PRODUCT FOCUS
Ultra-High-Speed Modems
Falling prices, rising speed

IN DEPTH
BYTE’s New Benchmarks

REVIEWS
IBM’s OS/2
ALR FlexCache
Quattro vs. Surpass
Double Helix vs. 4th Dimension
80386 Replacement Motherboards
“Turbo C ... will stun you with in-RAM compilations that operate at warp speed.”

—Richard Hale Shaw, PC Magazine

“Turbo Pascal 4.0 flies 4.0 is ballistic!” —Tom Swan, PC Week

Almost from its introduction, Turbo Pascal® has been the world-wide Pascal standard. It’s fast. It’s flexible. It’s affordable. And it gives you full control.

Compile more than 27,000 lines of code per minute*. And work in a complete, integrated programming environment with pull-down menus and a full-featured editor.

You don’t have to swap code in and out to beat the 64K barrier: it’s designed for large programs. Break your code into convenient modules and work with them swiftly and separately. If there’s an error in one, you can see it and fix it.

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. IBM® RAM

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

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<table>
<thead>
<tr>
<th>Heap Sort</th>
<th>Turbo C 1.5</th>
<th>Microsoft C 5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compile time</td>
<td>16.7 sec</td>
<td>16.3 sec</td>
</tr>
<tr>
<td>Compile &amp; link</td>
<td>19.5 sec</td>
<td>19.5 sec</td>
</tr>
<tr>
<td>Execute time</td>
<td>19.5 sec</td>
<td>19.5 sec</td>
</tr>
<tr>
<td>Code size</td>
<td>1119</td>
<td>1313</td>
</tr>
<tr>
<td>Execution size</td>
<td>6892</td>
<td>7891</td>
</tr>
</tbody>
</table>

Turboman pops in at the scientific laboratory of Professor Phillip Popper

I wonder how many programmers need my help today...

Anyone here needs Turbo Power - I can feel it!

Take a good look at the state of the art, Professor. Now you can really c

Wow!
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—William Zachmann, Computerworld"

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• The Editor Toolbox

Toolboxes require Turbo Basic 4.0
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System Requirements: For the IBM PS/2™ and the IBM® family of personal computers and all IBM® compatibles PC-DOS® IBM-PC/XT 2.0 or later. 386 EISA 64K to support toolboxes

Compare the BASIC differences

<table>
<thead>
<tr>
<th>Turbo Basic 1.1</th>
<th>QuickBASIC 4.0 Compiler</th>
<th>QuickBASIC 4.0 Interpreter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compile &amp; Link to stand-alone EXE</td>
<td>3 sec.</td>
<td>7 sec.</td>
</tr>
<tr>
<td>Size of EXE</td>
<td>28387</td>
<td>25980</td>
</tr>
<tr>
<td>Execution time w/o 80287</td>
<td>0.16 sec.</td>
<td>16.5 sec.</td>
</tr>
<tr>
<td>Execution time w/80287</td>
<td>0.16 sec.</td>
<td>286.3 sec.</td>
</tr>
</tbody>
</table>

The Elkins Optimization Benchmark program from March 1988 issue of Computer Language was used. The Program was run on an IBM PS/2 Model 60 with 80287. The benchmark tests compiler’s ability to optimize loop-invariant code, unused code, expression and conditional evaluation.
“Fastest and most approachable implementation of that language”
—Darryl Rubin, AI Expert, on Turbo Prolog

“Most powerful version of Basic ever”
—Ethan Winer, PC Magazine, on Turbo Basic

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Just $99.95

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—Jerry Pournelle, Byte 1/88

An affordable, fast, and easy-to-use language.

—Darryl Rubin, AI Expert

System Requirements: For the IBM PC/XT and the IBM family of personal computers and all 8088 compatible. PC-9000 (486-500) 3.0 or later. 386i RAM.
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Our New Benchmarks

Here they are: BYTE's new system benchmarks.

Our goals in developing these new benchmarks were very high: We set out to create a new suite of benchmarks that would give you the most comprehensive, accurate, and useful information on microcomputer performance that is available today; benchmarks that were appropriate for the current generation of hardware and software and that would not go out of date at any time in the foreseeable future.

It was a tall order, but based on our experience, research, and consultation with numerous industry experts, we believe we've succeeded. Once you've seen the benchmarks, we're confident that you will agree.

The new suite comprises high-level tests, which examine a machine's real-world performance, and low-level tests, which amplify and illuminate the high-level tests by providing a detailed, specialized examination of each machine's constituent subsystems.

The new benchmarks provide an impressive level of detail—not but merely numbers for numbers' sake. For example, when a machine turns in an unusually good or bad performance, our benchmarks show you exactly where the machine excels or falls short and which kinds of applications are affected. Just as important, they can reveal hidden strengths or weaknesses in machines that turn in otherwise seemingly average overall performance.

The wealth of information provided by our combination of high- and low-level benchmarks means that you're not locked into some narrow, preconceived or subjective interpretation of the results. Rather, you can easily use our benchmarks to estimate how any given machine will perform for your unique mix of applications. (If you've ever wasted time trying to guess how an arbitrary and artificial benchmark like the infamous NOP—no operation—test relates to real-world throughput, you'll appreciate the realism and immediate usefulness of our new benchmarks.)

Also, there's our objectivity: BYTE, alone among the leading computer publications, is not allied with a particular family of machines. We have no ax to grind about any particular product, no reason—intentional or otherwise—to stack the benchmark deck one way or another. Our system tests are deliberately not optimized to favor any particular brand, chip family, or architecture. This means we have a way to address the thorny issue of accurately and objectively comparing the relative performance of systems with different processors and designs.

We've—in effect—constructed a "level playing field" on which any machine can be put to the test with a minimum amount of tweaking. This also means we'll be able to adapt our benchmarks to handle brand-new chips and architectures in a remarkably short time.

But you don't have to take my word for any of this, because our benchmarks aren't of the "black box" variety—you know, the kind that spits out a result but doesn't tell you how the number was generated or what it really means. The "hows and whys" of our new benchmarks are explained in detail in this month's In Depth section, and the complete source code for all our low-level benchmarks is available via BYTEnet (free, except for the cost of your phone call), on BIX, in print in our Quarterly Listings Supplement, and on disk (see page 3). We invite your close inspection.

In the Reviews section, you'll see the new system benchmarks in action, with the results presented in easy-to-use, informative tables and graphs that should satisfy any level of curiosity about the reviewed systems.

At the top of each page of benchmark results you'll find an overall number, or index. This represents the cumulative performance of the machine on our applications-level benchmarks compared to several "standard" machines, such as the venerable 8-MHz IBM PC AT and the newer Compaqs and PS/2s. (Our new Macintosh benchmarks follow the same pattern; there are no new Macs to review at this time, so the new Mac system benchmarks do not appear in this issue's reviews. However, the Mac benchmarks are discussed in the In Depth section.)

Our high-level benchmarks measure the performance of each machine while running a wide variety of real-world commercial software packages, such as word processors, compilers, databases, CAD packages, desktop publishing packages, spreadsheets, and so on. These tests are designed to realistically exercise each machine's major subsystems—disk I/O, video, CPU, floating-point unit, and memory—in a variety of ways.

The overall index can serve to give you a "quick fix" on a particular machine, but, you should be aware that—like all generalizations—this overall number does not in itself provide high precision. That's why the index is visually joined to a graph that breaks down the overall performance into application-by-application results. Here, you can begin to see strengths and weaknesses emerge, and you can begin to use that information to see how a given machine meets (or fails to meet) your own specialized needs.

The numbers to the left of the graph provide the detailed results of the application tests, for even greater refinement and accuracy.

The lower portion of the page contains the low-level test results. On the right, a graph clearly illustrates relative performance on a subsystem-by-subsystem basis; on the left are the detailed, test-by-test results.

You can use the low-level results to examine, in as much detail as you wish, why a machine performed as it did in the high-level tests. They also let you compare machines at the most fundamental level, and to tailor our benchmark results to unusual applications not included in our high-level tests: Just examine the subsystem(s) your application will exercise most, and you can get a good idea of how the reviewed system will handle the task.

The Future

These new system benchmarks are the foundation for an entire new set of benchmarks. Over the next few months, you'll see additional refinements and improvements, including a new suite of software benchmarks.

BYTE was the first magazine to use objective benchmarks in evaluating personal computers. We're proud to continue that tradition with these—the first "second-generation" microcomputer benchmarks in the industry.

As always, we welcome your comments and suggestions.

—Fred Langa
Editor in Chief
And then... Maxell created the RD Series.

Never before has this level of Reliability and Durability been available in floppy disks. Introducing the new RD Series from Maxell. Twice the durability of the disks you're now using. Twice the resistance to dust and dirt. And the RD Series is ten times more reliable than conventional floppy disks. The Gold Standard has always meant maximum safety for your data. Now it means even more.
Have you read the latest from PC Magazine about ALR’s FlexCache 386?

“Even Compaq’s DeskPro 386/20 eats the dust made by the ALR FlexCache 20386 as it screams down the DOS highway...”

PC Magazine, March 15, 1988

A Philosophy of Value

At Advanced Logic Research (ALR) the philosophy of getting more for your money has become a tradition. A tradition recognized by a long line of excellent reviews from all the major trade journals. FlexCache 386 Series is based on the ALR 386/220, PC Magazine’s choice as “The Best of 1987”. Now the fastest PCs available, the FlexCache Series approach minicomputer performance and offer you the most for your money.

FlexCache dual bus architecture separates the standard 8MHz peripheral bus from the high-speed memory bus. This permits access at the 16MHz or 20MHz CPU clock rate. By keeping frequently used data close at hand, the cache memory controller eliminates wait states 95% of the time. Since 90% of all data transfers relate to the data bus, long delays in computations disappear.

Faster Than IBM or Compaq

This innovative design allows for up to 60% faster CPU/memory data through-put than the IBM PS/2 model 80-071 with the much touted microchannel. And the FlexCache 20MHz CPU “...consistently lays down a coating of dust on Compaq’s IBM-basher.” -Compaq DeskPro 386/20.

Balanced System/ Fast Disk

Full track data transferring (1:1 interleave) plus ESDI look-ahead buffering, allow FlexCache 386 systems to turn what used to be a data bottleneck into a super high-speed corridor. Compaq wants you to pay $7490 for their DeskPro 386/20 model 60 with a 60MB hard disk. But for the same price you can get ALR’s FlexCache 20386 model 150 with a 150MB hard disk and 200% faster transfer rate.

Room to Grow

The minicomputer-style chassis of the FlexCache 20386 offers space for five internal devices, allowing more data storage than any other PC available.

For the name of the ALR dealer nearest you call:

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Tom Dirolf - President - Technology Partners, Ann Arbor, MI

Can you be a "Yes Man"?
"We've had to learn to say yes, a lot. Yes to speed, power and affordability. Yes to Novell expandibility and a complete variety of networking solutions."
Sam Woo - President - Micro Age Computer Store, Dallas, TX

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If you think you can live with this kind of success, you may have what it takes to be an authorized Advanced Logic Research Reseller. If you know you can handle satisfying customers with the most advanced computing systems available, or your looking for an ALR dealer who already is, call ALR today at 1-800-366-2574 and we'll send you dealer information and a product package. Maybe you do have what it takes.
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Microbytes

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

Device Could Break the Chains Between Portables and Batteries

A new device that converts RF energy into DC is capable of powering small electronic devices, such as laptop computers, and could free portables from "battery bondage." "Using this device, you'll never need batteries for your laptop again," Sonic Electric Energy Corp. president Ray Weilage told Microbytes. He said the company has been showing a "prototype RF-powered computer" at its headquarters in Atlanta.

According to Rick English, technical analyst for Prudential-Bache, "Sonic's patent for the RF conversion device has been approved. They have a lock on the technology."

Weilage said Sonic has successfully shown the device is capable of powering small color TV sets and other little units, such as portable radios. "However, the expansion of the technology into computers and television sets opens a new field for making these units portable and power-source self-sufficient," he said.

"We have a cell that converts radio frequency to direct current under 66 MHz. That's on the other end of the spectrum from NASA's experiments with microwaves to power an airplane type of thing. We're on the other end of the spectrum working with the longer wavelengths," Weilage said.

The actual device "is very similar to the photoelectric cells that convert light to energy. It's the same thing, except that we're converting radio frequency to energy," Weilage said.

To power a laptop computer would take a box about the size of a pack of cigarettes. Weilage said the unit would add virtually no weight to a laptop and would cost a manufacturer "about $20."

The Sonic device draws the RF frequency from an antenna based on the Tesla coil theory. The efficiency of the device, Weilage claimed, stems from having reduced the Tesla coil to a microchip. "Bell Labs was the first to implement the Tesla coil technology on a microchip," said English, "but they were using it for a 'what if we could do this' type of experiment."

"DRAM Scam": Atari Chief Slams Shortage

America's computer industry is starved for computer chips, Japanese semiconductor firms are raking in the profits, and Atari CEO Jack Tramiel thinks it's all a scam—"the DRAM Scam," he calls it.

Tramiel used a press conference at the CeBIT '88 computer exhibition in West Germany to assail the "shortsighted and underhanded" trade policy of the U.S. and to denounce the "so-called DRAM shortage." He claimed there is plenty of chip manufacturing capacity in the world; however, because of trade agreements between Japan and the U.S., the supply can't match the demand.

"This is a case of calculated shortage," said Tramiel; the trade policy has foisted a classic manifestation of the Law of Unintended Consequences on the computer industry. A trade sanction against Japanese chip makers, intended to stop the "dumping" of low-cost chips on the American market while allowing the survival of the U.S. chip industry, has backfired, he said. As a result, there's a shortage of dynamic RAM chips and a dramatic increase in their price, which in turn has meant higher prices for computers.

Nine months ago, DRAMs sold for $1.50. "Today on the spot market, those same chips cost $6," Tramiel said. "That's not profit. That's robbery." The current world demand for DRAMs runs around 100 million per month, according to Tramiel; the total U.S. output is only 10 million. "It didn't take the Japanese long to figure out that they could get a higher price for selling fewer chips. They don't mind profiting from America's stupidity."

Tramiel wasn't totally negative. "I don't see this chip shortage lasting more

Nanobytes

- The hottest thing our traveling news hand saw at the massive Hannover Fair in West Germany—or at least it was treated as if it was the hottest thing—was a Macintosh 512K-byte clone. Representatives of a Taiwanese manufacturer had brought the illicit box to show to a select few. The fact that it used illegal copies of the Mac ROMs made the rep a little secretive. "We are not certain that Apple can maintain its grip on the technology," one of them said. "We feel it is a possible violation of U.S. antitrust laws." Asked what such a clone might sell for, the spokesperson said, "We would like to see the computer sell for around $795."

- Although some expect the shortage of memory chips to tighten up soon, computer makers are wrangling to get memory wherever they can. We've heard that certain Japanese semiconductor companies have been quietly distributing 4-megabit dynamic RAM chips to select customers. The DRAM shipments are invoiced "test samples" or "research samples," which could indicate that the chips are being offered in advance of actual production quantities. Japanese firms are increasing their outputs of dynamic ROMs; analysts say the few U.S. companies that supply DRAMs had better do the same.

- MIPS Computer Systems (Sunnyvale, CA) claims "sustained performance" of VAX MIPS with its new RISC processor, the R3000, which is about three times the claimed processing power of Sun's SPARC chip. The 25-MHz chip will be supplied by Integrated Device Technology, LSI Logic, and Performance Semiconductor. Perhaps as important as MIPS's new chip is its agreement with AT&T to de-
Motorola has established its 68000 as one of the powerhouse processors in the microcomputer market. Now the company's Microprocessor Products Group (Austin, TX) is aiming for similar success with the 88000, its 32-bit reduced-instruction-set computer (RISC) processor. The 88000 is based on a Harvard-style computer architecture, with separate address and data lines for a program's code and data. These dual "paths" allow code and data operations to operate in parallel, which improves throughput.

The 88000 is composed of three chips: the MC88000 central processor and two MC88200 cache/memory management units (CMMUs) that supervise the code and the data paths. The MC88000 has a register file of thirty-two 32-bit registers, built-in integer and floating-point math units, an extensible instruction set, and an extensible architecture. The extensible architecture is made up of eight special function units (one is the floating-point math unit) with 256 reserved op codes that allow a vendor to expand the MC88000's capabilities. Such expansions might include transcendental function support or a serial driver. The MC88200 CMMU has a built-in 16K-byte memory cache and performs bus snooping to maintain cache coherence.

A scoreboard function in the MC88000 maintains validity of the register file contents. For example, if a multiply operation uses two register values, and the contents of one of the registers is invalid (perhaps the fetch instruction loading the target register is still in progress), the scoreboard will stop the multiply operation until the fetch operation is completed. Scoreboarding lets software designers write RISC software without becoming mired in the details of moving data through the processor. It also allows certain code optimizations to be performed. Programs written for the 88000 are typically 10 percent larger or smaller than equivalent programs written in MC68020 code, according to Motorola officials.

From the beginning, both the MC88000 and the MC88200 were designed to support tightly coupled multiprocessing. You can use up to four MC88000s in parallel to boost processing power, or, if your application demands it, you can combine up to four MC88200s on a path to expand the path's memory cache to 64K bytes (128K bytes total). A single 20-MHz 88000 processor runs at about 15 to 17 million instructions per second and 34,000 Dhrystones. Motorola offers boards with combinations of one, two, and four 88000 processors.

In what's shaping up as a trend, companies are bringing out support tools with their new chips rather than just saying, "Here's the silicon, baby; you're on your own." For the 88000, there's an optimizing C compiler from Greencontinued
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C++ is now available for workstations from Apollo Computer (Chelmsford, MA). Apollo's version of the object-oriented programming language, called Domain/C++, is based on AT&T's C++ translator. The company intends to integrate the language with its Distributed Debugging Environment later this year.

Since many IBM-compatible computers have high-resolution EGA or VGA monitors, the company known for bringing graphics to monochrome PCs, Hercules Computer Technology (Berkeley, CA), has had to turn to other areas of the graphics market. Hercules is working on several products for enhancing the performance of VGA-based machines such as the IBM PS/2. The firm is also developing similar products for the Macintosh II.

The VGA package will coexist with an existing VGA board, connected via the VGA card's feature connector. It will allow you to use Hercules' RamPonte on a VGA system and will also "improve the performance of current bit-mapped graphics applications," according to Hercules CEO Jim Harris. Hercules hopes to show the VGA board at Fall COMDEX, with a Macintosh version following close behind.

Saba Technologies (Beaverton, OR) has retooled its Page Reader scanner to handle draft type from dot-matrix printers and to be a little faster at reading pages (about one per minute, the company says). The $1299 Page Reader 2.0 also now supports the Tag Image File Format, which means the graphics can be used in PageMaker and other programs that accept TIFF files.

The Computer Security Institute will demonstrate viruses and virus detectors at its conference for users of IBM and DEC systems. The program will emphasize network security, with sessions covering Ethernet and Mac-VAX networks. The event happens this month (June 13-15) in Arlington, VA. For more information, phone Irene at (617) 393-2600.

The market for used microcomputers has reached $1.2 billion, with FORTRAN, Pascal, Lisp, and Prolog languages available in mid-1988, and COBOL and Ada languages available in the second half of 1988. Tektronix has its DAS 9200 logic analyzer with a MC88000 probe for hardware prototyping and testing. Phoenix Technologies and Insignia Solutions announced programs to allow MS-DOS applications to run on the 88000.

Anticipated uses for the 88000 include large-scale parallel processing projects, big banking systems, AI workstations that use three-dimensional graphics, CAD systems manipulating three-dimensional objects, and jobs (such as in aerospace) that demand fault-tolerant computing. Tektronix has said it will incorporate the 88000 in color graphics workstations.

U.S. Firms Show Workstations Overseas

Although Atari and Commodore are known in the U.S. primarily for their low-cost home computers, both companies continue to work at high-performance machines. At the recent Hannover Fair in West Germany, they talked about their Transputer-based systems and Unix boxes that are in the works.

Atari demonstrated prototypes of its system based on the INMOS Transputer, the Abaq, at COMDEX in November. The company will ship "about 100 Transputers to developers in the next month," president Sam Tramiel told us at Hannover.

Commodore also announced its own Transputer-driven system. The company claims a processing rate about 10 times faster than an IBM PC AT. Each chip has four high-speed serial connections in addition to a normal bus. Four additional Transputers can be connected to the main processor.

Commodore is developing its system with a large-scale research institution, Gesellschaft fur Biotechnologische Forschung (the Society for Biotechnology Research). Commodore plans to develop a high-performance workstation around the Transputer for use primarily in laboratories and industries. This project is based on the Amiga 2000, which, when equipped with the Transputer system, offers a greatly enhanced graphics capability for such applications as modeling molecular structures.

Atari showed us a prototype of a Unix workstation. The system, when available, would be shipped with Unix System V version 3.1, according to Shiraz Shivji, Atari's head of research and development. However, the working unit that we saw demonstrated was a wire-wrapped prototype. Shivji said the actual boards are now being manufactured and that Atari will begin shipping systems to developers in "two or three months."

The workstation will have at least 4 megabytes of RAM, use a VME bus, and support Sun's Network File Structure. The system is based on the 68030 chip. It will use the International Standards Organization model for networking, have a SCSI port, and use X-Windows, Shivji said.

Commodore is also developing a Unix workstation. The Commodore model is based on the 68020 chip and will first appear as an add-on board for the Amiga 2000.

Mac the Mouth Shows How We Speak

You speak into a microphone. On the screen of a Mac II, you see a cross-sectional animated diagram of a person's head. As you speak, you see the lips, the teeth, and the tongue move in sync with your voice. You think to yourself, "Gee, I didn't know my tongue moved so much."

What makes this animation possible is a program under development by a small San Diego firm called Emerson & Stern. The primary purpose of the program, informally called Mac the Mouth, is to help people who have speech difficulties.

According to Jan Zimmerman, the CEO of the company, the program will help speech pathologists to correct speech problems that may be caused by hearing impairments, stroke, or head injury. It may also help people who want to lose their accent or develop a different one.

Mac the Mouth works by digitizing the sounds that a person makes when he or she says a word and breaking them down into a series of frequencies, similar to a standard spectrogram. The program then translates these sounds into an animated diagram of a person's mouth. The effect is almost that of being able to look into someone's mouth and watch his or her tongue move.

The program will allow people with speech impairments to have visual feed-

continued
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PC Resource Magazine has listed DesignCAD 3-D as one of the six new computer products worth watching in 1988.
lion, according to the National Association of Computer Dealers (Houston). Despite specialty stores and “computer brokers,” most used computers are sold in traditional ways: friend to friend or via classified ads, an NACD spokesperson said.

* Okay, he's rich and famous. But is he happy? “I'm frustrated,” said Apple vice president Jean-Louis Gassée. “I see the power of computing, but we're not doing it,” he told an audience at the University of California at Berkeley. “We're not building networks or systems that can be used by normal people.” Gassée warned that the “techno-clergy” must not become isolated from the rest of society. “The idea of 10,000 remote databases means absolutely nothing to most people,” he said.

According to Zimmerman, the software has already helped one of the company's programmers. The programmer, who emigrated from Thailand, had trouble pronouncing the “l” sound in words such as “really.” By using the program, she was able to see where her tongue should be correctly placed and was able to produce the correct sound.

Laser Printers Getting Higher Resolutions

You might not notice it, but higher-resolution laser printing is on the way. Several companies, including Fujitsu, Agfa-Gevaert, and Itek, demonstrated at the recent Hannover Fair in West Germany a new breed of laser printer based on a Canon engine and capable of producing output with a resolution of 400 dots per inch. And at least three companies introduced printers with resolutions of 500 dpi or better. These higher-resolution models represent a coming trend for the desktop publishing market as the gap between typesetting and desktop publishing narrows, according to analyst Tim Bajarin, vice president at the market research firm Creative Strategies.

Although the higher-resolution laser printers (500 dpi and beyond) sound impressive, their effectiveness is lost on the lower-grade paper used in most offices. At 400 dpi, the ink sufficiently

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“bleeds” to fill in the “step effect” that is typical of desktop publishing fonts. Anything above 400 dpi is wasted because of this bleeding, many desktop publishing experts say. And most eyes can’t differentiate between 400-dpi and 600-dpi output.

However, several software houses, including Aldus (of PageMaker fame), say they’d upgrade their page-layout programs to support 400-dpi printers. Toshiba and Kentek showed new printers using Phoenix’s PostScript clone. Kodak had a four-color laser printer producing 17 pages a minute.

Nashville Cats Plugging into MIDI

Would “Your Cheatin’ Heart” sound any different if Hank Williams recorded it today? Nashville, known as America’s country music capital, is home to hundreds of musicians who’ve plugged into computers as a tool for composing and recording.

“This is a pretty computer-based city,” said Tom Gerber, a MIDI studio technician and editor of a Nashville MIDI newsletter. “People are surprised when they come here and see what is going on. A lot of people are using Macintoshes for various parts of music publishing.” Despite Apple’s relatively late arrival on the electronic music scene with its MIDI adapter for the Mac and IIGS, the Macintosh is one of the favorite electronic axes of Nashville musicians.

Gerber noted that already five major recording studios are using Macintoshes in one way or another. “Some of them even started as MIDI studios,” Gerber said. “West Park Studios uses three Macs for sequencing, mixing control, and sound editing. DBS Studios uses a number of Macs, and Masterfonics, one of the top CD recording and mastering studios, uses them with MIDI.”

“Right now, most of the work is done on Mac Pluses and SEs,” Gerber explained. “There are software compatibility problems with the Macintosh II due to copy-protection schemes right now, but that is supposed to change in the next few weeks, and we’ll see more Mac IIs involved in MIDI here in Nashville.”

“Nashville is more than just country music,” Gerber noted. “I’ve done some ‘space’ music with the Mac for some performances. And many publishing houses use the Macs and MIDI for their lead sheets.”

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**LETTERS**

**Shuddering, Blurring Solved**

In his review of multiscan color monitors (February), George A. Stewart found two problems with our Flexscan 8060S when it was connected to the Macintosh II. We have fixed both problems.

The shuddering that occurred during disk access was caused by a special cable for the Mac II, whose proper pin assignment was not available when Mr. Stewart did his evaluation. We now sell the proper cable for the Mac II.

The blurring was not caused by the side of the monitor but generated because of a 0.1-volt difference in signal levels. The Macintosh II's signal level is 0.6 V; the VGA signal level is 0.7 V. As we refined the hardware level for matching both signals, the blurring problem improved.

Ted Fukada
Applications Engineer
Nanao USA Corp.
Torrance, CA

**Digivision on Monitors**

Having read "Multiscan Color Monitors," I think you may be interested in Digivision's range of multifrequency monitors. Compared to corporate giants Sony and NEC, Digivision is a relatively small company, though it's technically advanced in many areas of display unit development. In July 1987, Digivision successfully launched the world's first 12-inch autosync monitor, which was closely followed by a 10-inch unit in November 1987. At present, we are about to seek UL listing for these products with an eye toward entering the U.S. market.

The article was extremely interesting and technically informative—the best I or any of my colleagues have read on the subject so far. Previous articles have contained minimal technical information and descriptions, so your article was a refreshing change.

Leonora Walker
Marketing Executive
Digivision Ltd.
Leicester, U.K.

**Monitor Misconvergence**

I'd like to point out, however, a possible problem with some of the measurements. Doing the misconvergence and voltage regulation at a specific brightness level for each monitor is accurate only if each CRT has the same light transmission. The faceplate of the CRT can be made to give off different percentages of the display's light output by using lighter or darker glass. The darker the glass, the less light output there will be from the tube for the same amount of CRT drive.

However, the darker glass gives a better contrast ratio, so less light output is necessary. For example, if you had a CRT with a 90 percent transmission and a brightness of 50 footlamberts (ft-L), a darker CRT of 45 percent transmission would require only 25 ft-L for the same contrast ratio. Therefore, it is possible that your tests were unfair if a monitor had dark glass.

Misconvergence is a very important aspect of a monitor to consider. However, judging a series of monitors from looking at only one could be misleading. The CRT specs for misconvergence are typically 0 to 0.6 millimeter. Therefore, it is possible to see one monitor that is near perfect and another that is only good.

For your information, "voltage regulation" is referred to as "high-voltage regulation." The anode voltage of a color CRT is typically 24 kilovolts. If there is no regulation of this voltage, it will decrease as the screen gets brighter, which causes the display size to increase.

Jim Samuels
Chief Engineer
Princeton Graphic Systems
Princeton, NJ

**Smart EGA Plus Resolution**

In the Product Focus on enhanced EGA and VGA boards (March) by Curtis Franklin Jr., several errors appeared in the chart on page 104. NSI Logic's Smart EGA Plus board has a maximum resolution of 800 by 800 by 16 colors, and it supports VGA modes 11H and 12H, as the article states on page 106. The price of the board is $199.

Also, in 640 by 640 mode, I have not seen a flicker problem on NSI or other boards that are operating normally, so I have to assume that you were operating in 800 by 600 mode. You will see some flicker on all current high-resolution 800 by 600 boards running on the NEC MultiSync. This can usually be adjusted so it is not troublesome to the user. The degree of flicker is a function of the manufacturer of the monitor, the speed of the EGA chip/board, and, in some cases, the applications software.

Robert Gallagher
Director of Sales
NSI Logic Inc.
Marlborough, MA

**How About "Ubiquitous Electronic Device"?**

"It's All in the Symbols" by Merrill Cornish (March) punctures the lid of what may eventually be the computer industry's biggest can of worms. The household name of these ubiquitous electronic devices signifies a major stumbling block—as if we were to call automobiles "corner turners," ignoring their many other capabilities.

Mr. Cornish admirably points out the difficulties in parsing English language text (other languages have other difficulties), while also mentioning those associated with programming languages. But most people have a problem envisioning all those nonnumeric symbols he talks about—for starters, the 52 characters of the Roman alphabet that the standard keyboard can produce in dozens of fonts and in a variety of enhancements, such as underline, reverse, bold, italics, and so on, not to mention the combinations. This brings us to tens of thousands of possibilities before we start combining these letters into words and then into sentences and then adding symbols and punctuation.

Surely C. L. Sholes (of QWERTY fame) would say something like "#$%+" if he could see how his

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Circle 229 on Reader Service Card

JUNE 1988 • BYTE 23
keyboard has been contorted, augmented, and Mickey-Moused around just to accommodate a tiny number of the possibilities that are available on present-day computers.

Many languages use a variety of alphabets, and some, using pictographs, ideographs, and hieroglyphs, don’t even use alphabets at all. And then there are symbols—verbal, graphic, or iconic—that are used to represent concepts in music, science, religion, finance, road signs, and programming conventions, to name a few. For example, a red circle with a diagonal line drawn in it can represent three words, but a cross may represent several pages of words.

Relational databases, hypertext, expert systems, and so on represent the first step of a thousand-mile journey. It is a paradox that computer cognoscenti who can’t abide last year’s 16-bit processors wrestle daily with a keyboard that was designed for mechanical typewriters about 115 years ago. Mr. Cornish’s article has given us a hint of the revolutionary changes that will be necessary in software and in hardware before we can begin to realize the potential of these devices after we change the name of the machine.

Larry Salmon
Comptche, CA
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Circle 103 on Reader Service Card (DEALERS: 104)
explain why trees have leaves; however, I doubt if it will ever explain trees or leaves. Until computers function on a glacial level, they will never be able to successfully abstract humanity because we are not made of silicon chips. It is true that Godel proved (by the application of the Liar's Paradox) that there are no formal systems that cannot be made inconsistent and that there are no systems made consistent that cannot be made consistent. So much for symbols. There are no symbols that cannot be made meaningless and no symbols that are meaningless that cannot be made meaningful. Perhaps this man is just tired of silicon and electricity and is proposing a newer, more progressive, coherent light megabit processor. That may be in the future, but by that time I doubt if the computers will take anything that we say or do very seriously.

Joe Barnette
San Francisco, CA

Making Columns Wrap
Dick Fountain's column-wrap program (Focus on Algorithms, "Multicolumn Paged Text," March) is a fine base on which to erect improvements once you get it running. Unfortunately, in its present form it won't run at all. The problem is function spaces, which reads

Spaces := Copy(B1anks, 1, Num)

where Num is the number of spaces you want. This won't work, because in the Turbo Pascal Copy function the third parameter (Num) says how many characters to copy from the input string. Here the input string, Blanks, is merely 1 character long, so there's no way to copy, say, 38 characters out of it.

The simplest fix is to make the Constant Blanks contain 40 spaces between its two quotes, which is probably what Dick had in mind before a typesetter got at his listing.

There's also a typo in procedure WriteOutPage: The first appearance of the word Spaces should be followed by an end bracket.

Hugh Kenner
Baltimore, MD

Objects in Continuous Systems
In object-oriented programming, the programmer thinks in terms of objects, which often have a correspondence in the real world (e.g., a dictionary). These objects can respond to messages (e.g., continued
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search for a word). The dictionary example seems natural, in that it is inert (shut) until we want it to do something.

But what about continuous systems? Consider the idea of a billiard ball moving toward a cushion (or "rail," as I believe you call it in the U.S.). Clearly, "ball" should be an object—it responds to "hit" messages and knows how to move. But the cushion is not passive—it has elasticity and responds when contact is made. Is the cushion, too, an object? For the sake of argument, assume it is an object. How does it know when contact is made? Is it constantly on the lookout for approaching balls? This doesn't seem to fit the real world.

Another possibility is the addition of a third party—an overseer who spots where and when collisions occur and reports them to the cushion.

I am well aware that billiards video games exist and also of the existence of planetary simulation systems in which the laws of physics can be changed. Is Smalltalk natural for the implementation of such systems, in that the design of the software bears a close relationship to what exists in the real world?

Smalltalk experts, what do you think?

Mike Parr
Sheffield, U.K.

Take Two Computers and
Call Me in the Morning

You might well ask why am I writing to a computer magazine about a medically caused problem. I think I had better start at the beginning.

My wife, my son, and I were going to Reno, Nevada, in early June of 1985. I was to attend a week of schooling put on by the National Council of Juvenile Justice. It was funded by the federal government under a grant. I had decided to take my spouse and 15-year-old son with me and make the trip a working vacation. We drove our car during the day and stopped to eat, swim, and sleep in preselected camping areas at night.

We'd been traveling for several days and were almost to Reno when my wife said to me, "Dick, you're not driving very well, and your speech sounds funny. I think we should go to the hospital and see if they find something wrong with you."

We checked into the motel in Reno. I couldn't write very legibly, and I found it very difficult to keep my signature on the line provided for this. Yet I never felt any pain. Through this time I did not suffer from any physical discomfort.

The doctors at a hospital in Reno, after giving me a thorough physical examination and a CAT scan, all agreed that I had had a massive stroke of the right part of the brain stem. I had not only lost much of my sense of balance, but I had great difficulty in speaking, and I had double vision.

I was kept in the hospital in Reno for several days while I was given a battery of tests. When my blood pressure was no longer considered dangerous, my wife and I took an airplane to my home in South Dakota, while my son and brother drove our car back.

When I got home, my wife took me to the local hospital, where the doctor suggested that I go to the physical, occupational, and speech therapy unit. In therapy I was immediately placed on a computer, first the Visi-Pitch that was seen ed editor with variables. I learned to watch the track my speech therapist's voice made across the screen.

I then tried to copy her pattern with my voice. She also encouraged me to turn the page.

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When I got home, my wife took me to the local hospital, where the doctor suggested that I go to the physical, occupational, and speech therapy unit. In therapy I was immediately placed on a computer, first the Visi-Pitch that was part of an Apple computer, where I learned to watch the track my speech therapist's voice made across the screen.

I then tried to copy her pattern with my voice. She also encouraged me to turn the computer and Visi-Pitch on. I think this exercise helped my coordination, both physical and mental.

Next I was given the task of playing games on the computer. These games helped me reestablish hand-eye coordina-
Since its introduction just over four years ago, MicroSim's PSpice has sold more copies than all other commercial Spice programs combined. In addition to running on the IBM PC family, including the new PS/2, the Compaq 386, the Sun 3 workstation and the VAX/VMS family, PSpice is now available on Apple's Macintosh II.

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- Ideal switches for use with, for example, power supply and switched capacitor circuit designs.

In addition, all these PSpice options are available on the Macintosh:

- Monte Carlo analysis to calculate the effect of parameter tolerances on circuit performance.
- The Probe "software oscilloscope", allowing interactive viewing of simulation results.
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tion; they also made me think, and my ability to problem-solve improved daily. When I finally did return to work, one of my staff members had his own personal Apple IIc at work, and he encouraged me to make use of it at any time. I did this a great deal, using a word processor until I got my own Tandy 1000.

I do like mechanical things, and the computer is an electrical/mechanical device. Also, my son was heavily oriented to the use of computers, and to keep up with the rest of the world and my own child, I wanted to know more about them. Both my son and I now have computers at home. I can use both of my hands, and I attribute this digital dexterity to the use I gave to my hands while using the keyboard of my computer. I probably would never have written this letter if I had to rely on a typewriter, or a pen and paper.

The desire to become proficient in using a computer was the motivating agent I needed—physical as well as emotional. My doctor agrees with me. He gave me a prescription for a computer. My tax accountant said I could deduct most of the cost as a medical expense.

I will admit that I can type only about 12 words a minute, versus the 60 words a minute I could type before I had my stroke. I can no longer touch-type but have to watch my fingers all the time to make sure they go where I want them to. But at least they all still work.

So now you can see why I am writing this letter to a computer magazine. I simply want to say thanks, and I don’t know who to say thanks to.

Richard F. Stanford
Pierre, SD

Heatsinking 80387s

I would like to commend you on your In Depth section about floating-point processing (March). I particularly liked Mauro Bonomi’s article, “Avoiding Co-processor Bottlenecks.” I liked the whole concept of the graphic beach ball.

The Weitek/80387 combination is fantastic, but, based on table 1 in the article, the over one million Whetstone-per-second difference does not warrant the additional cost of $1000 to $1500. I have friends who heatsink their 16-MHz 80387s and run them between 23 and 25 MHz with good success, which brings their efficiency even closer to the Weitek/80387 combination.

Please let me know whether your Float, Calcpi, Savage, Dhrystone, and Whetsone programs are available for us BYTE readers to run in our own hardware through your bulletin board.

Doody R. Ungson
San Jose, CA

BYTEnet carries listings for all programs mentioned in BYTE articles. The phone number is (617) 861-9764.—Eds.

Up the Down Mouse

If anyone, for whatever reason, would like to learn opposite movements (i.e., moving your hand up creates an action down and vice versa, and moving your hand left creates an action right and vice versa), the solution is simple. Take your mouse, turn it 180 degrees and go to work. After a little practice, you may become quite good at it.

Bob Hester
Toulouse, France

Fixes

In the review of enhanced EGA and VGA graphics boards (March), we stated that Sigma Designs’ SigmaVGA board does not work with the IBM 8513 analog color monitor. Sigma Designs says that its board does work with the monitor when equipped with the correct cable.
The Ice Age Cometh

By way of background for the following letter: My talk to a meeting of authors of books in the Yourdon Prentice-Hall series was titled “We’re Eating Your Eggs.” It was built around the theme that much of the MIS community reminds me of dinosaurs having a debate over whether to evolve bigger teeth or longer tails, while the mammals are chowing down on their eggs. . . . —Jerry

Dear Jerry,

Just a note to you mammals to let you know how things are going here at Dinosaur Central . . . .

I just got a call from a fellow who wanted a price on converting 13,000 programs—about 7.8 million lines of code—from one system to another (incompatible) system. I gave him a price—I’m in business to do this sort of thing—but I thought this is really stupid.

I’m being asked to clone a dinosaur. The agency that wants the new dinosaur is willing to consider spending millions of dollars so that it will have a newer version of exactly what it has now. Incredible!

There’s a lot of this dinosaur cloning going on these days. Companies are moving their systems from IBM to DEC, or you can pick any other combination you want. If you think there are problems with compatibility between systems in the micro world, you ought to see how the dinosaurs have screwed it up. Even moving from one IBM system to a larger one requires the sort of planning previously reserved for D day.

All this cloning takes up a lot of time and energy. Once the dinosaur keepers have spent the time they need to keep their beasts in order, there really isn’t much time left for actual users who want the system to do something new or something old a little better.

Enter the mammals. The sales manager in the West Fencepost office can’t afford to wait for the dinosaur keepers to do their thing, so he goes out and gets himself a PC and gets someone to show him how to use Reflex or dBASE. He doesn’t care so much about what the dinosaurs are doing, except when they louse up an order for one of his customers.

Eventually, however, this guy is going to move upward in the company. He, or someone like him, is going to become president, and he’s going to remember how the dinosaurs hurt his efforts and how the mammals helped him. That’s when the Ice Age will start. Any vestiges of the dinosaurs that remain will have to earn their keep, either by keeping gigabytes of data accessible or by providing very fast computation in special situations. The mammals are going to call the tune.

—Jerry

Amiga vs. Atari

Dear Jerry,

I’m afraid your biases toward the Atari ST showed again in the November 1987 Computing at Chaos Manor.

Like all software-only emulations, pc-ditto is unacceptably slow. Unfortunately, the ST cannot make use of the Motorola 68020 microprocessor (as you implied), because the TOS operating system will not support it, as does the Amiga’s. Nor will it support more than 4 megabytes of memory, as does the Amiga.

The Amiga 500 offers far greater performance for a modest price increase. The Amiga 2000 makes true high-performance PC compatibility possible and can use a 15-MHz 68020 add-in card that offers most of the performance of a Macintosh II at about one-third the price.

The same individual who was responsible for one of your favorite computers, 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.
the Commodore 64, also guided the development of the Atari ST: Mr. Jack Tramiel. Accordingly, the ST was designed and built with but one thing in mind—cheapness. This would be apparent to anyone who has lifted the cover off an ST and examined its innards (I have).

Generally, Amiga software is of higher quality than comparably priced ST software. I will admit that there is slightly more ST software available, but is quantity more important than quality? I think not. More Amiga software will appear as programmers become accustomed to the computer's more sophisticated operating system.

Jeff Joseph
Minot AFB, ND

Well, sir, you have one view. I have both machines, and I have another view. True: pc-ditto is quite slow, about 80 percent as fast as a PC, while the Amiga 2000 is exactly the speed of a PC; as for the 68020 card for the Amiga side, I haven't seen one yet.

Actually, like most people who've been around as long as I have, I followed the Tramiel odyssey from its inception; and I've done quite a bit of poking around inside the Atari ST, including installing extra memory on a 540. I assure you I've had more Guru Meditations (Amiga's system error messages) than cherry bombs (Atari's).

I hope you're right about the upcoming software for the Amiga.—Jerry

Medical Spelling Checker?

Dear Jerry,

My mother is a physician who has trouble spelling. We have an IBM PC, which she uses for word processing, and a couple of spelling checkers (Word Proof and the one in PC-Write). However, we have been unable to find a medical word list for any IBM PC spelling checker. Do you know of a spelling checker that comes with a medical dictionary, or a medical dictionary that we could add to one of our current spelling checkers? (Since PC-Write can add words to its list, all we really need is a file of medical words on an IBM PC disk with enough information to decode the file format.)

We tried to contact Oasis Systems, the maker of Word Plus, which you've mentioned favorably. Our letter was returned. Has the company moved?

I enjoy reading your column in BYTE, but could you cover the Amiga more?

Michael Hanson
Seattle, WA

I don't know of a medical dictionary. It is relatively easy to make one if you have the kind of spelling checker that adds update words easily. The simplest way would be to get one of the medical CD-ROM units, put the text on-screen, aim the spelling checker at it, and add the medical words to the dictionary. A couple of hours of that should build one heck of a dictionary.

A second method would be to write as you normally do, look up every word the first time it comes up on-screen, be sure it's right, and add it to the dictionary. It won't take long before you've built a pretty powerful dictionary.

Oasis Systems is located at 6160 Lusk Blvd., Suite C-206, San Diego, CA 92121, (619) 453-5711.

Incidentally, the folks at Microlytics are always looking for new dictionaries to incorporate into their packages. They've got the one I built out of these columns in their latest one; it even knows how to spell Poumelle.—Jerry

The Trouble with Turbo

Dear Jerry,

I noted with interest your discussion of C compilers in your October 1987 Com-
continued on page 322
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Printer Woes

Dear Steve,

My NEC CP6 printer is capable of producing 360- by 360-dot-per-inch graphics, but the results that I have seen are far from this. (I have been using the Epson JX-80 printer definition for the best results, which are still poor.) It seems that the printer produces plenty of dots of resolution on the x-axis but far too few on the y-axis. This creates images that appear to have bands in them. I notice this fault with every bit-mapped reproduction I make.

Why is this happening? I would think that a simple dot-replica scheme built into the printer definition would create denser, darker graphics by simply replicating the solid lines.

Also, is it possible to use an analog monitor, such as an NEC Multisync, as a standard color TV if it's hooked up to a tuner?

Chris Durst
Laytonsville, MD

I think the bands in your printed output come from irregularities in the paper feed. Take a very careful look at the paper path and see if anything is binding or sticking, or if the paper is snagging on the cables in the back. Then make sure that the paper exits smoothly and doesn't bunch up or drag on the way out.

The real reason why you aren't seeing more dots on the page is that the printer driver software in the computer isn't sending them out. The printer commands provide the ability to put a dot nearly anywhere on the page; the software has to translate the screen image into the appropriate dot patterns.

You'd think that the printer could "fill in the dots" and produce a good-looking image, but it's not quite that simple. The problem boils down to the ratio between the dot's horizontal and vertical sizes, called the aspect ratio (there's also a screen aspect ratio, which is a different matter). Because each display mode has a different dot aspect ratio, there's no one way to translate a bit-mapped image from screen to paper. For example, the aspect ratios that show up in normal use are shown in table 1.

But the aspect ratio of a printer dot depends on the horizontal dot spacing and vertical line spacing. Only the software knows both the screen aspect ratio and the printer aspect and (presumably) reach a compromise. Given the number of different screen modes and printers, it's a wonder anything comes out at all.

As a simple example, take a 640 by 200 CGA image with a 1.12 dot aspect ratio. Try to find a way to represent that image on the paper with your NEC's 1.00 aspect ratio dots so that the image comes out about 8 inches wide and 6 inches tall. Be sure to look up the details of the print head dot patterns and restrictions on pining firing order. You'll probably have to move the paper in an irregular fashion to get the dots in the right places.

Once you've done that, repeat the exercise for the EGA display and see what changes. At some point you'll realize that you need a fraction of a dot to make the answer come out right, and that's where the problem lies.

Also, despite everyone's best efforts, paper just doesn't move reliably in tiny fractions of an inch. The resulting twists cause painfully obvious glitches in the dot patterns, and nobody's happy.

The good news, though, is the last line in table 1. VGA displays have 1-to-1 aspect dots, exactly matching laser printer dots. That means it's easy to get good-looking results on screen and paper. All you need is the right hardware.

Unfortunately, the Multisync won't work with a stock TV tuner. The problem is that the tuner produces standard National Television System Committee (NTSC) composite baseband video on a single output, while the Multisync expects to see separate RGB and synchronous inputs.—Steve

Expert Nutrition System

Dear Steve,

I am currently developing a set of rules for an expert system that will be used as an advisor in enteral and parenteral nutrition systems in intensive care unit patients. What is the best way to go about creating such an expert system? Should I learn a language such as Lisp or Prolog to write my own, or should I use some form of expert system shell? If the latter is the best, could you please let me know what is available?

J. D. Harrison
Nottingham, U.K.

Although not as extreme, the difference between programming an expert system in Lisp or Prolog and using an expert system shell is much like the difference between programming in assembly language and programming in a high-level language, such as BASIC. You'd have much finer control over your program if you used Lisp or Prolog, but you would also have the overhead of much of the "housekeeping" (e.g., the user interface, input screens, and file handling).

Since your object is to encode your expert knowledge of nutrition systems, it would be far easier to use a shell. You will have to do some additional homework to find the shell that is best for you. I recommend that you check out KnowledgePro from Knowledge Garden (473A Malden Bridge Rd., Nassau, NY, 11213). It's very easy to use and would be especially suited to a teaching-type expert system because of its built-in hypertext capabilities. Also contact ESSYS (P.O. Box 75158, Contract Station 14, Albuquerque, NM 87193), which is available to U.K., Europe, and Australia at this time.

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querque, NM 87194) for information on its EXSYS program.—Steve

Dead Drive Blues

Dear Steve,

Last weekend, a drive bearing on my 20-megabyte Hardcard started going bad. I bought the drive 17 months ago from Logic Array of Costa Mesa, California. Alas, the company is apparently no longer in business, so I can't get the drive replaced or repaired under my 2-year warranty.

Is there a company that sells 31/2-inch 20-megabyte hard disk drives without a controller? The dead drive is an NEC D3126, part number 134-200420-001.

David G. McDonald
Ames, IA

If you've got a genuine Hardcard from Plus Development, you should be able to get factory service. If, on the other hand, you've got one of the clones, you're sunk.

Although I hate to say this, I think the cheapest way out for you is to buy another card. While it's possible to pick up just the drive, you'll have to worry about connectors, cabling, mechanical hardware, and all that.

"But," I hear you say, "isn't that stuff standardized?" The answer, regrettably, is "not quite." The only way to find out whether a new drive will fit is to buy it and see. You can accumulate quite a pile of parts while you're thrashing around.

Given the price competition in hard-disk drive cards, I suspect you can replace that thing for about half of what you paid for it originally.—Steve

Help with Heath

Dear Steve,

I teach a course in which we use Heath trainers (5-MHz 8088 microprocessor, 64K bytes of RAM). These machines have an editor, an assembler, a debugging program built into ROM, and all the 8088 control signals (minimum mode) available for building circuits on breadboards. They're nice machines, but they lack disk drives and sufficient memory, so we can't use them to teach anything about the use of a disk-based operating system, a higher-level language, or disk files.

Heath also sells an upgraded version of the basic machine that you can fit with two 360K-byte floppy disk drives and 196K bytes of RAM. Except for the limited memory, this is what I'd like to use, but it costs twice as much as a good-quality IBM PC AT clone.

There ought to be an expansion board for a standard PC that would bring the microprocessor signals (through buffers and isolators) out to a breadboard. Do you know of any products of this kind? The only one I've heard about is the ezB Board from Sabadia Export Co., but a friend told me that he had severe problems trying to use it.

Maynard Fuller
Montreal, Canada

Given that you can buy an IBM PC clone for about $600 complete with monitor, drives, DOS, and keyboard, you would expect that someone would have a useful breadboard accessory for it. But I haven't seen one anywhere.

Perhaps the best thing to do is to get a cheap computer and a standard IBM PC prototyping card and have your classes roll their own. JDR Microdevices sells PC prototyping cards—check the back of a recent BYTE. The circuitry is simple enough that your students can probably handle the design on their own, and it will be a real learning experience.

One suggestion: If you're going to use ribbon cables to bring the signals out, make sure you have a ground lead between every signal wire, put the control signals in a separate cable, and keep the length down. Don't try to save wire by running 26 signals in a single cable. Although I haven't heard of the Sabadia board, I bet that's what the company tried to do. Even though we think of the PC as being pretty slow, those signals are still fast and delicate.—Steve

Memory Mayhem

Dear Steve,

I have an Intel 1010 Above Board/AT memory expansion board from Mead Computer. When I placed the order, Mead told me that I wouldn't have to disable the 384K bytes of my 1-megabyte motherboard.

After delivery, I phoned Intel technical support to ask about switch settings, and I was told that I'd have to disable the 384K bytes (above 640K) of my motherboard.

Mead Computer then told me that the 1010 board would work without complication in extended memory if I would start my extended memory location at 1.5 megabytes rather than at the customary 1.0 megabytes.

It will be a while before I actually start running OS/2. Please straighten me out regarding memory configuration.

Americus Mitchell
Kilmarnock, VA

If you don't disable the 384K bytes of RAM on the system board, you'll wind up with a "hole" between the end of the RAM at 1.384 megabytes and the start of the Above Board at 1.5 megabytes. All
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ASK BYTE

the programs I know of assume that the RAM is contiguous, so that hole is going to cause some problems. You've probably found that out, right?

Mead is correct in saying that the board will work, but only custom code that you write can take advantage of the disconnected RAM on the Above Board. All the standard code will fall into the hole and die.

The best solution is to disable the 384K bytes of system board RAM and have everything work. Anything else isn't going to be worth the effort. You'll wind up wasting a little chunk of those RAM chips, but so it goes.

As far as OS/2 goes, there's going to be a lot of blood in the streets when people find out that they can't run a "standard" version of OS/2 on clones that were sold as compatible with IBM PC ATs. The reason is that OS/2 can't use the BIOS routines in those clones: It must talk directly to the hardware because the BIOS code won't run in protected mode. And that means the clone vendors must supply modified versions of OS/2 for their machines.

If you've added oddball displays or other hardware, you won't be able to run the standard OS/2 from the vendor because it won't talk to the display. It's not at all clear how this problem is going to be resolved, but I'm certain that the final answer isn't going to make everyone happy.—Steve

Designing Chips

Dear Steve,

I've been working on an idea that may have commercial value, and I need to look into having a custom chip designed. Could you give me some insight into what to expect in terms of minimum quantities, design and production time, chip costs for the initial run, and so on? The chip I have in mind shouldn't require a dense mask, such as the 68020, but it does require a very high pin count (68 to 166 or more). All the major functional blocks are in commercially available chips, so a lengthy design phase shouldn't be necessary. Where should I start?

Your article "The BCC180 Multitasking Controller" (January through March) was very interesting, and I'd like to see more in the same vein. It's fairly obvious that the chip you're using is the most suitable one available today for general-purpose controller work. Way back when you started out with designs based around Zilog or Intel processors, why did you choose these architectures over Motorola's 6802, 6808, and 6811? I'm no expert, but it seems to me that if I have a specific control application, I can usually use a Motorola processor to accomplish the task and end up with a lower chip count than I can with a Zilog or Intel processor.

Finally, with regard to programming languages, when I do control work, I prefer using Forth. I know most of the arguments in favor of using BASIC. I don't agree with all of them, but I can understand why you've chosen to use BASIC. The fact remains, though, that Forth is the only language available that gives you an operating system and language in 16K bytes or less and that runs on almost every processor available today. Its code is compact, and execution is fast. I'd like to see Forth as an alternative to BASIC in your future articles.

Ken Martinson
Ringgold, GA

I assume that the custom chip you are asking about is an application-specific IC (ASIC). ASICs include programmable logic devices (PLDs), gate arrays, standard cells, or handheld custom ICs. The advantage of an ASIC is a single chip that replaces perhaps 30 or more standard logic parts and the board space that they would normally occupy. The design is more difficult to copy, and you can realize optimum performance because of reduction in pin and circuit board delays.

Designing with PLDs requires only a personal computer equipped with PLD software and a PLD programmer (which costs approximately $10,000). In comparison, setup costs for gate arrays or standard cells include nonrecurring engineering (NRE) fees, and the equipment requirements might include a CAE/CAD workstation, a timesharing computer, or both. The NRE costs for gate arrays range from $5000 to $80,000. For standard cells, this figure runs from about $20,000 to $150,000. Production turnaround for gate arrays and standard cells can run anywhere from 2 months to a year; turnaround for PLDs is perhaps a few minutes.

The choice of a microprocessor is not an easy one. Certainly it would be nice to choose the best chip for every job, but that's not practical. A number of factors—familiarity with the family, programming knowledge, software development equipment, factory support, and parts and sample availability—determine the processor of choice. In most cases, these items weigh more heavily when comparing architecture than does saving a chip or two in a design. Only in designs where constraints are rigidly dictated (such as volume productions and a small physical size) would I trade the things I continued
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BASIC is an interactive language that is easy to learn and available on virtually every computer. Forth is also interactive, but it’s not nearly as popular. The virtues in each have caused many to suggest the need for a single language that combines their best features. I use BASIC because of its popularity, but I will consider using Forth in a future article. — Steve

Optical Scanning

Dear Steve,

My company, Hemisphere Software, does contract programming and sells IBM PCs to small businesses and municipalities. We’ve been working on a project that is missing one important part. I need a scanner with an automatic feeder to read a continuous form 2.4 inches wide. This scanner will have only one typeface to read. The scanner must meet the following criteria:

• It must read a continuous form of paper 2.4 inches wide. The paper will hold text only, in black or blue ink. The paper has 22 character positions and no special spacing at the top and bottom of each page.
• The text is in code. The code equivalent for one word appears on each line.
• The text consists of 17 letters of the alphabet, numbers 1 through 9, and the asterisk. The letters can appear only in the following sequence, and only in these locations:

STKPWHRAO*ELFRPBLGTSDZ

Consequently, the letter T can appear only in the second or nineteenth position of the line, and so on. Numbers can appear instead of certain letters, as diagrammed below:

STKPWHRAO*EFLRBPLGTSZD

1 2 3 4 5 6 7 8 9

For example, line position 1 can be either blank, S, or 1.
• The scanner’s output is to be sent to an ASCII file. Each line of input will be one record.
• The scanner’s operation (start and stop) will be controlled from an MS-DOS IBM-compatible microcomputer.

To keep the price of the system as low as possible, we’re trying to keep the cost of the scanner below $1500. We’ll need two scanners as soon as possible, and we’ll be purchasing more later. Thanks for any help you can offer.

Stephen A. Gonzalves
Wilmington, NC

continued
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ASK BYTE

Every now and then I get a letter that reminds me just how weird the real world can get. A scanner to read 2.4-inch continuous paper with everything in 22-character codes? Zounds!

Although you call it a scanner, what you describe is really an OCR (optical character recognition) system in disguise. Mercifully, you’ve simplified some of the most vexing parts of the project by using only one typeface and two possible characters per position, so you don’t have to solve the general problem.

I first thought that a linear charge-coupled device (CCD) array would make a nice line sensor, with scanning down the paper handled by a gear motor pulling the sheet through the reader. Unfortunately, that puts the mechanical design in the critical path: The motor has to be fairly precise, the optics need to be quite good, and the whole assembly reeks of precision machine shop work. Ugh.

Another way to handle it would be to use a TV camera with a macro lens and an ImageWise (see the May 1987 Circuit Cellar) digitizer to grab an image of the sheet. With a full line extending completely across the screen, there’s enough resolution to get about 100 pixels on each character. That should be enough to handle the recognition part of the problem.

The reader might look something like this: a TV camera with macro lens and some lights, peering down at a flatbed section holding the paper. A motor and traction wheels draw the paper lengthwise across the flatbed. The ImageWise digitizer sends the TV picture of the PC over a serial link. The RTS and DTR lines can control the motor and lights, with CTS, DSR, and CD returning some status bits. All the OCR logic is in the PC, which keeps the cost of the scanner down by eliminating a lot of dedicated computing.

You don’t mention the throughput you need, but I doubt that the speed will get better than a few tens of seconds per line. That may sound slow, but even simple OCR requires a lot of computations because there are many bits in each line.

I’m not sure there’s enough room in your budget for development and manufacturing, even at $1500 per unit. At 25 units a year, you’ve got a buy of $37,500. Figuring a parts cost at $750 (even simple optics are expensive), you’re allowing about $19,000 for nonrecurring engineering, design, and programming expenses—figuring no profit at all on each unit. Not good.

If you take a look at standard OCR scanners, I think you’ll find they’re much more expensive than $1500, even though they’re in volume production. Even though you’ve simplified the problem, it still isn’t trivial.—Steve
...Keeps you going full steam ahead when other debuggers let you down! With four models to pick from, you’ll find a Periscope that has just the power you need.

Start with the model that fits your current needs. If you need more horsepower, upgrade for the difference in price plus $10!

When you move to another Periscope model, don’t worry about having a lot to learn... Even when you move to the most powerful model, Periscope III, an extra dozen commands are all that’s involved.

A Periscope I user who recently began using Periscope III writes, “I like the fact that within the first half hour of use I was debugging my program instead of learning to use the 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.

- **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.
  
  Periscope I has a board with 56K of write-protected RAM. The Periscope software resides in this memory, safe from runaway programs. DOS memory, where debugger software would normally reside, is thus freed up for your program.

  Periscope III has a board with 64K of write-protected RAM, which performs the same function as the Periscope I protected memory. 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!

**What Periscope Users Like Best:**

- “I like the clean, solid design and the crash recovery.”
  
  Periscope I user

- “I like the ability to break out of (a) locked up system!”
  
  Periscope II user

- “I am very impressed with Periscope II-X... it has become my ‘heavy duty’ debugger of choice, especially if I need to work on a memory resident utility or a device driver.”
  
  Periscope II-X user

- “… Periscope III is the perfect answer to the debugging needs of anyone involved in real-time programming for the PC... The real time trace feature has saved me many hours of heartache already.”
  
  Periscope III user

- **Periscope I** includes a half-length board with 56K of write-protected RAM; break-out switch; software and manual for $345.

- **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 8 MHz is $995; for machines running up to 10 MHz, $1095.

**Requirements:** IBM PC, XT, AT, or close compatible (Periscope III requires hardware as well as software compatibility); DOS 2.0 or later; 64K available memory; one disk drive; an 80-column monitor.

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Circle 15 on Reader Service Card (DEALERS: 16)
### COMPUTERS

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### PRINTERS

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### SOFTWARE & STARTER KITS

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PostScript for Programmers
Eliakim Willner

POSTSCRIPT
LANGUAGE PROGRAM
DESIGN
Glenn C. Reid

Adobe Systems Inc.,
Addison-Wesley Publishing
Co., Reading, MA: 1988,
224 pages, $22.95

Many programmers find their first experience with PostScript as refreshing and exciting as a badly needed vacation from run-of-the-mill work. It is an elegant and powerful language for putting words and images on the page. Fortunately, it is also very well documented.

Until recently, the primary PostScript resources have been two books from Adobe Systems, published by Addison-Wesley—the Language Tutorial and Cookbook, or "the blue book," and the Language Reference Manual, or "the red book." Glenn C. Reid's PostScript Language Program Design, the newest offering from Adobe, will certainly become known to PostScript aficionados as "the green book," and it will almost certainly become an indispensable companion to its two predecessors.

The blue and red books were written by the designers of PostScript. They are sufficient if you want merely to learn about the language. The new green book was written by a PostScript programmer. It is essential if you want to bridge the gap between theory and practice—to actually use the language.

Read the blue book before you begin using PostScript. It provides a feel for how to work with the language, using short examples to illustrate individual features.

The red book provides the rationale for PostScript and a formal definition of the language. It is a well-written reference. Keep the red book at your side as you code; it's invaluable when you need to know the fine points about a particular keyword.

Absorb the green book. Make its style and programming structure your own. The green book will teach you to think in PostScript.

A basic premise of the green book is that you must understand how the PostScript interpreter works if you are to use it efficiently. Reid states that the difference in execution speed between a poorly written PostScript program and a well-written one can be as great as a factor of 10 or more. He therefore carefully explains what the PostScript interpreter does when it encounters different language constructs, and why.

The many examples Reid uses serve a dual purpose. First, they serve as dissection models; he subjects them to a statement-by-statement analysis, explaining how each piece of code integrates with the rest and, in cases where a variety of means might have been used to reach the same end, detailing why he deemed the particular method selected to be the best.

The examples also serve as paradigms for your own code. In fact, permission is explicitly given for readers to incorporate actual code from the book into their own applications. This license would be hollow if the code were trivial. It isn't. Most of the examples represent substantial programming efforts. Taken as a whole, they embody many hours of continued

ALSO REVIEWED

Electric Language
Advanced C Programming for Displays
Prolog Programming in Depth
Computer Vision: A First Course
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BOOK REVIEWS

programming that you won’t have to do. See, for example, the four-page printer emulator listing. The groundwork has been carefully set, preliminary procedures have been written and analyzed, and a substantial and usable piece of code is wrought.

The green book opens with an overview of PostScript (it’s interesting to compare Reid’s overview with that of the authors of the red book). Chapter 2 provides a mild peek under the PostScript interpreter hood. This lays a groundwork for many of the rules that the author presents as the book progresses (more about those later). Chapter 3 describes the PostScript imaging model—the controls you’ll be using as you “drive” PostScript.

The individual chapters that follow deal with different aspects of the language. I recommend that serious users of PostScript read the book from cover to cover, then return to chapters of special interest. The chapters are generally self-contained, with occasional references to code from previous chapters.

I particularly appreciate Reid’s down-to-earth approach to programming. Too often, programming texts ignore some of life’s less pleasant realities, like the fact that memory isn’t an infinite resource, and that programmers spend far more time debugging code than writing it. Reid devotes chapter 13 to memory and file resource management, and it’s clear here (as it is throughout the book) that he speaks with the voice of experience. The issue of resource shortage isn’t delegated to chapter 13 exclusively; Reid deals with it as it arises in the context of other topics as well.

Chapters 14 (“Error Handling”) and 15 (“Debugging Techniques”) address the very important concept of what to do when things go wrong. Appendix A contains the listing of a PostScript error handler. Again, Reid doesn’t shrink the issue of debugging PostScript code, because it comes up in other chapters.

I spoke earlier of rules laid down by the author. I’m generally uncomfortable with what has been called the “programming proverbs” approach to teaching. Short, arbitrary rules (like “never use goto”) have so many exceptions that the rule, unqualified, is misleading or meaningless. But the approach can be effective if used with intelligence, as it is here.

For example, chapter 10 concludes with a brief set of guidelines for properly structuring documents. These fill up a page, not a single line, and are thus both easy to remember and qualified enough to be useful. Again, in section 12.3, the author provides an approach for dealing with printer error messages. These occupy half a page and provide a methodology, not a rote cookbook-style solution. The book does contain a series of italicized notes that contain unqualified rules, where appropriate.

Case in point, section 5.2: “Note: Never initialize or replace the existing state of the interpreter . . . ”

One would expect a book on PostScript to be attractively laid out, and the green book doesn’t disappoint. The format is clear, with plenty of white space. Listings and examples are clearly set apart. The entire book is set in a new and very attractive Adobe type family called Stone.

This is an excellent book. I would have added a section on Display PostScript and the programming issues it raises and included more detail on using PostScript with color output devices, since these seem just around the corner. But I suspect that we’ll see more from Adobe beyond the green book—and I’ll be looking forward to those additions.

BRIEFLY NOTED

ELECTRIC LANGUAGE: A Philosophical Study of Word Processing by Michael Heim, Yale University Press, New Haven, CT: 1987, 305 pages, $19.95. Philosophy teacher and writer Heim argues that word processing changes “the way we think about anything and everything.” Word processing encour-
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Circle 113 on Reader Service Card (DEALERS: 114)
### Book Reviews

**ADVANCED C PROGRAMMING FOR DISPLAYS** by Marc J. Rochkind, Prentice Hall, Englewood Cliffs, NJ: 1988, 331 pages, $40 (hardcover), $27 (paperback). Despite its title, this is not a book on computer graphics; it is limited to alphanumeric displays. But that’s not a fault. If you’re at all involved in getting alphanumeric data out of the keyboard and onto the display (and what programmer isn’t?) on a Unix- or MS-DOS-based computer, then Marc J. Rochkind’s book definitely belongs on your library shelf.

Wisely selecting the C language as his vehicle, the author tackles terminal emulation (for the Z-19; he should have selected the more common VT-100), raw and buffered keyboard I/O, an elaborate window system, and virtual screen handling. Keep in mind that, throughout the book, the author presents plenty of source code for both Unix and MS-DOS systems (he even dips into assembly language code on the 8088 to speed critical functions). You’ll find the early chapters particularly helpful in demystifying the Unix termcap database and curses screen management utilities.

The C source code presented is compatible with Microsoft and Lattice compilers on the MS-DOS side, and Unix System III, Xenix (based on Unix version 7), and 4.2 BSD and 4.3 BSD on the Unix side. The source code is available on floppy disk at extra cost.

—Richard Grehan

**PROLOG PROGRAMMING IN DEPTH** by Michael A. Covington, Donald Nute, and Andre Mellino, New York: Scott, Foresman and Co., 1988, 506 pages, $24.95. Aimed at readers somewhat familiar with computer programming (but not necessarily artificial intelligence (AI) techniques or languages), this book starts with the basics and delivers on its title, covering Prolog in depth. Intermediate and advanced Prolog users will also find the book’s comprehensive coverage of algorithms and techniques useful.

The book has been classroom-tested, and the polish shows: The text is uniformly good. Discussions on expressing procedural algorithms in Prolog and on Prolog as its own metalanguage are outstanding. A chapter titled “Additional Tech-

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### Quaid Analyzer Instruction Display

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Part of a Quaid Analyzer display

Quaid Analyzer is a powerful diagnostic tool that shows what is going on inside your computer. The > at the top is the cursor. You can move it with the arrow keys. When you move the cursor off the screen, the instructions scroll like text in an editor. You can move the cursor into a register and change its value, or see the instructions or data it points to. Of course, you can scroll through the data display as well, and type new values into memory. With Quaid Analyzer you never have to type a command.

This example shows the first instructions executed when VDISK.SYS installs itself. You can see that it changes stack pointers, then gets the DOS version number. We got to this point by loading Quaid Analyzer before DOS, then watching the DOS call and disk interrupts until the driver was loaded, then putting a breakpoint on its first instruction. Drivers are installed before DOS gives you the first prompt. What other software can you show you a device driver install?

Quaid Analyzer comes with a manual, and software on a 3 inch and a 5 inch diskette. If you are not satisfied with Quaid Analyzer, you can return it within 30 days for a refund. Quaid Analyzer is not sold by dealers in the United States or Canada. It is not copy-protected.

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BOOK REVIEWS

niques" contains genuine nuggets about trees, sorting, and object-oriented programming.

The second half of the book (on AI applications) is mostly expert-system-oriented; other chapters are devoted to discussions of natural language processing and Prolog's logical basis. Noteworthy among the expert-system topics are representation of uncertainty and extension of the Prolog inference engine.

The programming examples are written in Edinburgh Prolog, and they're practical, plentiful (80K bytes overall of source code), and available by mail or network. Turbo Prolog users will benefit from reading this book, too, even though not all the code can be translated into the Turbo dialect.

Appendices describe the features of Arity and Turbo Prolog and how to use the Prolog debugger.

—Alex Lane

COMPUTER VISION: A FIRST COURSE by R.D. Boyle and R.C. Thomas, Blackwell Scientific Publications, Oxford, England: 1988, 210 pages, $29.25. This textbook is aimed at advanced undergraduate computer science students, though anyone who doesn't mind a lot of math in the text could profit from it. The material is not strictly state-of-the-art or detailed, but it provides a solid background in established theory.

The authors distinguish three levels of vision tasks—low, medium, and high—and examine each in turn. Particularly good chapters cover low-level processing and segmentation. The material on knowledge representation concentrates heavily on semantic nets and frames, while the material on rule-based systems considers only production systems. R. D. Boyle and R. C. Thomas touch on neural networks briefly, more as an example of what can be done without using the ideas in the rest of the book.

The appendixes augment sections of the text instead of merely bulking up the book. They consist of C source code for histogram equalization and hierarchical edge detection, a brief introduction to Fourier theory, a table of three-dimensional interpretations of two-dimensional functions, and a discussion of Goed's algorithm. The remaining end material includes an appendix of solutions to chapter exercises, a list of references, a separate bibliography, and separate author and subject indexes.

As a brief, technical introduction to computer vision, this tome deserves a place on your shelf.

—Alex Lane

ILLUSTRATING PASCAL by Donald Alcock, Cambridge University Press, Cambridge, England: 1987, 184 pages, $12.95. Like its forerunner, Illustrating BASIC, this introductory programming text combines a visual emphasis and a totally hand-lettered format. The method can be very fast once you’ve adjusted. For instance, why use many words warning the reader never to write constant for const, when you can just display the word constant surrounded by little black bugs?

I’m not sure that the “Utter Beginner” Alcock presupposes will find the early pages transparent. Though each statement is clear, the tax on memory is great. Also, his examples often employ terms (e.g., truncate) that he hasn’t yet gotten around to defining formally.

But as things get more complex, and the diagrams that generally go with exposition become the exposition, the method pays off. By about midjourney, even experienced Pascalers may want to jump aboard. If there’s a clearer exposition of QuickSort than Alcock manages on one page, I don’t know it. As for pointers, stacks, queues, rings, binary trees, and even hashing: Alcock’s drawings and pithy comments are of unparalleled clarity, and his sample programs are fun. He claims to be covering the whole of the language as defined by ISO 7185. Though I haven’t checked that claim in detail, I’m inclined to believe it. I recommend the book.

