asks you to show how they are connected—that is, how plantation labor requires slavery. The words "describe" and "show how" are two stock phrases the compiler uses when it creates the final outline.

The outliner takes the list of ideas and organizes them. Initially, it chooses the clause that holds the first idea on the Idea list and develops those thoughts. Then it chooses the next clause containing the idea that is closest to the beginning of the Idea list. APT continues with this pattern until all the clauses are processed. It breaks any tie by choosing the clause that occurs first in the Connections section. Thus, "slavery" winds up first in the outline because you placed it first in your list of ideas.

After the system is finished with the first clause, it moves on and processes clause after clause until the program is done. If an idea appears in several clauses, the outliner will ask you to describe it only once. After that, the outliner will assume the concept is familiar. When you run your first input through the outliner, you should get the results shown in figure 2.

As the program organizes the ideas within each clause, it checks for left and right connectors and starts with the ideas on the appropriate side of the connector first. When it comes to ideas joined by symmetric connectors, it places the ideas in the outline in the same order as they are defined in the Ideas segment. This rule gives you some control over the final order of the outline, but the program will resort to the rule only after it finishes placing all ideas close to the other ideas with which they are being connected.

The next version will include an option that prevents the outliner from even considering using the topic on the right side of the left connector before the left side is used, and vice versa. In this case, there would be a dependency relationship between the clauses. The program would not develop a clause until all the other clauses it depends on are developed. Such a feature would be useful in situations requiring rigorous logical development, such as mathematical proofs. Figure 3 is a good example.

In figure 3, "implies" forces the left side, the necessary condition, to be developed before the right side. No matter how you rearrange the ideas, the compiler ensures that the left side of each connector "implies" comes before the right. It also places the first clause, "definition of right triangle implies Pythagorean theorem," before the second clause that uses "Pythagorean theorem" as a necessary condition on the left side of "implies." It wouldn't make sense to consider the second clause before the first clause is proven.

You can also break up the outline into a sequence of short Ideas, Connectors, and Connections segments so the definition of an idea is close to its use in a connection. This allows you to break the outline into more manageable segments—a process

continued

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IDEAS
Marie;
Jean-Phillipe;
François.

CONNECTORS
loves;
is married to;
doesn't know that.

CONNECTIONS
Marie loves François;
Marie is married to Jean-Phillipe;
Jean-Phillipe doesn't know that (Marie loves François);
François doesn't know that (Marie is married to Jean-Phillipe).

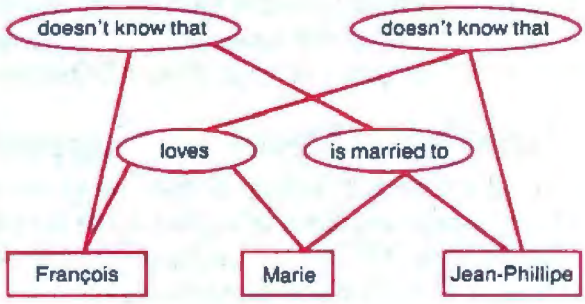

Figure 4: *The outline generator performs its work by representing the ideas in each clause as nodes. As more and more links are created, a directed acyclic graph, such as this one outlining a movie plot, is constructed. Each connection is added to the graph by creating a new node with pointers to the two nodes it connects.*

Describe: Marie

Describe: Jean-Phillipe

Show how: Marie is married to Jean-Phillipe

Describe: François

Show how: François doesn't know that (Marie is married to Jean-Phillipe)

Figure 5: *The outline produced from the acyclic graph in figure 4. The program produces this outline by searching downward from the root (the highest node in each clause). When it locates two ideas, it walks back up the structure, joining them, and continues making all the connections until it reaches the root again.*

roughly equivalent to defining a subroutine, but it does not include any notion of global and local ideas. Everything is global.

APT's Algorithm

The outline generator performs its work by creating a structure called an acyclic graph. A different node represents each idea. The program adds each connection by generating a new node with pointers to the two nodes it connects, as shown in figure 4. This new node is said to be "higher" than the two nodes it joins. The highest node is the last one entered in the graph for each clause. The connections are shown as two lines from the connector pointing downward to the ideas that are joined.

The program easily produces an outline from this structure. The highest node in each clause is known as the root. The program develops clauses by searching downward from the root. The idea nodes in each clause are at the foundation level. Every connection made is higher. When the program finds two ideas, it moves back up, joining them, and continues to make all the connections until it reaches the root again, as shown in figure 5. At each node, the program checks to see if the node is a left or right connector. If it is either, the outliner chooses the appropriate branch to be examined before the other. Otherwise, it picks the branch—either the left or the right—that leads to the first idea on the list. If it finds a node that another clause has used before, it stops here and moves back up the tree.

The outliner chooses between clauses by examining the positions of the idea nodes in the Ideas list. It picks the clause that includes the earliest idea defined in the APT program. This feature gives you some control over the order in which your ideas appear. If you want to rearrange your paper and move "farming differences," for example, so that this subject appears earlier in your material, you can move this idea to the top of the Ideas segment, and the outliner will do its best to accommodate the change.

The parser builds the tree with the help of symbol tables. In APT's present design, each word is a separate entity that is stored in a symbol table. Each token is saved as a list of words in its own table. As it constructs the directed acyclic graph, the program maintains a list of idea-connector-idea triplets already entered in the graph and checks to see if the particular phrase being processed is already there. If so, the program uses the existing location in the graph; if not, it constructs a new one.

Ordinarily, ideas end up as nodes at the bottom of the graph, but this doesn't have to be so. An equal sign can attach the idea to a node much higher in the graph.

For example, in figure 6, the equal sign connects the phrase "Joyce's Oeuvre" with the small tree representing three of his major books. Now these books can be referred to by the token Joyce's Oeuvre, and the token will represent the three. The system asks you to introduce the three books only once, when it first comes to Joyce's Oeuvre in a branch. From then on, it refers to the books as Joyce's Oeuvre.

You can use APT for many applications that require planning. Construction projects, for example, have phases that depend on one another, such as "the first floor requires a foundation before it can be built." You can easily convert these scenarios for APT's use by listing every step as an idea and connecting them with left or right connectors such as "must precede" or "requires." APT will try to arrange it so that connected stages of the project appear near each other in the outline.

Strengths and Weaknesses

At this point, it might appear as if this tool is only useful for disciples of Bertrand Russell and others who think that all

continued

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```
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Joyce's Oeuvre;
The city of Dublin;
A literary version of Dublin.

CONNECTORS
rises from;
centers around;
and.

CONNECTIONS
Joyce's Oeuvre = The Dubliners and Ulysses and
   Finnegan's Wake;
Joyce's Oeuvre centers around the city of Dublin;
A literary version of Dublin rises from Joyce's Oeuvre.
```

Figure 6: *With APT, you can group parts of the outline together using an equal sign. In this example, the equal sign connects three of Joyce's major books so they can therefore be referred to by the token "Joyce's Oeuvre."*

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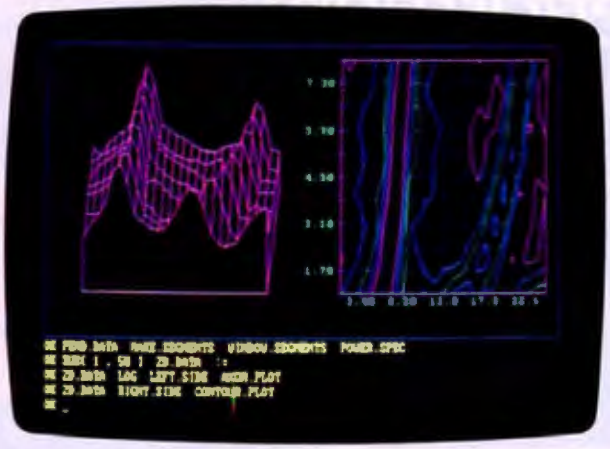
Editor's note: *The source code for APT is available in a variety of formats. See page 3 for details. The code was written with Lightspeed Pascal; however, minimal changes should allow it to work with other versions of Pascal.*

Peter Wayner is reading toward a Ph.D. in computer science at Cornell University. He can be reached on BIX c/o "editors."



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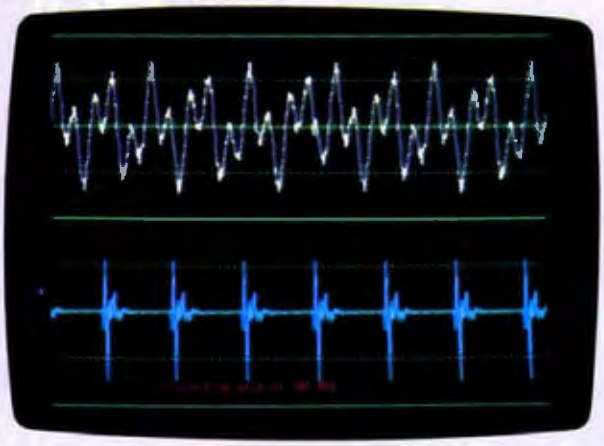

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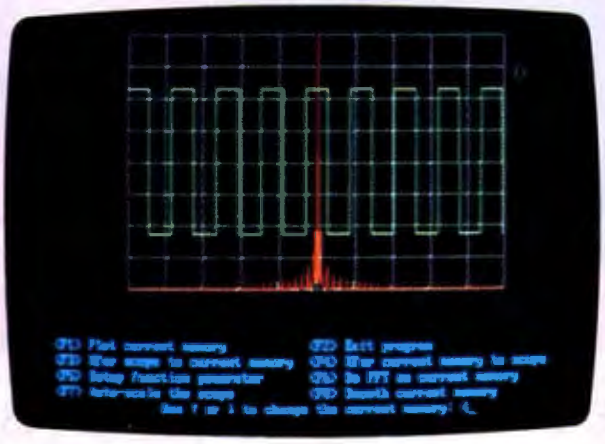

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PARALLELIZING PROLOG

Three approaches to running Prolog programs on multiprocessor machines

Dick Pountain

Once found only in academic environments, Prolog has graduated to the real world and is now available for just about every computer made. Applications developers are finding that Prolog's symbol-manipulation and built-in pattern-matching abilities make it particularly suited for programming expert systems, database query systems, and natural-language processing systems.

Such applications typically involve searching very large databases and need very fast computers to achieve adequate performance. They are therefore natural candidates for being sped up by parallel processing. Almost from its inception, Prolog researchers have wanted to implement the language on multiple CPUs so that the sequence of pattern matches that are involved in solving a Prolog goal would all be evaluated at the same time. Efficiency is not the sole rationale for this desire for parallelism; the philosophy of pure logic programming itself indicates that the order of evaluation of a program should not matter. What better way to escape from this order than by doing everything at the same time?

At a superficial glance, Prolog appears to be well suited to parallel evaluation. Prolog programs are descriptions of the problem rather than prescriptions for how to solve it. There is nothing in the text of a Prolog program that explicitly states in what order its parts should be evaluated.

However, all is not so simple as it seems. Prolog has to run on real-life computers and is only an approximation to the timeless, purely logical style of programming. Prolog programs use variables to hold values and so have an execution history, however fleeting. Although many features of Prolog make it more suitable for parallel execution than conventional languages, running tasks in parallel requires mechanisms for communication and synchronization between processes—mechanisms that are not present in current dialects of Prolog.

Research on parallel-logic programming languages is being pursued at a number of centers in the U.S., U.K., West Germany, Hungary, Portugal, and Australia, not forgetting, of course, the Japanese Fifth Generation Project, an important component of which is a parallel Prolog system. Recently, some implementations of parallel Prolog or Prolog-like languages have begun to filter out into the light of day, and at the 1988 CEBIT Electronics Fair in Hannover, West Germany, I encountered no less than three of them, each using different strategies.

CS-Prolog was developed by Ivan Futo and Janos Szeredi at the Computer Research Institute in Budapest, Hun-

continued

gary; Parsytec Prolog is from the German firm Parsytec; and the most radical solution to parallelizing Prolog, PARLOG, is a new language developed at Imperial College, London, by Keith Clark and Steven Gregory. (If you are not familiar with the structure of Prolog programs, the text box "Prolog Basics: Unification and Backtracking" on page 390 will set the stage for discussing parallelism in Prolog.)

The Old Order

Sequential Prolog uses a strategy called *depth-first, left-to-right* search, so that execution proceeds by first trying the clauses for a relation in sequence (down the page in the source code) and then, when a match is found, by trying the subgoals of the clause's body from left to right in sequence (across the page). People often prefer to talk about the OR and AND dimensions because the clauses of a Prolog program are connected by an implied logical OR, and the subgoals of a clause body by an implied AND (some dialects allow you to write this AND explicitly in place of commas).

The distinction between these two dimensions is important, as each requires different trade-offs to parallelize them, and it is possible to parallelize one dimension while leaving the other strictly sequential. In an OR-parallel Prolog, you would match a goal against all the clause heads simultaneously; the problem then amounts to choosing which one to evaluate, supposing more than one of them unifies. In an AND-parallel Prolog, you would test the clause heads in sequence as usual, but once one was unified, all the subgoals in its body would be evaluated simultaneously. The problem here is that since these subgoals may share variables, who gets to bind the variable? This is just the classic problem of communication and synchronization faced by all concurrent programmers. In both cases, the question of what happens to backtracking becomes a crucial matter. Let's now look at three different sets of solutions to these problems.

CS-Prolog

Communicating Sequential Prolog (CS-Prolog) works by adding the notion of time to Prolog, allowing you to suspend the execution of goals until certain conditions are met. CS-Prolog embodies a kind of AND parallelism, in the sense that subgoals can be concurrently processed by sending messages to activate other processes. This communication must be explicitly controlled by the programmer.

CS-Prolog runs on either a single-processor or multiprocessor implementation. In a single-processor system, CS-Prolog employs no actual or simulated parallelism, since there is never more than one process active at a time. However, CS-Prolog is currently being implemented on a network of INMOS transputers, and, in such an environment, each process is executed on a separate processor.

CS-Prolog adds a number of built-in predicates, the most important of which are `new()`, `send()`, `wait_for()`, and `hold()`. The predicate `new()` creates processes dynamically during a program run (a process is a Prolog goal that has its start time and end time specified but is otherwise evaluated just like an ordinary goal). The full syntax for a process creation is

```
new(Goal, Processname, Start, End).
```

The function `send(M, Processlist)` sends a message `M` to all the processes named in `Processlist`, and `wait_for(R)` suspends a process until it receives a message that will unify with `R`. A message can be any Prolog term. The function `hold(T)` suspends a process for a specified length of time `T`, while `suspend(P)` suspends a process unconditionally so it can only be reactivated with `activate_suspended(P)`.

There now arises the problem of how to cope with backtracking in such a distributed system. CS-Prolog distinguishes two kinds of backtracking: local and global.

In local backtracking, a process does not pass a communication point, that is, a point at which the process sent or received a message; local backtracking is always permitted and does not affect any other processes.

In global backtracking, a process passes one or more communication points and thereby directly affects the execution of other processes. Whenever the backtrack reaches a point where the process had sent messages using `send()`, then *anti-messages* are sent to those same processes, causing them to backtrack as well. The backtracking of the original process continues. On the other hand, when backtracking arrives at a point where the process has received messages via a `wait_for()`, and if there are any matching messages still waiting to be processed, the first one is selected and execution proceeds forward again. If no messages are waiting, the process remains suspended.

It's possible for a deadlock to occur during global backtracking if all processes are suspended and there are no messages in transit. In this case, a global monitor process running on one of the transputers or on a host computer has to recognize the situation and intervene to break the deadlock; it does this by choosing one process and forcing it to backtrack further and repeating this treatment until some process arrives at a `send()`, which reactivates other processes.

Programming in CS-Prolog is in many ways reminiscent of concurrent procedural languages like Ada, Occam, or Modula-2. Brainware, a German software firm, is working on an MS-DOS version of CS-Prolog that will run on PC multitransputer boards.

Parsytec Prolog

Parsytec Prolog is a fully compiled Prolog that uses a form of restricted AND parallelism where the programmer explicitly labels the subgoals that are to be evaluated in parallel. Parsytec designed this Prolog to run on its transputer-based Megaframe parallel-processing computer, which allows the company to create a high-performance application environment for industrial and laboratory control. You can also run Parsytec Prolog sequentially.

The Parsytec compiler actually maps parallel calls onto a tree of processors, so that the first subgoal runs on the root processor, the second subgoal on the first child processor, and so on. At present, you must configure the physical tree by hand using fixed links before program loading. (A new version is in development that uses INMOS's digital switch chip to configure the tree electronically at run time.) You can use the predicate `par()` to determine the number of available processors and the dummy subgoal `idle()` for setting up time delays to make sure a real subgoal gets executed on a particular processor.

A parallel call in Parsytec Prolog looks like this:

```
goal(A,B) :- ( test subgoal_1(A) & subgoal_2(B)).
```

The extensions to Prolog syntax are the `&` symbol, which replaces the comma to separate the subgoals of a parallel call, and the `|` symbol, called *guard*, which separates `test` from the body of the clause. If the condition `test` is true, then the two subgoals in the call body are evaluated in parallel; if false, the evaluation of the subgoals proceeds in a normal sequential

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Prolog Basics: Unification and Backtracking

Before understanding the three techniques for parallelizing Prolog, you need to understand the evaluation of a typical Prolog program. Using the Edinburgh syntax, you could define the Prolog relation `grandfather` as follows:

```
grandfather(X,G) :-
  father(P,G), mother(X,P).
grandfather(X,G) :-
  father(P,G), father(X,P).
```

What this says is that `G` is the grandfather of `X` if he is the father of `X`'s mother or the father of `X`'s father. The two lines beginning with `grandfather` are called *clauses*. The term `grandfather(X,G)` is the *head* of each clause, and the terms following the `:-` symbol make up the *body* of the clause. `X`, `G`, and `P` are variables. You can use this relation in conjunction with a database of facts about people's parents, such as

```
father(bill,tom).
father(tom,paul).
father(susan,tom).
father(sally,paul).
mother(bill,mary).
```

Then you could evaluate queries, or *goals*, like asking if Paul is Susan's grandfather:

```
? grandfather(susan,paul).
```

to which Prolog will reply yes. Alternatively, you can try to find all grandchildren of Paul.

