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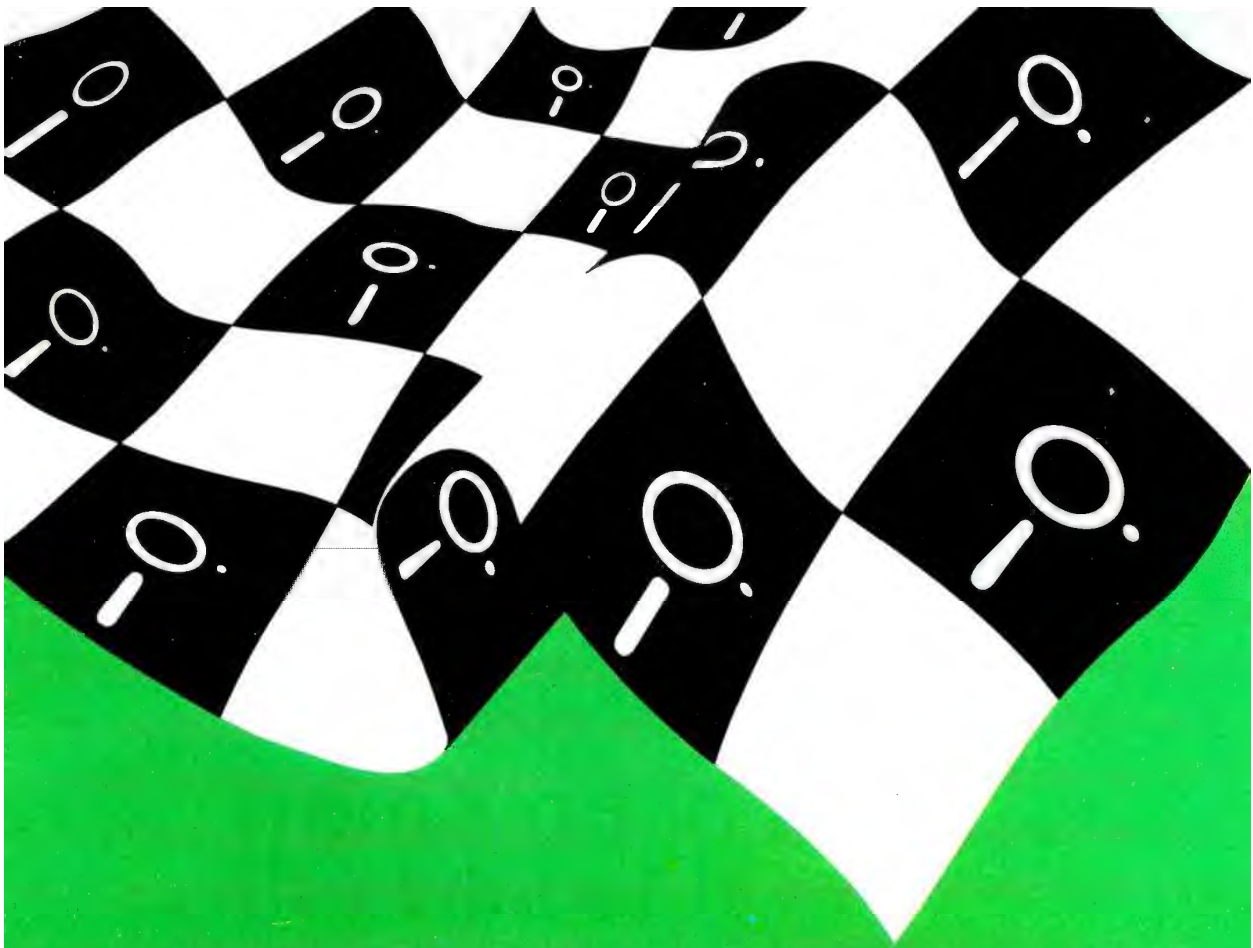
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to the IBM
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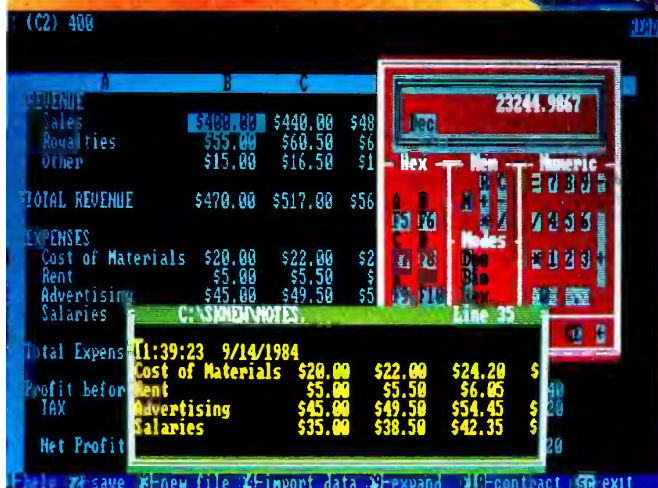
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IBM AND ITS PERSONAL COMPUTERS

There are two sides to the story of IBM's tremendous success in personal computers. The first side concerns what the IBM PC provided: a processor that could address a lot of memory, an 80-column screen, an open system architecture, a keyboard with upper- and lowercase and good cursor controls, and word-processing software that used correctly labeled function keys.