—Hugh Kenner

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- Hercules Graphics Compatible
- 1 extra Parallel Port
- 720 x 350 Resolution
- 132 Column by 25 or 44 Line Mode
- WY-530 14 inch Hi Res Monitor

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**XENIX**

- PCMOS/386 MONOCHROME SYSTEM
  - Hercules Graphics Compatible
  - 1 extra Parallel Port
  - 720 x 350 Resolution
  - 132 Column by 25 or 44 Line Mode
  - WY-530 14 inch Hi Res Monitor

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- 720 x 350 Resolution
- 132 Column by 25 or 44 Line Mode
- WY-530 14 inch Hi Res Monitor

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Circle 33 on Reader Service Card

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HOW TO THINK ABOUT STATISTICS by John L. Phillips Jr., W.H. Freeman and Co., New York: 1988, 198 pages, $17.95 (hardcover), $9.95 (paperback). Tools for doing statistical calculation are becoming commonplace in personal computer software—from spreadsheets to high-level languages to specialized math programs. Dedicated statistical packages are bringing the most sophisticated tools to personal computer users. With all that power, however, comes the potential for a great deal of confusion and misinformation: Statistical measures are easily misused.

This book’s admirable goal is not to teach you how to do statistics, but to teach you how to understand the statistics that others (or personal computers) do.

The front cover of the book claims that it “will help you understand statistical concepts vital to your education, your business, or your profession; evaluate the news, polls, and trends that affect you as a consumer and citizen; and make better sense of the social statistics, advertising claims, economic forecasts, and political issues you encounter every day.” How to Think About Statistics might actually deliver on 80 percent of that claim—if you’re willing to work at it.

This well-written book is really an introductory undergraduate text focusing on applications of statistics to education, political science, psychology, social work, and sociology. The textbookish outlook shows from the first sentence in the introduction, “You may be planning to study statistics not because you want to but because you have to.” The author overcomes the reluctance of a coerced undergraduate audience through the use of sample applications that follow each chapter.

The sample applications take the place of exercises found in most textbooks. They present a seemingly real-world problem (e.g., measuring the incidence of coups in Latin America) and then ask the reader, “How would you approach this problem?” The author warns that to get the most out of this book, it will probably be necessary to engage in a lot of page flipping. He even suggests that the reader keep two bookmarks handy for just that purpose. He’s right. The author’s solutions list the appropriate statistical approach and are followed by possible ways the resulting statistic could be misinterpreted. Unfortunately, the solutions buried in the back of the book contain some of the best parts of this book.

Phillips makes no assumptions on the mathematical capabilities of his audience, placing essential calculations inside boxes where they can be studied by those who have the background or interest, otherwise ignored or simply glanced at. The book leads the reader from understanding the purpose of a simple mean to contrasting means using analysis of variance, pausing along the way to explain standardization, correlation, causation, and contingency tables. Throughout, the emphasis is on understanding the purpose and shortcomings of the individual statistics rather than on the nitty-gritty of calculation.

People who have wondered what statistics are about (or who plan on using statistical software) will find this book a useful beginning.

—William Gould

CONTRIBUTORS

LEAD REVIEW: Eliakim Willner is vice president for research and development at Pecan Software Systems Inc. and co-author of Advanced UCSD Pascal Programming Techniques (Prentice Hall, 1985). BRIEFLY NOTED: David Weinberger (Brookline, MA) is a writer for Interleaf. Richard Grehan is a senior technical editor at large for BYTE. Alex Lane is a knowledge engineer for Technology Applications Inc. in Jacksonville, Florida. Critic and author Hugh Kenner lives in Baltimore. William Gould is president of the Computing Resource Center (Los Angeles, CA) and a manufacturer of statistical software.
In the mid to late 70's, when engineers designed with SSI and MSI, the demands that they made on logic analyzers reflected the technology that they worked with - low density, low complexity, and low performance.

Along came the 80's and with it PALs, GALs, PLAs, LCAs, ASICs, faster CISCs, and RISC machines. Technology leaped ahead... same old logic analyzers.

Finally, a machine tuned to the times. The Pc/La provides you with competitive sample speed and channel count, but more importantly, its superior trigger capabilities enable you to track down system bugs quickly and efficiently. No fumbling around the edges or shooting in the dark, you are right where you need to be.

There is no need to translate your problem into someone else's idea of logic definition. This instrument uses state syntax directly.

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The most affordable way to build a skyscraper.

MultiSync Plus
For superior business graphics, desktop publishing and CAD.
Or construct a bridge. Or design a circuit. Or even create a pie chart. With the MultiSync® Plus, high resolution graphics are well within reach. When used with the graphics board that was designed for it—the MVA 1024 from NEC—it may well be the ultimate value for all your CAD and business graphics applications.

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Introducing OmniLab 9240.
Totally Integrated Scope-Analyzer-Stimulus.

- Combine a 100 MHz digital oscilloscope with a time-aligned, 200 MS/s 48-channel logic analyzer. Next add synchronized analog and digital stimulus generators. Then a remarkable new triggering system. What you have is the 9240 — a whole new class of instrumentation. Expressly designed to speed challenging analog and digital analysis. And get you from concept to product faster.

- The 9240 is based on an innovative new instrument architecture that merges high-speed universal hardware and seamlessly-integrated software to create high-performance capabilities not available in separate instruments. Analog and digital traces are always time-correlated in a unique, single screen display. SELECT™ triggering bridges scope and analyzer techniques. And OmniLab’s stimulus generators can playback captured or edited signals.

- At the heart of the 9240 is SELECT triggering, the most straightforward and complete solution ever to triggering dilemmas. It’s one system, operating with synchronized analog and digital views of your data. By combining conventional oscilloscope and analyzer triggering with powerful RAM truth tables — plus min/max time qualification as needed — SELECT triggering helps you analyze hardware, debug software, and integrate systems more easily.

- OmniLab™ is a generation ahead of conventional digital scopes that often hide rarely occurring faults because they only show you a few cycles out of millions. With its continuous monitoring, you can use SELECT triggering to quickly catch every occurrence of rare events like metastable states, bus contentions, missing pulses, and buried noise glitches.

- The 9240 is like having a complete benchtop of instruments integrated with your PC/AT or compatible. Which you can easily customize for digital development, analog development, or a combination of both.

- With OmniLab, your productivity will soar. Because you achieve results with fewer instruments. And in fewer steps than ever before. By no means least, the 9240 delivers the best price/performance you’ll find anywhere, costing just $8900 fully outfitted. And most importantly, without compromising a single high-performance spec. Not a one.

- For more information, call toll free 800/245-8500. In CA: 415/361-8883. Or write for complete literature.

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NO-COMPROMISE 9240 SPECIFICATIONS

<table>
<thead>
<tr>
<th>DIGITAL OSCILLOSCOPE</th>
<th>LOGIC ANALYZER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digitizers: Two, 8 bit</td>
<td></td>
</tr>
<tr>
<td>Bandwidth: 100 MHz</td>
<td></td>
</tr>
<tr>
<td>Single-Shot Digitizing: 34 S/s to 204 MS/s</td>
<td></td>
</tr>
<tr>
<td>Repetitive Sampling: 680 MS/s</td>
<td></td>
</tr>
<tr>
<td>Scale Factor: 5 mV/div to 10 V/div</td>
<td></td>
</tr>
<tr>
<td>In 2-5 sequence</td>
<td></td>
</tr>
<tr>
<td>Record Length: 4K (16K, 64K optional)</td>
<td></td>
</tr>
<tr>
<td>Inputs: 40, timing and state</td>
<td></td>
</tr>
<tr>
<td>Asynchronous Clocking: 34 MS/s on 46 inputs:</td>
<td></td>
</tr>
<tr>
<td>Repetitive Sampling: 204 MS/s on 0 inputs</td>
<td></td>
</tr>
<tr>
<td>Synchronous Clocking: 680 MS/s on 46 inputs</td>
<td></td>
</tr>
<tr>
<td>Acquisition Memory: 0 to 34 MS/s</td>
<td></td>
</tr>
<tr>
<td>Disassembly Options: 4K samples (16K, 64K optional)</td>
<td></td>
</tr>
<tr>
<td>Over 150 microprocessors</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>ANALOG STIMULUS</th>
<th>DIGITAL STIMULUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output: 8mV to 8V peak-to-peak, 8 bit</td>
<td></td>
</tr>
<tr>
<td>Cycle Length: 4 to 4K samples (16K optional)</td>
<td></td>
</tr>
<tr>
<td>Clocking: 34 S/s to 34 MS/s</td>
<td></td>
</tr>
<tr>
<td>Functions: Record, edit and playback</td>
<td></td>
</tr>
<tr>
<td>Outputs: 24, 74F tri-state drivers</td>
<td></td>
</tr>
<tr>
<td>Cycle Length: 4 to 4K samples (16K optional)</td>
<td></td>
</tr>
<tr>
<td>Timing: 34S/s to 34MS/s</td>
<td></td>
</tr>
<tr>
<td>Functions: Record, edit and playback</td>
<td></td>
</tr>
</tbody>
</table>

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Omnilab display demonstrates capture of an embedded analog glitch (in top trace) with time-aligned presentation of the waveform’s digitized bit values (center) and numeric states.

---

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TEL: 530942 FAX: 415/361-8970

Computer Integrated Instrumentation

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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.

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 reach 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.

Call and get your free, 56-page bugbusting bible today.

And if you're in the middle of a nightmare right now, give us a purchase order number. We'll FEDEX you a sweet dream.

A division of Northwest Instrument Systems, Inc.
Saratoga Office Center • 12950 Saratoga Avenue
Saratoga, CA 95070 • Call 408/253-5933 today.

*Versions for COMPAQ, PS/2-30s and compatibles. Copyright © 1987 by Atron. 386 PROBE is a trademark of Atron. Call 44-2-855-888 in the UK and 49-8-985-800 in West Germany

Circle 25 on Reader Service Card
Stacked Planes for the Little Board

Thanks to a new expansion adapter, you can now use standard IBM PC-style expansion cards with Ampro's Little Board/PC single-board computer. The StackPlane/PC adapter lets you install plug-in cards in parallel to the computer board. Ampro says this means no more card cages and backplanes in embedded applications where space is tight.

The Little Board itself, measuring 5½ by 8 inches, is a PC-compatible CMOS module with an 8-MHz 8088-compatible processor. It can be configured with 256K bytes to 768K bytes of dynamic RAM, 32K to 288K bytes of EPROM, a floppy disk controller, a keyboard interface, a speaker interface, two serial ports, a parallel port, a PC expansion bus, and a SCSI bus. It needs about 4 watts of power from a 5-volt DC power supply, and it comes in eight versions.

Price: Little Board/PC, starting at $393; StackPlane/PC, $43.


Inquiry 751.

A Rugged 386

Do you need powerful computing capabilities under adverse conditions? KMS Advanced Products says you can take its new ruggedized computer "to the field or behind the lines"; in other words, just about anywhere.

The RMC-3000 is an 80386-based system in a case that looks like a Kaypro transportable except for the heavy metal housing and rows of rivets; there's also a rack-mount model available for your tank or air transport vehicle.

The system is fully compatible with the PC XT and PC AT, KMS says. The company will assemble just about any configuration you can come up with. The basic machine has 10 slots (one 16-bit and the rest 32-bit) and one serial and one parallel port, and it weighs about 45 pounds. You can mix storage options; KMS offers both 5¼-inch and 3½-inch floppy disk drives, hard disk drives, and tape drives.

Price: Starting at $13,900.

Contact: KMS Advanced Products Inc., 3850 Research Park Dr., P.O. Box 1868, Ann Arbor, MI 48106, (800) 521-1524; in Michigan, (313) 769-1780.

Inquiry 752.

A Powerful Crayon for Graphics Applications

This Crayon isn't for kids, and it's probably not for people who just want to put a little more speed into their day-to-day applications. This species of Crayon is an 80386-based rack-mounted system for folks who work in advanced graphics, CAD/CAM, animation, video, and other areas that require sophisticated imaging and animating capabilities.

Inside the box is a motherboard holding an 80386 processor (20 MHz, no wait states), 1 megabyte of memory (expandable to 16 megabytes using single-in-line memory modules), and a socket for an 80387 or Weitek 1167 math coprocessor. The Crayon 386 SP motherboard also supports "shadow RAM," which lets the Award BIOS run in high-speed RAM for increased performance. You can set the bus speed to 8 or 12 MHz, and there are two serial, one parallel, one SCSI, and one game port.

For storage, the basic system comes with one 1.2-megabyte 5¼-inch and one 720K-byte 3½-inch floppy disk drive, but the case has room for a total of six half-height drives. The proprietary multidrive controller can handle two floppy disk drives, two hard disk drives, and seven SCSI devices. For hooking up the sorts of equipment that graphics types will need (e.g., digitizers, pointing devices, and high-resolution cards), the system has six 16-bit and two 8-bit expansion slots. The Crayon has three fans to keep things cool.

Its maker says the Crayon 386 SP is fully compatible with the IBM PC AT and will run MS-DOS (3.3 comes with the basic box), OS/2, or Unix and supports EMS 4.0. For looking good in those contemporary art and video houses, the system is housed in a black case.

Price: $7495 for the basic system.

Contact: Video Graphic Systems, 4163 St. Clair Ave., Studio City, CA 91604, (818) 509-5738.

Inquiry 753.
Look Ma, No Keyboard

Now there’s an IBM PC-compatible laptop system that neither needs nor comes with a keyboard. Of course, a keyboard is available as an option, but you can simply input data into the system using your own handwriting.

The Linus Write-Top, from Linus Technologies, combines a laptop computer with a transparent digitizer tablet and a handwriting-recognition algorithm. The tablet is situated right above the computer’s flat panel display. The computer uses an 8- by 5-inch backlit supertwist LCD display with a resolution of 640 by 200 pixels. When you draw on the tablet, the display underneath responds as if you were actually drawing on paper. The company also claims that the computer can be taught to recognize any handwritten character and convert it to a standard character entered via a keyboard.

The Linus Write-Top features 640K bytes of CMOS static memory, an 8088-compatible processor, an internal modem, and a 3½-inch floppy disk drive. The computer weighs 9 pounds and is the size of your typical small laptop. The display/digitizer, which can be detached from the rest of the system, is about 11 by 11 inches and less than an inch thick. Options include a keyboard and a software package called CodeWrite that allows developers to adapt existing applications to receive handwritten input. Another package, Just-Write, is a word processor designed for handwritten input.

Price: $2995.
Contact: Linus Technologies Inc., 1889 Preston White Dr., Reston, VA 22091, (703) 476-1500.
Inquiry 754.

Output to Your Heart’s Delight

Do you need lots of printouts every day? Are you sick of waiting for your printer to tap, tap, tap along at its snail-like pace? If 600 lines per minute (lpm) of draft-quality text is fast enough, you might consider Output Technology’s OTC 2161. This dot-matrix printer gets its speed by using a three-headed print mechanism that prints two lines of text with each pass. And if you need higher-quality output, it prints 325 lpm in correspondence mode and 90 lpm in near-letter-quality mode.

The 2161 features a control panel with 16 switches and an expandable 8K-byte buffer. A parallel interface is standard, but you can also get RS-232C, RS-422, twinaxial, coaxial, or PrintNet interfaces. The printer emulates the Data-products LB600, Printronix P6080, and Epson FX-286e.

In addition to standard ASCII, the OTC 2161 comes with 12 international character sets, IBM Character Sets #1 and #2, and the IBM Code Page #437 and #850 sets. Options include extra font cartridges, additional emulations, additional character sets, a paper stacker, and a quietized pedestal. The 2161 weighs 80 pounds and includes free installation in addition to 6-month on-site service.

Price: $6450.
Inquiry 755.

A Security Guard for Your Modem

Gateway II prevents unauthorized folks from stealthily sucking data from your computer. Installed between a serial port and your modem, the stand-alone Gateway II prompts a caller to enter a name and password before permitting system access. If the correct information isn’t entered within a user-designated period, Gateway II rudely hangs up.

Every call is logged in Gateway II’s memory. You can even pick up that report from a distant system by using a modem.

Two models are available. Gateway II can store up to 100 passwords and telephone numbers (250 optional). For extra peace of mind, Gateway II DB (dial back) provides the additional security of logging the user into the Gateway II system and then calling back to a predetermined telephone number. It requires an external Hayes-compatible auto-dial modem.

Both Gateway II devices operate at from 300 to 19,200 bits per second (bps).
Price: $395 for Gateway II; $495 for Gateway II DB.
Contact: Adalogic Inc., 7844 McClellan Rd., Cupertino, CA 95014, (408) 257-1352.
Inquiry 756.
For problems involving engineering calculations or scientific analysis, the answer is MathCAD.

Transporting an iceberg to Southern California is a formidable task. Calculating the variables is just as demanding. How many tugboats would be needed to tow the ice mass? At what cost? How much fresh water would be lost?

Innovative solutions require extraordinary tools. For problems involving calculations or what-if analysis, the answer is MathCAD.

MathCAD is the only PC-based software package specifically designed to give technical professionals the freedom to follow their own scientific intuition.

You decide how to solve the problem – MathCAD does the "grunt work."

- Ends programming and debugging.
- Recalculates as variables change.
- Generates quick plots.

Easy to learn and use, MathCAD operates interactively in standard math notation. And its built-in functions provide all the power you need to solve real-world problems. MathCAD handles matrix operations, solves simultaneous equations, works with real and complex numbers, does automatic unit conversion, displays Greek characters and other math symbols, performs FFTs and much more.

There’s never been a better way to get fast, accurate solutions to analytical problems. That’s why 20,000 engineers and researchers are using MathCAD daily in applications as diverse as fluid mechanics, signal processing and molecular modeling.


MathSoft
Software Tools for Calculating Minds

CAN THIS ICEBERG SUPPLY TO L.A.?
A Clean Sweep for Data

It may not have the power of your fairy godmother’s magic wand, but DataSweep 1 is a hand-held character reader that lets you enter typed or printed information into your IBM PC by sweeping the reader across text.

According to Soricon Corp., the reader can scan 120 words per minute, with an accuracy of 99.3 percent. It can read from 8- to 14-point type and scan up to 8 inches of characters in one stroke. The two-button wand lets you activate reading with the front button and program the rear button to keyboard functions such as Return, Tab, and Indent. A multi-font feature automatically recognizes most popular font styles, including proportionally spaced text and some typeset text. You can use the reader with most word-processing, spreadsheet, database, and desktop publishing programs.

DataSweep 1 comes with the hand-held character reader, an interface board, and software. It requires an IBM PC, XT, AT, or compatible running under DOS 2.1 or higher and has a hard disk drive.

Price: $1250.
Contact: Soricon Corp., 4725 Walnut St., Boulder, CO 80301, (800) 541-7226; in Colorado, (303) 440-2800.
Inquiry 757.

DataSweep 1 scans up to 120 words per minute.

See It All on Your Mac SE

If your eyes are complaining about the Mac SE’s paltry 9-inch display, help is on the way in the guise of the V-Screen monitor from New Image Technology. Based on Princeton Graphic Systems’ LM-300 high-resolution monitor, the V-Screen lets you view a whole page of text and graphics on its 15-inch screen. An 8½-by-11-inch page appears “life-size” with a resolution of 72 dots per inch and a 1-to-1 aspect ratio.

The V-Screen uses paper-white (P-138) phosphors and has a hardware mechanism that lets the 600-pixel screen pan left to right across a full 1024-pixel virtual screen. The monitor comes on a tilt-and-swivel base and includes a controller card, software, and all connecting cables.

Price: $1150.
Inquiry 759.

...And Also on Your PS/2

If you’re using your PS/2 for those same desktop publishing and CAD applications as the Mac above, you too can get eyestrain relief with the king-size Ventsk PS 2000, an ultra-high-resolution monochrome text and graphics display for PS/2s equipped with the Micro Channel.

The PS 2000 has a truly Promethean 20-inch diagonal screen. It is VGA-compatible and has a maximum resolution of 1280 by 1024 pixels. It comes with an IBM PS/2 Micro Channel card and all the necessary cables. On the software side, the PS 2000 includes drivers for most popular desktop publishing and CAD packages.

Price: $2495.
Contact: Ventek Corp., 31336 Via Colinas, Suite 102, Westlake Village, CA 91362, (818) 991-3868.
Inquiry 760.

123-Key Keyboard Remembers Macros

ECO, the company that manufactures the popular DataDesk keyboard, is coming out with a new keyboard that offers more features. The Maxi-Switch Memory Pro for the IBM PC and AT includes a whopping 123 keys and can remember its own macros.

The keyboard includes nonvolatile EEPROM (electrically erasable programmable ROM) to allow it to record keyboard macros. According to the company, you can reprogram any of the keys from the keyboard or by running a utility program on the system. Having the macros stored inside the keyboard avoids compatibility problems that can be caused by garden-variety RAM-resident keyboard macro programs.

The Memory Pro includes many more keys than the familiar 84-key or 101-key keyboards of the IBM PC and AT. For example, two sets of function keys are provided: the traditional 10 keys to the left of the typewriter keypad, and a horizontal row of function keys above the typewriter keypad. These latter keys have removable transparent tops to accommodate legends describing their function. The keyboard also has separate numeric and cursor keypads.

Price: About $150.
Contact: EECO Inc., 1601 East Chestnut Ave., P.O. Box 659, Santa Ana, CA 92702, (714) 833-6000.
Inquiry 761.

GIVE YOUR LAPTOP A 5¼-INCH COMPANION

Laptop computers and their 3½-inch high-capacity floppy disks are great. But for better or worse, most of the world still runs on old-standard 5¼-inch floppy disks.

There’s no need to fear The Great Incompatibility: You can transfer and share data between disk sizes using the W525 Subsystem, an external 5¼-inch 360K-byte floppy disk drive that plugs right into your Toshiba, Tandy, Zenith, Sharp, Datavue, or NEC laptop computer.

The W525 Subsystem attaches to the external floppy disk drive port and comes with a power supply and cable for your specific model of laptop computer. It measures 2½ by 10 by 6¼ inches.

Price: $249.
Inquiry 758.
Why Paradox 2.0 makes your network run like clockwork

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

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

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

Aaron Brenner, LAN Magazine

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

Rusel DeMarla, PC Week

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

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

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

Mark Cook and Steve King, Data Based Advisor

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

Jim Seymour, PC Magazine

You don't have to be a genius to use Paradox
Even if you're a beginner, Paradox is the only relational database manager that you can take out of the box and begin using right away.

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

60-Day Money-back Guarantee*
For a brochure or the dealer nearest you Call (800) 543-7543

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

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**Sky Scanner in a Slot**

After you've scanned through the 200 channels received by your backyard satellite dish, then what? Norsat's Micro-Sat is a satellite dish receiver that plugs into a full slot in an IBM PC or compatible. It lets you receive audio, video, and data signals at up to 9600 bps. Jacks on the board's rear-edge connector output the audio, video, and base band. You can send data directly to your RS-232C serial port and view video input directly on your computer monitor.

You tune Micro-Sat using EPROM, binary-coded decimal switches, or through the data bus. It captures signals at a frequency between 950 and 1450 MHz. You can reset frequencies while running AUTOEXEC.BAT, and you can also select video invert and audio bandwidth via DIP switches or directly from your computer. The board is compatible with the VC II, B-Mac, and Oak descrambling systems and the C and Ku satellite bands.

Price: $1000.


Inquiry 789.

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**Konan's Ten Time Transfers Data at 4 Megabytes per Second**

Konan's Ten Time disk controller accesses data 10 times faster than most controllers, the company reports. Using an on-board RAM cache, the controller features a caching algorithm that results in a transfer rate of 4 megabytes per second for most data requests.

Both disk reads and writes are cached. When you write to the disk, it goes to the cache and is then written to the disk in the background. A 4-year battery protects your data if your computer goes down. If you request data that isn't waiting in the cache, a zero-latency read capability hastens disk access by reading and transferring data immediately, regardless of which sector the head lands on.

Ten Time features a 1-to-1 interleave and can control up to two hard disk drives and two floppy disk drives. It's compatible with DOS, Unix, Xenix, and Novell and 3Com networks, and requires an IBM PC AT or compatible.

Price: $695 for the hard and floppy disk controller; $395 for the hard disk controller; $695 for the hard and floppy disk controller.

Contact: Konan Corp., 4720 South Ash Ave., Tempe, AZ 85282, (602) 345-1300.

Inquiry 785.

---

**Capture That Image!**

FreezFrame lets you mix standard video and computer graphics. It's a full-slot board that provides a window into your VCR, video camera, laser disk player, or other standard NTSC video source. The board lets you capture images in real time, with up to 32,768 colors, and then superimpose text and graphics on top of the image.

FreezFrame has five display modes: EGA-Passthrough displays EGA images on the monitor; Real-Time lets you view video input directly on your screen; Freeze lets you display a still image captured during Real-Time mode; and EGA/CGA Low-Resolution Overlay lets you overlay text or graphics on a full-screen captured image.

FreezFrame gives you a maximum image resolution of 512 by 256 pixels. It captures images in 1/60 second and comes with 256K bytes of video RAM. The system runs on the IBM PC, XT, AT, and compatibles running DOS 3.0 or higher and requires a multifrequency analog monitor, and an EGA or CGA card for overlay capabilities.

Price: $1749.


Inquiry 786.

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**NuVista Delivers Ultimate Mac II Video**

Truevision's NuVista is a 32-bit video-capture and display board that occupies one NuBus slot in your Mac II. The board is based on Texas Instruments' powerful 34010 graphics processor and features a custom video cross-point chip. It supplies up to 16.7 million colors and provides a resolution of 1024 by 1024 pixels in 32-bit mode, though the resolution can be as high as 2048 by 2048 pixels in 8-bit mode. You can also capture a video signal in real time, and generate an analog video output signal. The board functions as the Mac II's standard graphics controller.

NuVista comes with either 2 or 4 megabytes of dual-port CMOS video RAM. It also includes input and output lookup tables, four channels of A/D and D/A conversion, and programmable pixel clock.

Price: $4250 with 2 megabytes of RAM; $5995 with 4 megabytes.

Contact: Truevision Inc., 3751 Shadeland Station, Suite 100, Indianapolis, IN 46256, (800) 858-8783; in Indiana, (317) 841-0332.

Inquiry 788.
The LOGITECH HiREZ Mouse—the only mouse expressly designed for high-resolution screens.

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

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

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

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

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

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

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

**THE HiREZ MOUSE**

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

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

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

**THE SERIES 2 MOUSE**

For those who've chosen the Personal System/2," the most logical choice is the LOGITECH Series 2 Mouse. It's 100% compatible with PS/2, and plugs right into the mouse port, leaving the serial port free to accommodate other peripherals.
THE ALL-PURPOSE MOUSE: SERIAL OR BUS

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

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

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

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

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

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

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

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

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

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

For the dealer nearest you, call 800-231-7717
Let the Computer Design that Servo

With the SDK-400, your computer designs, connects, and tests motion-control systems. Included in the servo design kit is a PC-compatible motion controller, a servo motor with encoder, and a power driver. It also comes with a power supply, connectors, and design software.

The motion controller plugs into the PC bus and accepts over 40 ASCII commands and motion profiles. The controller accepts ASCII commands from the keyboard.

Assembling the hardware is simplified by step-by-step graphic explanations included with the software. Diagnostic routines make sure you’ve connected everything properly, and then the software tunes the system for optimum performance. The software also includes modeling and analysis programs that let you evaluate system performance and teach you about the theoretical aspects of servo design.

The SDK-400 servo design kit requires an IBM PC, XT, AT, or compatible with DOS 2.0 or higher, at least 512K bytes of RAM, and a Hercules or EGA board.

Price: System 2, with motor encoder size 5-500, $1145; System 2, with motor encoder size 50-1000, $1175.

Contact: Galil Motion Control Inc., 1054 Elwell Court, Palo Alto, CA 94303, (415) 964-6494.

Inquiry 767.

Mr. Mox Powers up Your PC

Do you ever need to power up your PC to access files from a remote location? Mr. Mox, an AC power switch that you control with an external modem, may be the solution.

Mr. Mox features four grounded outlets, two of which are always hot; you control the other two with the Carrier Detect signal in your modem. You plug your PC into the outlets and daisy chain the DB-25 cable to the modem outlet on Mr. Mox and to the external modem.

Mr. Mox also includes a manual-override switch, a 100-second power-off delay, built-in surge protection, a 125-volt 15-amp circuit breaker, and a DB-25 cable.

Price: $99.95.

Contact: Kenmore Computer Technologies, 30 Suncrest Dr., Rochester, NY 14609, (716) 654-7356.

Inquiry 769.

A PC-Based Digital Scope

Rapid Systems says its PC-based R1200 digital scope is ideal for transient, vibration, modal, audio, and physiological waveform analysis. It features sampling rates selectable from 1 Hz to 1 MHz, a 64K-byte data buffer, 12-bit A/D converters on each channel, and antialiasing filters on each channel.

The R1200 is capable of zooming in vertically on waveforms to see increased 12-bit resolution. An autosave feature stores the sweeps mode to disk, and the scope offers optional real-time fast Fourier transform spectrum analysis.

Price: $2995.

Contact: Rapid Systems Inc., 433 North 34th St., Seattle, WA 98103, (206) 547-8311.

Inquiry 771.

Extend Your SCSI

The SCSI 50-pin parallel protocol normally operates to only 19.6 feet, or, with the differential version, it can be extended to 82 feet. But Paralan reports that with the Paraline SCSI enhancement products, you can operate at distances of up to 1000 feet, or up to 2 miles with fiber optic models.

The Paraline SCSI bus extenders are freestanding units that operate from wall-mount power supplies. The single extenders have one parallel interface and one serial connection. You mate the serial interface with coaxial or fiber optic cables (depending on the model). Hub models are also available, and they have one parallel and four serial connections.

Price: $305 for the coaxial version; $820 for fiber optic; $1195 for Parahub-4; $2625 for Parahub-4 fiber optic.

Contact: Paralan Group, 1414 Redwood Lane, Scotts Valley, CA 95066, (800) 636-8271.

Inquiry 768.

ASCII on the Wall

What is the hexadecimal ASCII code for a check mark? Which color codes will give your screen yellow letters on a blue background? What are the keyboard scan codes for your function keys? You can answer these questions with a quick glance at Topspot’s computer reference wall chart. The chart features an ASCII table with all 256 symbols; keyboard scan codes; codes for the 16 basic colors and gray scales; tables of hexadecimal, decimal, and binary numbers; box-drawing codes; and a musical-note frequency chart.

The wall chart measures 24 by 36 inches and has a metal edge and hook for easy hanging.

Price: $15.

Contact: Topspot, P.O. Box 881, Marion, IA 52302, (319) 377-0207.

Inquiry 770.

PURE PC POWER PROTECTION

When lightning’s crashing down, your hard disk drives and modems are safe with the DSDLP surge protector—at least from a surge of up to 6000 volts, according to Dynatech.

The DSDLP has sensors that detect undervoltages and power-line losses on up to four AC outlets and two telephone receptacles. It also filters RFI (radio-frequency interference) and EMI (electromagnetic interference) noise.

Price: $139.95; includes a 10-year warranty.

Contact: Dynatech Computer Power Inc., 5800 Butler Lane, Scotts Valley, CA 95066, (800) 638-9098; in California, (408) 438-5760.

Inquiry 768.
Oracle Corporation, the world's fastest growing software company, has just climbed past Ashton-Tate to become the world's largest supplier of database management software and services.

Why?
- Because ORACLE® runs on PCs, plus mainframes and minicomputers from IBM, DEC, DG, HP, Prime, Wang, Apollo, Sun, etc. — virtually every computer you have now or ever will have. Ashton-Tate's dBASE runs only on PCs.
- Because ORACLE is a true distributed DBMS that connects all your computers — PCs, minicomputers and mainframes — into a single, unified computing and information resource. dBASE supports only primitive PC networking.
- Because Oracle has supported the industry standard SQL language since 1979. Ashton-Tate promises to put SQL into dBASE sometime in the indefinite future.
- Because ORACLE takes advantage of modern 286/386 PCs by letting you build larger-than-640K PC applications on MS/DOS that run unchanged on OS/2. dBASE treats today's 286/386 PCs and PS/2s like the now obsolete, original PC.

Don't go down in flames. Bail out from dBASE. Call 1-800-ORACLE and order your $199-PC copy of ORACLE today. Or just ask and we'll send you information on ORACLE, the number one selling DBMS on minicomputers and mainframes.

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I understand this copy is for PC development only. Offer valid only in the US and Canada.

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PHONE

CREDIT CARD NUMBER

CARD EXPIRATION DATE

SIGNED

I am a value-added reseller (VAR): □ YES □ NO

JUNE 1988 • BYTE 77
FloPro 2.2 runs at 5 milliseconds per logic serve.

**Real-Time Machine Control on a PC**

FloPro 2.2, a CAM program for industrial applications, emulates the programmable controller processes of updating I/O and solving user logic. Using flowcharts as its programming language, the program can run at 5 milliseconds per logic serve, according to Universal Automation.

You can run FloPro in a simulator mode that allows the flowcharts to execute without the I/O attached to the PC. The FloPro debugger lets you view flowcharts; modify current status of the I/O, flags, timers, counters, and registers; display real-time status while executing; trace flowchart blocks and set breakpoints; cross-reference flowcharts; and terminate or resume execution.

FloPro also works in a multitasking environment.

The program includes 512 (each) inputs, outputs, flags, timers, counters, and registers; display real-time status while executing; trace flowchart blocks and set breakpoints; cross-reference flowcharts; and terminate or resume execution.

FloPro runs on the IBM PC and compatibles with DOS 3.0 or higher, 512K bytes of RAM, an EGA card, and a 132-column printer.

Price: $995 for the development system; $295 for the runtime module.

**Contact:** Universal Automation Inc., 9G Rebel Rd., Hudson, NH 03051, (603) 880-6553.

**Inquiry 772.**

**Compile any Microsoft BASIC Program on Your Apple IIGS**

Based on the Microsoft BASIC compiler, AC/BASIC is a native 16-bit compiler optimized for the IIGS’s 68016 processor. The compiler produces stand-alone applications by translating BASIC programs directly into machine language. It does not require a linker, but does require the run-time libraries included with the program. Absoft reports that you can take programs written in Microsoft BASIC for the Mac, IBM PC, or Amiga, and run and compile them on the IIGS through AC/BASIC.

In addition, AC/BASIC supports the IIGS sound and color capabilities. To run the compiler, you need at least 512K bytes of RAM on a IIGS and one 3½-inch floppy disk drive.

**Price:** $125.

**Contact:** Absoft, 2781 Bond St., Auburn Hills, MI 48057, (313) 855-0050.

**Inquiry 797.**

**MOVING FORTH WITH OS/2**

UR/FORTH for Microsoft OS/2 is a Forth programming environment for 80286- and 80386-based machines running OS/2.

UR/FORTH runs in protected mode and lets you take advantage of OS/2’s support for multitasking, interprocess communications, and virtual memory management.

UR/FORTH offers a direct threaded-code implementation, a segmented memory model, a hashed dictionary for fast compilation, use of dynamic memory allocation functions, and a uniform file interface. It includes a battery of string-handling operators, such as search, extract, compare, and concatenate, and a dynamic string-storage manager. A table-driven full-screen editor lets you edit as many as six files simultaneously.

You can invoke OS/2 system functions interactively from the UR/FORTH interpreter by typing the function’s parameters, followed by the function’s name. When you leave the OS/2 operating system, the status of the operation is left on the Forth stack, and other results are placed in the Forth data segment at addresses specified in the original call. You can also call OS/2 functions from within compiled Forth programs.

UR/FORTH supports text and graphics display modes of the CGA and EGA. It contains graphic drawing routines for reading or setting individual pixels, line drawings, arcs, ellipses, and circles; region filling with patterns or solid color; bit-block moves; and positioning of graphics at arbitrary graphics coordinates.

Software floating-point, 80287-assisted floating-point, and 80387-assisted floating-point function libraries are supplied. Laboratory Microsystems reports that you can use the software floating-point library on any 286- or 386-based machine.

To run UR/FORTH for OS/2 you need version 1.0 or higher of OS/2, a 286- or 386-based system, at least 2 megabytes of RAM, and a CGA, VGA, EGA, or monochrome display adapter.

**Price:** $350.

**Contact:** Laboratory Microsystems Inc., 3007 Washington Blvd., Suite 230, Marina del Rey, CA 90292, (213) 306-7412.

**Inquiry 773.**

An AC/BASIC control window.

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

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

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

Delivering SuperVGA HiRes now!

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

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

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

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You can't buy a faster 286 computer for the price. In fact, you can't buy a faster 286 computer at any price.
Because.
The handsome piece of high-tech wizardry you’ve just been admiring (on the previous two pages) is the new Dell System 220.
The first 286 computer running at 20 MHz. You read it correctly. 20 MHz.
Which means it’s as fast as most 386 computers, running MS' OS/2 and MS'-DOS at blistering speed. All from a tiny little corner of your desk.
Yet this engineering marvel costs less than half of what most other 386 computers sell for.
Which might lead you, quite reasonably, to wonder:
How can the people at Dell offer you so much for so little?
The short answer is that you buy direct from us, the manufacturer.
Eliminating the computer stores and their salespeople—who can add thousands of dollars to the cost of every computer.
"Speed is a good thing. Safe, reliable, no hassles speed is better still."
—Al Poor, Editor's Choice, PC Magazine
But while we eliminate the things you don’t need, we also make certain we never eliminate anything you actually do need.
The very first thing you need from any computer company, obviously, is terrific computers.
Well, we design and build our computers right here at our headquarters in Austin, Texas.
Putting a premium on speed, compatibility, and reliability.
Because we’re flexible, we often get new technologies to the marketplace faster than any other computer company.
In fact, we’re already shipping our version of MS OS/2, so you can run MS OS/2 applications, now as well as in the future.
"...includes a year’s on-site support...in the price of the computer. This is the sweetest support deal offered by any computer vendor in the business."
—Eric Knorr, PC World
As for quality control, around here it’s an obsession. Each and
every computer goes through a battery of diagnostic checks, including a comprehensive burn-in before we ship it to you.

Every single Dell computer also comes equipped with one other remarkable feature.

A level of service most retail computer stores can only envy.

Starting with expert technical advice before you even buy a computer. To help you decide which system best suits your needs.

Followed by a thirty-day money-back guarantee. To make sure you're completely satisfied.

And all systems come with a one-year limited warranty.

Then, we give you free technical support over the phone. With technicians who know the inside of our computers the way you know the back of your hand.

If on-site service should ever be required by you or your business, we'll send a Honeywell Bull service engineer to your office by the next business day.*

Our attitude towards service is perhaps best summed up by a phrase we hear around here, delivered in a no-nonsense tone by our Chairman, Michael Dell: "Fix it," he says. "Or give them their money back."

"The combination of technical know-how and service is impressive...it's a good bet the computer world will be hearing a lot more about Michael Dell in the years ahead!"

-Stanley W. Angrist, Forbes

In four years, we've become one of the largest personal computer manufacturers in the U.S. We've more than doubled our sales each year we've been in business; last year, our sales grew from $69 million to $159 million.

It shouldn't be any surprise. After all, we've been offering better computers, with better service—at better prices.

All you do is call us and place an order, and we ship it direct to you. Which makes buying a computer as simple as it can be.

Now, if you'd like the rest of the details on our hyper-fast 286 computer, and information on the rest of our line, there's only one more thing you have to do.

Turn the page.
Welcome to our store. To buy or lease a Dell computer, call (800) 426-5150. We'll help you select the right system.

For service and technical support, call our highly trained technicians at (800) 624-9896. In almost all cases, any problem can be solved over the phone.

These technicians are also supported by Honeywell Bull service engineers who can be dispatched to your office by the next business day, should on-site service be required. This optional service contract is available in over 95% of the United States, with over 1,000 engineers in 198 service locations.

We are so confident in our quality products that we also provide a Total Satisfaction Guarantee, which says that any system bought from us may be returned within thirty days from the date it was shipped to you for a complete refund of your purchase price.

We also offer a One Year Limited Warranty, which warrants each system we manufacture to be free of defects in materials and workmanship for one full year. During the one year period we will repair or replace any defective products properly returned to our factory.

Call or write for the complete terms of our Guarantee Warranty, and the Honeywell Bull Service Contract. Dell Computer Corporation, 9505 Arboretum Blvd., Austin, Texas 78759-7299.

Dell products are available on GSA contract #GS00K87AGS6127. Call us to get GSA pricing.

The Dell Computer Store.

The top of the line. It's the highest performance 80386 computer available, faster than the IBM PS/2 Model 80 and the Compaq 386/20. It runs at 20 MHz, with the latest 32-bit architecture for complete MS/OS/2 compatibility and maximum performance. Since it also has Intel's Advanced 82385 Cache Memory Controller, and high performance disk drives, the System 310 is ideal for intensive database management, complex research and development, CAD/CAM, and desktop publishing. As a network file server the system offers an unbeatable combination of price and performance.

Standard Features:
Intel 80386 microprocessor running at 20 MHz.
1 MB of 80 ns 32-bit RAM expandable to 8 MB without using an expansion slot.
Advanced Intel 82385 Cache Memory Controller with 32 KB of high speed static RAM.
Socket for 20 MHz 80387 coprocessor.
5.25" 1.2 MB or 3.5" 1.44 MB diskette drives.
Dual diskette and hard disk drive controller.
Enhanced 10-key keyboard.
1 parallel and 2 serial ports.
200-watt power supply.
Real-time clock.
6 expansion slots (6 available with hard disk drive controller and video adapter installed).
Dell System Analyzer.
MS-DOS and MS OS/2 compatible.
Security lock with locking chassis.
LIM 4.0 support for memory over 1 MB.
Real-time clock.
Three full-sized AT compatible expansion slots.
Socket for 80287 coprocessor. Dell System Analyzer.
MS-DOS and MS OS/2 compatible.
Security lock with locking chassis.
12 month on-site service contract (Available on complete systems).

Options:
16 MB of RAM upgrade kit.
20 MHz Intel 80387 math coprocessor.
2 MB or 8 MB memory expansion boards.

The New System
310.

As fast as most 386 computers, at less than half the price—more power for the money than any other system. The 80286 system that runs at 20 MHz, with less than one wait state. Completely compatible for both MS-DOS and MS OS/2 applications (it runs OS/2 faster than IBM PS/2 Model 80), and with a remarkably small footprint, the System 220 is the ideal executive work station for database management, business, or sophisticated connectivity applications. The system uses page-mode interleaved memory; the page-mode RAM operates at less than one wait state, and inter-leaving results in a performance increase of about 15 percent.

Standard Features:
80286 microprocessor running at 20 MHz.
1 MB of RAM expandable to 16 MB (8 MB on system board).
Integrated diskette and VGA video controller on system board.
One 3.5" 144 MB diskette drive. Integrated high performance hard disk interface on system board.
Enhanced 10-key keyboard.
1 parallel and 2 serial ports.
LIM 4.0 support for memory over 1 MB.
Real-time clock.
Three full-sized AT compatible expansion slots.
Socket for 80287 coprocessor. Dell System Analyzer.
MS-DOS and MS OS/2 compatible.
Security lock with locking chassis.
12 month on-site service contract (Available on complete systems).

Options:
3.5" 144 MB diskette drive.
Intel 80287 coprocessor.
1 MB RAM upgrade kits.

The New System
220.
**THE NEW SYSTEM 200.**

A great value in a full-featured AT compatible. An 80286 computer running at 12.5 MHz, this system is completely MS-DOS/2 compatible. It’s ideal for general business applications, as well as software development, local area networks, CAD/CAM, and desktop publishing. The System 200 offers high speed drive options, industry standard compatible BIOS, and on-site service. At these low prices, the System 200 is the best value in the 80286 marketplace. As Executive Computing said of this computer’s predecessor, “If faster processing speed and low cost are two key issues affecting your purchase decision, this machine might be the ideal choice for your office.”

**Standard Features:**
- Intel 80286 microprocessor running at 12.5 MHz.
- 640 KB of RAM, expandable to 16 MB (4.6 MB on system board).
- 5.25” 1.2 MB or 3.5” 1.44 MB diskette drive.
- Dual diskette and hard disk drive controller.
- Enhanced 101-key keyboard.
- 1 parallel and 2 serial ports.
- 200-watt power supply.
- Real-time clock.
- 6 expansion slots. (4 available with hard disk drive controller and video adapter installed).
- Socket for 8 MHz 80287 coprocessor.
- Dell System Analysts: MS-DOS & MS OS/2 compatible.
- Security lock with locking chassis.
- 12-month on-site service contract. (Available on complete systems).

**Options:**
- 512 KB RAM upgrade kit.
- 8 MHz Intel 80287 coprocessor.

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**THE SYSTEM 100.**

A full-featured, yet economical one-piece computer for office, school, or home. This system is fast, easy to use, and ready to run with Dell Enhanced MS-DOS 3.3, Microsoft BASIC Manager, and Microsoft Works software—more than a $400 value, included at no extra charge. Complete MS-DOS compatibility means you can run thousands of programs for business, personal finance, education, and entertainment. And the System 100 can grow, with the high quality options listed below. A price leader in 8088 technology, the System 100 boasts an innovative design that allows for more power, speed and convenience than most of its competitors.

**Standard Features:**
- Intel 8088 microprocessor running at 9.54 MHz selectable to 6.67.
- 640 KB of RAM.
- 3.5” 720 KB diskette drive.
- Diskette drive controller integrated on system board.
- Integrated high-quality 84-key keyboard.
- 1 serial and 1 parallel port.
- Two full-sized expansion slots available when video adapter is installed.

**One-half sized drive controller:**
- One-half sized expansion slot used.

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- 3.5” 720 KB diskette drive.
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**PRINTERS.** We now offer a full line of PC-compatible dot matrix and laser printers. Our dot matrix printers range from inexpensive near-letter quality printers to the highest resolution printers available. Our laser printers include some of the fastest, most reliable printers ever made. All are 300 dots per inch, and all support serial and parallel interfaces. And all printers come with our 30-day money-back guarantee and a one year warranty.

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All prices and specifications are subject to change without notice. Please inquire for current details.

Dell cannot be responsible for errors in typology or photography. In Canada, leasing is not currently available, and configurations and pricing may vary. **Available on System 100 at extra charge.**

**Circle 317 on Reader Service Card**
Anvil Forges Designs on Your 386

Anvil-5000pc integrates drafting, wire-frame, surface modeling, section analysis, and numerical control using the same data structure and interactive interfaces for all functions.

Its drafting capabilities include notes, labels, dimensions, cross-hatching, arrow on curve, balloon, text edit, surface finish, and true-position tolerancing. Its geometric features offer points, lines, arcs and circles, splines, conics, strings, and polylines.

The program has an integrated database, a warm reboot, and an open architecture. It can handle drawings of parts that have more than 340,000 entities.

The program supports VGA, PGA, and EGA. It comes with software modules, beginning with 3-D Design and Drafting, which is the core module of the system and is available immediately. Other modules will be released throughout 1988.

Price: 3-D Design and Drafting module, $3995; other modules will range from $495 to $1995.


Inquiry 774.

New Mathtool Module

Statistics I is the first module in Gulf's numerical analysis library, Mathtool. Statistics I calculates means, variance, moments, moving averages, frequency distributions, and cumulative frequency distributions. It also performs data smoothing, tests of hypotheses and significance, and confidence interval estimates.

The modules in the Mathtool series offer on-line editing of data, mathematical routines, and graphics output to the screen or printer. You can input your own data, ASCII files, or Lotus 1-2-3 files. Other Mathtool modules will include Matrix Analysis, Regression and Correlation, Probability, Differential Equations, Fourier Series, Bessel Functions, Numerical Integration, Analytic Geometry, Mathematical Functions, and Numerical Differentiation.

Statistics I operates as a stand-alone program or will work with other Mathtool units. They all run on the IBM PC, XT, AT, and compatibles with 256K bytes of RAM. A monochrome or color graphics card is recommended.

Price: $95.

Contact: Gulf Publishing Co., Book Division, Dept. R8, P.O. Box 2608, Houston, TX 77252, (713) 529-4301.

Inquiry 776.

Passage Into Two Dimensions

World Precision Instruments has designed Passage for two-dimensional plotting and numerical analysis on a Mac. The program lets you enter data from other programs. It will scale and plot multiple sets of the data, including asymmetrical error values. Passage also analyzes and manipulates the data, using routines to calculate integrals, fast Fourier transforms, and polynomial fits.

Passage runs on the Mac Plus, SE, and II.

Price: $495.

Contact: World Precision Instruments, 375 Quinnipiac Ave., New Haven, CT 06513, (203) 469-8281.

Inquiry 777.

SEG'S Plots Engineering Graphics

SEG'S is a scientific engineering graphics system that can plot over 5000 data points for each of 10 curves with up to four independent y axes. It features a Lotus 1-2-3-style interface and lets you produce presentation-quality graphics on many plotters and printers, including Hewlett-Packard pen plotters and LaserJets, and IBM graphics-compatible dot-matrix printers.

An internal numeric spreadsheet lets you enter, transform, and manipulate data mathematically to produce plots. You can enter data with the numeric spreadsheet, or you can import data from spreadsheet print files or ASCII data files.

To run SEGS, you need an IBM PC, XT, AT, or compatible with 256K bytes of RAM and DOS 2.0 or higher. It also runs on PS/2s and supports CGA, EGA, VGA, and Hercules Graphics cards.

Price: $195.

Contact: Edmond Software Inc., 3817 Windover Dr., Edmond, OK 73013, (800) 992-3425; in Oklahoma, (405) 340-0697.

Inquiry 778.

PCB Design on the Mac ll

EDS-1 is an electronic design program that combines modules for producing printed circuit board designs. Modules include schematic entry, PCB layout, routing, and a Gerber translator.

Vamp also offers EDS-II, which is essentially the same package as EDS-1, but includes a digital simulator.

Price: EDS-1, $1495.

Contact: Vamp Inc., 6753 Selma Ave., Los Angeles, CA 90028, (213) 466-5533.

Inquiry 779.

The successor of Pascal: JPJ TopSpeed Modula-2 produces better code than Microsoft C, Turbo C, Logitech Modula, and Turbo Pascal 4.0. The figures speak for themselves:

```
TopSpeed Modula-2  6
Microsoft C 5.0     1
Turbo C V1.5       3
Logitech Modula-2 V3.0  4
Turbo Pascal V4.0   5
```

Measured by British Standards Institution (BSI) (25 iterations of Sine on IBM AT)

In England and Europe contact:
Jensen & Partners UK Ltd., 63 Clerkenwell Rd.,
London EC1M 5NP, Phone: (01) 253-4333.
In England call Tbl Free 0800 444-143,
24 Hours. Compiler Kit £59.95, TechKit £29.95 (introductory offer only valid in the US).

JPJ TopSpeed Modula-2 is a professional Modula-2 development system with full support of memory models, multi-tasking, long data types, structured constants, long and short pointers, 80×87 inline code and emulator, separate compilation, direct BIOS/DOS calls etc. The comprehensive library includes CGA, EGA and VGA graphics support, math functions, sorting, file handling, window management and more. Here is what our users say:

"JPJ Modula-2 is the Modula-2 we have all been waiting for. JPJ Modula-2 will do for Modula-2 what Turbo Pascal did for Pascal."
—K N King
Author of Modula-2: A Complete Guide

"JPJ Modula-2 is a landmark product. The environment is better than anything on offer from Borland or Microsoft."
—Huw Collingbourne
Computer Shopper

The Compiler Kit includes: High-speed optimizing compiler, 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.

The TechKit includes: Assembler start-up source code for system, JPJ TopSpeed Assembler, TSR module, communications drivers, PROM locator and technical information.

Systems requirements: IBM PC or compatible, 384K available RAM and two floppy drives (hard disk is recommended).

To become part of the excitement, make use of our limited-time introductory price of $59.95 (after July 4, 1988: $99.95). 30 days unconditional money-back guarantee.

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Circle 146 on Reader Service Card
Camstat Analyzes Manufacturing Data

With this set of statistical functions, you can monitor, detect, correct, and improve quality control in manufacturing processes.

You can enter data into Camstat through its editing environment or from files generated by other applications. You can also create a series of prompts that you can use to enter data directly into the system, making it available on the manufacturing floor.

Camstat handles parametric, attribute, date, and character variables. You can split data into subsets, change values, transform values, and filter out subsets of data. Charting features include X-R, trend, and p-charts. Its graphics capabilities include histograms, cumulative sum plots, x,y plots, capability analysis, SPC control charts, and Pareto charts.

Camstat runs on the IBM PC AT or compatibles with at least 640K bytes of RAM, a math coprocessor, and an EGA or Hercules monochrome adapter. A drive, and an EGA or Hercules monitor. You can also create a series of Pareto charts.

Contact: Cameo Systems
1.2-megabyte floppy disk

Thermal Analyzes Semiconductors Temperatures

Thermal is a three-dimensional thermal-analysis program that assists you in redesigning semiconductor circuits. It calculates a grid of temperatures, up to 30 by 30, on as many as five power sources for a given substrate. A list of 20 substrates is included, or you can define new ones.

The program runs under Microsoft Windows and makes use of Windows' Clipboard, allowing you to integrate any of its display modes into other Windows applications. You can also create text files to use with other non-Windows programs.

You can view your output in graphic or text form. When viewing graphically, you can toggle isothermal and grid lines on and off. In text mode, you can display the cell and substrate input data as well as any calculated output data. You can also page through the data with the keyboard or mouse.

Thermal runs on the IBM PC and compatibles with at least 640K bytes of RAM, a math coprocessor, and Windows 1.03 or higher. A Windows-compatible mouse is recommended.

Price: $449.95.
Contact: Specific Solutions, Inc., 2880 San Tomas Expressway, Santa Clara, CA 95051, (408) 986-9200.
Inquiry 781.

Fit and Plot Your Curves

Curve-fitting routines performed by F-Curve include cubic spline, divided difference, polynomial and multiple linear regression with least squares, and nonlinear fits using the simplex technique. You can use Savitsky-Golay filters to smooth the data. The program also lets you calculate the value of y for any value of x on the smoothed curve, the value of the integral of the smoothed curve for any x interval, and the value of the derivative of the curve for any value of x.

Plotting capabilities let you plot data points with or without the fitted curve. You can plot data points with error bars or symbols or both.

F-Curve runs on the IBM PC, XT, AT, and compatibles.

Price: $39.95.
Contact: LEDS Publishing Co., Inc., P.O. Box 12847, Research Triangle Park, NC 27709, (919) 477-3690.
Inquiry 784.
Now we've given you even more reason—PC Tools™ Deluxe.

PC Tools Deluxe gives you all the best features of Fastback™, Norton™, XTREE™, Mace™, Sidekick® Lightning™ and Disk Optimizer—a $700 value—for just $79.

Other utilities may claim they “do it all,” but only PC Tools Deluxe delivers:

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• PCFORMAT for safe formatting of floppy and hard disks.

• A quick, reliable DISK CACHING utility for speeding up disk access.

• A fast COMPRESS feature that like Disk Optimizer dramatically improves hard disk performance.

Before you buy any of these other utilities, take a look at PC Tools Deluxe. Like PC Magazine, you'll find there's no reason to look any further. For the dealer nearest you, or to order direct, call (503) 244-6036, M-F, 8 a.m.-5 p.m. (West Coast time). Questions? Call us at (503) 244-5782.

Central Point Software
INcorporated
9700 S.W. Capitol Hwy.
Portland, OR 97219
Manage Your Money on Your Mac

The Macintosh version of Managing Your Money includes the same capabilities as the IBM version and allows you to integrate the financial "chapters" to come up with a budget, manage savings, calculate income, and more.

The program performs basic budget and checkbook management, tax planning, portfolio management, and retirement planning.

Managing Your Money for the Mac is not copy-protected and runs on the Mac 512ke, Plus, SE, and II. You must have two disk drives, one of which must have at least 800K bytes of RAM.

Price: $219.98.
Contact: Meca Ventures, 355 Riverside Ave., Westport, CT 06880, (203) 226-2400.
Inquiry 762.

Low-Cost Turbo-Charged Accounting

Everything you need to perform basic accounting tasks is integrated in Info-Team Turbo Accounting from Info Designs. The program includes modules for general ledger, accounts receivable, invoicing, accounts payable, and checking. The modules are integrated so that every time you enter or change information, the general ledger module is updated. On-line help is included in each module.

InfoTeam Turbo Accounting is available on 3 1/2- and 5 1/4-inch disks. It runs on the IBM PC, XT, AT, and compatibles.
Price: $99.
Contact: Info Designs Inc., 445 Enterprise Court, Bloomfield Hills, MI 48013, (313) 334-9790.
Inquiry 763.

Scoring Big with Mutual Funds

Mutual Fund Scoreboard disks are issued quarterly by BusinessWeek and cover equity and fixed-income funds listed in the NASDAQ system. The current version of the Scoreboard includes the critical fourth quarter of 1987 and covers approximately 728 equity funds and 536 fixed-income funds.

The Scoreboard offers more than 25 fields of information, including a rating by BusinessWeek, which measures a fund's performance adjusted for risk and sales charges. You can retrieve information from the fields in a variety of ways; for instance, you may want to know which no-load funds emphasize growth, or which outperformed Standard & Poor's 500-stock index in the past 5 years.

You can convert the data to Lotus 1-2-3 or ASCII format. The Scoreboard runs on the IBM PC and compatibles with at least 256K bytes of RAM and DOS 2.1 or higher. A data management program is included on each disk, so you can access and print the information.
Price: $49.95 per disk; $149.95 for annual subscription to either equity or fixed income disks; $239.95 for annual subscription to both equity and fixed income disks.
Contact: BusinessWeek, 1221 Avenue of the Americas, New York, NY 10020, (800) 553-3575; in Illinois, (312) 250-9292.
Inquiry 764.

Developing Business Programs

Concept 1.0 from Archimedes lets you prepare documents, design forms, write programs, generate spreadsheets, and organize a database. The word-processing, report-processing, and database management functions are integrated with a programming language. Archimedes says you can add macros, templates, and data libraries.
Concept comes with software for word processing and mailing-list management, a pop-up calculator, a calendar, and an accounts receivable module.

The program runs on the IBM PC, XT, AT, and compatibles with 512K bytes of RAM. It also runs on PS/2s, and there is a multiuser network version.
Price: $1495 for single-user version; $2495 for three-user version; $1995 for every three users added.
Contact: Archimedes Inc., O'Hare Lake Office Plaza, 2350 East Devon Ave., Suite 242, Des Plaines, IL 60018, (312) 635-0715.
Inquiry 765.

A Micro-Based Management Information System

EMIS II (executive management information system) keeps databases of phone calls, letters, prices, invoices, delivery dates, when to call back, and buying cycles. It can offer you figures on sales, call activity, time spent on the phone, internal memos, averages, and summaries.

The Dossier is the program's central file. Stored in the Dossier are names, addresses, phone numbers, ZIP codes, titles, and greetings, along with information fields that you can designate. You can display past activity of the account with the files and include forms, memos, call dates, buying patterns, and other information.

EMIS II has three levels of security. The first requires that you have an operator code.
The second limits certain data segments to only those users who have optional passwords.
The third level lets managers limit access of certain functions.
The program uses the Btrieve Record Manager, which sorts by midpoints, moving you closer to the desired files than alphabetical sorting, according to the company. You can separate databases into data segments, and transfer files between data segments. You can also import and export ASCII information.
The program also has a forms- and report-producing capability.

EMIS II runs on the IBM PC, XT, AT, and compatibles with 512K bytes of RAM. It also runs on PS/2s, and there is a multiuser network version.
Price: $1495 for single-user version; $2495 for three-user version; $1995 for every three users added.
Inquiry 766.

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In the matter of full-duplex data communication at 9600 bps, a number of approaches have been discussed. There's the CCITT-approved V.32. There are even some "pseudo V.32s" around. Some suggest that, because of their somewhat lower cost, non-standard modems may be the answer.

At Universal Data Systems, our position is carved in stone: for full end-to-end compatibility, regardless of equipment source, standardization on true V.32 is the only workable solution. That's why the fully featured UDS V.32 is the acknowledged price/performance leader.

Our exclusive near-end/far-end echo cancellation techniques, combined with trellis coding, result in -17dBm signal-to-noise ratio; that's plenty of horsepower for voice-grade lines.

As back-up for your dedicated four- or two-wire system, or for a 9600 bps upgrade of your present dial-up communications, check out the UDS V.32. It's the standard!

Universal Data Systems, 5000 Bradford Drive, Huntsville, AL 35805. Telephone 205/721-8000; Telex 752602 UDS HTV. $1595.00 Quantity One

TELEPHONE 800/451-2369

Universal Data Systems
Take a Closer Look

Zoom in on your text with ZoomText, a RAM-resident character-magnification program. It magnifies text from 2 to 8 times its normal size, and three fonts let you vary the thickness and spacing between characters. When you use it with a monochrome monitor, ZoomText supports all character attributes including reverse video, high intensity, blinking, and underline. With a color monitor, ZoomText supports all foreground and background colors as well. ZoomText doesn't require any special hardware, according to Algorithmic Implementations. It runs on the IBM PC, XT, AT, and compatibles with DOS 2.0 or higher. It uses 50K bytes of RAM and requires an EGA card and compatible monitor.

Price: $495.
Contact: Algorithmic Implementations Inc., 1463 Hearst Dr., Atlanta, GA 30319, (404) 233-7065.
Inquiry 791.

Multitasking Word Processor

Jandi Technologies calls EPEC the first word processor in a multitasking windowing environment. EPEC stands for “editor for productivity, enjoyment, and creativity.”

The windowing system supports overlaid windows and concurrent multitasking. The word-processing features include underline, boldface, text reformat, word wrap, pagination, and multiple undo and redo. You can also edit across windows, moving text between documents, or you can edit the same document in separate windows, so you don’t have to scroll to edit.

Other editing features include editing an area as if it were a subdocument, so you can reformat or reshape it if you need to accommodate graphics. You can also generate cross-references by listing lines and line numbers that contain a specific text string. You can assign up to eight function keys as macros.

The program runs on the IBM PC, XT, AT, and compatibles with 256K bytes of RAM and DOS 2.0 or higher.

Price: $99.
Contact: Jandi Technologies Inc., 155-U New Boston St., Woburn, MA 01801, (617) 932-0629.
Inquiry 793.

Bridging CP/M and DOS

DosDisk lets you use DOS disks on your CP/M system, according to Plu*Perfect Systems. You can log into the PC disk and read, write, rename, create, delete, and change the attributes of MS-DOS files. You cannot, however, format DOS disks or run MS-DOS programs. DosDisk will read ASCII, dBASE II, WordStar, and other formats, and it maintains the date and time stamps of DOS files.

The program supports standard 360K-byte disks. A resident system extension version uses about 4.75K bytes of RAM, plus 2K bytes for the command processor. The program runs on many CP/M systems. If it doesn’t run on your system and you have experience in Z80 programming, you can purchase a kit version and configure it to your system.

Price: $30; kit version, $45.
Contact: Plu*Perfect Systems, 410 23rd St., Santa Monica, CA 90402, (213) 395-4984.
Inquiry 794.

Stay in Tune with the Weather

Accu-Weather Forecaster translates National Weather Service codes and lets you display them in maps and graphs.

To use Accu-Weather Forecaster, you need to set up an account with Accu-Weather. Metacomet reports that an average forecasting session will cost $2 in connect-time charges with Accu-Weather.

The forecasting program lets you preselect what data you want from the database; it goes on-line and retrieves it, saves the data to disk, and logs off. You can specify temperature, barometric pressure, precipitation, and other variables for the entire country, or you can zoom in on individual regions or cities.

Accu-Weather Forecaster runs on the IBM PC with 256K bytes of RAM, DOS 2.0 or higher, two floppy disk drives, a color or monochrome monitor, and a CGA card or compatible. A version is available for the Mac 512, Plus, and SE. A Hayes-compatible modem is required.

Price: $89.95 for either the IBM or Mac version.
Contact: Metacomet Software, P.O. Box 31337, Hartford, CT 06103, (203) 223-5911.
Inquiry 795.
Atlantic Research Corporation now provides the missing link for creating a TEMPEST local area network (LAN)—our high performance, dedicated, multi-function TEMPEST Network Server. The T5172 Network Server, a TEMPEST version of the 3Com Networking System, can run Ethernet and AppleTalk—simultaneously.

The T5172 does more than fill the gaps in your network:

- It is compatible with ARC TEMPEST Macintosh IIs and Macintosh SEs, as well as TEMPEST IBM PCs and TEMPEST Zenith PCs;
- It optimizes network productivity, eliminating problems of complicated installation and use, incompatibility and lack of connectivity;
- It provides program and data sharing, print spooling, electronic mail, tape back-up and network facilities to up to 50 users; and
- It provides serial and parallel ports as well as Ethernet and AppleTalk ports.

Best of all the T5172 TEMPEST Network Server is a product of Atlantic Research Corporation—the Better Way since 1947.
Capture It In Color

The VIA and VIA/PC are boards that plug into the IBM PC, PS/2, and compatibles and enable you to capture color images from National Television System Committee video sources. VIA is compatible with mode 13 of the PS/2 VGA and MCGA graphics chips and provides a resolution of 320 by 200 pixels with 256 colors.

According to the company, the boards acquire a 320-by-240-pixel image with 65,536 colors in 1/60 second; the software then selects the most common 256 colors in the image for display. Both boards occupy full slots.

Price: VIA, $595; VIA/PC, $545.

Contact: Jovian Logic Corp., 42808 Christy St., Suite 230, Fremont, CA 94538, (415) 651-4823.

Inquiry 843.

Get the Big Picture

With GrandView, you can create outlines and word-processing documents and find relationships in the data you've accumulated. The program's outlining capabilities include a seamless interface between headlines and documents. You can have up to nine outline windows open simultaneously, and you can organize headlines and documents using Prioritize, Headline Naming, Category Sorting, and Mark and Gather functions. You can also view your outline in a variety of numbering formats.

Among GrandView's word-processing features are style sheets, paragraph formatting, block operations, and custom headline labeling. You can create headers and footers, use different fonts and type styles, insert hard page breaks, and produce tables of contents.

The program lets you relate information by assigning outline or word-processing information to categories. You can track the categories throughout the project and view the information by any category you choose.

GrandView runs on the IBM PC, XT, AT, and compatibles with DOS 2.0 or higher, 256K bytes of RAM, and two continued
Breaking the Baud Barrier

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

Leigh Tracy

W

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

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

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

**Modems Run 4 Times Faster**

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

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

### TurboCom Facts:

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

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

Easy to Send and Receive

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

```
SEND FILENAME PHONE NUMBER
```

TurboCom is ideal as a fast, low cost mailing system between offices or companies. The sending PC is aware of how much disk space is available at the receiving end. If a file is transmitted with the same name and extension, TurboCom will assign it a unique extension, i.e., _1, _2, _3. If the receiving PC does not have sufficient disk space for the file you are sending, TurboCom terminates the phone connection, saving time and wasted money.

Increased modem speed allows you to save up to 75% on your telephone time and costs. Because TurboCom can be programmed for delayed unattended transmission for automatic sending, you can transmit data when telephone rates are lowest. PC to PC data is transferred perfectly because TurboCom was designed with an advanced error-free high speed protocol. Because of TurboCom's high speed, cost savings, flawless operation and sensational low $89.00 price to connect two PCs, I give this product my highest recommendation.

**Turbo Your Laptop**

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

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

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Datran Corporation
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JUNE 1988 • BYTE 88PC-3
floppy disk drives or a hard disk drive. 
Price: $295 . 
Contact: Living Videotext Division, Symantec Corp ., 117 Easy St., Mountain View, CA 94043, (415) 964-6300. 
Inquiry 846.

LAN Saves Scarce Slots

If you're looking for an inexpensive, slotless way to connect your microcomputers, SimpleNET's OnePlus LAN may be the solution. It enables you to connect up to 32 microcomputers using serial ports. The product consists of a signal converter, NETBIOS software, the SimpleWare Network Management System, and 25 feet of cable.

OnePlus lets you transfer data among network nodes at a rate of up to 115,200 bits per second. It utilizes RS-485 signals and is written in assembly language.

OnePlus features file-sharing, record-locking, and password-protection capabilities. It also includes electronic mail and supports run-length-limited (RLL) disk drives.

Designed for IBM PCs and compatibles, OnePlus requires DOS 3.1 or higher and takes up 140K bytes of RAM on the file server and 100K bytes on workstations.

Price: $174.95 per node.
Inquiry 841.

Power Pascal Programming

Borland’s Turbo Pascal 4.0 Developer’s Library includes rewritten Tutor and Editor toolboxes and new versions of the Database, Numerical Methods, Graphix, and GameWorks toolboxes. The toolboxes are organized in modules, enabling you to link them into your programs with Turbo Pascal 4.0’s Make facility.

The Database Toolbox supports databases with over 2 billion records. The Numerical Methods and Graphix Toolboxes enable you to analyze and graph data. The Editor Toolbox features a small modular editor you can build into applications, and an enhanced MicroStar editor.

The Developer’s Library runs on the IBM PC and compatibles with DOS 2.0 or higher, Turbo Pascal 4.0, and 256K bytes of RAM.
Price: $395.
Contact: Borland International, 4585 Scotts Valley Dr., Scotts Valley, CA 95066, (408) 438-8400.
Inquiry 844.

Study the SCSI

You can monitor phase interactions and data exchanges with the FS600 SCSI Bus Monitor. The unit is about the size of a hardback book and utilizes a 12-MHz CPU to perform disassemble analyses and other tests without wait states. It also includes an 8K-byte buffer that enables you to capture information and examine it by phase of bus, byte by byte, or using a fast-step function. You can print out raw data or phase information, disassembled bus states displaying data bytes, and disassembled bus states with the number of data bytes.

The FS600 measures 2.3 by 10.3 by 6.8 inches and weighs 5 pounds.
Price: $1800.
Contact: FlexStar Corp., 606 Valley Way, Milpitas, CA 95035, (408) 946-1445.
Inquiry 842.
Master your mailings in minutes

**LetterMaster™**

**4:39** “Susan—Send our sales letter to all buyers of apples and cherries in Washington and oranges or bananas in Florida, in time for today’s 5:00pm pick-up.—Mr. Wermer.”

**4:32** Mailing lists sorted.

**4:33** Lists merged and purged.

**4:38** Personalized sales letters printed.

**4:41** Labels printed.

**4:45** Mailing complete and ready for pick-up.

**5:00** “Susan—Good work on that mailing.

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*LetterMaster merges lists and purges duplications in a matter of seconds. It's incredible! I can create instant custom mailing lists with a few keystrokes!*

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LetterMaster prints off any list onto leading brand address labels. It prints Rolodex cards and file folder labels, too.

*LetterMaster operates with all the popular word processing programs. About the only thing it doesn’t do is lick the envelopes!* System requirements for single user: DOS 2.1 or higher, IBM PC or compatible, 512K RAM, system requirements for network: Workstation DOS 3.1 or higher, 512K RAM, xerox communications 8770, IBM compatible, or network disk drive.


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HARDWARE VS. SOFTWARE ENCRYPTION: The Federal Government has stated that security and encryption must be implemented in hardware to be considered truly secure. Software encryption systems are inadequate and are easily penetrated. They simply are not secure.

THE SYSTEM: DESTECH consists of two main components: a half size internal PC card, for IBM and 100% compatibles, PC/XT/AT/PS 386, and a data security utility program, which allows corporate management to designate computer file usage and multiple levels of security.

Applications

- Electronic Funds Transfer For Financial Institutions
- Secure Banking/Accounting Software
- Data Protection for Business Applications

- Mainframe Communications
- Secure Technical and Engineering Data
- Secure Client Information
- Software Protection

Features


ENCRYPTION/DECRIPTION KEY: User defined 8 digit security key consisting of letters, numbers, control characters, etc.

RELIABILITY: All boards are manufactured in the United States and must pass stringent testing procedures.

MENUS: An easy to follow graphic main menu permits users to invoke encryption/decryption functions without the intervention of manuals.

MULTI-LEVEL SYSTEM CONTROL: Allows up to 99 users.

SECURE DRIVE: Automatic Encryption/Decryption is transparent to user.

BATCH COMMAND: Allows files to be queued and encrypted or decrypted automatically.

DISK SCRAMBLER: Encrypts or decrypts an entire disk. Encrypted system disks will not boot.