```
? grandfather(Z, paul).
```

to which Prolog replies

```
Z = bill;
Z = susan;
no
```

When trying to solve such goals, Prolog attempts to *unify* the goal with the heads of all the clauses for the relation in question. Unification, which is the very heart of Prolog, is a mathematical technique that attempts to make two expressions identical by choosing suitable values for the variables they contain. When evaluating `grandfather(susan, paul)`, the Prolog interpreter tries to unify this expression with the first clause head and succeeds by making `X = susan` and `G = paul` (this process is called *binding* the variables). When a goal unifies with the head of a clause, Prolog then goes on to evaluate the body of that clause, taking each term in turn from left to right, but replacing any variables that have already been bound by their new values. These terms are called *subgoals* and are evaluated just like the original goal, by trying to unify them with the clause heads for their own relations. In the example, Prolog first tries `father(P, paul)`, which unifies with the second clause for father by making `P = tom`; then `mother(X,P)` is evaluated and fails because Tom is not Susan's mother.

Although having failed to establish the truth of the clause body, Prolog does not give up. Instead it `backtracks` by undoing the binding of `P` in `father(P, paul)` and trying the next possibility, in this case `P = sally`, from the fourth clause. Sally is not Susan's mother, either, so the mother subgoal still fails, and there are no more possibilities for `P`. Prolog still perseveres by backtracking all the way; it undoes the bindings for `X` and `G` and tries the second clause for `grandfather`. This again unifies with `X = susan`, `G = paul`, and now the body of the clause succeeds with `P = tom`. This ability to backtrack lets Prolog find all the solutions to a query, as you will see if you trace the execution of `grandfather(Z,paul)` by hand.

In principle, the order of the clauses does not matter. You could shuffle the order of the `grandfather` or `father` clauses, and the goals would still succeed because of backtracking. However, backtracking takes time, and the order of the clauses *will* affect the speed of the program. If speed were the only consideration, you could eliminate the need for backtracking by trying all the possibilities at the same time, that is, in parallel, and dramatically increase performance. Unfortunately, not all Prolog programs are independent of order. It is quite easy to write programs in which the order of clauses or of subgoals affects the outcome of evaluation.

fashion. In a case like the above, where the subgoals share no variables at all, the test is redundant and may be replaced by `true`:

```
goal(A,B) :- ( true subgoal_1(A) & subgoal_2(B)).
```

Backtracking is permitted but is always sequential; that is, `&` is ignored during backtracking.

To eliminate conflicts over variable bindings, subgoals can share variables only if the variables are bound and independent. Parsytec provides special predicates to test if variables are bound and independent: `ground( )` and `indep( )`. In the following example,

```
goal(A,B,C) :-
  ( ground(C) subgoal_1(A,C) & subgoal_2(B,C)).
```

the variable `C` is shared between the two subgoals; `ground(C)` will be true if `C` is bound when the clause is called, and the parallel evaluation is permitted; otherwise, it reverts to sequential evaluation. A similar predicate called `indep(A,B)` checks that two separate unbound variables have not sneakily been unified prior to the call.

The kind of AND parallelism employed by Parsytec requires very little alteration to the syntax of typical Prolog programs. As an example, here is the parallel version of the QuickSort program from the third edition of *Programming in Prolog* by Clocksin and Mellish:

```
split(H,[A|X],[A|X],Z) :-
  A < H, split(H,X,Y,Z).
split(H,[A|??X],Y,[A|Z]) :-
  H =< A, split(H,X,Y,Z).
split(_,[],[],[]).

qsort([],[]).
qsort([H|T],S) :-
```

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```
split(H,T,A,B),
(true | qsort(A, A1) & qsort(B,B1)),
append(A1,[H|B1],S).
```

This version differs from the original only in the second subgoal of `qsort`. Parsytec reports that this program runs 2½ times faster on four transputers than on one, which means the parallelization is about 63 percent efficient here. QuickSort is not the ideal algorithm for parallel sorting because the two sublists produced by `split` are of arbitrary sizes, and so the parallel processors are not balanced in their work loads; an algorithm that shared the workload more fairly would give a better speedup.

You can simulate OR parallelism in a Parsytec Prolog by giving different names to what would normally be the clauses of a single relation and then invoking them all as AND-parallel subgoals. For example, so long as `X` and `Y` are only used as input (i.e., bound) parameters, `clause1`, `clause2`, and `clause3` will be executed in parallel, as shown:

```
clause1(A,B) :-  ...
clause2(A,[B|C]) :-  ...
clause3(A,[]) :-  ...

goal(X,Y) :-
  (true | clause1(X,Y) &
  clause2(X,Y) & clause3(X,Y)).
```

This technique can be an effective way of speeding up searches of large Prolog *factbases*, such as you might use in an expert system.

PARLOG

PARLOG is not Prolog, but a parallel-logic programming language with many similarities to Prolog. It employs both AND and OR parallelism and also performs unification in parallel. It renounces backtracking, however, in favor of what is known as *committed choice* between clauses. The clauses of a relation all have an initial *guard computation*. PARLOG tries all the clauses in parallel, and only those whose guards succeed are candidate clauses for evaluation. In PARLOG, the first candidate is chosen to be evaluated further; the program is said to *commit* to the use of this clause. PARLOG doesn't use backtracking and, therefore, finds only one solution to a goal.

In PARLOG, the guard computation consists of matching the clause head against the goal (as in ordinary Prolog) together with an optional test that can be placed before the clause body (like that in Parsytec Prolog). So, to commit to a clause, a goal must match the clause head, and the test (if present) must be true. To illustrate the syntax, here is the `split` relation from the QuickSort presented above, rewritten in PARLOG:

```
split(H,[A|X],[A|Y],Z) <- A < H : split(H,X,Y,Z).
split(H,[A|X],Y,[A|Z]) <- H =< A : split(H,X,Y,Z).
split(_,[],[],[]).
```

What was an ordinary subgoal in Prolog (e.g., `A < H`) has become a guard test here. The colon separates the guard calls from the body, and everything to the left of it is the guard computation. The `<-` symbol is equivalent to Prolog's `:-` symbol. PARLOG separates parallel conjunction of subgoals in a clause with a comma and employs the ampersand symbol to force sequential evaluation (exactly the opposite of the Parsytec syntax).

PARLOG handles the problem of binding variables in parallel with a binding mechanism that allows unification to be suspended, and by distinguishing between input and output variables. A PARLOG relation must have a mode declaration that fixes the direction of each of its variables, such as

```
mode split(H?,X?,Y|,Z|).
```

where the `?` means input and the `|` means output. The default mode for variables is input. The variables `H` and `X` carry values into a goal and will normally be bound in a call, while `Y` and `Z` return the answers and will normally be unbound in any call. A typical call might be `split(4, [1,5,6,4,2,7],X,Y)`, with the sublists returned in `X` and `Y`.

The rules for variable binding are as follows:

continued

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- No output variables will be bound until after the caller commits to a clause.
- All the input variables are unified in parallel, and only variables in the clause head, not the caller, can become bound. If unification would require binding a variable in the caller, then unification of that variable only will be suspended until another call provides a value for the variable.
- Similarly, guard tests cannot bind any variables in the caller and will suspend if they attempt it.
- Commitment to a clause cannot happen while such an input match or guard test is suspended.
- Once a clause is committed to, then all the output variables are unified with the clause head in parallel with evaluation of the subgoals in the clause body.

Though these rules might sound complicated when expressed in such terms, what underlies them is simply a "one-way traffic" system; inputs can only go in, and outputs can only come out.

This subtle binding strategy provides all the communication and synchronization needed in PARLOG in a way that is quite transparent to the programmer. No rolling back or undoing of variable bindings is ever necessary, because PARLOG variables are never bound more than once; this allows for a small and efficient implementation. Even better, the shared-variable problem ceases to be a problem and becomes an asset. Shared variables now become communication channels between processes, where a process is the evaluation of any subgoal in a parallel conjunction. Moreover, these channels are self-synchronizing (just like those in the Occam programming language), with receivers waiting patiently until a value is ready from the sender. The mode declarations of a program define a data-flow network in which the progress of execution is controlled by the availability of its data.

To try to illustrate how this works, consider a call to the `split` relation embedded in a parallel clause body:

```
mode feeder(X|);
mode consumer1(X?).
mode consumer2(X?).

.....feeder(List), split(4, List,X,Y), consumer1(X),
 consumer2(Y).
```

The second input argument of this call to `split` is not bound, so when the call is matched in parallel with the `split` clauses, all three attempted matches will suspend, because each would require binding `List` to something. Hence, the call to `split` cannot commit. Both `consumer1` and `consumer2` suspend, too, because their arguments are of mode input and are unbound. The only part of the evaluation that is not suspended is `feeder`, which must bind its output, `List`, to some value (otherwise it results in deadlock). If the value bound to `List` is a nonvariable, `split` can proceed to commit to a clause and produce its outputs, to be consumed in turn by `consumer1` and `consumer2`. Even if `feeder` binds `List` to a term containing variables (say, `[E|L]`), the input of `split` can still proceed since the binding took place elsewhere, and it would match both `split` clause 1 and 2 with `A` bound to `E` and `X` bound to `L`; now, however, the guard tests will suspend until a nonvariable binding for `E` is supplied from elsewhere (`H` is already bound to 4).

PARLOG enables some powerful programming techniques. For example, a process can produce as its output a list of terms containing variables and then suspend on one or more of these variables. This list acts as a list of messages sent to another process, and when the second process binds one of the variables, it is, in effect, returning a reply to the sender. This method, known as *back communication*, can be used to implement object-oriented message-passing systems very elegantly.

The binding scheme is not completely foolproof, however. Since guards can contain calls to user-defined relations, it's impossible for the language itself to enforce the delayed binding rule. PARLOG provides a primitive called `data(X)`, which causes suspension of binding. You can employ it in writing safe guards, but you might still ignore it and write *unsafe guards* that will bind variables in the caller. Research continues into compile-time and run-time checks for such unsafe guards.

Implementations of PARLOG for Sun workstations and the VAX already exist, and a simulated parallel version for the IBM PC has been demonstrated. Several PARLOG systems for multiprocessors are currently being developed.

The Parallel Debate

Highly parallel Prolog-like languages are likely to be enormously important in the quest for more intelligent computers. It is too soon yet to say which is the best solution for parallelizing Prolog, if indeed any one solution can be the best. Research is still proceeding mainly at the implementation level, and it will be some time before much serious application experience is accumulated. To further complicate matters, the design of parallel-processing hardware is also in its infancy, with no single architecture a clear winner.

The subject is bound to generate plenty of controversy because compromises are involved, and because Prolog purists can be very zealous. For example, is the abandonment of nondeterminacy in PARLOG too high a price to pay for its elegant synchronization mechanism? I would say not; some will disagree. Others may judge the synchronization mechanism in CS-Prolog too explicit and nondeclarative. But, then, any language that doesn't generate controversy is probably dead. ■

Dick Pountain is a BYTE contributing editor, a technical author, and a software consultant living in London, England. You can contact him on BIX as "dickp."

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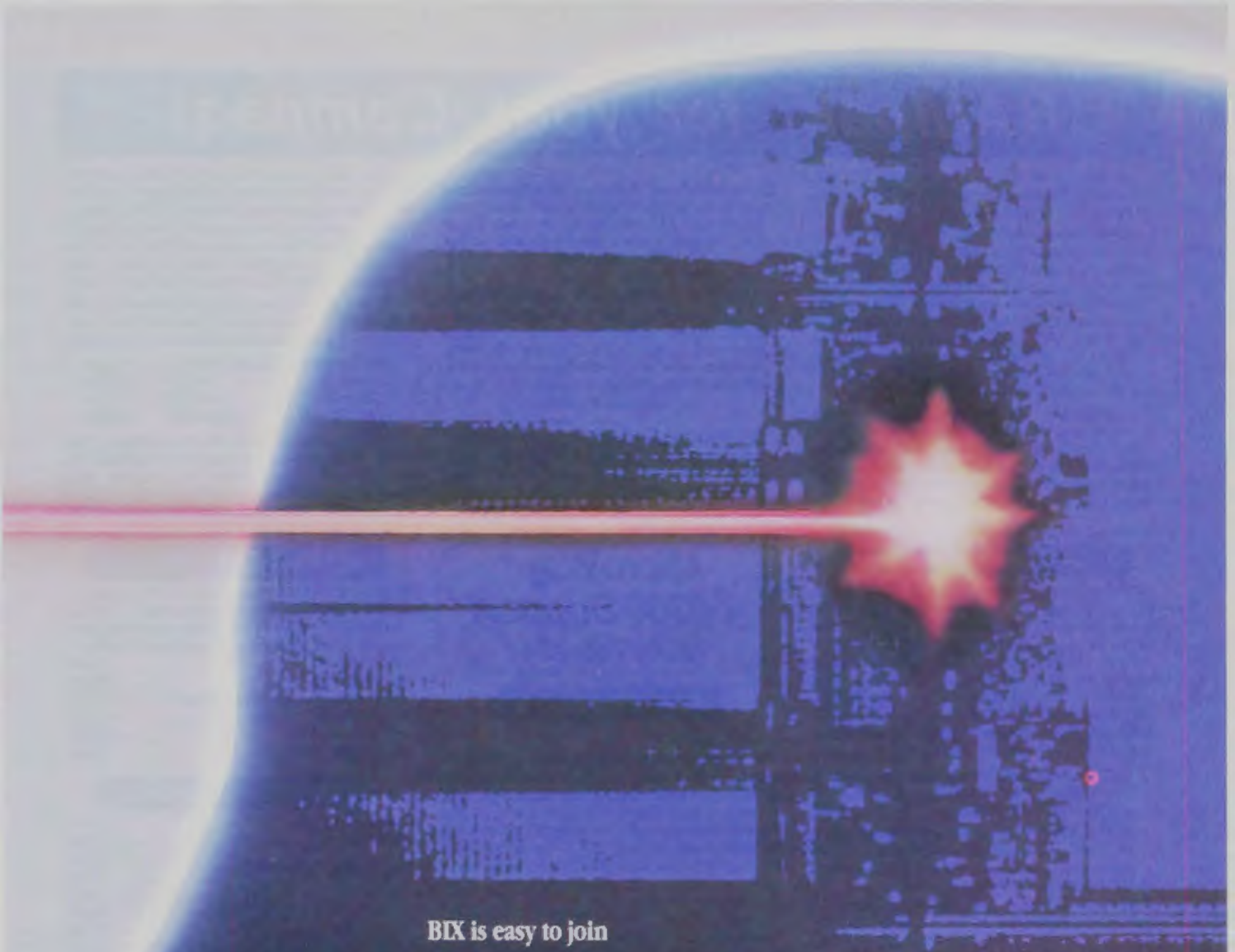

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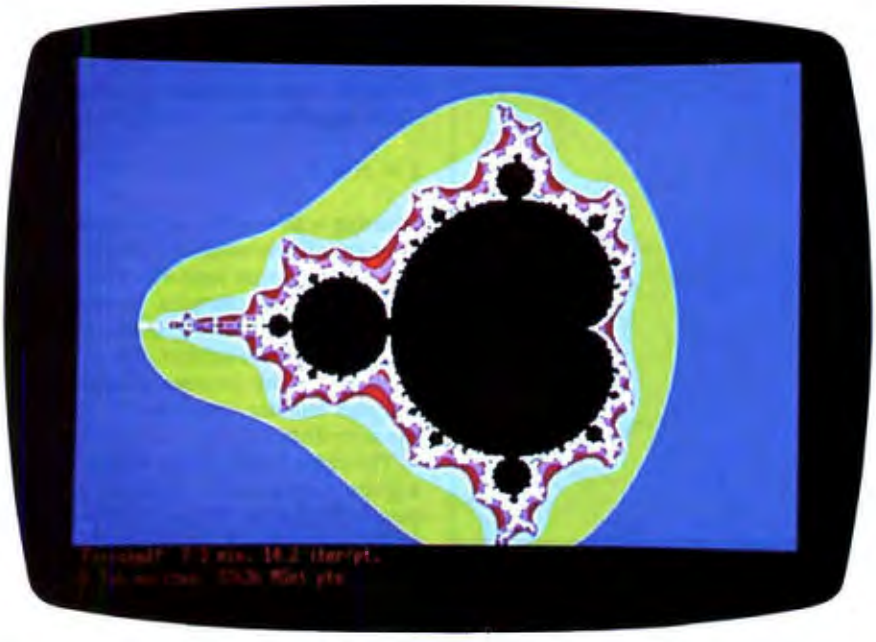


Steve continues the supercomputer project with a look at the Mandelbrot set

Photo 1: *The complete Mandelbrot set, as displayed by an EGA monitor (no magnification).*

In the first part of this article, I explored the limits of computer performance and described several multiprocessor architectures. In the next two parts, I will describe the Circuit Cellar Mandelbrot engine, a small-scale supercomputer designed to produce the familiar Mandelbrot set images much faster than is possible with an affordable scalar processor.