The second side of the story concerns the failure of other major companies to provide these same fundamental features earlier. In retrospect, it seems IBM stepped into a void that remained, paradoxically, at the center of a crowded market. The Apple III's word-processing software required you to memorize control codes and made no use of function keys. The Apple II required add-ons to provide such word-processing essentials as an 80-column screen and a full upper- and lowercase character set. The Apple development teams were laboring longer than they expected on software for the Lisa and the Macintosh. Eventually those projects bore fruit, but the world might have been different if Apple had first offered Lisa as a \$3000 machine with a 68000 microprocessor, a simple operating system, an 80-column screen, a good keyboard with cursor and function keys, two disk drives, and a set of four basic applications programs. The desktop, the bit map, and the mouse could have followed. The proprietary "Twiggy" disk drives could have given way to Tandons or Shugarts.

While Apple was trying, DEC and Data General were on the sidelines, Tandy's 16-bit system lacked software, Hewlett-Packard was concentrating on specialized markets, Commodore was thinking 8-bit and 64K bytes of RAM, AT&T was tied up by divestiture, and most other companies failed to convince enough prospective buyers that they were here to stay.

The void was there, and IBM stepped in. The array of IBM personal computers is now formidable: the PC, the Portable PC, the PC XT, the XT/370, the 3270 PC, the 68000-based S9000, and the PCjr (which badly needs to grow up). We did this *BYTE Guide to the IBM Personal Computers* because many

of our authors had interesting and original things to say about one or another of the IBM machines and we wanted to collect much of this material in one convenient volume. While our subscribers who own IBM PCs wanted more coverage of their machines in *BYTE*, we didn't want this coverage to be at the expense of our customary variety of features, reviews, theme articles, and columns in the regular issue.

We were hoping for the announcement of IBM's battery-powered portable and its multiuser personal computer in time for this issue, but as of this writing, such intriguing rumors remain rumors. Will the system based on IBM's proprietary 32-bit processor from the Austin group see the light of day? Will IBM's own operating system and applications software supplant those of independent software houses? Will the PCjr grow up? By entering the field of personal computing, IBM has brought the game of IBM watching to an audience of millions.

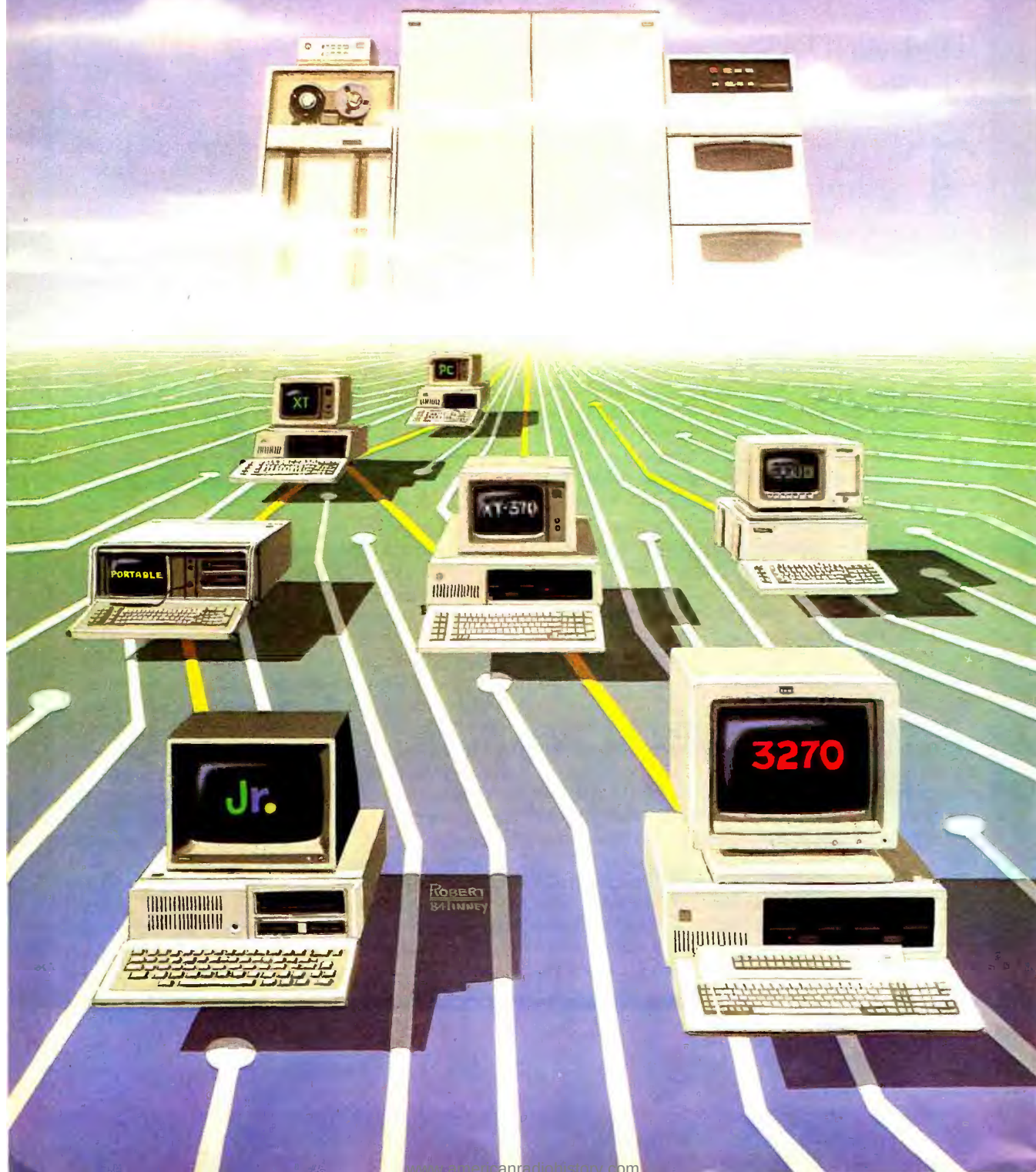
IBM has also given the field its third major standard, after the Apple II and CP/M. Standards sometimes deprive us of the latest and most innovative technology, but when a standard encompasses both hardware and system software, it cultivates the ground for a flowering of third-party software and peripherals. This increased base of software accompanied by hardware add-ons allows the standard machine to do almost any small computing task. Since the standard machine can do almost anything, everyone wants one.