TAMPER PROOF: Protection against accidental file modification.

DIRECTORY: Conveniently examine assigned security levels for all directories.

DIAGNOSTICS: Automatic encryption/decryption passes to insure error-free operation.

ADDITIONAL FEATURES: Compatible with PC/MS-DOS, Version 2.0 or higher, PS/2 System 30 - Power-Fail Protection - Secure Drive Operation - Secure Communications.

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Specifications are subject to change without prior notice.

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This device cannot be shipped outside the U.S.A. without authorization from the State Department and the Department of Defense.

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Circle 495 on Reader Service Card

JUNE 1988 • BYTE 88PC-7
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Complete System Packages

<table>
<thead>
<tr>
<th>SF-286</th>
<th>Monographs System</th>
<th>EGA System</th>
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<tbody>
<tr>
<td>8 MHz</td>
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<tr>
<td>10 MHz</td>
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<td>10 MHz (O w/ps)</td>
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<tr>
<td>12 MHz (O w/ps)</td>
<td>$1499</td>
<td>$1870</td>
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<tr>
<td>16 MHz (6036B)</td>
<td>$1950</td>
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Monographic System:
- Basic system features plus monographs card with printer port and 12” amber monochrome monitor with tilt/swivel base.

EGA System:
- Basic System features plus EGA deluxe graphics card (640 x 350) and Mitsubishi 1410C EGA monitor upgrade to Super EGA Bundle, at $150

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- Serial Mouse
- 150 Watt Power Supply
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- Memory board for PS/2
- Memory board for PS/2
- Memory board for PS/2
- Memory board for PS/2

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EGA Bundle $499
Everex EGA Deluxe autoswitch Graphics board, 132 columns PLUS Mitsubishi 1410C EGA monitor

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Everex Modems

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<tr>
<th>Everex Evercom half card modem, 300/1200 baud, fully Hayes compatible and Silicon software.</th>
<th>Emergency Pocket Modem $139</th>
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Seagate ST205 20MB $1699
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Seagate ST205 40MB (40ma) $829
Seagate ST205 20MB (40ma) $299

Call

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The answers can be found in “The Second Beginner’s Guide to Personal Computers for the Blind and Visually Impaired” published by the National Braille Press. This comprehensive book contains a Buyer’s Guide to talking microcomputers and large print display processors. More importantly it includes reviews, written by blind users, of software that works with speech.

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<table>
<thead>
<tr>
<th>COLOR MONITOR</th>
<th>RES.</th>
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<tbody>
<tr>
<td>CM 1222N</td>
<td>640 X 200</td>
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<tr>
<td>CM 1370A</td>
<td>720 X 400</td>
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<td>CM 1380F</td>
<td>640 X 350</td>
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<td>CM 1495</td>
<td>800 X 560</td>
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<td>MM 1295</td>
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<th>TERMINAL</th>
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<td>14&quot; Color Monitor</td>
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<tr>
<td>4 MULTI-COLOR MODE</td>
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<td>12&quot; Mono Monitor</td>
<td>RES: 800 x 560</td>
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<td>ZENITH 181/183-20</td>
<td>AST PREMIUM 286/386</td>
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<td>$1449/$2229</td>
<td>512K RAM, 1.2 floppy, 40 MB Fast HD, 320 MB Hard Disk, mono monitor, DOS 3.2, GW Basic</td>
<td>512K RAM, 1.2 floppy, 40 MB HD full monochrome system</td>
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<td>ZENITH FLAT SCREEN MONITOR CALL</td>
<td>386 Model In Stock</td>
<td>$2179</td>
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<td>IN STOCK! WYSE 386/WYSE Terminals</td>
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<td>TOSHIBA 1000</td>
<td>Model D Hard Disk Full Mono System $1195</td>
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<td>$749</td>
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<td>NEC Multispeed EL $1595</td>
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<td>NEC Multispeed 20MG $2435</td>
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- LONGREAL
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- Structured constants
- Array slices
- Wirth edition 3 implementation

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"Stony Brook’s is a terrific compiler... This experience with Stony Brook’s Modula-2 sold me on the product."

"The Stony Brook Modula-2 compiler is remarkably impressive... Initial tests indicated this compiler is competitive with Microsoft C 5.0 and Borland's Turbo C 1.5 in compilation time and code efficiency."
- Gene Haltiwanger, Journal of Ada, Pascal and Modula-2, March–April, 1988

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<th>Price (Mon/Color)</th>
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<td>PS II Model 30-002/021</td>
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<td>PS II Model 60-44MB/70MB</td>
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<td>AT 339 (BMHZ, 512K, 30MB)</td>
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<td>XT 2DR. 256K./089</td>
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<td>Mono. Disp. 8503/XT Style</td>
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### Seagate

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<td>20MB/30MB W/Controller</td>
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<td>30MB/40MB (4038/4051)</td>
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<td>40MB (ST251)/40MB (4053)</td>
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<td>80MB (4090)/80MB (277R)</td>
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### Compaq

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<td>IBM DOS 3.3</td>
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### Intel

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<td>$92/160</td>
</tr>
<tr>
<td>8087-2 XT/80287-6 AT</td>
<td>$145/249</td>
</tr>
<tr>
<td>80267-10 AT 10MHZ</td>
<td>$299</td>
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<tr>
<td>80337-16 for 80386</td>
<td>$455</td>
</tr>
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<td>80337-20 Base Systems</td>
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### OKIDATA

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (Mon/Color)</th>
</tr>
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<tbody>
<tr>
<td>182/182S 120CPS, 30nlq</td>
<td>$225/269</td>
</tr>
<tr>
<td>192 +193D 200CPS, 40nlq</td>
<td>$259/319</td>
</tr>
<tr>
<td>222E/293E 200cps, 100nlq</td>
<td>$359/489</td>
</tr>
<tr>
<td>393/393 Color 450 cps</td>
<td>$945/1029</td>
</tr>
<tr>
<td>ML294/ML2410</td>
<td>$727/799</td>
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<tr>
<td>Lazer Line 6</td>
<td>$1299</td>
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### IRWIN TAPE BACK UP

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (Mon/Color)</th>
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<tr>
<td>10 MB, Inter/External</td>
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<tr>
<td>20 MB, Inter/External</td>
<td>$325/455</td>
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<tr>
<td>40 MB, Inter/External</td>
<td>$459/535</td>
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<tr>
<td>Call for PS/2 Tape Back Up Units</td>
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<tr>
<td>Call for Archive, Tecom, Syenex</td>
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### Toshiba

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<td>321SL/341SL (216CPS)</td>
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<tr>
<td>351-SX351-2 Color</td>
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<tr>
<td>Toshiba T1000/T1100</td>
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<tr>
<td>T1200/T1320</td>
<td>$2295/2590</td>
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<td>T1220/T1500</td>
<td>$3675/4695</td>
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<tr>
<td>Toshiba Modern-Compatible</td>
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### NEC

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<th>Model</th>
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<tr>
<td>Multispeed EL/HD</td>
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<tr>
<td>Multisync II/Plus +</td>
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<tr>
<td>Multisync PC XL 20 +</td>
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<td>LC660/LC890</td>
<td>$1899/1915</td>
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<td>P760/P2200</td>
<td>$599/833</td>
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### Data

<table>
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<tr>
<th>Model</th>
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<td>88PC-14 BYTE • JUNE 1988</td>
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### Lotus 1-2-3

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### Lotus Symphony

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</thead>
<tbody>
<tr>
<td><strong>$259</strong></td>
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</tbody>
</table>

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A Color Paint Application for the Mac II

SuperMac Software’s PixelPaint does for color graphics on the Mac II what MacPaint did for the original 128K-byte Mac in black and white: It lets you draw in color using a simple user interface. The lasso, marquee, grabber, bucket, spray can, brush, pencil, and eraser tools that you used in MacPaint are included. You still have the ability to enter any style of text and draw lines of any thickness or direction, as well as rectangles, ovals, polygons, and freehand shapes.

However, these tools come with new capabilities, thanks to color. You can pick 256 colors out of a palette of 16 million for the bucket, spray can, brush, and pencil to use. You can draw the shapes in any color or have them filled with color as you draw them. PixelPaint also has two new tools: the eyedropper (click it on a particular color to use the same hue in a new spot—a lot simpler than trying to remember the color’s RGB values) and the arc tool (handy for drawing arcs or Bézier curves).

PixelPaint’s real power lies in this: Click on the box labeled Normal Tools and it becomes Special Effects, and these tools take a quantum leap in color capabilities. Now the bucket tool can do color blends, with the blend effect (e.g., top-to-bottom, left-to-right, sunburst, and venetian blinds) determined by selections in the option menu.

Spray can and brush operations cycle through the entire spectrum of colors as they work, or within a user-selected range of colors. With the brush, you can also perform shadow, charcoal, wash, smooth, shade, and smear effects. Lines can be drawn as fractals, radials, and neon (a line with colored edges that resembles a neon tube), as well as the cycle effects just described. Properly handled, these Special Effects yield color images whose appearance can only be described as breathtaking.

PixelPaint prints to PostScript devices like Apple’s LaserWriter and the Linotronic 100 and 300. I successfully printed a color image to a networked LaserWriter and got the expected gray-scale image. Printing to the Imagewriter II is not supported because PixelPaint images can have up to 256 colors, which is beyond the ability of the Imagewriter II to reproduce accurately. PixelPaint can open MacPaint, PICT, and encapsulated PostScript files, letting you import graphics from Mac applications like MacDraw, Adobe Illustrator, and Cricket Draw.

At a price of $495, you’d expect copy protection on such a product. But in a bold move on SuperMac’s part, PixelPaint was introduced without copy protection. The diligent user can produce publication-quality color graphics of great sophistication with PixelPaint. If you bought a Mac II to do professional graphics, you’ll do well to make PixelPaint your first software purchase.

—Tom Thompson

Don’t Be Intimidated by OS/2

The Norton On Line Programmer’s Guides: OS/2 API ease the task of learning and using OS/2 functions. The database of information is organized alphabetically and logically. While the alphabetic listing is valuable for experienced OS/2 programmers, the logical organization of the information is great for those of us who are trying to figure out what’s going on with this new operating system. One of the most valuable features is a cross-referencing line that points you to information related to what’s currently on the screen.

The program is menu-driven, and you can choose to start with an introduction to OS/2. It gives a brief summary of what OS/2 and DOS have in common and what’s different, lists which OS/2 function calls correspond to which DOS interrupts, and includes a section discussing 15 areas of OS/2 (e.g., multitasking and semaphores). The related function calls are grouped for each of the 15 areas.

From the menu, you can choose system, file, mouse, and video calls. The first level in each group is an alphabetic list of the function calls, followed by a short description. The second level gives you a detailed discussion of the function, including what parameters it requires, what it returns, what include files it needs, and whether it works in DOS mode.

continued
This is followed by an actual example of using the call, both from C and assembly language.

Other useful information you can find under the reference menu includes a complete list of the IOCTL functions (functions for sending device-specific commands to a device driver), a discussion of OS/2 device drivers and related functions, and the error and return codes for DOS 2.x, DOS 3.x, and OS/2. There is also a menu item for the ANSI escape sequences, the CONFIG.SYS commands, and the OS/2 structures, which are the predefined C structures that OS/2 function calls use to pass data to and from functions.

The package includes a version of the program for OS/2 mode and for DOS mode. In OS/2 mode, you can install the Norton Guides as a pop-up program that is available to all OS/2 screen groups or as a stand-alone application in one OS/2 screen group. When you run the Guides as a pop-up program, you activate them with a hot key (Shift-F1), and while the Guides are activated, the OS/2 hot keys for switching to another screen group are disabled until you leave the program.

The disabling of the screen group hot keys is a function of the OS/2 pop-up call; tasks continue to run in the background. If you want to be able to switch screen groups while the Guides are on the screen, you can install them as an application. The two methods of running the Guides let you have two databases open on the screen at the same time.

In DOS mode, you can have the Guides as a terminate-and-stay-resident (TSR) program that takes up about 65K bytes of RAM; you can easily remove it from memory if you need the space.

Other features include a compiler and a linker that let you create custom databases. There is a full-screen and a half-screen mode, and you can search for all or part of a keyword. An auto-lookup feature looks up the word under the cursor when you activate the Guides.

I highly recommend this program. Using it is an order of magnitude easier than thumbing through the OS/2 manual to get the information you need. The interface is intuitive, and the information is presented in a clear and even conversational manner.

### The Facts:

**The Norton On Line**

**Requirements:**
- IBM PC or compatible with DOS 2.0 or higher, or OS/2.

$150 with Instant Access Engine; $100 without engine

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

### Requirements:
- Programmer's Guides: IBM PC or compatible with OS/2 API
- DOS 2.0 or higher, or OS/2.

### FreeHand

FreeHand. Sounds like a light, fun sort of drawing program, right? Well, don’t let the name fool you. We’re talking serious drawing here. This is a Macintosh package for people who need to produce clean art and copy that are ready to go to the print shop.

The folks at Aldus may not like this comparison, but FreeHand is similar to Adobe Illustrator in that it uses a connect-the-dots approach. This is great for working up a polished version of a rough sketch. You scan the sketch, bring it into FreeHand, and then trace it. The program is like a multidimensional tracing pad.

The tricky part is doing the tracing. You can put down points (dots) on the object you’re tracing and then connect the points using various tools, or you can use the freehand tool that lets you draw by dragging the mouse. I found both methods to be awkward, but it’s not Aldus’s fault that the mouse is like drawing, as someone said, with a brick.

The FreeHand toolbox is geared toward building drawings using straight lines, curved lines, angles, diagonals, and shapes (squares, ellipses, and boxes with rounded corners). Transformation tools let you rotate, stretch or compress, slant, and reflect images. A text tool lets you add type to a drawing; it’s a basic Mac-style editor that lets you change fonts, specs, and even colors.

The program’s color capabilities make it a serious program for pre-press work. A print shop handles color in two ways: spots of one color here and there on an illustration, or process color, which basically breaks an image into tiny dots and colors them with a mix of four pigments that tricks the eye into thinking it’s looking at one color. FreeHand will let you set up a drawing to use spot or process color. (Adobe Illustrator 88 is supposed to have some of these same capabilities that make FreeHand shine, but we’re still waiting for it.)

There’s no room here to describe how the program does

### Drawing on the Mac

**The Facts:**

FreeHand 1.0

$495

Aldus Corp.
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This, but it lets you mix basic colors on your screen to get the shades you want. On a black-and-white screen, you get black, white, and gray instead of red, green, cyan, turquoise, or whatever. The program comes with a chart that shows you how to mix basic colors to get not-so-basic colors. The folks who wrote the FreeHand manual do a good job of explaining this whole process, but if you're not familiar with how color printing works, you should talk with someone who is before you take your copy down to the print shop.

FreeHand can send output to a PostScript device or to QuickDraw printers like the Imagenwriter. You can adjust the resolution so that a printer can make plates with the copy you provide. Setting up a drawing for printing is relatively easy.

As a way of converting a sketch into camera-ready copy, FreeHand is great. One of the things that's supposed to distinguish this package from, say, Adobe Illustrator, is its set of freestyle drawing tools. In other words, you can use this software to draw (rather than just trace), edit, and enhance pieces of art done outside the program.

As far as drawing and painting ability goes, I think there are better stand-alone programs with these capabilities than FreeHand. In software heaven, you'd have both: a good graphics package—like MacPaint, SuperPaint, or GraphicWorks—to create your original art, and FreeHand to get the art ready for the printer. However, the real world is not software heaven, and we mortals must pay for programs.

If I needed a package for drawing and painting and didn't need to worry about sending multi-layered illustrations to a print shop, I'd go with something else. But for serious stuff that's bound for the printing press, things like technical diagrams or ad copy, FreeHand wins hands down. If I needed both, I'd buy FreeHand and hope that Aldus adds some better freestyle drawing tools next time around.

-D. Barker

A Hand-Held PC Compatible

The Datacomputer is a portable computer designed for data collection and portable processing. It uses the same CPU as an IBM PC, so you can develop programs on the PC and download them to the Datacomputer. Its small size and ergonomic design make it a true hand-held computer.

Transferring programs to the Datacomputer is simple. I connected my AT to the Datacomputer with an RS-232C cable. Then I ran the data transfer program on the AT. Next I selected the Load Program function from the Datacomputer's on-screen menu. The NDCDL program can automatically download a program to the Datacomputer at 9600 bits per second (the default setting) using the XMODEM protocol. NDCDL also has an optional mode for interactive commands to change the COM port used, path names and filenames, and the data transfer rate. I could also connect one Datacomputer to another for a program transfer.

The computer uses an 80C88 microprocessor and a CMOS version of the 8088, and it has 128K bytes of RAM, expandable to 960K bytes with optional memory modules. The screen is a backlit 26-character by 8- or 10-line liquid crystal display. The keyboard includes a full-size numeric keypad and a small QWERTY keyboard. The unit measures 10 by 5 by 1½ inches and weighs 35 ounces. It is powered by either four or eight AA alkaline or nickel-cadmium batteries.

External connections to the computer include an 8-pin DIN serial printer port, a DB-25 RS-232C serial port, a DB-9 bar code scanner port, an optional RJ-11 modem jack, and a
Coming from Lotus.
The Facts:
Datacomputer DC 3.0
128K bytes of RAM, $1995;
384K bytes, $2245;
640K bytes, $2495;
960K bytes, $2795;
Developer's Kit, $2245...

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SHORT TAKES

Two TSRs to Help You Manage the RAM Traffic Jam

The Facts:
PopDrop 3.1
RAM Lord
$49.95
$99.95

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

Managing the gaggie of memory-resident programs that resides in a typical IBM PC’s RAM is about as much fun as keeping tabs on a room full of kindergarten kids. TSR programs are often a badly behaved lot when you force them to work together. They stomp on each other’s electronic toes, greedily grab for identical interrupts and precious memory space, and even throw tantrums by completely locking up your system.

OS/2 is supposed to eliminate all this so-called RAM cram. But in the meantime, you either have to live with it or take action. If you opt for action, remedies can come in the guise of two programs (themselves memory-resident) designed to deal with TSR discipline.

InfoStructures’ PopDrop has been around for a few years, and version 3.1 is a completely new incarnation. It has developed into an effective and useful program with an elegantly simple user interface. Each time you run PopDrop, it generates a record of your system’s RAM status (taking up about 600 bytes of RAM space the first time it’s used; about 200 bytes thereafter). Then you load one or more of your resident programs “on top” of it. You can create layers of TSRs in your system RAM by simply rerunning PopDrop at any point. All the TSRs you’ve loaded between invoking the program become a layer.

But no matter how clever TSR programs like PopDrop are, the programs are often a badly behaved lot when you force them to work together. They stomp on each other’s electronic toes, greedily grab for identical interrupts and precious memory space, and even throw tantrums by completely locking up your system.

In contrast to PopDrop, RAM Lord from Waterworks Software takes a different and unique approach to managing TSRs. It lets you have access to up to 20 RAM-resident programs while taking up only the RAM space that the largest single TSR requires (plus 26K bytes for itself). For example, let’s say you use a dozen TSRs regularly, and the largest takes up 50K bytes of memory. In this case, RAM Lord would keep a 76K-byte kernel in RAM. You use your TSRs just as you always have, but instead of their all being crammed into the RAM, RAM Lord keeps copies of the actual programs in a swap area on your disk.

RAM Lord works quietly and well. Its major disadvantage is speed. Because it’s storing your RAM-resident programs on

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SHORT TAKES

Delta’s Mini Modem: A $99 Powerhouse

W hen I first looked in the Delta Voyager’s box, I didn’t intend to review the tiny modem that sat inside. But after hooking it up to a Toshiba T1100 Plus, I knew this was a product I had to write about. The little powerhouse costs only $99, recently reduced from $149. It’s about the size of a cigarette pack (2½ by 1 by 3½ inches) and runs on a 9-volt battery, off a car’s cigarette lighter, or off an AC adapter. It weighs about half a pound.

Delta Voyager is a Hayes-compatible 300-/1200-bps modem that has 28 characters of nonvolatile configurable memory, remote ring, tone sensing, a low-battery light, and dial-tone monitoring. Also, it’s compatible with Bell 103 and 212 and CCITT V.21 and V.22 standards. It operates in full- or half-duplex mode.

To install the modem, you hook it directly into the RS-232C port, with modular RJ-11 telephone cable connecting to the phone line. It’s a little awkward, sticking straight off the back of the computer, and it seems like it might be too heavy to stay attached to the RS-232C port. At just 8 ounces, however, it stayed attached, and I had to allow just about 4 inches between my computer and the wall.

Delta reports that you can operate under battery power for up to 10 hours. I didn’t try any marathon sessions, but I used it on a daily basis for 2 weeks with no trouble whatsoever. A shrink-wrapped 9-V alkaline battery is included, along with telephone cable and a DB-25-to-DB-9 adapter. Delta also offers an external 9-V AC adapter as an option, although you can use any standard adapter with an external plug (I used the one that came with the Toshiba). Procomm 2.4.2 also comes with the modem.

Used with a battery-powered portable computer, the Delta Voyager gives you complete flexibility in telecommunications. The only feature the Voyager lacked that I missed having was a speaker. But at $99, this modem is hard to beat.

—Anne Fischer Lent

The Facts:
Delta Voyager (DM-1200)  Options:
$99  AC adapter, $4.95

Delta Computer Corp.  AC adapter, $4.95
260 Forbes Blvd.
Mansfield, MA 02048
(617) 339-5575
(800) 255-3358
Inquiry 857.

disk, there’s a perceptible delay when you press a hot key. On a fast AT the delay isn’t objectionable, but on my disk-based laptop it was uncomfortably slow. That disadvantage essentially disappears if you have extended or expanded memory available. Then RAM Lord keeps its swap area there, with no perceptible delay.

If you regularly use more than a few RAM-resident programs, you need one of these programs. At $49.95, PopDrop is reasonably priced, but it requires regular interaction. Although RAM Lord costs twice as much, it is well worth the extra bucks. Once you’ve installed it, you can forget about it as it quietly and firmly manages your RAM space.

—Stan Miaskowski
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DSC NEXOS meets or exceeds the performance of today's fastest LANs on all types of application packages, due to the speed of the 20 MHz 386-based NEX/Server™ and high-performance NEX/Link™ interface cards. Network response stays lightning-quick, even during peak demand periods. The NEX/OS™ operating system also contains a powerful performance bonus: a "database engine" which can process data at the server. Only the needed data is transmitted, not the whole file. This cuts network traffic, unlocks files in milliseconds instead of minutes, and speeds processing up to 600% on databases which utilize this facility. (Current listing of databases which utilize the DSC NEXOS database engine available on request.)

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High-Speed Modems

John H. Humphrey and Gary S. Smock

We fly to Paris in 4 hours, seal deals by facsimile in minutes, and can't stand to wait more than 24 hours to get important mail. It's not surprising that high-speed modems, able to accurately send 3 megabytes across the country in less than an hour, are the fastest growing segment of personal computer communications.

The advantages of high-speed modems are clear: substantial savings in communications charges and in time. Until recently, these high-speed units have commanded premium prices, but prices have fallen sharply during the past year. The 13 modems we review here send data at a rate of at least 9600 bits per second and range in price from about $900 to over $2000.

But as in any field of rapid growth, standards and uniformity among high-speed modems have lagged behind in the rush to provide the most impressive performance for the most palatable price. Unlike the highly standardized 1200- and 2400-bps modems we're used to, most high-speed modems work at top speed only when communicating with another such modem. The incompatibility is due to the push for greater performance at a given price and to the use of several competing—and confusing—standards for high-speed data communications.

A Good but Shortsighted Start

The central force for standardization in the communications industry is the CCITT, headquartered in Geneva, Switzerland. In 1976, the CCITT drafted the first standard for 9600-bps modems. This recommendation (V.29) was designed to speak specifically to modems operating at 9600 bps over 4-wire, leased-line facilities with synchronous data.

In 1984, the CCITT adopted another standard (V.32), which provides for a 9600-bps modem to be used on dial links. V.32 includes avant-garde communications technology known as echo cancellation to achieve full-duplex operation over 2-wire facilities.

Echo cancellation makes extensive use of high-speed digital signal processors (DSPs). Both sending and receiving modems transmit simultaneously at identical carrier frequencies, and the inbound and outbound data signals clash and overlap, interfering with one another.

The modem knows what signals it just transmitted, transmitted 100 milliseconds ago, transmitted 2 seconds ago, and so on. It creates scaled and inverted copies of the waveforms that it transmitted and adds these into the received data stream to cancel the interference from its transmitter, leaving only the incoming signal for its receiver to process. This is an incredibly complicated task that typically requires the service of DSPs with performance in the range of 25 to 50 million instructions per second.

As published today, V.32 does not provide rules regarding the use of asynchronous data, which was left for “further study.” Basically, the CCITT did not foresee the rapid buildup in end-user demand for a moderately priced, asynchronous, 9600-bps, dial-up modem. At the time V.32 was adopted, high-speed modems were predominantly the realm of corporate users, where physical size, price, and power consumption were of secondary importance to solid analog performance, consistent reliability, and growth flexibility.

But user demand for 9600-bps communication has been growing faster than the ink was drying on V.32. modem manufacturers, struggling with the technical impact of designing reliable echo-cancelling circuits, have chosen to offer stopgap alternatives to feed user demand during the interim period required to design and cast echo-canceling circuits into inexpensive silicon building blocks.

Today, V.32 modems are beginning to ship in increasing numbers. They are still bulky, power-consuming, and expensive. Most manufacturers have jumped the gun, designing in asynchronous (i.e., synchronous/asynchronous) converters to allow the modem to use asynchronous data. A number of smaller, lower-cost 9600-bps modems are also available, the product of stopgap design efforts.

Competing Modem Techniques

To achieve high-speed dial-up communications for personal computers, there are three core requirements: an asynchronous interface, full-duplex operation, and a reliable and inexpensive modem engine capable of working under dial-up line conditions.

V.32 achieves the first two objectives but falls down in the third area. To get around the R&D investment required to develop a true V.32 modem, many manufacturers have elected to produce high-speed modems that are not compatible with V.32 but that do provide 9600-bps operation. These manufacturers use one of four modulation approaches that provide alternatives to the V.32 standard. (For more information on the theory and technology of the competing techniques, see the text box “High-Speed Modem Modulation” on page 106.)

V.29 and V.32 Revisited

The first—and most popular—modulation approach involves changes to V.29 core engines, which are available in chip sets from several sources. V.29 chips were originally tooled to serve modem manufacturers' needs for conventional 4-wire, leased-line, synchronous modems and for fax machines.

Two techniques, ping pong and statistical duplexing, are used to build V.29-based 9600-bps microcomputer modems. continued
Hayes V-Series Smartmodem 9600

Fastcomm Turbo 2496

Case 4696/VS

Ven-Tel EC18K-34

Microcom AX/9624c

USRobotics Courier HST

Racal-Vadic 9600VP

Data Race Race BMX-VM

Telcor Accelerator 2496MA

Data Race Race VM I

Telebit TrailBlazer Plus

Telenetics 9600E/V.32

Concord 296 Trellis
Both start with a core V.29 engine and build an isochronous converter onto it. V.29 is intrinsically half-duplex, however, and a method to simulate full-duplex operation is needed. This is where the two V.29 approaches differ.

In the ping pong approach, data you send to the modem is buffered. The two modems automatically switch their carriers on and off rapidly, exchanging data each time they have the link for transmission. A form of ready/busy flow control is used between the modem and your computer to prevent you from losing data.

Statistical duplexing uses a low-speed reverse channel, which is added at frequencies above or below the V.29 engine's pass band. The reverse channel is intended to handle data at up to 300 bps, and is there to service data at keyboard rates. Should a conversation change dynamically (i.e., you were inputting and receiving file data, but now your partner is inputting and receiving file data), the modems sense this change by watching the relative queue length of their I/O buffers. The modems exchange control information to swap the assignment of their high-/low-speed channels.

A second approach used by a few firms makes use of the technically easier to design portions of V.32's modulation. The key technical problem with V.32 is echo cancellation, which is required for full-duplex operation. One modification uses V.32 without echo cancellation and employs the ping pong approach to simulate full-duplex operation. The other method grafts a low-speed reverse channel onto the core V.32 high-speed center channel to handle keyboard input.

**Please Squeeze the Data**

The third approach involves data compression. Although a number of the modems we tested offer some form of data compression, what if we can get a really big “squish”? Data compressors find clever ways to shrink 10-bit ASCII data to, say, 4 or 5 bits for transmission, then convert back to 10 bits at the other end. They look for repeated strings in the original string when received. If the compression algorithm is efficient enough to absolutely guarantee a four-to-one advantage, modem makers don’t have to use fancy high-speed modem engines at all. With a guaranteed 4-to-1 compression, they can get by with low-cost V.22bis (standard 2400-bps) technology that now exists. The drawback to this is that you need a similar modem at the other end of the link to achieve 9600-bps speeds. An unexpected benefit is built-in compatibility with existing 2400-bps modems operating without compression.

**Multicarrier Technology**

The fourth approach borrows from spread spectrum communications technology used by the military in secure communications systems. This technology breaks the data into discrete pieces and spreads them across the available bandwidth on separate carrier frequencies, keyed at different time intervals. This requires the enemy to know which spreading algorithm is being used to recover the individual pieces of the communication. Without the correct algorithm, the transmission looks like random noise.

Modems using multicarrier technology spread the telephone bandwidth with hundreds of individual carrier tones, each of which is modulated quite slowly. Digital data is fed to the modem and buffered. Individual bits are fed to the multiple carriers and data is passed over the link in n-length, bit-parallel fashion.

The advantage of this approach is its ability to “map around” bad spots in telephone lines. If discrete portions of the telephone line are of poor quality, the modems recognize this and simply do not place carrier tones in those areas. In theory, this lets the modems operate at full speed under good line conditions and slowly fall back under poorer line condi-

---

**Table 1: The modems reviewed use a variety of techniques to achieve high-speed data transfer. Prices vary as well, from a low of $895 to a high of $2295.**

<table>
<thead>
<tr>
<th>Chip set</th>
<th>Concord 296 Trellis</th>
<th>Data Race BMX-VM</th>
<th>Data Race VMI</th>
<th>Fastcomm Turbo 2496</th>
<th>Hayes V-Series Smartmodem 9600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum input speed (bps)</td>
<td>19,200</td>
<td>19,200</td>
<td>19,200</td>
<td>19,200</td>
<td>19,200</td>
</tr>
<tr>
<td>Error correction</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Data compression</td>
<td>Optional</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Duplexing technology</td>
<td>Statistical</td>
<td>V.32</td>
<td>V.27 asymmetric</td>
<td>Dynamic</td>
<td>V.32 HDX</td>
</tr>
<tr>
<td>Compatibility</td>
<td>V.29 and V.27 with statistical duplexing, V.22bis, V.22, 212A, and 103 optional</td>
<td>Data Race units, V.29, (V.22bis, V.22, 212A, and 103 optional)</td>
<td>Data Race units, V.29, (V.22bis, V.22, 212A, and 103 optional)</td>
<td>Fastcomm units (speeds above 2400 bps), V.22bis, V.22, 212A, 103, and V.29</td>
<td>Hayes V-Series Smartmodem 9600, V.22bis, V.22, 212A, and 103</td>
</tr>
<tr>
<td>Price</td>
<td>$1395 w/ data compression</td>
<td>$1795</td>
<td>$995</td>
<td>$1245</td>
<td>$1195 w/ options</td>
</tr>
</tbody>
</table>
HIGH-SPEED MODEMS

The 13 modems we tested for this review all use at least one of the modulation approaches discussed above. When you look at the features for each modem in table I and the results of the tests we ran, remember that high-speed data communications must be tailored to individual situations. Before you purchase a high-speed modem (or a set of modems), take a careful look at precisely how the features and performance of a system will match your needs. That said, let’s look at the modems.

Case 4696/VS: The Case 4696/VS is a full- or half-duplex V.29 modem with statistical duplexing that operates at speeds of 300, 1200, 2400, and 9600 bps. Data compression and error correction are provided through the six classes of MNP (Microcom Networking Protocol) that this product supports. This unit provides the Microcom SX and the AT command sets, and it is compatible with Microcom's AX/9624c and other conventional V.22bis, V.22, Bell 212A, and Bell 103 modems.

Concord 296 Trellis: This is a true full-duplex V.32 product with MNP class 4. It features an AT command set, a Concord command set, and operates either asynchronously or synchronously at 4800 or 9600 bps. It supports 2-wire dial or leased-line operation.

Data Race Race BMX-VM: The BMX-VM operates in half-duplex V.29 mode and uses a high-speed line-turnaround technique to simulate full-duplex operation. The modem has an AT command set, a BMX command set, error detection/correction, data compression, and flow control. It supports V.29 and V.27, and an option adds V.22bis, V.22, Bell 212A, and Bell 103 compatibility.

Data Race Race VM I: The Race VM I employs error detection/correction, data compression, and flow control to offer full-duplex asynchronous communication. It features an AT command set, a Race command set, and supports connection to either dial or leased 2-wire lines. An option is available for V.22bis, V.22, Bell 212A, and Bell 103 compatibility. Half-duplex synchronous operation is possible when the modem is operating in its V.29 mode at 4800, 7200, and 9600 bps.

Fastcomm Turbo 2496: The Turbo 2496 uses a design based upon the V.29 recommendation and simulates a full-duplex asynchronous channel by using a proprietary modem-to-modem protocol with error detection and correction when operating at speeds greater than 2400 bps. The unit features an AT command set with some additional extensions, flow control, and compatibility with other modems at 0 to 300, 1200, and 2400 bps.

Hayes V-Series Smartmodem 9600: This Hayes modem uses a modified V.32 design that provides full-duplex transmission at 0 to 300, 1200, and 2400 bps, plus half-duplex transmission at 4800 and 9600 bps. At the higher speeds, a ping pong protocol is used to simulate full-duplex operation. This product is compatible with all earlier Hayes products and with modems that support the V.22bis, V.22, Bell 212A, and Bell 103 modulation. In addition to having true Hayes AT commands, the modem features error control, flow control, and adaptive data compression.

Microcom AX/9624c: The Microcom AX/9624c supports the V.22bis, V.22, Bell 212A, Bell 103, V.27, and V.29FT (fast train) modulation standards and provides its own SX command set, as well as an AT command set. Fast train is a technique within the V.29 standard that provides for an abbreviated handshaking between sending and receiving modems. This modem supports MNP classes 1 through 6 and provides data compression and error correction. The AX/9624c is compatible with the Case 4696/VS.

<table>
<thead>
<tr>
<th>Model</th>
<th>Modulation Support</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcom AX/9624c</td>
<td>V.22, V.22bis, V.27, Bell 212A, Bell 103</td>
<td>AT command set, error correction, data compression, flow control</td>
</tr>
<tr>
<td>Racal-Vadic 9600VP</td>
<td>V.32, V.29, V.22, Bell 212A, Bell 103</td>
<td>AT command set, error correction, data compression, flow control</td>
</tr>
<tr>
<td>Telco Accelerator 2496MA</td>
<td>V.29, V.22</td>
<td>AT command set, error correction, data compression, flow control</td>
</tr>
<tr>
<td>Telebit Trailblazer Plus 9600E/V.32</td>
<td>V.29, V.22</td>
<td>AT command set, error correction, data compression, flow control</td>
</tr>
<tr>
<td>Telenelec EC18K-34</td>
<td>V.29, V.22</td>
<td>AT command set, error correction, data compression, flow control</td>
</tr>
<tr>
<td>USRobotics Courier HST</td>
<td>V.29, V.22</td>
<td>AT command set, error correction, data compression, flow control</td>
</tr>
<tr>
<td>Ven-Tel</td>
<td>V.29, V.22</td>
<td>AT command set, error correction, data compression, flow control</td>
</tr>
</tbody>
</table>

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continued
High-Speed Modem Modulation

How high-speed modems work is a complete mystery to many people. The electrical fundamentals are straightforward. The real tricks involved lie in consistently and reliably demodulating the signal over a broad range of receiver conditions caused by telephone line conditions that can vary in real time on a given call.

Envision a sinusoid of fixed frequency whose phase is changed at discrete time intervals (the baud rate). If we are careful to sample the waveform at these periodic and discrete baud intervals, we can measure the phase changes that represent the data.

Figure A shows a sinusoidal signal that has been phase-modulated to produce +90, +180, and +270 degree relative phase shifts over three successive baud intervals. If we preassign digital meanings to the relative phase changes (0 = 0, 0; 90 = 0, 1; 180 = 1, 1; and 270 = 1, 0), we have encoded digital information and are sending data faster than the fundamental data transfer rate. Here, 2 bits of information (a dibit) is exchanged on each baud interval.

If we increase the encoding density (tribits and quadbits), we can send even more information per baud interval. The baud rate is restricted by the fixed bandwidth of the telephone line; the rate of information exchange is not. The price we pay for higher encoding densities is the complexity of the modem's hardware—being able to differentiate between smaller discrete signal differences.

In the example shown, the modem need only differentiate between 90-degree shifts. If we carried the example one step further (tribit encoding), the modem would have to slice the phase domain into eight pieces ($2^3 = 8$). Such a modem would need to be able to distinguish between 45-degree phase differences.

Modems don't actually shift a single sinusoid. They make use of vector algebra by summing quadrature components. Suppose we have two signals (A and B) of identical frequency that are 90 degrees out of phase with each other (a sine wave and a cosine wave). We say these signals are orthogonal or in quadrature to each other.

Vector algebra (remember physics?) tells us that the sum of the two (signal C) is another sinusoid of the same frequency at 45 degrees (see figure B1). Also note that if we scale the two orthogonal signals with discrete multipliers (+1 or -1) before summing the two, we can place the resultant vector at any one of four discrete positions, each of which differs from the other by even 90-degree multiples (see figure B2).

Hence, we have taken a complicated modulation problem (changing the phase of a single sinusoid) and reduced it to electrical functions that are easy to perform (inverting a signal and summing two signals). Figure B2 represents precisely what takes place inside the familiar Bell 212A 1200-bps modem—differential phase shift keying (DPSK).

Although higher-speed modems operate similarly, the encoding density is greater. In the DPSK example shown, we restricted the amplitude values placed upon our orthogonal components to integer values (+1 and -1). If we allow the quadrature components to be scaled by fractional values before summing the two signals, we can combine amplitude modulation with phase modulation and achieve an even greater encoding density.

Another form of DPSK modulation that is used commonly offers 4800-bps communication. There are two popular (and similar) schemes. One used in the U.S. is called the Bell 208 discipline; its counterpart in Europe is the CCITT V.27 discipline.

Instead of a simple 4-point constellation like that shown in figure B2, the V.27 discipline offers an 8-point constellation, where the individual points of the constellation form a circle about the origin separated by 45-degree angles. V.27 is a half-duplex technique using a single-carrier frequency centered at 1800 Hz that is modulated at 1600 baud using tribit encoding. Thus, we get 4800-bps communication in one direction at a time (1600 baud x 3 bits/baud).

Figure B3 shows the constellation pattern associated with newer 2400-bps dial-up modems that utilize quadrature-amplitude-modulation (QAM) technology to achieve full-duplex communication according to the CCITT V.22bis recommendation. This is a 16-point constellation, which implies that the modems exchange quadbits ($2^4 = 16$) of information at each baud interval.

V.22bis technology is full-duplex.
Each modem transmits its own carrier, and they are separated in frequency by prearrangement. The originating modem transmits at 1200 Hz; the answering modem transmits at 2400 Hz. The carriers are modulated at 600 baud using the 16-point constellation shown and provide 2400-bps (600 baud x 4 bits/baud) information interchange.

To achieve 9600-bps communication rates, several techniques are in use today. The oldest one stems from the CCITT V.29 recommendation. V.29 was originally written to provide 9600­bps communications over 4-wire leased lines using a synchronous data format. There is no reason why the core technology cannot be used in asynchronous dial-up environments, and a number of manufacturers have elected to do so.

V.29 uses the same generic 16-point QAM constellation shown for V.22bis in figure B3. However, the carrier assignment is changed. Instead of using two discrete carrier frequencies, V.29 places a single carrier frequency in the center of the voice band at 1700 Hz. The modulation rate is increased from 600 baud to 2400 baud, which causes the modem to take up virtually all the available bandwidth the telephone line has to offer. This means that only one of the two modems can send data at a given time, but they operate much faster—9600 bps (2400 baud x 4 bits/baud).

The newest modulation technique (V.32) is quite similar to V.29 in many respects. It uses a single carrier frequency at 1800 Hz instead of 1700 Hz, a 2400-baud modulation rate, and a core 16­point constellation. V.32 differs from V.29 by offering an optional 32­point constellation (quintbit encoding), which is trellis-encoded.

The fifth bit is a logical derivative of the other four. It represents an integrity check similar to the ninth bit that is used in IBM PC and PC XT machines for memory-parity purposes or hamming-code techniques used in more advanced error-correction-encoding memory storage systems. Trellis encoding gives the modem superior signal-to-noise performance.

V.32 is true full-duplex 2-wire modem technology. Echo cancellation is used to separate the transmitted and received data streams of analog waveforms that are propagating simultaneously through the 2-wire link.

Racal-Valic 9600VP: The 9600VP offers full-duplex asynchronous operation at 300, 1200, and 9600 bps. It's modified V.29 design offers error control, selective retransmission, and data compression, and it adjusts its speed dynamically to optimize current line conditions. The unit provides an AT-compatible command set, nonvolatile telephone number storage, and compatibility with the standard communication protocols when operating in the Bell 212A or Bell 103 modes. Speed conversion and five types of flow control are available.

This modem offers true full-duplex data transmission during interactive sessions that have relatively low data­throughput requirements and a half­duplex link while transferring large amounts of data in one direction. The dynamic duplex technology will automatically select the appropriate duplexing method based on data traffic patterns.

Telcor Accelerator 2496MA: The Accelerator uses a proprietary data­compression and error­detection technique with its V.22bis design to increase data throughput. It supports full-duplex interface speeds of 1200, 2400, 4800, and 9600 bps, along with several interface and flow­control protocols. The unit is configured by an AT command set with some unique extensions. When not communicating with another Accelerator, this modem will communicate with V.22bis, V.22, Bell 212A, and Bell 103 modems.

Telebit TrailBlazer Plus: The TrailBlazer Plus features compatibility with modems that support the V.22bis, V.22, Bell 212A, and Bell 103 standards, plus its own Packetized Ensemble Protocol (PEP). Supported interface speeds are 300, 1200, 2400, 4800, 9600, and 19,200 bps. This unit features automatic error detection and correction, flow control, an AT command set, and support of MNP classes 1 through 3.

Teledynamics 9600/V.32: This is a V.32 modem with an AT command set and error control. It offers full-duplex asynchronous or synchronous operation at 4800 and 9600 bps. An option switch sets you enable/disable its trellis-encoded modulation at 9600 bps. The modem can monitor call progress electronically with terse or verbose responses or via a built­in speaker. Front­panel controls provide the ability to manually answer, originate, and disconnect calls, as well as set errors and operate at 4800­bps operation and select error control. The unit also provides nonvolatile storage for ten 40­character telephone numbers.

USRobotics Courier HST: The Courier HST is compatible with V.22bis, V.22, Bell 212A, and Bell 103 modems, plus those that support the USRobotics high­speed technology (HST). When operating at interface speeds of 4800 bps to 19,200 bps, the Courier HST operates in the HST mode with error control and will either fall back or spring forward as line conditions permit. The unit supports MNP classes 1 through 5, data compression, flow control, and has an AT command set with extensions.

Ven-Tel EC18K-34: This modem is also known as the PathFinder 18K and features a high-speed mode that supports interface speeds to 19,200 bps. The unit uses PEP at the higher speeds, making it compatible with the TrailBlazer Plus and other PEP modems. It is also compatible with modems that support the V.22bis, V.22, Bell 212A, and Bell 103 standards. In the high-speed mode, the modem uses data compression, error detection, and error correction, and it adjusts its operating characteristics to compensate for line changes. An AT command set with extensions is supported, as is MNP at speeds of 2400 bps and below.

[Editor’s note: Cermetek, NEC, and Universal Data Systems also make 9600­bps modems. Although none could supply us with units in time for this review, we will evaluate them in an upcoming issue.]

Measuring Modem Performance

We used Telequality Associates' SNR (signal­to­noise ratio) Map technology to measure the performance of the modems. (For more information on SNR Map technology, see the text box “How Testing Was Conducted” on page 108.) The performance parameter we collected was throughput efficiency as a percentage of the data rate driving the modem. For purposes of comparison, our test setup drove all modems at 9600 bps, although many of the units tested offered higher nominal I/O speeds.

Figures 1a and 1b provide raw test data in graphical form for two modems. We annotated the graphs to show the peak or maximum throughput efficiency measured, the mean or average efficiency recorded, the range, and the standard deviation of the test data.

Ideally, we like to see performance where both the peak and average efficiencies are high and close to one another. We also desire a value approaching 40 for the range, indicative of a low headroom demand. (Headroom is a term used in conventional modem engineering that describes the margin between signal strength and noise required to operate properly.) Let's like to see small values of standard deviation, indicating a very consistent modem.

Let's look at figure 1a, which shows

continued
How Testing Was Conducted

Figure A provides a simplified block diagram of our test system. Modem #1 and modem #2 represent the target modems under test. In each case, the target modems were a pair of identical models from one manufacturer.

The central office (CO) simulator provides operating loop current to simulate the DC conditions of a typical connection to the telephone network. The CO simulator also provides conventional ringing voltage to trigger the modem’s automatic answer function.

Additionally, the CO simulator is connected to a hybrid (2-/4-wire converter) that separates the transmitted signal from the received signal, as telephone lines do. The isolated transmit signal is then impaired by the telephone channel simulator, which has programmable frequency response, group delay, and gain characteristics that can simulate varying telephone line conditions.

A programmable amount of noise is then summed with the signal to establish the desired SNR. The hybrid and CO simulator deliver this signal (i.e., scaled signal summed with the appropriate level of noise) to the other modem.

The RS-232C ports of the modems are connected to data-pattern generators and checkers. Serial data is given to, say, modem #1 for transmission, and the 8-bit binary data stream output from modem #2 is checked. The tester is capable of both one-way data flow or two-way simultaneous data flow.

Some of the modems evaluated were true full-duplex devices; others merely simulated full-duplex operation. We decided to test the modems by sending data in only one direction for the simulated full-duplex modems and in both directions for the true full-duplex units.

Testing in one direction corresponds only to the conditions of a file transfer where one modem has nothing to transmit while it receives a large amount of data. We noted that the throughput of the simulated full-duplex modems suffered dramatically if asked to traffic two-way 9600-bps full-duplex data.

We tested the modems under two different operating environments. One provided a -26-dBm received signal strength over a C2 line simulator, providing typical phone line conditions. The other presented a -26-dBm signal strength over a 3002 simulator, providing poor phone line conditions.

At each signal level, we decreased the SNR by adding noise to the received signal until the modem’s throughput efficiency dropped to less than 10 percent of the tester’s nominal 9600-bps feed rate.

At each point in SNR space, the modems exchanged a minimum of 81,920 bytes. We used proprietary methods to ensure that the resulting data was within a 4 percent accuracy band with a 90 percent confidence level. We determined throughput efficiency by measuring the total time required to transmit and receive data. Time used by the modems to correct errors was included in the elapsed time for that particular block.

Since we knew the number of data bits received and the total time required to receive the error-free data, we calculated and expressed the number of bits per second as a percentage of the nominal rate. We constructed a special precision timer for the test to ensure the accuracy of data clocking to within 1-millisecond increments.

We configured the modems with factory default options and then programmed them for testing with as few changes as possible. Since binary data was being transmitted, we disabled XON/XOFF flow control in favor of hardware flow control. We fixed the interface speed of the test system at 9600 bps, the minimum common denominator between all the modems tested.

Due to variations in data-compression techniques used in the modems, we followed the manufacturers’ recommendations regarding the transfer of 8-bit binary data. Some modems actually had lower throughput when data compression was used to transfer our pseudorandom data than without compression.

If the manufacturer failed to make recommendations for handling pseudorandom data, we ran a pilot test to determine the optimum setting for the compression feature. All modems employed some form of error correction.

Figure A: This simplified block diagram shows the setup for testing each pair of modems.
the resulting test data taken from the Telenetics 9600E/V.32 modem (a true V.32 unit) operating under typical line conditions (simulated C2 channel with a received signal level of -26 decibels below 1 milliwatt [dBm]). The modem was almost 100 percent efficient in transferring data at 9600 bps as long as the SNR accompanying the received signal was above the modem's native headroom needs of 24 dB.

In this example, the 9600E/V.32 needed operating conditions where the received signal level was 24 dB greater than channel noise. As long as these conditions were met, the modem's receiver operated flawlessly. Once the modem's headroom needs were violated, its receiver performance fell dramatically.

If you operate a conventional modem below its native headroom needs, data errors result. Modems that have error correction don't make data errors. Their throughput degrades, due to the extra time they spend in retransmission to correct the flawed data.

From the shape of the curve, you can see that error correction is not a panacea, since modems exhibit extremely sharp roll-off characteristics. By forcing the modems to operate just a few decibels below their headroom needs, they make a fast transition from perfect throughput to no throughput at all.

Figure 1b shows test data for the Ven-Tel EC18K-34 modem, which employs multichannel modulation technology. The Ven-Tel modem is also operating under typical line conditions. There are a number of differences between the operating characteristics of these two modems. First, both the peak and average throughput efficiencies measured for the Ven-Tel modem are lower than for the Telenetics modem. With a maximum efficiency of 73.6 percent, the Ven-Tel modem delivered a peak communications speed of 7066 bps under 9600-bps feed-rate conditions.

The Ven-Tel modem showed a much broader range of operation than the Telenetics modem, meaning that its headroom needs are smaller. This confirms the advertised benefits of multichannel modulation. The modem can brown out instead of blacking out under poor line conditions.
configuration of its multicarrier assignment to deal with signal quality degradation. A trade-off was executed. Ven-Tel purchased a greater operating range at the expense of consistency in throughput.

Comparing Efficiencies
Now that we have a handle on how the data was analyzed, we can proceed to a side-by-side comparison of the modems. Table 2 shows performance in terms of raw bps numbers. To consolidate the data in a meaningful fashion, we used statistics to represent key aspects of performance. Figure 2 shows the group’s performance on typical lines and poor lines by graphing the differences in their efficiencies. We think that figure 2 offers a more complete basis than the raw bps rates for comparing the modems.

All the true full-duplex machines (Concord, Telcor, and Telenetics) had consistently better throughput than their pseudo-duplex cousins. Among the latter, the USRobotics, Microcom, and Case modems turned in performances approaching those of the true full-duplex modems.

With the exception of the Telenetics modem, which refused to operate over our poor line conditions, the true full-duplex modems showed virtually no operating distinction between running over good or bad lines. The Race BMX-VM, Fastcomm, Hayes, Racial-Vadic, Telebit, and Ven-Tel modems were resistant to channel differences, however, they were still not as efficient as the full-duplex units.

The Case and Microcom modems both ran over our poor line but exhibited a significant loss of throughput efficiency. The Race VM I, Telenetics, and USRobotics modems simply failed to exchange data under our poor line conditions. These are, indeed, grueling operating conditions rarely encountered in dial-up America. However, other modems tested were able to handle the poor line conditions successfully.

The surprise among the lot was Telcor’s Accelerator 2496MA. This modem used conventional 2400-bps V.22bis engine technology and was robust and efficient in handling our 9600-bps stream of pseudorandom data. While a number of other modems tested offered data-compression technology, the Telcor modem showed outstanding consistency in crunching 10-bit ASCII data.

Some Caveats
Overall, these modems are complicated. They have extensive hardware and software options that can have a serious impact on performance. To achieve top performance, you must carefully control the following three parameters: error correction, data compression, and raw data transfer rate.

Almost all these modems offer built-in error correction. If you work with a terminal emulator that employs data blocking and error correction, you can choke one of these modems to death by setting the size of your feed blocks too small and starving the modem’s built-in buffer.

We sent pseudorandom data, which is hard to compress. Some of the modems offered options to engage or disengage the compression function so they wouldn’t choke when fed incompressible data. One modem (Hayes) used data compression that was not user-deletable. Perhaps, had we sent spreadsheet or text files, we would have observed significantly better throughput with the Hayes

---

Table 2: When fed data at a rate of 9600 bps, the true full-duplex modems from Concord, Telcor, and Telenetics consistently showed better throughput than the pseudo-duplex models. With the exception of the Telenetics modem, the true full-duplex modems operated at about the same rate over typical and poor phone lines. This table shows only throughput, not efficiency, and some of the modems can accept data at higher speeds (up to 19,200 bps).

<table>
<thead>
<tr>
<th></th>
<th>Typical line throughput (bps)</th>
<th></th>
<th>Poor line throughput (bps)</th>
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<tr>
<td></td>
<td>(C2, - 26 dBm)</td>
<td>Maximum</td>
<td>Average</td>
<td>Maximum</td>
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<td>Case 4696/VS</td>
<td>8429</td>
<td>6422</td>
<td>4925</td>
<td>3274</td>
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<td>4704</td>
<td>4529</td>
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<tr>
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<td>5136</td>
<td>0</td>
<td>0</td>
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<td>2486</td>
<td>3341</td>
<td>2102</td>
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<td>5002</td>
<td>4742</td>
<td>4973</td>
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<td>6115</td>
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<td>5798</td>
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<td>8083</td>
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</table>

Table 2: When fed data at a rate of 9600 bps, the true full-duplex modems from Concord, Telcor, and Telenetics consistently showed better throughput than the pseudo-duplex models. With the exception of the Telenetics modem, the true full-duplex modems operated at about the same rate over typical and poor phone lines. This table shows only throughput, not efficiency, and some of the modems can accept data at higher speeds (up to 19,200 bps).
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In the May 12, 1987 edition of PC Magazine where 87 modems were reviewed, only three were awarded Editors Choice: "For a high-performing 2,400-bps modem with a slew of extras, check out Multi-Tech Systems' MultiModem224E... with [its] high immunity to line noise and the extra advantage of MNP error correction, [this modem] should do a fine job of managing fast, error-free data communications."

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* The compression throughput of MNP Class 5 is, like all compression schemes, dependent on the type of data being sent. The more "compressible" the data, the greater the throughput. For example, a typical text file transfer at 2400 bps should yield a throughput of between 4400 and 4900 bps. And the MultiModem224E's speed conversion and flow control features let you set your modem's RS232C port at 4800 or even 9600 bps, to take full advantage of the Class 5 compression.

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Figure 2: Again, the full-duplex modems showed greater efficiency than the half-duplex modems. Among the latter, the USRobotics, Microcom, and Case modems turned in performances approaching those of the full-duplex units. (In ideal performance, maximum and average efficiencies are high and close to one another, the standard deviation is a small value, and the range is a large value.)

Company Information

Case Communications Inc.
7200 Riverwood Dr.
Columbia, MD 21046
(301) 290-7710
Inquiry 891.

Concord Data Systems
45 Bartlett St.
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(617) 460-0808
Inquiry 892.

Data Race Inc.
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Suite 108
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(512) 692-3909
Inquiry 893.

Fastcomm Data Corp.
12347-E Sunrise Valley Dr.
Reston, VA 22091
(703) 620-3900
Inquiry 894.

Hayes Microcomputer Products Inc.
P.O. Box 105203
Atlanta, GA 30348
(404) 449-8791
Inquiry 895.

Microcom Inc.
1400A Providence Hwy.
Norwood, MA 02062
(617) 762-9310
Inquiry 896.
HIGH-SPEED MODEMS

and ISDN (Integrated Services Digital Network) communications links. V.42 doesn’t neglect current modems, however; during initial handshaking, a V.42 device will query the other modem and use LAP M only if it is appropriate to do so.

If one of the modems is not equipped with LAP M but has MNP capability, both modems will begin to exchange data under MNP. Therefore, current users of modems equipped with MNP can take comfort in the knowledge that their hardware is not likely to become obsolete.

It’s also clear that intelligent data-compression algorithms will be increasingly important in data communications. If a lowly 2400-bps V.22bis modem can be souped up to consistently pass data at 9600 bps, combining data-compression technology with a good V.32 engine offers the possibility of reliable and cost-effective dial-up communication at effective rates of 38,400 bps.

The wild card in the data communications picture is ISDN. There are those in the telecommunications and data communications industries who predict that the increased bandwidth and line quality of ISDN will provide their own solutions to the data rate problem. These experts tell us that ISDN is an inevitable part of our communications future and that any present plans should be built around the features offered by ISDN.

ISDN holds a tremendous promise for corporate users shuttling mixed voice and data signals between plant sites. But ISDN is not the only logical alternative, and it won’t be implemented overnight. It took 100 years to wire America with copper, put a telephone in virtually every household, and train us to say “Hello” in response to a ringing bell. In the 1960s we started to replace rotary dialing with tone dialing, and as we enter the 1990s, manufacturers are still churning out equipment with pulse-dial fallback.

While we look to V.42, ISDN, and beyond, V.32 and other modems are here, and their price and availability can only get better. Semiconductor manufacturer Rockwell International has announced a CMOS chip set for V.32. Others in the industry (TRT from France and Atlantic Network Systems from England) are shipping highly integrated V.32 modems with proprietary chips. The 9600-bps and faster modems reviewed here are just the beginning of the push to make dial-up modems even faster and better.

John H. Humphrey and Gary S. Smock are general partners of Teleequality Associates in Golden, Colorado, providing engineering consultation and design and product testing in telecommunications.
One Language For All

BB⁺ Specifications:

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- I/O functions
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File Structures:

- INDEX
- KEYED

- INDEXED
- SERIAL
- PROGRAM
- STRING

System Structure

- Multi-tasking—actively provides record and file level locking
- Program overview
- Public programming which provides:
  - Local variables
  - Dynamically called sub-programs
  - Argument passing
  - Automatic public program drop
  - Program memory at exit
  - Public program in memory

Language Structure

- Interactive program development
- Online syntax checking
- Compound statements
- User defined functions
- Unlimited nesting
- Remote I/O files
- Program self modification
- Case insensitive console mode
- Various debugging tools

BB⁺ Utility Set

- File Browser
- Create Data Bundle
- Calculator
- Clear Workspace
- Program Compare
- Copy File
- Define/Redline Files
- Directory Listing
- Erase File
- Generate Shell Scripts
- Program List/View Reference
- Move File
- Program Renumbered
- Rename File
- File Analyzer
- Execute O/S Shell Command
- Search and Replace Function
- Color & FUNC Keyword Setup
- Time/Date/Environment Set
- Utility Menu
- Visual Utilities Interface
- EXE/UNIX/EXE conversion utilities

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- Create and manage menus, data-entry forms, context-sensitive help, and text displays—all within windows.
- Develop window-based OS/2 programs right now, without the headaches of learning OS/2 screen management. Run the same source code in PCDOS and OS/2 protected mode.
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Control functions that you write and attach to fields and/or keys can read, compare, validate, and change the data values in all fields of the form. Upon entry or exit from any field, control functions can call up subsidiary forms and menus, change the active field, exit or abort the form, perform almost any task you can imagine.

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ALR’s FlexCache 20386 Catches Compaq

Mark L. Van Name

In the race for the world’s fastest 80386-based personal computer, the list of top contenders is growing. If the standard BYTE benchmarks are any indication, Advanced Logic Research’s FlexCache 20386 is in a dead heat with the reigning speed champion, the Compaq Deskpro 386/20.

The 20386 achieves its speed by using a FlexCache architecture that is much like Compaq’s Flex architecture. It uses two concurrent buses, an Intel 82385 cache controller, and a cache of 32K bytes of very high-speed (35-nanosecond) static RAM (SRAM). It is in the over-five-digit cost class, although it is still considerably cheaper than the Compaq Deskpro 386/20.

There are four basic 20386 systems: the Model 60 ($5990), the Model 100 ($6490), the Model 150 ($7490), and the Model 300 ($9990). All four include a 20-MHz 80386 processor, 1 megabyte of 80-ns dynamic RAM (DRAM), 32K bytes of cache memory, a socket for a 20-MHz Intel 80387 math coprocessor, a 1.2-megabyte 5¼-inch floppy disk drive, an enhanced-small-device-interface (ESDI) based hard disk drive (in Models 150 and 300) or a run-length-limited (RLL) based hard disk drive (in Models 60 and 100), one RS-232C communications port, one parallel port, and a keyboard that follows the style of the IBM Enhanced AT keyboard. ALR also throws in a Setup Utilities disk and Phoenix Technologies’ Control/386 software. The units differ only in the size (60, 100, 150, or 300 megabytes, respectively) and speed of their hard disk drives. Any machine this powerful could function well as a multiuser system or a network file server.

The system also needs a monitor, a video card, and operating system software. ALR’s EGA-compatible monitor costs $699, while its EGA card adds $399. MS-DOS/GWBASIC 3.3 tacks on another $149. My evaluation unit also came with a second megabyte of DRAM ($899), an 80387 ($1195), and a 1.44-megabyte 3½-inch floppy disk drive ($349). This package, which includes what many Model 150 users are likely to want, totals $11,180. For those whose pockets are not quite so deep, ALR also has a 16-MHz 80386-based system, the FlexCache 16386: The Model 60 sells for $4690, and the Model 100 costs $5690.

Tying the Performance Race

Because the Compaq Deskpro 386/20 was the previous performance leader, I compared the 20386’s test results to that machine’s times. (The performance table compares it to several other systems as well.) Using the new BYTE benchmarks, the 20386 beat the Deskpro 386/20 in the CPU tests by a small margin. Clearly, there is not much of a difference between the computational power of the two systems, but the 20386 holds a slight advantage. Since both machines use the same CPU and cache controller chips, and both have the same size and speed cache, the performance differences probably stem from the 80-ns DRAM memory of the 20386, as opposed to the Deskpro 386/20’s 100-ns DRAM.

Many of the newer 80386-based machines include a disk-caching utility that can often improve performance. The 20386 does not include a disk-caching utility with its version of MS-DOS, but there is one in the Control/386 program that is bundled with the system. However, because Control/386 puts the 20386 in virtual 8086 mode, you cannot run any protected-mode programs while using it—and BYTE’s C benchmarks run in protected mode. I did run the BASIC and Spreadsheet tests with Control/386’s disk cache enabled, but it made no measurable difference.

The 20386 lost the FPU benchmark tests. The 80387 coprocessor in my machine was a 16-MHz chip, not the advertised 20-MHz version. This chip was supported by a special 32-MHz oscillator that ALR attached to the motherboard as an obvious patch. An ALR spokesperson said that the company had to use the slower 80387 and the slower oscillator because it could not get a 20-MHz 80387 from Intel. The spokesperson said that later versions of the 20386 will use a 20-MHz 80387 and will not include the slower oscillator.

The hard disk drive benchmarks also
ALR'S FLEXCACHE 20386 CATCHES COMPAQ

FlexCache 20386

Company
Advanced Logic Research Inc.
10 Chrysler Ave.
Irvine, CA 92718
(714) 581-6770

Components
Processor: 20-MHz 32-bit Intel 80386; socket for 16-MHz Intel 80386 coprocessor
Memory: 1-megabyte 32-bit 80-nm DRAM on motherboard, expandable on motherboard to 2 megabytes and expandable on a two-card memory card set to 10 megabytes; 32K bytes of 35-nm static RAM for the cache; 128K bytes of BIOS ROM
Mass storage: 1.2-megabyte 5½-inch floppy disk drive; optional 1.44-megabyte 3½-inch floppy disk drive; 100-, 150-, or 300-megabyte hard disk drive
Display: Optional Casper TE 5154 EGA monitor; optional ALR EGA board
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 RGB-intensity monitor port with DB-9 connector; two 32-bit slots for memory-expansion cards; two 8-bit and four 16-bit expansion slots

Size
7½ by 17 by 26 inches; 75 pounds

Software
Setup Utilities disk with diagnostics tests and system setup; Control/386

Options
1-megabyte upgrade: $799
1-megabyte memory card set: $999
4-megabyte RAM pack set: $2100
1.2-megabyte 5½-inch floppy disk drive: $179
1.44-megabyte 3½-inch floppy disk drive: $349
20-MHz 80387 coprocessor: $1195
150-megabyte hard disk drive: $2999
300-megabyte hard disk drive: $4595
ALR EGA card: $399
EGA monitor: $699
MS-DOS/GW/BASIC 3.3: $149

Documentation
Quick Installation Reference Guide
FlexCache 16386/20386 Series;

Price
Model 60: $5990
Model 100: $6490
Model 150: $7490
Model 300: $9990
System as reviewed: $11,180

Inquiry 883.

reflect the even match between the two machines. Both hard disk systems had comparable performances, with the 20386 winning the Full Platter and 1-megabyte Write tests. An older test, the Coretest (version 2.7), rates the 20386's hard disk as marginally faster on seeks but slightly slower on data transfers than the Deskpro 386/20's hard disk.

The ALR EGA card was substantially slower than the Compaq EGA card. The speed difference was apparent in the text-mode tests, where the Deskpro offered a 2- to 3-second advantage. That advantage was less in the graphics-mode tests, where the results were more evenly divided.

The Livermore Loops, LINPACK, and Dhrystone tests went decisively to the 20386, but not by a substantial margin. Firstly, the Applications benchmarks were a split decision. The computers traded wins in the Word Processing tests, although the FlexCache came out slightly ahead. The Spreadsheet tests gave similar results, but the Compaq took a slim lead here. The Database tests went to the Deskpro, but, again, not by much. The Scientific and Engineering tests gave a slight edge to the FlexCache, and the Compiler test showed once more that the computers were evenly matched.

Neither computer scored a knockout in any of the test categories. Like two evenly matched prizefighters, the FlexCache 20386 and the Deskpro 386/20 stand bloodied but unbowed.

Of course, the 20386's great performance would be useless if it could not run AT-compatible software or use standard hardware options. Fortunately, everything that I tested worked. I ran the following programs: Lotus 1-2-3 version 2.0; Quarterdeck Office Systems' DISKVIEW 2.0; with Quarterdeck Expanded Memory Manager 386 version 1.10; Kermit 2.30; The Norton Utilities 3.00; Symantec Q&A 1.1; Borland's Reflex 1.14, SideKick 1.56A, SuperKey 1.16A, Turbo C 1.0, Turbo Pascal 4.0, and Quattro 1.0; Digitalalk's Smalltalk/V 1.2; MicroPro's WordStar 3.3 and 4.0; and Microsoft's PC Paintbrush 2.0, Word 4.0, and Windows/386 2.0. I also successfully installed a fully populated Intel Above Board/AT, an Everex Evercom II 2400-bit-per-second internal modem, and a Microsoft Serial Mouse.

In the course of my compatibility tests, I ran into a few minor but annoying problems. First, for 1-2-3's copy-protection scheme to work, I had to set the 20386 to its slower speed while 1-2-3 read the key disk. Once 1-2-3 was done with the key disk, I returned the 20386 to its normal high speed and ran 1-2-3 with no difficulties. Since you can control the system's speed from the keyboard, this is no real hardship.

A second problem occurred any time a program, such as Setup or the Above Board/AT configuration and test software, rebooted the system. When this happened, I got the error message No timer tick interrupt. The unit ran fine, but the message was disturbing. The company said that this problem occurred because my evaluation unit included an older BIOS version, and that the production 20386s use a newer BIOS that fixes this problem.

I also tried booting up OS/2. The 20386 couldn't load OS/2 while running at 20 MHz, and ALR suggested that I slow the machine to 10 MHz. At that speed, OS/2 did load and run, and then I changed the speed to 20 MHz. The ALR spokesperson said that a new version of the ROM BIOS would eliminate that problem in future versions of the machine.

One Big Box

The very first thing that strikes you about the 20386 is its size. It is over an inch thicker, 1 inch deeper, and about 5 inches longer than a standard IBM PC AT. It is also heavier; my unit weighed in at around 75 pounds, and a fully configured system can approach 100 pounds. ALR designed the unit to stand upright on the floor, supported by a stand that you can attach to its bottom with four screws.

The biggest benefit of the large chassis is the addition of two extra half-height floppy disk drive bays at the top of the unit. The standard 1.2-megabyte floppy disk drive fills one of these new openings. There are two more typical bays below these new areas. With all these drive bays, you can fit up to one full-height hard disk drive and five half-height devices in the 20386. To help support these many devices, the power supply has a steady-state rating of 220 watts, with peaks up to 300 watts. You could take full advantage of the 20386's drive capacity by putting two of ALR's 300-megabyte hard disk drives into a Model 300 and placing its tape unit below the standard floppy disk drive; this would give you a system with 600 megabytes of disk storage and a tape drive.

To get a peek inside the unit, you only have to loosen the two thumbscrews on the rear of the unit that attach a side panel to the body, and then remove that panel. Once you are inside, the way ALR arrived at this design becomes obvious (see photo 1). The chassis surrounds an inner, coverless chassis that is the standard AT size and is bolted to the sides of the new container—as if the company took the continued
APPLICATION-LEVEL PERFORMANCE (In minutes and seconds)

WORD PROCESSING

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<th>Word Processing</th>
<th>Databases</th>
<th>Engineering/Scientific</th>
<th>Compilers</th>
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<td>Hide/redraw</td>
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LOW-LEVEL PERFORMANCE (In seconds)

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CONVENTIONAL BENCHMARKS

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Notes:
1. All figures were generated using the 8086/8088 version of Small-C (16-bit integers). Figures for the 80386 machines shown here do not use 80386-specific instructions.
2. The floating-point benchmarks use 8087-compatible instructions only.
3. Error3 reported for the floating-point benchmarks indicate the difference between expected and actual values.
4. Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100.)
5. Read and write times for the File I/O benchmarks are in seconds per Kbyte.
6. For the Livermore Loops and Dhrystone tests only, higher numbers mean faster performance.

For a full description of all the benchmarks, see "Introducing the New BYTE Benchmarks" on page 239.

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cover off one of its older machines and then dropped it into this newer chassis. The older chassis sits at the bottom of the new one, leaving room at the top for the two additional half-height devices.

This design leaves the power switch in an interesting spot. It is a large red rocker switch on the right side of the inner chassis—but that side is now in a cavity at the top of the taller, floor-standing unit. ALR solved this problem by putting a small (4-inch by 2½-inch) metal door on the back of the system near the top. To turn on the unit, you loosen the restraining thumbscrew, open the door, and reach in and flip the power switch. The company defended this design by pointing out that, while this procedure is certainly awkward, it makes it difficult for anyone to turn off the unit accidentally.

Both the inner and outer chassis, as well as nearly all of the system, are metal, so I expected an FCC Class A certification. Instead, the 20386 has only FCC Class B approval. An ALR spokesperson said the company could get Class B approval easily but had not filed for it because it expected this system to be used primarily in the office and only rarely in a home.

When you poke around inside a bit more, you find that ALR reused more than just the old chassis: The motherboard actually connects to an extender that is plugged into the 80386 socket on the motherboard. It is mounted on three standoffs that are glued to the motherboard to prevent contact with the chips on the motherboard.

The motherboard itself is about 13½ inches by 12 inches. It contains all the standard AT circuitry, such as the clock and the AT bus, as well as up to 2 megabytes of 80-ns DRAM. It is a very busy board, however, with almost 120 chips—not counting the DRAM chips. My unit had 72 DRAM chips on the motherboard, giving it 2 megabytes of memory.

The system has eight full-length expansion slots. On the bottom are two special 32-bit slots. Even though they look exactly like standard AT slots, you can use them only for the ALR 32-bit memory card set. These two cards are installed together and hold, in 1-megabyte increments, from 1 to 4 megabytes of 80-ns DRAM. ALR also offers a 4-megabyte daughtercard that attaches to the memory card set. This gives you 8 megabytes of additional memory on this two-card set, for a maximum configuration of 10 megabytes.

There are also two 8-bit expansion slots and four 16-bit slots. In my evaluation unit, ALR’s EGA card occupied one of the 8-bit slots, and the ESDI disk controller card and the serial/parallel/floppy disk controller card filled two of the 16-bit slots. Two 16-bit slots and one 8-bit slot were empty.

The FlexCache Architecture

The 20386’s FlexCache architecture works much like the Compaq Flex Architecture that I described in my review “Compaq Flexes Its Muscles” (February BYTE), but it is a different hardware design. There are two different buses that operate concurrently. One is the standard 16-bit AT bus that the system uses for peripherals. The other is a 32-bit local bus that is connected to the 82385 cache controller and the cache. The 8086 and 8087 use this 32-bit bus to retrieve data from memory.