This installment deals with overall design issues and the algorithms and methods used in the software.

Picking the Problem

Many of the letters that prompted this project detailed the letter writer's favorite fantasy computer. Some of the projects were awesome in scope, featuring multitudes of bit-slice processors, ganged up with megabytes of static RAM and kilobytes of custom microcode!

As I explained last month, the Mandelbrot set calculations are nearly ideal for a multiprocessor because the problem can be divided among any number of processors and there is no need to communicate between processors during the solution. (I could have tackled North American weather forecasting, but the resulting project would have been out of the reach of nearly everyone.)

But a Circuit Cellar project is a blend of the challenging and the commonplace. It must be challenging enough to be interesting and informative, but it must use relatively commonplace components so that interested readers will be able to afford it. Building a supercomputer out of the latest custom LSI components would certainly be challenging, but few could afford the resulting hardware.

The cost of a multiprocessor is controlled by two major factors: the cost of each individual processor element and the level of communication between them. Element cost is obvious: If a single element costs $500, how many people would be willing to buy 64 of them? The level of communication determines how many ports each element must have and how complex those ports must be.

The Circuit Cellar Mandelbrot engine uses Intel 8751 processors rather than the 8088 or 80286 chips found in IBM PCs, ATs, and compatibles. The 8751 is similar to the 8031 used in many of my Circuit Cellar projects during the last few years, except that it contains 4K bytes of on-chip EPROM for program storage. Although processors in the 8051 family are often thought of as simple controllers, you are about to see what happens when a bunch of them concentrate on a single task: The engine becomes a beehive of activity!

There are several compelling reasons for choosing a processor from the 8051 family: performance, capability, and price. The performance with a standard 12-MHz crystal is just under 1 million instructions per second because most instructions take one or two cycles of 12 clock periods each. The chip includes a

continued

bidirectional serial port and extensive interrupt support, as well as a reasonably competent instruction set. Finally, a processor element can be a single-chip 8751 or an 8031 with an external EPROM, depending on whether cost or board space is more important; the cost per element ranges from under $10 to $40.

Figure 1 shows a block diagram of the Mandelbrot engine and the connection to the AT controller. The engine can include any number of processor elements between 1 and 255, and performance increases smoothly with the number of elements. The AT connection uses a standard serial port for data transfer, with the port control lines handling handshaking and array resets.

Listing 1: (a) *Pseudocode for the Mandelbrot set program kernel.* **(b)** *The same code without the* SQRT *function.*

(a)

```
(Given a complex point c and an
 iteration limit K)
 z = 0+0i
 count = 0
 while (count <= K) and
       (SQRT(Re(z)^2 + Im(z)^2) < 2.0)
    z = z2 + c
    count = count + 1
 end while
```

(b)

```
(Given a complex point c and an
 iteration limit K)
 z = 0+0i
 count = 0
 while (count <= K) and
       ((Re(z)2 + Im(z)2) < 4.0)
   z = z2 + c
   count = count + 1
 end while
```

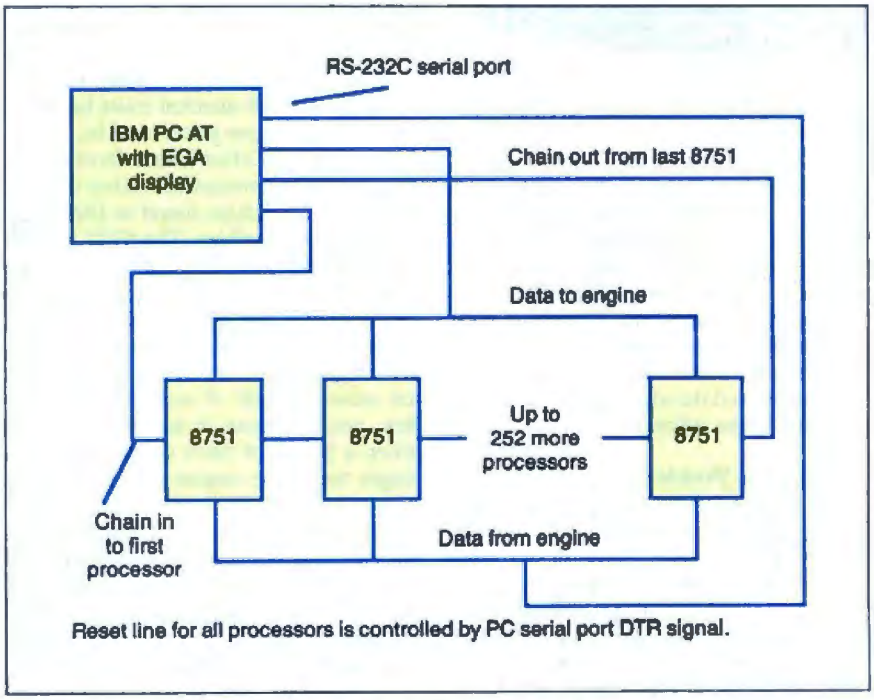


Figure 1: *A block diagram of the Circuit Cellar Mandelbrot engine.*

The Complex Plane

Photo 1 shows the entire Mandelbrot set displayed on an EGA monitor. You can look at the image as either a mathematical object or the output of a computer program, but you've got to understand both views to know how the Mandelbrot engine works.

Discovered by Benoit Mandelbrot, an IBM Fellow at the Thomas J. Watson Research Center, the Mandelbrot set is probably the best-known example of a fractal figure. Indeed, for many people, "Mandelbrot set" is synonymous with "fractal" and constitutes their only brush with complex numbers.

Mathematically, the Mandelbrot set is a set of points in the complex plane. A complex point c is in the Mandelbrot set if the magnitude of z in iterative formula

$$z = z^2 + c$$

(starting with $z = 0 + 0i$) remains finite after an infinite number of iterations.

The text box on page 404 gives a brief introduction to complex numbers and arithmetic for those of you who may be a little shaky on the subject. Pay particular attention to the process of squaring a complex number, because it's central to the algorithm.

The criterion for determining whether a given point is in the set should give you pause. No computer can run through an infinite number of iterations in a finite amount of time, so we can never be certain that a point is in the set. The best we can do is show that a given point is definitely not in the set, but that is sufficient to create all the pretty pictures.

It turns out that if the magnitude of z exceeds 2.0 after any iteration, it will eventually "blow up" to infinity after some additional number of iterations; therefore, that point is definitely not a member of the Mandelbrot set. If it remains below 2.0 for all the iterations we attempt, the best we can say is that it hasn't blown up yet and that the point may be a member of the set.

The test becomes more reliable with more iterations. For example, if one point blows up after 2 iterations and its neighbor survives 1000 iterations, the second one is probably a Mandelbrot set point. The iteration limit must be the same for all the points in a given image, although the particular value depends on where that image lies in the complex plane.

The algorithm behind the Mandelbrot set is shown in listing 1a. As you can see, despite the foregoing discussion, it's simple enough to fit on only a few lines—the

sort of program I like.

Figuring the magnitude of a complex number requires a square root, but that is a difficult and time-consuming operation for a microprocessor. Fortunately, we can avoid extracting a square root by simply changing the comparison: Whenever the magnitude exceeds 2.0, the square of the magnitude will exceed 4.0. Listing 1b shows the revised loop.

Determining whether a point is in the Mandelbrot set is simply a matter of evaluating the algorithm in listing 1b until it terminates. If the final count is less than the iteration limit, the point is definitely not in the Mandelbrot set. If the count equals the iteration limit, the point is either in the set or the limit is too low to rule it out; in either case, we assume that the point is in the set.

By convention, all the points in the Mandelbrot set are colored black. The iteration count for the remaining points selects one of the colors available on the display, so the rainbow hues are a direct indication of the size of the iteration count. The blue pixels in photo 1 had the fewest iterations, the green ones had more, and so on up to the bright white pixels adjacent to the central black area marking the set proper.

Floating Points

The center of the image in photo 1 lies at -0.5 + 0i in the complex plane, and the horizontal axis is about 3.6 units long. The EGA was in 640- by 350-pixel mode, so 224,000 separate pixels are shown on the screen. You have to evaluate the algorithm in listing 1 at each one of those points, so you can see why Mandelbrot set images take so long to create.

Because the entire area of the Mandelbrot set must lie within a circle 2.0 units in radius centered on the origin (think about it for a while), the calculations must be done with numbers that can represent fractions. The familiar integer variables used for most purposes in programs simply do not have the range of values needed for the Mandelbrot set.

Because IBM designed the original PC with a socket for a math coprocessor, nearly everyone is familiar with floating-point numbers. In fact, that single design decision may have had more to do with the spread of PCs in the engineering domain than any other; for the first time, floating-point math on a small computer wasn't prohibitively slow.

But it turns out that floating-point numbers are not well suited for the Mandelbrot set calculations, despite the fact that they are quite easy to use. The Mandelbrot engine uses real numbers, to be sure, but they have a fixed-point representation rather than floating-point. To explain why, I must first detour into floating-point numbers and return via fixed points.

All numeric values within a computer are represented by a fixed number of bits. Remember that a single byte of 8 bits can take on 256 different values, and that 2 bytes can count 65,536 values. The C programming language (and others, as well) allows long integers that have 4 bytes and about 4×10^9 different values. The key idea is that a given number of bits can take on only a fixed number of different values.

The mathematical definition of a real number poses a problem for computer implementations. Between any two real numbers, no matter how close together, are an infinite number of other real numbers. Representing an infinite quantity requires an infinite number of bits, so computers simply can't represent all the real numbers correctly.

Floating-point numbers represent "lots" of real numbers in a "few" bits. The trick is similar to the scientific notation I used just above. Instead of writing 4,000,000,000, I used 4×10^9 and saved quite a bit of space. Each floating-point number has three parts: the mantissa, the sign, and the exponent. The mantissa encodes the significant figures of the real number, the sign tells you if the mantissa is positive or negative, and the exponent represents the magnitude.

Figure 2 shows the floating-point equivalents of some common numbers. Note that the exponent is actually an exponent of 2 rather than the 10 used in scientific notation. The exponent is selected so that the mantissa is always between 0.5 and 1.0, which you can see by comparing the values for 1, 0.5, and 0.25. Because the decimal point (or, more exactly, the binary point) can be located anywhere in the mantissa, the representation is called floating-point.

Figure 3 shows the IEEE standard format for the floating-point numbers

continued

$0.0 = -1^0 \times 0 \times 2^0$
sign = 0
mantissa = 0
exponent = 0 (by convention)

$1.0 = -1^0 \times 1 \times 2^0$
sign = 0
mantissa = 1
exponent = 0

$2.0 = -1^0 \times 1 \times 2^1$
sign = 0
mantissa = 1
exponent = 1

$-2.0 = -1^1 \times 1 \times 2^1$
sign = 1
mantissa = 1
exponent = 1

$0.5 = -1^0 \times 1 \times 2^{-1}$
sign = 0
mantissa = 1
exponent = −1

$-0.25 = -1^0 \times 1 \times 2^{-2}$
sign = −1
mantissa = 1
exponent = −2

Figure 2: *Some common numbers written in the floating-point format.*

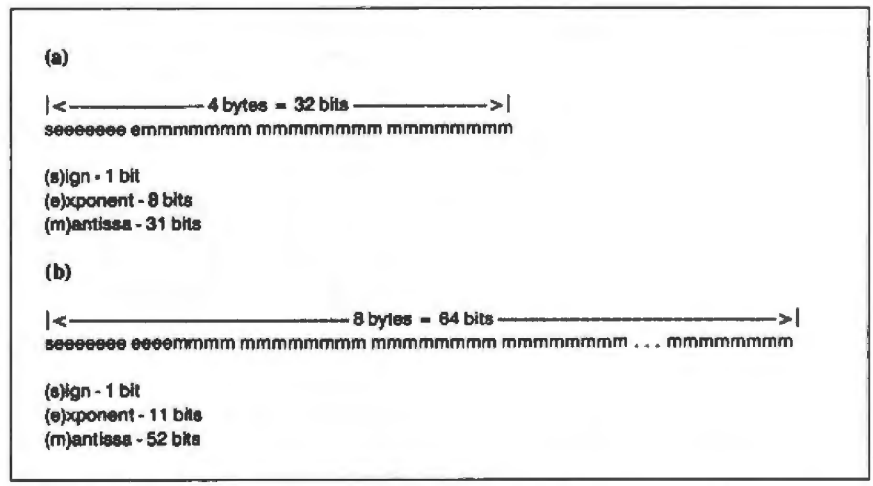


Figure 3: *IEEE standard floating-point formats.* **(a)** *The format for 4-byte floating-point numbers* (`float`). *This representation has a range of +/− 3.4 × 10^{-38} to +/− 3.4 × 10^{38} and a precision of six to seven decimal digits.* **(b)** *The 8-byte* `double` *format, which has a range of +/− 1.7 × 100^{-308} to +/− 1.7 × 10^{308} and a precision of 15 to 16 decimal digits.*

known to Microsoft C programmers as `float` and `double` variables. C programs typically use `double` variables whenever floating-point numbers are required, but there's a trap for the unwary in this practice.

Many common real-world programming problems are well behaved, in that the real numbers are all within a few orders of magnitude of each other. For example, in electrical engineering, the range of values extends from about 10^{-15} to 10^{12} or so (1 femtofarad to 1 gigahertz, for example). Calculations tend not to exceed these bounds, so programmers can get away with double variables most of the time.

Mandelbrot set calculations, on the other hand, require more precision than even `doubles` can provide. Photos 2a through 2c show the spike on the left-hand edge of the Mandelbrot set in increasing magnification. As you can see, there's not much change in structure as you zoom in on the set. This is one of the defining characteristics of a fractal figure. The level of detail and overall structure are similar at all magnifications. In some sense, the picture is the same regardless of the magnification.

To contrast this with ordinary objects, try magnifying the period at the end of this sentence by a factor of 10,000. The period is about 0.015 inch across, so the disk would be 150 inches in diameter. The difference in structure between the page and the period should be obvious.

Photo 2c magnifies the tip of the spike by 10^{12}. This is a magnification almost beyond comparison, but here's an analogy: The mean distance between the earth and sun is 92×10^6 miles or 5.83×10^{12} inches. One inch magnified by a factor of 10^{12} is one-fifth of the way to the sun.

Pixels in photo 1 are 0.0056 (3.6/640) units across, while pixels in photo 2c are 5.6×10^{-15} units across. The horizontal coordinates of the left edge of the spike are about 2.0 in both pictures, so you are looking at a single picture that spans 15 orders of magnitude. Recall that `float` variables have only six digits of precision, and you will begin to see why they would be inadequate.

Because the Mandelbrot set calculations use the results of one iteration as the source for the next pass, there is an inevitable loss of precision in the calculations. This is often called truncation error, because the true value of a real number must be truncated to fit within the available precision. The size of the truncation error increases with the number of iterations and is roughly the logarithm of the iteration count.

The calculations in photo 1 were carried out with an iteration limit of 64, so about two digits ($\log 64 = 1.8$) of precision were lost to truncation near the black areas marking the Mandelbrot set. Many interesting images require hundreds of iterations, so the precision loss can exceed three or four digits.

If the image requires 15 digits of precision just to represent the coordinates and 4 digits to contain the truncation error, what happens when the program uses `float` variables having only 6 digits? The answer is painfully obvious: See photo 3. Some of you have seen this effect in your programs, and now you know what caused the failure.