But everyone also comes to want more. IBM's standard will not be the last, and not just because a one-computer and a one-company world would be dull. Apple's Macintosh offers a superior user interface that attracts passersby. AT&T is capable of creating a standard. HP, DEC, Tandy, and other companies are not to be ignored. IBM itself could bring forth a dazzling new generation of technology.

For the present, it makes more sense to enjoy the benefits of the current IBM standard than to curse it because it could be better. But enjoying the benefits of this standard shouldn't prevent us from keeping an eye open for something really new.

—Phil Lemmons, Editor in Chief

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IBM Guide

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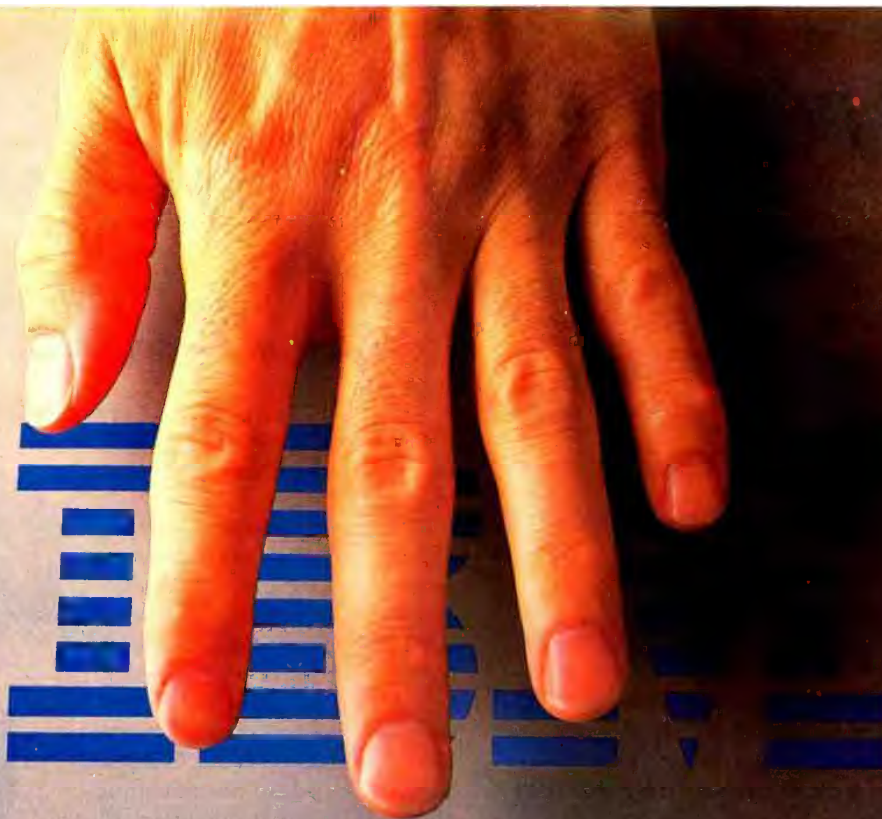
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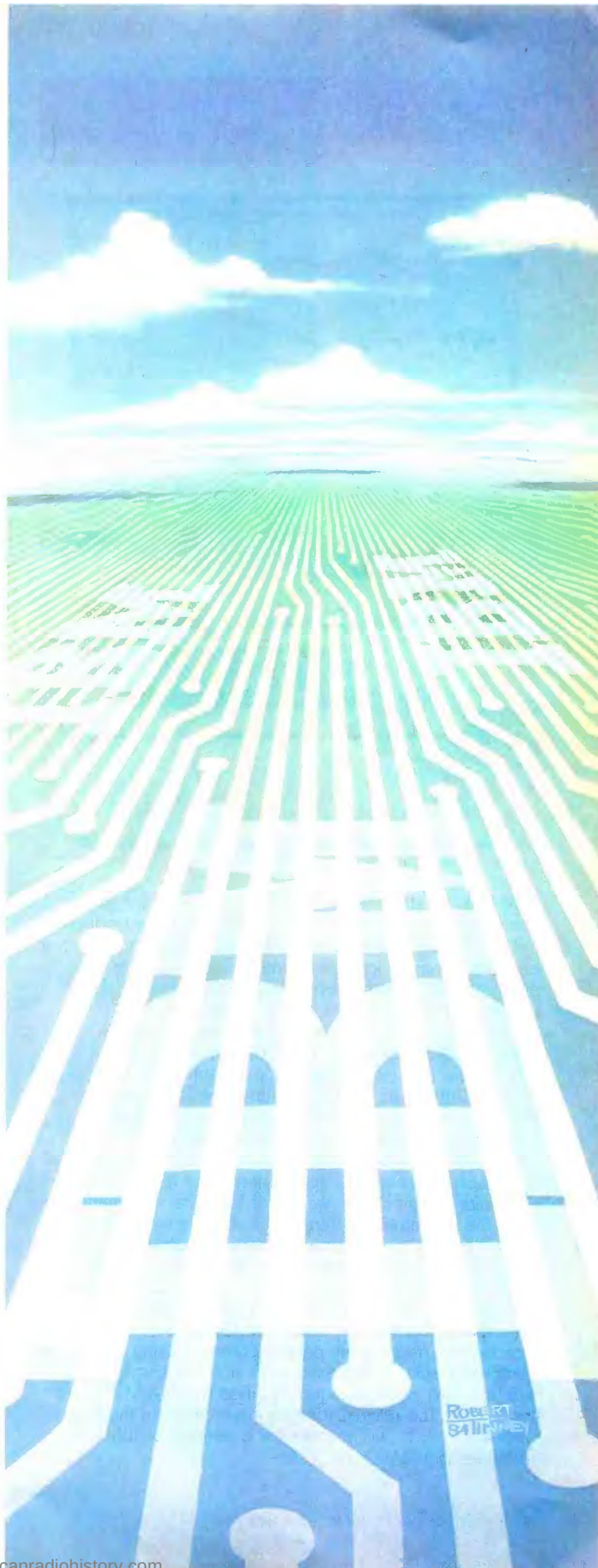
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ILLUSTRATION BY ROBERT TINNEY



The IBM Personal Computer



IBM has established itself as the nation's major micro-computer producer in the three years since it introduced the IBM Personal Computer in August, 1981. Drawing on a reputation for service and reliability with its larger computer systems, IBM has been able to quickly woo corporate America and even entice home users.

Catering to over a million IBM PC users, software publishers have created for the computer one of the largest bases of microcomputer programs, thereby contributing further to the PC's proliferation. The 16-/8-bit 8088 processor makes it possible for users to write larger, more complex programs that offer more sophisticated features yet are easier to use than previous 8-bit personal computer applications. The IBM PC's five expansion slots and the wealth of technical information available let numerous third-party vendors manufacture add-on boards that help the PC flex its productive muscle.

IBM has expanded its PC line and recently reduced its prices in an effort to grab an even larger market share by competing more aggressively with the IBM compatibles. An expanded line also means that IBM is competing directly with itself. Many people currently using larger IBM computers, such as the System 34 and the Displaywriter, will find their needs adequately filled by an IBM PC at a lower cost. The IBM PC, one of the company's most successful products, will account for 6 percent of IBM's revenues in 1984.