A cache controller tries to satisfy any CPU memory request with data already in the cache. When it can (a hit), the CPU can keep working without waiting on the slower memory. When the desired data is not in the cache (a miss), the CPU waits while the cache controller gets the data from the slower DRAM system memory. ALR claims a cache hit rate of 95 percent. The 82385 also handles all the cache management chores required to ensure that data in the cache is valid.

The BIOS (Phoenix Technologies version 1.00 04 on my evaluation unit, version 1.10 001F on future units) is stored in slow ROM chips that sit on the AT-compatible bus. To speed up access to the ROM BIOS, the system copies it to the 128K-byte area just below the 16-megabyte memory line. If the computer contains an ALR EGA card, it also copies the EGA ROM BIOS to that area. The 20386 then protects that memory so no program can write on the BIOS.

Whole Lotta Storage

My unit contained a Toshiba 1.2-megabyte 5¼-inch floppy disk drive and a TEAC 1.44-megabyte 3½-inch floppy disk drive. ALR also offers a 360K-byte 5¼-inch floppy disk drive.

My hard disk drive was a 151.2-megabyte Control Data Corp. Model #94166-182 drive. It was controlled by a Western Digital ESDI controller that runs with 1-to-1 interleaving. The Core Disk Performance Test Program indicated that the drive system had a data transfer rate of...
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- PASTE COMMAND – This powerful command allows you to extract data from your dBASE III PLUS files and paste it into your spreadsheet or word processing application.

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call (800) 437-4329, Ext. 555.*
*In Colorado, call (303) 799-4900, Ext. 555.
780.9K bytes per second, an average seek time of 18 milliseconds, and a track-to-track time of 4.8 ms.

The EGA-compatible card in the review unit was made by ALR. It was driving a 13-inch Casper Model TE 5154 enhanced color monitor, which comes with a tilt-and-swivel base.

The keyboard was made by Maxi-Switch. It follows the IBM Enhanced keyboard layout and has two legs that you can tilt. The key action was good and produced a mechanical click. You can use a DIP switch on the back of the keyboard to swap the functions of the Caps Lock and Control keys.

**Documentation and Software**

The 20386 came with the ALR 386/2 version 4.0 Setup Utilities disk. The disk contains a Setup program, a program for doing a low-level disk format, an expanded memory manager (QEMM.SYS), a driver for 3½-inch floppy disk drives (in case you are not running MS-DOS 3.3), an ESDI driver, system diagnostics, a program to patch the disk-related bugs in MS-DOS 3.2, and the SETSPEED.EXE program. With SETSPEED, you can set the system to its normal high speed (20 MHz), or you can have it run at its low speed and emulate a 10-MHz system.

ALR also bundles Control/386 version 1.15 from Phoenix Technologies with the 20386. This package contains many programs that can help you run an 80386-based system, including an Enhanced Expanded Memory Specification (EEMS) driver, a disk-cache program, and hard disk utility programs.

Four manuals accompanied my system: a quick installation and reference guide, a user's guide, an operating manual for the high-resolution color display monitor, and a user's guide for the Control/386 programs. The main manual, entitled FlexCache 16386/20386 User's Manual, is reasonably well written and clear. It contains many useful technical charts and explanations.

**After the Sale**

The 20386 comes with a one-year parts and labor warranty. You have to pay to ship your system to ALR, but the company pays return shipping. This warranty, however, does not cover any options that your dealer installs.

You also get unlimited telephone support with the 20386. The support staff seemed generally knowledgeable and pleasant. They were able to answer all my questions about operating the machine and adding options to it.

You also can extend your service warranty for one, two, or three additional years with the ALR Extended Warranty Program. A one-year extension costs $579 for the Models 100 and 150, and $749 for the Model 300.

**Tops in Price and Performance**

Because of the 20386's 20-MHz CPU and FlexCache architecture, currently only the Deskpro 386/20 is in its performance class. On the down side, the 20386 is big, and some of the engineering (at least on my evaluation unit) could be more polished. The Deskpro 386/20, while more crowded and difficult to take apart, is a more finished product. On the other hand, a Deskpro 386/20 Model 130, equipped comparably to my evaluation unit but with 20 megabytes less disk storage, costs $1730 more.

The FlexCache 20386 has power to burn. But you should plan to spend over $3000 for most ready-to-use configurations. If you can afford it, the FlexCache 20386 is (at least for the moment) tied for tops in PC performance.
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A Tale of Two Laptops

Wayne Rash Jr.

Cramming the functionality of a complete desktop computer, including monitor, power supply, and hard disk drive, into a briefcase-size package is no small task. Although we're now seeing laptops with far more power than a year ago, design problems still mean compromises.

That's the case with NEC's and Hewlett-Packard's latest laptops. While the MultiSpeed HD and Vectra CS Model 20 are both MS-DOS machines with hard disk drives and liquid crystal displays (LCDs), they are as unlike each other as two such computers can be. Both have solid strengths, and both have significant weaknesses.

The HP Vectra CS Model 20 ($3595) is designed for long battery life and to function well as a desktop computer. It has a full-size keyboard and a screen that maintains the normal aspect ratio of an 80-column monitor. Typing on the Vectra is easy. In fact, the Vectra may have the best keyboard of any laptop computer available. However, the long battery life and the large screen and keyboard create problems with size and weight. In addition, because of the emphasis on long battery life, HP has outfitted the machine with a display that is not backlit. In short, the Vectra is large, heavy, and difficult to use as a portable.

NEC, on the other hand, has opted for convenience in the MultiSpeed HD ($3695). The computer is smaller and lighter than the Vectra, and it has one of the best screens I've used. Along with the small, light computer comes a small, light battery that tends to run out of steam pretty quickly: The MultiSpeed runs for only an hour or two on internal power.

Like the Vectra, the MultiSpeed has an excellent keyboard, although it is less like that of a desktop IBM PC. In addition, the screen does not preserve the aspect ratio of the PC, so your pie charts may look like egg charts.

Hewlett-Packard's Approach

HP seems to have placed its emphasis on building a machine that would do well as an office desktop computer that could occasionally be taken into the field. HP claims that the Vectra has exceptionally long battery life for a hard disk drive computer—up to 10 hours. But this machine is unlikely to gain much favor while traveling: Its 19½-pound weight and great size conspire against it. In addition, I was unable to get it to run longer than 6 hours before the battery died.

As a desktop machine, it performs better than other laptops. The full-size keyboard with separate numeric keypad is about the same size as keyboards on traditional desktops. It has 12 function keys along the top of the keyboard, and the Control and Alt keys are arranged as they are on the IBM Enhanced keyboard. You do not need to learn those mysterious triple-key combinations that plague other laptops.

In the office, you can remove the 7-inch by 9¼-inch, 80-column by 25-row LCD screen and plug in a standard monitor. The video controller lets you use either a CGA or an EGA monitor; a switch beneath the battery lets you select the one you want to use. To get to the switch, you have to remove the battery—a step that also erases the setup information for the computer.

The monitor plugs into a 9-pin connector on the rear of the computer, next to the parallel printer port. Also on the rear are covers for expansion slots for Expanded Memory Specification (EMS) memory, serial ports, and modems. The 3½-inch floppy disk drive and the 20-megabyte hard disk drive emerge from the top of the computer. Also on the top is a bar graph, resembling a fuel gauge, that shows the life remaining in the lead-acid battery.

The Vectra laptop uses an 8086-compatible NEC V30 processor running at 7.16 MHz. It has 640K bytes of 120-nanosecond (ns) RAM, room for an 8087 math coprocessor, and a high-density 1.44-megabyte 3½-inch floppy disk drive. The computer supports the use of proprietary-bus expansion cards that let you add memory, I/O ports, or modems; this lets you set up the machine for your specific use more easily than with other laptops. You can add an HP-422 serial

continued
A TALE OF TWO LAPTOPS

<table>
<thead>
<tr>
<th>Vectra CS Model 20</th>
<th>MultiSpeed HD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Company</strong></td>
<td>NEC Home Electronics (U.S.A.) Inc.</td>
</tr>
<tr>
<td>Hewlett-Packard</td>
<td>1255 Michael Dr.</td>
</tr>
<tr>
<td>Customer Information Center</td>
<td>Wood Dale, IL 60018</td>
</tr>
<tr>
<td>(800) 367-4772</td>
<td>(800) 447-4700</td>
</tr>
<tr>
<td><strong>Components</strong></td>
<td><strong>Components</strong></td>
</tr>
<tr>
<td>Processor: 7.16-MHz NEC V30; socket for optional 8087 math coprocessor</td>
<td>Processor: NEC V30 running at 4.77 MHz and 9.54 MHz</td>
</tr>
<tr>
<td>Memory: 640K bytes, expandable to 4 megabytes of EMS memory</td>
<td>Memory: 512K-byte ROM</td>
</tr>
<tr>
<td>Display: CGA on internal LCD screen; CGA and EGA for external monitor</td>
<td>Display: CGA on internal backlit LCD screen or external monitor</td>
</tr>
<tr>
<td>Keyboard: 92 keys, including separate numeric keypad</td>
<td>Keyboard: 85 keys, including separate numeric keypad</td>
</tr>
<tr>
<td>I/O interfaces: Parallel printer port; four internal proprietary-bus expansion slots</td>
<td>I/O interfaces: Bidirectional parallel printer port; RS-232C (25-pin) serial port; CGA monitor port; floppy disk drive controller/expansion port</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td><strong>Size</strong></td>
</tr>
<tr>
<td>16½ by 14 by 3½ inches; 19½ pounds</td>
<td>13¼ by 12½ by 3½ inches; 14 pounds</td>
</tr>
<tr>
<td><strong>Software</strong></td>
<td><strong>Software</strong></td>
</tr>
<tr>
<td>HP Personal Applications Manager</td>
<td>MS-DOS 3.2; in ROM: Telcom, Outliner, Filer, Dialer, Notepad, Setup</td>
</tr>
<tr>
<td><strong>Options</strong></td>
<td><strong>Options</strong></td>
</tr>
<tr>
<td>Dual serial adapter with 0 to 2 megabytes of RAM: $220 to $1415</td>
<td>300-1200-bps modems: $399</td>
</tr>
<tr>
<td>200-bps synchronoust/asyncronous modem: $595</td>
<td>300-1200/2400-bps modems: $499</td>
</tr>
<tr>
<td>1200-bps asynchronous modem: $450</td>
<td>Leather carrying case: $249</td>
</tr>
<tr>
<td>HP Vectra DOS 3.2: $95</td>
<td>Semi-rigid carrying case: $129</td>
</tr>
<tr>
<td>12-inch monochrome monitor: $325</td>
<td>Car DC cable: $20</td>
</tr>
<tr>
<td>13-inch enhanced monitor: $845</td>
<td><strong>Documentation</strong></td>
</tr>
<tr>
<td>Recharger: $155</td>
<td>Price</td>
</tr>
<tr>
<td>Soft case: $150</td>
<td>$3695</td>
</tr>
<tr>
<td><strong>Documentation</strong></td>
<td>Inquiry 885.</td>
</tr>
<tr>
<td>62-page Setting Up the Portable Vectra CS; MS-DOS manual; pamphlets for disk-cache program; support guide</td>
<td></td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td><strong>Price</strong></td>
</tr>
<tr>
<td>$3595</td>
<td></td>
</tr>
</tbody>
</table>

To make matters worse, the Vectra’s LCD screen was essentially illegible in the well-lit aircraft cabin. It remained hard to read in reasonably well lit hotel rooms. The lack of backlighting was a serious handicap under many of the conditions where a laptop computer would be the logical choice. The brightness and contrast controls varied the display, but they could not raise the screen brightness to readable levels.

Using the Vectra is complicated by the minimal documentation that HP provides with the machine. All you get is a slim setup guide, an MS-DOS manual, and some pamphlets that accompany the software and accessories. Additional manuals are available at extra cost.

NEC’s Approach

The NEC MultiSpeed computer has earned praise since the floppy disk version was introduced last year—and it deserves the praise. Like its floppy disk-based sibling, the hard disk drive version of the MultiSpeed is well designed and easy to use. Unlike the Vectra, it is light, relatively small, and convenient to use out of the office.

It is also nearly as convenient to use as a desktop machine as the Vectra is. The backlit LCD screen removes in seconds to allow the MultiSpeed to support a standard CGA monitor. The keyboard is excellent, and, like the Vectra, the MultiSpeed supports a separate numeric keypad, although its location is slightly less convenient—above the keyboard rather than next to it.

The external monitor plugs into a 9-pin connector on the rear of the computer. Also located on the rear are a standard parallel printer port, a 25-pin serial port, and a floppy disk drive expansion connector. The rear panel also has a switch that controls the speed of the processor so you can switch between 4.77 MHz (for compatibility with the original IBM PC) and 9.54 MHz. There is also a reset switch on the rear. The connectors are protected by small plastic covers that look like they would get lost easily.

Included with the MultiSpeed are cables that allow the use of Zenith and Toshiba external 3½-inch floppy disk drives, and a cable that lets you connect the machine to an IBM PC so the PC can use the MultiSpeed’s disks. This permits considerable flexibility in transferring information to and from the MultiSpeed.

The MultiSpeed’s 3½-inch floppy disk drive is located on the right side of the machine. This drive supports the standard 720K-byte MS-DOS format for 3½-inch drives—the same format that Data General, Zenith, and Toshiba use.

Traffic Pains

Clearly, HP did not design the Vectra laptop for air travel. Its weight and size make it inconvenient to carry onboard an aircraft, but this is insignificant compared to the inconvenience of actually using it on one.

I carried the Vectra on a cross-country flight in a United Airlines DC-10. Even though I was traveling First Class, the Vectra was simply too large to use comfortably; using it in Coach would have been out of the question. The computer’s weight even bent the table attached to my seat. (These travel pains were eased somewhat by a roomy and attractive vinyl carrying case that looked like leather and was comfortable to carry.)

continued
## NEC MultiSpeed HD HP Vectra CS Model 20

### APPLICATION-LEVEL PERFORMANCE (In minutes and seconds)

<table>
<thead>
<tr>
<th>WORD PROCESSING</th>
<th>NEC</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>XyWrite III + 3.52</td>
<td>Med. Large</td>
<td>Med. Large</td>
</tr>
<tr>
<td>Load</td>
<td>N/A</td>
<td>25</td>
</tr>
<tr>
<td>Word count</td>
<td>1:10</td>
<td>10:119</td>
</tr>
<tr>
<td>Search/replace</td>
<td>1:19</td>
<td>1:15</td>
</tr>
<tr>
<td>End of document</td>
<td>0:05</td>
<td>0:07</td>
</tr>
<tr>
<td>Block move</td>
<td>3:33</td>
<td>2:24</td>
</tr>
<tr>
<td>Spelling check</td>
<td>3:21</td>
<td>4:17</td>
</tr>
<tr>
<td>Microsoft Word 4.0</td>
<td>5:41</td>
<td>3:1</td>
</tr>
<tr>
<td>Cursor move</td>
<td>N/A</td>
<td>1:27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DATABASE</th>
<th>NEC</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>dBASE III + 1.1</td>
<td>Copy</td>
<td>3:51</td>
</tr>
<tr>
<td>Index</td>
<td>1:32</td>
<td>1:29</td>
</tr>
<tr>
<td>List</td>
<td>4:27</td>
<td>3:18</td>
</tr>
<tr>
<td>Append</td>
<td>6:49</td>
<td>5:31</td>
</tr>
<tr>
<td>Delete</td>
<td>1:08</td>
<td>1:06</td>
</tr>
<tr>
<td>Pack</td>
<td>4:12</td>
<td>3:30</td>
</tr>
<tr>
<td>Count</td>
<td>N/A</td>
<td>2:24</td>
</tr>
<tr>
<td>Sort</td>
<td>3:06</td>
<td>2:36</td>
</tr>
</tbody>
</table>

**Indexes show rotational performance; for all indexes, an IBM PC AT 5 MHz; graphs are based on indexes.**

### LOW-LEVEL PERFORMANCE! (In seconds)

<table>
<thead>
<tr>
<th>CPU</th>
<th>NEC</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matrix</td>
<td>18.71</td>
<td>21.53</td>
</tr>
<tr>
<td>String Move</td>
<td>116.54</td>
<td>118.67</td>
</tr>
<tr>
<td>Byte-wide</td>
<td>116.54</td>
<td>118.69</td>
</tr>
<tr>
<td>Word-wide</td>
<td>58.27</td>
<td>59.38</td>
</tr>
<tr>
<td>Odd-bnd.</td>
<td>104.32</td>
<td>113.86</td>
</tr>
<tr>
<td>Even-bnd.</td>
<td>121.66</td>
<td>132.82</td>
</tr>
</tbody>
</table>

**Indexes show rotational performance; for all indexes, an IBM PC AT 5 MHz; graphs are based on indexes.**

### CONVENTIONAL BENCHMARKS

<table>
<thead>
<tr>
<th>NEC</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINPACK</td>
<td>8846</td>
</tr>
<tr>
<td>Livermore Loop (M/FLOPS)</td>
<td>0.0024</td>
</tr>
<tr>
<td>Dhrystone (MS C 5.0) (Dhr/sec)</td>
<td>1.164</td>
</tr>
</tbody>
</table>

For a full description of the benchmarks, see “Introducing the New BYTE Benchmarks” on page 239.
for their laptops. The 20-megabyte hard disk drive is hidden deep in the machine.

The MultiSpeed's computing power comes from NEC's 9.54-MHz V30 microprocessor. There is no provision for an 8087 math coprocessor. The first 126K bytes of the 640K-byte memory is low-power CMOS RAM that stays powered up by the battery and can be used as a nonvolatile RAM disk. The RAM disk software is included with the system.

The 2200-milliampere nickel-cadmium battery that powers the MultiSpeed when it's being used as a portable is beneath an easily removed cover just behind the screen. It is designed for quick replacement, making its short life somewhat less of a problem. Still, you can expect only an hour or two of operation using both the hard disk drive and the screen backlighting.

The MultiSpeed gets its name from its ability to operate at two different speeds. This function is controlled by a DIP switch on the rear panel of the machine. While there was once a need for the slower speed to satisfy some copy-protection schemes, the problem seems to have disappeared; although a few games still operate properly only at the slower speed, the multiple-speed capability seems to be of questionable value.

Included with the MultiSpeed is a collection of ROM-based applications. The machine's 512K-byte ROM contains Telcom, Outliner, Filer, Dialer, Notepad, and Setup. The machine has sockets for four additional ROMs beyond the two that contain the applications.

A dedicated key, labeled "Pop-up" on the keyboard, invokes these applications. When the key is pressed, a menu appears, and you select the program you want. The machine normally has these applications enabled, along with the RAM disk, but you can clear them out of memory if you need the space. In addition to the ROM software, the MultiSpeed also includes MS-DOS 3.2, and there is a help key that produces ROM-resident help screens for the built-in applications.

On the Road with the MultiSpeed

The MultiSpeed HD is built for the convenience of the person who must use it while traveling. This machine fits well on the tables in First Class on a DC-10, and its weight is within their capabilities. The screen was easily visible under any lighting conditions I encountered while traveling. Unfortunately, the short battery life limits your productivity on a long flight.

The MultiSpeed also works well in hotels and offices. The external power supply can use 50- or 60-Hz power from 100 to 220 volts. In short, you can use it anywhere. Its relatively small size and light weight make it easy to carry while traveling, and its rugged fabric case is well designed.

The machine's use is enhanced by the excellent manuals that have become one of NEC's strong points. The four manuals are clearly written, well illustrated, and very helpful to users who find themselves with questions in places where they can't ask for help.

Similar Performance

A quick look at the benchmarks (see the graphs on page 128A) shows that these two machines perform similarly, despite the difference in CPU speeds. It's clear that the Vectra operates without wait states, negating much of the Multi-Speed's potential speed advantage. Still, the MultiSpeed is slightly faster in all the standard CPU benchmarks. This can be attributed primarily to its slightly higher clock speed.

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1-800-4 CORVUS

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A TALE OF TWO LAPTOPS

The two machines split wins in the hard disk tests, with the Vectra coming out slightly ahead in the tests that go through the operating system for disk access. The screen display tests came through with another split, with the MultiSpeed a bit faster in graphics and the Vectra much faster at displaying text. Although the Vectra turned in a slightly higher overall score in the applications benchmarks, these tests also failed to deliver a strong winner. Some of the applications, such as Excel, Lotus 1-2-3, and AutoCAD, showed the MultiSpeed to be the faster machine. Others, notably dBASE III Plus and Word, favored the Vectra. It is important to note that the results of the Vectra running Word showed a level of performance not supported by other tests. It looks like the Vectra's key-repeat rate and graphics display connected perfectly with Word to make the HP computer a real screamer on this application.

While the benchmarks didn't show either computer to be clearly superior to the other, they did show that both computers perform well. Both machines consistently ranked closer to the IBM PC AT than to the IBM PC.

A Winner on Convenience

In terms of convenience, there is a significant difference between the machines. On one hand, there is the massive Vectra with a full-size keyboard and long battery life. On the other hand is the convenience of the MultiSpeed, tempered by its short battery life.

The Vectra's strengths make it a good solution if you need a machine that works well as a desktop computer but must occasionally be taken out of the office. The key word here is "occasionally." The lack of backlighting makes using the Vectra a chore in the field.

The Vectra's size and weight also conspire against its usefulness. The battery is again partly the culprit, but so is the placement of the numeric keypad, which is located in the same place as the keypad on desktop machines. Nice, but I'm not convinced it's worth the cost in space and weight. The MultiSpeed's keypad works quite well located above the letter keys, and it allows for a much more compact machine.

The MultiSpeed performs nearly all the functions that the Vectra does, and it works equally well as a desktop machine, except that it does not support an EGA monitor. In addition, unlike the Vectra, the MultiSpeed is a willing traveler. It can be used conveniently out of the office, although, because of the short battery life, it cannot be used for long.

In spite of the battery-life problem, the MultiSpeed's usability and portability make it one of the best laptops available. Clearly, a great deal of thought went into meeting the needs of laptop users. If I had to make a choice between the MultiSpeed and Vectra, I'd choose the MultiSpeed.

There are other choices, however. If you're willing to live with a couple of extra pounds, the highly regarded Zenith Z-183 provides the best of both worlds. It has a screen the size of the Vectra's that's as easy to read as the MultiSpeed's. Its keyboard is not as good as the Vectra's or the MultiSpeed's, but its battery life is nearly as good as the Vectra's, lasting nearly 5 hours in the latest tests I performed. There's also the T3100/20 from Toshiba, which gives you all the performance of the IBM PC AT, with an 80286 and a fast hard disk drive, but which has no battery. For me, it's a toss-up between the MultiSpeed and the Zenith.
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Circle 123 on Reader Service Card
Revitalize Your Old AT

Don Crabb

The dream of every computer owner is to take the old machine and make it run faster, give it more versatility, keep it compatible with current software, and do all that for very little money. Most owners, however, just replace the old machine with a newer model. While the price of 80386-based machines has dropped over the last year, you can still expect to pay $3000 and up for the privilege of owning one. And if you've set your sights on the high end of the market (such as the Compaq Deskpro 386/20 or the IBM PS/2 Model 80), you can expect to pay over $10,000. Equip these high-end models with big, fast hard disk drives and lots of memory, and the price reaches the $20,000 range. In addition, you absorb the cost of your old AT, which just languishes in the background once you've bought an 80386 machine.

There is an alternative. You can replace the original motherboard in your computer with a newer 80386 motherboard. With a 32-bit processor and 32-bit data and address paths, an 80386 machine can give you a tremendous performance advantage over an 80286-based system. These motherboards typically cost about $1500 and up—less than a full 80386 system but more than an 80386 accelerator card. They offer better performance than accelerator cards, however, because combining an accelerator card and an older AT motherboard can create an I/O bottleneck.

Many of the early 80386 boards (such as the Intel iSBC 386 AT) did not take advantage of very-large-scale-integration (VLSI) custom chips; consequently, they were crowded designs whose performance was far below the predicted level. That has all changed in the last several months: A whole slew of 80386 replacement motherboards for PC XT and PC AT chassis has appeared.

For this review, I looked at four 80386 motherboards made for AT-style chassis: the Fortron 386, the Micronics 386, the Turnpoint 386, and the Whole Earth Electronics (Mylex) 386. These boards are designed to improve the overall performance of your AT by 2 to 4 times by executing instructions on a faster 16- or 20-MHz 80386 chip. They also supply additional fast 32-bit RAM that can be used to further increase system performance while maintaining compatibility with DOS 3.x and your applications software.

These boards replace the existing motherboard in your AT. Basically, you must disassemble your AT to install one of the boards. They have the usual complement of slots (32-bit, 16-bit, and 8-bit), plus keyboard connectors, a keylock, LED connectors, jumpers, a battery-powered clock/calendar, coprocessor sockets (for 80387 or 80287 chips), and a power supply connector that you'd expect to find in any AT-style motherboard.

AT Chassis Required
Besides upgrading an AT, you can easily build your own 80386 machine around
one of these boards by adding a power supply (185 watts or greater), a generic AT chassis, an AT-style keyboard and cable, a combination floppy disk drive/hard disk drive controller, a floppy disk drive, a hard disk drive, a speaker, a key­lock, a turbo switch, and status LEDs, plus a monitor and an EGA or VGA video card. All you’d have to add to this mix is DOS 3.1 or higher, and you’d have a fast, inexpensive 80386 machine.

Some of the boards come with 32-bit memory standard on the board itself, while others come with their standard RAM on a 32-bit plug-in card. In any case, each board I tested came with a minimum of 1 megabyte of 32-bit RAM.

But if you’re not up to building a new system from scratch, these boards will function nicely in most AT-style computers. As long as your machine’s motherboard conforms to the AT’s motherboard form factor (roughly 12 inches by 13 inches), you should be able to install any of these boards as an upgrade replacement. Your only other consideration is your keyboard; if it’s not AT-compatible, it may not work with the particular keyboard ROM BIOS installed in the motherboard you buy. Other hardware compatibility issues are minor, since you are giving up your existing AT motherboard in favor of a new system with new ROM BIOS, a new processor, new RAM, and so on.

Not for the Novice
Replacement motherboards are not for the timid or the novice, or even the casual board twiddler, and don’t let anyone try to tell you otherwise. While these boards can boost your AT’s performance, they can be very tricky to install and configure. I’ve been building and using com­puters for 20 years, and I can’t imagine anyone thinking that the complete dismantling of an AT and installation of a new motherboard is “simple.” The manufacturers of all the boards I tested caution against inexperienced people installing these boards. Indeed, many of the 80386 motherboards now on the market were originally sold only to OEMs because of the difficulty of installing them.

Typically, you have to ground the AT’s chassis (with a grounded antistatic mat), yourself (using a wrist grounding strap), and the replacement motherboard (using an alligator clip wired to a separate ground) before you begin. Then you have to dismantle your current AT, noting where all the board connectors are located and how they’re connected.

The grounding process also has to be done carefully to avoid a ground loop that would reinforce any static problems. A ground loop is what occurs when you have more than one common ground for any electrical potential. You want only one true ground for any such potential. Ground loops tend to reinforce static effects rather than dissipate them. The best situation is to run one true earth ground to each electrical surface you want to ground; such grounding is called an isolated ground. By definition, isolated grounds cannot result in ground loops.

After dismantling your AT, you have to install the new 80386 motherboard in the chassis. Then you reconnect the power supply, install the disk controller, and re­install the disk drives, keyboard, keylock, status LEDs, turbo switch and LED...
## REVITALIZE YOUR OLD AT

<table>
<thead>
<tr>
<th>Type</th>
<th>Fortron 386 replacement motherboard</th>
<th>Micronics 386 replacement motherboard</th>
<th>Turnpoint 386 replacement motherboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td>Fortron Corp. 2380 Qume Dr., Suite F San Jose, CA 95131 (408) 432-1191</td>
<td>Micronics Computers Inc. 935 Benicia Ave. Sunnyvale, CA 94086 (408) 732-0940</td>
<td>Turnpoint America 150 North Center St., Suite 224 P.O. Box 41334 Reno, NV 89504 (702) 786-4484</td>
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<tr>
<td>Design Topology</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td>Components</td>
<td>Processor: 80386 running at 16 MHz with one wait state; socket for optional 80387 or 80287 math coprocessor Memory: 2 megabytes of RAM standard on 32-bit plug-in memory card (no RAM on motherboard); optional 2- or 8-megabyte accessory memory card; Award Software or Phoenix Technologies 386 ROM BIOS and keyboard BIOS Slots: Four AT-style 16-bit slots; two proprietary 32-bit slots for system memory; two XT-style 8-bit slots Other: Speaker, turbo switch, and LED connectors; keyboard jack supplied; standard AT-style power connectors supplied; two serial ports and one parallel port; real-time clock/calendar with battery backup for system configuration CMOS RAM Warranty: One year</td>
<td>Processor: 80386-20 running at 20 MHz with zero wait states; compatibility speed operation at 16, 8, 6, and 4.77 MHz; optional Intel 80287-8, 80287-10, 80387-16, or 80387-20 math coprocessor (test unit included an 80387-20 on a special daughterboard that also held the 80386-20) Memory: 1 megabyte of RAM on motherboard; optional 2-megabyte 32-bit memory board; expandable to 10 megabytes with optional 8-megabyte 32-bit memory board; Phoenix 386 ROM BIOS; Award keyboard ROM BIOS; Award ROM BIOS and Phoenix ROM BIOS also available at no extra cost (board has sockets for both ROM BIOS and can be software-selectable as desired) Slots: Five AT-style 16-bit slots; two XT-style 8-bit slots; one 32-bit slot for proprietary RAM board Other: Speaker, turbo switch, and LED connectors; keyboard jack supplied; standard AT-style power connectors supplied; battery backup for CMOS configuration table and real-time clock Warranty: One year parts and labor</td>
<td>Processor: 80386-16 running at 16 MHz with zero wait states; optional 80287-10 math coprocessor Memory: Optional 2-megabyte 32-bit RAM board; AMI 386 ROM BIOS; optional Award or Phoenix BIOS; AMI keyboard BIOS Other: Speaker, turbo switch, and LED connectors; keyboard; AT-style keyboard jack supplied; standard AT-style power connectors supplied; system support functions include seven-channel DMA, 16-level interrupt, three programmable timers, and a real-time clock; CMOS RAM to maintain system configuration parameters; battery backup for CMOS configuration table and real-time clock Slots: Five AT-style 16-bit slots; two XT-style 8-bit slots; one 32-bit slot for proprietary RAM board Warranty: One year parts and labor</td>
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<tr>
<td>Size</td>
<td>12 by 13 inches; conforms to AT motherboard form factor</td>
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<tr>
<td>Software</td>
<td>ROM BIOS utility for running ROM in 32-bit RAM</td>
<td>RAM BIOS and EGA BIOS utilities for relocating BIOS into 32-bit RAM; MICEMM (LIM/EMS) software</td>
<td>None supplied</td>
</tr>
<tr>
<td>Price</td>
<td>With 2-megabyte DRAM card: $2250</td>
<td>With 2 megabytes of DRAM: $2950</td>
<td>With 512 bytes of DRAM: $1495</td>
</tr>
</tbody>
</table>
Whole Earth Electronics (Mylex) 386

80386 replacement motherboard

Whole Earth Electronics
1231 57th St.
Emeryville, CA 94608
(415) 653-7758
(800) 323-8080

Eight-layer

Processor: 80386-16 running at 6 MHz or 16 MHz with zero wait states; optional Intel 80287-8 math coprocessor, running at 8 MHz or 10 MHz (can be externally clocked to run at 10 MHz)

Memory: 1 or 4 megabytes of RAM (must be specified when ordering, since the board RAM is not field-upgradable); 64K bytes of 40-ns 32-bit SRAM cache; AMI 386 ROM BIOS, rev. 09/23/87, with firmware setup and diagnostics, including real-time clock setup; AMI keyboard BIOS, version 6

Slots: Six AT-style 16-bit slots; two XT-style 8-bit slots

Other: Speaker, turbo switch, and LED clocked to run at 10 MHz

Mininal Instructions

None of the documentation supplied with these boards will win any awards for information or appearance. The manuals are for competent hardware jockeys who know all about address lines, dynamic versus static RAM (SRAM), and memory interleaving. At that level, they are a minimal success. Still, as a card-carrying member of the Hardware Jockeys of America, I wished for even more technical information in the manuals. All of them could have used complete board schematics instead of the paltry drawings of gross topology that were included.

The best of a mediocre lot was the Turnpoint manual. The worst was the Fortron, since it lacked any visual aids. Still, I’d rate none of the manuals above a minimally satisfactory level. For novices, these manuals represent a disaster waiting to happen: one more reason why inexperienced people should not be turned loose with these boards. A dead AT will likely be the result.

Looking at the Hardware

All the boards are approximately 12 by 13 inches, the AT motherboard form factor, so they all should fit into a standard AT-style case. Each board is predrilled for mounting according to the AT standard mounting stanchions. Each comes with an 80386 CPU chip, a number of 8- and 16-bit slots, connectors for a keyboard and a speaker, a keylock, an external battery (for the on-board clock/calendar), a power-on-LED, and supporting circuitry. All the boards can support a floating-point coprocessor (80287 or 80387, but none of the tested boards supports the Weitek WTL 1167 chip.

The Micronics board came with an 80386 running at 20 MHz and included an optional 20-MHz 80387 math coprocessor. The rest used 80386 chips running at 16 MHz. The Fortron board has a socket for an 80287 or 80387. The Mylex board uses an 8-MHz 80287, while the Turnpoint uses a 10-MHz 80287.

All the boards included at least one 32-bit expansion slot, except the Mylex board. Its 32-bit RAM cannot be expanded with external cards, so it is limited to on-board RAM (1 or 4 megabytes)—a significant disadvantage. Each board supported the 8-MHz I/O bus timing common for ATs.

The Mylex memory was composed of 36 256K-by-1-bit dynamic RAM (DRAM) chips (including parity chips), for a total of 1 megabyte of DRAM, using 120-nanosecond (ns) chips. Mylex also includes 64K bytes of 40-ns 32-bit high-speed SRAM that caches the entire 16-megabyte memory-address space, with no-wait-state caching, improving performance over an uncached processor. It is implemented with a write-through algorithm. The board comes with the 386 ROM BIOS and keyboard BIOS manufactured by American Megatrends International (AMI). Mylex does not include any software to relocate the BIOS or EGA BIOS to RAM. With 1 megabyte of DRAM, the board lists for $1595.

System support functions of the Mylex board include seven-channel direct memory access (DMA), 16 levels of hardware interrupt, three programmable timers, and a real-time clock. CMOS RAM is used to maintain system configuration parameters. A battery backup for the CMOS configuration table and the real-time clock/calendar is included.

The Fortron board ($2250) includes no RAM on the motherboard, but it has 2 megabytes standard on a proprietary 32-bit plug-in memory card. I also received an extra 2 megabytes on a second memory card. Each memory card has 72 120-ns 256K-by-1-bit DRAM chips (including parity chips). Each card arranged the chips into 1-megabyte RAM banks, with two-way interleaving between the banks.

The Fortron board did not include any SRAM cache, and this lack affected its performance rating: It was the slowest of the boards running the benchmarks.

The Micronics board came with 2 megabytes of RAM on the motherboard. In this configuration, the board sells for $2950. The memory is composed of 72 100-ns 256K-by-1-bit static-column DRAM chips (including parity chips).
Included with the reviewed board was an additional 2 megabytes of 32-bit RAM on a proprietary plug-in card. The maximum memory you can load on the accessory card, using 1-megabit chips, is 8 megabytes, giving the Micronics board a maximum of 10 megabytes of 32-bit RAM. The Micronics board is the only one of the four I tested that uses static BIOS when you order this board. For $50 over the list price, Micronics will supply one of the four I tested that uses static BIOS when you order this board. For $50 over the list price, Micronics will supply

<table>
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<tr>
<th>Table 1: The Micronics 386, with its 20-MHz 80386, was the speed champ, comparing favorably to the Compaq Desktop 386/20. The Whole Earth (Mylex) 386, Fortron 386, and Turnpoint 386, all with 16-MHz 80386s, had performances comparable to the IBM PS/2 Model 80.</th>
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<tr>
<td><strong>Board</strong></td>
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<td><strong>386</strong></td>
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<td><strong>Sort</strong></td>
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<td><strong>Disk access in BASIC</strong></td>
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<td><strong>Fibonacci</strong></td>
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<td><strong>Savage</strong></td>
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<td><strong>Sieve</strong></td>
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<td><strong>Sort</strong></td>
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For a description of the C-language benchmarks, see “A Closer Look” by Richard Green in the September 1987 BYTE. All times are in seconds, except for the Ohrystone test, which is in hry slones per second. The Disk Access benchmarks write and then read a 64K-byte sequential text file to a hard disk. Sieve runs one iteration of the Sieve of Eratosthenes. Calculations performs 10,000 multiplication and division operations. The Spreadsheet tests load and recalculate a 100-row by 25-column Multiplex (1.06) spreadsheet. The 40K File Copy benchmark copies a 40K-byte file on the hard disk. The BASIC benchmark programs were run with MS-DOS 3.2 and GWBASIC 3.3 on all the motherboards. The Compaq Desktop 386/20 ran MS-DOS 3.31 and GWBASIC 3.3. The IBM PS/2 Model 80 ran PC-DOS 3.3 and BASICA 3.3.

*For the Diskstone test only. Higher figures denote faster performance.

Included with the reviewed board was an additional 2 megabytes of 32-bit RAM on a proprietary plug-in card. The maximum memory you can load on the accessory card, using 1-megabit chips, is 8 megabytes, giving the Micronics board a maximum of 10 megabytes of 32-bit RAM. The Micronics board is the only one of the four I tested that uses static BIOS when you order this board. For $50 over the list price, Micronics will supply one of the four I tested that uses static BIOS when you order this board. For $50 over the list price, Micronics will supply

utilization of some custom VLSI

the design and layout of the Compaq 386/20 board (with the exception of Micronics’ 387 daught-

terboard), while the Fortron and Turnpoint boards follow the Intel iSBC 386 board layout. The Mylex board conforms to the design of the AMI 386 board.

Although speed differences surfaced during testing, all these boards juice up the performance of a tired PC AT quite nicely. None showed excessive post-production engineering modifications, although the Mylex board did have a few new traces added after the substrate had been cast. Overall, each board has a solid, quality-built appearance.

**Compatibility Testing**

I tried every DOS-compatible application I could lay my hands on with these boards. That included all categories of applications: integrated programs such as Framework II version 1.1, Symphony 2.0, SuperCalc 3 version 1.0, Lotus 1-2-3 version 2.01A, Smart Software 3.10, Enable 2.0, and Open Access II version 2.05; project management programs like Time Line 1.0, ABT Project Manager 1.0, and Harvard Total Project Manager 1.0; database programs like dBASE III Plus 1.1, Paradox 2.0, Unix 1.1, Informix-SQL 1.1, Revelation 1.0, and DataFlex 2.2; financial programs like Managing Your Money 2.0 and Financial Independence 1.0; the CAD program
The best thing next to an IBM PC. Or any PC.

The economics of IBM ASCII displays.
The affordable Models 310 and 410, when equipped with cartridges, offer PC terminal function for all multi-user PCs. That includes the IBM® RT-PC™ computer and the IBM PS/2™ family.

What's more, Models 310 and 410 offer many popular emulations. Optional cartridges provide features such as concurrent DEC™ and PC connectivity, and auto dial. Both models come with a 3-year warranty. Add an IBM Maintenance Agreement, and you'll get five years of IBM service for just $54.

The ergonomics of IBM ASCII displays.
They're not only economically attractive, they're easy to look at. Flat 14" screens offer non-glare viewing. Green or amber/gold short-persistence phosphors produce crisp character resolution. And each model uses the advanced 102-key IBM keyboard.

“Want more information? Just ASCII.”
For a free brochure and to find a distributor near you, call 1-800-IBM-7257 ext. 89. Or call your IBM Marketing Representative.
AutoCAD 1.1; word processors, including WordPerfect 4.2, Samna Word IV version 1.0, and MultiMate 1.0; several languages, such as Turbo Pascal 87 version 1.0, Microsoft FORTRAN 1.0, Microsoft C 4.0, and Lattice C 1.0; a statistics package called Systat 1.1; and a number of other programs, including some shareware utilities, games, and communications programs.

Without exception, each board ran these applications at the full rated speeds 80386 speeds of 16 or 20 MHz. AMI, Phoenix, and Award Software's 386 BIOS provide complete compatibility. A few old games and some custom programs, including Flight Simulator 1.0, wouldn't work on these boards at the full rated speeds.

I also briefly tested each board's ability to boot a Microsoft OS/2 system disk (version 1.02). Each booted the disk properly, except the Mylex board (OS/2 needs 2 megabytes to operate, and more to run multiple applications). I also tried a beta version of database software for OS/2 on all but the Mylex board. It crashed frequently on the other boards. Since this beta software also crashed repeatedly on an IBM PS/2 Model 80, it's not a fair test of OS/2 compatibility.

Based on my testing and the availability of different ROM BIOS for each board, I'd say that each of these boards, given sufficient memory, will handle OS/2 and multitasking applications properly.

I also had the chance to test each board with Microsoft Windows/386. Each board did the job properly, although I ran out of memory when I tried to open applications on the Mylex board.

Performance Results

All benchmarks (see table 1) were run with the replacement motherboard installed in the chassis of an 8-MHz IBM AT configured with a 30-megabyte hard disk drive (40-millisecond average access time), an IBM EGA card and enhanced color monitor, one 1.2-megabyte floppy disk drive, the combined IBM hard disk/floppy disk drive controller, and the standard AT keyboard. I used MSDOS 3.2, GWBASIC 3.3, and Multiplan 1.06 to run the benchmarks.

I took advantage of every hardware and software performance assist available on each board when testing: If a board had an 80287 or 80387 coprocessor, it was installed and used. If a board came with utility software to move ROM and EGA BIOS code out of slow ROM chips onto the fast 32-bit RAM, I used it. In short, I tested these boards under their best possible performance configurations, given the equipment I was supplied. I tested the Fortron board using an 80287-10 math coprocessor, since it did not come supplied with one; I used the same 80287-10 in testing the Mylex board, instead of the 80287-8 supplied. Finally, I tested the Turnpoint board with its own 80287-10.

The Micronics board was the fastest of the reviewed boards during benchmark testing. It ran away from the others, which is not too surprising considering its 20-MHz clock speed, 80387-20 chip, and 100-ns static-column DRAM. It also effectively relocated ROM and EGA BIOS into the 32-bit speed RAM, using a special utility, RELocate.EXE. The EGA BIOS relocation was effective; it really helped EGA I/O performance. The ROM relocation speedup was not noticeable in my tests.

The Turnpoint board was faster than the Mylex board, although not by a significant percentage, despite the Mylex board's 64K-byte RAM cache. The Fortron board proved to be the slowest of the group, although it still provided a sizable performance jolt to my test AT. The ROM BIOS Fortron utility, for pulling the ROM BIOS into 32-bit RAM, had no effect on my benchmarks. Neither the Turnpoint board nor the Mylex board included a ROM BIOS copying utility aimed at improving performance.

Recommendations

If speed and raw horsepower were the only considerations, the choice would be Micronics. But making a choice purely on speed is a mistake because it ignores other buying concerns, the most important of which is value. If a replacement motherboard costs too much to buy, then all the performance in the world won't benefit you. For me, value is just as important as performance, especially since the four boards I tested all made my tired old AT come to life.

With these biases in mind, I picked the Turnpoint 386 board as my first choice in this group. The Turnpoint has the best manual, as well as the second best benchmark times. It was about equally troublesome to install as the other boards. Turnpoint's technical staff was hard to reach, but knowledgeable the one time I got through. The Turnpoint board combines speed, RAM expandability (up to 10 megabytes), and an attractive price ($1495 with for a board with OK bytes of DRAM). Overall, it was the best buy of the lot, combining solid performance with a good price.

At $2950 with 2 megabytes of DRAM, the Micronics board was the most expensive one I tested, although that $2950 buys a lot: an 80386-20 and an 80387-20, a choice of the Phoenix or Award ROM BIOS, and memory expandability to 10 megabytes. The Micronics board performed much like the Compaq Deskpro 386/20 in my benchmarks, and the technical-support staff was reliable over the phone. The board also supports LIM/EMS through a software assist—a feature the other boards lack. The Micronics board performed flawlessly during my tests.

Although the Micronics 386 has outstanding performance, it's just too pricey compared to the other boards I tested. If Micronics could get the single-unit price down to under $2000, it would easily be the pick of this litter. As pricing currently stands, the Micronics board checks into the number two spot on my preference list.

The Whole Earth Electronics (Mylex) board was a decent buy in its 1-megabyte version at $1595, but the 4-megabyte version (the only other choice) was an expensive $3095. The Mylex board was a fine performer, even though it ended up third in my benchmark tests. It comes with a 64K-byte processor cache—a performance plus that didn't shine during testing but might make an important difference in day-to-day software use.

The biggest advantage of the Mylex board is that the company selling it. Whole Earth Electronics is an established company with a good reputation, and you can feel comfortable buying from it. Still, the Mylex 386 suffers from some performance compromises. The most important is the lack of a 32-bit expansion slot. You order the board with either 1 or 4 megabytes of 32-bit RAM. In these days of OS/2 and expanded and extended memory support, 4 megabytes is often not enough. Since I'm a memory junkie even more than I'm a CPU speed freak, I already have some custom applications that can easily use more than 4 megabytes of memory, so the Mylex board is third on my list.

The Fortron board was the second most expensive of the lot ($2250 with 2 megabytes of DRAM), sported the most conservative board design, and afforded the slowest performance in this fast company. Its conservative design will likely reward its purchasers by reliable performance and long life. For some, it has the best technical support—which you may need, given the poor manual. I'd buy the Fortron board only if I was nervous about the long-term reliability of other boards; it ranked last on my personal preference scale.

Don Crabb is the director of instructional laboratories for the computer science department of the University of Chicago and is a lecturer in the department and the college. His articles and reviews have appeared in industry magazines, newspapers, and journals.
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The Proteus 386A is perfect for CAD/CAM, desktop publishing, file serving, data base management or multi-user and LAN operating environments.

<table>
<thead>
<tr>
<th>Speed</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MHz</td>
<td>$2595</td>
</tr>
<tr>
<td>20MHz</td>
<td>$3190</td>
</tr>
</tbody>
</table>

**386A Standard Features:**
- 80386 CPU, 16/20MHz, Ø-wait-state.
- 64K Cache memory.
- 1024K RAM.
- Clock, calendar and battery backup.
- Dual floppy and hard disk controller.
- 200 watt power supply.
- ROM based setup and diagnostics.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive.
- Dual floppy and hard disk controller.
- 200 watt power supply.
- ROM based setup and diagnostics.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive.
- Optional hard disk.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive.
- Optional hard disk.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive.
- Optional hard disk.
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The 286GTX is perhaps the fastest 12MHz computer around. It provides perfect compatibility with an overall throughput of 16MHz.
InfoWorld said of the Proteus 286GTX, “It is a superb value, scores high in our benchmark tests, and Proteus has the best warranty and technical support.”

<table>
<thead>
<tr>
<th>Speed</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>12MHz</td>
<td>$1750</td>
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</tbody>
</table>

**286GTX Standard Features:**
- 80286 CPU, 12MHz, Ø-wait-state.
- 32K Cache memory.
- 1024K RAM.
- Clock, calendar and battery backup.
- Dual floppy and hard disk controller.
- 200 watt power supply.
- ROM based setup and diagnostics.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive.
- Optional hard disk.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive.
- Optional hard disk.
- Made in U.S.A.

**PROTEUS 286F**
10MHz, Ø-wait-state
This 80286 based AT compatible computer is perfect for networking, CAD/CAM, desktop publishing or business applications.

<table>
<thead>
<tr>
<th>Speed</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>10MHz</td>
<td>$1495</td>
</tr>
</tbody>
</table>

**286F Standard Features:**
- 80286 CPU, 10MHz, Ø-wait-state.
- 1024K RAM.
- Clock, calendar and battery backup.
- Dual floppy and hard disk controller.
- 200 watt power supply.
- ROM based setup software.
- Reset switch.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive.
- Optional hard disk.
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Our 286E provides performance and value unbeatable by any other comparably priced machine.
InfoWorld magazine said, “For best machine in power, the Proteus 286E is the clear winner. We recommend it.”
The 286E is ideal for home or office.

<table>
<thead>
<tr>
<th>Speed</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>10MHz</td>
<td>$1295</td>
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</table>

**286E Standard Features:**
- 80286 CPU, 10MHz.
- 1024K RAM.
- Clock, calendar and battery backup.
- Dual floppy and hard disk controller.
- 200 watt power supply.
- ROM based setup software.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive.
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- Made in U.S.A.

**PROTEUS 286F**
10MHz
The Proteus 286F is perhaps the fastest 10MHz computer around. It provides perfect compatibility with an overall throughput of 16MHz.

<table>
<thead>
<tr>
<th>Speed</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>10MHz</td>
<td>$1495</td>
</tr>
</tbody>
</table>

**286F Standard Features:**
- 80286 CPU, 10MHz, Ø-wait-state.
- 1024K RAM.
- Clock, calendar and battery backup.
- Dual floppy and hard disk controller.
- 200 watt power supply.
- ROM based setup software.
- Reset switch.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive.
- Optional hard disk.
- Made in U.S.A.

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<table>
<thead>
<tr>
<th>Brand/Type</th>
<th>Vol. MB</th>
<th>Access Time (ms)</th>
<th>Price</th>
</tr>
</thead>
<tbody>
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<td>Seagate</td>
<td>20MB</td>
<td>6.5ms</td>
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<tr>
<td>Seagate</td>
<td>40MB</td>
<td>28ms</td>
<td>$595.00</td>
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<tr>
<td>Miniscribe</td>
<td>44MB</td>
<td>28ms</td>
<td>$665.00</td>
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<td>Miniscribe</td>
<td>72MB</td>
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<tr>
<td>Princeton</td>
<td>100MB</td>
<td>24ms</td>
<td>$Call</td>
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<tr>
<td>Maxtor</td>
<td>140MB</td>
<td>18ms</td>
<td>$Call</td>
</tr>
</tbody>
</table>

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An AT in a Mac II?

Naor Wallach

It’s high noon at the job, and you and a coworker are frantically preparing a crucial report for that big 1:00 meeting. You’ve been breaking records laying out graphics for the report, thanks to the Macintosh II on your desk, and you can hear your cohort pounding away at the keyboard in the other room, computing spreadsheet numbers. You’ll drop these numbers into tables that you’ve laid out inside the report. Finally, with 10 minutes to spare, in rushes your collaborator with that spreadsheet data — on a 5¼-inch DOS disk.

Is this simply a high-tech office nightmare? Unfortunately, no. With today’s mix of PC and Macintosh computers, there’s a growing problem of sharing data between workers who use incompatible microcomputers.

AST Research’s solution to this problem is the Mac286, an AT-on-a-board that costs $1599. Equivalent to a complete AT motherboard, the Mac286 shares a Mac II’s hard disk drive, keyboard, and video display. This lets Mac owners not only share data with PC users but actually run MS-DOS programs (say, to correct a minor error in those spreadsheet numbers mentioned earlier). Most AT-compatible software runs unchanged on the Mac286, with the exception of programs that require an EGA board or other PC expansion cards, or programs that need expanded memory beyond MS-DOS’s standard 640K bytes.

I reviewed the Mac286 on a Mac 11 with 5 megabytes of RAM, a 40-megabyte hard disk drive, the Apple Macintosh II Video Card with memory expansion installed, and an AppleColor video monitor. I used Apple’s 5¼-inch PC floppy disk drive with the Mac286. The Mac II ran either MultiFinder 1.0 or System 4.2 and Finder 6.0.

The three floppy disks contain all the software necessary to install and operate the Mac286 system. Two 5¼-inch floppy disks, labeled MS-DOS 3.2 System Disk and MS-DOS 3.2 Supplemental Disk, supply the MS-DOS operating system and software. The MS-DOS system disk contains the standard PC system programs, such as ATTRIB.EXE and FORMAT.COM. The second disk includes GW-BASIC, an assortment of drivers, and an installation batch file. Those familiar with MS-DOS will recognize these two disks as the standard disk set that comes with every IBM PC-compatible microcomputer.

On one 3½-inch Macintosh disk, the Mac286 software is maintained by the two computers is maintained by holding the Mac286’s 80286 in a wait state until the request is completed.

Installing the Computer

The Mac286 came packed in a large box that held the two boards, three manuals, and three floppy disks. I was dismayed to find the boards were sandwiched between three flimsy pieces of white foam and that they weren’t wrapped in any nonconductive plastic sleeves. This packaging provides no protection against electrostatic discharge (ESD), which means the chances are good that you could damage the Mac286 before you even install it.

One of the three manuals contains installation procedures that tell you how to open the Mac II, remove the back panels, and mount the two boards in the NuBus slots. You must locate the boards in the NuBus slots farthest away from the Mac II power supply when you install them. If they’re placed in any other slots, the weight on the monitor atop the Mac II might push the boards together and short them out. Finally, you connect the floppy disk drive, close the hood, and prepare to start the Mac II.

The first board is a processor card with an 8-MHz Intel 80286 CPU and a socket for an 80287 math coprocessor. The second board contains the system’s RAM. This RAM consists of four 256K-byte-density single in-line memory modules (SIMMs), providing 1 megabyte of parity-checked RAM. The first 640K bytes of RAM is MS-DOS user memory, and AST uses the remaining 360K bytes to house the PC ROM BIOS routines.

The memory board also contains support electronics, such as the direct-memory-access (DMA) controller, the interrupt controller, timers, and a floppy disk controller. A floppy disk connector is located to the rear of the memory card. You must supply your own 5¼-inch floppy disk drive.

These boards operate as a NuBus slave under the control of a Macintosh application. This application emulates several popular PC displays, manages a file that emulates a hard disk drive for the Mac286, and sets certain AT system configuration parameters.

On the Mac286 card, calls to ROM BIOS routines are either handled by the Mac286’s support hardware (e.g., calls to the floppy disk controller), or intercepted and processed by the Mac II’s 68020 (e.g., calls to the hard disk drive, printer, or video display). Process synchronization between the two computers is maintained by holding the Mac286’s 80286 in a wait state until the request is completed.
AN AT IN A MAC II?

Mac286

Type
IBM PC AT emulator for the Macintosh II

Company
AST Research Inc.
2121 Alton Ave.
Irvine, CA 92714
(714) 863-9991

Features
- 8-MHz 80286 processor; socket for optional 80287: 1 megabyte of RAM, of which 640K bytes is user memory; connector to 360K-byte 5¼-inch floppy disk drive; MDA, CGA, and Hercules Monochrome Graphics Adapter emulation; hard disk emulation on host computer’s hard disk drive; MS-DOS 3.2, GWBASIC, and utilities (on 360K-byte 5¼-inch floppy disks); Mac286 1.0 application (on 3½-inch floppy disk)

Size
Two boards, each 12.86 by 4 inches

Hardware Needed
Macintosh II with two empty adjacent NuBus slots (preferably slots farthest away from power supply); 5¼-inch external floppy disk drive

Software Needed
System 4.2/Finder 6.0 or higher

Documentation

Price
$1599

Inquiry 890.

Mac II. Unfortunately, the installation document has a number of errors about what files you need to copy for the Mac II. Despite these errors, it doesn’t take long for an experienced Mac user to sort it out.

The MultiFinder Size resource indicates that the Mac286 application requires 640K bytes of RAM to operate properly, which means that if you plan to operate the Mac286 under MultiFinder, you’ll need a minimum of 3 megabytes of RAM in the Mac II. Otherwise, the standard 1 megabyte of memory will do.

You start the Mac286 by launching the Mac286 version 1.0 application. A new window appears on your screen, titled Mac286 V1.0. You should have the MS-DOS system disk in the PC floppy disk drive so the Mac286 can boot from it. After a few seconds, the window is redrawn and the standard MS-DOS messages of memory tests and prompts for time and date flash by. The window’s title then changes to describe the current PC video mode in use.

The Mac286 screen display is a drag-gable window on the Mac II monitor that emulates one of three different PC video display modes. You choose from the monochrome 80-column by 25-row mode, Hercules mode, and CGA mode by selecting the Configuration Options item from the Misc menu and clicking on the appropriate radio button. The Configuration Options dialog box also lets you choose to emulate the PC COM1 or COM2 serial ports and which physical Macintosh port (printer or modem) to assign to the COM port. Again, this is accomplished via radio button choices. You must quit the Mac286 version 1.0 application and relaunch it for these selections to take effect.

Now you’re ready to make your DOS C drive. This “drive” is actually a file called z86 Drive C on the Mac II’s hard disk, with the Mac286 application managing the DOS file structure. Not surprisingly, you first run FDISK to make a DOS partition in this file. The default disk drive size is 20 megabytes, but if you’re short of room on your Mac II’s hard disk, the installation procedures supply a table with the proper cylinder numbers to partition for smaller disk sizes. Next, you format the C drive with the system option to copy the boot tracks to the drive. Finally, you select Warm Boot from the Misc menu and let the Mac286 restart.

This hard disk emulation is pretty good. The Mac286 actually boots from this file, and the DOS AUTOEXEC.BAT and CONFIG.SYS files on this emulation drive cannot be edited like they do on a normal AT computer. You make the appropriate subdirectories and copy your favorite DOS programs from the PC drive into this file.

To print from the Mac286 computer, you can use either an Epson printer emulation through AppleTalk to a LaserWriter, or PostScript if you have a direct serial connection to a PostScript laser printer. You select which print mode to use from the Printer Options item under the File menu.

The three manuals provided are the Mac286 User’s Manual, MS-DOS User’s Manual, and GWBASIC User’s Manual. The MS-DOS manual is a copy of Microsoft’s standard MS-DOS manual; the GWBASIC manual is also Microsoft’s standard product. The Mac286 User’s Manual covers installing the board set, installing the MS-DOS software in your Mac’s hard disk, and configuring the different options that make the system useful to you. In general, this manual is very helpful and well written. The only exceptions are the errors in the installation portion of it.

AST does include an errata sheet that covers certain missing menu selections, operations that are described in the manual but won’t operate as advertised if you are using MultiFinder (e.g., Microsoft Mouse emulation and PC sound emulation), a recommendation to operate in two-color mode to enhance screen refresh speeds, how to build a modem cable, and notes on printing to the LaserWriter.

Running DOS on the Mac

As with installing the system, to start the Mac286 you must launch the Mac286 application. Once the DOS-emulation window opens and the Mac286 boots, you can treat your Macintosh like any AT clone. If you’re running under MultiFinder, you can instantly transfer to a Macintosh application and return. Even without MultiFinder, you still have access to all your desk accessories. The Mac286 application has an FKey menu with a pull-down keypad emulation where you can use the mouse to select PC-keyboard keys or key combinations, but to use the Mac286 productively you need Apple’s Extended keyboard with its built-in PC function keys.

To test PC compatibility, I tried running XyQuest’s XyWrite II Plus 3.06B on the Mac286, because XyWrite is notorious as an ill-behaved program that makes calls directly to the PC ROM BIOS. Also, the text formatting of a XyWrite file is identical to a MacWrite text-only document: carriage returns are present at the end of paragraphs rather than at the end of lines. This makes it easy to transfer ASCII text files from one computer to another.

XyWrite ran without a hitch as I used the PC function keys on the Extended keyboard. I could delete lines and select and move blocks of text without problems. The display settings in the B-W.INI file set the Mac286 window to the specified colors when XyWrite started.

However, the screen refresh rate in the Mac286 window is excruciatingly slow. I had initially set the Mac II display mode to 256 colors, and the screen refresh in every one of the three supported Mac286 PC video modes was slower than molasses. In monochrome mode, for example, when you do a DOS DIR command, the screen does not show each line as it passes by, but rather jumps up about 3 to 5 lines at each refresh. This means you miss some filenames if you have more files than can be displayed in one screen on your monitor. In CGA mode, a DIR command will jump over 10 to 12 lines at a time. As mentioned earlier, AST’s ad-
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<DT-Connect™> is an open interface specification which permits the direct connection of stand-alone data acquisition and frame grabber boards to processor boards for greatly accelerated signal (DSP) and image processing.

Fred Molinari, President.
Table 1: In most of the benchmark tests, the Mac286 outperformed the IBM PC AT. The Disk Write and Read times are good, considering that the Mac286 must interrupt the host 68020 processor to perform hard disk I/O. There is no apparent degradation of the Mac II’s performance with the Mac286 idle in the system.

<table>
<thead>
<tr>
<th></th>
<th>Disk Write</th>
<th>Disk Read</th>
<th>Calculations</th>
<th>Sieve</th>
<th>40K File copy</th>
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</thead>
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<tr>
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<td>15</td>
<td>9</td>
<td>15</td>
<td>48</td>
<td>8</td>
<td>2</td>
<td>3</td>
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<tr>
<td>8-MHz IBM PC AT</td>
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<td>20</td>
<td>61</td>
<td>20</td>
<td>1.2</td>
<td>3</td>
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<tr>
<td>Mac II with Mac286</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>24</td>
<td>6</td>
<td>1</td>
<td>3</td>
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<tr>
<td>Mac II</td>
<td>8</td>
<td>6</td>
<td>6.7</td>
<td>24</td>
<td>6</td>
<td>2.4</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Note: The Disk benchmarks write and then read a 64K-byte sequential text file to the hard disk. Calculations performs 10,000 multiplication and division operations. Sieve runs one iteration of the Sieve of Eratosthenes. The 40K File Copy benchmark copies a 40K-byte file on the hard disk. The Spreadsheet tests load and recalculate a 25-row by 25-column Multiplan (1.06) spreadsheet. All BASIC benchmark programs were run with MS-DOS 3.20 and GWBASIC 3.20. For the Mac II, Microsoft BASIC 2.10b was used for the system benchmarks. Multiplan 1.02 was used for the spreadsheet tests, and a 25-by-25-cell spreadsheet was used. System 4.2 and Finder 8.0 were used.

dendum indicates that you get better performance running the Mac II monitor in the two-color (black-and-white) mode. This helps performance a little, but it causes problems running some programs that expect to have a CGA monitor with more than two colors present.

A serious problem showed up when I issued the XyWrite print command. When the Mac286 application attempted to print to the networked LaserWriter, the system crashed spectacularly, without even the courtesy of a bomb box. I traced this problem to my having supplied XyWrite with the wrong .PRN printer file. When I copied the file JEPSONFX.PRN into the XyWrite directory and modified XyWrite’s STARTUP.INT file to use this Epson printer file, the printing problem with XyWrite disappeared.

I also experimented with Lotus 1-2-3 version 2.01, Turbo Pascal 3.0, Multiplan 1.06, and Wizard’s Crown, a game sold by Strategic Simulations, and I had no problems beyond the extremely slow screen refresh rate.

One of the major concerns of anyone contemplating buying a PC emulator is performance. To address this concern, I compared the Mac286 to an 8-MHz PC AT. Table I compares the Mac286 to the IBM PC AT using BYTE’s standard BASIC benchmarks. I also ran the standard system benchmarks on the Mac II to see if the presence of the Mac286 might degrade the Mac II’s performance, and these numbers are also given in table I.

As the results show, the Mac286’s performance is better than or similar to that of an 8-MHz PC AT.

Getting It from There to Here

There are two ways to transfer text information between the Mac286 and the Mac II. You can select text from a Macintosh word processor, such as MacWrite 5.0, and paste it into a PC word processor—in this case, XyWrite. This works, but only for short pieces of text. I selected and copied 10K bytes of text from a MacWrite document into the Clipboard and then pasted it into XyWrite. The transfer was painful to watch. The text was placed into XyWrite a character at a time, and the transfer took 53 minutes to complete— with the Mac II in the two-color mode.

This process doesn’t work very well in the other direction: You get all sorts of escape characters from the XyWrite display buffer pasted into MacWrite. You cannot cut and paste graphics from one computer to another.

Fortunately, AST has provided another method for transferring text files between the two computers. At start-up, the AUTOEXEC.BAT file runs three drivers—DSTEP1.SYS, DSTEP2.EXE, and DSTEP3.EXE—that let the Mac286 see the Mac II hard disk drive as a D drive. Folders and filenames that follow MS-DOS conventions appear in a DIR D: command. The only file types that appear in this directory scan are files of type TEXT, CRLF (MS-DOS text with carriage return/linefeed combinations at the end of lines), and BINA (an MS-DOS executable file). Transferring a file from the Mac II hard disk to the Mac286 emulated hard disk is simply a matter of issuing the command COPY D:DOCUMENT C: (see photo 1). Unlike the copy-and-paste procedure, this transfer works both ways.

A File Type item under the File menu lets you specify the default file type when you copy a file to D or prompts you for the file type when you do the copy. Files continued
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Naor Wallach is a senior development engineer at Eastman Kodak Co. in Rochester, New York. He uses a Macintosh II at work and at home.
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![Image of printer models and prices]

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IBM OS/2 Standard Edition

IBM's OS/2 Standard Edition 1.0 is an 80286-based multitasking operating system that implements virtual memory on a segment basis. When you buy IBM's OS/2 Standard Edition, you get a dual-mode operating system: In DOS mode, you can run only one application, and in OS/2 mode you can run multitasking applications in each of 12 sessions. The system comes on four 1.44-megabyte 3½-inch floppy disks—one installation disk and three system disks. The documentation consists of a 310-page user's reference in a three-ring binder and a 51-page spiral-bound user's guide.

IBM OS/2's Standard Edition runs on the IBM PC AT, XT 286, and PS/2 Models 50, 60, and 80. It requires a minimum of 2 megabytes of memory, or, if you give up the DOS compatibility box, you can get by on 1.5 megabytes. I ran OS/2 on a PS/2 Model 50 with 3 megabytes of memory (using the Intel Above Board) and a 20-megabyte hard disk drive. The installed system took up approximately 3.4 megabytes of hard disk storage. OS/2 can support up to 16 megabytes of physical memory. In theory, the Intel 80286 is capable of addressing a gigabyte of virtual memory. OS/2, however, constrained by the 32-megabyte limit on the size of a hard disk drive, provides only a 48-megabyte virtual address space.

OS/2 Standard Edition ($325) does not include the graphical user interface, the Presentation Manager. According to IBM, the Presentation Manager won't be available until the end of the year (see the text box "Future Versions of OS/2" on page 147).

The command interface of OS/2 is very similar to DOS (see table 1). Most commands work in both modes; only a handful are specific to DOS mode or OS/2 mode. This allows users already comfortable with DOS to ease themselves slowly into OS/2 and its advanced features. Upon closer examination, though, it takes a little mental mode-switching to keep straight which commands work in which mode and in what form. Some commands work in both modes identically, but some have features that are specific to only one mode. According to IBM, when the Presentation Manager becomes available, you will have the option of replacing the command prompt with windows and menus.

There are some caveats to be aware of when using DOS programs in the DOS-compatibility mode. For example, for those DOS programs that access a serial port directly, you'll need to run a specific program (Setcom40) that lets the DOS program access the target port addresses. Also, the number of device drivers you have installed at system start-up nibbles away at the memory pool allocated to the DOS mode.

You can install OS/2 over your current DOS system without reformattting your hard disk. There are two factors that allow you to do this. First, OS/2's directory structure is identical to DOS's, allowing both types of programs to share the same hard disk and access the same files. Second, OS/2's hidden system files, IBMIBO.COM and IBMDO.COM, are smaller than DOS's, allowing these files to overwrite the old ones.

A Familiar Feeling
If you are familiar with DOS, then you will be immediately comfortable with OS/2. Choosing the DOS or OS/2 command prompt puts you in a screen group (a virtual display of the computer screen) with a DOS-like command prompt (C:)

The Standard Edition of OS/2 comes with a full-screen user shell called the Program Selector (as shown in the photo above). The Program Selector is a rudimentary graphical user interface that gives you windows with a start list on the left side of your screen, a switch list on the right side, and a pop-down menu. The start list (left window) shows the applications you can initiate. The switch list (right window) shows currently running applications that you can choose to run specifically or hop between. From the pop-down menu, you can update the start list by adding or deleting programs. All have context-sensitive help along the way.

In OS/2, certain key combinations are special "hot keys." The Alt-Esc combination cycles you through the screen groups; Ctrl-Esc brings you back to the Program Selector. The only way to move between DOS and OS/2 mode is with one of these hot keys. A comforting help line continued
across the top of the screen reminds you of the Program Selector key. With the help command, you can get an explanation of an error message and a recommended action to take by typing Help followed by the error message number. Most error messages are available online, but you can turn to the back of the manual to find those that aren't. You can also use Help to turn the help-line display on and off.

I didn't find OS/2's power readily apparent because its commands look so much like DOS's. The power is there, nonetheless.

OS/2 provides an environment where applications are protected from one another. Because of its multitasking nature, OS/2 has to assume more responsibility for resource management. In OS/2, a process consists of one or more threads (a dispatchable unit of work) and the associated system resources (i.e., memory, disk files, pipes, queues, and so on). A session is a collection of one or more processes associated with a screen group. OS/2's tasking model is a multilevel priority scheme with four priority classes (listed in order of decreasing priority): time critical, foreground, regular, and idle. The time-critical, regular, and idle priority classes each have 31 priority levels; OS/2 gives the foreground process a boost over other regular class threads when the Priority command in CONFIG.SYS is set to dynamic.

The time-critical class is for threads doing communications or real-time operations. The foreground class is the screen group that is currently using the display. Regular-class threads are those processes operating in screen groups that are not currently using the screen and keyboard. Idle-class threads are noninteractive processes initiated with the Detach or Run commands. OS/2 uses a preemptive time-slicing dispatcher to switch the processor among the threads. This means that all threads get a fixed period of time to use the CPU before OS/2 interrupts their execution and moves on to the next thread.

**Flexible System Configuration**

At boot time, the CONFIG.SYS file determines whether or not you will have both DOS and OS/2 modes and then sets many of the attributes of each mode. The number of commands that you can put in the CONFIG.SYS file has increased dramatically. Some commands affect only the DOS compatibility box, some affect only the OS/2 environment, and some work in both modes. Leaving a command out of the CONFIG.SYS file causes the system to take the default value for that command. For example, if I booted the PS/2 Model 50 without a CONFIG.SYS file, the system would configure itself automatically with a DOS compatibility box.

Thankfully, the package comes with an automated installation program that, in about 10 minutes, creates the desired CONFIG.SYS file and the directories, and copies the files from the supplied disks to their proper places. The directories thus created are C:\; C:\OS2, C:\OS2\INSTALL; C:\OS2\INTRO, and C:\SPool. The system files go into C:\; system utilities and installable device drivers go into C:\OS2. Temporary files waiting for the printer go to C:\SPool. C:\OS2\INSTALL and C:\OS2\INTRO contain the installation programs and a program called "Introduction to OS/2," respectively.

Listing 1 shows the CONFIG.SYS file created for installation on the PS/2 Model 50. PROTSHELL loads the user-interface program (in this case, the Program Selector) and CMD.EXE, the OS/2 command processor. CMD.EXE is equivalent to DOS's COMMAND.COM. CMD.EXE has /C switch that is similar to COMMAND.COM's /C option in that you can pass a command to the copy of the command processor. An additional switch, /R, lets you pass a command to a copy of the command proces-

### Table 1: Because IBM OS/2 Standard Edition is a dual-mode operating system, you have to keep straight which system utilities, configuration commands, and batch commands work in which modes. Some commands work only in OS/2 mode and are mainly concerned with multitasking issues; some commands work only in DOS mode and are there for compatibility. The majority, however, are dual-mode commands that you can use from either DOS mode or OS/2 mode.

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1 These commands are new with IBM OS/2 Standard Edition.

2 In OS/2 mode, these commands will accept multiple filenames.
Future Versions of OS/2

IBM's OS/2 Standard Edition 1.0 is but the first of several versions of OS/2 that will become available in the next year or two.

The next new version, which IBM says will be ready in July, will be IBM's OS/2 Extended Edition 1.0. This version will be similar to the Standard Edition, but will include two built-in applications: a communications manager and a database manager. It will sell at a list price of $795. Whereas several computer manufacturers may offer versions of the Standard Edition of OS/2 for their customers, the Extended Edition will be offered only by IBM.

In October, IBM will reportedly begin shipping 1.1 of the Standard Edition.