Using `double` variables doesn't solve the problem. Photo 2a needs about 18

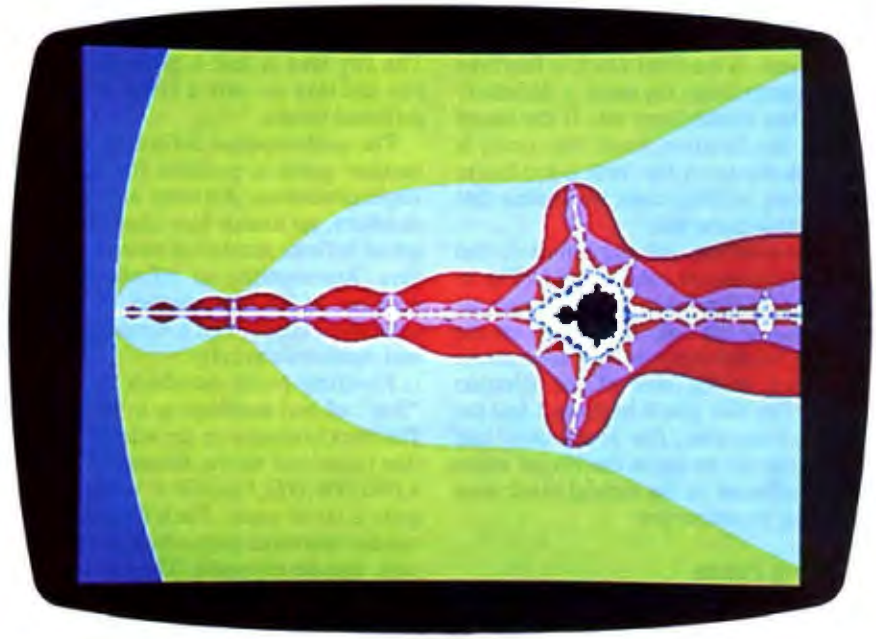


Photo 2a: *The "spike" at the left end of the set magnified 10 times.*

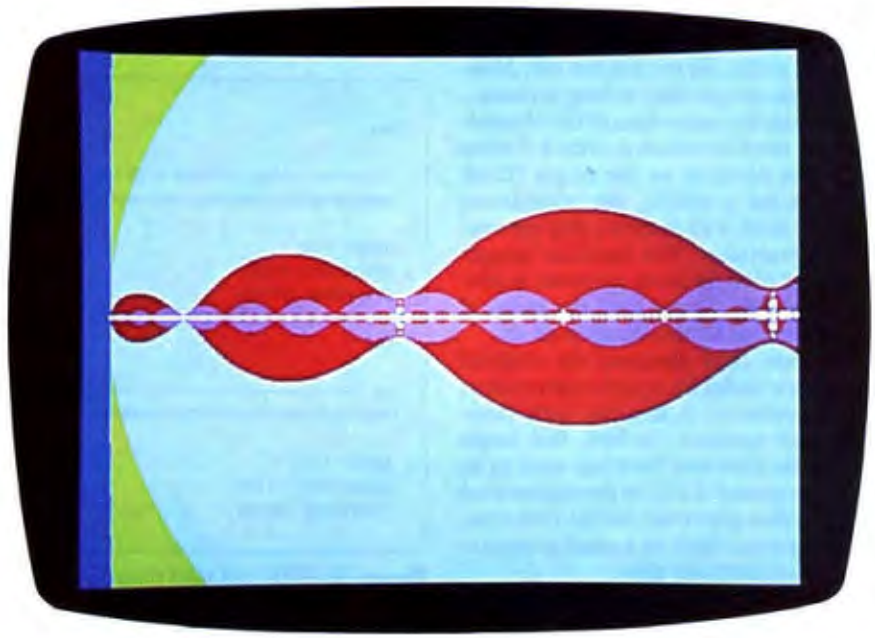


Photo 2b: *The "spike" at the left end of the set magnified 100 times.*

digits of precision, which is 2 or 3 more than `double` numbers can offer. What can you do?

Fixed Precision

Although the Mandelbrot set calculations require high precision, they don't require a large dynamic range. The entire Mandelbrot set lies within coordinates of +2.0 to −2.0, and the largest useful magnitude is only 4.0; some of the exponent bits in `float` and `double` numbers are wasted. Being able to represent numbers as large as 10^{308} is no advantage in these calculations.

Figure 4 shows how real numbers are encoded in the Mandelbrot engine. There is no exponent, so there is no way to "float" the binary point in the mantissa. With the binary point in a predetermined location, these numbers are *fixed-point* numbers. The values are stored in two's complement notation, rather than the sign-magnitude used in IEEE floating-point numbers. The complete value occupies the same number of bytes as a `double` number, but it has at least three more digits of precision.

It turns out that fixed-point number programs are both simpler and faster than floating-point code, simply because there's no need to work with the exponent. Simplicity is particularly important in the Mandelbrot engine, because the code is written in 8051 assembly language.

Fixed-point addition is also easy to understand. Listing 2 shows the 8051 code needed to add two fixed-point numbers, given two pointers to the start of each number. The loop simply adds corresponding bytes and propagates any carries to the left.

It's worth noting that the 8051, despite its Intel heritage, stores 2-byte integers with the high-order byte in the low-order address, so the addition proceeds downward from the high addresses. This is the convention used by Motorola processors and is exactly opposite from the Intel 8088 family. As you might expect, there are conversion routines in the AT driver code to convert from the 8088 convention (low byte first) to the 8051 convention (high byte first).

Although addition is simple, multiplication and division are not. I was able to skip division because the Mandelbrot set calculations didn't need it, but multiplication was essential. The 8051 instruction set includes a multiply that produces a 16-bit product from two 8-bit inputs in only 4 microseconds (μs), but combining the partial products into the final answer took some tricky coding.

Multiplying two 8-byte fixed-point numbers produces a 16-byte product. A little pencil work will show you that there are 64 multiplies and 56 2-byte additions to combine the partial products. Because each addition can generate a carry into the next byte, there are a considerable number of additional steps to propagate the carries throughout the partial products. Finally, the product has to be aligned so that the binary point is in the right location (if the point can't float, the number must).

Normal extended-precision multiplication routines use a series of nested loops to handle the repetitive calculations. Because this routine is used four times in each iteration, I coded it as a monster macro that creates about 2.5K

continued

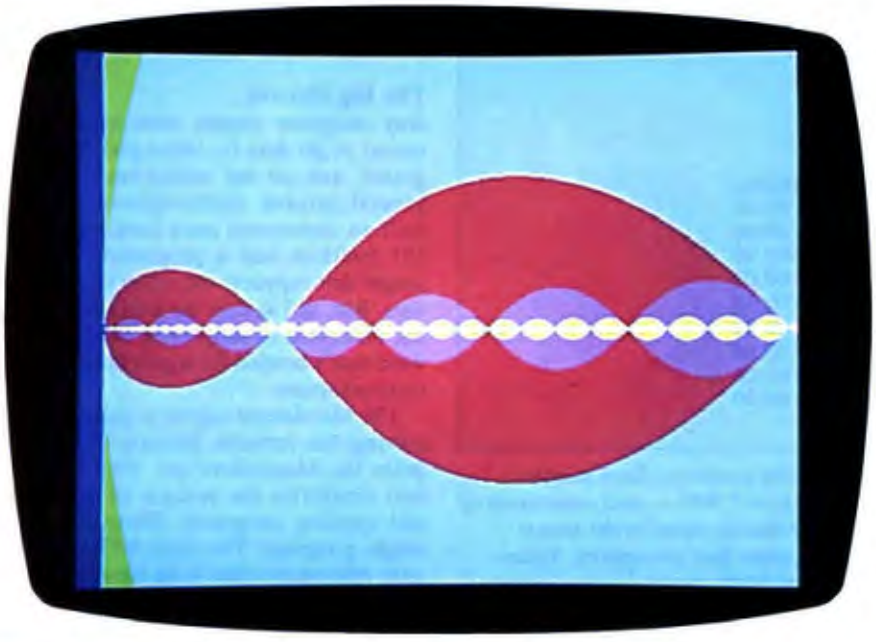
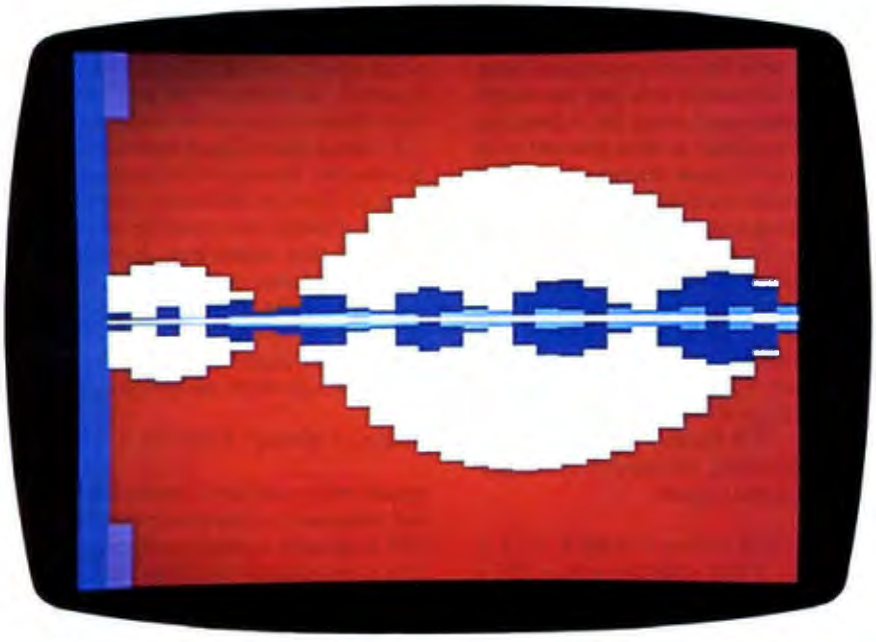


Photo 2c: *The "spike" at the left end of the set magnified 10^{12} times.*



hoto 3: *Using `float` variables while performing the same magnification as in hoto 2c (10^{12} times) makes precision loss due to truncation obvious.*

bytes of straight-line code. Space considerations prohibit printing such an incredible bulk here, but it's available for your inspection on the Circuit Cellar BBS.

Because the dynamic range is so low, many of the math routines check their inputs to prevent overflows. For example, the squaring routine will flag an attempt to square a number greater than 2.0. Unlike most math routines (which signal an error), that overflow simply indicates that the magnitude of a complex number will exceed 4.0, so the Mandelbrot calculations for that case are finished.

```
|<---------- 8 bytes = 64 bits ---------->|
siiiffff ffffffff ffffffff ffffffff ffffffff . . . ffffffff

sign - 1 bit
integer - 3 bits
fraction - 60 bits
```

Sample values, with only the first 4 bytes shown:

Value	Binary	Hexadecimal
0.0	0000.0000000000000000000	00 00 00 00
1.0	0001.0000000000000000000	10 00 00 00
2.0	0010.0000000000000000000	20 00 00 00
−1.0	1111.0000000000000000000	F0 00 00 00
−2.0	1110.0000000000000000000	E0 00 00 00
0.5	0000.1000000000000000000	08 00 00 00
0.25	0000.0100000000000000000	04 00 00 00
−0.5	1111.1000000000000000000	F8 00 00 00
−0.25	1111.1100000000000000000	FC 00 00 00

Figure 4: *Circuit Cellar Mandelbrot engine fixed-point numbers. Each number occupies 8 bytes of storage and has a range of −8.0 to +7.999. . . and a precision of 19 decimal digits. In Intel 8051 code, the high-order byte is stored in the lowest address; this is the reverse of the convention used in other Intel processors. Values are stored in two's complement notation. The implied binary point does not occupy a bit location.*

Back in the bad old days, when computers filled rooms with racks of vacuum tubes, there were no math coprocessors. A great deal of work went into creating algorithms that could use fixed-point numbers to give useful results. Having to deal with a little of that analysis for this project made me appreciate the early pioneers a whole lot more.

Now that you have an appreciation for the calculations behind the Mandelbrot set, I can describe how the engine actually works.

The Big Picture

Any computer system must have some means to get data in, select and run programs, and get the results back out. A general-purpose multiprocessor (if that isn't an oxymoron) must have extensive I/O facilities and a programming language that supports the array of processors. But, as I said in the beginning, I'm not interested in supporting all the software that's needed for a general-purpose supercomputer.

The Mandelbrot engine is dedicated to solving the iterative formula that computes the Mandelbrot set. That dedication simplifies the process of selecting and running programs: There is but a single program! The Intel 8751 single-chip microcontroller is an ideal processor element, because that program is burned into the on-chip EPROM. Once

Complex Numbers

A complex number is made up of two separate numbers, which, for historic reasons, are called the real and imaginary components. The imaginary component is distinguished by a lowercase i either before or after the number. For example,

1+2i or 1+i2

is a complex number with a real part of 1 and an imaginary part of 2. The real and imaginary components are rarely integers, so you'll often see complex numbers written with decimal fractions:

1.2345 + 0.4321i

Electrical engineers often use j instead of i, because the symbol for electric current is i.

Because complex numbers have two components, they can be plotted on a plane, with the real component along the *x* (horizontal) axis and the imaginary component along the *y* (vertical) axis. This plane is often referred to as the complex plane because it contains all possible complex numbers.

Adding and subtracting complex numbers is a simple matter of keeping track of the real and imaginary components separately. For example, the sum (1+2i) + (3+4i) evaluates to 4+6i, while the difference (1+2i) − (3+4i) becomes −2−2i.

Forming the square of a complex number is a somewhat trickier operation. Squaring the number 3+4i proceeds in this fashion:

$$(3+4i)^2=(3+4i) \times (3+4i) = 3\times3 + 3\times4i + 3\times4i + 4i\times4i = 9 + 12i + 12i + 16i^2 = 9 + 24i - 16 = -7+24i$$

Simplifying $(16i)^2$ to −16 uses the fact that i denotes the square root of −1, which is why the imaginary component is called "imaginary"—it isn't one of the numbers we use in the real world.

I'll avoid describing complex division because the Mandelbrot formulas don't need it. If you're interested, your local library probably has a book on complex numbers that shows how division of complex numbers works.

Each complex number has a magnitude that represents the "size" of the number. The magnitude of the complex number z is given by the formula

$$\mathrm{Mag}(z) = \sqrt{(\mathrm{Re}(z)^2 + \mathrm{Im}(z)^2)}$$

where Re(z) and Im(z) denote the real and imaginary components, respectively. The magnitude is simply the hypotenuse of a right triangle with sides Re(z) and Im(z). For example, the magnitude of 3+4i is $\mathrm{Mag}(3+4i) = \sqrt{(\mathrm{Re}(3+4i)^2 + \mathrm{Im}(3+4i)^2)} = \sqrt{(3^2 + 4^2)} = \sqrt{(9 + 16)} = \sqrt{(25)} = 5$.

programmed, the chip doesn't need a disk drive or tape drive to get started; simply turn on the power and release the reset line, and the program is up and running immediately.

The issues of data communication are not so simply resolved. Once again, though, because we are dealing only with the Mandelbrot set, there is little need for interprocessor communication during the computations. Although the 8751 includes an on-chip serial port, there isn't enough room for a general-purpose network, and there isn't enough space in the EPROM for much of a network operating system.

Refer back to figure 1 to see how the communications are handled. All the 8751 serial inputs are connected together and driven by the AT's serial output. Similarly, all the 8751 serial outputs are connected together to drive the AT's serial input. Of course, there are communication buffers along the way to ensure that the ports are not overloaded.

Each processor has a unique ID number assigned during the initialization sequence, which I'll describe next month. The AT can address a message to any number of processors in the array. If the message goes to a single processor, all other elements ignore the message and continue with their computations.

It's easy enough to control transmissions from the AT to the engine's processors, because there is only one sender on the line. Getting information back without collisions between processors could be very complicated, but another characteristic of the Mandelbrot set calculations came to our rescue.

Despite the exquisite precision required during the enormous number of calculations in each engine, the results can be summed up in 1 or 2 bytes. Polling each processor for its result didn't make any sense, because the necessary handshaking would reduce the effective data rate by at least a factor of 4. Some coordination is required, though, because the processors must return their results in a known sequence.

The "chain-in" line shown in figure 1 organizes the output communications. It daisy chains through all the processors in the engine, so the AT is connected to the first processor, which drives the second, which drives the third, and so on to the last processor, which is connected back to the AT. The key to this is the 8751 program, which will output its result only when its chain-in line is active, then toggle its chain-out line when transmission is complete.

The AT driver program gets ready to receive a set of results, then toggles its chain-out line. The first processor sends its result, then the second, and so forth through the array. The last processor sends its result and toggles the AT's chain-in line, which tells the AT that all results are complete. The cycle repeats when the AT is ready for the next set.

Because the driver program knows how the processors were assigned to pixels, it can put the results into the right places. The actual screen painting occurs between sets of pixels to reduce the loop overhead, so the results are metered out of the engine in bursts. The 8751 program will send only 1 byte if the iteration limit is less than 256, which reduces the

continued

Listing 2: *The 8051 code to add two fixed-point numbers.*

```
;-----------
; Add two long integers
; R0 points to the high order byte of the target
; R1 points to the high order byte of the source
; Mashes A, B, and R1
; Returns R0 unchanged
NUMLEN      EQU 8    ; bytes per fixed point number
long_add    PROC
PUBLIC  long_add
   MOV      A,R0          ; point to end of target
   ADD      A,#NUMLEN-1
   MOV      R0,A
   MOV      A,R1          ; point to end of source
   ADD      A,#NUMLEN-1
   MOV      R1,A
   MOV      B,#NUMLEN     ; number to add
   CLR      C             ; set up for loop
   L?loop   EQU  $
   MOV      A,@R0         ; pick up target
   ADDC     A,@R1         ; tack on buffer
   MOV      @R0,A         ; drop into target
   DEC      R0            ; tick pointers
   DEC      R1
   DJNZ     B,L?loop      ; repeat for all bytes
   RET
long_add    ENDPROC
```

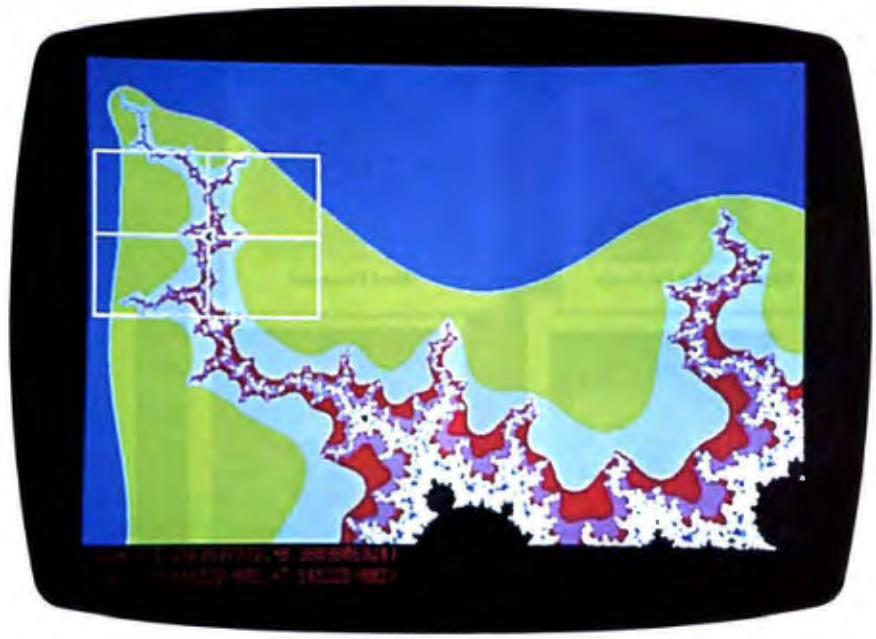


Photo 4: *The driver program's zoom box. It is possible for you to home in on an interesting part of the array and magnify it.*

data transmission time by a factor of 2 for most images.