Name
The IBM Personal Computer

Manufacturer
International Business Machines Corporation
Entry Systems Division
POB 1328
Boca Raton, FL 33432
(800) 447-4700

Size
5½ by 20 by 16 inches; 25 pounds

Components
Processor: Intel 8088, 4.77-MHz; socket for addition of the 8087 math coprocessor
Memory: 40K bytes ROM, 256K bytes RAM standard, 640K bytes RAM maximum with memory-expansion card
Keyboard: 83-key layout with 10 function keys and numeric/cursor keypad; detachable with 6-foot coil cable; adjustable typing angle
Mass Storage: 360K-byte double-sided 5¼-inch floppy-disk drive
Expansion: Five expansion slots (one used by floppy-disk drive controller)

Software
Diagnostics, Microsoft cassette BASIC interpreter in ROM

Optional Hardware	
64/256K-byte Memory Expansion Card with 64K bytes	\$265
64K-byte Memory Module	\$100
Monochrome Display	\$275
Monochrome Display and Printer Adapter	\$250
Color Monitor	\$680
Color/Graphics Monitor Adapter	\$244
Disk drive (5¼-inch floppy disk)	\$425
Asynchronous Communications Adapter	\$100
8087 Math Coprocessor	\$230
Graphics Printer	\$449
Personal Computer Cluster Adapter	\$400
Personal Computer Cluster cable kit	\$110
Fixed Disk Drive Adapter	\$590
10-megabyte Fixed Disk	\$1395
PC Expansion Unit	\$2880

Optional Software	
Personal Computer DOS 1.1 (with Advanced Disk BASIC)	\$40
Personal Computer DOS 2.1	\$65
Personal Computer Cluster Program	\$92

Documentation
Guide to Operations, BASIC Reference Manual

Prices	
256K bytes of RAM and one floppy-disk drive	\$1995
256K bytes of RAM and two floppy-disk drives	\$2420

SEEQUA SHOWS YOU HOW TO GET AN IBM PC FOR JUST \$1995.

BUY A CHAMELEON BY SEEQUA.



The Chameleon by Seequa does everything an IBM PC does. For about \$2000 less than an IBM.

The Chameleon lets you run popular IBM software like Lotus® 1-2-3™ and dBase II.® It has a full 83 key keyboard just like an IBM. A disk drive like the IBM. And a bright 80 × 25 character screen just like an IBM.

But it's not just the Chameleon's similarities to the IBM that should interest you. Its advantages should, too. The Chameleon also has

an 8 bit micro-processor that lets you run any of the thousands of CP/M-80® programs available. It comes complete with two of the best programs around, Perfect Writer™ and Perfect Calc.™ It's portable. And you can plug it in and start computing the moment you unwrap it.

So if you've been interested in an IBM personal computer, now you know where you can get one for \$1995. Wherever they sell Chameleons.

The Chameleon by



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8305 Telegraph Road
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Chameleon shown with optional second disk drive.

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The IBM Personal Computer XT



Many users soon tire of slow floppy-disk response time, limitations on the size of data files, and the bother of shuffling around their 360K-byte floppy disks and yearn for true "mass" storage. Enter the IBM PC XT, a machine that includes 10 megabytes of storage on a compact hard disk in place of one of the floppy-disk drives. The PC XT can also support a second 10-megabyte drive in a separate expansion unit, making for a fixed disk space of 20 megabytes, or the equivalent of 5000 typewritten pages in a desktop machine.

The PC XT has eight thin expansion slots in place of the PC's five, allowing PC XT users to take advantage of more third-party peripherals without feeling cramped for space. However, three of the expansion slots are already taken by the asynchronous communications adapter and the floppy-disk and hard-disk controllers. The power supply on the XT, however, has been beefed up to handle the extra demands for power, doubling the wattage to 130 watts.

DOS 2.1 offers a hierarchical file system with subdirectories to help organize all the files that will now fit onto the PC XT's hard disk. But the euphoria of a faster disk drive and seemingly limitless disk space eventually gives way to the realization that you can fill up even 10 megabytes sooner than you think.

Name
IBM Personal Computer XT

Manufacturer
International Business Machines Corporation
Entry Systems Division
POB 1328
Boca Raton, FL 33432
(800) 447-4700

Size
5½ by 20 by 16 inches; 32 pounds

Components
Processor: Intel 8088, 4.77-MHz; socket for addition of the 8087 math coprocessor
Memory: 40K bytes ROM, 256K bytes RAM standard, 640K bytes RAM maximum with memory-expansion card
Keyboard: 83-key layout with 10 function keys and numeric/cursor keypad; detachable with 6-foot coil cable; adjustable typing angle
Mass Storage: 10-megabyte fixed disk, 360K-byte double-sided 5¼-inch floppy-disk drive
Expansion: Eight expansion slots (three used by asynchronous communications, floppy-disk drive, and fixed-disk adapters)

Software
Diagnostics, Microsoft cassette BASIC interpreter in ROM

Optional Hardware	
64/256K-byte Memory Expansion Card with 64K bytes	\$265
64K-byte Memory Module	\$100
Monochrome Display	\$275
Monochrome Display and Printer Adapter	\$250
Color Display	\$680
Color/Graphics Display Adapter	\$244
8087 Math Coprocessor	\$230
Graphics Printer	\$449
5¼-inch floppy-disk drive	\$425
Personal Computer Cluster Adapter	\$400
Personal Computer Cluster cable kit	\$110
10-megabyte fixed disk	\$1395
PC XT Expansion Unit	\$2290

Optional Software	
Personal Computer DOS 2.1 (with Advanced Disk BASIC)	\$65
Personal Computer Cluster Program	\$92

Documentation
Guide to Operations, BASIC Reference Manual

Price
\$4395

A printer should complement your computer, not compromise it.