—Rich Malloy

Listing 1: The CONFIG.SYS file created for the Model 50 by the installation program.

```
PROTSHELL=DMPCE.EXE SHELL11F.CNF SHELL11F.EXE CMD.EXE /K
BUFFERS=30
DISCACHE=64
MAKWAIT=0
MEMMAP=SHRAP,MOVE
PRIORITY=DYNAMIC
PROTECTONLY=NO
SWAPPATH=C:\
THREADS=64
SHELL=C:\COMMAND.COM /P
BREAK=OFF
FCBS=16,8
RMSIZE=640
DEVICE=C:\OS2\POINTDD.SYS
DEVICE=C:\OS2\MOUSEB05.SYS
RUN=C:\OS2\POOL.EXE /D:LPT1 /O:LPT1
DEVICE=C:\OS2\COM02.SYS
DEVICE=C:\OS2\EGA.SYS
```
the Priority command, you can choose to have the system dynamically vary the priority level of the threads based on the amount of I/O and CPU usage. The system also gives any foreground threads a boost in priority over any background threads. When you choose dynamic priority, Maxwait is the number of seconds that can pass before a thread waiting for the processor gets a boost in priority. With absolute priority, there is no foreground boost, and the system doesn’t adjust the priority of the regular-class threads.

Unlike DOS, the asynchronous communication support in OS/2 is an installable device driver: COMO1.SYS for IBM PC ATs and COMO2.SYS for PS/2 machines. COMOx.SYS supports COM1 through COM3 for full-duplex interrupt-driven communication. The functions it provides are transmission and reception queues, automatic control modes for modern control signals, and XON/XOFF for transmit and receive. COMOx.SYS uses about 9K bytes of DOS-mode memory, so if you don’t need its capabilities, you can leave it out of your CONFIG.SYS file. Also, if you do install the communication device driver, some DOS programs require you to execute the Setcom40 command before they can find the COM port (more about this later).

According to the company, COMOx.SYS is guaranteed to support 4800-bit-per-second communications on a 6-MHz AT while running a DOS-mode application in the foreground. I didn’t have an OS/2 communications program with which to test this, however.

For PC ATs and XT 286s, OS/2 includes mouse drivers for Mouse Systems’ PC Mouse, Visi-On’s Serial Mouse, and Microsoft’s Serial, parallel, and In-Port Mouse. On the PS/2 side, it includes drivers for the first two mice plus the Microsoft Serial and IBM PS/2 in-board Mouse. The POINTDD.SYS device driver works in conjunction with the mouse driver to provide mouse-pointer drawing support.

In OS/2 mode, the base system contains the ANSI support that lets you redefine keys, manipulate the cursor, and change screen-display colors. In DOS mode, however, you still need to install ANSI.SYS; this device driver has no effect on OS/2 mode. Another device driver used only for DOS mode is EGA.SYS. It provides support for the EGA register interface.

Other device drivers include VDISK.SYS, which installs a virtual disk, and EXTDSKDD.SYS, which lets you access an external disk using a logical drive letter. You should install virtual disks after any external drives so you won’t affect their drive-letter assignments. OS/2 takes care of loading the standard default device drivers for the keyboard, display, printer, disk, fixed disk, and clock; don’t put them in your CONFIG.SYS file.

**Batch Commands and CMD.EXE**

Batch commands and the internal commands supported by CMD.EXE are a subset of the DOS-mode commands, necessitating the different batch-file extensions between OS/2 and DOS. SetLocal and EndLocal work together to let you change and restore the drive, directory, and environment setting during batch-file execution. The ExtProc command lets you use your own batch processor instead of CMD.EXE. To use ExtProc, you have to put it on the first line of the OS/2-mode batch file that you want your external batch processor to execute.

In OS/2 mode, if you interrupt a batch file, you don’t get the option of continuing. Continuation can’t take place in a multitasking environment because it’s impossible to predict what state the system will be in when the batch file recommences.

The OS/2-mode command processor, CMD.EXE, embellishes some of the dual-mode internal commands. For example, you can Type or call a directory (Dir) of multiple filenames. You can put multiple commands on the same line by separating them with the & character. Also, you can use the * symbol to precede special characters (such as & and !) and have them considered as text.

OS/2 expands nicely on the redirection capabilities of DOS. CMD.EXE uses the digits 0 through 9 as internal file identification numbers to which you can redirect a program’s input or output. Digits 0, 1, and 2 are the file numbers for standard input, output, and error, respectively. In DOS, you could redirect standard input and output, but not standard error. Also, with OS/2 you can use digits 4 through 9 to stand for files of your choosing, to which any output of a process will be written.

OS/2 lets you process commands conditionally. Separating two commands with an & causes the second command to be processed only if the first was successful. If you separate commands with a |, the second command executes only if the first was not successful.

Pipes in OS/2 mode are true pipes. That is, OS/2 uses a storage buffer to hold the data being piped between processes rather than a temporary file, as in DOS and DOS mode.

**System Utilities**

Both the DOS mode and the OS/2 mode share many of the system utilities. While some of the dual-mode commands will be familiar to DOS users, some will be new. The ExtProc command mentioned earlier is a new dual-mode command, and so is Patch, which lets you apply IBM-supplied corrections to fix faulty code.

Some of the dual-mode commands act a little differently from their DOS 3.x counterparts. When you specify Format/a, for example, the hidden system files IBMINFO.COM and IBMDOS.COM are transferred to the target disk, as you would expect. But Format also uses a text file in the root directory, called Formats.Tbl, to specify it to the other 50 or so system files required to make a boot disk. One slight problem with creating a bootable disk with the /s option is that Format can’t find any files that are outside the root directory (e.g., it can’t find an installable device driver in C:\OS2). The FORMAT command tells you which files it cannot copy so that you can copy them manually.

Unlike DOS, you cannot use Chkdsk’s /F (fix) parameter on the drive from which you started the system; you must boot up from the floppy to restore any continuing
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lost clusters on the hard disk. The /F option requires that you cease all activity on the disk you want to fix. However, because of OS/2’s virtual memory, there’s always the possibility of disk activity if OS/2 needs to move a segment in memory or swap a segment out to disk.

Some dual-mode commands have more functions in OS/2 mode. The Mode command lets you set the operational mode of devices, such as the communications port, the display, the parallel printer, and system-wide disk I/O write verification (as opposed to a per process basis with Verify). You must have COMOx.SYS installed to use Mode to set the communications ports.

While Mode is a dual-mode command, the manual recommends you set the COM port from the OS/2 mode because some parameters are available only in OS/2 mode. You can also query the setting of the COM port from OS/2 mode and use this output as input to another mode command. Mode no longer has an option to send the output from the parallel port to a serial device; the Spool command supplies this function and requires COMOx.SYS to do it.

The more interesting commands are those intended for OS/2 mode only. The Start command lets you start an OS/2 session from another session. Using Start in the autostart batch file gives you another way, in addition to the Program Selector, to configure the system to automatically load whatever applications you normally use. Detach lets you initiate a noninteractive background process. Using a Run command in the CONFIG.SYS file has the same effect as issuing a Detach command from the system prompt.

A print spooler is necessary in a multitasking system where multiple applications share one printer. In OS/2, the print spooler, Spool, is separate from the Print command. Spool is an exclusively OS/2 function that intercepts files sent to the printer from multiple sources. You can start it with a Run command from the CONFIG.SYS file or with a Detach command at the command prompt. Either way, it is a process that runs at idle priority (i.e., when nothing else is going on).

Spool gives the data it receives temporary filenames and keeps them in the subdirectory, C:\SPOOL. Spool accepts only parallel devices for input, but it will send its output to either parallel or serial devices. You can have up to three print spoolers active, servicing three printers.

The spooler works fine in conjunction with the Print command, but there is a problem with using DOS editors with the spooler. Because most DOS programs do not contain code to inform the print spooler when to close and print the file, the output is not printed until you exit the application. You can press Ctrl-Alt-PrtSc to force the spooler to start without leaving the application. This key combination successfully forced output to the printer from XyWrite III Plus. However, it’s important to wait until the application has sent the entire file to the queue before forcing the output, or else the spooler will split the output into two files.

The Print command can send output to the printer or cancel the printing of one or more files, but it doesn’t have an option for listing the files waiting in the queue as it did in DOS 3.3. OS/2 has the same 32-megabyte size limit for hard disk drives as DOS 3.3 and, like DOS 3.3, gets around the barrier by letting you partition your hard disk into a primary and extended partition. Fdisk has an option to then create a logical drive in the extended partition.

I found the manual’s description of Fdisk awfully vague. When I first saw the second selection on the Fdisk menu, “Change the Active Partition,” I thought I could install DOS 3.3 in one partition.

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and OS/2 in another, and use Fdisk to change which operating-system partition was active. This wasn’t the case. You can use this option only if you install another operating system (such as Xenix) on the primary partition.

**Serviceability Aids**

In a multitasking system a lot of things can go wrong, and it can be difficult to track the problem down. In OS/2 mode, however, because programs run in protected mode, certain components of the system continue to run even if the system is partially disabled. OS/2 has a system trace and memory dump facility. Both of these functions are not for the faint of heart: They’re intended for use with aid from an IBM service representative.

You can use the Trace command to turn event tracing on or off, and you can invoke this command either at the OS/2 prompt or at boot time by placing a statement in your `CONFIG.SYS` file. If you don’t want to turn tracing on at boot time, you must place a `Tracebuf` command in the `CONFIG.SYS` file to set the size of a circular trace buffer. `Tracefmt` takes the contents of the trace buffer, analyzes each record, and sends the output to the standard output device.

To use the memory dump facility, you should have one formatted disk holding the `Createdd` command file on hand to start the dump. Because `Createdd` uses the `Format` command, `Format` should be accessible from the current directory or from the search path. `Createdd` dumps all memory beginning at address 0 until the entire memory contents have been placed on the disk. To initiate the dump, you hold down the Control and Alt keys and press the Num Lock key twice. (Don’t press this until you’re absolutely ready, because the system will cease all current activities without flushing the buffers or other system cleanup operations.) A memory dump can take several disks, but one 1.44-megabyte floppy disk was enough to hold the contents of the 3 megabytes of RAM on my system. You can stop the procedure each time you are prompted to put in another disk.

**DOS Compatibility**

Most programs run in the DOS compatibility box without problems. The manual warns that programs with copy-protection schemes that depend on timing or the operating system may not work. Those programs that are timing-dependent or hardware-specific, such as device drivers, may give problems. I ran Sidekick 1.52A, XyWrite III Plus, HyperACCESS 3.32, Lotus 1-2-3 version 2.01, AutoCAD 2.52, MathCAD 2.0, STATA 1.5, DIAL (Microsoft’s bulletin board system), and dBASE III Plus 1.1 in the DOS-mode box, and they operated much as they do in DOS.

There were some differences, though. XyWrite usually caught the hot keys and put one of its own help screens up just before OS/2 switched me to another screen group. Although initially confusing, this was not a functional problem.

Because DOS programs that access a COM port were not written for a multitasking environment, many of them go directly to the port without bothering to see if another application is currently using it. `Setcom40` makes the address of the COM port available to a DOS-mode application so it can access the port when the `COM0x.SYS` device driver is installed. After the DOS-mode program is through, `Setcom40` also removes the address so an OS/2 application can use the port. It’s important not to issue this command while a running OS/2 application is using the port. I had to turn on `Setcom40` before using DIAL from the DOS-mode box, but not before using HyperACCESS.

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I ran into a problem with an incompatible device driver. The Sysgen Bridgefile, an external 5¼-inch floppy disk drive, would not run in the compatibility box. According to the company, it is working on a new driver. For the time being, I installed the Sysgen driver onto my DOS 3.3 boot disk and rebooted from that whenever I wanted to transfer files from the 5¼-inch format to the PS/2 Model 50.

Some of the old, little-used command options have been weeded out of the DOS mode. Format no longer formats eight sectors per track, or a single-sided disk. Exec2bin, Ctty, and Graphics are no longer supported. The Label command does not delete a label from a disk. Files is ignored in the CONFIG.SYS file. Print doesn’t support the /B, /U, /M, and /Q parameters, which deal with buffer size, scheduling of the print spooler, and the queue size of the spooler. You no longer have to specify the path name for the code page file with Country, change the code page with the Mode command, or load the NIs Func command to use Chep to change code pages.

Improved Documentation

The OS/2 user’s reference is much easier to navigate through than the DOS 3.3 manual. It is smaller and better organized. As with the DOS user reference, the OS/2 user reference lists the system utilities and batch commands alphabetically, with cross-references to other related commands. There is a large section on the CONFIG.SYS file commands. IBM has adopted a command diagram using lines and arrows that is clearer than the command format using brackets, capitals, and small letters.

The manual does a great job of showing which commands work in which modes through the use of a box icon. If the upper three-quarters of the box is filled in with black, it indicates that the command works only in OS/2 mode. If the lower left one-quarter of the box is filled in, the command works only in DOS. However, if the box is absent, it’s a dual-mode command. Appendix A lists all commands in a table and indicates the mode each one operates in. The appendix also includes a useful section on DOS compatibility.

Test Results

To get some idea of how the scheduler works, I created a dual-mode version of BYTE’s Sieve benchmark program in C and a compute-bound infinite loop and ran them together in various combinations. I used these programs on an IBM PS/2 Model 50 to find out how the CONFIG.SYS commands work together and how the DOS mode fits into the scheme of things. For these tests, I considered only regular- and foreground-class threads. Time-critical and idle-class threads do not have their priority dynamically adjusted by the system.

The way the scheduler works is that any higher-priority thread that is ready to run gets the CPU before any lower-priority thread. A CPU-intensive process at a higher priority could starve out processes at a lower priority. In CONFIG.SYS, if you set the priority to dynamic, the system will adjust the priority of lower-priority threads by boosting the priority of these processes by 1 after the number of seconds specified by Maxwait passes. It will also give any threads running in the foreground a boost over regular-class threads running in the background.

To see how this works, I started a CPU-intensive infinite loop in the foreground and ran 100 iterations of the Sieve in the background. When it was the only process running, the Sieve took 22 seconds; the contents of the foreground loop took approximately 47 seconds running alone. I ran these programs with both
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Table 2: To show the difference between dynamic and absolute priority, I ran a compute-bound infinite loop in a foreground screen group and 100 iterations of the Sieve of Eratosthenes in a background, OS/2 screen group. Under dynamic priority, the smaller the value of Maxwait, the more often the background process gets to run. Under absolute priority, Maxwait's value has no effect on the scheduling of the foreground and background processes; while the Sieve and foreground process are both running, they appear to be competing equally for the processor. It is interesting to note that in these tests, the performance of the DOS-mode foreground process is comparable to the OS/2 mode foreground process. (Times are in minutes:seconds.)

<table>
<thead>
<tr>
<th>Foreground</th>
<th>Background</th>
<th>Priority</th>
<th>Maxwait</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS/2 Mode</td>
<td>46, 47, 48</td>
<td>Dynamic</td>
<td>0:01</td>
</tr>
<tr>
<td>46, 47, 47</td>
<td>5:41</td>
<td>Dynamic</td>
<td>0:03</td>
</tr>
<tr>
<td>46, 47, 46</td>
<td>17:40</td>
<td>Dynamic</td>
<td>0:10</td>
</tr>
<tr>
<td>70, 46, 46</td>
<td>0:47</td>
<td>Absolute</td>
<td>0:01</td>
</tr>
<tr>
<td>70, 46, 46</td>
<td>0:45</td>
<td>Absolute</td>
<td>0:03</td>
</tr>
<tr>
<td>69, 47, 46</td>
<td>0:46</td>
<td>Absolute</td>
<td>0:10</td>
</tr>
<tr>
<td>DOS Mode</td>
<td>5:37</td>
<td>Dynamic</td>
<td>0:01</td>
</tr>
<tr>
<td>46, 47, 47</td>
<td>5:37</td>
<td>Dynamic</td>
<td>0:01</td>
</tr>
<tr>
<td>46, 47, 46</td>
<td>18:30</td>
<td>Dynamic</td>
<td>0:03</td>
</tr>
<tr>
<td>70, 46, 46</td>
<td>0:49</td>
<td>Absolute</td>
<td>0:01</td>
</tr>
<tr>
<td>70, 46, 46</td>
<td>0:46</td>
<td>Absolute</td>
<td>0:03</td>
</tr>
<tr>
<td>46, 47, 46</td>
<td>0:42</td>
<td>Absolute</td>
<td>0:10</td>
</tr>
</tbody>
</table>

Notes:
- Time slice = 32.248
- The ellipses mean that the time for the foreground program continued at the last number.
- A DOS-mode process is suspended when it is in the background.

Table 3: Comparing times for applications running under DOS mode and DOS 3.3 shows that you get varied results.

<table>
<thead>
<tr>
<th>Application benchmarks</th>
<th>DOS 3.3</th>
<th>OS/2 mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>XyWrite</td>
<td>2:51</td>
<td>2:44</td>
</tr>
<tr>
<td>Microsoft Word</td>
<td>0:31</td>
<td>0:33</td>
</tr>
<tr>
<td>Lotus 1-2-3</td>
<td>2:46</td>
<td>2:52</td>
</tr>
<tr>
<td>dBASE III +</td>
<td>8:35</td>
<td>6:08</td>
</tr>
<tr>
<td>AutoCAD</td>
<td>16:02</td>
<td>24:40</td>
</tr>
<tr>
<td>STATA</td>
<td>0:52</td>
<td>0:32</td>
</tr>
<tr>
<td>MathCAD</td>
<td>0:35</td>
<td>0:36</td>
</tr>
</tbody>
</table>

OS/2 and DOS mode in the foreground (see table 2).

When priority was dynamic, the foreground task executed at a fairly constant rate no matter what was going on in the background. When priority was absolute, however, the foreground tasks and the background tasks executed in a round-robin fashion. In these tests, because I started these processes from the command line, they all had the same priority when I configured priority to be absolute. The programmer can set the priority of a thread; in this situation, a lower-priority thread would not get the processor from a higher-priority compute-bound infinite loop.

Table 2 also shows that when DOS mode is in the foreground, it gets scheduled the same way as an OS/2-mode task running in the foreground. A task running in DOS mode is suspended when it is switched to the background.

Table 3 shows the total time for each program's test in the application benchmark suite. (For a description of the application benchmarks, see the article "Introducing the New BYTE Benchmarks" on page 239.) In general, DOS mode was slower on the loads from disk. DOS mode was about 4 minutes slower performing the Hide command in AutoCAD than was DOS 3.3. DOS mode had some notable speedups: 5 seconds faster for the XyWrite block move test, and 20 seconds faster for the STATA graphics test. It also showed a lot of improvement in many of the dBASE III Plus tests in the Copy, Index, Append, Pack, Count, and Sort tests. In these tests, it was 29, 21, 24, 55, 41, and 31 percent faster, respectively.

The only problems I came upon when running the application benchmarks in OS/2 mode were memory problems. I had to remove COM10X.SYS from memory to run the fast Fourier transform test of MathCAD. The memory limitations prevented me from running the Lotus 1-2-3 Monte Carlo tests at all; the Monte Carlo requires over 512K bytes of memory.

Is It Worth It?
At this time, the average end user can't do a whole lot with IBM OS/2 except run DOS applications in the DOS-mode box. I don't currently have any user applications that take advantage of the advanced capabilities of OS/2, and the thrill of running 12 simultaneous disk directories wears off quickly.

So the question is, is it worth the money and effort to convert to OS/2 Standard Edition now? I think it is. The DOS compatibility box seems to be pretty compatible for most applications unless you have a real memory bog of a program or an incompatible device driver. You can easily boot from a DOS floppy and just run under DOS if you don't want to struggle with these issues.

It takes time to absorb the concepts of a system this complex. Even just the stuff you have to know to be an end user takes some mental adjustment. It took me a few weeks just to get used to the concept of screen groups, the fact that OS/2 has over 50 files in the root directory, and to figure out what the CONFIG.SYS commands were good for, just to name a few things.

If you happen to be an applications developer, these are exciting times. Norton Guides has an on-line reference for the OS/2 Application Programmer Interface (API) that makes the approximately 200 OS/2 functions accessible with a keystroke. Laboratory Microsystems has an alternative to the very expensive Microsoft Software Development Kit ($3000) and IBM Toolkit ($795), called UR/FORTH ($350), which is a great system for becoming familiar with the OS/2 API. Unlike C, FORTH lets you simply try out an OS/2 function right at the FORTH prompt. You don't have the lengthy edit, compile, link, and run cycle of C. I am expecting an avalanche of OS/2 applications any day now. It will be interesting to see how well they all play together.

Eva M. White is a technical editor at BYTE.
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  - Missing value correlation, SSCP, covariance, Spearman
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  - ANOVA, ANCOVA, MANOVA, repeated measures, canonical
  - Discrimination
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<tr>
<th>PROGRAMS</th>
<th>PRICE</th>
</tr>
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<tbody>
<tr>
<td>TURBO BASIC</td>
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</tr>
<tr>
<td>TURBO C</td>
<td>100</td>
</tr>
<tr>
<td>C-TERA</td>
<td>100</td>
</tr>
<tr>
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</tr>
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</tr>
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<td>R&amp;TURBO</td>
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<tr>
<td>INPORMIX SQL</td>
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</table>

**OBJECT-ORIENTED PROGRAMMING**

- ACTION
- ADVANCE V C++
- CALL
- FEAT.+2
- SMARTS
- COMMUNICATION APPLIC. PACK
- COMMUNICATIONS
- CUSTOMER
- APPL. SUPPORT
- APPLICATIONS
- EQUSOLVER

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- DBMS
- DBF
- DBASE
- DFS
- FDS
- FORTRAN

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- LTD.
- CALIF.
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Circle 187 on Reader Service Card
Two Mac Databases
Go Toe-to-Toe

Charles Spezzano

Double Helix II and 4th Dimension are two of the leading heavyweight contenders in the Macintosh database arena. Both are relational database systems that let you link multiple files of records. With these systems, you can set up customized turnkey database management applications. In fact, you can do almost anything you want in designing customized database applications on the Macintosh.

Despite these similarities, Double Helix II and 4th Dimension have very different personalities. Helix is one of the most visually oriented databases available for the Mac. You don't have to type in instructions for anything; instead, you move icons around. This has been Helix's trademark since its introduction back in the days of the first 128K-byte Macs.

At that time, Helix was a cute but limited program that couldn't even do subtotals. Now it has matured, and it still has an abundance of icons per square inch of computer screen. It also has all the heavyweight features most users need, except for a procedural programming language and a built-in graphics generator.

There is nothing "cute" about 4th Dimension. If you prefer to build your custom applications with a sophisticated Pascal-like programming language, then 4th Dimension is currently the stand-out choice among Macintosh databases. If, however, you don't want to program, then Double Helix II easily and comfortably supplies you with the capability to create your customized relational application.

Double Helix II 40
Odesta Corp. offers Double Helix II version 40 for $595. The program comes on two 3½-inch floppy disks and runs on a Mac Plus with 1 megabyte of memory and a hard disk drive.

Helix has fans like the Mets have fans. Even when Helix had flash and potential, but little power or real business capability, users still loved it. Now, Double Helix II is an easy-to-operate but versatile program for the serious user who prefers to create databases in a graphics development environment by using a palette of icons rather than traditional programming.

What's called a file of records in other programs is called a relation in Double Helix II. A collection of relations is a multifile database. When you open a new relation, you are provided with a palette of seven icons. These icons represent the tools that you use to create the relation's structure.

Once you open and name a relation, you can create a field by dragging a Field icon out of its icon "well." Double Helix II handles five different types of data fields: text, number, date, flag (true or false), and picture (screen image of any sort). In addition to setting the type of field that you create, Double Helix II also provides a format button that lets you specify the exact output format of a number, date, or...
flag, and a validate button that lets you set restrictions on the information entered into this field. You don't have to specify a length for a field (see table 1). Double Helix II allows up to 32,500 characters per field, but it does not allocate a fixed amount of space. Rather, it allocates only the space you actually use when entering data into that field for any record, even if that space differs from record to record.

Once you create fields, you design a form so that you can enter, view, and manipulate the information they will contain. You build applications on forms by manipulating icons that represent each element or data-management activity, such as a value, a calculation, or a selection process.

With Double Helix II, everything you do with your data requires a form. You will need data-entry forms, report forms, mailing-label forms, and so on. Helix doesn't have separate components, such as a report generator that has different procedures that you must learn for each component. You use Template icons exclusively for form design.

You use View icons to enter and view data. For this process, you simply drag and name a View icon, select the Template you wish to use, pull down the view menu, and select Show Form. The form you created in the Template icon is now displayed and ready for data entry. When it's time for your first report, you drag and name a new Template. Then, as with the data-entry form, you can customize a design a report form, or you can use a Quick command to automatically generate a columnar report.

You can design fields to display and print in a variety of fonts, sizes, and styles. Double Helix II can index the fields to let you view records in a particular order and to help speed up the retrieval of information. To build an index, you use the Index icon. Essentially, you name the index and drag the field to be indexed to the top of a field list. A dialog box shows you that your index is being built, and also how much of the process remains to be completed.

You can join separate fields of information, such as first name and last name, with a calculation. To do this, you use the Abacus icon. In this case, you might name the Abacus icon "Full Name." When you double-click on the Full-Name Abacus icon, a window opens with oblong icons along the left-hand side. These are the famous Helix Calculation Tiles that let you visually program instead of using a programming language with its syntax protocols. You can also use tiles for complex calculations involving number fields; the procedure is similar and just as simple.

The next icon you might use is the User icon, which lets you create personalized custom menus for other people using your application on a single workstation or a multiuser network. Once you name the User icon and double-click on it, a window appears with the necessary elements for creating custom menus either manually or automatically. The automatic procedure assigns all the View icons to the menu.

To further customize your application, you can assign keyboard command equivalents to your menu choices. To do this, you simply click on and drag a number or letter from an on-screen keyboard at the bottom of the custom menu window and place it on top of the appropriate menu choice. Other icons add further power and flexibility to your use of an application.

Key New Features
Posting is the most eagerly awaited new feature of Double Helix II, especially by users of Helix accounting applications. It has been given its own icon on the Helix palette. Basically, posting refers to a database's ability to automatically change previously stored data in response to information that is being entered.

More specifically, the posting function automates data management in three ways: It provides an automated method for changing the information in stored records; it lets you change data simultaneously in more than one record and more than one relation; and it provides a method by which you can create more than one new record by simply pressing the Enter key.

In day-to-day business use, here's what this means. With posting, you can automate tasks such as maintaining running totals and global replacing or updating of data either in multiple records in the same file or in multiple files. You can also generate audit trails, enter information that you cannot view or access on the entry form, or tag printed or dumped records.

Double Helix II offers increased protection against data loss and unlimited personalized custom menus and forms for each user. Other features include faster printing; page numbers for reports; "insert" (temporarily) fields into which you can enter data for calculations without having to store it; nonselectable rectangles that protect against tampering with the values in specified fields; storing...
or printing page set-ups; dump and load parameters; shade defaults; shade invalid fields; and data validation. A new Object Manager makes working with large numbers of icons and other objects more efficient.

You can use a Revert command to discard changes and reopen the original collection. Helix offers icon well labels, a duplicate suppression/previous tile that eliminates repeating identical entries in a list and blanks out subsequent repeating columns, and over 20 new Abacus tiles, including those for date and time manipulation. A new "Why?" menu, which works with the new data validation features, explains why the data you enter does not meet the criteria previously specified.

For small business owners, managers, and professionals, Double Helix II provides a good combination of power and flexibility, plus ease of use and a short learning curve. Even new database users will be able to build custom applications. By contrast, experienced database programmers will probably be distracted by the new visual development environment in which they will find themselves.

**4th Dimension 1.0**

This new program from Acius comes on four 3½-inch floppy disks and runs on a Mac Plus with 1 megabyte of memory and a hard disk drive.

 Few Macintosh software packages have been as eagerly awaited or given as much fanfare as 4th Dimension. It has been heralded as the greatest French import since the Statue of Liberty. For the most part, this is one time when all the clamor may be justified.

4th Dimension brings to the Macintosh world the first database that maintains a single file; relationships between files; input, output, and dialog layouts; procedures (programming); custom menus; and password security. This multiwindow design environment lets you switch quickly between the five available editors.

The user environment comes into play once you've designed a database using the design environment editors—a process in which you can enter data and test the layouts and procedures you have created. You can view and print data through input and output layouts, create standard reports and eight types of graphs, import and export data, set an ASCII map (a character translation table), execute procedures, print mailing labels, and search and sort records.

When I used 4th Dimension's search and sort method, I found that it required fewer steps and was more self-evident than Helix's Query icon method. Helix does offer a simple "quick query," but this method restricts you to three search criteria: "starts with," "contains," and "is found within."

The user environment also contains database functions that let you do the following: enter data without customizing the database; test portions of your application as you develop them; use the generic user-interface for ad hoc queries and database maintenance; and check the design and placement of layouts and dialog boxes.

If you decide to go all the way to a turnkey application, the custom environment lets your application run like a stand-alone program with its own pull-down menus, password protection, and a run-time version (read-only database) that is available separately for $295 with four disks in the package. The run-time version only implements an application that has been designed with the full version of the program. It does not let you change the structure of the database.

**Five Editors**

With this overview of the three major environments in mind, you can now take a closer look at the five editors available within the design environment. The structure editor lets you create files, assign fields and field types, and create links between files. In the structure window, the entire database is visually represented, with the fields of each file contained in a rectangle.

There are eight types of fields: alphabetic and numeric (2 to 80 characters); text (an editing environment that provides scrolling and word wrap and accepts up to 32,767 characters); real numbers; short (16-bit) integers; long (32-bit) integers; date; pictures; and subfile. A subfile field is actually a file attached to an individual record. Subfiles can have up to 32,767 records, each record having as many as 511 fields. Subfiles nest to five levels.

You may give each field any of six available data- and error-checking attributes: mandatory, display only, can't modify, indexed, unique, and standard choices. The standard choices attribute lets you create a list of prepared entries, from which you can pick when you enter data.

The layout editor is the second of the five design environment editors. Layouts are similar to Helix forms, but 4th Dimension provides more drawing tools to create them.

You can select a standard layout from eight choices or custom design an input or report format. You select fields to be included in each layout as well as create Macintosh interface tools such as check boxes, scrollable areas, buttons, graph areas, and any variable you want to include on the layout. You can include displays of layouts from other files or fields from linked files. You can also display formats for dates, numbers, and variables.

The procedure editor brings you into contact with 4th Dimension's full-featured, Pascal-like programming language. You can use either the flow chart or the listing method for writing procedures. You use the procedure editor to write and modify global procedures for use as menus, commands, and subroutines.

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**Table 1: Although 4th Dimension is a robust program, Double Helix II has unlimited capabilities.**

<table>
<thead>
<tr>
<th></th>
<th>4th Dimension</th>
<th>Double Helix II</th>
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<td>Files per database</td>
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<td>Fields per file</td>
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<td>Total links</td>
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</table>

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(JUNE 1988 • BYTE 161)
times, or to create layout procedures that control processing for a specific layout (e.g., input, output, or dialog). You can also use it to create file procedures for controlling files.

You use the menu editor to create custom menu bars and menu command choices. 4th Dimension's menu editor is similar in capability to Helix's custom menu features.

The final editor, password, provides the capability of creating a multiple-level password system that can control access to the design and user environments as well as protect menu bars, titles, and items. There is one drawback, however, to 4th Dimension's password scheme: it's an either/or system. Either users can get into a particular layout or they can't. By contrast, Double Helix II lets you further specify exactly what you can do with a particular layout once you've accessed it. On the plus side, though, 4th Dimension's password system keeps track of how many times you use each password, and the date when you used it last.

In my opinion, this is the premiere Macintosh application development tool for experienced programmers. No other program looks and feels like a graphics-oriented Macintosh package, while at the same time giving veteran programmers the procedural language, host language interface, and multiuser AppleTalk support with which they can create a large-scale, completely customized database application. Many users, however, will be in over their heads trying to develop complete turnkey applications with this version of 4th Dimension. The company promises that a future version will provide pop-up menus and similar tools for nonprogrammers.

Linking Files: A Comparison

With both 4th Dimension and Double Helix II, you use the mouse to link files. You link two 4th Dimension files by drawing a line between the linking fields, or from a field in one file to another file of records, which will become a subfile of that field. When you later create the layout for a file, you can include data from any linked file.

4th Dimension automatically writes a layout procedure program that moves the data between the linked files. You can modify these programs with the procedure editor or use that editor to create your own procedures to work with linked data. You might find managing file links with 4th Dimension difficult, depending on your skills in writing these programs.

Double Helix II links are for looking up data in or posting data to another file. You can create these links by dragging objects into the blank spaces on files or by specifying a dialog box what you want placed into the spaces. A subform link, which provides a means to display a list of data from one file within the form of another file, is created in the file containing the data and is then brought into the form where it will be displayed. This procedure is perhaps the most tedious in Helix and involves approximately 20 separate steps, including creating an Index, a Template, and a View icon.

Lines and arrows show the links between files. These links must be set during the design process—a disadvantage compared to Double Helix's Look Up files, which let you, while working in one file, retrieve data from another file without the necessity of a predesigned link. With 4th Dimension, if you realize after the fact that cross-file data retrieval requires a link you had not created, you must go back and modify the design of the database.

Making Comparisons

I ran BYTE's benchmark tests on these two programs on a Macintosh 512e that had been upgraded to 1 megabyte of RAM with a Dove 524S MacSnap memory board and SCSI port upgrade. Attached to the SCSI port was a Nova 30 hard disk drive from Micro Tech.

Except on the initial task of importing a 1660-record file, 4th Dimension was significantly faster than Double Helix II (see table 2). It performed searches and built an index three to four times faster than Helix did. These results strongly suggest that, in day-to-day use, 4th Dimension will prove to be a speedier performer than Double Helix II.

The 1660-record ASCII file I imported into both Double Helix II and 4th Dimension consisted of 15 fields per record. Helix took 13 minutes, 20 seconds to complete the importing process while 4th Dimension completed it in 39 minutes, 8 seconds.

I then asked both programs to search an unindexed field for the last record in the file. Helix found and displayed the record in 4 minutes, 45 seconds. 4th Dimension did it in 1 minute, 45 seconds. I conducted a search for a nonexistent record, again on an unindexed field. Helix took 4 minutes, 50 seconds, and 4th Dimension reported back in 1 minute, 20 seconds.

When I indexed the Last Name field in each database, Helix took 6 minutes, 7 seconds, and 4th Dimension took 2 minutes, 55 seconds. Both programs completed searches on the indexed field too fast for me to record on my stopwatch.

And the Winner Is?

These two programs are excellent choices for building custom database applications, because they both make good use of the Mac interface, they have all the features needed to create a turnkey system, and there are so few toe-to-toe competitors currently available for the Mac. Your selection of one or the other may rest largely on whether or not you prefer to build those applications through the visual object-oriented Double Helix II method or with 4th Dimension's traditional programming language.

Other Macintosh database application development programs face stiff competition from these two programs. They both create applications that make good use of the Macintosh interface. They both provide multiuser access. 4th Dimension also steals the high-end programming show from dBASE Mac with smoother search and sort methods, multiuser access, and a host language interface.

In spite of the excitement over the appearance of 4th Dimension in the U.S., I still prefer Double Helix II for my own database needs. That's because I am among the user category of small business owners, managers, and professionals for whom programming is an unwelcome chore. Many full-time programmers, however, will be waiting with open arms for 4th Dimension.

Charles Spezzano, of Denver, Colorado, is the author of "Database Managers" in BYTE's Applications Software Today (Summer 1987).

<table>
<thead>
<tr>
<th>Table 2: Except for the &quot;load sample file&quot; test, 4th Dimension was significantly faster than Double Helix II. All times are in minutes:seconds.</th>
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<td>Load sample file</td>
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<tr>
<td>Search for nonexistent record</td>
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<tr>
<td>Index a field</td>
</tr>
</tbody>
</table>

Charles Spezzano, of Denver, Colorado, is the author of "Database Managers" in BYTE's Applications Software Today (Summer 1987).
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Double Threats to Lotus 1-2-3

Diana Gabaldon

Quattro and Surpass are two spreadsheet programs that, at least in some ways, outshine Lotus 1-2-3. And they do it by being data-compatible with 1-2-3 worksheets. In fact, you could consider Quattro and Surpass functional supersets of 1-2-3.

But there the similarities end. Each program has its own approach to providing a better spreadsheet. Quattro offers an easy-to-use interface and a very attractive price, while Surpass adds features that let you consolidate several different spreadsheets.

Quattro 1.0

Quattro looks and feels a whole lot like 1-2-3. I was immediately able to do good things with Quattro without so much as looking at the user’s manual. If you’re a fluent 1-2-3 user, you’ll get the hang of this program in about 30 seconds. If you’re not, it might take you a couple of hours. Quattro’s creators decided not to stray too far from the de facto 1-2-3 standard. It has all the familiar Lotus features, such as block definitions and moves, range naming, built-in functions, file handling, and many of the familiar keystroke rhythms of 1-2-3. But Quattro’s creators have gone out of their way to make some of 1-2-3’s functions easier to use.

Borland International’s $247.50 package runs on the IBM PC, XT, AT, Portable, PS/2s, and compatibles. You need 384K bytes of RAM, but more memory is strongly recommended. Quattro provides both 5¼- and 3½-inch floppy disks and requires DOS 2.0 or higher.

Instead of residing in a two-line area at the top of the screen à la 1-2-3, Quattro’s menu choices are displayed in pop-up windows. You press the slash key, and Quattro’s first-level function menu appears as a list of command options in a vertical window. As you use your up arrow and down arrow keys to highlight your choice, Quattro displays more details of each function on the first line of your screen.

If you’re 1-2-3 adept, you already know many of Quattro’s capabilities. Block functions (e.g., copy, move, erase, and name ranges) and column, row, erase, file, and print are essentially the same as 1-2-3’s similarly named functions. You can also do a search and replace within a range of cells; this is a very powerful feature that 1-2-3 lacks.

While most popular spreadsheets let you query a database in some fashion, Quattro also lets you assign field names in a query. This means that Quattro names cells in your database, according to labels in the first row of cells. You can then reference these field names instead of cell addresses when specifying the criteria for your query—a more convenient and somewhat faster way of doing things. The program also has useful features such as dependent minimal recalculation, in which only cells affected by spreadsheet changes are refigured.

You can customize Quattro to a very sophisticated level. With this flexibility, you have a range of options: from selecting the most desirable interface to developing your own menu system. You can change either to an interface virtually indistinguishable from Lotus 1-2-3, or to a novice-level menu system.

Quattro’s graphics are spectacular. With this program you have the ability to create just about every kind of graph you can think of, with every sort of pattern, legend, marker, grid, and title. About the only thing you can’t do is add free-form text to a graph. You can store a graph as an .EPS or .PIC file (the most common graphics file formats) for later desktop publishing purposes, or you can put it in a PostScript file for laser printing.

Quattro’s print functions include a Top Heading and Left Heading function; these are the familiar 1-2-3 Border commands. In 1-2-3, I always had trouble remembering whether it was the Column or the Row border that showed up on the left. You will enjoy Quattro’s more descriptive command names, which spell continued
DOUBLE THREATS TO LOTUS 1-2-3

Quattro 1.0

<table>
<thead>
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<tr>
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<tr>
<td>Language</td>
<td>C and assembly</td>
</tr>
<tr>
<td>Computer</td>
<td>IBM PC, XT, AT, Portable, PS/2s, and compatibles with 384K bytes of RAM and DOS 2.0 or higher</td>
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<tr>
<td>Documentation</td>
<td>340-page reference guide</td>
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Surpass 1.01

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<tr>
<td>Company</td>
<td>Surpass Software Systems Inc.</td>
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<tr>
<td>Format</td>
<td>8088 version with three 5¼-inch floppy disks or two 3½-inch floppy disks; 80286/80386 version with one 5¼-inch floppy disk and two 3½-inch floppy disks</td>
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<td>Language</td>
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<td>IBM PC, XT, AT, PS/2, or 100 percent compatible with a hard disk drive, 512K bytes of RAM, MS-DOS or PC-DOS 2.0 or higher, and a monochrome or graphics display adapter</td>
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<td>650-page document with quick reference and quick access guides and reference manuals</td>
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<td>Price</td>
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<td></td>
<td>For 10-workstation network version: $1995</td>
</tr>
<tr>
<td>Inquiry</td>
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</table>

easier, faster spreadsheet formatting.

On the down side, Quattro is a memory hog. I had trouble running spreadsheets with 100 columns or more on an IBM XT with 512K bytes. However, the program will use expanded memory, if available. For a first-time spreadsheet user, Quattro is a fine choice. At a much lower price, it offers all of Lotus 1-2-3's main features plus a few extras, such as the ability to use dBASE files. If you're spreadsheet shopping, Quattro is a good pick.

Surpass 1.01

You can run Surpass Software Systems' spreadsheet on an IBM PC, XT, AT, PS/2, or 100 percent compatible with a 5¼- or 3½-inch floppy or hard disk drive, a minimum of 512K bytes of RAM, MS-DOS or PC-DOS 2.0 or higher, and a monochrome or graphics display adapter. According to the company, this $495 package works with all RAM-resident accessory programs. When I tried it with SideKick (version 1.56), I had no problems. The package also comes with a special version of Surpass that uses the additional machine instructions of the 80286/80386 chips for better performance and memory utilization.

Surpass does a good job of matching or outdoing 1-2-3. Their user interfaces and general modes of operation are similar. Not provided by Lotus 1-2-3, however, is Surpass's abilities to use both extended and expanded memory and to load an entire spreadsheet into either.

Surpass's screen appearance is slightly different from that of 1-2-3. This is because Surpass uses windows and pop-up menus. You can have several spreadsheets visible in windows simultaneously, and you can concurrently summon and dismiss menu windows at will.

You can open and view multiple directories and disks with this spreadsheet's Visual File Manager, and you can view and graphically traverse the disk's directory tree. You can sort files by name, extension, size, DOS order, or time stamp.

Surpass does not have Quattro's ability to search and replace within a range. However, it does let you search a worksheet for a text string, formula, or numeric value, and for a specific condition, such as \( +A1<200 \). This command causes the program to search for cells containing a value of less than 200. There is a separate \( \text{REPLACE} \) function that will let you replace, append to, or delete specified character strings.

There are several nice small features, such as undo, zoom, automatic adjustment of column width to the width of the longest item in the column, macro recording (the program writes a macro by recording your keystrokes), and tracing (single-step execution of a macro so you can see where problems occur). You can keep macros in macro libraries—a feature that lets you use the macros with different spreadsheets rather than only in the spreadsheet where they were created.

You can set recalculation to either manual or automatic. As with Quattro, Surpass also has dependency-based minimal recalculation. This means that only cells dependent on the last data entry are recalculated—a process that considerably speeds up the recalculation function in large spreadsheets where changes affect only a few cells. More important, with Surpass, recalculation also runs in background mode so you can continue with data entry or other spreadsheet functions while it takes place. Surpass can use the 8087, 80287, or 80387 math coprocessor (not required), which, if used, increases recalculation speed.

The graphics in this program are certainly adequate for most business uses. There are 21 different types of graphs, among them some interesting three-dimensional bar charts. I particularly liked being able to print a graph without having to exit from Surpass to a separate printing program. Quattro also has this feature, but it does not have Surpass's slide show feature, which lets you set up a programmed sequence of selected graphics screens for later viewing.

Every new software product has one feature that's supposed to really knock your socks off—a feature that everyone mentions when describing the product. Surpass has something it calls a "hot link," a feature that lets you consolidate spreadsheets.

In a way, a hot link is similar to a relation in dBASE III. Just as a Set Relation command effectively joins two separate database files, a hot link joins two or more separate spreadsheets. Once two or more Surpass windows (spreadsheets) are hot-linked, they effectively act as one. And with hot links, you can build graphs that use data from several different spreadsheets. This feature is similar to that in the just-out NextView from ADC & Associates, with its distributed spread-
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For video purposes, the Network Card Plus provides Hercules monochrome text and graphics, including RamFont mode—which combines the versatility of graphics mode with the speed of text mode. RamFont lets word processors, like WordPerfect 5.0, show actual italics, bold face, and multiple type styles and sizes. And it lets spread-sheets, such as Lotus 1-2-3, display more information on a screen. All without sacrificing speed.

In short, the Network Card Plus answers two critical needs—networking and advanced video. At the affordable price of just one card.

For information—or to learn where you can buy the Network Card Plus—call toll-free 1-800-532-0600 ext. 402 (U.S.) or 1-800-323-0601 ext. 402 (Canada).

*Requires inexpensive networking software, such as TOPS/DOES. ©1988 Hercules Computer Technology, Inc., 921 Parker Street, Berkeley, California 94710.
Technical Support 415-579-0748; Sales 415-540-0232. Hercules and RamFont are trademarks of Hercules Computer Technology, Inc. Other products are trademarks of their respective holders.

Circle 125 on Reader Service Card (DEALERS: 126)
The problem is what to buy. Both Quattro and Surpass offer some distinct advantages over the present version of Lotus 1-2-3. Specifically, Quattro comes in at a much lower price. At $247.50 (compared to $495 for 1-2-3), Quattro, with its customization possibilities, is a good value, though it is no speed demon. Surpass, on the other hand, offers the additional features of background recalculation, spreadsheet consolidation through its hot links, and slightly better graphics—all for the same price as 1-2-3.

Those advantages may disappear, however, when Lotus introduces the enhanced version of 1-2-3. Moreover, either Surpass or Quattro works with the large number of add-in products developed for 1-2-3, and if you depend on any of those add-ins, you're also dependent on 1-2-3.

Borland International worked hard to make Quattro “better” than 1-2-3. It may not be better, but it's very good. Surpass Software Systems made its hot-link concept very valuable for users, and it's also very good.

So until the new version of 1-2-3 is ready, I recommend Surpass if you need the ability to consolidate several spreadsheets. If you don't need that feature, you might consider Quattro the better buy.

Diana Gabaldon is editor of Science Software, an international journal for scientists who use computers, and an assistant research professor for Arizona State University's Center for Environmental Studies.
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### Performance/Price Chart

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### Technical Specifications

- Power C includes: Power C compiler with integrated Make, Power C Linker, Power C Libraries (450 functions), the Power C book (580 pages), and support for ANSI standard
- IEEE floating point
- auto-sensing of 8087/80287
- automatic register variables
- unlimited program size
- mixed model (near & far pointers)
- graphics on CGA, EGA, VGA, & Hercules

**Optional Products:**
- Power Ctrace debugger
- Library source code
- BCD Business Math

**Minimum System Requirements:**
- DOS 2.0 or later
- 2 floppy drives or hard drive
- Runs on IBM PC, XT, AT, PS/2 and compatibles

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A Spreadsheet for Unix

Paul Schauble

Although Lotus 1-2-3 has spawned a host of imitators, Q-Calc Standard is different: it runs under Unix. Q-Calc Standard is compatible with Lotus 1-2-3 version 2.01, can use .WKS and .WKS spreadsheets, and has multiuser capabilities inherent in Unix-based systems.

Q-Calc operates under various versions of Unix System V; BSD 4.1, 4.2, and 4.3; Xenix V; and HP-UX. It runs on a wide variety of hardware, including the IBM PC AT and compatibles, many 80386 machines such as the Compaq Deskpro 386, and many 680x0-based systems such as the Macintosh II, Sun workstations, Convergent Technologies workstations, and the NCR Tower. Other Unix systems include the IBM RT PC, Honeywell Level/6, DEC VAX, and IBM 30xx mainframes, to name a few.

For graphics output, Q-Calc supports Tektronix 4014, HDS 220, and Visual 550 terminals. It also supports some bit-mapped workstations, such as those from Sun. Q-Calc produces hard-copy graphics on PostScript-based printers, the HP LaserJet, IMAGEN Impress printers, the IBM Proprinter, and an assortment of pen plotters.

My review package came with a single 1.2-megabyte 5¼-inch floppy disk and a manual in an 8½- by 11-inch three-ring binder. The clearly written and well-organized manual includes installation instructions, a tutorial, and a reference section. The tutorial is a good introduction to Q-Calc, but it does not have enough examples on how to use Q-Calc commands to introduce a novice to spreadsheets. The reference section has a fairly complete index. The features and command set are close enough to 1-2-3 that an experienced user might not need the manual.

The version of Q-Calc I used was optimized for Xenix running on an IBM PC AT-compatible 80386-based system and required 250K bytes of RAM and 500K bytes of hard disk space. This package costs $450; versions for other systems sell for up to $4000. For this review, Q-Calc was run under SCO Xenix 2.2.1 on an Everex 3000, a 16-MHz 80386 system with 4 megabytes of RAM, and a CGA card.

**Installation Problems**

Unix software is more difficult to install than MS-DOS software. The IBM PC AT and MS-DOS standard covers not only the software but also most of the details of the hardware. An MS-DOS program running on the IBM PC AT knows exactly what type of hardware it’s using. In contrast, because Unix runs on a very large variety of hardware, a Unix program must be explicitly configured for the type of hardware it will run on.

The installation proved to be the most difficult part of this review. The installation section of the Q-Calc manual gives specific instructions for installing the program on a Xenix V system. When I followed these instructions, the system displayed an error message, tar: 0 files extracted, from one of the Unix utilities. There were no other installation instructions packaged with the disk, nor any manual update. I probed the distribution disk for a half hour, with the Xenix utilities dd, tar, and ls showing me how the disk is organized, and I was then able to complete the installation. The instructions in the manual were apparently for another version of Xenix.

Q-Calc was designed and written by Quality Software Products and is published, distributed, and supported by UniPress Software. The software had been repackaged by UniPress for various operating systems, and the manual had not been updated.

After installation, you must configure Q-Calc for the specific terminal hardware that each user runs. This process identifies the functions available on the screen and keyboard. Each user has his or her own profile, which describes the keyboard and screen in use and sets Q-Calc options. For example, the profile may specify that a Control-Z is equivalent to the slash (/) graph view command. The profile also determines printer setup, query before delete, and many other Q-Calc options.

The defaults provided work well with many common terminals. The ANSI terminal model, used by Xenix for the CGA, and the VT-100 terminal model were usable without specific customization. Other terminals may require building a user profile. This task is comparable in difficulty to making a Unix terminal entry. It is a job for an experienced Unix user or system administrator.

**Spreadsheet in Action**

The organization of Q-Calc and its commands and functions are almost identical to those of Lotus 1-2-3 version 2.01. Macros work in the same way, although you must invoke them by a different key sequence than Alt-keystroke. Several of my macros did not work correctly because a Q-Calc feature interrupted the macro and asked for confirmation when I attempted to delete rows or columns, or when I erased region commands. However, I could disable the confirmation feature through the user profile.

Also, Q-Calc provides a feature that is unique to Unix systems. The Lotus file import and export features have been extended to work with Unix pipes. This lets you process part of a worksheet through...
any filter program, or read from any file
or database through a filter. A filter can
read a database file and convert it into a
worksheet format. Most filters are writ­
ten in C. Writing a filter is not difficult
for a programmer, although the average
spreadsheet user will probably not want
to do it.
Q-Calc uses the same file format as
Q-Calc and 1-2-3. Some of the 1-2-3 keys,
like PageUp, PageDown, and most of the
function keys have the same use in Q­
Calc and 1-2-3. The standard Q-Calc
keyboard assignments follow the 1-2-3
keyboard as closely as possible. The cursor
keys, PageUp, PageDown, and most of the
function keys have the same use in Q­
Calc and 1-2-3. Some of the 1-2-3 keys,
such as Escape and Control-right, cannot

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80386-based computer such as IBM® PS/2™ Model 80 or
COMPAQ® DESKPRO 386™ or
80286-based computer with
luname™ inboard™ 386/AT.
One 1.2 Mb (5½") or one 3½" microfloppy disk drive.
One hard disk drive.
DOS 3.0 or later.
2 Mb RAM recommended.
Supports monochrome, CGA, EGA, VGA, and Hercules™ monitors.
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Circle 199 on Reader Service Card

A SPREADSHEET FOR UNIX

Table 1: Benchmark results clearly show that Q-Calc runs slower than Lotus 1-2-3 even with an 80287 math coprocessor chip. (All times are in seconds.)

<table>
<thead>
<tr>
<th>Worksheet</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Xenix</td>
</tr>
<tr>
<td></td>
<td>Q-Calc with 80287</td>
</tr>
<tr>
<td>Savage</td>
<td>33</td>
</tr>
<tr>
<td>Columns</td>
<td>7</td>
</tr>
<tr>
<td>Scroll Right</td>
<td>66</td>
</tr>
</tbody>
</table>

be duplicated on the Xenix keyboard. All the commands are also available by entering a Control-X followed by a letter for the specific command. Some users prefer this form for commands because it is the same on all terminals, while the function keys may be in different locations or missing completely. An apparent bug prevented me from marking a region by starting at the lower left corner and moving up. Another bug resulted in several aborts with core dumps when I pressed PageUp. I saw this both with worksheets imported from Lotus 1-2-3 and with worksheets constructed with Q-Calc. This problem occurred only when operating on a color video card and appears to be a bug in SCO Xenix. Q-Calc operated correctly with a monochrome video card.

[Editor's note: To verify that Q-Calc does operate correctly in a Unix environment, BYTE obtained another copy of Q-Calc and installed it on an AT&T Unix PC Model 7300 running Unix System V. The Unix version of Q-Calc had the correct installation instructions. On the AT&T 7300 system, Q-Calc ran all the test spreadsheets with no problems.]

Graphics

The Q-Calc Standard/Graphics package is priced separately from Q-Calc. Its operation is very similar to PrintGraph. You use Q-Calc to prepare and preview the graph and to make a graph file. This file is then made into hard copy using one of the supplied graphics drivers. All the 1-2-3 graphics types (e.g., line, bar, and pie charts) are supported. In addition, Q-Calc adds a commodity chart that plots high, low, and closing price information from a stock market chart.

The supported set of graphics display devices in Q-Calc is very limited. In particular, the IBM CGA and EGA video cards are not supported in graphics mode. Q-Calc can draw crude graphs using ASCII or the IBM line-drawing character set. This is barely adequate for debugging and proofing graphs and is essentially worthless for presentations. UniPress is aware of this limitation but has no specific plans to remove it. Instead, the company invites you to write your own device driver—not something the average spreadsheet user wants to undertake—and provides interface specifications.

Growing Pains

This product shows a lot of potential, but the current version is lacking in polish. In comparison with the best PC-DOS spreadsheets, Q-Calc is slow, limited in display versatility, and awkward to use. This package isn’t going to make anyone rush out and buy a Unix system just to do spreadsheets. Almost all these limitations are the result of Unix software standing at arms’ length from the hardware. Where MS-DOS applications have been optimized for performance on PCs, Unix applications are optimized for portability. If you must use Unix, it is difficult to conceive of a spreadsheet program that works in this environment that would remove all these limitations.

Still, Q-Calc has some problems. The lack of automatic installation procedures is usual for Unix software, but having to inspect a hex dump of the distribution disk is not. UniPress needs to improve its documentation in this area.

The utility of Q-Calc depends on the environment it will be operating in. It is best used where other considerations dictate using both DOS and Unix and require spreadsheet use on both systems. In this case, Q-Calc’s similarity to 1-2-3 and its ability to use .WSK and .WK1 files are major advantages that might outweigh its other problems. Q-Calc could be an excellent product for this niche. If this interchangeability is not a requirement, then you should examine other alternatives.

Paul Schauble is an independent program developer in Glendale, Arizona, who has been working with Unix-based systems for over 10 years.
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Circle 107 on Reader Service Card (Dealers: 108)
A New Member of the Family

Jerry Pournelle

Someday this place is going to vanish under a vast sea of paper, software, and cables. Looking at the view from my chair, you'd probably say it could happen in the next few hours: there is literally no flat surface, including the couch and the top of the fish tank, that isn't covered with something. It's just like the day after Christmas—and I certainly enjoy having all this to play with—but I'm afraid it's getting out of hand.

Still, my desk was actually down to bare wood last night, and there's nothing on it now that isn't relevant to this column; I've got some new volunteers to help sort through the software; and my motto—"Every day throw something away"—has cleared out enough of the storeroom that much of this clutter can be put away when I get a free moment.

On the other hand, my column is due tomorrow, Prince of Mercenaries is almost completed but long overdue, Wrath of God is due all too quickly, and I'm going to Memphis in 3 days, then to a meeting of the advisory board of the Lowell Observatory, during which time more will come in. Sigh.

Zanna Lee

One reason for the clutter crisis is that I've spent the last 2 days setting up Zanna Lee, the Zenith Z-386. It took longer than I thought it would, but then everything does, and I suppose it's not surprising that changing to a new main machine would be complex.

One reason for the change is disk capacity. Zanna Lee has an 80-megabyte hard disk drive made by the Magnetic Peripherals Division of Control Data. I've heard good things about them, but I confess some partiality to Priam hard disk drives. I've bad one of those in the Golem, my CompuPro Z80/286 Dual Processor, since about 1983, and there's been no hint of a problem; ditto for the 40-megabyte hard disk drive in Fast Kat the Kaypro 386.

I first saw Priam hard disk drives at the first Atlanta COMDEX; they were showing the then-new system of mechanical head lifters that click in on power loss. Now just about everyone uses that concept, and a good thing, too.

Anyway, I invited my son Alex over to help set up the Z-386. Our first job was to configure Zanna Lee's hard disk drive. Actually, the machine did come preconfigured, but in my rush to transfer data from Fast Kat to Zanna Lee, I copied a whole bunch of files off Fast Kat's root directory. Some were system utilities, and one was, I think, COMMAND.COM; anyway, shortly after that we got version conflicts with CHKDSK and other utilities, sometimes even on start-up depending on the CONFIG.SYS file, and then Zanna Lee stopped talking to most of the partitions on the hard disk drive.

This was annoying enough that I decided it was time to see that the exact same version of DOS was running on every machine in the house. I suppose strictly speaking that's not legal; but in my defense I have an original DOS for every machine, so all I'm actually doing is updating.

Updating DOS is easy but tedious, and you do have to pay attention. First, you copy all the DOS system utilities from your floppy disk copy (surely you aren't working with the original disk!) to the appropriate hard disk drive subdirectories. That turned out to be a problem, since many of my machines came preconfigured. Those system utilities reside in the \UTIL subdirectory on one system, \BIN on two others, \2861 on a third, and so forth. I still haven't decided what to standardize on.

Anyway, eventually I got it done, after which I went around using the SYS command on everything in sight. The whole DOS update procedure is described in great detail in Chris Devoney's Using PC DOS (Que, 2d edition)—a book I can't get along without.

Once we had DOS updated, we still had to configure the hard disk drive. The Z-386 came with Zenith software to accomplish that, but after about 4 hours of working with it (and discovering that it likes a version of DOS different from the one we had just installed everywhere, sigh), we gave up and got out SpeedStor.

I don't seem to have the latest version of SpeedStor, but the one I do have worked fine. SpeedStor is menu-driven and quite well documented: the manual actually explains what's going on. Most of its text about hardware applies to IBM PC XTs, PC ATs, and very close clones, and there's little about backplane systems like the Z-386, but there's enough to get the job done. Recommended.

SpeedStor offers the alternative of formatting Zanna Lee's hard disk drive as one great big drive, but there are drawbacks to doing that. After thinking about the situation, we partitioned the drive into three more or less equal chunks, meaning that Zanna Lee now has drives C, D, and E. Once that was done, I made a floppy disk copy of the new C:\ partition to save the system and setup files, then used Fastback Plus to bring over everything from the Kaypro onto the Z-386's C, D, and E drives, and finally copied over the Kaypro stuff with the systems and setups I'd just saved.

After that, it was time to purge the Kaypro of files I don't have permission to keep on more than one machine; the tool of choice there is PC Sweep, a shareware program that is invaluable for chores like this.

Zenith sent a Z-515 memory board for the Z-386. That's 4 megabytes of 32-bit memory, which is a lot. The Z-515 can be set up to dedicate part of that memory to...
to the Expanded Memory Specification (EMS), as well as automatically filling out the main system memory to 640K bytes. The EMS option looked like a good idea at first, and in my first installation I reserved some memory for EMS; but on reflection this seemed pointless.

The real advantage of having a 386 is the ability to use DESQview or VM/386 so you can keep lots of different programs and utilities in memory; and if you have those, you don’t really need expanded memory. If you do reserve memory for EMS, you’ll find that as far as the computer is concerned, that memory has just plain vanished: it’s not shown as either system or extended memory on boot-up. It’s also simple to disable EMS.

Mice and Memory

The next step was to install a mouse. The Kaypro has been using the Logitech Bus Mouse, which is a good one, but that takes up a slot. On the other hand, I sure didn’t want to use Zanna Lee’s only serial port for the mouse. I was going to have to put some kind of board in there. Why not make it do double duty?

The easiest solution would have been Logitech’s EGA&Mouse board. That works fine, especially with Logitech’s excellent Autosync monitor; I used both in Zanna Lee’s setup exercises. If you want a good EGA system, I think there’s no better value for the money than the EGA&Mouse board.

Autosync is a fine monitor, but I’m in love with the 14-inch Zenith ZCM-1490 Flat Technology Monitor; you can’t believe how nice that is, even in a sunny room with windows behind you. It’s good enough, in fact, that I’m going to try it as the main screen in place of the Electrohome 19-inch monitor.

I’m a bit concerned about the screen size, but after all, I used a 14-inch Hitachi monochrome monitor for years; and perhaps because the ZCM-1490 is truly flat, text displayed on it seems easier to read than on traditional monitors. One fair warning: the ZCM-1490 has an internal fan. It’s not loud enough to bother me, but you can hear it.

The ZCM-1490 is driven by the Zenith 31-kHz video card. Video cards used to come with serial ports, but Zenith’s doesn’t. I wish it did; I could simply address that to COM2 and plug the mouse in. For that matter, I wish computer designers would recognize that mice are essential and slots are in short supply: a single serial port isn’t enough. Machines should come with at least two serial ports.

Since I’d have to use a slot anyway, the simplest solution was to install a Cheetah Combo card. This takes an AT slot and comes with a megabyte of 16-bit memory, a serial port, and a parallel port. I can’t use a second parallel port—who can?—but the serial port can be addressed as either COM1 or COM2. Cheetah cards come with an installation program that’s absurdly simple to use: you just tell the program what you need, and it shows you a pictorial diagram of how to set the DIP switches on the Cheetah card.

I addressed the Combo card to just above the address of the Z-515, giving Zanna Lee 640K bytes of system memory and 4608K bytes of expanded memory. The top megabyte of that is 16-bit memory, and thus considerably slower than the rest, but it’s not likely I’ll use it much either; I’ll probably turn it into a RAM disk when I get time to figure out how to do that.

CD-ROMs

The next step was to install the Amdek Laserdek. This comes with a controller card. By now, the Z-386 was getting a bit full. Only three slots were left: one short
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PC (8-bit) slot, one AT (16-bit) slot, and one full-size 32-bit Zenith slot.

Like most clones, the Zenith's PC and AT slots and bus are fully IBM compatible. Again like all 386s, the 32-bit slot and bus are not standard; each manufacturer has a particular bus design, which is why if you want 32-bit memory, you have to buy it from the manufacturer of your 386 machine. Someday, I hope, that will change.

The controller requires only a short (PC) slot, so that's where I put it. It took about 5 minutes to install the Amdek CD-ROM hardware. There are two cable connectors on the back of the reader. Neither one is labeled, which bothered me until I read the instructions: they're interchangeable. Either can connect to either the computer or another drive.

The Laserdek is external, and fairly awkward in size, being 14 inches wide, 13 inches deep, and 3 inches high. There are ventilating holes on top. I got to wondering why the thing is so large, so I opened it; there's no real reason for it to be so large. The Laserdek mechanism is about the size of a disk drive, and the rest of the box contains very loosely arrayed electronics.

On the other hand, I learned that it's very sturdily made, and so long as the monitor is not so heavy that it actually distorts the case shape, and you don't completely block off the holes on the side behind the Laserdek, there's no reason you can't put it on top of your computer and the monitor on top of it.

Software installation comes in two parts: installing the DOS extensions so your computer can find the Laserdek, and installing software so you can read the actual contents of the laser disk.

The first part is pretty simple. The instructions and software come with the Laserdek, and a Setup program does most of the work. The instructions are not too informative, but if you follow them, you'll soon have the computer listening to the Laserdek. The important thing is to put the proper statements into CONFIG.SYS and AUTOEXEC.BAT, and copy a program called MSCDEX.EXE into a place where the system can find it.

One option is to put a good part of the access software into expanded memory. The command processor extensions take about 40K bytes of system memory, and some of that—I confess I haven't tried the experiment—apparently can go into EMS if you like.

Another option is the letter designation of your CD-ROM. By default, it's the "next" device; in my case, since Zanna Lee has logical hard disk drives C, D, and E, the CD-ROM becomes F. You can, however, explicitly name the letter if you like.

Once installed, the CD-ROM drive acts like a write-protected hard disk drive. You can read its directory, change directories within it, copy files from it, and do anything you could do with a truly enormous disk that you can't write to.

Once a caution. If you have a CD-ROM disk in the drive, it spins continually. I don't know if this does any harm or not; after all, 8-inch floppy disk drives spin constantly, as do hard disk drives. On the other hand, it's one more thing to worry about. I noticed when I opened the Laserdek that if there is no disk the motor shuts down, so I left the drive empty during my overnight heat test.

It's my practice when I fill a system with boards to let it run all night and test it the next afternoon, when it's as hot as it's likely to be. I did that with the Z-386, and, sure enough, the machine hung during the boot-up process.

This was annoying. "Heat problems," I muttered. "Too much memory, plus the..."
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<thead>
<tr>
<th>Microstat-II</th>
<th>88 seconds</th>
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</thead>
<tbody>
<tr>
<td>Leading Competitor</td>
<td>160 seconds</td>
</tr>
<tr>
<td>Microstat 4.0</td>
<td>731 seconds</td>
</tr>
</tbody>
</table>

In seconds. Tests on an 8 MHz AT-type machine, no co-processor, file with 12,000 cases.

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CD-ROM controller, plus the WORM (write once, read many) drive controller, plus all the other stuff. Overloading the bus, maybe. Too much heat.”

I took the cover off the machine to cool things off. It didn’t seem particularly warm in there. Could I be doing something wrong?

As a matter of fact, yes. It wasn’t Zanna Lee’s fault at all. If you have the CD-ROM drive turned on, but there’s no disk in there, when MSCDEX.EXE runs, there is a 30-second interval during which it tries to access the Laserdek but can’t do it. Eventually it times out and continues with the start-up process.

If, on the other hand, you have the Laserdek turned off (whether there’s a disk in the drive or not), the delay is about 1 second. In neither case is there an error message. The solution to this might be to switch the Laserdek off when it isn’t in use, but, alas, the on/off switch is on the back where it’s not easy to get at.

Other than that, the installation of the Laserdek went smoothly and simply. I tested it against about a dozen CD-ROM disks, and it was able to read files from all of them. So far, so good.

Bookshelf

Once you get the Microsoft DOS extensions installed so that DOS can find the CD-ROM drive, you’ll still need software to make use of the information in the CD-ROM. There are exceptions to this—for example, the public domain software CD-ROMs distributed by user’s groups. I have one published by Aldic Publishing. This thing contains about a million programs, including utilities, games, languages, source code, and a partridge in a pear tree, all accessible as soon as you’ve run MSCDEX.EXE.

However, while you can cram hundreds of megabytes of ordinary files onto a CD-ROM—and get at them without anything special—most of the other neat things you can do with CD-ROMs are more complicated.


As I’ve said before, every professional writer has those books, but not many of us actually use them because it’s too much trouble to get the book and look things up.

Microsoft Bookshelf makes that a lot easier. It’s not perfect. The worst glitch is the “coarseness” of the scroll bars. If you’re browsing through, say, The World Almanac, you can use the on-screen scroll bars (maybe Apple will sue Microsoft for “look and feel”?) to jump through the text, but the smallest possible movement of the scroll-bar bullet corresponds to over 50 screens of text, which you have to page through one at a time if what you want is right in the middle of that 50-page clump. This defect is pretty serious, since the whole point of having Bookshelf is quick access to the included documents.

Bookshelf doesn’t support all word processors. In particular, it won’t quite work with Symantec’s Q&A Write. I can access and use Bookshelf from within Q&A Write; Bookshelf can even look up misspelled words and find synonyms. What I can’t do is paste the results into the text. When I try, the program tells me that the write function has been disabled.

I presume that Bookshelf does this when it doesn’t quite understand the word processor that you’re using, but so far I’ve been unable to get anyone at either Microsoft or Symantec to admit knowing anything about it.

Bookshelf is a valuable addition to any writer’s tool kit; as I’ve said before, I’m willing to bet that within a couple of years Bookshelf or something like it will be as ubiquitous among writers as word processors are now. It’s valuable enough, in fact, that I’m seriously thinking of switching over to a word processor that can make good use of Bookshelf.

If I do switch, it will probably be to XyWrite III Plus. The Bookshelf manual says that it works fine with XyWrite III Plus, while every week I find that more of my colleagues have fallen in love with XyWrite. This word processor is rapidly becoming the default text editor on New York’s Publishers Row, partly because it integrates with Atex so well, and partly because it’s almost infinitely customizable.

Installing Bookshelf is theoretically simple: you log onto the CD-ROM drive and run Setup; everything you need is right there on the CD-ROM itself. In practice, it wasn’t quite that easy. Setup ran all right, and it went in to modify my CONFIG.SYS and AUTOEXEC.BAT files; but when I then rebooted the system to invoke Bookshelf itself, I got the disturbing error message Out Of Environment Space. Looking up “environment” in Chris DeVoney’s Using PC DOS produced words but not much enlightenment.

Environment, as it happens, is memory that DOS reserves to store things it needs to know; in particular, the path, the
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names of various devices, and other strings it needs to look at fairly often. The default environment is 160 bytes; you can increase it (in 16-byte increments) by using the SHELL command. However, Using PC DOS also warns you that careless or improper use of SHELL can lock up your computer something awful, to the point where you may have to boot with the original system floppy disk.

Since I didn’t really understand environment to begin with, and I sure didn’t have time to recover from a locked-up system, I called Microsoft technical support and resetting won’t do you a bit of good.

Increase environment space to 512 bytes.

Once I got the CD-ROM drive properly inserted into your CONFIG.SYS will increase environment space to 512 bytes. If you do invoke SHELL, do not omit the /P; if you do leave it out, have an unmodified floppy boot disk handy, because your machine is going to be dead in the water, and resetting won’t do you a bit of good. Believe me.

Lost in Space

Once I got the CD-ROM drive properly installed and Microsoft Bookshelf running, it was time to look at other CD-ROM disks. In particular, I wanted a good look at the two disks of space data I got from the Jet Propulsion Laboratory. One of these disks features a number of images from the Voyager Uranus encounter; the other is a sampler of data and images from all over the solar system.

The software needed to display these disks is called IMDISP, and it’s more ambitious than good. The documentation that comes with it is simultaneously tedious and dense. It took me an hour to figure out what was going on, and I still don’t understand all the commands. Some of them seem to hang the machine.

Attempting to access many images gives the comment Attempt to read past end of file. Others tell me Input file does not have a proper label and ask me to specify the number of lines; in the example they give 370, but nowhere does it explain where that number came from or how you might figure out how many lines there are on each of the many images on the disk.

Even so, there’s a lot to see on these disks. The images of the Jupiter Galilean moon Io are easily accessed and startlingly good. I make no doubt that careful reading of IMDISP’s operations manual will eventually let me access nearly all the images on both disks. It will take work, but it should be worth the effort.

It’s probably not worth buying a Laserdek just for the JPL disks; on the other hand, it’s one more reason to have a Laserdek. Besides, it’s pretty certain that there will be many other disks of scientific data.

One oddity: since EGA video doesn’t have square pixels, the images are somewhat egg-shaped.

Pournelle’s Insight

Last month, as I was listening to Dr. Joseph Dionne, chairman of McGraw-Hill, speak at the CD-ROM conference in Seattle, I was suddenly hit with some inspiration.