You may wonder why I would pick a serial link instead of a parallel port. The answer is simple: It works! A standard RS-232C serial link can send 1 byte in about 380 μs at 28,800 bits per second. Compared to the time required to compute that byte, the transmission time is small. Only for trivial pictures does the transmission time for the full array approach the computation time.

You might also wonder what effect the daisy chain has on the result throughput. After all, all the down-chain processors must wait on any processor that's not ready when its chain-in signal becomes active. I'll discuss performance next month, but suffice it to say that it's not all that bad. The processors already polled have started on their next set of computations, and the remaining processors are probably still running through the current iterations. Only in the case where one processor hits a point in the Mandelbrot set while all others are outside does this delay become significant.

Because results from the Mandelbrot set calculations are shown on a graphics display, it's only natural that you should use a graphical means to select which part of the array to view. The driver program creates an overall view of the array, shown in photo 4.

Coming Attractions

Now that you understand how the Circuit Cellar Mandelbrot engine works, I can describe the actual hardware used to build it. In the final part of the series, I'll cover the hardware construction and the AT driver program needed to get the images up on the screen. ■

To receive information about the Circuit Cellar Ink publication for hardware designers and developers, please circle 100 on the Reader Service inquiry card at the back of the magazine.

Special thanks to Ed Nisley and Merrill Lathers for their expert contributions to this project.

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.

There is a multiline Circuit Cellar bulletin board system (running TBBS 2.0M) that supports past and present projects in BYTE and Ink. You are invited to call and exchange ideas and comments with other Circuit Cellar supporters. The 300-/1200-/2400-bps BBS is online 24 hours a day at (203) 871-1988.

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. The author of several books on electronics, he can be reached on BIX as "sciarcia."

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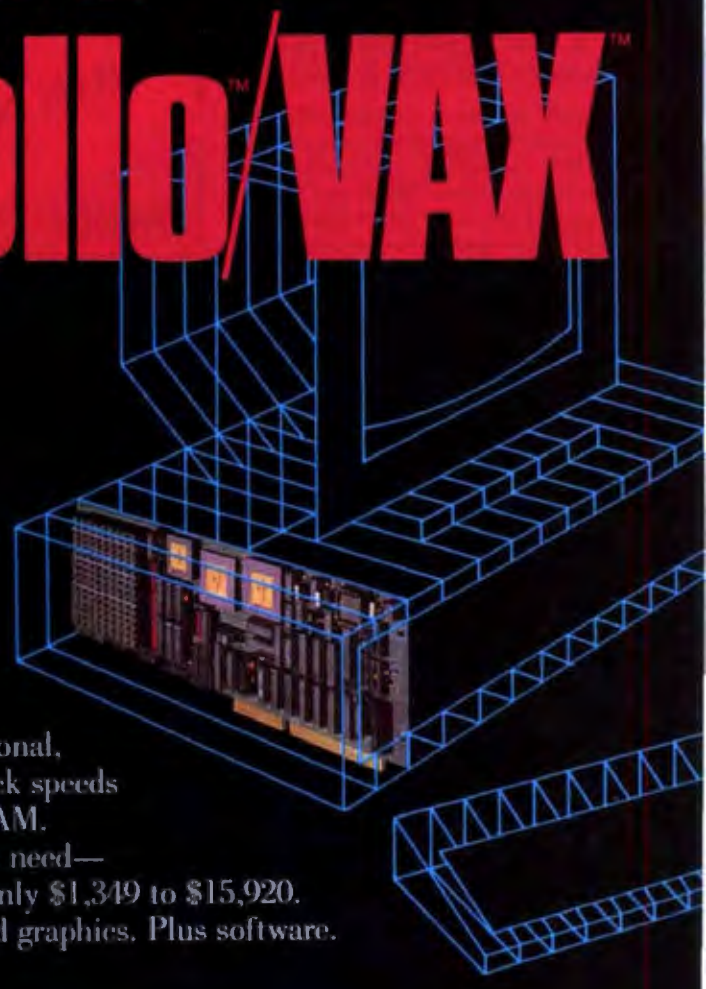

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EMBEDDED LANGUAGES

ExTalk allows users to extend the capabilities of your application programs

Though the term "embedded languages" suggests a subject explored only by programmers, the topic is closer to home than you might think. Have you ever created your own custom log-on routine with your favorite communication package's script language? Or written a macro for your word processor to remove superfluous spaces between words? Script and macro programs are both embedded languages.

You could think of embedded languages as miniature programming environments within an application that permit the user to customize and extend the application beyond what its designers had anticipated. There are other examples of embedded languages (so called because the language is *embedded* within the larger application); for example, some database packages include embedded languages so extensive that most of your work with the package actually involves programming on a par with "traditional" high-level language development.

In this article, I am going to describe a simple language that I have designed that you can embed in your application program to provide a facility for users to extend the application. I call the language ExTalk. ExTalk is a fairly standard Algol-like procedural language with the expected control structures, like IF...THEN...ELSE, WHILE...DO, BEGIN...END, and functions with arguments. It also supports object-oriented programming with message passing and inheritance. If you've had experience with C, Pascal, or any of the modern versions of BASIC, then you'll most likely be right at home with ExTalk's syntax.

In addition to providing normal programming constructs, ExTalk has a facility for extending the language with functions that are unique to the application it is embedded in. So, for example, if you're writing the world's next great CAD program, a user could call on this facility to access functions already built into your package for drawing polygons on the screen. Or perhaps you're building a communications program and you've already designed the routines for handling the Kermit protocol; ExTalk's extension capabilities would allow a user to call your Kermit routines from a communication's script to create a custom file-transfer program.

What's Inside

ExTalk consists of a compiler that translates ExTalk source programs into code for a virtual machine. This virtual machine code is then executed by an interpreter. This approach simplifies the process of porting ExTalk to other machines that support the C language (ExTalk is written entirely in C). It will work with any compiler that is compatible with K&R C. (If you've got the BDS C compiler, you're probably out of luck.) To add ExTalk to an application, you simply compile ExTalk's compiler and interpreter and link them into your application program.

As I mentioned earlier, ExTalk's syntax should be familiar to most programmers. An example of ExTalk code for the factorial function is shown in listing 1. This is the standard recursive implementation of the factorial function. Notice that there are no type declarations; in ExTalk, data is typed, not variables. Consequently, any variable or function parameter can take on any type of value.

To use this function, you need to compile it into *bytecode*, the instructions that the ExTalk interpreter understands. You compile the function through the ExTalk compiler, which stores the resulting code as the value of the function name symbol—`factorial`, in this case. Listing 2 shows the code that the ExTalk compiler produces for the `factorial` function. (I've added comments to clarify the code.)

By careful examination of the code, you have probably deduced that the ExTalk virtual machine is a stack machine (see the text box "Inside ExTalk" on page 412). That is, instead of registers, the EVM's primary operating storage during instruction execution is a FIFO stack (see figure 1 for a diagram of the virtual machine's architecture).

Instructions always operate on the top few stack entries. For instance, the `MUL` instruction multiplies the top stack entry with the second stack entry and replaces both with the result. The `LIT` instruction moves a value from an array of literals associated with the compiled function to the top of the stack.

Each of the bytecode instructions consists of an op-code byte, possibly followed by one or more extension bytes. The `MUL` instruction takes just a single byte while the `BRF` (branch on false) instruction takes 3 bytes—one for the instruction, and two extension bytes to encode a 16-bit offset from the base of the function as the target for the branch.

The bytecode interpreter simply fetches each instruction and simulates the effect of that instruction, thereby creating the virtual machine. Some instructions move values to and from the stack; others load or store values into

continued

Listing 1: *ExTalk listing for a function that computes the factorial of a number* n.

```
Function factorial(n)
  If n = 0
    Then 1
    Else n * factorial(n - 1)
```

global symbols or function arguments.

You call the ExTalk bytecode interpreter with a single argument—specifically, the name of the function to execute. The function itself must not take any arguments, and its return value is discarded upon completion. The interpreter starts by creating a dummy stack frame for the named function and then transferring control to the function. If the function is compiled bytecode, the interpreter enters the instruction fetch cycle. If it is an extension function (which I'll describe in a moment), the interpreter then calls the corresponding C function.

Extending the Language

For ExTalk to be useful as an embedded language, the developer must be able to extend it with functions specific to the application you decide to embed it in. You could do this by adding op codes for each application-specific function you want ExTalk to support, and then writing the additional C routines the bytecode interpreter will need to handle these new op codes. This has the advantage that the interpreter will not require special code to dispatch to the application functions. However, it has the disadvantage that only a limited number of op codes are available (256, since ExTalk has an 8-bit op code), and ExTalk already uses some to define its rudimentary instructions.

I have chosen a different tack. Instead of adding op codes, I have introduced a new data type for application functions. When the bytecode interpreter executes a CALL instruction, it looks at the data type of the procedure being called. If the procedure is a compiled bytecode procedure, it invokes the interpreter recursively to execute the bytecodes that are associated with the called function. If the procedure is an application function, the bytecode interpreter retrieves the address of the C language procedure that handles the application function and calls that function. Since the C procedure has access to the EVM's stack, you can use that stack to pass arguments to and from ExTalk and the application functions.

An example of an application-specific function appears in listing 3. Since I wrote ExTalk on a Macintosh computer, this example shows how to draw a line in a Macintosh window.

The ExTalk compiler generates code that pushes the arguments on the stack from left to right. Since the stack grows from high memory to low memory, the arguments appear in reverse order on the stack. When an extension function is called, the last argument is on the top of the stack (in the stack element array sp[0]), and each preceding argument is at a higher location in the stack (the next-to-last argument is in sp[1], and so on). Since the LineTo function takes two arguments, the first is in sp[1] and the second is in sp[0].

First, the routine calls chktype to check the types of the two arguments. For LineTo, both arguments must be integers. Next, LineTo fetches the values of the arguments from the stack. Since ExTalk allows arguments of any type to be passed to functions, each value on the stack contains both a type field and a value field. The chktype macro checks the type field of the specified stack entry. When a routine fetches the value of a stack entry, it uses the value field. The expression sp[1].v.v_integer fetches the integer value of the second element on the stack.

After fetching the values of the two arguments, LineTo saves the current port, sets the port to the graphics window, and

continued

Listing 2: *ExTalk virtual machine bytecode for the program in listing 1.*

```
    PUSH      ; make room on the stack
    ARG 00    ; move argument zero to the stack
    PUSH      ; make room on the stack
    LIT 02    ; move literal 2 to the stack (0)
    EQ        ; compare the top two stack entries
    BRF L1    ; branch if they are not equal
    LIT 03    ; move literal 3 to the stack (1)
    BR L2     ; branch around the else clause
L1  ARG 00    ; move argument zero to the stack
    PUSH      ; make room on the stack
    VAR 04    ; move value of FACTORIAL to the stack
    PUSH      ; make room on the stack
    ARG 00    ; move argument zero to the stack
    PUSH      ; make room on the stack
    LIT 05    ; move literal 5 to the stack (1)
    SUB       ; subtract the top two stack entries
    CALL 01   ; call the FACTORIAL function
    MUL       ; multiply the top two stack entries
L2  RETURN    ; return from FACTORIAL
```

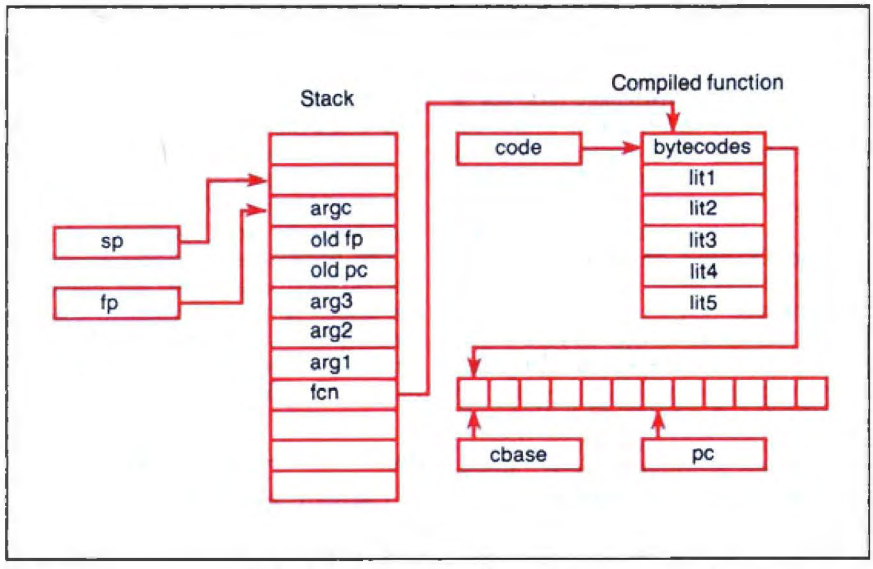

Figure 1: *Inside the ExTalk virtual machine. The stack-pointer pseudoregister is sp, and the frame-pointer pseudoregister is fp. The pseudoregister code points to the current compiled function and is used for access to the literals. The cbase pseudoregister points to the base of the string of bytecodes associated with the current function, and pc points to the op code of the next bytecode instruction to execute.*

Inside ExTalk

Following is a list of the instruction set for the ExTalk virtual machine. I've grouped the instructions based on operation and provided a brief description of each.

Branch Instructions:

BRT	*nnnn*	Branch on true
BRF	*nnnn*	Branch on false
BR	*nnnn*	Branch unconditionally

The branch instructions BRT, BRF, and BR take a 16-bit offset in the 2 bytes following the op-code byte. If the branch is taken, the new PC is determined by adding the offset to the base address of the bytecode string.

Constants and Variables:

LIT	*nn*	Load literal
VAR	*nn*	Load a variable value
SET	*nn*	Set the value of a variable

The LIT, VAR, and SET instructions take an 8-bit offset into the literal vector in the byte following the op-code byte.

Subroutine and Messaging:

CALL	*nn*	Call a function
SEND	*nn*	Send a message to an object
SENDSUPER *nn*		Send a message to superclass of self
RETURN		Return from a function

The CALL, SEND, and SENDSUPER instructions take the number of arguments in the byte following the op-code byte.

Arguments, Instances, and Class Variables:

ARG	*nn*	Load an argument value
ASET	*nn*	Set an argument value
IVAR	*nn*	Load an instance variable value
IVSET	*nn*	Set an instance variable
CVAR	*nn*	Load a class variable value
CVSET	*nn*	Set a class variable

The ARG, ASET, IVAR, IVSET, CVAR, and CVSET instructions take the argument, instance variable, or class variable number in the byte following the op-code byte.

Miscellaneous:

TRUE	Load top of stack with true
FALSE	Load top of stack with false
PUSH	Push nil onto stack
NOT	Logical negate top of stack
ADD	Add top two stack entries
SUB	Subtract top two stack entries
MUL	Multiply top two stack entries
DIV	Divide top two stack entries
REM	Remainder of top two stack entries
BAND	Bitwise AND of top two stack entries
BOR	Bitwise OR of top two stack entries
BNOT	Bitwise NOT of top stack entry
SHL	Shift second stack entry left by first
SHR	Shift second stack entry right by first
LT	Compare top two entries for less than
EQ	Compare top two entries for equal to
GT	Compare top two entries for greater than

draws the line. Finally, the routine restores the saved port (using the SetPort( ) routine), pops the arguments off the stack, stores the return value on the top of the stack, and exits.

To make the LineTo function available to ExTalk programs, you must enter it into the symbol table. You do this with the following:

```
add_function("LINETO",
             ex_lineto);
```

This adds the symbol LINETO to the symbol table and sets its value to be the address of the C function ex_lineto. Now, all references to the symbol LINETO will refer to this extension function.

You can now use the LineTo function in ExTalk just like any built-in function. Listing 4 shows an ExTalk function that draws a square using the LineTo function and the MoveTo function, which is defined using the same method I showed with LineTo. (Notice that ExTalk is not case-sensitive. It considers the symbols LINETO and LineTo to be identical.)

A typical application would probably contain several hundred application-specific functions. A spreadsheet might have functions for computing sums and averages of ranges of cells, while a communications program might have functions for controlling the modem and sending and receiving strings of characters. These functions could be implemented either as extension functions, like LineTo above, or as functions in ExTalk itself built on top of the lower-level extension functions, as I did with the square function.

In either case, ExTalk, along with the application-specific extension functions, gives the user much more control over the behavior of the application than would be possible without an extension language. The user can add new functions to the application without having to wait for the next release of the application. Thus, you give the user much more flexibility in tailoring the application to suit his or her needs without having to resort to the kitchen sink approach.

The ExTalk Compiler

The ExTalk compiler reads a text file containing ExTalk source code and sends the compiled result to memory. You call the compiler with a single argument that is simply the name of the file to compile. Functions are compiled, and the resulting function is stored as the value of the function name symbol.