It's a simple fact that your small computer can compute a lot faster than your printer can print. A problem that becomes even more frustrating in business, when your computer is tied up with your printer while you're ready to move on to other work.

Of course, the only thing more frustrating than waiting on a slow printer is waiting on a printer that's down. Unfortunately, chances are the initial printer you purchased with your computer system just isn't designed to work on continuous cycle high volume printing.

More than likely, you've already experienced one, if not both of these frustrations. But now, you can turn printer frustration into printing satisfaction with the new Genicom 3014, 3024, 3184, 3304 or 3404. Professional printers for personal computers...price/performance matched for small business systems.

Designed and built to increase productivity and maximize the value of your personal computer, the range of 3000 PC printers offers 160-400 cps draft, 80-200 cps memo, and 32-100 cps NLQ printing...performance for both high productivity and high quality printing.

The 3014/3024 models print 132 columns. The 3184, 3304

and 3404 models give you a full 136 column width, and offer color printing as well.

Each printer is easy to use, lightweight, functionally styled and attractive. And you can choose options from pedestals and paper racks to document inserters, sheet feeders and 8K character buffer expansion, plus more.

Genicom 3000 PC printers feature switch selectable hardware, dual connectors and dual parallel or serial interfaces. Plus the 3014 and 3024 emulate popular protocols for both Epson MX with GRAFTRAX-PLUS™ and Okidata Microline 84 Step 2™, while the 3184, 3304 and 3404 emulate popular protocols for Epson MX with GRAFTRAX-PLUS™. So your current system is most likely already capable of working with these Genicom printers without modification.

Most important, the Genicom 3000 PC printers are quality-built, highly durable printers designed for rapid, continuous duty cycle printing.

So why wait? And wait. And wait. Get a Genicom 3000 PC printer now.

Genicom Corporation, One General Electric Drive, Dept. C411, Waynesboro, VA 22980. In Virginia, call 1-703-949-1170.

GENICOM

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For the solution to your printing needs call

TOLL FREE 1-800-437-7468

In Virginia, call 1-703-949-1170.

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Okidata Microline 84 Step 2 is a trademark of Okidata Corporation

Circle 68 on inquiry card.

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The IBM PCjr



While the IBM Personal Computer exceeded IBM's initial sales projections as a business computer, it has had mixed success as a home computer, primarily because it costs more than several of the lower-priced home computers. The IBM PCjr, a scaled-down, limited version of the IBM PC for the home market, starts at \$599 for 64K bytes of memory and no disk drive. Most users will want the expanded model, which has a disk drive and 128K bytes of memory and sells for \$999.

Both models are designed to compete directly with the Apple II family of machines, but the PCjr's shortcomings have cooled its reception. The complaints against the PCjr start with its "chiclet" style keyboard, whose flat, rectangular keys are not labeled and are spaced far apart (this was to allow for keyboard overlays that would redefine the keys). Another major drawback is that many regular IBM PC programs won't run on the PCjr because it has a limit of 128K bytes of memory. In addition, you can add only one disk drive to the PCjr. Further, its innovative cordless keyboard, which uses an infrared link to communicate with the expansion unit, has received mixed reviews.

Name
IBM PCjr

Manufacturer
International Business Machines Corporation
Entry Systems Division
POB 1328
Boca Raton, FL 33432
(800) 447-4700

Size
4 by 14 by 11½ inches; 6 pounds, 9 pounds with disk drive

Components
Processor: Intel 8088, 4.77-MHz
Memory: 64K bytes ROM, 64K bytes RAM standard, 128K bytes RAM maximum
Display: Built-in color adapter
Keyboard: 62-key layout with function control and cursor control keys; detached with infrared link; adjustable typing angle
Expansion: two cartridge slots

Software
Diagnostics. Microsoft cassette BASIC interpreter in ROM

Optional Hardware	
Disk drive (360K-byte half-height 5¼-inch floppy disk)	\$480
64K-byte Memory and Display Expansion	\$140
Internal Modem	\$199
Adapter Cable for Serial Devices	\$25
Attachable Joystick	\$40
Keyboard Cord (6-foot)	\$20
Keyboard Overlays (5)	\$10
Television Connector	\$30
Color Display	\$680
Adapter Cable for IBM Color Display	\$20
Compact Printer (thermal)	\$175
Compact Printer Adapter	\$40
Graphics Printer	\$449
Parallel Printer Attachment	\$99
Color Printer	\$1995
Personal Computer Cluster Adapter	\$400
Personal Computer Cluster Cable kit	\$110

Optional Software	
BASIC Interpreter Cartridge (Microsoft)	\$75
Personal Computer DOS 2.1 (with Advanced Disk BASIC)	\$65
Personal Computer Cluster Program	\$92

Documentation
Guide to Operations, Hands-On BASIC for the IBM PCjr

Price	
64K-byte Entry Model	\$599
128K-byte Extended Model with one floppy-disk drive	\$999



MEET OUR DIRECTOR OF PUBLIC RELATIONS.