Dionne was speaking about CD-ROMs from a publisher’s view. In the course of his speech, it became obvious that there’s a far larger CD-ROM market than I ever thought of. McGraw-Hill makes and sells a lot of them and is about to market more. All are hideously expensive and generally sell to a rather narrow vertical business market; most contain topical information that’s updated fairly often. The

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And see how being picky actually increases your choices.
After you get the computer to acknowledge the WORM drive, you need to decide whether to partition your WORM disk cartridge into large sections—up to 128 megabytes—or to stay within the DOS 32-megabyte limits. It’s simplest to use short segments, and being lazy, that’s what I did. The decision isn’t irrevocable; that is, it is not possible to change the 32-megabyte segment I already formatted, but according to the documents I can, if I like, install the proper software and set the next partition to be 100 megabytes. I suppose I’ll have to try that sometime.

So far, all I’ve done with the WORM is test it. It certainly works. You use it just like any other drive, except that you want to be careful since you can’t erase anything written. If you write two different files with the same name to the disk area, WORM-TOS keeps track of that, and there’s software that lets you step back through the various versions of files with that name until you find the exact one you like; then you can read it or copy it. The default, of course, is the latest one.

I intend to get a lot of good out of my WORM: I have a lot of work on old CP/M 8-inch disks. The Golem can read those disks, and I can use Compupro’s ARCNET PC system to transfer them over. I haven’t yet tested the WORM drive’s ability to work with the network, but I’m prepared for it not to; all I really need is to get those files onto Zanna Lee’s hard disk drive. Then I’ll move them to a WORM cartridge.

WORMs are great for archiving. I don’t know how long WORM cartridges last, but they could be nearly eternal. To the best of my knowledge, none of them have gone bad from age alone. Of course, they haven’t been around all that long, but they’re certainly more durable than any floppies I’ve ever seen.

They’re also great for backups. I’d rather have a WORM than a tape drive.

Now What Do I Do?
The major point of setting up Zanna Lee was to compare new 386 control software, particularly IGC’s VM/386, with DESQview.

DESQview, as most of you probably know, is a control program that lets you keep a whole bunch of programs in memory and jump around among them. There are ways to let programs run simultaneously, although, except for communications programs, I don’t find that nearly so useful as being able to go quickly from one program to another. I’ve used DESQview for about a year now, and I’d really hate to try getting along without it—unless, of course, I can find something better.

VM/386, on the other hand, is a program that lets you set up several virtual machines and jump back and forth among them. Each virtual machine thinks it is a single 640K-byte computer. Each can have a different CONFIG.SYS, and each can run a different AUTOEXEC.BAT on start-up. Each can be reset (with Ctrl-Alt-Delete) independently of the others.

Each of these programs has strengths and weaknesses. VM/386, for instance, really creates independent virtual machines—and since your computer has only a limited number of peripheral devices, you’ll have to assign and reassign them as you change from one virtual machine to the next. There’s no housekeeping program to track that for you.

DESQview, on the other hand, lets you load certain things into memory prior to invoking DESQview, then use them in any window you have open. The system mouse, for instance, is recognized at all levels; in VM/386, the mouse is another device that has to be switched among...
Items Discussed

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Inquiry 947.

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Model 80 ...........................................$7499  
ZCM-1490 ............................................$999  
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1000 Milwaukee Ave.  
Glenview, IL 60025  
(800) 842-9000, extension 1  
Inquiry 949.

VM/386 won't let you set up the WORM drive to be available to every window; if you want the WORM, it has to be installed in each virtual machine. This is also true for the CD-ROM device drivers. My preliminary experiments show that this works; that is, I can have Microsoft Bookshelf available in several virtual machines, but only if it's loaded into each on start-up.

VM/386 uses less system memory than DESQview; each virtual machine can be a true 640K-byte system. DESQview has enough system overhead that it's between hard and impossible to make a window leave more than 512K bytes available.

DESQview, on the other hand, has system utilities like MARK and TRANSFER (cut and paste; it doesn't always work, though). VM/386—at least the current version—has no such thing. If you want to transfer something from one place to another, you first have to grab it with a memory-resident program like SideKick, store it on disk, then change virtual machines and retrieve it. This is awkward.

DESQview has some odd glitches. For example, sometimes I'll hit the Alt key to bring up the DESQview command window, tell it to open a file, select CrossTalk and tell it to open Crosstalk. The machine trundles for a second, the CrossTalk logo appears on the screen—and then everything closes down so that I'm at the point where I was before I opened the DESQview command window in the first place!

The first few times this happened I was so upset that I quit DESQview and reset the computer, but it happened often enough that eventually I just did everything again exactly as before: invoke DESQview, tell it to open a file, select CrossTalk, open that. This time it worked fine, and examining the other windows showed that apparently none of them were harmed. This may be a harmless bug, but it's annoying. Maybe VM/386 won't do things like that, although it probably will.

I'd hoped to know a lot more about VM/386 by now, but it took longer to set up Zanna Lee than I'd thought; and once I was caught by deadlines, I had no choice but to go back to DESQview to get this written. With any luck, by next month I'll know more not only about VM/386, but also about Microsoft Windows/386.

I also have OS/2, but I don't think I want to do anything with it. OS/2 1.1 with Presentation Manager (i.e., OS/2 plus a bug-free Windows) may be interesting, but I think I can safely ignore the current version, at least until there's a lot continued
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Comic Books?
I like Infocom games—I really do—so when I got the latest release from Infocom I was ready to try it despite the title: "Lance Mastodon vs. the Blubber Men of Jupiter."

What I had, I soon discovered, isn't a game at all. It's a kind of comic book with primitive animation. It is not an interactive story; there's only one action line, one ending, and nothing you can do will change the story at all. The gimmick is that you can read the comic book from the viewpoint of the hero, the villain, and subsidiary characters. The idea is to read along until you come to one of the (obvious) choice points, where you can jump off the track and follow some other character. You can also run the "projector" backward to a choice point and shift again.

From time to time, the action is interrupted to let you witness a comic book dialogue between two critics who have supposedly been watching this mess on a movie screen. For reasons best known to the designers, these rather unattractive male cartoon figures aren't wearing any clothes. They say a few meaningless things about the action so far, and the story continues. The breaks are clearly intended to make you go to the main character's story line from time to time, and they're needed, since hero Lane Mastodon is so dumb that only a twit would want to watch things from his point of view.

The artwork is pretty grim; it's certainly so compared to what real comic artists are doing now in Marvel Comics and the Watchman series. The story line might amuse cretin dwarves, though I doubt it; not only is the story implausible, but it knows that you know that. The notion is to invite you to share the joke. If you can do that, feel free; you might even enjoy this mess.

I watched this thing through to the end because I was interested in the technique, but you'd have to pay me money to get me to do it again. In my judgment, Infocom has come up with the answer to software piracy: a story so dumb that no one in their right mind would want to steal it.

Take It Apart
Disassembly of a program is the art of taking a finished program and turning it into source code that can be reassembled into the original. It's a black art even with good disassembler programs.

When I first got started with microcomputers, my mad friend Dan MacLean introduced me to a computer maniac we called "The Mad Disassembler." This chap worried excessively that somewhere out there was a program to which he didn't have source code. He worked in the computer department of a large aerospace company, and thus had some pretty powerful machinery at his disposal; and whenever he saw a new program, he'd take it apart with the company's mainframe. So far as I know, he never did anything with the source codes he generated. He just liked to have them.

If the original programmer had taken steps to make disassembly difficult, that merely added spice. One example is Michael Shrayer's Electric Pencil, which was a disassembler's nightmare. Shrayer had encrypted all the ASCII messages. He wrote meaningless code sequences and jumped around them. In places where a careful programmer had error traps, Shrayer had time bombs. And so forth. None of that mattered: within a week, "The Mad Disassembler" had a complete source code to Electric Pencil.

Back in those days, a lot of disas-

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Assembler programs were distributed on bulletin boards.

I haven't noticed many disassemblers lately, so when I received Snoop II from TriDOS, it was like a voice from the past. Just for amusement I aimed Snoop II at a popular word-processing program. I was amazed at the results. Disassembly is still as much art as science, but Snoop II takes a lot of the sting out of it. Recommended for the insatiably curious.

**Documentor**

There are probably more people programming in dBASE II than in any other language. Every one of them needs The Documentor.

This program takes dBASE code and creates documentation for it. It generates a concordance and a cross-reference list. It comments code. It sets it up for pretty printing. The result is impressive. If you do any dBASE programming, you need this program. Highly recommended.

**Winding Down**

Once again I'm out of space, and I haven't started good. One thing I simply have to talk about next time is the Amiga 2000, which can be a highly frustrating machine. The disk access is slow. It bombs far more often than it ought to. The PC part of it is plain vanilla, and because of the way Commodore chose to let the Amiga half-communicate with the PC, very few add-on PC boards will work. For all that, the Amiga 2000 has a prominent place here, because it's just plain fun (if frustrating).

If you do have an Amiga, be sure to get Math Aquarium, one of the most unusual programs I've ever seen: it turns equations into visual treats, providing both colorful and informal results. It isn't quite worth buying an Amiga just for this.

I also want to talk about Expert 87, which, despite its name, isn't an expert-system program at all, but rather a program to help make your preferences explicit and identify conflicts. It can also be used to generate consensus opinions from a group of experts. Used properly, this could be an extremely valuable program in both home and business.

The book of the month is by Archer Jones, *The Art of War in the Western World* (University of Illinois Press). This is a comprehensive military history with strong theoretical analyses, and quite the best work of its kind since Lynn Montross's *War Through the Ages*.

The computer book of the month is Peter Norton's *DOS Guide* (Brady). Norton's book isn't as encyclopedic as DeVoney's *Using PC DOS*, but for that very reason it's easier to read. Norton is very good at highlighting obscure but useful DOS features. Get DeVoney's book for reference, but read Norton's book to understand what's going on.

The game of the month remains Empire (from Interstel) for the Atari ST. I can't believe how much time I've spent on that game.

I'm writing this at tax time. I was going to use TurboTax on the IBM PC, but the new MacIntax package came yesterday, and I may as well get some use out of the Mac Plus, assuming that there is life after tax reform. Wish me luck.

Jerry Pourmelle 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 Pourmelle, 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.
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Circle 133 on Reader Service Card
There seems to be a lot of virus programs kicking around these days, nasty little scraps of code that know how to attach themselves to other programs and then reproduce like crazy. Last week, my Macintosh became infected with one of them. I still haven’t figured out how it happened, but at this point it’s immaterial. The little fellow seemed relatively benign; all it did was copy itself into my system file—and every application I used thereafter.

Fortunately, someone on BIX quickly posted a description of the virus and a coherent treatise on removing it. I followed the instructions to the letter and had a clean system within several hours, but the narrowness of my escape left me shaken.

A couple of years ago, I inadvertently launched a program that left a time bomb implanted in my MS-DOS computer. It slowly and imperceptibly chewed away at my file allocation table, eventually trash¬ing the directory for 30 megabytes’ worth of hard disk. In contrast, this Mac virus was sweetness and light; at least it didn’t do anything destructive. It had a silly “look what I can do” bravado about it, rather than the sheer hostility of the earlier IBM PC program.

My first reaction was a deep sense of relief at getting away from the virus unscathed. After a few minutes, though, the relief gave way to anger and outrage. My hard disk is a very personal place; my privacy had been violated.

Sad to say, I believe there’s going to be a lot more of this kind of thing. As computer ownership spreads in our society, the population of computer users is going to become more and more like the general population of which it’s a subset. What this means, unhappily, is that we can expect to see all the ills of our civilization reflected in events in the microcomputer world.

Our one faint hope in this dark time is that the act of launching a destructive virus program will turn out to be a rare event rather than a commonplace one. If it goes the other way—and launching a virus becomes the equivalent of scrawling graffiti on a wall—it’s going to be tough out there.

I’m already being very careful about which electronic bulletin boards and on­line services I use as a source of software downloads; I won’t touch a program that hasn’t been thoroughly checked by a competent sysop. I’ve “inoculated” both my Tandon IBM PC AT clone and Mac SE with antiviral software, though experience suggests that these viruses will quickly mutate to overcome these feeble countermeasures. Right now, I’m hoping that widespread paranoia about viruses won’t kill off alternate distribution schemes, or we’ll witness the death of shareware.

What can be done about this plague? Not a whole lot, at least not directly. We can try to broadcast the notion that writing and distributing infectious or destruc­tive programs is simply not cool and thereby discourage the casual prankster. But we won’t be able to control vandalism in software until we can control it on the streets.

Prodigious Planner
It’s time to haul out the superlatives for InstaPlan (InstaPlan, $99), the first MS­DOS project management package I’ve seen that I might actually consider using. It’s well designed, complete, fast, powerful, and inexpensive. What more could you want?

I ought to interrupt this flow of praise to point out that I usually find project management software to be the most irritating stuff that crosses my desk. I’ve got a number of reasons. First, the discipline of project management itself is grounded in obscure jargon; most of the software follows that lead and is incom­prehensible to anyone without an advanced degree in obfuscation. Second, the accompan­ying manuals (like most com­puter documentation) provide good information on how to use the software but little advice on why or when; unless you know what to do beforehand, you’re lost.

Third, I can’t shake the suspicion that most managers have little use for Gantt charts, PERT, and critical path analysis; scribbled notes and flowcharts seem adequate for all but the most enormous proj­ects. It’s one of those cases where computerizing the task often takes more time than simply doing it. And finally, this is an expensive category; project manage­ment packages start at $300 or so and continue up the scale to between $1000 and $2000. That’s quite a bit higher than most other software aimed at the average businessperson.

For me, the most important point in InstaPlan’s favor is its price. At $99, it’s the lowest-priced full-featured product in its category. The price is reasonable enough to let you buy it on a whim, to see if you like or need project tracking software in your daily routines. Since project management is an arcane art, nearly im­possible to learn quickly without a good software package, it makes a lot more sense to start out with InstaPlan than with one of its competitors at quintuple the price.

If you discover that project manage­ment is over your head and something you’ll never need, you can throw Insta­Plan out the window without feeling too much guilt. On the other hand, Insta­Plan has so much going for it that it might in­spire you to adopt its approach to planning and implementing all sorts of proj­ects, from medium-size to gigantic.

But price isn’t the only consideration. InstaPlan offers great flexibility and an initial planning approach that beats anything else I’ve seen. Like all project man­
DOCUMENTATION is thorough and clearly written, which I demand for any subject as convoluted as project management. Within a few minutes, I'd mastered the difference between Gantt and PERT and was arriving at an understanding of InstaPlan's Gantt Variance View. It was all falling into place rapidly. Hats off to the author.

InstaPlan is an excellent piece of software, quite capable of holding its own against all but the most expensive project management products. I'm hesitant to compare it directly to the over-$1000 members of this fraternity, which are aimed at serious managers with big problems, but I'd bet that it could be used in many situations as a low-price substitute without any loss of functionality.

InstaPlan is a good deal for anyone who merely wants to experiment, but it also has the strengths to satisfy those with professional requirements.

Highly recommended.

**RagTime Repeat**

About a year and a half ago, I wrote about a Macintosh desktop publishing package called RagTime. It was an odd blend of layout program, word processor, and spreadsheet. Though I found it easy to use, I was annoyed at the lack of business graphics, which struck me as essential in a product aimed at this market niche. I also found both the word-processing and layout elements of the program to be inferior to stand-alone products.

But there was still something charming about RagTime; it was appealing, though I wasn't quite sure why. So I railed about its shortcomings, hoping my diatribes would reach the ears of RagTime's manufacturers.

Time has passed, and I'm now poking at RagTime 2 (Orange Micro, $295), the latest version of the package. Unfortunately, it still fails just short of greatness; it's an attractive product that doesn't quite have the horsepower to take it to the top of the heap. I find this even more frustrating than a program that's simply rotten; I want to grab the programmers and shake them until they make this program live up to its potential.

Since that isn't going to happen, I suspect RagTime will quietly vanish sometime down the road when the inevitable desktop publishing shakeout occurs. In the meantime, though, if the product's unique collection of features speaks to you, I recommend it. RagTime is an acceptable desktop publishing tool for anyone who needs to manipulate both text and small spreadsheet grids.

The basic look of the program is somewhat reminiscent of Ready-Set-Go. You continued
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Joel Robinson, the developer, commented: "We've already sold over 100,000 Gasavers. Ironically, we find more people buy the Gasaver for its third benefit of cleaning out carbon to extend engine life than buy it for its fuel savings or octane boosting."

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work with "frames" that you draw on your page as you need them. Frames can hold text, pictures, or spreadsheet data. You can link text frames with "pipelines." Changes flow between frames, so editing is a smooth process. Each frame has a unique identifying number that can be displayed or hidden at your discretion; the number is most useful with spreadsheet frames, which can reference each other.

Here's a brief list of some of the features you get in RagTime 2: user-selected or defined colors (which is irrelevant if you don't have a color output device); algorithmic hyphenation of text in any of 11 languages; kerning of text; import of paint, PICT, encapsulated PostScript, FOTO, and Tag Image File Format (TIFF) graphics; import of SYLK work-sheets; multicolumn or split-frame options; object-oriented group and shuffle functions; a forms mode that lets you zero out values or text and save a layout as a blank form; search-and-replace on typefaces and type attributes so you can change from one look to another; 253-row by 253-column spreadsheet frames that can reference cells in other frames up to the limits of memory; ability to have 15 documents open at once; and so on.

Now here's what you don't get: a spelling checker, dictionary-based hyphenation, business graphics based on the spreadsheets you've built in RagTime, adjustable guidelines, and style sheets.

RagTime has a pretty solid list of features, even allowing for the few omissions, and the program works well. If you're interested in self-calculating forms, RagTime is not as spectacular as Trapeze, the forthcoming Wingz, or the upcoming revision of Excel, but it gets simple jobs done with less hassle than any of the flashier products.

However, desktop publishing software from other manufacturers is not standing still; it's getting better faster than RagTime is. This year will see new versions of PageMaker, Ready-Set-Go, and QuarkXPress, all of which will probably out-feature RagTime. They won't have the built-in spreadsheet, of course, and they'll be more expensive, but RagTime will not look great in comparison.

But I have to say that I do like the product. I just don't want you to go out and buy it, then accuse me of glossing over its deficiencies. Take that as a midlevel recommendation with a grain of salt.

Ezra Shapiro is a consulting editor for BYTE. You can contact him c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Because of the volume of mail he receives, Ezra, regrettfully, cannot respond to each inquiry.
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Benchmarks

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Introduction

Benchmarks

For the past six months, the lights at BYTE have been blazing at all hours—weekdays, weekends, and holidays alike. What generated this flurry of activity? The short answer is "benchmarks."

No, not running them. We've been designing, coding, and testing an entirely new suite of BYTE benchmarks. Along the way, we've overhauled the Small-C language to work with today's state-of-the-art microprocessors. We're making both our benchmark code and the new versions of Small-C freely available on disk, via BYTEnet and BIX, and in print.

Why did we do all this? Because we'd realized for some time that our old benchmarks—like most benchmarks currently in use—were tired, worn, and in need of replacement. Some were originally developed for old-style, narrow-bandwidth machines. Others, including some established standards, really didn't do a very good job of testing what they purported to test. In one way or another, almost all had aspects we believed we could improve—that we had to improve—if we were to continue our tradition of providing the kind of reliable, meaningful results that you demand and deserve.

In this issue, we present the first of our new tests in "Introducing the New BYTE Benchmarks," written by the BYTE editors who have come to know the subject so intimately: Richard Grehan, Tom Thompson, Curtis Franklin Jr., and George A. Stewart. In coming months, we'll be expanding on the foundation established here. We welcome your comments, compliments, and constructive criticism.

Also in this month's In Depth section, we look at the whole subject of benchmarking. We begin with an overview of what benchmarks are and what they should be in "That 'B' Word!" by Bill Nicholls. This article deals with such questions as why we write benchmarks, what they're for, and what they tell us—and don't tell us. It also discusses some of the more familiar benchmarks in our industry.

In "Problems and Pitfalls," Alfred A. Aburto Jr. discusses what's wrong with many benchmarks, what kinds of mistakes we're apt to make in writing them, and how we tend to misinterpret—or overinterpret—benchmark results. His article also details some of the problems found in many of today's popular benchmarks.

Finally, Ron Fox presents "Why MIPS Are Meaningless," an article that discusses micro benchmarks—those that test the various parts of a system rather than the system as a whole. Ron also presents a series of his own micro benchmarks that you can use to test some of the components in your own system.

Benchmarks—you can't live with them, and you can't live without them. They are infinitely tedious to design and code, because there seems to be an infinite number of variables within them. But they are also the best method we have so far for comparing one system—or component or software package—to another. Well-designed benchmarks provide an objective evaluation of competitive products and thus give us the information with which to make informed choices.

—Jane Morrill Tazelaar
That “B” Word!
What it is, where it’s going, and why we subject ourselves to it

Bill Nicholls

BENCHMARKS. SAY THAT word in some circles and you might be swearing. It drags up memories of nights spent writing benchmark programs, modifying them, testing them, and testing them some more, only to find that you’re not testing what you thought you were, the compiler has optimized your code out of existence, or you’re comparing the proverbial apples and oranges.

A benchmark is simply a standard for judging the performance of various computers. But what gives the “B” word emphasis is that there’s no official standard for benchmarks, and, to make matters worse, computer technology isn’t exactly holding still.

Given that the task is difficult and ever-changing, why do we try to do it? First, without benchmarks, we have no basis for preferring one computer over another except price. And second, given any architecture, benchmarks provide feedback on how well it performs, thus providing information for those designing new architectures.

Benchmarks measure performance, a complex issue, and yet they supply only a simple number as a result. Unless a benchmark clearly identifies what it’s testing (i.e., a single component or the whole system), these simple numbers can be the seeds of misinformation.

One such seed is MIPS, or millions of instructions per second. With no standard set of instructions and no standard MIPS benchmark, you can’t compare MIPS across different CPU architectures with any hope of accuracy; sometimes, you can’t even compare them accurately within a single line of machines. MIPS has become “meaningless information on performance for salesmen.”

Regardless of the difficulties, however, we need benchmarks—both general-purpose and specific—that don’t become worthless as technology changes.

What Makes a Good Benchmark?
A good benchmark has four general requirements. First, it must be meaningful. The benchmark must test a factor that is relevant to the user. Second, the benchmark must be accurate. Results should contain a measure of the accuracy achieved, and that measure should be reported as part of the results. Third, the test should be repeatable. The variance in results (called noise) should also be reported. Fourth, the benchmark should be able to discriminate between systems that are really different and report similar results for similar systems.

A meaningful benchmark is a test that measures something relevant to our purposes. The trick, of course, is to ask the right questions. Given the output from a good benchmark (e.g., a table of benchmark data based on running the same program with the same level of compiler optimization), you can do a valid comparison of the results between systems.

You can divide benchmarks into two categories: microscopic, looking at the components of a system in detail, and macroscopic, looking at the system as a whole. You must be careful, however, not to interpret the results of microscopic tests as having meaning at the macroscopic level.

Micro benchmarks are useful for finding the maximum capability of a component within a system. They are helpful in system design and in estimating maximum performance possible for an application under development. Hardware comparisons made with the same executable code can be quite valid for the test performed. And since different compilers for the same language, or even different languages, can compile the same test for a given machine, we can develop tables of software comparisons as well. For a further discussion of micro benchmarks, see “Why MIPS Are Meaningless” by Ron Fox on page 225.

Real applications are valuable as system benchmarks, as long as the work you choose is representative of what you’re trying to test. Recently, it has become possible to find applications that are supported across a wide range of configurations and, in a few cases, across systems; these benchmarks are becoming more and more meaningful as the end user performs more complex work.

Designing a benchmark test is a lot more difficult than it appears. Most people start by running benchmarks, then decide what they want to accomplish. The correct approach is to decide what you need to establish, choose appropriate benchmarks, run them, look at the significance of the results, and, finally, decide whether the differences are significant.

Choosing the appropriate benchmark requires some understanding of each benchmark process and its relative accuracy. You need to separate those benchmark
marks that test components from those
test systems, and try not to compare the
results of those two different catego-
ries of tests. And you need run only those
tests that reflect the environment and
work you intend to perform. If you add
benchmarks beyond this, you increase
work and confuse the issue by adding re-
results not relevant to your objective.

Having run a suite of benchmarks, how
do you determine what they mean? There
is no simple answer to this because it
depends on your objectives. If you are
evaluating processors for pure perfor-
ance and use an appropriate bench-
mark, a significant difference between
results makes a decision fairly easy.

What makes a difference significant is
the issue of repeatability. If you run the
same test 10 times, are all the answers
within 1 percent of each other? Within 10
percent? If you know that noise number,
you can conclude that differences be-
tween systems less than the noise amount
are insignificant; a benchmark that shows
differences between systems less than the
noise amount can’t be used to differenti-
between them.

Studying the Classics
Several benchmarks have been around
long enough to be considered classics.
Whetstone, one of the oldest, was
designed to be representative of typical
scientific programs. It was based on the
analysis of 949 ALGOL 60 programs.
Whetstone was originally considered
quite good, but recent analysis has shown
that it’s vulnerable to modern optimizing
compilers.

The best general-purpose test de-
veloped thus far is Dhrystone (named as a
pun on Whetstone). Despite sensitivity to
some kinds of optimization, it’s a good
effort and a useful performance test. Re-
visions are under development to address
known weaknesses; the current version
(1.1) has some flaws that are being ad-
dressed in version 2.0.

The Sieve, another classic, generates a
small set of primes using an algorithm
that does a minimal amount of calculation.
In addition, the run is quite small, and
some modern compilers recognize the
algorithm and perform special opti-
mizations on it. While it purports to test
computational performance, it primarily
tests integer operation and indexing. This
and other familiar benchmark tests are
discussed in “Problems and Pitfalls” by
Alfred A. Ahurto Jr. on page 217.

The SI (Norton’s System Indicator) is
an example of a benchmark built without
remaining independent of architectural
differences within a single family of
chips. Originally intended to point out the
differences between various 8088
speeds, the SI gives misleading results
when used to compare different genera-
tions, such as 8088 versus 80286.

Why We Need New Ones
In the past, BYTE’s benchmarks have
been flawed, as in their continued use of
unrealistic I/O tests like Format and
Copy. The standard tests didn’t cover a
wide enough range, and some of the tests
had very little discriminatory power. A
second problem was the limited set of com-
parisons in any one article. A full set of
comparisons over a range of bench-
marks would have been helpful. The new
set of benchmarks described in “Intro-
ducing the New BYTE Benchmarks” on
page 239 resolves many previous prob-
lems and shortcomings.

PC Labs’ benchmarks also contain
basic weaknesses. Some of the tests lack
discrimination. The test results for dif-
ferent products are so close that any signifi-
cant differences are lost in the noise.
Another problem is the use of subjective
goodness judgments without providing a
scale for the basis of judging. Printer
quality output is a prime example of this
problem. A third problem is the use of
multiple testing personnel, adding an-
other subjective element to the results.

PC Tech Journal has compiled detailed
component benchmarks and pseudo-real-
world tests. While accuracy in the com-
ponent tests has been a prime concern,
some of the tests have minimal discrimi-
natory power, and the results are often
difficult to read. However, the basic data
is good. The real-world tests typically are
limited in value because of the small size
of the environments tested, making ex-
trapolation to larger environments with
different structures risky. One example
of this is the database benchmark series.

The Software Digest benchmarks are a
different class of tests than most of the
others. Most of them are subjective, but
a major effort has been made to limit this
subjectivity by averaging test results over
a number of cases to smooth any single
observation. The overall score generally
reflects the product’s measurement.
However, the basic tests are judgmental
in nature, and the standards used may not
reflect what you consider important.
This remains a problem despite the de-
tailed reporting of the component results.

The Art of Benchmarking
Benchmarking is not just science or en-
gineering; it is an art. While parts of the
process have been reduced to engineering
techniques, the task as a whole remains
very much an application of the human
art of judgment. “Good judgment comes
from experience. Experience comes from
bad judgment.” This homily is the key to

progress in benchmarking. Until you’ve
had hands-on experience benchmarking
a number of systems, the results of your ef-
fort are liable to be unpredictable.

The earliest benchmarks, such as the
Sieve, tested the CPU and memory. It
appeared to be easy to test the CPU, and
that was central to an understanding of
performance. But both the Sieve and our
understanding of performance have un-
dergone substantial evolution since then.
Further problems have arisen as tests for
one generation of equipment were rerun
on a later generation; for example, some
tests designed for the IBM PC were later
used for an 80386 system.

To date, benchmark testing of I/O has
been limited, and much of what we’ve
done is too simple. The typical I/O
benchmark failed to test random access
and such items as repeated access to di-
rectories and file access tables. One ex-
ception to this is the Coretest hard disk
benchmark for the IBM PC AT and com-
patibles, which tests both random access
and transfer rates.

Graphics is another area of limited
testing. With the exception of component
tests of the EGA by PC Tech Journal and
some performance tests by BYTE, little
has been done. The main problem in
benchmarking graphics and video is the
extreme sensitivity of the results to hard-
ware configuration and the quality of the
code. Another whole class of problems
arises when you try to figure out what to
test (see references 1 and 2).

Although benchmarking components
(i.e., micro benchmarks) may be the most
popular test, how the system runs
when you use it for practical work is the
most important. Except for the Whet-
stone, this important fact did not get
much attention until recently. Using popu-
lar applications as benchmarks is bring-
ning some interesting facts to light, such as
the sensitivity of an AT or 80386 system,
especially a multiuser system, to the per-
formance of the disk subsystem. In many
cases, this performance is more impor-
tant than CPU performance and has led to
a demand for faster disk subsystems.

An effort is under way at the IEEE to
develop benchmarking standards. It has
been delayed by the lack of anyone to
head the volunteer effort. When a set of
IEEE standards can be developed, they
will be of great value in reducing the cur-
rent chaos in the area of benchmarking.

On the Hard Side
Identifying the problems involved in
benchmarking is an ongoing process.
The more we learn, the more problems
we find. The basic dilemma is the num-
ber of variables. Even in simple cases,
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THAT "B" WORD!

Even without multitasking, changing operating systems can change your results. The differences can be caused by overhead variations between the operating systems, or by different facilities and compilers. Typically, changing the operating system per se doesn't produce a major effect, but the variation in facilities, compilers, and concurrent tasks complicates the measurements.

Tomorrow and Tomorrow

We can now see the directions of tomorrow's benchmarks: improving the current ones and using both synthetic and real applications. Third-generation development has begun already with Dhrystone 2.0, Calcpi, search, and memory-access routines.

At this time, there are still fixed system benchmarks. That is, the benchmark designer fixes the steps and operations involved, and the user isn't allowed to change them. In the future, we'll see synthetic benchmarks, or benchmark shells, that contain a large number of basic operations typical of applications code. Users can then develop scripts that reflect their current or future applications and run those scripts on several machines.

The future will also bring more real applications used as benchmark tests. This is perfect if you are using that specific application, and also useful if you are using that category of application. The reason for this change is simple. As systems become more complex, the work involved in generating and validating a new system benchmark increases. At some point, the work involved in creating the new benchmark exceeds the value that you can get out of it, and real applications test the system sufficiently.

The years ahead will see significant improvement in benchmarking capability as these trends bear fruit. The limiting factor, as it has always been, is the understanding and care of the person using the benchmarking process.

Editor's note: For BIX references and selected readings, see graphic-disp/biblio-graphy on BIX.

REFERENCES

Bill Nicholls is an author and a computer consultant with BGW Systems Inc. in Puyallup, Washington.
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The compilers are presently available in two formats: Microport Unix 5.3 or MS-DOS as extended by the Phar Lap Tools. MicroWay will port them to other 80386 operating systems such as OS/2/16 if the need arises and as 80386 versions become available.

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Problems and Pitfalls

What's wrong with the old benchmark programs?

Alfred A. Aburto Jr.

FROM TIME TO TIME, even benchmarks need a checkup. It's time to review the state of their health when the mere mention of benchmarks sparks debate and controversy. And it's time for treatment when we find anomalies in the data or contradictory results between one independent series of tests and another.

The trouble with benchmark results doesn't always lie in the programs; it often lies in the test methods and procedures used or how the results are reported. And often it appears that the tests haven't taken into account all the variables that can significantly affect performance.

It's easy to make errors in conducting benchmark tests and unknowingly report erroneous, misleading, or contradictory results. Despite the problems and the controversy, however, developers and evaluators of computer hardware, software, and systems continue to use benchmark programs to demonstrate product improvements. And the rest of us run them, or read them, to help us decide which products to buy.

Getting All Your Ducks in a Row

The lack of controlled and appropriate test methods and procedures causes many of the problems with benchmarks. For example, if we wish to compare the performances of processor A and processor B using C language compilers, then we must ensure that the C compilers used generate the best code for each CPU. If we fail to account for all the differences in code-generating efficiency between C compilers, our results may be controversial and unreliable, relative to our original objective. Poor-quality software can easily mask the native processing power of an otherwise capable CPU.

Another example: We know that disk-buffer size can greatly affect the performance of disk I/O, but we rarely see the buffer size taken into account, analyzed, or even mentioned in many of the typical disk I/O or spreadsheet tests. We simply can't leave unknown or hidden variables floating around in our tests.

Rick Richardson's excellent summaries of Dhrystone 1.1 results (Usenet, comp.arch, September 20, 1987) contain many examples that illustrate the variations in benchmark performance on the same CPU at similar clock speeds. For example, the 80386 results at 16 MHz and 20 MHz showed performance results ranging from 1724 to 9436 Dhrystones per second. Certainly, this variation of 5.5 in performance isn't due to the CPU type, which was an 80386 in each case, or to the clock speed, which changed by only a factor of 1.25. Therefore, it must be due to other factors, such as the type of C compiler, compiler and linker options, global code optimizer, cache memory, number of memory wait states, and so on.

These results illustrate how important it is to keep track of all the variables that might significantly affect the outcome of a benchmark test. If you don't, then you can't expect to make "apples-to-apples" comparisons of system performance.

Optimized or Obliterated?

Optimizing compilers can significantly affect a poorly designed benchmark program. They can eliminate subroutine-call overhead delays by in-line-coding the subroutines, remove loop-invariant code, automatically assign register variables, eliminate common subexpressions, and perform other operations that destroy the intent and usefulness of the benchmark. The trouble isn't that compilers optimize code; it's that many benchmarks are highly susceptible to optimization.

Dhrystone 1.1, Whetstone, Float Loops, QuickSort, and Savage can all be optimized to varying degrees. For example, a compiler can significantly improve the Whetstone's performance by in-line-coding its three tiny subroutines, but that ruins one of the Whetstone's primary features: measuring procedure-call efficiency. Also, if the subroutines are in-line-coded, the Whettes-per-second performance output becomes misleading and invalid. The performance isn't improved because the system executed floating-point operations any faster, but because the optimizing compiler removed hundreds, or even thousands, of processor instructions from the code.

In addition, some versions of the FORTRAN and C Whetstone programs contain loop-invariant code, which an optimizing compiler may completely remove. It may also delete floating-point instructions—perhaps millions of them, depending on the loop count—resulting in an invalid and misleading Whetstone-per-second output. Other benchmarks suffer a similar fate.

In Dhrystone 1.1 in C, optimizing compilers can remove useless code and...
in-line-code and optimize the string-copy and compare routines, improving performance by as much as factor of 2. It’s wonderful that optimizing compilers can improve performance in these ways; however, the results of the Dhrystone are no longer valid.

In the Float program, an optimizing compiler can remove all floating-point instructions, resulting in an empty shell. It can also obliterating the Loops program, resulting in a meaningless benchmark that takes no time at all to run. The compiler can in-line-code the QuickSort subroutine and automatically place its variables in registers, resulting in ambiguous performance comparisons. It can reduce Savage to a simple loop, a = a + 1.0, producing a trivial program that no longer computes the transcendental and trigonometric functions originally intended.

The benchmarks that are susceptible to these compiler problems need to be redesigned to prevent optimizers from invalidating their measures of performance or distorting and confusing performance comparisons. Dhrystone 2.0 is intended to achieve this goal. However, there doesn’t seem to be much hope for the Whetstone, Float, or Loops programs. Such benchmarks as the Sieve, Fibonacci, and Bench seem to be mostly—but not totally—immune from high degrees of optimization.

**Sifting through the Sieve**

Jim Gilbreath originally proposed the Sieve of Eratosthenes as a benchmark for computer systems in 1981 (see reference 1). It has since become a classic, frequently quoted in the literature and used by developers to demonstrate compiler and system improvements. Results exist for hundreds of different computers and numerous flavors and versions of compilers. It is unfortunate, however, that no single database of results has been maintained to provide a historical perspective on Sieve performance, although Gilbreath’s early work (see references 1 and 2) did contain hundreds of results.

The Sieve won wide acceptance primarily because it was simple; it was easily coded in many different computer languages, and it computed something useful that was recognizable and verifiable: prime numbers. These are strong points in favor of the Sieve, because, in general, those benchmark programs that do nothing useful or verifiable are the ones most susceptible to compiler optimization (e.g., Loops, Float, and Dhrystone 1.1). The Sieve speed at generating prime numbers tells us something about the efficiency of the total system—compiler plus hardware. Performance improvements reflected in the Sieve will also be reflected in other applications that do similar types of operations.

The Sieve was intended to measure system efficiency, or capability, with respect to memory references, simple operations, and all contained 68020 CPUs with 32-bit memory at very similar clock speeds, yet there was a factor of 3.4 maximum variation in performance. The outstanding performer was Definicon Systems’ DSI-780 with the Silicon Valley Software (SVS) C 2.0 compiler.

Trevor Marshall, then of Definicon, explained that these results were due to SVS C’s automatic use of register variables (variables whose “home” is a designated CPU or FPU register instead of RAM). That is, while the source code says int, the SVS C compiler actually generates register int variables. This is a form of code optimization. The Sun Microsystems C compiler also generates register int variables, but only when you set the -O optimize flag during compilation. Other compilers, such as Amiga Lattice C and Aztec C, can also work with register int, but the variables

| Table 1: Sieve performance variations for an Amiga with a 14.32-MHz 68020 and 32-bit memory (100 iterations). Note the difference the variable type makes on the run time. |
|---|---|---|---|
| C compiler | Variable type | Run time (seconds) | C library |
| Aztec C 3.4B | int (16-bit) | 12.3 | 16-bit |
| Aztec C 3.4B | short (16-bit) | 12.3 | 16-bit |
| Aztec C 3.4B | long (32-bit) | 17.0 | 32-bit |
| Lattice C 4.0 | int (32-bit) | 14.7 | 32-bit |

More Chaff for the Sieve

Another problem came to light with the Sieve benchmark results published in the September 1987 BYTE (see reference 4). Table 2 contains those Sieve results and some others. All the systems ran the same Sieve source code, all used C compilers, and all contained 68020 CPUs with 32-bit memory at very similar clock speeds, yet there was a factor of 3.4 maximum variation in performance. The outstanding performer was Definicon Systems’ DSI-780 with the Silicon Valley Software (SVS) C 2.0 compiler.

Trevor Marshall, then of Definicon, explained that these results were due to SVS C’s automatic use of register variables (variables whose “home” is a designated CPU or FPU register instead of RAM). That is, while the source code says int, the SVS C compiler actually generates register int variables. This is a form of code optimization. The Sun Microsystems C compiler also generates register int variables, but only when you set the -O optimize flag during compilation. Other compilers, such as Amiga Lattice C and Aztec C, can also work with register int, but the variables

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must be defined as such within the source code.

In contrast, some compilers, such as those available with some Unix systems, ignore a request for register int variables; since register variables have no specific memory address, they can cause problems with subroutine calls and pointers. Other compilers generate extremely poor code with register variables; for example, some force a register variable to have an address for a subroutine call by unnecessarily pushing it onto the stack and then pulling it from the stack back into its home register. All these features of register variables can greatly affect the Sieve performance and confound the performance comparison of system A with system B if we aren't careful to understand both the system's and the compiler's operation.

We can avoid these problems by deliberately coding the Sieve to run efficiently with and without register variables defined. When the Turbo-Amiga Aztec C compiler was run with register variables defined, the run time decreased to 6.3 seconds. We could make further improvements if we redefined the Sieve's global variable, size, as a register variable, too. In this case, the Sieve run time decreased to 5.8 seconds, much more in line, in view of the clock-speed differences, with the DSI-780's SVS C result of 4.9 seconds.

As stated by Gilbreath, the Sieve was designed partly to examine memory efficiency, but it fails to do this because the array size is fixed and relatively small. Actually, it's very small, since modern CPUs can address vast memory spaces, and typical microcomputer systems might have 1 or more megabytes of RAM.

Table 3 shows the memory-efficiency problems that can occur with some systems as you increase the Sieve's array size. Notice the great penalty paid in performance by the IBM PC XT and the IBM PC AT as the array size passes the 32K-byte boundary. The efficiency loss appears to be related to inefficiencies in the address calculations with signed long instead of signed short integers.

The problem might have been avoided, at least temporarily, if the array-index variables had been defined as unsigned short instead of int. However, for arrays larger than 64K bytes, the variable type, in this case, must be long or ulong.

In any case, varying the array size has taught us something about the relation between Sieve performance and memory efficiency; that is, the relative ranking of Sieve performance depends on the array size (see table 3). Thus, it's not always correct to deduce a relative ranging of Sieve performance based on a fixed array size; you can obtain a more accurate picture of performance by varying the array size.

A revised Sieve program, designed to handle these problems and ambiguities, is available in the BIX supermicros conference.

Floating Away

The original Float program in C (see reference 3) is perhaps one of the worst examples of a benchmark program. (Reference 4 corrects the worst of the errors.) A number of optimizing compilers, such as those available for the Sun and VAX systems, can logically reduce the code to a simple case. The result is an invalid Float program that does no floating-point operations and runs in almost no time at all.

A compiler can optimize the Float to such a great extent because it's a contrived program that performs no useful task and provides no outputs. Compilers such as Microsoft C 5.0 can optimize the Float so that the resulting code bears little resemblance to the original source code.

The Float is intended to perform double-precision floating-point multiplication and division, but it provides no useful output and doesn't check floating-point accuracy. Some sort of computational accuracy check and output would be desirable, since accuracy is important in floating-point processing. Also, a finite relationship exists between speed and accuracy in floating-point processing. A floating-point benchmark program should provide estimates of both.

Another failing of the Float is that the program provides no register double option. Without this option, the program can report misleading comparison results, since some types of compilers automatically generate register double variables (even if the source code says double only). Other compilers do so only when the register double option is put in the source code or when the -0 optimize flag is set during compilation.

Running the Float with register double variables instead of double variables can, in some cases, result in a change in performance of a factor of 3. For example, an Amiga with a 68020 at 14.32 MHz and Maxx Aztec C 3.4B (a non-optimizing compiler) takes 2.98 seconds to run the Float with double variables, but it takes only 1.04 seconds with register double variables.

If the -0 flag is set, the results become confused, with timings of a fraction of a second or 0. If these various factors continued
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PROBLEMS AND PITFALLS

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 aren't accounted for in the benchmark testing, the comparison results will be confused and not very meaningful.

The Float program is a good example of how to optimize do-nothing code to nothing. It should be laid to rest and a new floating-point scalar-arithmetic benchmark constructed. My suggestions for its specifications, based on my experience with the Float, are as follows:

- The program should do something useful, recognizable, and verifiable.
- It should exercise single- and double-precision floating-point operations.
- It should provide accuracy-check output.
- It should provide register double and register float options.
- It should exercise scalar-arithmetic addition, subtraction, multiplication, and division (+, -, *, and/) operations.
- It should apply weighting factors so that the outputs reflect typical usage of the floating-point addition, subtraction, multiplication, and division operations. This is important because otherwise the divide operation, which takes the most time to execute, may unfairly bias the results. Also, it's just not used as frequently as the others. For example, the Weitek 1167 FPUs take about 0.6 microseconds for a double-precision add, but about 3.8 µs for the divide.
- While the standard output based on typical instruction usage is provided in thousands, or even millions, of floating-point operations per second, I would prefer KFLOPS.
- The program should provide a peak KFLOPS estimate based on the addition operation. This would shed some light on the range of performance you can expect.
- The code must be optimized from the beginning as much as possible to prevent optimizing compilers from doing dastardly things to the performance results.

Some progress has been made toward achieving these requirements in the FLOPS.C program, which is available in the BIX supermicros conference under the long.msg topic.

To Soothe a Savage Beast

The Savage benchmark is named for Bill Savage, who published the original BASIC version (see reference 5). A listing of the C version of the program is available in reference 3. Savage exercises some of the standard math functions (tan, atan, exp, log, and sqrt). It is one of the few old BYTE or C benchmarks that provide an error check; it has some problems, however.

The Savage error result is dominated by the atan(x) function, so the accuracy obtained does not reflect the much greater accuracy available from the other functions. The error in atan(x), when x is greater than 500 or so, is generally so large that you can't run Savage reasonably in single-precision. In general, the only way to keep the error under control is to run with double-precision only. The function atan(x) requires many digits of precision to maintain reasonable accuracy when the argument x is large.

Savage in C also doesn't account for register double variables. This isn't a significant problem; only about a 10 percent variation in performance has been observed when running Savage with and without register double variables.

Although it hasn't happened to my knowledge, Savage could be optimized to a trivial loop of a+b+1.0, resulting in a Savage test where no math functions are tested at all.

Finally, Savage doesn't account for the typical usage frequency of the standard math functions. The sin(), cos(), and sin cos() type of functions are frequently used in graphics and many other applications, yet Savage doesn't test them.

We need a new benchmark program for the standard math functions. It should test all the functions, provide accuracy checks, and weight the performance outputs in accordance with typical usage.

Fib Is a Little White Lie

The Fibonacci program in C (see reference 3) has problems similar to those found with the other benchmarks. The question of whether int equals 16 bits or 32 bits is not addressed in this program.

The outer loop contains one loop-invariant call to the fib() function. You can completely separate the loop and the function call without affecting any calculations except the timing. Due to this loop-invariant code, the outer loop is subject to deletion by a smart compiler.

The program doesn't provide a register int option. When I assigned some of the variables to registers, the performance didn't improve; it degraded by approximately 30 percent. This illustrates how under certain conditions compilers have troubles handling register variables efficiently.

Fib uses a recursive function call to calculate the twenty-fourth Fibonacci number starting from a value of 1 for the first and second numbers. You could simplify the logic in the function call somewhat, because the function's input parameter x is always greater than 2 (it is fixed at 24). Fibonacci seems to be an attempt to test recursive function-call efficiency, but the trouble is that no compari-
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son reference point is provided.
I wonder how useful Fibonacci is as a benchmark. A test of recursive function-call efficiency is an interesting point, and Fibonacci is an extremely simple benchmark, but it seems to take forever to run on most systems. For a performance comparison, I coded a nonrecursive form of Fibonacci into the original benchmark and made a timing comparison. The results were unbelievable at first, but each program was calculating exactly the same sequence of Fibonacci numbers. These were the results, in seconds, for an Amiga with a 68020 and 32-bit memory at 14.32 MHz (for 100 iterations):

recursive run time = 55.10
nonrecursive run time = 0.0118

The Fibonacci appears to be a good test of procedure-call, or function-call, efficiency. The performance differs by a factor of over 4500. Apparently, recursive function calls are highly inefficient. This leads me to believe that Fibonacci could be turned into a useful benchmark test providing insight into the comparative efficiency of recursive function calls.

Sorting Things Out
QuickSort in C (see reference 3) has problems similar to those encountered in the other benchmarks. It doesn’t define int variables as 16-bit or 32-bit. It should use variable types, long and short, so that the results are uniformly comparable in most cases.

The program doesn’t account for significant variations in performance that can occur when some compilers automatically generate register int or register long variables. Options for register int and register long should be part of the program. The function random() is simple and could be in-line-coded to eliminate the function-call overhead delay. Some compilers can optimize this program considerably.

To qualify as a meaningful benchmark, QuickSort needs a specific purpose. It’s not clear exactly what the program is supposed to be testing.

Dry Stones?
The Ada Dhrystone benchmark was created by Rheinhold P. Weicker. Reference 6 contains documentation and a listing of it. The C version of the Dhrystone is by Rick Richardson, who maintains a database of results.

The Dhrystone is a good benchmark that attempts to measure system performance based on an analysis of real program usage. It measures CPU performance plus compiler efficiency based on a statistical analysis of typical programs. It does no floating-point operations whatsoever, because they weren’t found to be typical overall. Dhrystone is a general program not intended to describe system-performance expectations for numerous specific applications.

Dhrystone 1.1 has problems similar to those found in the other benchmarks. It provides no useful output that you can use to verify correct operation. It appears to be dominated by string-handling procedures, which some compilers can optimize to various degrees. The new Dhrystone program, version 2.0, is designed to prevent optimizing compilers from distorting its measure of performance, Dhrystones per second.

The Dhrystone doesn’t address the int ambiguity (16 or 32 bits, short or long). You can improve the performance of those compilers where int is 32 bits by changing int to short. The benchmark has an option to handle register variables.

Overall, the Dhrystone is one of the more outstanding benchmark programs currently available, but it can’t be used in isolation to describe specific system performance on different applications.

Out with the Old
What’s wrong with the old benchmarks? Just about everything. But benchmarks can be improved. We need to provide more uniform and unambiguous measures of performance. We need to be sure that our benchmarks have specific purposes and that they perform those purposes under carefully controlled conditions. Some tests can be modified, and others must be rethought, redesigned, and rewritten. This process has been started; the new BYTE benchmarks are introduced on page 239.

REFERENCES

Alfred A. Aburro Jr. is a systems engineer at the Naval Ocean Systems Center, San Diego, California.
Why MIPS Are Meaningless

Component benchmarks tell you about subsystems, not about the system as a whole

Ron Fox

Scientific Computing tends to weight floating-point and memory performances highly, while word processing tends to weight integer computations more heavily. In theory, if you know the application mix, and you measure the performance of each subsystem in isolation, you should be able to calculate the system's performance as a whole—when it's running those applications.

A typical computer system consists of several subsystems. A typical set of subsystems might be an integer and logical ALU, the processor, memory, I/O interface, and a floating-point unit (FPU). The overall performance of a computer system is some weighted sum of the performances of these subsystems. The weights vary, depending on the application mix.

One way to determine the performance of each subsystem is to time the execution of programs that isolate the subsystem. These programs are called micro benchmarks, because they look at performance in microscopic detail, whereas application-level benchmarks look at performance from a macroscopic view, as a whole.

Some problems crop up in each of the subsystems when you try to produce micro benchmarks for them; problems also crop up when you try to compare the performance of two systems at the microscopic level.

Under the Microscope
The first step in building an accurate micro benchmark is to isolate the particular computer subsystem you want to test. Practically speaking, this is an almost impossible task.

Consider the Savage benchmark, which is primarily intended to test the accuracy and speed of transcendental functions. Careful analysis shows that the program uses the ALU to control the loop, and that it accesses memory for program fetches and data. The effect of these contributions is small for CPUs without an FPU capable of performing transcendents; however, as FPUs with direct transcendental support (via rough lookup tables and series corrections) become common, you can no longer ignore the contributions of the rest of the program to execution time.

Thus, we have the basic principle of micro benchmarking: It is not possible to build a program that totally isolates the performance of a single subsystem. The best we can hope to do is to correct for the contributions of the subsystems we aren't benchmarking.

To make these corrections, we rely on incremental timing. This involves taking time estimates on two different sections of Savage. Editor's note: The author has created a series of benchmark programs that are discussed in this article. They are available on BIX and in other formats. See page 3 for details.

The first section of SAVAGERF.C estimates the time required for the overhead calculations; the second section times the complete benchmark. (See the text box "Time on the Bench" on page 230.) The difference between these two is the incremental time required to perform the transcendental calculations; that's the part we really wanted to time in the first place.

Isolating the ALU
A commonly used measure of performance for the ALU subsystem of instructions is MIPS, or millions of instructions per second. It would be more descriptive to call them meaningless instructions per second. As you can see from the two 8088 assembly language code fragments in figure 1, depending on your choice of instructions, MIPS can vary by an enormous amount. We need a more stable set of measurements than that.

You can usually divide the instruction set of an ALU into several instruction groups: data movement, simple arithmetic, multiplication and division, bit operations, and flow control. Typically, the instructions within each group have similar timings.

In addition, if you expand the number of instructions used into reasonably sized classes, you can create benchmarks that make the processor do some semblance of real work. Throughout the process, however, you must remember that you want to write benchmarks that isolate the time contributions of the class of instructions you're interested in from the time used by other, overhead instructions and from the effects of finite memory speed.

The data-movement class of instructions is responsible for moving data from memory to processor, processor to memory, and memory to memory on processors capable of memory-to-memory operations.
The first step in building an accurate micro benchmark is to isolate the subsystem you want to test. Practically speaking, this is an almost impossible task.

operations. The program MOVESRF.C is a benchmark that times register-to-memory moves, constant-to-memory moves, and memory-to-memory moves. It also times its overhead incrementally, timing the differences between loops with one or two randomimeter calls—included to prevent optimization—and looking at the differences to produce a time for the execution of the loop construct alone.

Even in this case, however, the timing is not necessarily for the moves alone. Some CPUs might need additional instructions to compute the effective address of the source or destination operands before they can actually do the moves. On the MC6800 8-bit micro, for example, the single indirection-and-index register would require quite a bit of register shuffling to do the bit-memory move.

In addition, CPUs without autoincrementing address modes must do some additions between loop passes. Since these computations are necessary for typical data-movement operations, whatever the context, it is fair to include them in the timing for the data-movement group. This overhead is functional, unlike that associated with the benchmark itself. Note that I haven’t eliminated additions to the timing due to memory speed from this benchmark.

We can create benchmarks for simple arithmetic, multiplication, division, and bit-manipulation operations by modifying MOVESRF.C. If we use the data-movement timings as a base for the incremental timings, we can get purer timing numbers for these operations. The benchmark MOVESRF.C estimates times for these instructions.

The flow-control instruction group includes all instructions that break up the linear flow of control from one instruction to the next. These include conditional branches, procedure calls, and unconditional branches. Since a conditional branch without a prior condition test is useless, this class of instructions often includes condition-code-setting instructions, such as tests and compares, despite the fact that such operations usually fall more in the range of simple arithmetic.

The benchmark program FLOWRF.C estimates the time for subroutine calls and conditional branches. The overhead-timing routine for the conditional branch tries to separate the condition test from the actual branch. How successful this attempt is depends on the CPU. Incremental timing between the conditional branch and the procedure call lets us pinpoint the amount of time used by the call/return pair quite accurately. In high-level languages, you can’t separate the call and return, as they are naturally paired in the language constructs.

If you wanted to, you could refine the FLOWRF.C benchmark further. As it stands, the call/return pairs are not pure; that is, returning a result takes some time. In addition, since most computers don’t care if the conditional branch is part of an IF...THEN...ELSE WHILE, or FOR construct in a high-level language.

<table>
<thead>
<tr>
<th>The NOP program loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOOP: NOP ; 3 clocks</td>
</tr>
<tr>
<td>JMP LOOP ; 15 clocks</td>
</tr>
<tr>
<td>Total : 18 clocks = about 0.5 MIPS (at 4.77 MHz)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The IDIV program loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOOP: IDIV BX ; 165 to 184 clocks</td>
</tr>
<tr>
<td>JMP LOOP ; 15 clocks</td>
</tr>
<tr>
<td>Total : 180 to 199 clocks = about 0.05 MIPS (at 4.77 MHz)</td>
</tr>
</tbody>
</table>

Figure 1: Why MIPS are meaningless. You could use either of these two code fragments to estimate MIPS on a machine, but their execution times differ significantly.
Asynchronous FPUs provide higher throughput on programs with a mix of floating-point and integer computations. It is sufficient to time a single conditional-branch construct. The IF is convenient, since it is easy to create an incremental-timing benchmark.

Examining the FPU
It is of secondary importance whether an FPU is intrinsic to the processor (as it is on the MicroVAX and the IBM 3090), a tightly bound coprocessor (such as the 80387 and the 68882), or a loosely bound peripheral (such as the various Weitek floating-point chip sets). What is most important is the degree of asynchronism with which the FPU can operate relative to both the ALU and earlier floating-point operations.

The simplest FPUs are synchronous; the ALU can't continue fetching and executing instructions until the FPU becomes idle. Asynchronous units, on the other hand, can run independently of the ALU. A program can start a floating-point operation, go away and do some integer operations, and then at some later time synchronize with the FPU, either transparently in hardware (as on the FPU option boards in the DEC PDP-11/45) or programmatically (as in the 8087 family of coprocessors).

Asynchronous units can provide higher throughput on programs with a good mix of floating-point and integer computations. If the program can schedule code well between the ALU and the FPU, it can keep both units active and reduce the total time required for execution.

Some asynchronous units provide internal asynchronism for independent floating-point operations. The simplest way of doing this is with multiple functional units. For example, the FPS-164 attached minisupercomputer contains independent floating-point adders and floating-point multiplication and division units. They let the FPU add and multiply completely independently.

A slightly more complex form of asynchronism is pipelining, in which you break a time-consuming operation into several subtasks. The computation moves from stage to stage, and the FPU can accept a new computation each time the entry stage becomes idle.

While the first computation on an n-stage pipeline requires n units of time to complete, the second will complete one unit of time later. Thus, if a program can keep the pipeline full, the FPU can crank out computations with a throughput of one per unit of time; if the pipeline empties out, the FPU requires n time units for one computation or for the first of a series all over again, and the throughput time increases significantly. The FPS-164 pipelines the multiplication and division units to further improve potential throughput.

Parallels and Pipelines
Microscopic benchmarks for FPUs should explore the various possible opportunities for parallelism. They should try to determine how well you can schedule code to take advantage of any potential for parallelism, as well as test for its presence. The program FOPSRF.C tests for parallelism and measures the speed at continued

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Time on the Bench

When doing the precise timings required of micro benchmarks, using a stopwatch is not good enough. The errors in start and stop times with a stopwatch are on the order of milliseconds, while you want benchmark timings for micro benchmarks to be accurate to microseconds if possible.

The best way to time a micro benchmark is to have the program use the system-timing functions to start and stop its own "stopwatch." When you need very precise timing, you must also estimate the time required to call the stopwatch functions. The incremental timing approach takes this time into account.

With the exception of the memory thrash benchmark, all the programs discussed in this article used a set of timer routines that should be relatively easy to port to any machine with timing functions: The routine initimer() initializes the timing system and determines the time required to actually get the time, and gettimer() returns the time as a double-precision floating-point number representing the time used since the call to initimer() in seconds.

Listing A is a Microsoft C-compatible module containing these functions. If you wish to port these routines to other systems, the clock() function returns the time used by the processor. The time given is a clock_t type, which is really an integer with CLK_TCK ticks per second.

```c
#include <stdlib.h>
#include <time.h>
#include <stdio.h>
static clock_t calctime, cumcal;
double gettimer()
{
    clock_t time;
    long Clock();
    time = clock();
    time = time-cumcal;
cumcal += calctime;
    return (double)time/(double)CLK_TCK;
}
void initimer()
{
    double time1, time2;
    /* Calibrate the clock */
    calctime = 0;
cumcal = 0;
time1 = gettimer();
time2 = gettimer();
calctime = (clock_t)((time2-time1)*CLK_TCK);
cumcal = time2;
}
```

which basic floating-point operations can be performed. It's basically a modification of OPSRF.C.

To explore possible parallelism between the FPU and the ALU, we would need to introduce integer computations between the floating-point computations. If the total benchmark timings remain relatively constant or don't increase by the previously measured time required to perform the inserted integer operations, then parallelism exists. We can explore it by successively increasing the number of integer operations added between the floating-point operations until the benchmark time begins to increase significantly.

If we want to explore pipelined parallelism, we must string several floating-point operations together within a single loop. Without pipelining, the time should go up linearly with the number of operations in the loop. With pipelining, the incremental time required for each additional operation should be quite small relative to that required for a single operation.

An additional micro benchmark would be to estimate the time required to perform transcendental functions and to test the accuracy with which they are performed. Many older FPUs can't directly compute transcendental functions, such as logarithms and tangents, while newer ones, such as the MC68881/2 and the Intel 80x87, can.

When you test the transcendental functions, it is important to both time them and test their accuracy. SAVAGERF.C does this and is also a relatively simple program. It uses functional inverses to perform the accuracy tests. TRANSF.C is a more systematic test that times the basic transcendental functions and tests for their accuracy.

Between Memory and CPU

None of the subsystems discussed so far are as tightly bound as the CPU and its memory. The CPU fetches instructions from the memory subsystem, the instructions get their operands from the memory, and the CPU deposits the results of an instruction in the memory after the instruction is completed. As CPUs become faster, eventually it will cease to be cost-effective to build an entire memory system fast enough to keep up with the processor. There are two possible ways to deal with this: Allow the memory to bottleneck performance, or incorporate a hierarchical-memory system.

Hierarchical-memory systems contain small amounts of high-speed memory capable of running at processor speed, larger amounts of memory that are somewhat slower, and so on, in an increasingly slower hierarchy of memory subsystems. The most common multilevel memory hierarchies are three-level virtual memory systems. Typically, the fastest level is an associative cache from which the CPU references instructions and perhaps some data as well. The second level is the main memory; in most systems, this level is simply dynamic RAMs. If you use a cache for your instructions, you can use relatively inexpensive, slower RAMs for the main memory.

In a virtual memory system, main memory is segmented, typically into fixed-size units known as pages. A memory map makes a correspondence between the virtual addresses that a program sees and the physical addresses that main memory sees. Some virtual pages
may not have corresponding physical pages; the nonresident pages are kept on a "backing store," which is often a disk drive.

Hierarchical-memory systems work well because typical programs obey the principle of "referential locality": that is, memory references tend to be clustered about a relatively small set of addresses for a relatively long period of time. We can explore the effectiveness of this organization by running nontypical programs. For example, THRASH.C, a benchmark written by Hank Vaccaro, randomly references elements of a large array. It is interesting to plot the speed per reference against the array size. A modified Thrash program, THRASHRF.C, gathers the data for just such a plot.

The graph in figure 2 shows the timings for THRASHRF.C when run on a MicroVAX II under VMS (virtual memory operating system). Although this machine doesn't have a cache to speak of—it does have an instruction-prefetch queue, but the timing of the benchmark should be dominated by data references—the program address space is nevertheless accessible in a distinct three-level hierarchy.

Under VMS, each program has a "working set" of addressable pages. For the run shown in figure 2, this working set was 3000 512-byte pages, or 1.5 megabytes. As long as you confine your references to this working set, the program should execute quite rapidly. Once the program gets outside the 1.5-megabyte range, however, it begins page faulting; that is, it references memory locations that the program can't directly address. When THRASHRF.C needs a new page of memory, VMS places a page from the working set on a list—this will be the free list if the page hasn't been modified, or the modified list if it has. The needed page then becomes part of the working set.

Memory references tend to cluster around a small set of addresses for a long period of time.

When VMS puts a page on the free or modified list, it doesn't immediately break the actual binding between page and process virtual address. Eventually, VMS writes modified list pages to disk and then puts them on the free list, still bound to the processes from which they came. Only when VMS needs the page for another process or for another virtual address within the original process is this binding broken.

---

Figure 2: When a program tries to address memory outside the working set of directly addressable pages, execution time increases: slightly on a soft fault (memory found on the free list), and significantly on a hard fault (disk I/O required).
or the modified list is called a soft fault.

A page fault that can be satisfied only by a free physical memory, a significant number of hard faults begins to occur. This kind of code expansion makes it difficult to claim that a C benchmark actually tests memory-movement timing. The most we can say is that it tests the timing of typical memory references within high-level-language programs.

This kind of code expansion makes it difficult to claim that a C benchmark actually tests memory-movement timing. The most we can say is that it tests the timing of typical memory references within high-level-language programs.

Listing 1: (a) shows the code generated by the Ecosoft-C88 C compiler for the FOR loop shown, while (b) shows the code I was trying to benchmark.

```c
; for( i = 0; i < ASIZE; i++)
; dest[i] = 0;
;
; Code generated by ECO-C88

Listing 1: (a) shows the code generated by the Ecosoft-C88 C compiler for the FOR loop shown, while (b) shows the code I was trying to benchmark.