The compiler consists of a lexical scanner, a parser, and a code generator. It makes a single pass over the source code. The parser is an ordinary recursive descent type, and it generates bytecodes during the parse rather than building an intermediate representation of the program. Listing 5 shows the part of the compiler that handles the "+" and "−" operators.

First, ExTalk calls the do_expr3( ) function to parse and generate code for the expression to the left of the operator. Then, using the token( ) function, it fetches the next token to see if it is either a "+" or a "−." If it is, the program generates a PUSH instruction to reserve space on the run-time stack for the second operand and then calls do_expr3( ) to parse the expression to the right of the operator. After parsing the right-hand expression, ExTalk generates the instruction that will perform the operation (addition or subtraction) on the two values that are left on the top of the stack.

continued

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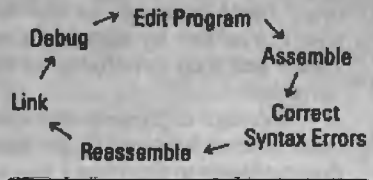

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Listing 3: *An ExTalk application-specific function. This routine uses the Macintosh* LineTo *routine to draw a line from the current pen position to the position given by the top two arguments of the ExTalk machine's stack.*

```
/* ex_lineto - application function 'lineto' */
int ex_lineto()
{
  WindowPtr save;
  int h,v;
  chktype(0,DT_INTEGER);
  chktype(1,DT_INTEGER);
  h = sp[1].v.v_integer;
  v = sp[0].v.v_integer;
  GetPort(&save);
  LineTo(h,v);
  SetPort(save);
  sp += 2;
  sp->v_type = DT_NIL;
}
```

Listing 4: *Drawing a square using the routine defined in listing 3.*

```
Function square(x,y,size)
 Begin
   MoveTo(x,y);
   LineTo(x+size,y);
   LineTo(x+size,y+size);
   LineTo(x,y+size);
   LineTo(x,y);
 End
```

ExTalk repeats this process until it no longer finds a "+" or a "−," and then calls the `stoken()` function, which saves the current token so that the next call to `token()` won't lose whatever token `do_expr2()` didn't match.

Object-Oriented Programming

I designed ExTalk to support object-oriented programming. In addition to being able to define functions, you can also define classes of objects in ExTalk. Listing 6 is an illustration of an ExTalk class definition.

This class definition describes a class called Square with instance variables `x`, `y`, and `size`. Each instance of this class will have values for each of the instance variables. Instances respond to the message `show` by displaying the square, and to the message `x:y:` by moving the square to a new location. The Square class itself responds to the message `new_x:y:size:` by creating a new instance and then initializing its instance variables.

A message expression consists of an open bracket followed by an expression that evaluates to the object that is to receive the message. In the case of unary messages, the receiver is followed by the message selector. The message `show` is an example of a unary message (a message with no arguments).

In the case of messages that take argu-

continued

Listing 5: *This routine in the ExTalk compiler contains the parsing for "+" and "−" operators within an expression.*

```
do_expr2()
{
 int tkn;
 do_expr3();
 while ((tkn = token()) == '+'
        || tkn == '-')
   switch (tkn)  {
     case '+':
       putcbyte(OP_PUSH);
       do_expr3();
       putcbyte(OP_ ADD);
       break;
      case '-':
       putcbyte(OP_PUSH);
       do_expr3();
       putcbyte(OP_SUB);
       break;
   }
  stoken (tkn);
}
```

Listing 6: *Defining classes within ExTalk. This code defines a class called* Square.

```
Class Square
 IVars x,y,size;
 CMethod [self new_x: xx y: yy size: ss]
         [[super new] init_x: xx y: yy size: ss]
 Method [self init_x: xx y: yy size: ss]
   Begin
    x := xx; y := yy;
    size := ss;
    self;
   End
   Method [self show]
   Begin
     MoveTo(x,y);
     LineTo(x+size,y);
     LineTo(x+size,y+size);
     LineTo(x,y+size);
     LineTo(x,y);
     self;
   End
   Method [self x: xx y: yy]
    begin
     x := xx;
     y := yy;
     self;
    end;
```

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ments, each argument is preceded by a keyword. The string resulting from combining all the keywords is the selector. For instance, the message `[mysquare x: 10 y: 20]` will move `mysquare` to (10,20). The selector for this message is the string `x:y:`, and the arguments are 10 and 20.

Here is an example of creating a new instance of the class `Square`:

```
mysquare := [Square new_x: 100 y:
              200 size: 20]
```

Once you have created an instance of the Square class and stored it as the value of the symbol `mysquare`, you can display it using this expression:

```
[mysquare show]
```

You can move it to a new location using this expression:

```
[mysquare x: 100 y: 200]
```

You can use objects to model parts of the application. For instance, a word processing program might have classes of objects to represent chapters, paragraphs, and footnotes. A communications program could use objects to represent conferences and messages during communications with an on-line service like BIX. See the August 1986 BYTE for a complete description of object-oriented programming.

Portable Simplicity

ExTalk is a simple language that can be embedded in an application to provide user programmability. It is easily understood by people who are familiar with C, Pascal, or modern versions of BASIC, and its implementation is portable across different machines and operating systems. It should be useful to developers who want to add an embedded language to their applications.

Next Month

Rick Grehan returns with a series on large database management using keyed files. ■

Editor's note: *ExTalk is available in a variety of formats. See page 3 for details.*

David Betz is the author of the popular XLisp programming language. He can be reached on BIX as "dbetz."

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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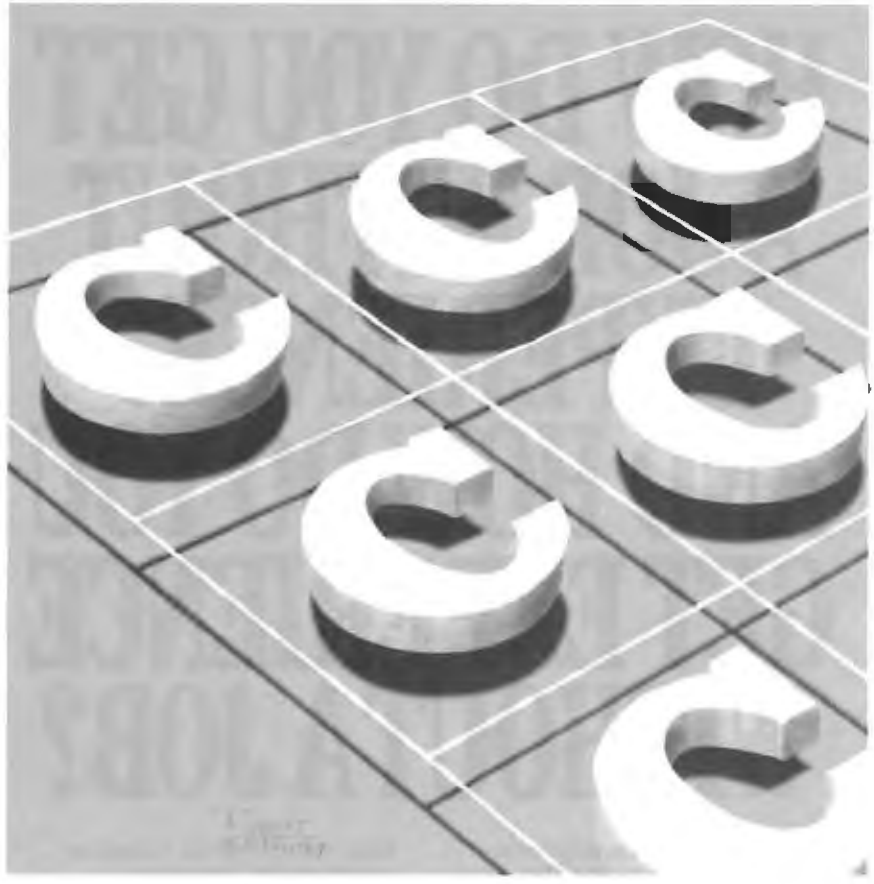
ADDING DIMENSION

Here's a technique that provides the fastest possible access to an array element in C



Many of today's popular programming languages support the multidimensional arrays used in graphics, modeling, and simulation or even for locating a specific position on a screen. Most implementations of BASIC do; Turbo Pascal does; FORTRAN does; but C does not. Is there any way around this omission? You bet there is. You can implement `DIMENSION A (N,M)` and `X= A(I,J)` in C, and not through a pseudodimensional substitute either. I know, because I've done it.

If you have a compiler that supports structure return, you can also write statements such as

```
X = matrix_operator(A,B);
```

where `A`, `B`, and `X` are matrix structures and `operator` can be multiply, add, inverse, and so forth. Most important, the function `matrix_operator()` can dynamically dimension `X`, and you can access elements by applying the simple bracketed-integer access format.

Problem Evaluation

To analyze the problem, consider the basic two-dimensional array of floating-point numbers or matrix. If you declare it as

```
double array[n][m];
```

then there will be a minimum of $n \times m$ double units of storage allocated at compile time in the current storage class. With this method, you must set n and m constant before compiling, a statement that would be illegal in C if n and m were variable. As a consequence, you must allocate memory whose size will depend on the maximum size of array expected. Moreover, if this array is declared as local storage class, then it may consume valuable stack space.

A Pseudomultidimensional Dynamic Array

There is a simple way you can create a pseudomultidimensional dynamic array by using the `malloc()` function with a pointer to the desired storage unit. Consider the array whose label is A. The following method transforms A into a one-dimensional array with multidimensions `dim_1, dim_2, ...`:

```
double *A;
A = (double *)
   malloc(sizeof(double)
   * dim_1 * dim_2 * ...)
```

According to the rules of C, you can only access elements in this type of array by one index: `x = A[q];`.

This method, therefore, has a major drawback; to access individual elements, you must present array size variables

continued

ILLUSTRATION: ROBERT TINNEY © 1988

dim_1, dim_2, and so on at every indexing operation, multiply them by the corresponding index, then add them together to reduce to the required offset *q* that corresponds to the linear array A. For example, if you wanted to extract *A*(*i*,*j*, . . . ,*k*), you would write

```
x = A[ (i * dim_1) + (j * dim_2)
   + . . . + k ];.
```

Although this method is feasible, it can become awkward even when you try a simple operation such as matrix multiplication.

The One-Dimensional Array

To evolve a general method for elegantly handling multidimensional dynamic arrays, you first construct a memory-allocation function so the allocated memory can be accessed by integer indices. You do this with the calloc( ) function.

If an array has only one dimension of *n*, you can use this simple solution:

```
double *A;
A = (double *)
   calloc(n, sizeof(double));
```

As in the previous pseudomultidimensional case, you can access the *i*th element by x = A[i];. Once interaction with A is no longer required, you can free the memory with

```
free((char *) A);.
```

The Two-Dimensional Array

In order to create a two-dimensional array of size $n \times m$, you must declare a pointer to an array of pointers to the desired storage units by writing

```
double **A;
```

and you must give the pointer variable A memory space for *n* pointers of size *pointer to double*:

```
A = (double **)
   calloc(n, sizeof(double *));
```

You can access each of the *n pointers to double* by an index, as in the one-dimensional example. The key here is that you must give each of these *n* pointers memory space for its corresponding *m* storage units, effectively creating an *n*-quantity of *m*-size one-dimensional array containing the desired storage units:

```
for (j = 0; j <= n - 1; ++j)
 {
 A[j] = (double *)
        calloc(m, sizeof(double));
 }.
```

Combine these three sections into a function, and you're finished. Since accessing is done via indirection, the order in which you establish pointers is important. You must give allocation to the highest-level pointer first so the next-level pointer can know of its predecessor's existence. Again, according to the rules of C, you can express the "pointer to pointer to double" variable A as A[][], thus reaching down to the smallest unit—in this particular case, a double. Thus, you can obtain the (*i*, *j*th) element by writing x = A[i][j]; of the dynamically allocated array A of size *n*, *m*. This statement is the corresponding free function to complement the two-dimensional allocation function.

To free the allocated memory, you use a freeing order that is the reverse of the allocation order. Thus, all the memory used by A would be freed accordingly:

continued

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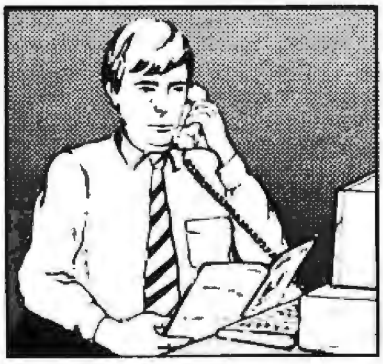

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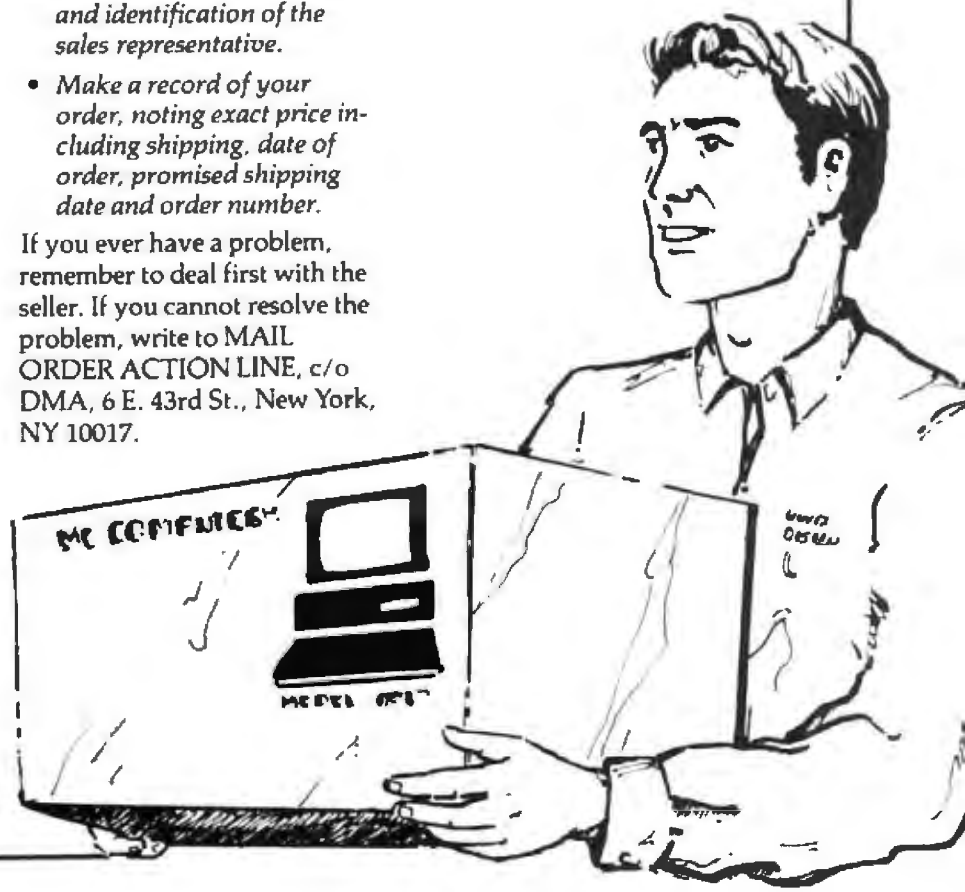

```
for (j = n - 1; j >= 0; j--)
 {
 free((char *) A[j]);
 }
free((char *) A);.
```

Note that the rightmost dimension of *m* is not required. This is because the last call to `calloc()` in the allocation function manages unit storage internally. `A[][]` is a scalar and not a pointer, whereas `A` and `A[]` were established as pointers and therefore can be the only ones freed.

Listing 1: *This listing illustrates the dimensioning function for a three-dimensional array* `A(m,n,p)`.

```
double *** A;

A = (double ***) calloc(n, sizeof
                        (double**));
  for (j = 0; j <= n - 1; j++)
    {
    A[j] = (double **) calloc(m,
                sizeof(double *));
      for (i = 0; i <= m - 1; i++)
        {
        A[j][i] = (double *) calloc(p,
                        sizeof(double));
        }
    }
```

Listing 2: *This is the corresponding three-dimensional freeing function.*

```
for (j = n - 1; j >= 0; j--)
    {
    for (i = m - 1; i >= 0; i--)
      {
      free((char *) A[j][i]);
      }
    free((char *) A[j]);
    }
  free((char *) A);
```

Listing 3: *If you want to have access to an array created by another function, you can use this technique.*

```
main_function()
  {
  double ** X;
  X = other_function();  /* [X]
                    is dimensioned. */
      .
      .   /* Your access to what
           was [A] via pointer [X]. */
      .
  matrix_free(X); /* Here you free
              memory allocated by   */
  }  /* other_function() to clean the
        heap. */

  double ** other_function()
    {
    double ** A;
    matrix_dimension(A);
    return(A);     /* The address of the
                      array in the heap */
    }              /* is returned to the
                      main_function()   */
                   /* before pointer A
                      disappears.       */
```

The General Case

For the three-dimensional array `A(m,n,p)`, you would use the dimensioning function in listing 1. You should see a pattern emerging that can be carried to any number of dimensions.

You can access the (*i*, *j*, *k*th) element by `x = A[i][j][k];`. The corresponding three-dimensional freeing function is shown in listing 2. As before, the rightmost dimension is not required.