Quite a few important people are saying some very good things about our Serial Port Expanders. They're saying things any company would like to hear. Things like "reliable," "sophisticated," and "affordable."

They're talking about the wide range of applications — port contention, multiplexing, time-sharing and networking. They can't seem to tell us enough how pleased they are with our units. But they're trying . . .

"BayTech's Serial Port Expanders were a key solution for Federal Express employees using PCs and peripheral devices. There just weren't enough I/O ports. We needed to talk to more devices. BayTech's units filled that gap. I looked for price and capabilities. With BayTech's Expanders, everything was just right."

Sam Ho, Technical Advisor,
Federal Express



We manufacture Serial Port Expanders in four, eight and sixteen port units. We manufacture a model that allows other units to be cascaded for those needing increased expansion.

Seventeen models are available providing a comprehensive range of applications. Many companies are using our units in different divisions,

different locations.

And everyone seems pleased . . .

NCR

"Three of BayTech's 524Fs (any-port-to-any-port model) are used as smart switches between NCR's personal computer, the



Decision Mate 5, and three other processors — NCR's 3240s — which in turn drive twenty-six, 2160 terminals. These cash registers are used at the front gates of Opryland and, on demand, pull totals of gate receipts, number of tickets sold, attendance — even the weather! We are happy with BayTech's units."

Dave Armelli, Administrative
Manager, NCR

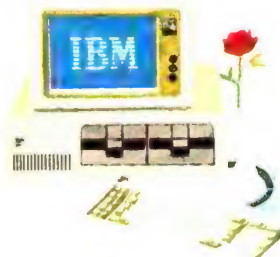
"I looked for a box that could be used to interface different types of terminals and peripherals with the box being able to do the dirty work. I researched five or six companies. BayTech's units — considering sophistication and price — were the best."

Tom Redd, Product Manager -
Engineering & Manufacturing, NCR

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"We use the (BayTech) Multiports with our IBM PCs to expand communications. They're used to control

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Red Karshick, Automation
Engineer/Logic Process
Development, IBM



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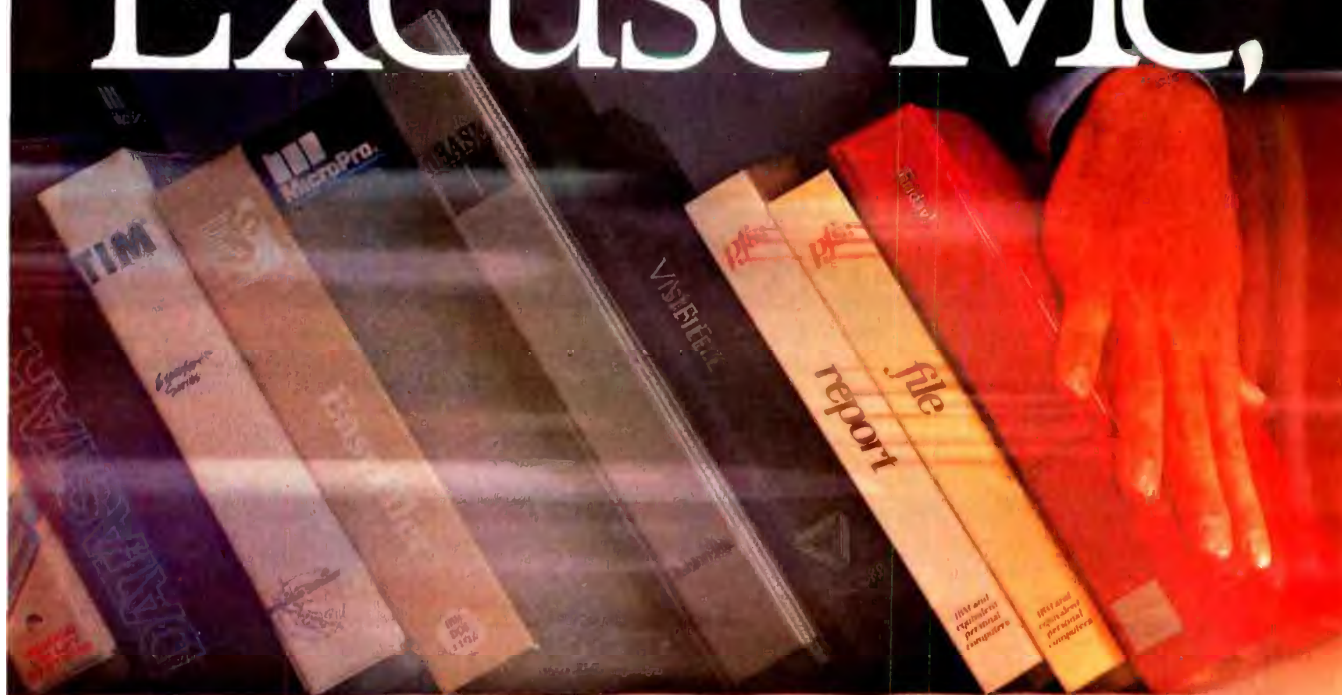
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"Excuse Me,



Make Way For Hayes' Please.