```c

```

(b)  

```

```

Thus, if a page is removed from the working set and is then requested before it is bound to another process, the free- and modified-page lists act as a cache, preventing the costly disk I/O that you would otherwise need to obtain the page. A page fault satisfied from either the free or the modified list is called a soft fault. A page fault that can be satisfied only by a disk I/O is called a hard fault. These provide the two additional levels of the memory hierarchy.

Figure 2, therefore, shows three distinct speeds. The fastest timings occur when the memory references all lie within the 1.5-megabyte working set of pages. Next is a plateau that involves a large number of soft faults, but few or no hard faults; that is, the memory references fit within the free physical memory of the MicroVAX II but are too big to fit in the process’s working set. The MicroVAX II has “only” 9 megabytes of physical memory; once the referenced program address space no longer lies within the free physical memory, a significant number of hard faults begins to occur. This accounts for the third timing plateau, where hard faults begin to dominate program execution time.

Stumbling Blocks

In trying to produce a set of reasonably portable high-level-language benchmark programs, I have ignored the actual generated code. My approach results in two problems. First, using high-level languages makes the exact sequence of the instructions being timed imprecise; and second, optimizing compilers can reduce the program until some timing loops are doing nothing.

The first point is fairly easy to see. Let’s look at the generated code from one instruction in the MOVESRP.C benchmark. The compiler is Ecosoft’s C88, which is deliberately not a highly optimizing compiler. Listing 1a is the generated machine code for the clear-memory loop of the memory-access timings, but listing 1b shows what we had really wanted to benchmark.

This kind of code expansion makes it difficult to claim that a C benchmark actually tests memory-movement timing. The most we can say is that it tests the timing of typical memory references within high-level-language programs.

In writing micro benchmarks, you effectively have two choices: You can build portable benchmarks and put up with the associated imprecision, but be able to compare performances between different architectures (e.g., Intel 80x86 vs. MC680x0 vs. AT&T32000); or you can build benchmarks in assembly language, allowing complete control over the instruction sequence timings, but requiring extensive rewrites to compare different architectures. This allows comprehensive comparisons within an architecture (e.g., Intel 80386 vs. 80286 vs. 80186 vs. 8086 vs. 8088, or MC68008 vs. 68000 vs. 68010 vs. 68020 vs. 68030).

On the other hand, with a highly optimizing compiler, you must deal with code deletion. The optimizer can decide to remove large pieces of the code that you wanted to time. One example of this is the original FLOAT.C benchmark, which, for nonoptimizing compilers, measures the speed of the multiplication and division family of floating-point instructions. For an optimizing compiler, however, the benchmark effectively disappears.

Reasonably good optimizing compilers can determine that the computations are loop-invariant and that they are all done with constants and thus can be computed at compile time. Once this is done, the compiler deletes all but one of the pairs of multiplications and divisions in the loop, pulls the computations outside the loop, evaluates them at compile time, notices that the loop is null, and deletes the loop, leaving a program that executes instantaneously.

One technique you can use to prevent your benchmarks from being annihilated is to write all computational results based on a certain condition. This condition could be determined by user input or hardcoded into a separately compiled function, thus hiding from the compiler’s optimizer. If you avoid loop-invariant computations and compile-time constants, you can prevent most loop and expression optimizations.

No Substitute for Understanding

There is really no substitute for understanding the architecture you are studying. If you don’t understand how the subsystems interact to form a system, even the results of a good micro benchmark are useless. For example, a micro benchmark might demonstrate that an ALU can give 5 million additions per second. If, however, the system is I/O-bound, these results are misleading.

No micro benchmark is completely portable, due to the wide variations in the ways computer systems are designed. For example, a memory-reference benchmark does not have much meaning on a vector processor. High-level-language micro benchmarks have their own set of problems: for example, the trade-off between portability and instruction-stream precision, and the battle against ever-improving compiler optimizers.

Micro benchmarks measure in detail the performance of the selected subsystems of a computer system. If your system will be used in a well-defined set of applications, micro benchmarks can give you an idea of its performance.

ACKNOWLEDGMENTS

I would like to thank Trevor Marshall, Al Aburto, and Hank Vaccaro. Their active participation in the supermicro/benchmark topic on BIX sparked my interest in performance measurements.

Ron Fox develops data acquisition programs for the National Superconducting Cyclotron Lab at Michigan State University in East Lansing, Michigan.
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BENCHMARKS

Introducing the New BYTE Benchmarks

A set of staff-written programs that gauges total system performance

Richard Grehan, Tom Thompson, Curtis Franklin Jr., and George A. Stewart

THE GOAL OF benchmarking is a noble one. You run a program on a computer, and a number pops out to tell you whether or not the computer is worth its salt.

But benchmarking is like playing the Oriental game of GO. Rules that at first appear simple blossom into complexity as you begin applying them. So, what starts out sounding like the simple job of devising programs to test the relative performance of microcomputer systems runs you headlong into the problems of different CPUs, different FPUs, different operating systems, and before you know it you're just a pair of eyes peering through the turns of a Gordian knot. The trick is to design some sort of common ground, a model that acts as a guiding force to keep things real and reasonable.

To date, no benchmarks have openly, clearly, and reliably tested both within and across brands and architectures. Oh, there are plenty of "black box" benchmarks: Plug in a disk, spin it up, and get a number. But what does the number mean? How does it relate to the real world? What actually was tested? And how? You might as well read tea leaves.

There are also all kinds of machine-specific benchmarks. For example, you can grind away at any one of the many PC benchmarks until your system smokes, and you still won't have any idea how your machine stacks up against, say, a Mac II or SE.

Our new benchmarks are a major first step toward remedying these and other flaws. The benchmarks include a set of low-level tests and a set of application-level tests. (Tables 1 and 2 show test results for PC-DOS/MS-DOS machines and Macintosh machines, respectively.) For the low-level tests, we started by going back to the Small-C compiler, first devised for the CP/M world, and building from there (see the text box "BYTE Small-C" on page 256). We devised tests, chose algorithms, coded, debugged, and debugged again.

No black box, these: BYTE's benchmarks have always been open, and our newest ones follow in that tradition. We will freely distribute the source code of both the benchmarks themselves and the custom versions of Small-C. You can read the source code; you can see exactly what our benchmarks test, and how.

Why Small-C?

Low-level benchmarking presented us with a number of dilemmas. If we wanted laser-beam accuracy, we'd have to handcode in assembly language whatever algorithms we picked for every processor out there, and someone would always be popping up with a coding trick that would shave 2 bytes and 20 clock cycles off the code. (Notice we said "algorithms"; we wanted benchmarks that at once were low-level and had some connection to the real world. We didn't want to just code up a big pile of NOP or MOVE.L D1, D1 instructions and time them.) And assuming we did take that tack, we'd end up arguing over what the "best" implementation of a given algorithm would be for a given processor. Would it be the smallest version? The fastest? Not necessarily the same thing.

We chose to modify the Small-C compiler for the 80x86 and 68xxx machines so that it would give us the spyglass into assembly language that we wanted and, at the same time, provide us with a vehicle that was as close as possible to being common across different processors. To put it another way, Small-C defined a model, and we would ask each processor to take its best shot at executing that model. Naturally, where one processor would have an instruction that might give it an advantage in one area of the model, another processor would have an advantage in a different area.

Small-C lets us create benchmarks based on algorithms that bear a resemblance to real-world applications. We can then port those benchmarks more easily from machine to machine than if we had hand-coded them, and—thanks to the fact that Small-C emits assembly language source code—we can understand why one processor performs better than another for a given algorithm. Additionally, Small-C's #asm directive lets us dip into pure assembly code. This is especially handy in those cases where we "step outside" the bounds of Small-C to test some system feature it doesn't support.

And last but not least, Small-C is in the public domain, so we can freely share our source code with you.

It opens the doors for discussions on optimization techniques, improvements to the run-time library, language design, and more.

CPU Benchmarks

• Sieve. You may think that we're just keeping the Sieve of Eratosthenes around
because we've become so attached to it. There's some truth in that, but within that truth lies other, more compelling facts that we can't ignore: Language and system designers the world over have used the Sieve as a basic performance test. The Sieve makes use of arrays (indirect addressing), comparison operations, and simple math. We thought it worthwhile to keep the old firehorse around.

For comparison, listing 1 contains the complete source code file for the new BYTE Sieve of Eratosthenes.

• Sort. The new Sort benchmark now uses three sorting algorithms: a Quick-sort, a Shell sort, and a heapsort. All three sorting techniques make heavy use of indirect addressing, comparison operations, and basic integer math operations. But there are differences that allow the new benchmark to exercise more aspects of the machine than the old Sort did. Specifically, Quicksort is a recursive sorting procedure, while Shell sort uses a repeating-loop algorithm, and the heap sort uses a repetitive call to an subroutine. (Currently, the time reported for the Sort benchmark is the aggregate for all three algorithms. However, if you're interested in determining which algorithm works fastest, you can modify the source code to report on the individual times.)

Listing 2 contains the source code for the Sort algorithms' major subroutines.

• Matrix. The job of the Matrix benchmark is to exercise the kind of operations that must take place to manipulate matrices—in this case, two-dimensional arrays. Primarily, this involves indirect addressing, but the Matrix benchmark also tests integer math operations. Note that some integer math must occur as a program calculates the offset of an array element. Most high-level compilers that support multidimensional arrays handle this math for you automatically, but since BYTE Small-C allows only one-dimensional arrays, such math is necessarily explicit.

The Matrix benchmark times three common matrix operations: Add two square matrices, multiply two square matrices, and perform a transposition on a square matrix. The benchmark calculates the total time for all these operations and prints the results. You'll find the source code for the major routines of the Matrix benchmark in listing 3.

• String Move. The String Move benchmark's operation is easy to state: It moves lots of bytes from one place to another. Here, however, is a program whose portability becomes tricky. Consequently, the String Move benchmark makes heavy use of assembly language routines, and these routines are coded differently for each processor. There is another detail

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**Table 1: BYTE benchmarks for PC-DOS/MS-DOS machines.**

<table>
<thead>
<tr>
<th>Low-level Test</th>
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<th>IBM PC AT</th>
<th>IBM PS/2</th>
<th>Compaq 1</th>
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1 All figures were generated using the 8086/8088 version of Small-C (16-bit integers).
2 Figures for the 80386 machines shown here do not use 80386-specific instructions.
3 The floating-point benchmarks used 8087-compatible coprocessor instructions only.
4 The errors reported for the floating-point benchmarks indicate the difference between expected and actual values, correct to 10 digits or rounded to two decimal places.
5 Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100).
6 Read and write times for the File I/O² benchmarks are in seconds per Kbyte. All others are in minutes:seconds.fractions.
7 For the Livermore Loops and Dhrystone tests only, higher numbers mean faster performance.
NEW BYTE BENCHMARKS

<table>
<thead>
<tr>
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<th>IBM PC</th>
<th>IBM PC AT</th>
<th>IBM PS/2 Model 80</th>
<th>Compaq 386/20</th>
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**SS 

| Engineering/Scientific |        |           |                   |               |
| AutoCAD 2.52           | 10:30  | 2:45      | .54               | .35           |
| Load SoftWest          | 6:15   | 2:21      | .41               | .28           |
| Regen SoftWest         | 2:15   | .35       | .13               | .08           |
| Load St. Pauls         | .59    | .21       | .07               | .05           |
| Hide/redraw            | 2:18/30 | 1:44/45  | 14:07             | 9:01          |
| STATA 1.5              | 2:39   | .49       | .36               | .19           |
| Graphics               | 1:48   | .37       | .16               | .11           |
| ANOVA                  | .02/10 | .10       | .04               | .03           |
| MathCAD 2.0            | 2:32   | 1.00      | .17               | .12           |
| IFS 800 pts            | 2:57   | .52       | .18               | .12           |
| FFT/IFFT 1024 pts.     |        |           |                   |               |

**COMPILERS**            |        |           |                   |               |
| Microsoft C 5.0        | 31/49  | 9.45      | 4.48              | 3.00          |
| XLisp compile          | .41    | .11       | .06               | .03           |
| Turbo Pascal 4.0       |        |           |                   |               |
| Pascal S compile       |        |           |                   |               |

**GENERAL SYSTEM SPECIFICATIONS**

1. The PC system includes a 4.77-MHz 8087, 512-Kbyte system memory, a CGA card, and a 20-megabyte external hard drive.
2. The PC AT includes an 8-MHz 80287, 512-Kbyte system memory, a CGA card, and a 30-megabyte hard drive.
3. The IBM PS/2 Model 80 includes an 16-MHz 80387, 6-megabyte system memory, a VGA graphics adapter, and a 40-megabyte hard drive.
4. The Compaq Deskpro 386/20 system includes a 20-MHz 80387, 6-megabyte system memory, an EGA graphics adapter, a 300-megabyte hard drive, and a 20-MHz 82385 cache controller.

All disk tests refer to a single DOS partition on the hard drive except for Hard Seek, which refers to the entire disk.

with the String Move benchmark that makes its port across processors, shall we say, "uneven." We can best illustrate this by describing how the benchmark runs for the different processors.

8086/8088/80286—The benchmark moves bytes a byte at a time and a word at a time. For the word-at-a-time moves, the benchmark actually runs its test twice, first for odd-byte alignment and then for even-byte alignment.

68000/68020—The benchmark moves bytes a byte at a time, a word at a time, and a doubleword at a time. Since the 68000 must access words and doublewords on even-byte boundaries, there is no odd-byte-boundary test.

80386—This version of the benchmark will be a kind of hybrid of the first two. Bytes will be moved a byte at a time, a word at a time, and a doubleword at a time. For the word- and doubleword-width moves, the benchmark will test even- and odd-byte alignments.

The following is pseudocode for the new BYTE String Move benchmark:

```
begin main
    count = 10000
    allocate_memory(source_buffer)
    allocate_memory(dest_buffer)
    begin timer
    transfer_bytes(source_buffer, dest_buffer, count)
    end timer
    report(elapsed_time)
    begin timer
    source_buff_pointer = odd
    dest_buff_pointer = odd
    transfer_word(source_buffer, dest_buffer, count)
    end timer
    report(elapsed_time)
    source_buff_pointer = even
    dest_buff_pointer = even
    transfer_word(source_buffer, dest_buffer, count)
    end timer
    report(elapsed_time)
    release_memory(source_buffer)
    release_memory(dest_buffer)
end main
```

One further note: For the 80x86 versions...
sions, the String Move benchmark uses the REP MOVESx instructions. Since these instructions use DS as the source segment and ES as the destination segment, this has the effect of testing moves from one segment to another.

**FPU Benchmarks**

Most of the work for the floating-point coprocessor benchmarks went into crafting a floating-point coprocessor library that we could attach to BYTE Small-C (see the text box "Small-C Support Functions" on page 261). Small-C does not support a floating-point data type. This means that BYTE Small-C has to manipulate floating-point numbers as arrays of bytes, and perform floating-point operations by making calls into the floating-point library. For example, to add two floating-point numbers in BYTE Small-C, the instruction would look like this:

```c
f2add(ptr1, ptr2, ptr3);
```

where ptr1 and ptr2 are pointers to the arrays holding the floating-point numbers, and ptr3 points to the array holding the destination. Consequently, the code to implement a floating-point algorithm looks like a series of function calls rather than a traditional assignment statement.

This also means that BYTE Small-C will not have a floating-point emulator library. We decided that such a library would involve too much work for too little return; emulating floating-point operations involves integer math and logical operations, and our other benchmarks already give an indication of the processor's performance in such areas.

We did, however, code the coprocessor library so that calls into it are similar across processors, and the source for the floating-point benchmark program is almost identical for the 80x86 and 68xxx processors. The library also includes functions for converting from integer to floating-point and back, as well as an output routine that can print floating-point numbers in scientific notation.

BYTE's new floating-point coprocessor benchmark is in two parts, packaged in a single program. The first part is a large loop that simply tests the four basic math operations: add, subtract, multiply, and divide. The second half gives the transcendental functions a workout; it executes a numerical integration algorithm known as the *trapezoidal rule* for two functions—*sin(x)* and *e*—over a fixed interval. Both the basic math and transcendental tests return results as well as execution times, so we'll be able to test accuracy as well as speed.

Listing 4 contains the source code for the floating-point benchmark.

---

### Table 2: BYTE Macintosh benchmarks.

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<thead>
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<th>Test Type</th>
<th>Mac Plus</th>
<th>Mac SE</th>
<th>Mac II</th>
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<tr>
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<td>67.1</td>
<td>21.2</td>
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<tr>
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<td><strong>String Move</strong></td>
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<tr>
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<td>Long word-wide</td>
<td>147.0</td>
<td>92.4</td>
<td>22.9</td>
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<td><strong>Sieve</strong></td>
<td>200.1</td>
<td>170.2</td>
<td>40.2</td>
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<tr>
<td><strong>Sort</strong></td>
<td>179.7</td>
<td>154.2</td>
<td>44.2</td>
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</tbody>
</table>

| **FLOATING POINT** |           |         |        |
| Math               | N/A       | N/A     | 175.3  |
| Error              |           |         | 0.0    |
| Sine(x)            | N/A       | N/A     | 84.8   |
| Error              |           |         | 1.05E-9|
| e^x                | N/A       | N/A     | 112.5  |
| Error              |           |         | 1.05E-9|

| **DISK I/O**       |           |         |        |
| Sub-Finder Seek    |           |         |        |
| Sony:              |           |         |        |
| Sector read        | 66.6      | 61.9    | 62.7   |
| 40K-byte read      | 137.0     | 137.1   | 136.1  |
| Sector read        | 63.0*     |         |        |
| 40K-byte read      | 136.8*    |         |        |
| SCSI:              |           |         |        |
| Sector read        | 46.7*     | 41.1    | 14.6   |
| 40K-byte read      | 65.5*     | 52.6    | 19.4   |
| **File I/O**       |           |         |        |
| Seek               | 7.7       | 5.5     | 2.0    |
| Read               | 1.16      | 0.52    | 0.23   |
| Write              | 0.92      | 0.09    | 0.04   |
| **1-megabyte**     |           |         |        |
| Write              | 13.9      | 14.8    | 5.2    |
| Read               | 7.5       | 8.1     | 1.6    |

| **VIDEO**          |           |         |        |
| Text               | 17.3      | 15.1    | 5.6    |
| Drawstring         | 4.3       | 3.8     | 1.8    |
| **Graphics**       |           |         |        |
| Slow test          | 96.6      | 84.4    | 46.2   |
| QuickDraw          | 1.1       | 1.1     | 0.3    |

| **LINPACK**        |           |         |        |
| Single precision   | 2685      | 2319    | 364**  |
| Double precision   | 4894      | 4229    | 348**  |

---

* All figures were generated using the 68000 version of Small-C. Figures reported for the Mac II do not use 68020-specific instructions, except where noted.
* The floating point benchmarks used the SANE library.
* These times are for the floppy disk drive.
* These times are for the Mac/30 hard disk drive.
* Read and write times for the File I/O benchmark are in seconds per Kbyte. All others are in minutes:seconds.fractions.
* The Slow test uses codes written in Small-C to perform the circle draw and fill. The QuickDraw version uses QuickDraw commands to draw and fill the circle.
* For the Dhrystone test only, higher numbers mean faster performance.
### Application Test

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Mac Plus</th>
<th>Mac SE</th>
<th>Mac II</th>
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<td><strong>WORD PROCESSING</strong></td>
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<td>08:16</td>
<td>06:14</td>
<td>04:05</td>
</tr>
<tr>
<td>Search/replace</td>
<td>1:32/10:39</td>
<td>1:20/9:40</td>
<td>07:30/9:05</td>
</tr>
<tr>
<td>Find last page</td>
<td>03:07</td>
<td>03:06</td>
<td>02:03</td>
</tr>
<tr>
<td>Merge small.txt</td>
<td>13:18</td>
<td>12:17</td>
<td>08:07</td>
</tr>
<tr>
<td>Spelling check</td>
<td>3:22**</td>
<td>2:47/21:43</td>
<td>1:09/7:40</td>
</tr>
<tr>
<td>Store document</td>
<td>15:13</td>
<td>14:10</td>
<td>12:27</td>
</tr>
<tr>
<td>MultiWord (small/large)</td>
<td>11:11.13</td>
<td>10:10</td>
<td>06:35</td>
</tr>
<tr>
<td>Microsoft Word 3.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cursor down 640 lines</td>
<td>2:27</td>
<td>2:2</td>
<td>1:21</td>
</tr>
<tr>
<td>Search/replace</td>
<td>1:15</td>
<td>1:07</td>
<td>1:22</td>
</tr>
<tr>
<td>Store document</td>
<td>48</td>
<td>46</td>
<td>16</td>
</tr>
<tr>
<td>Aldus PageMaker 2.0a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load document</td>
<td>17</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>(20,586 words)</td>
<td>1:32</td>
<td>1:31</td>
<td>0:29</td>
</tr>
<tr>
<td>Change/bold</td>
<td>1:25</td>
<td>1:10</td>
<td>0:29</td>
</tr>
<tr>
<td>Align right</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut and refill</td>
<td>0:50</td>
<td>0:44</td>
<td>0:19</td>
</tr>
<tr>
<td>first 10 pages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place 80K-byte graphics file</td>
<td>0:26</td>
<td>0:21</td>
<td>0:10</td>
</tr>
<tr>
<td>Print document to PostScript file</td>
<td>2:59</td>
<td>2:26</td>
<td>0:52</td>
</tr>
<tr>
<td><strong>SPREADSHEET</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microsoft Excel 1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full right B1...AY50</td>
<td>32</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Undo fill</td>
<td>21:13</td>
<td>17:20</td>
<td>5:22</td>
</tr>
<tr>
<td>Recalc</td>
<td>1:01</td>
<td>1:01</td>
<td>0:31</td>
</tr>
<tr>
<td>Load rlarg3.x12</td>
<td>0:50</td>
<td>0:41</td>
<td>0:15</td>
</tr>
<tr>
<td>Recalc rlarg3.x12</td>
<td>0:06</td>
<td>0:06</td>
<td>0:02</td>
</tr>
<tr>
<td><strong>DATABASE (1200 RECORDS)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McMax 87.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copy</td>
<td>31</td>
<td>28</td>
<td>10</td>
</tr>
<tr>
<td>Index</td>
<td>20</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>List</td>
<td>2:14</td>
<td>2:11</td>
<td>2:04</td>
</tr>
<tr>
<td>Append 832 records</td>
<td>34</td>
<td>32</td>
<td>11</td>
</tr>
<tr>
<td>Delete</td>
<td>02</td>
<td>02</td>
<td>0:1</td>
</tr>
<tr>
<td>Pack</td>
<td>12</td>
<td>11</td>
<td>0:4</td>
</tr>
<tr>
<td>Count</td>
<td>07</td>
<td>07</td>
<td>0:3</td>
</tr>
<tr>
<td>Sort</td>
<td>1:08</td>
<td>1:54</td>
<td>0:19</td>
</tr>
<tr>
<td><strong>ENGINEERING/SCIENTIFIC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minlecd 3.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load</td>
<td>25</td>
<td>23</td>
<td>0:6</td>
</tr>
<tr>
<td>Redraw</td>
<td>1:30</td>
<td>1:37</td>
<td>2:54</td>
</tr>
<tr>
<td>Hide and shade</td>
<td>1:16</td>
<td>1:55</td>
<td>3:59</td>
</tr>
<tr>
<td>Data Desk 1.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression analysis</td>
<td>5:13</td>
<td>5:13</td>
<td>1:01</td>
</tr>
<tr>
<td>Correlation analysis</td>
<td>5:59</td>
<td>5:59</td>
<td>1:17</td>
</tr>
<tr>
<td><strong>COMPILERS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightspeed C 2.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XLISP compile</td>
<td>2:51</td>
<td>2:25</td>
<td>1:02</td>
</tr>
<tr>
<td>Turbo Pascal 1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pascal S compiler</td>
<td>17</td>
<td>14</td>
<td>0:07</td>
</tr>
</tbody>
</table>

---

**Note:** Insufficient memory to spell-check BYTE benchmark large document

---

### Disk I/O Benchmarks

As storage subsystems become responsible for more and more of the time you spend at the computer, it becomes more important to get an accurate picture of how a particular disk will affect total system performance. If hardware and software vendors could agree on a single way to access disks, the job of benchmarking would be easy. Unfortunately for those of us who have to write and run the benchmarks, there are almost as many schemes for getting at storage as there are storage devices.

In addition to the number of access methods and interfaces available, the number of components involved with any storage access makes accurate performance testing of any one component very difficult. In general, the storage device itself, the device controller, and the computer's operating system are involved with any transaction. In some interface systems, such as small-computer-system-interface (SCSI) systems, a device driver is involved as well.

In most situations, it's impossible and nonsensical to divorce the performance of the disk from the performance of its controller or driver. Our benchmarks don't attempt to force this separation, concentrating instead on factoring various degrees of operating-system overhead out of the performance equation. Since different programmers and hardware designers view the facilities of operating systems with varying degrees of contempt, we varied the tests based on how heavily they rely on each operating system's file system.

The first test in the suite is the BIOS-level benchmark. On an IBM PC or compatible running MS-DOS, this benchmark "goes around" the operating system, manipulating the disk with direct calls to the machine BIOS. This test is designed to gauge the speed of the disk/controller combination, with as much of the operating system overhead as possible factored out of the results.

The program begins by getting information from the disk and then proceeds to test the disk in four stages, with each stage repeated 100 times. The program first seeks between the two outermost tracks, reading one sector on each. It then seeks between the two innermost tracks, the outermost and middle tracks, and the outermost and innermost tracks, reading a sector on each track. The times from all these seeks are collected, and an "average seek time" is calculated.

The following is pseudocode for the BIOS-level benchmark:

```plaintext
begin main
get_disk_info
```
We gave this card a built-in IC memory.

THE MITSUBISHI PLASTICS IC MEMORY

BEE CARD SYSTEM

If you need to carry information but don't want to carry a computer, the Mitsubishi Plastics IC Memory "Bee Card" System is for you.

The Bee Card is a plastic card that contains from one to four ICs. Offering unprecedented convenience, versatility, reliability and economy, it makes slow-access cassette tapes and floppy disks obsolete.

It's also exceptionally sturdy and durable. With a thickness of only 1.8mm (0.07in), it's compact enough to carry in your wallet. Yet offers a memory of from 64K to 1M bits.

Best of all, the Bee Card frees you from on-line systems. Which makes it perfect for use in the field. In almost any field.

Cards come in four types and a variety of memory capacities. Mask-ROM cards are designed for readout
And we’re giving you a lot of ways to use it.

Plays up to 100 melodies with electronic musical instrument.

Offers new freedom of font choice.

only. OTP ROM cards, for one-time programming. EEP ROM cards can be electrically erased and reprogrammed. And S-RAM cards, with replaceable lithium cell, are erasable and programmable at high speed.

You’ll be hearing a lot about these cards in the not-too-distant future. And seeing a lot of them, too. In computerized navigation systems for automobiles. At hospitals, recording and storing patient charts. In industrial stock inventory control. And even at music stores, playing your favorite tunes electronically.

When you carry the Mitsubishi Plastics Bee Card, the future of information handling is right where you want it.

In the palm of your hand.

Mask-Programmed ROM Card
64K bits 128K bits 256K bits
1M bits (2M bits) (4M bits)
EEP ROM Reprogrammable Card
64K bits (byte mode)
128K bits (byte mode) 2-chip type
64K bits (page mode)
128K bits (page mode) 2-chip type

OTP ROM One-Time Programmable Card
64K bits 256K bits
512K bits
1M bits

Available in the near future

S-RAM Card
64K bits 128K bits 256K bits
512K bits 1M bits

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Circle 190 on Reader Service Card
NEW BYTE BENCHMARKS

disk_identifier
number_of_heads
number_of_cylinders
sectors_per_track
outer_track_seek
first = outermost_track
second =
next_to_outermost_track
doseek (first, second)
display (accumulated_time)
inner_track_seek
first =
next_to_innermost_track
second = innermost_track
doseek (first, second)
display (accumulated_time)
half_platter_seek
first = outermost_track
second = (total_tracks)/2
doseek (first, second)
display (accumulated_time)
full_platter_seek
first = outermost_track
second = innermost_track
doseek (first, second)
display (accumulated_time)
end main

begin doseek (first, second)
accumulated_time = 0
begin repeat (100 times)
begin timing
seek to (first), sector 1
read 1 sector
stop timing (calculate elapsed time)
accumulated_time = accumulated_time + elapsed_time
end repeat
end doseek

We have confidence in the results we get from this test, but it does have a couple of shortcomings. First, since it deals with the hardware in a most intimate fashion, the program is quite hardware-dependent. It will have to be significantly rewritten for new systems that might come out. The second will become more apparent as more of the world moves to the SCSI interface for hard disks. SCSI is a black-box design that effectively hides the geometry of the device from programmers. It is so effective at this hiding that our BIOS-level test will simply not translate to the SCSI environment.

The next benchmark is not nearly so subversive as the BIOS-level test. In the second BYTE disk-subsystem benchmark, the operating system is used, but at a level of explicit device calls instead of relying on its file system. The testing methodology is relatively straightforward in an MS-DOS system. The main portion of the program is run twice. In the first iteration, the device is told to step through its sectors in 10 even steps, reading one sector at each step. In the second iteration, the same 10 steps are used, but eight sectors are read at each stop. The time for each of these iterations is reported. This test is designed to be portable across a variety of system types, though we realize that some degree of reprogramming will be required for each new system.

Pseudocode for OS-Level—Explicit:

begin main
    test_device = drive to be tested
    get_disk_info (test_device)
    disk_identifier
    number_of_heads
    number_of_cylinders
    sectors_per_track
    total_sectors
    accumulated_time = 0
    sector = 0
    begin repeat (50 times)
        track_seek (0, 1)
        begin repeat (10 times)
            sector = sector + (total_sectors/10)
        end repeat
        track_seek (sector, 1)
        end Timing; calculate elapsed time
        accumulated_time = accumulated_time + elapsed_time
        end repeat
    end repeat
begin repeat (50 times)
    track_seek (0, 1)
    begin repeat (10 times)
        sector = sector + (total_sectors/10)
    end repeat
    track_seek (sector, 8)
    end Timing; calculate elapsed time
    accumulated_time = accumulated_time + elapsed_time
    end repeat
end repeat

end main

begin track_seek
    (sector_position, #_sectors_to_read)
    move to sector at (sector_position)
    read (#_sectors_to_read)
    end track_seek

A case in point is the way this benchmark was ported to SCSI drives under the Macintosh operating system. After several conversations with the folks at Jasmine Technologies, who produce SCSI drives, we decided that going beneath the Finder to make calls directly to the device driver provided by the disk drive manufacturer results in the functional equivalent of the MS-DOS version. This is probably the test that will require the most effort to port to new interfaces and operating systems.

The third test owes a great debt to our old file I/O C-language benchmark. The program is designed to measure the interaction of the disk/controller and the operating system's file system. In the normal course of working with a storage device, the three basic operations exist: creating files, appending files, and reading files. The benchmark creates 10 files of varying sizes. Each is then appended by a chosen amount. The test then uses an arbitrarily chosen number (actually a constant pseudorandom number) to determine the location and size of the reads and writes that follow. Reading and writing in the last portion are performed at a ratio of three reads for every write, since this approximates the usage pattern of disk users we observed. The accumulated times for reading, writing, and seeking are returned, along with the total number of bytes written and read.

This program translated readily to the Macintosh. The only significant change was to allow for the difference in the way the 80x86 and 680x0 processors deal with pointers to disk addresses. The 80x86 processor requires two integers for the pointer, and so two "random" numbers must be generated for the read and write addresses. The 680x0 uses a single 32-bit integer and requires only one "random" number.

Pseudocode for OS-Level File:

begin main
    count = 120
    write_time = 0
    write_bytes = 0
    read_time = 0
    read_bytes = 0
    seek_time = 0
    total_seeks = 0
    begin repeat (10 times)
        create_file
        end repeat
    begin repeat (10 times)
        extend_file
        end repeat
    random_read_and_write
    report
    end main

begin create_file
    file0_size = 4000
    file1_size = 10000
    file2_size = 500
    file3_size = 2800
    file4_size = 25000
    file5_size = 19000
    file6_size = 8000
    file7_size = 8800
    file8_size = 300
    file9_size = 21111
    for each file begin
        open file
        continued
It's no secret, in the laser printer world, you select either PostScript or HP LaserJet compatibility. You buy your printer from HP, your board from QMS and your software from Adobe.

*Destiny pulls it all together.*

Thanks to our LaserAct II® laser printer, our PageStyler (PostScript language compatible) software and PageStyler board. We go beyond HP LaserJet Series II compatibility by offering complete PostScript compatibility with our own PageStyler software embedded in our ASIC processors for the IBM PC® add-on board. The boards, printers and software offer full compatibility for the PostScript standard on our LaserAct II printer which is already fully compatible to the LaserJet Series II.

The LaserAct II offers 512K memory, upgradable to 4.5MB, 50% faster throughput than HP LaserJet Series II, and can become a full HPGL plotter with vector graphics features. Four months on-site service from TRW is standard.

Destiny's PageStyler software technology also extends to upgrade HP LaserJet Series, Canon LBP Series, and Acer LP Series laser printer users for PostScript compatibility at a much more affordable cost.

Adobe and PostScript are trademarks of Adobe Systems, Inc. HP and LaserJet are trademarks of Hewlett-Packard. QMS and PageStyler are trademarks of Destiny Technology. QMS is a trademark of QMS, Inc. "LaserJet" is a trademark of Canon Inc.
NEW BYTE BENCHMARKS

write_bytes = write_bytes + flex_size
begin timer
    write the file
end timer; calculate elapsed time
write_time = write_time + elapsed_time
end
open file
for each file begin
    write_bytes = write_bytes + file
end extend file

begin random read and write

begin extend file
file0_append = 12000
file1_append = 20300
file2_append = 31111
file3_append = 3400
file4_append = 9099
file5_append = 20755
file6_append = 7000
file7_append = 400
file8_append = 22000
file9_append = 27000
for each file begin
    open file for appending
    write_bytes = write_bytes + file
end extend file

The final test in our suite is simplicity itself. It uses all the help the operating system can offer to first write and then read a 1-megabyte file. Here is pseudocode for Large File Read and Write:

begin write
    allocate 10000 byte buffer
    fill buffer with character 'A'
    open file 'bigfile.dat'
    begin timer
    append file
    end timer; calculate elapsed time
    write_time = write_time + elapsed_time
    close file
end

In all, we’ve tried to create a suite of tests that will give all users an idea of how a disk subsystem will perform in a variety of circumstances, and will also give users with special requirements an indication of how the device will perform with the level of control they require.

BYTE Video Benchmarks

One of the most fundamental operations a microcomputer performs frequently is writing to its display. Like the process of printing a document, this type of task can become “bound” by the rate at which the display hardware can update the screen. Naturally, faster display hardware permits these video operations to finish sooner, freeing the processor to handle other tasks. Our tests measure this aspect of a microcomputer’s performance.

Deciding how best to measure this particular microcomputer subsystem posed a bit of a problem. A test of any sophistication became dependent on the algorithms used to implement the test program. This is clearly undesirable: The first requirement for the tests is that the effect of the software should be minimized. This means that the benchmarks should be coded in assembly language to minimize this effect and to execute as fast as possible.

However, another requirement of the benchmarks, at odds with the first, is that the benchmark programs have to run on a wide variety of machines, meaning that the test programs have to be portable as well. Fine-tuned assembly language procedures garner the best possible speeds for a given microcomputer but would be useless on another machine, and might not even work on the same machine with a new operating system or a new version of the old operating system.

The problem was resolved by devising a set of simple low-level video benchmark tests that would test certain basic graphics operations. The bulk of the benchmark programs would be written in Small-C, and, where it became necessary, assembly language would be used to operate the display hardware.

An important point must be made here. These programs were primarily designed to be portable. The best possible implementation for a given test was not used, nor were the tests designed to provide the fastest possible speed. The benchmarks provide a nominal measurement of basic graphics operations that could be compared across machines.

Having said that, what did we decide to measure? For IBM PCs, PC compatibles, and PS/2 systems, there are several basic video operations: writing characters (text), positioning the cursor, and manipulating pixels. For the Macintosh, everything drawn on the screen is a collection of pixels: Theoretically, there is no distinction between text and graphics. Nevertheless, the Macintosh is used often as a word processor where text is manipulated on the screen, so we believe that, in reality, the distinction between text and graphics still applies.

Video Specifications
Measuring text throughput is simply a matter of writing a certain number of characters on the screen and measuring the time it takes to do this. Since cursor positioning is often used in word-processing applications, we decided that its effects would also be measured as a part of text operations. First, 80,000 characters of text are written to the display. Then the cursor is repositioned, and 80,000 characters are written again.

Pseudocode for the new BYTE Text Throughput benchmark:

continued
Listing 1: Source for BYTE's new Sieve benchmark. If you're a regular reader, you'll find it's practically identical to the source we've used before. The only additions are the timing functions gtime() and calctim().

/*
** BYTE Sieve Benchmark Version 1 for 8088/8086/80286/80386
** Feb. 17, 1988 Written in BYTE Small-C
** Based on Small-C by J.E. Hendrix
** This program executes the infamous Eratosthenes Sieve Prime Number Program from BYTE, Jan. 1983.
**
** Operation:
** 1. Turn on stopwatch
** 2. Execute SIEVE for LOOP iterations
** 3. Turn off stopwatch
** 4. Report time and number of primes found
** 5. Exit
*/
#include stdio.h
#define size 8190
#define LOOP 100
#define TRUE YES
#define FALSE NO

int tblock[4]; /* Timer holding array */
char flags [size + 1];

main()
{
    int i, prime, k, count, iter;

    /* Announce yourself */
    printf("BYTE Sieve Benchmark\n");
    printf("%d iterations\n", LOOP);

    /* Start timer and execute loop */
    gtime(tblock);
    for (iter = 1; iter <= LOOP; iter++)
    {
        count = 0; /* prime counter */
        for (i = 0; i <= size; i++) /* set all flags true */
            flags [i] = TRUE;
        for (i = 0; i <= size; i++)
        {
            if (flags [i]) /* found a prime */
                { /*
                    prime = i + i + 3; /* twice index + 3 */
                    printf("\n%d", prime);
                    /*
                    for (k = i + prime; k <= size; k += prime)
                        flags [k] = FALSE;
                    /* kill all multiple */
                    count++; /* primes found */
                }
        }
    }
    calctim(tblock);

    /* Report results */
    printf("Results: (HH:MM:SS:1/100ths)\n");
    printf("Elapsed time: \%d:%d:%d:%d\n", tblock[0],
           tblock[1],tblock[2],tblock[3]);
    printf ("%d primes.\n", count);
            /* primes found on 100th pass */

    /* Exit */
    printf("Press RETURN to exit: ");
    fgetc(stdin);
    exit(0);
}
Listing 2: Source for the major routines of the Sort benchmark.

(a) The Quicksort algorithm.

```c
qsort(array, bot, top)
int array[], bot, top;
{
    int i, j, temp;
    while (bot<top) { /* First...make a heap */
        j=top;
        temp=array[bot];
        /* Partition array */
        while((i<(top/2));i>1;--i) { 
            if(array[i]<temp) { 
                temp=array[i];
                array[i]=array[O];
            } 
        } 
        /* Call qsort recursively */
        qsort(array, bot, i-1);
        bot =i+1;
    }
}
```

(c) The heapsort routine.

```c
hsort(array, bot, top)
int array[], bot, top;
{
    int i, temp;
    /* First...make a heap */
    while(bot<top) { /* Set ranges and choose partitioning element */
        sift(array, i, top);
        i=bot; /* Extract maximum */
        j=top; { /* Extract maximum */
        temp=array[bot];
        sift(array, 0, i);
        while (i<j) { aray[i]=aray[O];
            temp=aray[bot];
            while((i<j)&&(aray[i]<=temp)) 
                i+=1;
            while((i<j)&&(aray[i]<=temp)) 
                i+=1;
        } 
        /* Call hsort recursively */
        hsort(array, bot, i-1);
        bot =i+1;
    }
}
```

(b) The Shell sort routine.

```c
shsort(array, bot, top)
int array[], bot, top;
{
    int i, gap, next, temp;
    /* Set gap width */
    gap=(top-bot)/2;
    do {
        next=1; /* No exchanges yet */
        do { /* Exchange happened */
            while((2*i)<j) {
                if(k<j)
                    if(array[k]<array[k+i]) ++k;
                if(array[i]<array[k]) {
                    temp=array[k];
                    array[k]=array[i];
                    array[i]=temp;
                    if(array[k]<array[k+i]) ++k;
                } 
            } 
            if(array[i]<array[i+gap])
                temp=array[i];
            array[i]=array[i+gap];
            array[i+gap]=temp;
        } while((next=0);
        return;
    }
}
```

Although graphics operations are simply a matter of manipulating pixels, pixel throughput requires more than simply blasting pixels to the display. Pixels are used to represent objects. As these objects are drawn, the state of certain pixels must be read to permit certain graphics operations, such as clipping, to be performed on the object. Finally, drawing these objects can require that certain areas of the screen be flooded or filled with colors. Since the color must fill only the object drawn for the Pixel Throughput test is flooded with color using a seed fill.

For the Pixel Throughput test, the object drawn is a circle. We chose a circle for the target object because, interestingly enough, the algorithm for drawing a circle was much simpler than algorithms to draw lines; thus, it minimized the code overhead for the test. The circle is drawn eight times around a common origin, with the radius of each successive circle increasing by a fixed amount. Once each circle is drawn, it is filled with a color using a seed-fill algorithm, and then the next circle is drawn. The seed-fill algorithm may not be the fastest possible for this test, but the seed fill demands that the state of many pixels be read and written, which is the point of the measurement.

Pseudocode for the new BYTE Pixel Throughput benchmark:

```c
begin main
    count = 80000
    get_current_mode(old_mode);
    get current
    ; video mode
    prompt_user_for_mode(video_mode);
    ; see what user wants
    length = determine_length(video_mode);
    ; type of mode determines
    ; number of chars per line
    ; line string = build_string(length)
    ; lines = count / length
    row = column = 1
    row_counter = column_counter = 1
    begin timer
    switch_video_mode(video_mode);
    ;begin repeat (lines)
    ; while (row < length) 
    ; begin repeat (count)
    ; move_cursor(row, column);
    ; position
    ; cursor...
    ; display_char(
```

continued
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IBM. The Bigger Picture

*Based on performance test results published in the April, 1987 and January, 1988 issues of PC Digest, comparing the PS/2 Models 30, 50, 60 and 80 to the IBM PC XT, running Lotus 1-2-3 and DisplayWrite 4.

This simulated screen shown was developed using the IBM Storyboard Plus program. IBM, Personal System/2 and PS/2® are registered trademarks, PC XT, Operating System/2, OS/2, Micro Channel and DisplayWrite are trademarks of IBM Corporation. Lotus and 1-2-3 are registered trademarks of Lotus Development Corporation. © IBM 1988.
Listing 3: The major components of the Marrix benchmark:
(a) adds two square matrices, (b) multiplies two square matrices, and (c) performs the transposition of a matrix. Note that Small-C supports only one-dimensional arrays, so we have to simulate square matrices.

(a) madd (array1, array2, array3, rows, cols)
    int array1[], array2[], array3[];
    int rows, cols;
    {
        int i, j;
        for (i=0; i<rows; ++i)
            for (j=0; j<cols; ++j)
                array3[i*cols+j] = array1[i*cols+j] +
                array2[i*cols+j];
    }

(b) mmult (array1, array2, array3, row1, col1, row2, col2)
    int array1[], array2[], array3[];
    int row1, col1, row2, col2;
    {
        int i, j, k;
        for (i=0; i<row1; ++i)
            for (j=0; j<col2; ++j)
                array3[i*col2+j] = 0;
            for (k=0; k<col1; ++k)
                array3[i*col2+j] += array1[i*col1+k] *
                array2[k*col2+j];
    }

(c) mtrans (array1, array2, row, col)
    int array1[], array2[];
    int row, col;
    {
        int i, j;
        for (i=0; i<col; ++i)
            for (j=0; j<row; ++j)
                array2[i*col+j] = array1[j*row+i];
    }

begin main
    number_of_circles = 7
    get_current_mode(old_mode)
    ; get current video
    ; mode
    prompt_user_for_mode(video_mode)
    ; see what user
    ; wants
    switch_video_mode(video_mode)
    ; change mode
    set_size(video_mode, cx, cy)
    ; get x-y limits for
    ; this mode
    begin timer
    radius = 20
    ; starting size
    draw_circle(cx, cy, radius, color)
    begin repeat
        (number_of_circles)
        radius = radius + 10
        draw_circle(cx, cy, radius, color)
        ; draw new
        ; circle
        flood_circle(cx+radius=5, cy, color) ; flood the

The benchmark programs work reliably across the IBM PC family, from the first PC to the PS/2 Model 80. This is because the video buffer’s address has remained stable over time, although the size of the video buffer has grown. A menagerie of video modes has been introduced since then, each with its own idiosyncrasies.

Nevertheless, the PC video benchmark programs support MDA, CGA, EGA, MCGA, VGA, and Hercules graphics modes. The test prompts the user for the desired video mode, and the output is modified as necessary to support the mode requested. The timings for the tests are measured by the computer under test.

For the Macintosh, a window of fixed size is opened. This window fits within the smallest Mac display: the 9-inch diagonal built-in monitor on the Mac Plus and Mac SE. The active port is set to this window, and the graphics operations are run. QuickDraw is used to draw text or pixels in the window. Again, the computer itself times the operations to minimize error.

Down the Pike
As graphics boards with coprocessors become available, the benchmarks will be modified to work with them. If necessary, more sophisticated tests will be devised to thoroughly test the new capabilities provided by these coprocessors.

Applications-Level Benchmarks
BYTE’s new applications-level benchmarks are designed to measure system performance in five areas of interest: science/engineering, database management, word processing, software development using compilers, and spreadsheet calculation. Each application area places a different balance of demands on a system’s resources, and, as a result, a group of systems may achieve different rankings in the various tests.

The key variables that determine performance in these tests are CPU, effective presence of an FPU, effective presence of a GPU, operating system, speed of memory, and disk. (We say “effective” because not all applications are written in such a way as to take advantage of numeric and graphics coprocessors, relying instead on the CPU.) The terms FPU and GPU refer not necessarily to chips but also, in some cases, to floating-point or graphics processor boards.

Why test applications, given the abundance of numbers emanating from our low-level and mid-level tests? Primarily as a reality check. Most users will not have firsthand experience with our lower-level benchmarks, but they will almost certainly have some experience with one or more of the application areas we’re testing. Perform a global replace on 1000 occurrences of the word first—anyone can relate to that. Our applications benchmarks will give you an easy-to-grasp handle on system performance.

Applications benchmarks also offer some corroboration of the results from lower-level tests. A system that does extremely well on the FPU benchmarks should excel in certain areas of our engineering/scientific benchmarks as well. In cases where our applications results are at odds with our lower-level measurements, deeper probing is called for. This brings up a third use for applications

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NEW BYTE BENCHMARKS

BYTE Small-C
Richard Grehan

Small-C has a history that stretches back to 1980 when Ron Cain first presented it in the May Dr. Dobb’s Journal of Computer Calesthenics and Orthodontia. Originally written for 8080-based CP/M machines (there were lots around back then), Small-C’s attraction was its ability to compile itself. Compiling a program with Small-C yielded assembly language source that you fed to M80 and L80 (Microsoft’s CP/M assembler and linker) to create an executable file. Though Small-C handled only a subset of the features of a full-blown C compiler (e.g., it supported only char and int data types), it was powerful enough to handle applications that were quite robust. For proof, check the references at the end of this text box. L. E. Payne and J. E. Hendrix took this version of Small-C, added substantially to its syntax, and presented a hefty system library for the language. Again, this version of Small-C ran on 8080-based CP/M machines.

BYTE Small-C is a modified version of Hendrix and Payne’s Small-C with all the necessary enhancements added to bring it to processors and operating systems in widest use today. As of this writing, BYTE Small-C is running on the 8088/8086 (and 80286) under PC-DOS, on the 68000 and 68020 of the Macintosh family, and on the 80386 using Phar Lap’s RUN386 environment. As with the original Small-C, BYTE’s version emits source code that you hand to the appropriate assembler and linker. I’ve tried to keep the language as consistent across ports as possible; I’ve also tried to keep the library routines as similar to Payne and Hendrix’s in operation and call structure as I could. There are some differences—some good, some bad.

Here’s a potpourri of major features BYTE Small-C enjoys (or doesn’t enjoy) over its predecessors:

- The original Small-C handled many of its logical, math, and comparison operations by calling a math/logic library. When you consider that Small-C was running on an 8080 processor, the reasons for this are obvious—a 16-bit subtraction operation would consume many bytes of code. BYTE Small-C encodes such operations “in-line,” and it can do this thanks to the improved instruction sets of today’s processors. The result is faster code, since the program doesn’t have to do a CALL instruction just to perform an add or subtract. For some operations, this also generates more code (since some comparison operations require several instructions), but given the amount of memory most machines have today, I decided that the speed-to-size trade-off was worth it.
- The 8088/8086/80286 version of BYTE Small-C defines integers as being 16 bits big. The 80386, 68000, and 68020 versions, however, use 32-bit integers. Pointer variables follow the same pattern (which means, of course, that the data area for an 8088/8086/80286 program is restricted to 64K bytes).
- The 8088/8086/80286 version generates code that is MASM-compatible. The 68000 and 68020 version emits MDS assembler/linker-compatible code. Finally, the 80386 version produces code for Phar Lap’s 386/ASM/ LINK package. I’ve recoded the library for the PC-DOS machines to make use of the DOS functions added with DOS 2.0 and higher (i.e., the Unix-style file I/O calls). The Macintosh version uses a run-time library adapted from code first presented by Steve Williams (see references).

Finally, I would like to personally thank the people who have gone before me, and whose work made all this possible—namely, Ron Cain, J. E. Hendrix, L. E. Payne, and Steve Williams. They have all put staggering amounts of time into work that they have graciously shared with us, and they have permitted us to share it with you. BYTE Small-C will be released into the public domain in source-code form (see page 3 for details). Use it, modify it, learn from it, and all we ask is that if you create something with it, give conspicuous credit to those whose efforts brought it to you.

REFERENCES

Richard Grehan is a BYTE senior technical editor at large.

benchmarks—as a way of measuring total system performance.

In most applications, we have selected more than one program to use. We picked programs that have a significant user base and fit nicely with our testing needs (e.g., having macro languages and the ability to execute batch files). Where possible, we picked programs that are available on both the Macintosh and the PC.

Avoid the natural temptation to see these tests as software benchmarks. For instance, in the word-processing area, we are not testing the performance of Word versus XyWrite on MS-DOS computers; the tests weren’t set up to make that kind of comparison at all. We use more than one program in each category as a way of better covering the application, and to gain extra assurance that our overall rankings are independent of the particular program we used to test the application performance. For instance, it might be that XyWrite and Word would produce a different ranking on a given set of computer systems. That’s important, because it tells you that there may be no clear winner in that application area.

Science/Engineering

Scientific and engineering applications place heaviest emphasis on graphics and numeric processing. We divide this area into CAD, statistics, and numeric analysis/plotting of functions. All our applications programs will use the 80x87 (68881 for the Mac) FPU if one is installed.

For the CAD test, we use a 208,172-byte .Dwg file called SOFTWEST.DWG that produces a multilayer printed circuit board layout. The file is from The Great Softwestern Company and was specifically designed to exercise CAD functions. We also use AutoCAD’s St. Paul’s Cathedral file, STPAULS.DWG; the drawing includes thousands of vectors and is a good test of raw graphics speed. Timed tests are:

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Small-C Support Functions

To aid in the crafting of the low-level benchmarks, we created quite a number of support functions to interface with our Small-C programs. This is particularly true of the floating-point coprocessor benchmark. So that you'll find the source and pseudocode in this article more readable, here is a brief catalog of the more important functions and what they do.

Floating-Point Functions
Small-C has no floating-point type, so the library functions operate on blocks of 8 bytes (you can use a four-element integer array). This means that numbers are manipulated in the IEEE long-real-number format (i.e., 1 bit for the sign, 11 bits for the exponent, and 52 bits for the mantissa). Nearly all these floating-point functions operate on their arguments via pointers.

- finit() - Initialize the floating-point coprocessor.
- int2float(ptr) - Converts the 2's complement integer (stored as a quadword) pointed to by ptr into floating-point format.
- int2float2int(ptr) - Converts the floating-point number at ptr to a 2's complement integer (quadword).
- fadd(facl, fac2, dest) - Adds the floating-point number at fac1 to the floating-point number at fac2 and places the result at dest.
- fsub(facl, fac2, dest) - Subtracts the floating-point number at fac2 from the floating-point number at fac1, placing the result at dest.
- fmul(facl, fac2, dest) - Multiplies the floating-point number at fac1 by the floating-point number at fac2, placing the result at dest.
- fdiv(facl, fac2, dest) - Divides the floating-point number at fac1 by the floating-point number at fac2, placing the result at dest.
- fload(ptr) - Loads the floating-point number onto the top of the coprocessor's internal stack.
- fstore(ptr) - Stores the top number on the coprocessor's internal stack at ptr.
- fadd(ptr, fsub(ptr), fmul(ptr), fdiv(ptr) - These functions operate like their f2xx counterparts mentioned above, except that fac1 is the top number on the coprocessor's stack, fac2 is given by ptr, and the result is left on the coprocessor's stack.
- fsubs() - The top number on the coprocessor's stack is set to its absolute value.
- fcons(n) - Loads the top of coprocessor stack with the constant given by n. For n = 0, 1, 2, the constants loaded are 0, 1, and x, respectively.
- foomp(ptr) - The floating-point number at ptr is compared with 0. This function returns 1 if ptr < 0, 0 if ptr = 0, and -1 if greater.
- fremap(ptr, ptr2) - This function returns -1 if ptr < ptr2, 0 if ptr = ptr2, and +1 if ptr > ptr2.
- fcomp(ptr1, ptr2) - This function returns a -1 if less, 0 if equal, and +1 if greater.
- fcompz(ptr) - The floating-point number at ptr is compared with 0. This function returns 1 if ptr < 0, 0 if ptr = 0, and -1 if greater.
- flprinter(n, ptr) - Prints the floating-point number at ptr in scientific notation (i.e., +/-xxxx.xxxE+/+-y).
- fex(ptr, dest) - Calculates the sine of the floating-point number at ptr and returns the result in dest.
- fcompz(ptr) - Calculates the cosine of the floating-point number at ptr and returns the result in dest.

Timing Functions
- gtime(tblock) - This function returns the current system time in the four-element integer array tblock[], so that tblock[0] holds hours, tblock[1] holds minutes, tblock[2] holds seconds, and tblock[3] holds hundredths of a second for MS-DOS machines, or sixtieths of a second for Macs.
- calctime(tblock) - This function calculates the difference between the current time and the time held in the tblock[]. The resulting elapsed time is returned in the tblock[] array and has the same format as described in the gtime() function.
dling-dependent, since it requires generation of a 10,000-plus list of hidden lines.

For statistical work, we use STATA 1.5 (MS-DOS) and Data Desk Professional (Macintosh). In the MS-DOS case, we execute two do-files; one (SE6) performs a series of ANOVA operations, and the other constructs and displays 27 data graphics. In the Macintosh case, we do a regression analysis and a correlation analysis on a set of 10 1000-observation variables.

As an additional check on computation speed, we ran a couple of models written for the MS-DOS-based MathCAD program. One model (reported as SE7) performs an iterative floating-point operation to generate 800 x,y points in a list, and then plots the points; another computes the fast Fourier transform (FFT) and inverse FFT on a 1024-point data set. The time to execute the entire FFT is reported as SE8.

Database Management
We use dBASE III Plus (MS-DOS) and dBASE McMax (Macintosh) as typical DBMS tools. Both packages run a do-file that performs eight timed tests using a 1200-record, 490K-byte mailing list.

DB1. Copy 1200 records to another file.
DB2. Create an index file on a randomly sorted field.
DB3. Using the indexed file, list last name, first name, country to the screen.
DB4. Using the indexed file, append 832 records to the database.
DB5. Using the indexed file, seek and delete the appended records.
DB6. Pack the (unindexed) database.
DB7. Count records with a specified country field.
DB8. Sort the database to another file, two sort keys.

Word Processing
The word-processing tests use XyQuest’s XyWrite III Plus, Microsoft Word 4.0, and Aldus PageMaker 1.0a for MS-DOS computers; and MacWrite 5.0, Microsoft Word 3.01, and Aldus PageMaker 2.0a for Macintosh computers. Two ASCII documents are used: small.txt (6072 words) and large.txt (24,108 words). For the PageMaker test, we fill in Aldus’s blank Business Templates with our own text and graphics files to create a 35-page handbook document.

Using a XyWrite macro program, we time each of the following operations for small.txt and large.txt:

WP1. Load document (large.txt only).
WP2. Count words.
WP3. Global search and replace, then
WP4. Global find and replace.
WP5. Insert.
WP6. Copy.
WP7. Cut.
WP10. Italic.
WP12. Underline.
WP13. Center.
WP14. Right align.
WP15. Left align.
WP17. Counter.
WP18. Page number.
WP21. Times Roman.
WP22. Times Roman bold.
WP23. Times Roman italic.
WP24. Times Roman bold italic.
WP25. Times Roman 18 point.
WP26. Times Roman 18 point bold.
WP27. Times Roman 18 point italic.
WP28. Times Roman 18 point bold italic.
WP29. Times Roman 18 point gray.
WP30. Times Roman 18 point normal.
WP31. Times Roman 18 point Times Roman.
WP32. Times Roman 18 point Times Roman bold.
WP33. Times Roman 18 point Times Roman italic.
WP34. Times Roman 18 point Times Roman bold italic.
WP35. Times Roman 18 point Times Roman gray.
WP36. Times Roman 18 point Times Roman normal.
WP37. Times Roman 18 point Times Roman Times Roman.
WP38. Times Roman 18 point Times Roman Times Roman bold.
WP39. Times Roman 18 point Times Roman Times Roman italic.
WP40. Times Roman 18 point Times Roman Times Roman bold italic.
WP41. Times Roman 18 point Times Roman Times Roman gray.
WP42. Times Roman 18 point Times Roman Times Roman normal.
WP43. Times Roman 18 point Times Roman Times Roman Times Roman.
WP44. Times Roman 18 point Times Roman Times Roman Times Roman bold.
WP45. Times Roman 18 point Times Roman Times Roman Times Roman italic.
WP46. Times Roman 18 point Times Roman Times Roman Times Roman bold italic.
WP47. Times Roman 18 point Times Roman Times Roman Times Roman gray.
WP48. Times Roman 18 point Times Roman Times Roman Times Roman normal.
WP49. Times Roman 18 point Times Roman Times Roman Times Roman Times Roman.
WP50. Times Roman 18 point Times Roman Times Roman Times Roman Times Roman bold.
WP51. Times Roman 18 point Times Roman Times Roman Times Roman Times Roman italic.
WP52. Times Roman 18 point Times Roman Times Roman Times Roman Times Roman bold italic.
WP53. Times Roman 18 point Times Roman Times Roman Times Roman Times Roman gray.
WP54. Times Roman 18 point Times Roman Times Roman Times Roman Times Roman normal.
NEW BYTE BENCHMARKS

/* Go home */
finit();

printf("Press RETURN to exit:");

fgetc(stdin);

exit(0);

/*
* fourbang()
** Executes a loop of floating-point additions, subtractions,
** multiplications, and divisions.
*/

fourbang()
{
    int ten[4]; /* Holder for 10 */
    int one[4]; /* Holder for one */
    int temp[4]; /* Temporary storage */
    int i;

    /* Announce yourself */
    printf("Basic Math Test (+,-,*,/)\n");

    /* First set up constants */
    ten[0]=10;
    fint2float(ten);
    fconst(1);
    fstore(one);

    /* Initialize temp location */
    fload(ten);
    fstore(temp);

    gtime(tblock);

    /* Do the operation */
    for(i=0;i<FCOUNT;++i)
    {
        f2add(temp,one,temp);
        f2sub(temp,one,temp);
        f2mult(temp,ten,temp);
        f2div(temp,ten,temp);
    }
}

calctime(tblock);

A new concept in managing
Megabytes
of memory

IX-Box*

Have you ever spent hours

- searching for a letter which you know exists,
  but can't seem to find?
- looking for an address which you can only remem-
  ber half of?
- tracking down a variable which was initialized
  somewhere in your programs, and which is now caus-
  ing them to crash?
- rummaging through your ultra-modern database,
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  key field when setting it up?
- searching your literature index for an urgently
  needed article?

- looking and looking, but without suc-
  cess?

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/* Now calculate an empty loop */
gtime (mtblock);
for(I=0;i<FCOUNT;++i) {
calctime (mtblock);
}

/* Report results */
printf("***Results: (All times are HH:MM:SS:1/100ths"
);
printf("Total time: %d:%d:%d:
",mtblock[0],mtblock[1],
tblock[2],tblock[3]);
printf("Empty loop time: %d:%d:%d:"
,mtblock[0],mtblock[1],
tblock[2],tblock[3]);
printf("Value:"
);
printf(10,temp);
printf("\n\n":
);
return;
/*
 *** finteg()
 ** Do integration.
 **
*/
finteg()
{
    int two[4];    /* Holder for two */
    int pitwo[4];  /* Holder for pi/2 */
    int temp[4];   /* Temp location */
    int sinex[4];  /* Sine value */
    int ex[4];     /* e^x value */
    int accum[4];  /* Accumulator */
    int x[4];      /* Holder for x */
    int i;

    /* Announce yourself */
    printf("Trapezoidal rule for sin(x) 0->x->pi/2 
");
    /* Generate 2 */
    two[0]=2;
fint2float(two);
    /* Generate pi/2 */
    fgetpi2();   /* Get pi over two */
fstore(pitwo); /* Store pi over two */
    /* Generate stepsize */
    temp[0]=ICOUNT;
fint2float(temp);
f2div(pitwo,temp,temp); /* Stepsize in temp */
    /* Clear accumulator */
fconst (0);
fstore(accum);
    /* Store x(0) */
fconst (0);
fstore(x);
    /* Do trapezoidal rule for sine(x) */
gtime (tblock);
    for(l=0;i<ICOUNT+1;++i) { continue
fain(x,sinex);            /* Get sinex */
f2add(accum,sinex,accum);
if((i!=0)&&(i!=ICOUNT))
f2add(accum,sinex,accum);
} 
f2add(x,temp,x);       /* Increment by step */

f2mult(accum,temp,accum);  /* Times stepsize */
f2div(accum,two,accum);    /* Divided by 2 */

/* Calculate time */
calctim(tblock);
/* Get time for an empty loop */
gtime(mtbloc);      
for(i=0;i<ICOUNT+1;++i)
calctim(mtbloc);
/* Report results */
printf("***** Results: (All times are HH:MM:SS:1/100ths)\n");
printf("Total time: %d:%d:%d\n",tblock[0],tblock[1],
tblock[2],tblock[3]);
printf("Empty loop time: %d:%d:%d\n",mtblock[0],mtblock[1],
mtblock[2],mtblock[3]);
printf("Value:");
fltpnt(10,accum);
printf("\n\n");

/* Now do trapezoidal rule for e^x */
printf("Trapezoidal rule for e^x 0->\n");
/* Generate stepsize */
temp[0]=ICOUNT;
fltn2float(temp);
fconst(1);

div(temp);
fstore(temp);  /* Stepsize in temp */
/* Clear accumulator */
fconst(0);
fstore(accum);
/* Store x(0) */
fconst(0);
fstore(x);
/* Do trapezoidal rule */
gtime(mtbloc);  
for(i=0;i<ICOUNT+1;++i)
{
    fex(x,ex);
    /* Get sinex */
f2add(accum,ex,accum);
    if((i!=0)&&(i!=ICOUNT))
f2add(accum,ex,accum);
    } 
f2add(x,temp,x);       /* Increment by step */

f2mult(accum,temp,accum);  /* Times stepsize */
f2div(accum,two,accum);    /* Divided by 2 */

/* Calculate time */
calctim(mtbloc);
/* Get time for an empty loop */
gtime(mtbloc);      
for(i=0;i<ICOUNT+1;++i)
calctim(mtbloc);
/* Report results */
printf("**** Results: (All times are HH:MM:SS:1/100ths)\n");
printf("Total time: \d:\d:\d:\d\n", tblock[0], tblock[1],
tblock[2], tblock[3]);
printf("Empty loop time: \d:\d:\d:\d\n", mtblock[0], mtblock[1],
mtblock[2], mtblock[3]);
printf("Value:\n");
printf(10, accum); 
printf("\n");
/* Go home */
return;

*/
fgetpi2()
** Puts the value pi/2 on top of the floating-point stack.*/
fgetpi2()
{
int two(4); /* Holder for 2 */
two[0] =2;
float2float(two);
const(2); /* Get pi on top of stack */
ediv(two); /* pi/2 now on floating point stack top */
return;
}

search and replace the original text
(small. txt = (6072 - 4898) x 2 =
2348 instances, large.txt = (24,108 -
20,477) x 2 = 7262 instances).

WP4. Find the last page of the paginated
document.
WP5. Perform 12 block moves.

With Word, we time the following:

WP7. Move cursor down 640 lines.
WP8. Delete forward, 1552 characters.

MacWrite doesn't do word counts
(WP2), so we use a desk accessory,
MultiWord Counter. Microsoft Word
does tests WP3, WP7, and the store.

PageMaker provides us with an opportunity
to manipulate both text and graphics in a desktop publishing test. We take
a large document and then time these operations:

WP9. Load text document (20,586 words
of text).
WP10. Convert all text from normal to
bold.
WP11. Realign all text from the left to
right column guide.
WP12. Cut the first 10 text pages and re-
fill the document.

WP13. Place a large graphic.
WP14. Output the document to a Post-
Script printer file.

The tests are the same for MS-DOS
and Mac machines, except for the graphic
placed in WP12. For MS-DOS we use a
70K-byte AutoCAD PLT file, and for the
Mac we use an 80K-byte scanned encap-
sulated PostScript format image.

Spreadsheet
Our spreadsheet tests use Lotus 1-2-3 on
MS-DOS computers and Microsoft Excel
on both MS-DOS and the Macintosh;
these are leading packages for the respective
machines. We time the following
tests for Lotus 1-2-3:

SP1. Given a 75 by 2 spreadsheet (11) of
the form:

1
(a75*1.001)
(a1*1.001) (b1*1.001)
(a2*1.001) (b2*1.001)

... (a75*1.001) (b75*1.001)

perform an overlapping block copy as follows:
from (b1..bw75) to (a1..bx75),
resulting in an extension of the above ma-
trix to 75 by 75.
SP2. Recalculate.
SP3. Load a sparse-matrix spreadsheet

WP15. Load text document (24,420 words)

WP16. Output document to a Post-
Script printer file.

The tests are the same for MS-DOS
and Macintosh systems, except for the
graphic placed in WP12. For MS-DOS systems, we selected
Lightspeed C 2.11 and Turbo Pascal 1.0.

The C test is a compilation of XLisp
source files. The source consists of 25
files containing 225K bytes of code.
For Pascal, we compile the Pascal S source
code, which consists of four files con-
taining 44K bytes of code.

Compilers
Two compiler tests round out our appli-
cations benchmarks. For MS-DOS sys-
tems, we chose two widely used com-
pilers, Microsoft C 5.0 and Turbo Pascal
4.0. For Macintosh systems, we selected
Lightspeed C 2.11 and Turbo Pascal 1.0.

The Fundamental Things Apply
There you have them—the new BYTE
microcomputer benchmarks. As you've
seen, each is the result of a good deal of
consultation, introspection, and analysis.
The process is open-ended, too. Some of
these benchmarks are going to be modi-
fied as new equipment appears—but then
again, that's the beauty of what we've
done. We've now got benchmarks that
can remain consistent and valid in spite of
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Features

273  Ciarcia's Circuit Cellar: Computers on the Brain, Part I  
     by Steve Ciarcia

289  Error-Free Fractions  
     by Peter Wayner

303  A Personal Transputer  
     by Dick Fountain

313  Dynamic Memory Management in C  
     by David L. Fox
ARCHITECTURE If the micro world were not so varied, QNX would not be so successful. After all, it is the operating system which enhances or limits the potential capabilities of applications. QNX owes its success (over 55,000 systems sold since 1982) to the tremendous power and flexibility provided by its modular architecture. Based on message-passing, QNX is radically more innovative than UNIX or OS/2. Written by a small team of dedicated designers, it provides a fully integrated multi-user, multi-tasking, networked operating system in a lean 148K. By comparison, both OS/2 and UNIX, written by many hands, are huge and cumbersome. Both are examples of a monolithic operating system design fashionable over 20 years ago.

MULTI-USER OS/2 is multi-tasking but NOT multi-user. For OS/2, this inherent deficiency is a serious handicap for terminal and remote access. QNX is both multi-tasking AND multi-user, allowing up to 32 terminals and modems to connect to any computer.

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Computers on the Brain

Clever signal amplifiers, noise rejection, and A/D conversion are all part of the HAL EEG

A lot has been written recently about artificial intelligence (AI). Some writers declare that we are on the threshold of the most important advances in computing since Boole and Babbage began fooling around with two-valued logic and the difference engine. Others decry the hype and note that the majority of recent software releases are now touting some form of AI influence in their design or execution, weakening the meaning of the term in order to sell products.

Even after 100 years of study, not all psychologists are in complete agreement as to what constitutes intelligent behavior (look around you—how much have you seen lately?). Intelligence has generally been defined as the global ability to solve problems, to adapt to new situations, to form concepts, and to profit from experience.

However, it is obvious that there are many different types of behavior—many different ways of responding to the same problem—that can be called intelligent. Within the last 20 years, experts have paid much attention to the basic types of intelligence and how they are mediated by the biological substrate of the human brain.

Experts have long supposed that human beings use two major modes of thought: the way of reason and the way of emotion. A commonsense view is that these two ways of thought occasionally conflict. Some writers conceptualize the differences as analytic versus synthetic, successive versus simultaneous, or even digital versus analogical.

Paralleling the conceptualization of two modes of thought have been the results of research on the two hemispheres of the brain. Psychobiologist Roger Sperry of the California Institute of Technology won the 1981 Nobel Prize for Physiology and Medicine for his studies on the functions of the two hemispheres of the brain.

Essentially, Sperry and his colleagues studied individuals who had undergone a commissurotomy, an operation that severs the main bundle of nerve fibers that support the bulk of neural communication between the left and right hemispheres. They found that each hemisphere seems somewhat specialized for different tasks. For approximately 95 percent of the population (right-handed individuals and two-thirds of left-handed individuals), it appears that the left hemisphere of the brain is better organized for executing tasks characterized as:

- Verbal: language skills, speech, reading and writing, recalling names and dates, and spelling.
- Analytical: logical and rational evaluation of factual material.
- Literal: literal interpretation of words.
- Linear: sequential information processing.
- Mathematical: numeric and symbolic processing.
- Contralateral movement: controlling movement on the right side of the body.

The right hemisphere is better organized for tasks characterized as:

- Nonverbal: using imagery rather than words.
- Holistic: processing information simultaneously, in parallel.
- Visuospatial: functions involving perceptions of location and spatial relationships.
- Emotional: experiencing feelings.
- Dreaming: imaginative and metaphorical visual image-making.

Hemispheric Activation Level Detector

This month's Circuit Cellar project is a brain-wave-monitoring biofeedback device that provides real-time information about predominant hemisphere activation. That is, this Hemispheric Activation Level Detector (HAL, for short) graphically displays the relative amounts of brain-wave activity in each brain hemisphere (see photo 1).

HAL can distinguish among grossly different conscious states, such as between concentrated mental activity and pleasant daydreaming. For example, if you are debugging a program, HAL should show a predominance of left-hemispheric activity. If you are listening to some light music and daydreaming, it should show a predominance of right-hemispheric activity.

HAL is a relatively sophisticated, low-cost, stand-alone, fully isolated four-channel electroencephalogram (EEG) brainwave monitor. It gathers analog brain-wave voltages from four sets of scalp contacts, filters them, converts them to digital values, and transmits them via an RS-232C port (making HAL compatible with any computer) for recording or analysis.

HAL includes a two-channel fast Fourier transform (FFT) analysis-and-display routine for an IBM PC. (HAL's PC software is intended only as a graphics display demonstration—and there are limitations in processing power when using a straight 4.77-MHz PC—so it displays only two channels, even though HAL sends data on four channels.) If you have a more powerful machine, you should be able to expand the software to display more channels.

When running this special analysis-and-display package, the PC separates out various amplitudes and frequencies of alpha, beta, and theta waves, as well as phase differences between the hemispheres. The result is a graphical representation of what is going on in your brain in real time.

continued
Warning

HAL is presented as an engineering example of the design techniques used in acquiring brain-wave signals. It is not a medically approved device, no medical claims are made for it, and it should not be used for any medical diagnostic purposes. Furthermore, the safe use of HAL requires that the electrical power and communications isolation described in its design not be circumvented. HAL is designed to be battery-operated only. Do not substitute plug-in power supplies.

Analyzing HAL’s circuitry illustrates practical design techniques, including differential amplifiers for low-level signal detection in a high-background-noise-level environment, a low-frequency band-pass filtering-rectifying-integrating detector, optoisolation for safety, and A/D conversion.

I’m presenting HAL as a two-part project. This month, I’ll look at the problems involved in picking up microvolt-level signals, amplifying and digitizing them, and sending them to your computer.

Science and the Brain

As I investigated this area, I found that a great deal of serious research has been going on regarding what we know about how our brain works. Much of this thinking is finding its way into computer science; even the Macintosh and the IBM PC now have neural-network hardware and software available for the experimenter.

In his book Megabrain, Michael Hutchison quotes National Institute of Mental Health neurochemist Candace Pert (discoverer of the opiate receptor in the brain and researcher on endorphins—the brain’s own painkillers):

There’s a revolution going on. There used to be two systems of knowledge: hard science—chemistry, physics, biophysics—on one hand, and on the other, a system of knowledge that included ethology, psychology, and psychiatry. And now it’s as if a lightning bolt had connected the two. It’s all one system—neuroscience. . . . The present era in neuroscience is comparable to the time when Louis Pasteur first found out that germs cause disease.

Hutchison further quotes neuroanatomist Floyd Bloom of the Scripps Clinic in La Jolla, California:

A neuroscientist used to be like a man in a Goodyear blimp floating over a bowl game: He could hear the crowd roar, and that was about it. But now we are down in the stands. It’s not too long before we’ll be able to tell why one man gets a hot dog and one man gets a beer.

Much of the activity in this area has centered around the electrical characteristics of the brain. Advances in semiconductor technology have made available inexpensive ICS that let you design physiological monitoring equipment with laboratory quality at experimenter prices. When interest in alpha-wave biofeedback peaked about 15 years ago, a good-quality EEG feedback unit (which provided less information than HAL) cost $1000 for just one channel. Now, you can build four channels for under $200.

Digging into the Waves

The brain is a source of many electrical signals. An EEG is a recording (usually a strip chart) of the electrical potential differences between pairs of electrodes fastened to the scalp.

Silver-silver chloride electrodes pick up the signals. You must take some care to clean the area of the scalp with alcohol and perhaps use a mildly abrasive conducting cream to ensure good electrical contact. Ideally, there will be less than 10 kilohms impedance between any two electrodes, but anything under 25 kilohms works (I’ll describe placement of the electrodes next month).

It takes a trained eye to determine specific information about a person from an EEG. At present, we can only generalize as to what these recordings mean, and we are unable to correlate specific waveforms with intelligence. The observable electrical activity, however, does offer some clues.

According to medical and psychological research, by monitoring this activity, you could, in a gross way, investigate how the brain functions in a variety of circumstances. For example, if you monitor the two hemispheres while a person is solving problems, the type of problem could be indicated by the relative preponderance of one hemisphere’s activity as compared to the other’s. Sometimes you can even determine the activity (sleep versus reading; relaxed versus agitated).

The electrical signals we are currently able to monitor and identify from the brain are categorized as follows:

Alpha: Research has already indicated that in an awake person, the presence of alpha waves indicates a relaxed person with an absence of problem-oriented brain activity. (Alpha-wave activity describes electrical activity in the range of 8 to 12 Hz, a nearly sinusoidal signal at a voltage level of between 5 and 150 microvolts [µV]—typically 20 to 50 µV.)

Beta: When a person is thinking or attending to some stimulus, alpha-wave activity is replaced by beta-wave activity (14 to 25 Hz, activity of a lower amplitude).

Theta: Theta-wave activity (4 to 8 Hz, 20 µV and higher) usually appears during sleep, but it has been associated with deep reverie, mental imagery, creativity, dreaming, and enhanced learning ability.

Delta: Delta-wave activity (from 0.5 to 4 Hz) is seen in the deepest stages of sleep.

In addition, you must remember that I am describing an attempt to correlate cerebral electrical activity with subjectively observed events (types of cognitive tasks). While brain waves may be varying tens of times per second, our subjective experi-
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To eliminate unwanted noise, HAL incorporates a band-pass filter that rejects frequencies under 4 Hz and over 20 Hz. While this compromises delta-wave acquisition, it does filter out most of the undesired signals.

A Noisy Environment

It's possible for HAL to "hear" more than we want. HAL is sensitive enough to detect artificial signals: muscle activity from the forehead, eye and head movements, heart-rate activity, brain-wave "spikes" or irregular slow-wave activity, and—if you're not careful—60-cycle power-line hum. To eliminate this

ence varies more slowly. It may take a second or two to change concentration and to focus on a new task. Hence, you need to integrate the readings over a short period of time. Previous re-

search in this area suggests that ¼ second to ½ second is reasonable.

HAL's Circuitry

HAL's hardware circuitry is divided into two sections: preamplifier/filter and digitizer/control (see photo 2). The preamplifiers and filters acquire and boost the microvolt-level analog signals to useful levels. The digitizer section does the signal conditioning and A/D conversion and sends the data through an optocoupler to the host computer for analysis (see photo 3).

Several factors contributed to the evolution of the analog section of the circuitry. Initially, I planned to use narrow passband hardware filters to detect and measure only the alpha waves for each channel. Such an approach would discard a significant amount of information coming from the brain, essentially making the monitor capable of only simple "digital" discrimination—the presence or absence of alpha waves. This hardly seemed an achievement, since it merely duplicated the simple alpha biofeedback units available for the last 15 years.

Discussions with hardware and software experts eventually led to the conception of a more sophisticated system, one in which I considered the slowness of the EEG waveforms, the speed of the A/D conversion, and the analyzing power of an IBM PC. Ultimately, I decided that the HAL EEG monitor would function as a raw data accumulator and transmitter. The host computer would perform all signal analysis and display the results. (HAL's data output is RS-232C serial and can be analyzed and displayed on any computer. I chose to use an IBM PC here only for convenience.)

I expanded the bandwidth to allow the possibility of analyzing beta and theta waves. Even though these amplitudes are much lower than alpha waves, they are associated with some interesting phenomena.

To accomplish this task, I had to develop a special preamplifier/filter that would amplify only the specific EEG signals picked up from the scalp of the subject and amplify them to a level that is high enough for A/D conversion. Each HAL preamplifier/filter channel takes six operational amplifiers (op amps). Four of them provide amplification and impedance matching, and two others provide 60-Hz rejection filtering.

I designed the amplifiers and active filters in figure 1a around the TL-084 quad op amp and used as many common values as possible. The TL-084 provides junction-field-effect-transistor inputs with picoampere bias currents, low power consumption, and adequate input noise level. (If you are building this project, you should not substitute another type of op amp.) The bandwidth of the analog section is about 16 Hz (−3 dB at 20 Hz).

You can calculate the equivalent input noise by integrating the noise voltage as a function of frequency over the bandwidth. This 180-nanovolt equivalent noise, combined with the noise from the differential input stage multiplied by the system gain, yields a calculated output noise level of approximately 2.5 millivolts (mV).

Actual measurements of the noise output of the four-channel prototype were 3.5 mV root mean square, with a source imped-
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ance of 13-kohm impedance per input. I decided this was acceptable for the system with a 10-mV per bit A/D sensitivity.

I used three sections of IC1A to make a differential input instrumentation preamplifier. (Note that all six op amps associated with channel A are labeled IC1A and IC2A. Channel B’s op amps are labeled IC1B and IC2B, respectively, and so forth.) An ideal difference amplifier will amplify only the voltage difference between the two inputs. Voltages that appear on both inputs when referenced to the ground lead are called common mode voltages.

For example, if the voltage on one input is +50 µV and the other input is +15 µV, the difference signal would be 35 µV and the common mode signal would be 15 µV. HAL measures the difference signal between the two electrode positions. The difference amplifier measures this difference by applying one signal to the inverting input of the op amp and the other signal to the noninverting input.

The ability of the op amp to amplify only the difference is specified as the common mode rejection ratio. In HAL, I measured this experimentally by shorting the inputs, applying an input signal between the shorted inputs and ground, and comparing the output with that obtained by applying the same signal across the two inputs. The common mode output was 43 dB down below the differential output. (You would correctly suspect that the major component of common mode voltages in HAL will be induced by the 60-Hz power line. I’ll discuss how HAL rejects the 60-Hz signals later.)

I set the voltage gain of the preamplifier to 5800 and incorporated AC coupling between the stages to eliminate DC offset voltages and provide some low-frequency roll-off. Feedback capacitor C3 provides high-frequency roll-off, with the gain down 9 dB at 60 Hz. The third-order active filter stage has a -3-dB frequency of 22 Hz and is 30 dB down at 120 Hz. You’ll find the same third-order filter at the input of each final amplifier to the A/D converter (ADC), thus providing another 30 dB, for a total of 69 dB attenuation at 60 Hz.

The interstage coupling capacitors set the low-frequency passband of the amplifiers. The low-frequency roll-off is 24 dB
per octave, with the -3-dB point at 6 Hz. This is well above muscle activity and other noise.

A 2.5-volt reference diode sets the analog references to the ADC at 1.75 V and 3.25 V, or ±1.25 V of half the power supply. The last amplifier stage is DC offset to one half the power supply voltage, with the AC signals having a permissible peak value of 1.25 V. I set the overall gain of the amplifier stage to 12,500 so that a 100-µV signal would be the maximum input. This amounts to about 0.8 µV per bit sensitivity.

Since the ADC0808 is generally thought of as a DC converter and HAL measures AC signals, offsetting the reference to the ADC lets it measure signals that swing above and below some point designated as "zero" (offset binary converter). When you apply 0 V to the ADC, its output will be 80 hexadecimal.

A voltage gain of 12,500 corresponds to 82 dB (20 × log Av). The 60-Hz rejection of 69 dB results in a 60-Hz gain of 13 dB (82 dB − 69 dB). The common mode rejection of 43 dB reduces the 60-Hz gain to a loss of −30 dB (13 dB − 43 dB). This all means that a 60-Hz common mode signal at the inputs is reduced by a factor of 0.03 in getting to the ADC.

To show up as a ±1-bit ripple on the data, the common mode input signal would have to have an amplitude of 300 mV peak to peak. This 300 mV would be reduced by a factor of 0.03 to become 10 mV at the ADC. When I connected a 1-inch unshielded lead to HAL's input, it picked up about 100 mV peak to peak of noise. This seems adequate, but all the same, don't use HAL while standing directly beneath a neon sign transformer!

The Digitizer and Control Section
The signals from the four preamplifier/filter channels go to four of the eight analog inputs of the ADC0808. An 80C31 CPU performs channel selection and transmission to the host CPU. (While it is possible to duplicate the preamplifier/filter section to ultimately produce an eight-channel version of HAL, the current level of software for the 80C31 is designed for only four channels.)

Figure 1c shows the microcontroller part of the headset circuit.
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CIRCUIT CELLAR

The 80C31's port 1 connects to the ADC0808's data outputs, with all the control and status bits handled by port 3. Bits from port 1 also drive the serial output line and the two even need interrupts. It samples the two switches, reads the left and right hemisphere voltages from the ADC0808, and sends the results out serially. Each data sample consists of a 5-byte bus, no port bits are left for anything else.

The timing requirements are so simple that the code doesn't even need interrupts. It samples the two switches, reads the left and right hemisphere voltages from the ADC0808, and sends the results out serially. Each data sample consists of a 5-byte

---

Figure 1e: HAL's A/D converter, on-board CPU, and RS-232C port.
transmission. The data sequence is first byte, two switch position codes with 6 bits of leading zeros, followed by 4 bytes of sequentially sampled A/D channels.

HAL is battery-powered. Four alkaline C cells provide +6 V, and 4 AA cells provide -6 V for the op amps. The CMOS digital circuitry runs from the 6-V supply. Current drain with all CMOS components is 225 milliamperes (mA) at 6 V and 50 mA at -6 V. (OK, I know that most chips like 5 V, but CMOS digital chips will work fine in this application at 6 V.) An addi-

continued
the FFf software in the PC presumes that all the data points are on the link (the PC code needs 64 samples per second; we don't have to transmit at 4800 bits per second and there's lots of idle time sampled at the same instant in time. As a requirement, then, send it faster because the PC analysis program would choke).

The Control Program

Optocoupler by means of a BS-170 field effect transistor. A levels compatible with the serial input of the IBM PC host computer. The MAX232 is powered by the separate 9-V battery (10 mA) provides power for the serial communication. The two-push-button switch inputs (J6) allow operator signaling to the host computer. Serial data output drives the TIL111 optocoupler by means of a BS-170 field effect transistor. A MAX232 (IC6) converts the optocoupler's output to RS-232C levels compatible with the serial input of the IBM PC host computer. The MAX232 is powered by the separate 9-V battery to maintain isolation between HAL and the PC when the serial port is connected. (Do not try to use the 6-V C cells that power the main HAL circuit to power IC6.)

The Control Program

HAL's firmware control program (the main loop is shown in Listing 1), contained in a 2764 EPROM (IC9), is called BIO31. Nearly all BIO31's time is spent in line waiting for timer flag 0 (TFO) to become a logic 1. Whenever that happens, the code reloads timer 0 to produce the next 1/64-second delay and clears the flag again.

While the 5 bytes in each sample take only 6.25 milliseconds to transmit at 4800 bits per second and there's lots of idle time on the link (the PC code needs 64 samples per second; we don't send it faster because the PC analysis program would choke), the FFT software in the PC presumes that all the data points are sampled at the same instant in time. As a requirement, then, BIO31 runs the ADC as fast as possible between samples. I used in-line code to eliminate the overhead of subroutine calls and returns, although I'll be the first to admit that the few microseconds probably don't make any difference at all. Listing 2 shows what's needed to grab channels 0 and 1 from the ADC0808. Throughout the conversions, the accumulator holds a copy of port 3, so changing the ADC channel address is simply a matter of adding 1 to the proper accumulator bit and reloading port 3. The code sets the ADC ready bit to a 1 to make sure that the bit is always an input; writing a zero to that bit would turn it into an output.

Toggling the ADC's start bit using a pair of CLR/SETB instructions provides a 1-microsecond pulse on that output. One of the nice things about the 8031 is that you can tell exactly how long each instruction will take, so generating precise time intervals is quite simple.

The ADC0808 takes a few microseconds to drop the line that signals the end of conversion before starting the next one, so the code includes a loop to wait for that bit to go away before continuing. This is one of those cases where the computer can out-run the peripheral!

Next Month

I'll examine the software components of HAL, including an 8088 machine language discrete FFT callable from BASIC. I'll provide BASIC source code so you can design your own software and reconfigure HAL into a sophisticated brain-wave biofeedback monitor or a continuously recording EEG, or so you can add additional channels. ■

Special thanks for help provided on this article to Dr. Robert Stek, David Schulze, Rob Schenck, Jeff Bachiochi, and Ed Nisley.

BIBLIOGRAPHY


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 08520.


It's virtually impossible to provide all the pertinent details of a project or cover all the designs I'd like to in the pages of BYTE. For that reason, I have started a bimonthly publication called Circuit Cellar Ink, which presents additional information on projects published in BYTE, new projects, and supplemental applications-oriented materials. For a one-year subscription (6 issues), send $14.95 to Circuit Cellar Ink, P.O. Box 3378, Wallingford, CT 06494. Credit card orders can call (203) 875-2199.

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Computers can store rational numbers exactly with the use of factorial-base format

Most computer users know their machines can't represent all fractions exactly. Many programmers even know why. Something about finite memory and infinitely repeating decimals....

However, if you're willing to depart from conventional (exponential-base) representation formats, you can store fractions exactly. You can even do exact calculations without fear of dreaded roundoff errors. A Pascal listing presented in this article demonstrates the technique (see listing 1).

Unfortunately, rational-number math written in Pascal cannot keep up with highly optimized floating-point code: The computations done in the demonstration program aren't so fast as those done in floating point. But they are exact.

The mathematics involved aren't really new; nineteenth-century German mathematician Georg Cantor (see reference 1) presented the scheme and proved that it allows any rational number to be represented exactly in a finite series-no repeating decimals (see the text box "A Mathematical Proof" on page 290).

Before explaining why factorial base gives exact fractions and conventional exponential base does not, I'll show how similar they are.

A Question of Place Values

Both systems use place values to represent infinitely many different numbers with a finite set of digits. For instance, in base 10, the sequence of digits 104.32 corresponds to the series

$$1 \times 10^3 + 0 \times 10^2 + 4 \times 10^1 + 3 \times 10^0 + 2 \times 10^{-1}.$$ 

The place values are 10^3, 10^2, 10^1, 1/10^1, and 1/10^2.

Before proceeding, a word about notation. Every base-2 number in this article is identified by a subscripted 2, as in 10.1101_2. Every factorial-base number is identified by a subscripted F, as in 12.13_F. I'll often spell it out as {}_F.

The base-2 systems indigenous to silicon worlds are the same as base 10, except that they use 2 as the radix instead of 10 and have only two distinct symbols or digits, as in 10.11_2, which really means:

$$1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0,$$

with place values 2^3, 2^2, 2^1, 2^0, and 1/2^1.

Factorial bases are almost the same, except that the place values are factorials rather than exponential values: 301.102_F corresponds to the series

$$3 \times 3! + 0 \times 2! + 1 \times 1! + 1/2! + 0/3! + 2/4! = 19 \frac{3}{2}. $$

Recall that the notation 3! (3 factorial) means 3 \times 2 \times 1, and in general, n! means n \times (n-1) \times (n-2) \times \ldots \times 1. So the place values are 3!, 2!, 1!, 1/2!, 1/3!, and 1/4!. As a convenience, figure 1 gives the ten factorial place values around the decimal point.

One major difference between exponential base and factorial base concerns the use of digits: In factorial-base notation, the largest allowable digit depends on which place you're looking at: in \dot{a}_{n-1}a_{n-2}a_{n-3}\ldots a_1, you must have 0 \leq a_i \leq |i|.

For instance, in 321.123_F, each digit is at its maximum value for the position it's in.

Computing with Factorial-Base Numbers

Analogies between the factorial-base and base-10 computation make the new system especially attractive. Numbers that contain the maximum value in each digit, like 321_F (which is equal to 23 base 10) are 1 less than the value of a 1 in the next significant position (1000_F = 24), just as 9999 = 10,000 - 1. Fractions that contain the maximum value in each position are close to 1 in both cases (.123456_F and .999999).

The whole process of adding two factorial-base numbers is exactly the same as adding two base-10 numbers if you remember that the maximum value allowed in each position changes from one place to another, so that you know when to carry.

For instance, adding \frac{1}{64} (.001_F in factorial base) to \frac{1}{64} (.023_F) looks like this:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>carry</th>
</tr>
</thead>
<tbody>
<tr>
<td>.0</td>
<td>0</td>
<td>1_F</td>
</tr>
<tr>
<td>.0</td>
<td>2</td>
<td>3_F</td>
</tr>
<tr>
<td>.1</td>
<td>0</td>
<td>0_F</td>
</tr>
</tbody>
</table>

Addend

Addend

Sum

Note that two carries are needed because the maximum value is 3 in the right column and 2 in the center column. The process of carrying digits extends similarly to the integer portion.

The algorithms for the other functions are also analogous to ordinary arithmetic. Division is the most difficult operation, just as it is in regular arithmetic, requiring an estimation process to calculate the digits.

The Root of the Problem

The best introduction to factorial-base arithmetic comes from learning exactly where the base-10 and base-2 representations fail. Both handle all integers exactly, but only some rational fractions exactly. For instance, \frac{1}{2} is exactly .5 in base 10 and exactly .1_2 in base 2. But \frac{1}{3} is nonterminating and hence inexact.
ERROR-FREE FRACTIONS

A Mathematical Proof

The proof that any rational number has an exact factorial-base representation has two parts. First, that any integer \( p \) can be expressed as a sum of \( n \) products involving factorials:

\[
p = \sum_{i=1}^{n} a_i i!
\]

with \( a_i \leq i \). The exact, finite factorial representation is just the sequence of coefficients \( a_1, a_2, a_3, \ldots, a_n \).

Choose \( n \) such that \( n! < p < (n+1)! \) and set \( a_n \) to the integer part of \( p \) divided by \( n! \). Notice that this \( a_n \) cannot exceed the maximum value for this position, \( n \), because \( p \) is less than \( (n+1)! = (n+1)! \).

Repeat this process with \( p \) set equal to the remainder of the previous division, and it will return the value for \( a_{n-1} \). This continues until all the digits are computed. The process must terminate exactly (i.e., give a 0 remainder) at \( a_1 \), because the remainder stays less than \( i + 1 \) at each step, and, at \( a_1 \), the only nonnegative integers less than \( 1 + 1 = 2 \) are 0 and 1. Both of these leave no remainder after division by 1.

Furthermore, the representation \( a_1 \ldots a_n \) is unique because the largest value that can be represented with \( n+1 \) digits is strictly less than the multiplier of the \( n \)th digit (\( n! \)), so the \( i! \)s terms are linearly independent with respect to multipliers that lie between 0 and \( i + 1 \).

The second part of the proof establishes that every \( p/q \), \( p < q \), can be represented as a sum of \( n \) quotients involving factorials:

\[
\frac{p}{q} = \sum_{i=1}^{n} \frac{a_i}{(i+1)!}
\]

with \( a_i \leq i \). The exact, finite factorial representation is just the sequence of coefficients \( a_1, a_2, a_3, \ldots, a_n \).

The proof begins by pointing out that if \((i+1)\ p > q\) then \(p/q > (i+1)/(i+1)\). Compute \(a_i\), as the result of integer division of \((1 + 1)\ p\) by \(q\), which in this case is 1 if \(p/q\) is greater than \(1/2\) and 0 if it isn’t.

Set \( p\) equal to the remainder of this division and repeat this step to calculate \(a_{i-1}\) as the result of integer division \((2 + 1)/p\) by \(q\). The value \(a_{i-1}\) is between 0 and 2.

in finite space (0.333333... in base 10 and 0.10101011 in base 2).

The difference between exact and inexact fractions lies in the denominator’s relation to the base number. For instance, 2 divides both 10 and 2; hence, \(1/2\) is exact in bases 10 and 2. The number 3 divides neither 2 nor 10 and thus \(1/3\) has no exact representation in either base.

In general, the base-\(n\) representation of a fraction \(p/q\) terminates only when there exists an integer \( m \) such that \(p/q = m/n\) for some integer \( i \). For example, in base 10, the number \(1/3\) has an exact decimal representation because \(1/3 = 15/10^2 = 0.15\).

In this respect, base 10 has a slight advantage over base 2: It can represent all fractions of the form \(p/2^k\), while base 2 can handle only those in the form \(p/2^i\). Base 30 would be better still because \(30 = 2 \times 3 \times 5\), and it’s not difficult to realize that base 210 \((2 \times 3 \times 5 \times 7)\) could handle an even larger part of the rational numbers.

Continuing along these lines, the base would eventually grow so big that it would be difficult to use, and it would still leave out a portion of the rational numbers—the ones with factors that are relatively prime to every prime factor in the base.

Factorial-base numbers are an elegant alternative. They provide a base system that can handle any \(p/q\) without much extra effort. For example, \(1/3\) in factorial base is .02p, because \(1/3 = \frac{1}{3} + \frac{1}{3} \). The fraction \(1/3\) is \(\frac{10}{21}\), and 23 becomes \(321\). The text box above gives some of the math theory.

Putting Theory into Practice

The Pascal program in listing 1 provides a routine that converts a rational number in the form \(p/q\) to factorial base, as well as other routines that do addition, subtraction, multiplication, division, absolute value, and negation. The routines are based on the work of Patrick Staley at Southwestern University (see reference 2).

The numbers themselves are stored in an array. The integer continued
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Figure 1: The ten factorial place values around the decimal point.

Listing 1: A Pascal program demonstrating the use of factorial-based numbers for exact fractions.

PROGRAM fact;
CONST
maxarraysize = 12;
TYPE
number = ARRAY[1..maxarraysize] OF longint;
(constant array for the coefficients of a factorial-base number)
(number. Slot 1 contains a(2-1).
(Slot 1 is used to carry the integer)
(p of the number.)
VAR
i, j, m: integer;
a, b, c: number;
{Factorial-Base numbers for calculations.}
k: longint;
{A temporary register.}
BEGIN
{converts into a factorial-base number.}
VAR
x: real;
{A floating-point variable}
zero, one: number;
{Two global variables}
BEGIN
{with regular arithmetic.}
PROCEDURE convert (VAR result: number;
p, q: longint);
BEGIN
{Tests two numbers and returns)
FOR i := 2 TO maxarraysize DO
{true if x<>y}
BEGIN
p := p * 1;
result[i] := p DIV q;
p := p MOD q;
END;
END;{Convert}
FUNCTION lessequal (x, y: number): boolean;
{Tests 2 numbers and returns true if x<y}
BEGIN
i := 1;
WHILE (x[i] = y[i]) AND (i<maxarraysize) DO
BEGIN
i := i + 1;
lessequal := (x[i] < y[i]);
END;
FUNCTION notequal (x, y: number): boolean;
{Tests two numbers and returns true if x<>y}
BEGIN
i := 1;
WHILE (x[i] = y[i]) AND (i<maxarraysize) DO
BEGIN
i := i + 1;
notequal := (x[i] <> y[i]);
END;
end;

The algorithms themselves are not much different from the steps that everyone learns by rote in grade school. Addition and subtraction are carried out term by term, and a third routine called smooth handles carrying the overflow and borrowing from the previous term. Two short routines handle multiplication and division term by term, calling smooth to handle borrow and carry. Higher-level functions use these routines to perform multiplication and division of complete factorial-base numbers.

The procedures for addition and subtraction are very stable and will overflow only if the results grow larger than the size of the largest integer the machine can represent. The multiplication routine can overflow sooner; for instance, when a number is multiplied by a large integer, it is possible to overflow the individual term's array component. If the division routine is operating upon two numbers of similar size, the results will not overflow the machine, but if a larger number is divided by a number close to 0, an overflow error can occur. (The estimation algorithm could be improved to help avoid this problem.)

Some Experimental Results
I've used mathematical reasoning to show the benefits of factorial-base numbers, but how do these numbers work in practice in a computer? To find out, I executed the following code using factorial-base and standard floating-point (an extension of the exponential-base) number formats:

```pascal
x := 1/n;
for i := 1 to 30 do
x := (n+1)*x;
```

Mathematically, the function \( f(x) = \left(1 + \frac{1}{n}\right)x - 1 \) is invariant at the point \( x = 1/n \); that is, \( f(x) = x \) for \( x = 1/n \). On paper, then, you would expect the Pascal variable \( x \) to remain unchanged after 30 iterations of the loop. This was the case when I used factorial-base numbers. But the standard floating-point system failed badly and returned 286.331.161.6 instead of .33333 when \( n \) was set to 3.

From previous discussions, you might expect the floating-point software to find the correct answer at least for \( n = 10 \) because \( \frac{1}{10} = .1 \) exactly in base 10. This was quite far from the truth: \( x \) should have equaled .1 but turned into 2.36378547759 e21 after 30 loops. All the calculations are, of course, done in binary. The floating-point software finds the correct answer only when \( n = 2 \).

The only negative aspect of the factorial-base system is the slowness of the calculations. My Pascal program could not compete with the optimized floating-point code. The algorithms aren't that different from the regular arithmetic, but they must deal with the shifting base, which adds a lot of overhead. The factorial-base arithmetic could be recoded into assembly code for better speed. Even better, it could be converted into silicon by designing a special chip.

Until such a time, the code should be saved for problems where speed can be sacrificed for accuracy. These problems may range from mathematical analysis (as in the last example) to...
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FUNCTION smooth (VAR x: number): number;
(Takes a number and does all the carrying)
(and the borrowing.)
VAR
  i: integer; {A counter}
BEGIN
  FOR i := maxarraysize DOWNTO 2 DO
    BEGIN
      x[i - 1] := x[i - 1] + x[i] DIV i;
      IF (x[i] < 0) AND (x[i] MOD i <> 0) THEN
        x[i - 1] := x[i - 1] - 1;
        x[i] := x[i] MOD i
    END;
  smooth := x;
END;

FUNCTION add (x, y: number): number;
{Adds two factorial numbers}
VAR
  i: integer;
  temp: number;
BEGIN
  FOR i := 1 TO maxarraysize DO
    temp[i] := x[i] + y[i];
  add := smooth(temp);
END;

FUNCTION subtract (x, y: number): number;
{Subtracts two factorial numbers}
VAR
  i: integer;
  temp: number;
BEGIN
  FOR i := 1 TO maxarraysize DO
    temp[i] := x[i] - y[i];
  subtract := smooth(temp);
END;

FUNCTION absolute (x: number): number;
{Returns the absolute value of x.}
(This is trickier than flipping a bit
because the sign bit is attached to x[1].)
(So if x[1] < 0 then compute -x[1] subtract
the rest of the terms x[2..n])
VAR
  i: integer; {a counter}
  y: number; {Temporary, for subtraction.}
BEGIN
  IF x[1] < 0 THEN
    BEGIN
      y[1] := -x[1];
      FOR i := 2 TO maxarraysize DO
        y[i] := 0; {Zero rest of the array.}
      x[1] := 0;
      x := subtract(y, x);
    END;
  absolute := x;
END;

FUNCTION negative (x: number): number;
{Converts a positive x to negative form.}
VAR
  i: integer; {counter}
  temp: integer; {A temporary register if x<0}
BEGIN
  IF x[1] < 0 THEN
    BEGIN
      y[1] := -x[1];
      FOR i := 2 TO maxarraysize DO
        y[i] := 0; {Zero rest of the array.}
      x[1] := 0;
      x := subtract(y, x);
    END;
  absolute := x;
END;

FUNCTION multbyint (x: number; 
  int: longint): number;
{Multiplies x by an integer int.}
VAR
  i: integer;
  temp: number;
BEGIN
  FOR i := 1 TO maxarraysize DO
    temp[i] := x[i] * int;
  multbyint := smooth(temp);
END;

FUNCTION divbyint (x: number; 
  int: longint): number;
{Divides x by the integer int.}
VAR
  i: integer; {A counter}
  carry, part: longint; {Two registers to carry on digits.}
  temp: number; {Temporary result}
  negativeflag: boolean; {Set to true if a negative number.}
BEGIN
  negativeflag := (x[1] < 0);
  IF negativeflag THEN
    x := absolute(x);
  carry := 0;
  FOR i := 1 TO maxarraysize DO
    BEGIN
      part := x[i] + carry * i;
      carry := part MOD int;
      temp[i] := part DIV int;
    END;
  temp := smooth(temp);
  IF negativeflag THEN
    temp := negative(temp);
  divbyint := temp;
END;

FUNCTION multiply (x, y: number): number;
{Multiplies x and y in factorial base.}
VAR
  i: integer; {A counter.}
  partial, temp: number; {The partial sum of the multiplication}
  (and a register)
BEGIN
  partial := zero; {Zero the array.}
  FOR i := 1 TO maxarraysize DO
    BEGIN
      y := divbyint(y, i); {Shift y over one decimal place.}
      temp := multbyint(y, x[i]); {Now temp contains y*(x[i]/i!).}
      partial := add(partial, temp); {Add it in and continue.}
    END;
  multiply := partial;
END;

FUNCTION divide (x, y: number): number;
{Divides x by y in factorial-number representation. Begins by scaling the numbers to find an easy, accurate way of computing the first value. After that it proceeds to use long division.}
VAR
  i, j: integer;
  negativeflag: boolean; {A marker to preserve sign.}
  temp, partial: number; {A temporary number: partial result.}
  denom: integer;
BEGIN
  FOR i := 1 TO maxarraysize DO
    BEGIN
      y := divbyint(y, i); {Shift y over one decimal place.}
      temp := multbyint(y, x[i]); {Now temp contains y*(x[i]/i!).}
      partial := add(partial, temp); {Add it in and continue.}
    END;
  multiply := partial;
END;

continued
Select the points you want to remove from your regression model...

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(The p part of an approximation of)
(the denominator.)

denomfact: longint;

(A factorial counter.)

{q part of the denominator.)

(approx: p/q.)

pos; integer;

{Marks the position being calculated.)

estimate: longint;

(An estimate of this value.)

BEGIN

negativeflag := ((x[l]<0) AND (y[l]>0)) OR

((x[l]>0) AND

(y[l]<0));

(Take care of negative & positive numbers.)

x := absolute(x);

y :z absolute(y);

i := l;

denomfact := 1;

denom := y[l);

WHILE (denom<100) AND (i<7) DO

(Get approximately 3 significant figures)

BEGIN

i := i + 1;

denom := denom * i + y[l];

denomfact := denomfact * i;

END;

posit := 1;

partial := zero;

WHILE (notequal(x, zero)) AND

(posit<mmaxaraysize) DO

BEGIN

estimate := (x[l] * denomfact) DIV denom;

REPEAT

temp := multbyint(y, estimate);  
estimate := estimate - 1;

UNTIL lessequal(temp, x);

x := subtract(x, temp);

(Calculate the remainder)

partial[posit] := estimate + 1;

(Record the result.)

pos; := posit + 1;

(Move over one notch.)

x := multbyint(x, posit);

(Shift the numerator over one notch.)

END;

(Do loop until x=0 for best accuracy.)

partial := smooth(partial);

IF negativeflag THEN

divide := negative(partial);

END;

PROCEDURE print (x: number);

(prints out a number.)

VAR

i: integer;{a counter}

y: number;

{A temporary register if x<0.)

BEGIN

IF x[l]<0 THEN

(The numbers are stored in the form)

(sum x[l]!/ so convert to an)

(equivalent positive number by)

(subtracting the x[2..max] terms)

(from -x[l], the integer part of)

(the number.)

BEGIN

y[l] := -x[l];

FOR i := 2 TO mmaxaraysize DO

y[l] := 0;

(zero the rest of the array.)

x[l] := 0;

x := subtract(y, x);

write(' ');  

END;

write(x[l]: 3, '.');

FOR i := 2 TO mmaxaraysize DO

write(x[i]: 3);

write l n(' ');  

END;  

BEGIN {Main Program)

FOR i := 1 TO mmaxaraysize DO

zero[i] := 0;{Zero the array.)

one := zero;

one[l] := 1;

(Set 1 equal to zero plus one.)

float l := 1 / 3;

a := one;

a := divbyint(one, 3);{Set a equal to 1/3)

FOR i := 1 TO 30 DO

BEGIN

float := 4 * float - l;

a := multbyint(a, 4);

a := subtract(a, one);

END;

print(a);

writeln('Using floating point: ', float:

20);

END;  

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<table>
<thead>
<tr>
<th>1 user (DOS)</th>
<th>1 user (OS/2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost per system</strong>:</td>
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A Personal Transputer

The prototype Atari Abaq, with the Helios operating system, could put a Transputer on your desk

The Atari Abaq is the first of a new breed of computers built around the INMOS Transputer chip, a high-performance 32-bit processor with a unique communications-based architecture designed for parallel processing systems.

Since its launch in 1984, the most common application for the Transputer has been in the "personal supercomputer," an array of Transputers acting as a powerful calculating engine, with a conventional computer acting as a frontend and supplying disk and display services through a conventional operating system such as Unix or PC-DOS. For this type of work, and in embedded control applications, Transputer programs (usually written in the Occam language) run on the bare hardware, with no intervening operating system to provide standardized services.

Beyond the personal supercomputer arena, the lack of a standard operating system that runs on the Transputer itself has become an obstacle to its wider adoption. The Transputer has a totally new architecture and instruction set: on-chip static RAM in place of registers, a hardware stack for expression evaluation and a 4-gigabyte linear address space with no memory management. (See "The DSI Transputer Development System" by John Poplett and Rob Kurver in the February BYTE.) Because of these new features, industry-standard operating systems would need to be completely rewritten for the Transputer. More importantly though, no existing operating systems have the characteristics to make full use of the Transputer's power.

Existing multitasking/multiuser operating systems (e.g., Unix and its relatives) were originally developed on minicomputers and expect to see a single CPU that runs multiple tasks by time-slicing in a shared memory space. The Transputer was designed with an altogether different model of computing—one in which different processes run on different processors with separate memory spaces.

This model is more like a local-area network of machines, in which different tasks can be distributed to different workstations. Extensive efforts are being made to produce versions of Unix in which the kernel can be distributed over many processors, but no such version is in widespread use yet.

The job of providing a new sort of operating system for the Transputer is now approaching completion, spurred on by Atari's announcement of the Abaq at the Fall 1987 COMDEX. The new operating system is called Helios and is being written by Perihelion Software Ltd. of Cambridge, England. Perihelion Software is run by Tim King, late of Metacomco, developer of AmigaDOS for the Commodore Amiga. Helios is a general-purpose operating system for Transputer systems, and although Atari is an important customer for Helios, there are several others, including the graphics supercomputer firm, Meiko.

Transputer-Powered Graphics Workstation

"Abaq" is a Hebrew word meaning "from the sands" (suggesting silicon), and the root from which "abacus" is derived. The Atari Abaq was developed by Perihelion Ltd. (sister to Perihelion Software) and is due to be launched in September. [Editor's note: Because a Belgian firm has prior rights to the name Abaq, it is likely that Atari will have to find a new name before the September release.] It is a Transputer-powered graphics workstation that, at least in its first iteration, uses an Atari Mega ST as an I/O processor. At the time of this writing, it exists only as a board-level prototype. The basic machine will be powered by a single T800-20 floating-point Transputer, but more Transputers can be added in groups of four by inserting cards into expansion slots (three on the prototypes, but probably four in the final design).

At present, two versions of the Abaq are being planned. One is an add-on for an existing Atari Mega ST; the other is a stand-alone computer containing an ST motherboard. Both share the same technical specifications.

Because Atari doesn't provide the necessary expansion slots, the add-on unit will require the ST to be dismantled to gain access to the expansion bus on its motherboard, resulting in twin boxes and twin power supplies. The stand-alone machine will be housed in a single box with a footprint similar to the Mega ST's.
but deeper. An ST motherboard installs underneath a similarly sized board containing the 20-MHz Transputer and its 4 megabytes of dynamic RAM; the Abaq video circuitry and blitter with 1 megabyte of dual-ported video RAM; a SCSI port for the 40-megabyte hard disk drive, and the expansion slots.

The Abaq offers fast, high-resolution graphics assisted by a custom blitter chip, code-named Charity. Charity is an entirely new design; it is not the Atari device used in previous Mega STs. It is being implemented using an 8500-gate, 2-micron, CMOS (complementary metal-oxide semiconductor) uncommitted logic array. Fifty working samples of the first revision have so far been made for development work. Charity performs block moves on two-dimensional rasters of color pixels. It employs 32-bit-wide data paths and shares the bus with the Transputer CPU; it can copy rasters to and from the full address range, not just within video RAM.

The chip normally reads and writes one address location at a time and can simultaneously handle 4 or 8 pixels, depending on the video mode. The blitter allows all the normal Boolean masking operations between source and destination for overlaying and transparency effects. It also permits tests on pixel values within a given range so that the programmer can distinguish absolute colors on the screen despite the possibly discontinuous mappings of the lookup table. Charity should perform general color blits at around 10 million pixels per second.

Charity also has a special pixel block move (PBM) that can be used only when the destination raster lies entirely in video RAM. PBM permits 32 pixels to be written in one or two cycles—a process that gives an area-fill or line-drawing capability of from 64 to 128 million pixels per second (equivalent to about 100 full screens per second). PBM also puts single-color font data onto the screen extremely rapidly, enabling quick screen updating for desktop publishing applications.

The Abaq’s video system has four display modes. Mode 0 furnishes a 1280-by-960-pixel display with 4 bits per pixel; mode 1, a 1024-by-768-pixel display with 8 bits per pixel; mode 2, a 640-by-480-pixel display with 8 bits per pixel, double buffered (i.e., two separate screens for animation effects); and mode 3, 512 by 480 pixels with 32 bits per pixel.

A 24-bit hardware color lookup table maps 8-bit inputs into 24-bit outputs. Full 8-bit digital-to-analog converters (DACs) are employed to provide the analog video signals to drive the color monitor’s RGB guns.

In modes 1 and 2, you can choose the 256 displayed colors from a palette of 16 million. In mode 3, the color lookup table is bypassed and 8 video bits are sent directly to each DAC, giving a fixed palette of 16 million colors—the remaining 8 bits are used as overlay and tag bits. Overlay bits are decoded in hardware and can be used to support a number of hardware-encoded cursors, while the tag bits can be used by suitably written applications programs to mark separate screen areas for efficient object-oriented graphics and sprite effects.

Abar will be offering only one high-resolution monochrome monitor with a 146-MHz vertical scan rate for mode 0 operation in 16 shades of gray—features aimed at desktop publishing and CAD/CAM users. For other modes, off-the-shelf monitors such as the NEC MultiSync Plus or XL will suffice. Still under review is the question of color operation in mode 0—but the quality of monitor required would be very expensive.

So far, Abaq’s developers have designed two kinds of Abaq expansion cards. The Transputer farm board contains four T800 Transputers with 1 megabyte of dynamic RAM each, while the memory expansion board contains 20 megabytes of DRAM. A four-slot Abaq could contain 17 Transputers or 84 megabytes of RAM, or combinations in between—for example, 13 Transputers and 24 megabytes of memory (three Transputer boards plus one memory board). No industry-standard bus has been adopted for these cards that can simply receive the Transputer memory bus signals. The Transputer links are not brought to the edge connector, but you can join them independently with point-to-point wiring to set up different configurations.

In the prototype machines I saw, the Abaq/ST interface was rudimentary, but in the finished machine, you will be able to use GEM (the Digital Research Inc. standardized operating system software supplied with the Atari ST) on the Abaq screen, and access the Abaq hard disk and other SCSI peripherals from the Atari ST.

The Helios Operating System

The Abaq is a powerful enough graphics workstation, but it is the Helios operating system that will make this workstation extraordinary. The goal of Helios is to allow Abaos to be networked together in such a way that all the processors in all the machines are potentially available to all users.

Because typical workstation users are happy with Unix, Helios is deliberately being designed to look as much like Unix as possible. The Helios shell looks exactly like the Unix C Shell and supports all the normal Unix commands. Internally, however, it works very differently from Unix in several respects:Helios has a distributed kernel versus Unix’s centralized kernel; it does not need to spawn new processes in software because the hardware handles this procedure; and it names every system object, whereas Unix names only files and directories.

However, Perihelion has emulated Unix version 7 calls to the point where much of the software—especially the development tools—can be ported by little more than a recompilation. I have seen the MicroEMACS editor, running on an Abaq, ported using public domain C source code.

Thus, Perihelion is writing much of Helios in C rather than Occam; the rest is in Transputer assembly language. The in-house-produced C compiler is based on the excellent Norcort portable compiler.

The Nucleus of Helios

Helios is a fully distributed operating system that works by message-passing. At a minimum, every Transputer in a Helios network must run a system program called the “nucleus,” which consists of about 30K bytes of code. With its various workspaces, the nucleus needs about 100K bytes. The program is subdivided into four modules: the kernel, the processor manager, the loader, and the system library.

The kernel is responsible for managing all the Transputer’s hardware resources; it implements the message-passing mechanism and allocates RAM to tasks from both the Transputer’s on-chip RAM and the external DRAM. The kernel also provides a service called the name server (described in more detail later), which contains list-processing and semaphore services.

The processor manager creates new tasks, controls them while they run, and then terminates them and releases their resources. In Helios, a task is not the same as a Transputer process. It is built out of one or more concurrent Transputer processes and will contain other resources like open files, static data areas, and dynamic storage such as a stack and a heap.

Helios doesn’t need to support processes as such, because on the Transputer they are provided and scheduled by the hardware. Spawning a new process requires just a couple of Transputer instructions. Thus, Helios needs no equivalent of the Unix fork procedure.

The loader is responsible for loading objects into the processor and unloading them when they are no longer needed. It translates program images and puts them into memory, loads resident modules for code sharing, and handles data objects such as fonts and other bit-mapped images.

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The system library is a resident code module that supports the equivalent of the system calls in an ordinary operating system. All applications programs must talk to the machine through this library. Many tasks can share resident Helios modules, resulting in great code economy. The Helios 1s command, for example, occupies 663 bytes compared to 11K bytes under Unix.

The system library also keeps track of the resources allocated to running tasks; a table of pointers to the task’s resources is the first parameter passed in any Helios system call. A second library provides Unix-compatible system calls, thus localizing and isolating any Unix compatibility problems.

**Server Tasks Are Transparent**

The network hardware is uncomplicated and is based on buffered Transputer serial links that operate at up to 20 megabits per second. In the worst case, you will always have at least one Transputer in your own workstation. But when other users log off, you will be able to use the Transputers in the other workstations to accelerate your own software. Or there might be a large box of Transputers on the network, such as a Melko Computing Surface, shared by all users—just as laser printers are currently shared by network users. First there were file and print servers. Now, Helios introduces us to the notion of a “compute server.”

Helios tasks may communicate only through message-passing. By contrast, the individual processes within a task can communicate by any means a programmer may wish to devise. The overall Helios design is based on a client/server model with some similarities to that of AmigaDOS—no surprise, given that both designs are descended from the Cambridge Distributed Operating System. Applications tasks request services from system server tasks by sending them messages.

In Helios, server tasks can be running anywhere on the network and are totally transparent to the user and to applications programs. This transparency is achieved by the ability of the kernel’s name-server task, which can search the network to locate other servers. Like files in an ordinary operating system, servers in Helios are called objects. When you type the ls command, you will see servers listed as well as files.

Running ls again on one of these server names will list its contents. If it is a disk server, you will get a directory of files. For another kind of server, you might get a list of running tasks. If you have the necessary access permissions, you could type ls followed by the path name of a disk belonging to another workstation in the network and it would be duly listed. From then on, the name of that disk drive would appear in the directory list for your own workstation, because the name server now knows its location.

Helios servers are written to be “stateless” ; that is, the success of a request for a service never depends on the success of a previous request. Achieving statelessness involves some repetition of information; for example, every file read or write request must supply the name of the file and its position pointer. But the trade-off is that the system is inherently fault-tolerant; any request can be repeated until it succeeds.

**The Message-Passing Mechanism**

Helios’ message-passing mechanism must be able to pass messages between tasks on different processors, as well as between tasks on the same processor. Helios handles this operation by sending messages to message “ports.” These ports are software data structures that relate to the Transputer’s hardware links in much the same way that tasks relate to processes. A message port located on a remote processor is represented in the sender processor by a surrogate port to which the message is sent.

This surrogate port contains a physical link address and passes the message to a port on a next-door-neighbor processor, which may itself be a surrogate port. The message is thus passed hand to hand until it is eventually received by a real message port. The message leaves a trail of port descriptors in each processor through which it passes, pointing back to its source. By default, the surrogate ports along the trail will be deleted to avoid wasting memory, but you can set a flag in the message header to preserve the ports and hence keep the route open for use by further messages.

If for some reason (e.g., a hardware or software failure) a message cannot be delivered to its destination, an exception is raised and returned to the sender for another try. If the exception itself fails to arrive, a timeout will occur on one of the ports. There are no routine acknowledgments of messages; they are assumed to have arrived safely if no exception is returned. Theoretically, it would be safer to have the receiver acknowledge every message, but such a process would double the time it takes to send a message. This trade-off can be justified by the high reliability of Transputer links compared to a conventional LAN.

You can build further error recovery into applications programs at a higher level. For example, the program could lock out dead links or processors (as it would bad disk sectors) and reroute messages through the good parts of the system.

While the Helios messaging system is simple and speedy, the link speed of 20 megabits per second is not fast compared to the speed with which a 10-MIPS Transputer accesses memory. Thus, message-sending is still a relatively slow operation.

Tasks that need to have a predictable real-time response must either poll the reply port using a short timeout—so they are not suspended waiting for the reply—or else spawn a child process to watch the port for them.

**Distributing Programs**

Since there is no hardware memory protection available, Helios provides a software protection scheme based on capabilities. A capability is a 64-bit data structure that contains a checksum encrypted with an access mask.

This scheme operates all the way from the level of protecting data objects from the unwanted attentions of rogue tasks, to restricting human access to files. Whenever a task creates a new object, the system gives the object a unique encryption key with which it encrypts its creator’s access mask and then returns the capability. A task can only access that object if it owns a valid capability containing the necessary access permission.

All client requests to servers must be accompanied by a valid capability—this process is rather like presenting a credit card. Helios allows only whole programs, rather than their component processes, to be assigned to separate processors. In this respect, Helios represents a regression from the highly parallel approach taken by Occam.

A native Occam program running on the bare hardware can have many component processes executed concurrently on different Transputers, enabling the implementation of highly parallel algorithms such as pipelines. The Helios approach, however, still allows three lesser levels of parallelism.

The first level is Unix-like; pipes connect small single-function programs such as file filters, or editors and compilers. A Helios routine called the task-force manager assigns each such program to a separate processor, if enough are available, and implements the pipes using real Transputer links. The processors can either come from the user’s own cluster of private workstation processors, or be allocated from a shared pool just for the duration of the execution.

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Clearly, the Abaq is not yet the Transputer machine for the rest of us. But such a price would be relatively inexpensive for a workstation network that should provide at least as much power as the newest offerings from Sun and Apollo. And Helios could become the basis for even less expensive machines that will finally truly bring the Transputer into the personal computer arena.

Dick Fountain is a BYTE contributing editor, a technical author, and a software consultant living in London, England.
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Dynamic Memory Management in C

Here's how to use C's built-in memory functions to produce better programs, plus some debugging code to make using them easier.

Memory management is the process by which programs keep track of where the data they need is stored in the computer's memory. When the correspondence between data and physical memory locations changes during the execution of a program, its memory management is said to be dynamic.

Some pitfalls are waiting for you when you use C's memory management tools, but there are techniques for avoiding them.

C Memory Management and Memory Functions

Much of the memory management done by C is transparent to the programmer. For example, the declaration `int i;` reserves one word of memory to store the value of the variable `i`. If this declaration occurs outside a function, then other functions can access `i`; in this case, `i` is an external, or global, variable. If the declaration occurs inside a function, the word used to store `i` is allocated on the stack. Here, the allocated memory is available inside the function, but discarded when the function returns, making it available for use by another function. This sophisticated memory management scheme requires no effort on your part: You simply declare a variable, and it is available wherever the declaration is in effect. In addition to the built-in memory management through global and local declarations, the standard C library contains several functions that give the programmer access to the heap. These functions are listed in table 1.

The malloc() function returns a pointer to a region of at least size contiguous bytes of memory that can be used in any way you see fit. Free() returns a block of memory to the heap that was obtained by malloc(). Malloc() and free() are the same as new() and dispose() in Pascal. Realloc() changes the size of a block of memory reserved by malloc(). The memory block requested can be larger or smaller in size. It is important to note that realloc() may modify the pointer to the memory block. If this happens, the contents of the original block (up to the smaller of either the old or the new block size) are copied to the new location. Finally, calloc() provides an alternative to malloc() when requesting a block. It differs from malloc() in two ways: It uses two arguments to specify the block size, and it zeros the contents of the allocated memory block.

Advantages of the Memory Functions

Why would anyone use these functions when C has built-in memory management for variables? One answer is that a C compiler can allocate only fixed amounts of memory for a program when it is compiled. For example, suppose you have written a program for sorting a list of numbers. Before the numbers are sorted, they are read into an array in memory that's declared as `double numbers[1000];`.

This array works fine until you need to sort a list of 1001 numbers. To fix the problem, you can change the declaration to `double numbers[5000];` and recompile the program. This solves the immediate problem of sorting the larger list, but it introduces a new problem: The rest of the memory reserved for the array goes to waste. Worse, the program won't load unless it has enough memory to allocate the entire array, whether or not all of the array is used. If the array is large enough, the program won't run at all on many microcomputers. Only those with lots of memory will work. You can avoid both problems by using malloc() or calloc() to dynamically allocate memory for the array, making it as large as possible on a given machine at run time. This would fail only when the data set is too large for the machine—a limitation that everyone must live with.

Unnecessary limits caused by fixed array sizes are all too common. For example, in MS-DOS, try setting the Path environment variable to a string of more than 127 characters. As in the previous example, using fixed-size arrays to store the command lines is wasteful, since you must make the array size large enough to hold the longest possible line. Listing 1 shows a routine called getline() that reads a line of any length. This routine avoids the wastefulness of fixed-size blocks by adjusting the...
#include <stdlib.h>

## Purpose:
ANSI standard header containing declarations of memory management functions.

```c
void *malloc(size_t size);
```

### Purpose:
Dynamically allocates memory. The size of the memory requested, in bytes, is passed to malloc(). A pointer to the block is returned if the operation is successful; otherwise, NULL is returned.

```c
void free(pointer);
```

### Purpose:
Releases memory blocks allocated by calloc(), realloc(), or malloc(). The pointer to the block is passed to free().

```c
void *calloc(nitem, itemsize);
```

### Purpose:
Dynamically allocates memory. The size of the memory requested, in bytes, is passed to malloc(). A pointer to the block is returned if the operation is successful; otherwise, NULL is returned. The pointer returned can be different from the one passed to malloc():

```c
void *realloc(oldptr, newsize);
```

### Purpose:
Modifies the size of an allocated memory block while preserving its contents. A pointer to the old block is passed to realloc(). A pointer to the new block is returned if the operation is successful; otherwise, NULL is returned. The pointer returned can be different from the one passed to realloc():

```c
void *calloc(nitem, itemsize);
```

### Purpose:
Similar in function to malloc(), except that the contents of the block are zeroed. The size of the allocated block (in bytes) is nitem*itemsize. A pointer to a block whose size can hold the items requested is returned if the operation is successful; otherwise, NULL is returned.

### Table I: The common C language functions that access the heap.

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
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<tbody>
<tr>
<td>malloc()</td>
<td>Dynamically allocates memory.</td>
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<td>realloc()</td>
<td>Modifies the size of an allocated memory block.</td>
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<tr>
<td>realloc()</td>
<td>While preserving its contents.</td>
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<tr>
<td>free()</td>
<td>Releases memory blocks allocated by calloc(),</td>
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The examples given so far have all dealt with simple arrays. The benefits of using malloc() and free() to perform dynamic memory management are multiplied when they're used with more complex data structures, such as linked lists and trees. While it is possible to store a tree in an array of node structures, you must keep track of which array elements contain active nodes and which are unused and available as new nodes. malloc() does all the bookkeeping for you. To create an empty node structure, you simply execute:

```c
nodeptr = (struct node *)malloc(sizeof(struct node));
```

When the node is no longer needed, you use free(nodeptr) to get rid of it.

### Disadvantages
Like most things of value, the benefits of dynamic memory management are not without cost. The first drawback that comes to mind is increased overhead. This overhead turns out to be quite small. The memory allocated by malloc() is as efficient as any pointer in C. The extra work is required only when a block is created or released. The additional memory used by malloc() for bookkeeping is significant only if many very small blocks are being used.

Dynamic memory management's second cost is that debugging is more difficult. Exceeding the size of an allocated memory block is one of the toughest programming errors to find and correct. Adjacent areas of memory are written into as a result of this error, and you won't detect the damage until you attempt to use the contents of the overwritten memory. These modified values generate all sorts of strange bugs that don't point to the real problem. In the case of an array allocated at compile time, the variables assigned to memory adjacent to the offending array are determined by the declarations in the source code. Since related variables are often declared together, there is a good chance that the problem will be localized.

The location of objects in memory is not under your direct control when you use malloc(), and there is a good chance that completely unrelated data will be stored adjacent to one another in memory. Even worse, most implementations of malloc() store the data needed to maintain the free list adjacent to the allocated block. Overrunning the end of a block won't destroy data visible to you, but it corrupts the free list. As before, this causes problems when you attempt to allocate a new block of memory using the damaged portion of the free list, and the program may crash as a result—even while executing code that is far from the actual cause of the problem. This kind of bug is very difficult to locate.

The free list can also be damaged by calling free() with a pointer that wasn't obtained from malloc(). This error is easy to make when a program is allocating memory for many data structures. The seriousness of this error depends on the implementation of free(). Consistent with the lean and mean philosophy of C, most versions of free() do only minimal checking.
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DYNAMIC MEMORY MANAGEMENT

Listing 1: The source code for getline.c, a routine that reads a line and adjusts storage to hold the line, regardless of its length.

```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define MEMINCR 256 /* Increment in size of memory block. */

char *getline(FILE *infile)

FILE *infile;
char *r;
size_t n,m;
int c;

n = 0; /* # of bytes read. */
m = MEMINCR; /* Available space. */
r = malloc(n+MEMINCR+1); /* Allow room for \0 */
do {
    if (--m = 0) {
        if ((r = realloc(r, n+MEMINCR+1)) == NULL) return NULL;
        m = MEMINCR;
    }
    if ((c = getchar(infile)) == EOF) { return NULL; }
    r[n++] = c;
} while (c != '\n');
r[n] = '\0'; /* Terminate the string. */
if ((r = realloc(r, n+1)) == NULL) { return NULL; }
return r;
```

This minimizes the overhead of calling free() but transfers the responsibility of writing correct code to the programmer.

Avoiding Bugs

Since programs using malloc() to manage memory are susceptible to some nasty bugs, the best course is to write correct code in the first place. By far the most effective way to minimize the number of bugs in your code is to think before you write. The extra time spent on careful design of the program and its data structures will be more than repaid when debugging the code.

Programmers often reject programming techniques that result in more reliable code because they believe (rightly or wrongly) that these techniques result in slower programs. This concern for efficiency is doubly misplaced. First, it comes at the wrong time. You should consider efficiency during the design phase, particularly in the choice of the algorithm you use. Second, efforts to improve performance are usually done in the wrong place. Execution speed is relevant only to those parts of a program that execute for a significant amount of time during the program’s operation. In most programs, this is only a small fraction of the code. Finally, speed is of little importance if the

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Listing 2: A function to handle error-checking for calls to malloc(). If the request fails, the program is stopped after printing an error message; otherwise, the pointer returned by malloc() is passed to the program.

```c
/* mmalloc -- Allocate nbytes of memory using malloc(). Exit if malloc() fails */
#define include <stdlib.h>
char *mmalloc(nbytes) unsigned nbytes; {
    register char *s;
    if ((s = malloc(nbytes)) == NULL) {
        fprintf(stderr, "Out of memory!
"
            Request for %u bytes failed.\n", nbytes);
        exit(1);
    } /* Exit() could be replaced with a call to a garbage collection or compaction routine and the malloc retried. */
    return s; /* Return only if s points to a valid block of memory. */
}
```

program does not work correctly. The choice between a program that produces the wrong answer quickly and one that gives correct results more slowly is obvious.

Now consider some ways to make the use of malloc() more reliable. Always check the value returned by malloc() to verify that memory was actually allocated. It’s a nuisance to have to write if (malloc(...) == NULL) error(...); every time you need to allocate some memory, especially when you’re certain there is enough memory. You can avoid this inconvenience by using the function supplied in listing 2.

The idea of encapsulating the error-checking in a separate routine is a simple example of the general principle of information hiding. Malloc() itself provides another example. The details of how malloc() keeps track of the size and location of available memory blocks are hidden from the program calling malloc(). This has several advantages: Keeping the interface to the rest of the program simple minimizes the chance of making an error. The methods and data structures hidden inside a library routine can be thoroughly tested and verified, independently of any application.

A Debugging Tool

No matter how carefully you design and write your programs, sooner or later you will be bitten by one of the nasty bugs dynamic memory management makes possible. There is a debugging tool that will help you find the source of the problem.

The basic idea is this: Before every call to a memory management function, insert code that will make a copy of the sizes and locations of blocks allocated by malloc(). This copy is compared with the information maintained by malloc(). Any discrepancy is reported immediately. This lets you locate the source of the error at once instead of waiting for the delayed and often disastrous results of overwriting adjacent memory.

The debugging code is in the form of three routines (tsmalloc(), trealloc(), and tfree()) that are called instead of the corresponding library functions. These routines are located in memchk.c. The comments in memchk.c tell you how to make these functions available to your program, and address implementation details.

To implement such a tool, you need to know how malloc() works. This violation of information-hiding results in a severe portability problem, since there are many ways to write a memory allocator. You would need a different version for every C compiler. I’ve used Kernighan and Ritchie’s implementation of malloc, as published in their book, The C Programming Language (Prentice Hall, 1978, page 173), to guide the implementation of the debugging routines presented here. Since this book should be in every C programmer’s library, you can use it to assist you in porting the debugging routines to a new compiler.

As described by K & R, the basic data structure used by malloc() is the free list, which is a linked list of available memory blocks. Each block in the list has an associated header structure containing the size of the block and a pointer to the next block in the list. Blocks that have been allocated and that the program is using are not included in this linked list, but they still have a header containing the size of the block. A call to malloc() results in a search of the free list to find a block large enough to satisfy the request. This block, or a portion of it, is then removed from the free list, and a pointer to it is returned to the caller. Free() inserts the block pointed to into the free list at the correct location and updates the link pointers in the header structures to maintain the free list. To prevent memory fragmentation, adjacent free blocks are merged. Only the structure of the header is important to the debugging tool. This structure is

```c
struct header {
    struct header *ptr;
    /* Link to next block. */
    unsigned int size;
    /* Size of block. */
};
```

Although the details differ, all the versions of malloc() I have seen use a variation of this algorithm. I’ve used the debug functions in memchk.c successfully with Ecosoft Inc.’s C88 C compiler 4.05. I’ve also used Manx Software Systems’ Aztec CB6 C compiler 4.10, although I had to add K & R’s version of malloc to use memchk.c with it. If you have the source code for your library, you might want to tailor the malloc() checker in memchk.c to your compiler.

In addition to checking the block size and location on every call to free() or realloc(), another check is performed: The number of blocks in the free list is counted every time a memory management routine is called. Since only one block at a time is added to or removed from the free list, any substantial change in the length of the free list between memory calls indicates that pointers connecting the linked list are corrupted.

Finally, there is a routine called memlist() to list all the currently allocated memory blocks. This can be useful if called at the end of your program. If all the allocated blocks are freed, it should not produce any output. If some blocks are still allocated, it indicates that you do not have memory management under complete control. The uncertainty about which blocks are in use and which are not can be a source of serious errors.

Using C’s dynamic memory management functions results in programs that are portable and that adapt to the amount of memory available on the host computer. The disadvantages can be controlled by careful program design and the coding techniques I’ve described. Attention to program design and good programming style, especially important with dynamic memory management, will improve the reliability of any program.

Editor’s note: The C source code for the debugging tools is available in a variety of formats. See page 3 for details. To use the tools, you’ll need a C compiler.

David L. Fox of Golden, Colorado, is the chief scientist at Minimum Instruction Set Computer Inc. He has spent the last 4 years developing programmers’ tools and expert systems.
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putting at Chaos Manor, I agree that C compilers are getting better and more competitive. I have only three, but I find that they vary considerably in completeness and technical support.

My venture into the world of C has been as a self-taught hobbyist rather than as a professional. I am therefore more sensitive to and irritated by systems and documentation that assume all users are computer science graduates who write their own functions in assembly language to fill in the missing gaps in the product.

My sad experience with Borland's Turbo C is an example, even though you generously suggested it as a "clear choice for beginners and dilettantes." I am somewhere between these extremes, but I find this package one of the most deficient of the lot. Can you imagine a system that comes with two nice volumes of in-scrren-level functions to simplify the in-scrren? In fact, the IBM PC version contains practically no screen functions whatsoever. You cannot locate cursor position, read the cursor column or line, or even scroll.

On the bright side of this competition, C Ware's excellent DeSmet C compiler and debugger provide no less than 17 screen-level functions to simplify the interface between the C program and the IBM PC and its clones. You can fold them into the standard function library with a simple routine.

When I wrote to Borland asking for help or information on the Turbo C deficiency, the company took more than 3 months to answer and then simply told me that no screen functions were provided because they were "not standard." To my amazement, Borland recommended that I buy these functions from another company. So much for Borland's support for what might otherwise be a useful compiler. I am now back and happy with my C Ware DeSmet C compiler, while Borland's inadequate product is gathering dust on my bookshelf. Let the nondilettante buyer beware.

Walter K. MacAdam
Hanover, NH

Thanks. As I said in my column, I have to base what I say about C compilers on what I'm told by people I farm them out to; I don't program in C, and I have little right to an opinion of my own. Perhaps the people I used to test Turbo C were too advanced to notice the problem.—Jerry

Does BYTE Slight Amiga?

Dear Jerry,

I'm somewhat surprised that your February column devoted so much space to the Atari Mega ST. I am the former owner of an Amiga 1000 and now the happy owner of an Amiga 2000.

I'm not anti-Atari. I just don't believe that you or the other writers who contribute articles to BYTE are giving the Amiga its due. I can understand how you might have trouble dealing with Commodore. I certainly have. I think, however, that the company seems to be getting its act together and appears to be more responsive to its customers. I wouldn't have bought another Amiga if I didn't think the company was on the right track. There were times I wished I'd purchased a Macintosh or any other computer, but I don't feel that way now.

Quite a few new third-party hardware products are now on the market or being developed for the Amiga. Significant software is showing up. I don't see any mention of it in BYTE. The last article of consequence was the Commodore A2000 product preview in March 1987. A lot has changed between them and now.

In the low-cost home market, Commodore offers the 500, a computer that stacks up quite well against the Ataris and in many respects offers a better, more expandable value. The 2000 has given the Amiga owner a machine whose expandability and flexibility are far-reaching: 68020 and 68030 cards, MS-DOS compatible and possible OS/2 compatibility, possible Macintosh compatibility, 704- by 470-pixel resolution, a multifunction board, and rumored new Denise and Agnes upgrades, just to name some of the advantages.

I'd appreciate it if you'd see what could be done to bring the developments in this line of computers to the attention of BYTE readers. If you and any other writers for BYTE have serious objections or reservations concerning the Amiga, I wish you'd address them in the magazine. I'd hate to think that you would just ignore it.

John H. Harvey Jr.
Minneapolis, MN

I think you have two misconceptions. First, I rely on the BYTE people in Peterborough for support and information, but my column is an independent operation.

Second, I live in Hollywood, amidst huge stacks of hardware and software, and there's only me to deal with it all. I try to keep up with what's going on, but so much comes in that I'm hard-pressed to look at it all. The fact is that Atari takes the trouble to see that I get most of the interesting third-party hardware and software for its machines, and Commodore doesn't.

I recently got an Amiga 2000 and had a couple of Amiga experts over to help set it up; I'll have a report pretty soon. However, I can write only about what's here, and the Commodore machines I have are pure vanilla. On the Amiga 2000, the IBM PC half has exactly the same speed as the earliest PC, while the Amiga half is built around a 68000. No 68020 on the Amiga, and no way to run OS/2 on the PC. I wish I did have something with all the goodies you describe. Does anyone?—Jerry
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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, 50,000 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 INF and OUT (or PEEK and POKE with Apple's 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

<table>
<thead>
<tr>
<th>RE-140</th>
<th>$129</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

Reed Relay Card

<table>
<thead>
<tr>
<th>RE-158</th>
<th>$99</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

Analog Input Card

<table>
<thead>
<tr>
<th>AD-142</th>
<th>$129</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

12 Bit A/D Converter

<table>
<thead>
<tr>
<th>AN-146</th>
<th>$139</th>
</tr>
</thead>
<tbody>
<tr>
<td>This analog to digital converter is accurate to ±0.5%. Input range is -4V to +4V. Resolution 1 millivolt. The on board amplifier boosts signals up to 10 times to read microvolts. Conversion time is 120ms. Ideal for thermocouple, strain gauge, etc. 1 channel. (Expand to 8 channels using the RE-155 card).</td>
<td></td>
</tr>
</tbody>
</table>

Digital Input Card

<table>
<thead>
<tr>
<th>IN-141</th>
<th>$59</th>
</tr>
</thead>
<tbody>
<tr>
<td>The eight inputs are optically isolated, so it's safe and easy to connect any &quot;on/off&quot; devices, such as switches, thermostats, alarm loops, etc. to your computer. To read the eight inputs, simply use BASIC INP or (PEEK).</td>
<td></td>
</tr>
</tbody>
</table>

24 Line TTL I/O

<table>
<thead>
<tr>
<th>DG-148</th>
<th>$85</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connect 24 input or output signals (switches or TTL device) to your computer. The card can be set for: input, latched output, strobed output, strobed input, and/or bidirectional strobed I/O. Use the 8255A chip.</td>
<td></td>
</tr>
</tbody>
</table>

Clock with Alarm

<table>
<thead>
<tr>
<th>CL-144</th>
<th>$86</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powerful clock/calendar with battery backup for Time, Date and Alarm setting (time and date); built in alarm relay, led and buzzer; timing to 1/100 second. Easy to use decimal format. Lithium battery included.</td>
<td></td>
</tr>
</tbody>
</table>

Touch Tone® Decoder

<table>
<thead>
<tr>
<th>PH-145</th>
<th>$79</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each tone is converted into a number which is stored on the board. Simply read the number with INP or POKE. Use for remote control projects, etc.</td>
<td></td>
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</tbody>
</table>

A-BUS Prototyping Card

<table>
<thead>
<tr>
<th>PR-152</th>
<th>$15</th>
</tr>
</thead>
<tbody>
<tr>
<td>3½ by 4½ in. with power and ground bus. Fits up to 10 IC's.</td>
<td></td>
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</tbody>
</table>

Smart Stepper Controller

<table>
<thead>
<tr>
<th>SC-149</th>
<th>$299</th>
</tr>
</thead>
<tbody>
<tr>
<td>World's fastest stepper controller. On board microprocessor controls 4 motors simultaneously. Incredibly, it accepts plain English commands like &quot;Move arm 10.2 inches left.&quot; Many complex routines can be defined as &quot;macros&quot; and stored in on board memory. For each axis, you control coordinate (relative or absolute), moving, speed, step type (half full wave), scale factor, units, holding power, etc. Many inputs: 8 limit &amp; &quot;wait until&quot; switches, panic button, etc. On the fly reporting of position, speed, etc. On board drivers (350mA) for small steppers (MO-133). Send for SC-149 flyer.</td>
<td></td>
</tr>
</tbody>
</table>

Remote Control Keypad Option

<table>
<thead>
<tr>
<th>RC-101</th>
<th>$49</th>
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</thead>
<tbody>
<tr>
<td>To control the 4 motors directly, and &quot;teach&quot; sequences of motions.</td>
<td></td>
</tr>
</tbody>
</table>

Power Driver Board Option

<table>
<thead>
<tr>
<th>PD-133</th>
<th>$89</th>
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</thead>
<tbody>
<tr>
<td>Boost controller drive to 5 amps per phase. For two motors (eight drivers).</td>
<td></td>
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</tbody>
</table>

Breakout Board Option

<table>
<thead>
<tr>
<th>BB-122</th>
<th>$19</th>
</tr>
</thead>
<tbody>
<tr>
<td>For easy connection of 2 motors. 3ft. cable ends with screw terminal board.</td>
<td></td>
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</tbody>
</table>

Stepper Motor Driver

<table>
<thead>
<tr>
<th>ST-143</th>
<th>$129</th>
</tr>
</thead>
<tbody>
<tr>
<td>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 $199</td>
<td></td>
</tr>
</tbody>
</table>

Stepper Motors

<table>
<thead>
<tr>
<th>MO-103</th>
<th>$15 or 4 for $39</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pancake type. 24V, dia. 2.2&quot; shaft, 7.5/step, 4 phase bidirectional, 300 steps/sec, 12V, 36 ohm, bipolar, 5 oz-in torque, same as Airpax K82701-P2.</td>
<td></td>
</tr>
</tbody>
</table>

Current Developments

Intelligent Voice Synthesizer, 14 Bit Analog to Digital converter, 4 Channel Digital to Analog converter, Counter Timer, Voice Recognition.

A-BUS Adapters for:

- IBM PC XT AT and compatibles. Use one short slot AR-133, $69
- Apple II, II+, IIe, uses any slot AR-133, $69
- TRS-80 Model 102. 200 plugs into 40 pin "system bus" AR-133, $69
- TRS-80 Model 100. Uses 40-pin socket (Socket is dedicated on adapter) AR-133, $69
- TRS-80 Model 3.4.0. Fits 50-pin switch (With hard disk use exp cable) AR-133, $69
- TRS-80 model 4P. Includes extra cable. 50 pin bus is required AR-133, $69
- TRS-80 Model 1. Plugs into 40 pin bus on K/B or E/E AR-133, $69
- Color Computers (Tandy). Furs ROM slot Multiport, or Y-cable AR-133, $69

A-BUS Cable (3 ft, 50 cond.)

<table>
<thead>
<tr>
<th>CA-163</th>
<th>$24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connects the A-BUS to one A-BUS card or to first Motherboard Special cable for two A-BUS cards: CA-162, $34</td>
<td></td>
</tr>
</tbody>
</table>

A-BUS Motherboard

<table>
<thead>
<tr>
<th>MB-120</th>
<th>$99</th>
</tr>
</thead>
<tbody>
<tr>
<td>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 5 motherboards can be joined this way to a single A-BUS adapter. Sturdy aluminum frame and card guides included.</td>
<td></td>
</tr>
</tbody>
</table>

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- 80287 $169
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- 80187 $2712
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- 1024 x 1024 pixel command buffer
- 1024 x 1024 pixel status buffer
- 1024 x 1024 pixel address buffer
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<tr>
<th>Feature</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
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<td>$295</td>
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<tr>
<td>Multiple VT241 emulators, including true double-high-double-width character, true smooth scaling, graphics support, and downloadable fonts</td>
<td>595.00</td>
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<tr>
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<tr>
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<tr>
<td>Usage is easy. No One or VMS support for DOS DOS DOS support.</td>
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- Regular AT Side Case
- Digital Display Case
- 200-Watt Power Supply
- AT Style Keyboard

**$955.00**

**PERIPHERALS AT/XT**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floppy Disk Controller W/ Cable</td>
<td>$22.50</td>
</tr>
<tr>
<td>Hard Disk Controller W/ Cable</td>
<td>$72.20</td>
</tr>
<tr>
<td>Dual 64K Memory Sup Card, OK</td>
<td>$64.30</td>
</tr>
<tr>
<td>Monochrome Graphics Printer Card</td>
<td>$43.80</td>
</tr>
<tr>
<td>Color Graphics Card</td>
<td>$38.80</td>
</tr>
<tr>
<td>Color Graphics Printer Card</td>
<td>$56.00</td>
</tr>
<tr>
<td>Expandable Adapter (EGA)</td>
<td>$13.70</td>
</tr>
<tr>
<td>Color/ Monochrome Display Card</td>
<td>$81.30</td>
</tr>
<tr>
<td>Parallel Printer Card</td>
<td>$18.60</td>
</tr>
<tr>
<td>Diamond Game Case</td>
<td>$18.60</td>
</tr>
<tr>
<td>Serial 1152 Card</td>
<td>$25.00</td>
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<tr>
<td>Dual Serial 1152 Card</td>
<td>$36.30</td>
</tr>
<tr>
<td>Mouse For AT/XT W/ Driver Software</td>
<td>$61.80</td>
</tr>
<tr>
<td>Multi I/O Card</td>
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<td>4.77/10MHz XT Turbo Motherboard</td>
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<td>150-Watt Power Supply</td>
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<td>150-Watt Power Supply (UL)</td>
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MS DOS 3.2 w/software Back 179
1.2 Meg MITSUBISHI Floppy Drive 79
300K TEAC/S BS floppy Drive 79
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Printer Stand manufactured by IBM 14
HP Laser Jet f w/toner Cartridge 169
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Circle 59 on Reader Service Card

Circle 196 on Reader Service Card

Circle 82 on Reader Service Card

Circle 91 on Reader Service Card

Circle 120 on Reader Service Card

DYNAMIC RAMS

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PROCESSORS

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<tr>
<td>10+ $10.00 ea.</td>
</tr>
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</table>

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<thead>
<tr>
<th>ICs</th>
<th>QUANTITY</th>
<th>DESCRIPTION</th>
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<td>1048Kb 100 ns</td>
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<td></td>
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</tbody>
</table>

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(DEALERS: 39)

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8087-1 198
80287-6 228
80287-16 438
80387-20 728

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Mouse Systems serial 198
Mouse Systems Buss 198
Fastrap Trackball 198

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- On-board speaker
  1200 baud external 98
  2400 baud ½ card internal 148
  2400 baud external 168

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- 20 MB Card 328
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- EGA monitor 640x350 378
- NEC MultiSync II 640x560 648
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- Letter Quality Printers
- EPSON LQ-850  Call
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- Near Letter Quality Printers
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- MICROSOFT
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EPSON 24 Pin $369
- LQ-500
- List Price 529
- Letter Quality Printers
- EPSON LQ-850  Call
- EPSON LQ-1050  Call
- EPSON LQ-2500  Call

EPSON 9 Pin $198
- LX-800
- Near Letter Quality Printers
- EPSON FX-86e  Call
- EPSON FX-286e  Call
- EPSON EX-800  Call

HP LaserJet II $1798
- List Price 2595

Laser Printer $998*
- Interface required
- 300 x 300 DPI
- 8 pages per minute
- HP compatible
- Standard or legal size
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#### Static RAMs

<table>
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<tr>
<th>RAM Type</th>
<th>Speed (ns)</th>
<th>Price</th>
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COMING UP IN BYTE

PRODUCTS IN PERSPECTIVE:

Just as the need for more memory has been growing, the demand for more disk-storage capacity is also growing. Our Product Focus for July will feature 40-megabyte hard disk drives that offer an access speed of 30 milliseconds or faster. We’ll also look at several 40-megabyte hard disk cards that offer an alternative for upgrading disk storage.

A system review compares five IBM PC AT-compatible computers, all of which run faster than the standard 8-MHz IBM PC AT and come in at lower prices.

Hardware reviews: Orchid Technology’s ColorVue SE board brings color to the Macintosh SE. The only board of its kind so far, it’s designed to let Mac SE owners hook up color monitors, run their applications in color, and print color hard copy.

Most owners of IBM PC AT-compatible and 80386 computers should have no problem running OS/2 when they decide to switch. IBM PC owners, though, don’t have this option with their standard system, since OS/2 does not run on the PC’s processor. Two new boards, though, promise to bring OS/2 compatibility to PC compatibles. Microsoft’s Mach 20 board and Sota Technology’s MotherCard 5.0 both add an 80286 processor to a PC.

Multitasking alternatives on 80386 systems are covered in software reviews. We will review three noteworthy packages: Concurrent DOS 386 from Digital Research, VM/386 from IGC, and ProBas from Hammerly.

Application reviews are MicroGraphic’s Designer for MS-DOS systems, a powerful graphics-oriented program, and Newspace, a file-compression utility for the IBM PC.

Products found in Short Takes for July will include Soft PC, UR/Forth, Condor: Build Your Own, Ogivar 286 Portable, GrandView, EasyTalk, and Choice Words.

IN DEPTH:

We will spotlight multitasking on 80386-based computers. Using the power of these machines to perform simple tasks like word processing or database management is a little like cracking walnuts with a sledgehammer. So much of the computer’s “brainpower” is sitting idle that, if machines could get bored, these units would be in tears most of the time. What can you do, though? An elegant solution is to have your machine do lots of things at the same time. The problem with that answer has heretofore been that, when you pile lots of tasks onto the same processor, it slows way down. There are ways of getting around that, and we’ll tell you about them.

FEATURES:

Features will include a piece on Integrated Services Digital Network, or ISDN, a rapidly advancing communications technology that allows digital data, voice, and sometimes even video to be carried directly over the switched telephone network. Dick Fountain will report on the newest Transputer processor innovation—a chip called Viper—to come out of the British Isles. It promises to seriously challenge the traditional structures of computer design. Additionally, in the Circuit Cellar, Steve Ciarcia will present the second part of his brain-wave-monitor construction project.

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<td>5) When TIPS says: “Enter Subscriber Number” (Enter by pushing the numbers and symbols [# or * enclosed in the boxes] on telephone pad ignoring blank boxes) Enter [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]</td>
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<td>6) When TIPS says “Enter magazine code &amp; issue code” Enter [ ] [ ] [ ] [ ] [ ] [ ] [ ]</td>
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<td><strong>END SESSION</strong></td>
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