With this method, you should watch for a number of things regarding the use of the `calloc()` and `free()` functions. Be aware that `calloc()` allocates memory in the "heap." This means that if you create a dynamic array A within your function, even if the pointer variable A were declared local, that array should be freed upon exit from your function.

The reason for this operation is that heap management generally is handled by the operating system, and memory allocated there is not recovered automatically on exit from the allocating function as local stack variables would be. Moreover, the scope of the pointer variable A is only function-wide, and when the function is exited, the variable's address information is gone.

The remaining problem is that, to the operating system, the allocated portion of memory still seems occupied. Therefore, subsequent calls to your function will pile up memory in the heap until there is no more memory available. Your function, however, will continue to operate properly, but only up to that point.

This restriction would be imposed in a situation where you want to have access to an array created by another function. To overcome it, you apply a technique similar to the pseudocode in listing 3.

Now you have the complete solution. The upshot of this method is that only one pointer is passed as argument, not the entire array. There may be instances where you require a copy of the original array, and you can easily program according to C rules.

A Note for 8086 Programmers

A key advantage of this method for 8086-type segmented memory is that when you compile your program for the large memory model, each indexed pointer will be assigned its own data segment, because it is treated as a `far` variable. That is, the declaration

```
double **A;
```

continued

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becomes equivalent to

```
double far * far * A;
```

or "A is a far pointer to an array of far pointers to double."

You can calculate the total number of segments from the following formula:

$$\left[\prod_{i=1}^{k-1} A_i \right] + k$$

This formula shows a *k*-dimensional array where A_i are the dimensions of the array name with A_1 the leftmost and A_k the rightmost:

```
array_name[A1][A2]...[Ak]
```

Therefore, each indexed pointer can handle 64K bytes of your smallest unit. For the double case here, you can comfortably use all the available memory without resorting to special keywords for one matrix, so long as it is nearly square.

Fastest Possible Access

With this technique, you can create and use multidimensional arrays as easily as in other popular languages. Moreover, when you use C, your program accesses the individual storage units by indirection, as opposed to leaving open a possibility that the final pointer may be resolved by index multiplication. Thus, there is no doubt that you have the fastest possible access to a storage unit.

To get a better idea of how the technique is implemented, you can study the sample program. It uses the following matrix structure:

```
struct mat
 { double **a;
  /* "a" short for "array" */
    int   rows;
    int   cols; } ;
```

This structure holds a pointer and two integers that define the size of the matrix. Dynamic C contains an input, output, and do-something functions. ■

Editor's note: *Dynamic C is available in a variety of formats. See page 3 for further details.*

Christopher J. Batory is president of Micropath, a Montreal, Canada, firm specializing in radio-telecommunications software and services. He can be reached on BIX c/o "editors."

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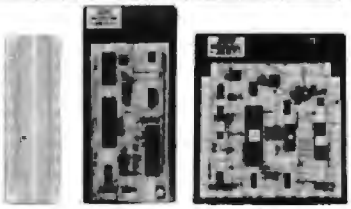

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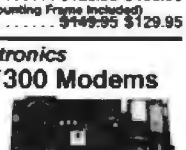

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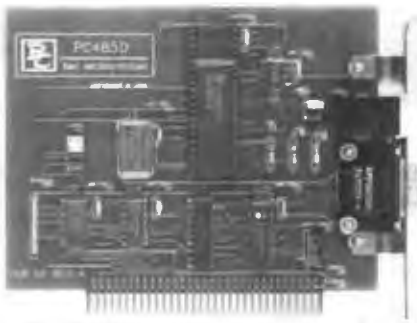

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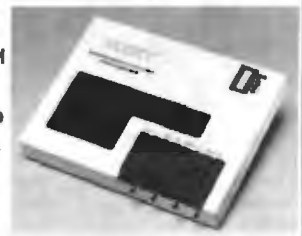

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PPC301-6RA	6 ft.	12.95

DB-25 - 25 Line Cables Male-Male

Stock #	Length	Price
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25MM-10	10 ft.	7.95
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call Other cables available

DB-25 - 25 Line Cables Male-Female

Stock #	Length	Price
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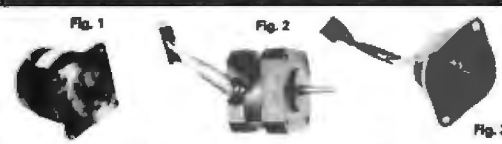

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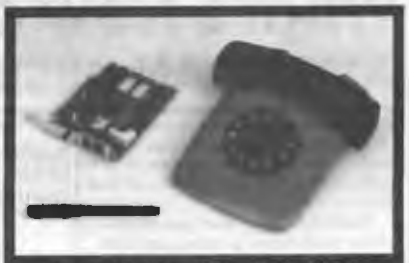

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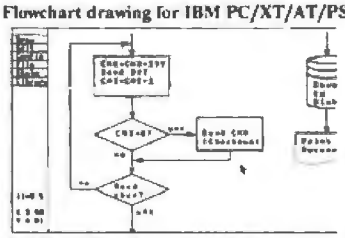

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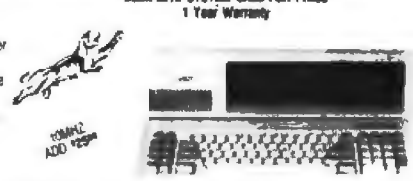

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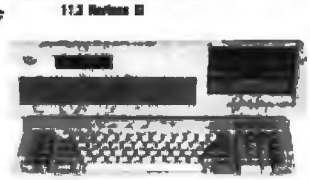

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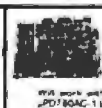

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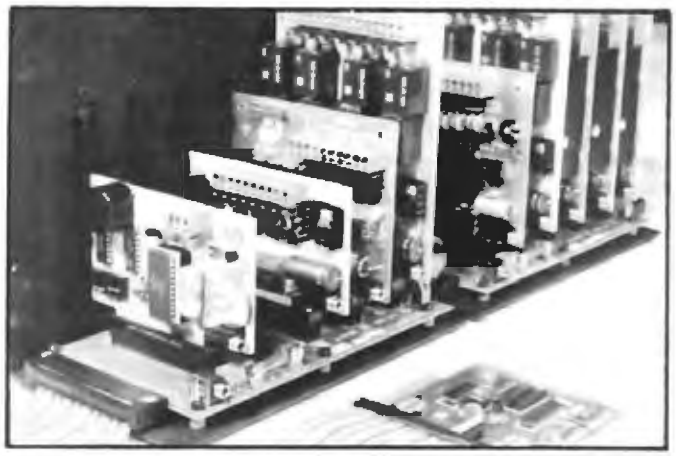

An A-BUS system with two Motherboards
A-BUS adapter (IBM) in foreground

Plug into the future

With the A-BUS you can plug your PC (IBM, Apple, TRS-80) into a future of exciting new applications in the fields of control, monitoring, automation, sensing, robotics, etc.

Alpha's modular A-BUS offers a proven method to build your "custom" system today. Tomorrow, when you are ready to take another step, you will be able to add more functions. This is ideal for first time experimenting and teaching.

A-BUS control can be entirely done in simple BASIC or Pascal, and no knowledge of electronics is required!

An A-BUS system consists of the A-BUS adapter plugged into your computer and a cable to connect the Adapter to 1 or 2 A-BUS cards. The same cable will also fit an A-BUS Motherboard for expansion up to 25 cards in any combination.

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.

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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).

24 Line TTL I/O — DG-148: $65

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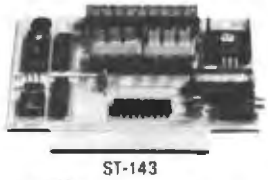
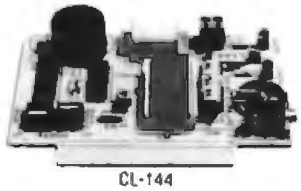
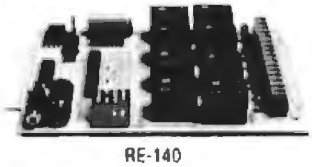


ST-143

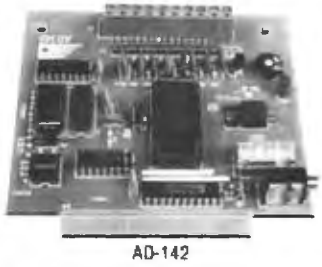


CL-144



RE-140

IN-141



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Remote Control Keypad Option — RC-121: $49
To control the 4 motors directly, and "teach" sequences of motions.

Power Driver Board Option — PD-123: $89
Boost controller drive to 5 amps per phase. For two motors (eight drivers).

Breakout Board Option — BB-122: $19
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Stepper motors are the ultimate in motion control. The special package (below) includes everything you need to get familiar with them. Each card drives two stepper motors (12V, bidirectional, 4 phase, 350mA per phase).

Special Package: 2 motors (MO-103) + ST-143 — PA-181: $99

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TRS-80 Model I. Plugs into 40 pin I/O bus on K/B or E/I	AR-131 $39
Color Computers (Tandy). Fits ROM slot. Multipak or Y-cable	AR-138 $49

A-BUS Cable (3 ft, 50 cond.) — CA-163: $24

Connects the A-BUS adapter to one A-BUS card or to first Motherboard.

Special cable for two A-BUS cards: — CA-162: $34

A-BUS Motherboard — MB-120: $99

Each Motherboard holds five A-BUS cards. A sixth connector allows a second Motherboard to be added to the first (with connecting cable CA-161, $12). Up to five Motherboards can be joined this way to a single A-BUS adapter. Sturdy aluminum frame and card guides included.

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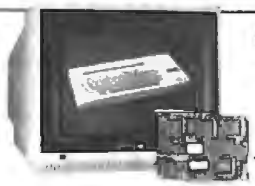


Color Monitor Better Than EGA

~~$495~~ **$289**

Ideal for CAD/CAM and Desk Top publishing applications. The Roland CD/240 color monitor has a resolution of 720 pixels by 400 lines on a .31mm dot pitch 12" non-glare screen. VGA specifications in text mode EGA in graphic mode.
Comparable monitor and card packages retail at over $1095. California Digital has made a special purchase and is able to offer the CD/240 and 132 column VGA/EGA graphic card for only $389.

NEC/890 Laser Printer

$3295

PC Magazine has chosen the NEC-890 best laser printer of the year. (Jan. 12, 1988). And its obvious why... the printer is Postscript, Hewlett Packard, and Apple compatible, and comes standard with three megabytes of memory. The 890 accepts data from parallel, serial and Apple-Talk devices.
NEC has also incorporated 40 built-in fonts along with two paper trays into this industrial quality laser printer.

Hewlett Packard Laser II, 8 pages per minute	**$1659**
QMS PS/810 2 Meg., 35 fonts, Postscript 8 pgs	**3879**
Apple Laser Writter II	**1899**
Texas Instruments 2115 Postscript 15 pgs.	**5426**
Quadram Quadlaser with 5 megabytes	**2995**

Panasonic INFO CENTER

~~$1395~~ **$295**

Panasonic's Information Center is the perfect tool for any executive who is concerned about efficient use of time. Incorporated in a single sleek enclosure is a **two line** speakerphone with conference calling and 100 number autodial phone directory.
Transmit, receive and edit MS/DOS files via the self contained 1200 baud **auto-Logon modem**. Connects to your host computer, logs in and enters your security password all with one key stroke! Press another button and the Info-Center is ready to auto receive (unattended) files to a 360K-byte disk drive.
Insert the diskette into your PC and your ready work on information just received from your branch offices.
Compact **Telex terminal**. Connect to Western Union and you're ready to transmit, receive and edit World wide Telex and TWX communications.
Besides all this the InfoCenter doubles as a VT-100 nine inch amber screen terminal that is ready to connect to your PC or Minicomputer. **Need hard copy...**No problem. Connect any Centronic compatible device directly to the printer port, you're ready to output from screen, disk, modem or Telex.
Time management, phone log, clock-calander appointment reminder alarm and memo pad are just a few of the features you can expect from the Panasonic KX-D4985 InfoCenter.
One hundred page reference manual is available for $10. May be applied to $295 purchase price.

20" Analog Color

~~$895~~ **$659**

Ever try gathering a classroom of students around a 12 inch monitor? The 20 inch analog RGB monitor is the ideal solution. High screen resolution of 1200 pixels by 950 lines allow extra fine detail without the dots looking like golf balls. 256 colors and VGA compatible.
Super value originally sold for over $2000. Only 350 available.

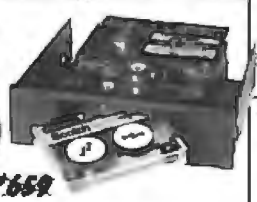
Hitachi CD-ROM

$495

Compact disk is a relatively new medium for storage of read-only digital data. One removable disk is capable of storing over 500 megabyte of data on a disk the same size as an audio CD.
The CDR-3500 will install in a PC in the space of one 5¼" drive.
Other CD/ROM Products Available: Sony 510 internal $539.
Amdek Laserdrive/1 system $679. Hitachi CDR-1503SUY external with IBM host adapter and MS ext. DOS $699: Panasonic WORM drive $1895.

40 Meg. Tape Back-up

$239 ~~$659~~



Head Crash, Power Spikes or just poor disk maintenance...
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 destroyed.
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.

Summagraphics DIGITIZER

$219

The Summagraphics Bit Pad is a 12 by 12 inch high resolution digitizer that easily connects to the serial port of your computer. Included four button cursor with crosshair sights is ideal for tracing, digitizing and menu selecting.
While supplies last, California Digital is offering this $595 Summagraphics Bit Pad digitizer for only $219.

$119 2400 Baud Modem

2400 baud with forward error correcting make the Maxon MAX/2400 an unbelievable value at only $119.
Fully compatible with the Hayes command set and CCITT V.22 standards. Error correcting, autobauding and "adaptive equalization" allow the MAX/2400 to maintain reliable data transmission over marginal phone lines.
Manufactured by Maxon Systems, one of the Worlds largest producers of consumer electronics. Originally priced at $295. While supplies last California Digital is offering the MAX/2400 at only $119.

	One	Two	Ten
TEC501 ½ height sgl.side	**49**	**39**	**35**
TANDON 101/4 full ht. 96 TPI.	**99**	**89**	**79**
FUJITSU 5¼" half height	**65**	**63**	**57**
MITSUBISHI new 501 half ht.	**119**	**109**	**105**
MITSUBISHI 504A AT comp.	**149**	**139**	**135**
TEAC FD55BV half height	**89**	**85**	**79**
TEAC FD55FV 96 TPI, half ht.	**119**	**109**	**105**
TEAC FD55GF for IBM AT	**109**	**105**	**99**
PANASONIC 455 Half Height	**109**	**99**	**89**
PANASONIC 475 1.2 Meg./96	**119**	**115**	**109**
Switching power supply			**49**
Dual enclosure for 5¼" drives			**59**
3½" DISK DRIVES			
SONY MP-53W 720K/Byte	**129**	**125**	**119**
SONY MP-73W, 2 Meg.	**159**	**149**	**call**
TEAC 35FN 720 K/Byte	**129**	**119**	**115**
TEAC 35HN/30, 2 Meg.	**159**	**149**	**145**
5¼" form factor kit			**20**
8" DISK DRIVES			
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QUME 841 single sided	**119**	**109**	**99**
SHUGART 851R dbl. sided	**319**	**309**	**299**
REMEX RFD4000 dbl. sided	**189**	**179**	**165**
OLIVETTI 851	**189**	**179**	**165**

Hitachi 11 by 17 Plotter

~~$895~~ **$695**

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.

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.

40 Megabyte Hard Disk Kit

$397

Forty megabyte internal hard disk drive, controller and cables all for only $397.
The kit includes the a 40 millisecond Miniscribe 3650 drive and a half slot Western Digital controller.

Five Inch Winchester Disk Drives

Price does not include controller.	each	two+
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SEAGATE 238 30 Meg. RLL	259	249
SEAGATE 251/1 51 M. 28mS.	459	445
SEAGATE 4096 96 M. 35mS.	659	639
MINISCRIBE 8425 25 M 65ms	239	227
MINISCRIBE 3650 50M 51 ms.	419	399
MINISCRIBE 6085 90 meg.	795	779
MINISCRIBE 3053 25 ms. ½ ht.	469	439
FUJITSU 2242 55 M. 33mS.	1299	1229
FUJITSU 2243 86 M. 35mS.	1595	1619
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XEBEC 1410A 5¼" foot print	239
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74LS09	.19	74LS157	.40	74LS258	.69
74LS10	.19	74LS158	.40	74LS259	.99
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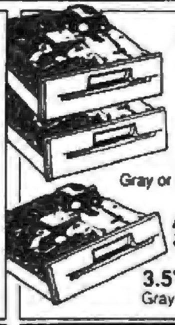

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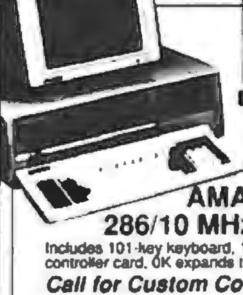

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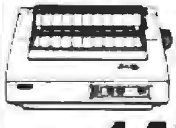

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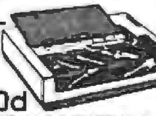

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2N2907	.25	4N33	.69
2N3055	.79	4N37	1.19
2N3904	.10	MCT-2	.59
2N3906	.10	MCT-6	1.29
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1.0µf	15V	.12
6.8	15V	.42
10	15V	.45
22	15V	.89
1.0µf	35V	.45
2.2	35V	.19
4.7	35V	.39
10	35V	.89

DISC

10pf	50V	.05
22	50V	.05
33	50V	.05
47	50V	.05
100	50V	.05
220	50V	.05
.001µf	50V	.05
.005	50V	.05
.01	50V	.07
.05	50V	.07
.1	12V	.10
.1	50V	.12

ELECTROLYTIC

RADIAL

1µf	50V	.14
4.7	50V	.11
10	50V	.11
47	35V	.13
100	16V	.15
100	50V	.23
220	35V	.35
470	25V	.30
2200	16V	.70
4700	25V	1.45

AXIAL

1µf	50V	.14
10	15V	.14
10	50V	.16
22	16V	.14
47	50V	.19
100	35V	.19
470	50V	.29
1000	16V	.29
2200	16V	.70
4700	16V	1.25

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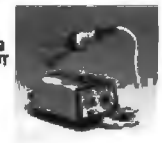

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PS-A $49.95

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PS-ASTEC $24.95

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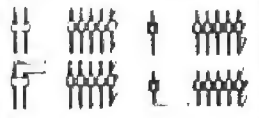

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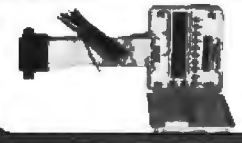

IDC CONNECTORS/RIBBON CABLE

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	.86	1.35	1.78	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	.83	.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' PLASTIC RIBBON CABLE	RCxx	1.80	3.20	4.10	5.40	6.40	7.50

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS BELOW

EPROM ERASERS

SPECTRONICS CORPORATION

Model	Timer	# of Chips	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

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- ERASES 2 EPROMS IN 10 MINUTES
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GC-10

$19.95

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DESCRIPTION		ORDER BY	CONTACTS					
			9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.45	.59	.69	.89	1.35	1.85
	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.89	–	.79	2.27	–
	FEMALE	DBxxSR	.55	.75	–	.95	2.49	–
WIREWRAP	MALE	DBxxPWW	1.99	2.56	–	3.89	5.90	–
	FEMALE	DBxxSWW	2.79	4.27	–	5.84	8.95	–
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	–	–
	PLASTIC	HOODxx	.39	.39	–	.39	.69	.79

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.

MOUNTING HARDWARE 59¢

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	.99	.99	.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	.82	.79	.89	1.09	1.29	1.39	1.49	1.89	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	.35	.49	.59	1.29	1.49	–	.85	1.49	1.59

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS ABOVE

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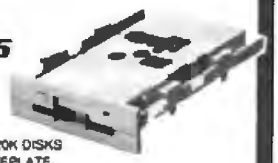

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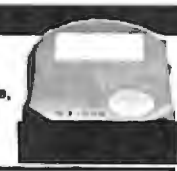

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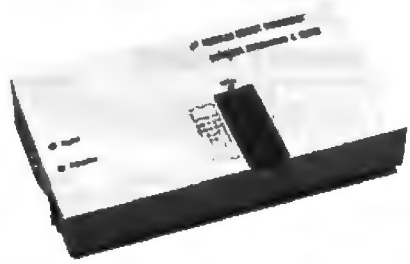

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COMING UP IN BYTE

PRODUCTS IN PERSPECTIVE:

As we go to press for November, here is the tentative lineup of articles on tap for December. While last-minute changes or delays can always occur, the following are those pieces we plan to bring to you.

In the **front of the book**, as usual, will be the Microbytes, Nanobytes, and What's New Sections, along with Short Takes—next month on new languages, add-ins, printers, and more. Putting in their usual appearance will be columnists Jerry Pournelle, with Computing at Chaos Manor; Ezra Shapiro, with Applications Plus; Wayne Rash, with Down to Business; Don Crabb, with Macinations; Brock N. Meeks, with COM1:; and Mark Minasi, with OS/2 Notebook.

First Impressions for December will include a look at a new relational database and a new 80286 laptop.

The **Product Focus** for December will look at low-cost plotters. Over 20 plotters were assembled at the BYTE Lab and put through a series of standardized tests. Every size and configuration, from desktop to free-standing to wall-mounted, were given a thorough going-over by our lab staff and technical editors.

System reviews will include the Sun 386i and the Dell System 220. Both are 80386-based systems that, in their own ways, should be of interest.

The Quickcapture board from Data Translation will be the focus of a **hardware review**. It is a black-and-white image capture card for the Macintosh.

In **software reviews**, we look at Merge 386, a DOS/Unix hybrid from Locus, and Slick, a text editor from MicroEdge.

Application reviews include Lotus Agenda and MacDraw II.

IN DEPTH:

Our In-Depth section deals with **groupware** in December and includes the following articles: an overview on collaborative work systems, groupware versus local-area network applications, artificial intelligence techniques in groupware, and a roundup of groupware products.

FEATURES:

We'll have **Ciarcia's Circuit Cellar** and Rick Grehan's **Some Assembly Required** for hardware and software constructionists, respectively. Additonally, we'll have pieces on **open look Unix, writing tidier Pascal code**, and **avoiding the fallacies of believing everything your calculations tell you.**

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1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170
1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200

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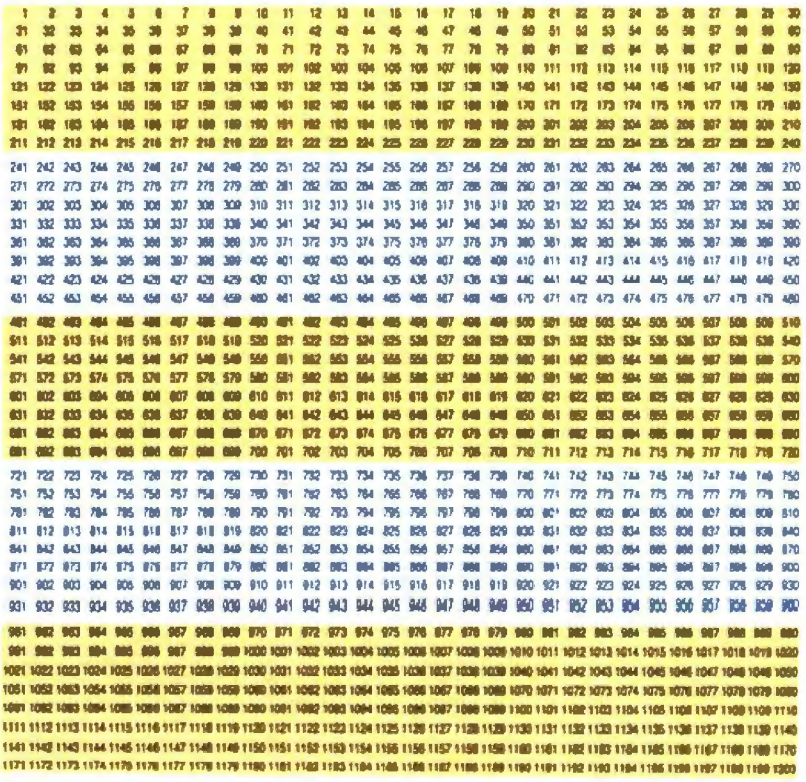

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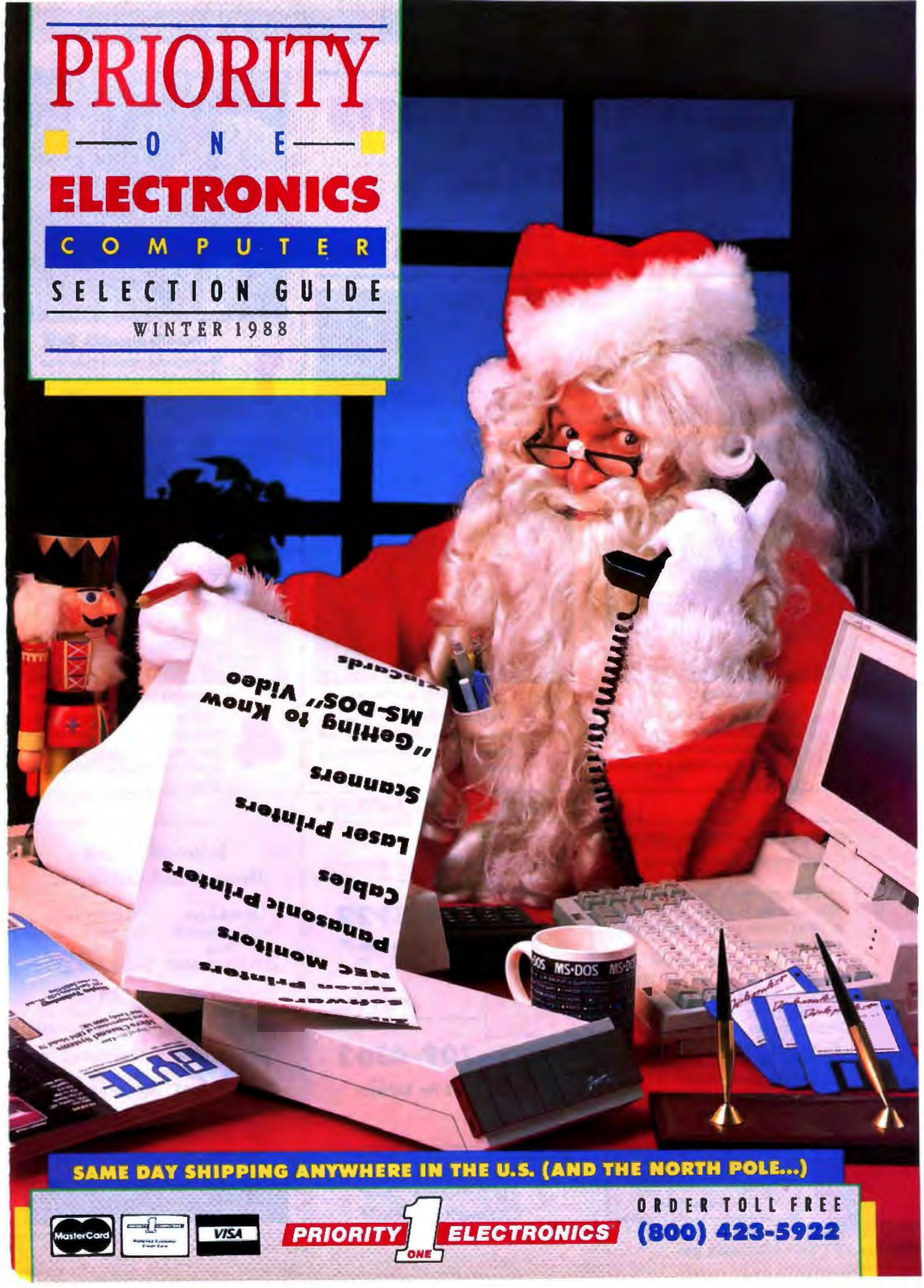
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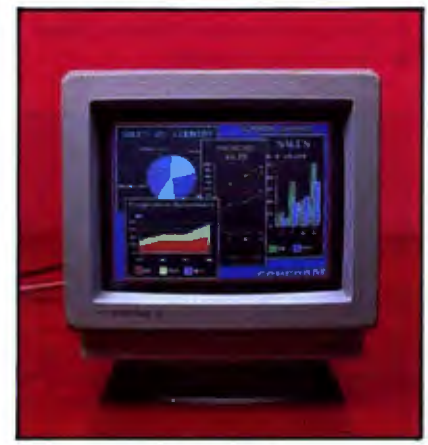

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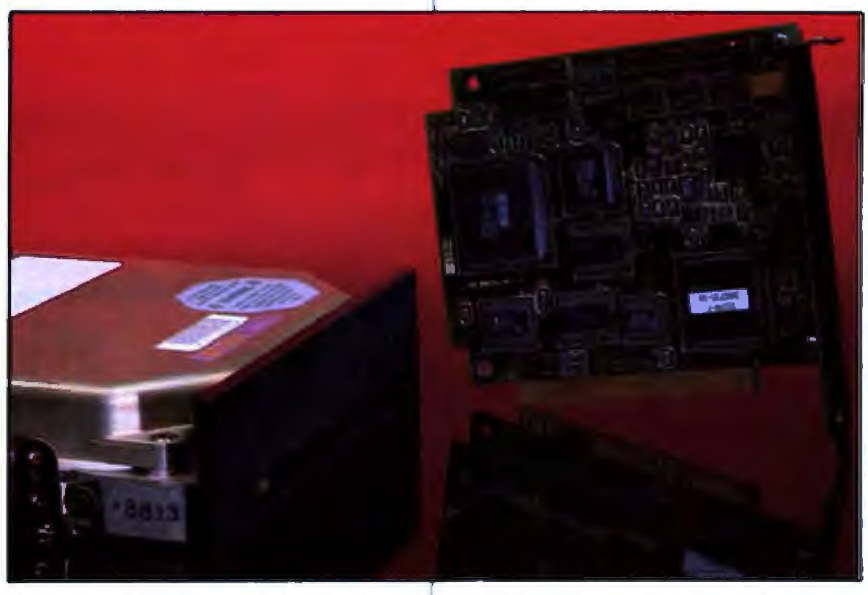

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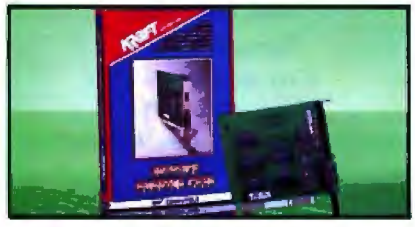

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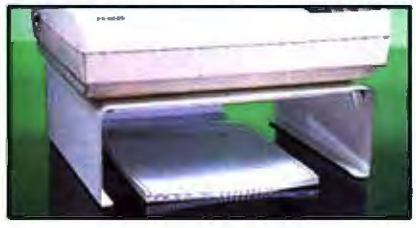

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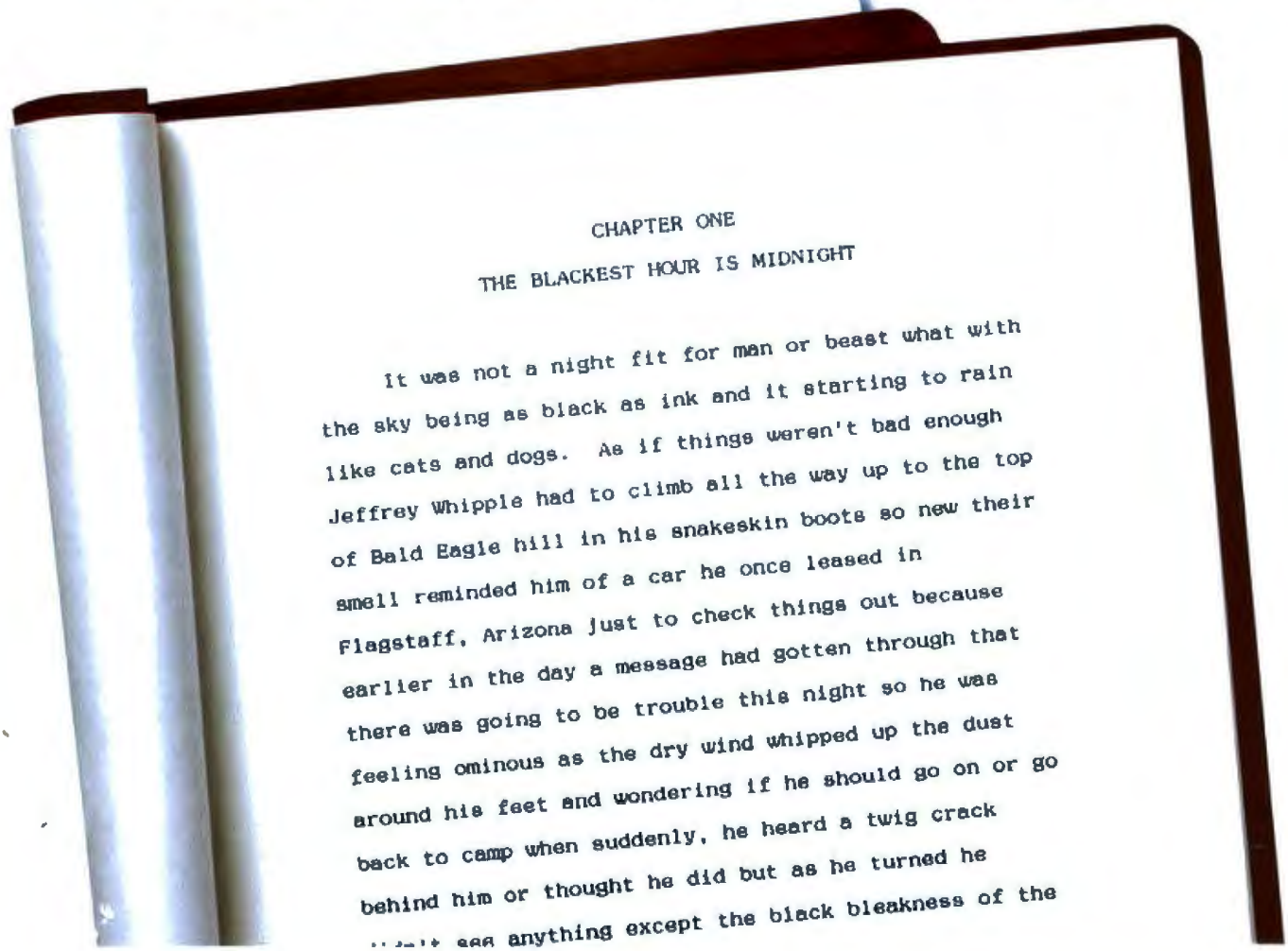

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