An advanced, easy-to-use data management system for the IBM® PC and compatibles.

Want to get your paperwork out of a clumsy file cabinet and onto your PC's screen, where you can manage it better? Frustrated with data base software that's either too limited or too difficult to use? Hayes offers you a simple word of kindness.

Please.™ A powerful, yet easy-to-use, system for organizing and managing your information. *Please* is flexible enough to store any data you enter, and it'll return data to you in exactly the form you need. *Please* does more.

It does it all faster. And it's sure to please!

"The menu, Please?"

Menus list all your options and tell you exactly which keys to press for every *Please* feature.

That's to be expected. As the telecomputing leader, Hayes built its reputation on quality design, reliability

and customer support. Now these same standards have been applied to a new data management system that is going to instantly change the way you do business!

Say you're looking for an efficient way to maintain sales data. *Please* leads you every step of the way in creating a sales database that might include names, addresses, dates and figures. These categories are called "fields" in database lingo, and they're the very heart of your database structure.

Want last month's total in a particular region? Press a few keys and it's yours! A few more keystrokes and you'll know who's moving product, and what's your biggest seller.

Please will supply you with labels for a mailing to selected customers. It can send customer information to your word processor for a promotional letter. And it can receive data from

your spreadsheet program. *Please* will even look up a name and company for you, your Hayes Smartmodem* will dial the phone number, and you're ready to talk!

Taking this same sales database, you might also want to define special

fields for a custom Output Plan.

With a defined field for "COMMISSIONS DUE,"

Please can automa-

tically compute each salesman's commissions, and print them out in a report of your own design. All this and more, just for saying "Please."

And if you ever change your mind and want to change the structure of your database, please feel free. Step-by-step instructions show you how.

You have the same flexibility with any database you and *Please* design. You can store up to 16 million records and 200 custom Output Plans for each database! More than you're likely ever to require. But isn't it nice

"Make it snappy, Please!"

Need a report fast? You and *Please* can put together a Quick List in a matter of seconds.

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Please™



"Put it here, Please."

Design a special screen format to position data in a particular place.

Just in case you ever need it?

Now you might think that a data management system that does all this must be difficult to use. Right? Rest assured. *Please* works hard so you don't have to. An easy-to-follow sample disk shows you everything you need to know to create your first database. Three *Please* menus show you which keys to press to access every feature. And whenever you need it, *Please* provides on-screen HELP messages, tailored to a specific task. So you needn't waste time reading through a list of unrelated instructions on your screen. Or stop what you're doing to consult a manual. In no time at all, and with no assistance at all, you'll be a *Please* database pro!

knowing all that storage power is there?

"Merge these, Please!"

Combine data from one database into another, without changing your original.

Everything about *Please* is designed to save you time and effort. So what could make data management even easier? *Please Application Templates*, that's what!

To help you get up-and-running immediately, we've developed a series of practical, pre-designed templates. You'll appreciate their well-thought-out structure, and "fill-in-the-blank" ease. Choose several! For business and personal use.

Including *Mailing List*, for storing names and addresses and producing mailing lists. *Contacts*, for man-

aging facts and figures about your sales contacts. *Applicants*, for following applicants throughout the interviewing process. *Appointments*, for maintaining your calendar and tracking all of your business expenses. *Household Records*, a complete home management system. And more! Your dealer has details!

Buy *Please* now! Get a **FREE Mailing List** template from your dealer.

Second **FREE** template of your choice, direct from Hayes!

Help yourself. *Please!* And take advantage of these two valuable offers. See your dealer right away!



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Circle 74 on Inquiry card.

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The IBM Portable Personal Computer



Transportable IBM PC-compatible computers have been around for some time and have taken a slice out of IBM's market, so it was inevitable that IBM would develop a transportable PC. The IBM Portable Personal Computer features a 9-inch amber monitor, a color/graphics monitor adapter, a 360K-byte half-height 5¼-inch floppy-disk drive, seven expansion slots (of which two are already used), 256K bytes of memory, a 130-watt universal power supply for use here or abroad, and a carrying bag for the system unit. It's a fairly complete, self-contained system except for the lack of parallel and serial ports for attaching a printer and modem. These can be added via the expansion slots, but then you have only one full-length slot available. The other four slots will take only half-length cards, of which there are not that many.

The amber monitor with the color/graphics monitor adapter is the only display option unless you connect an external color monitor, because the monochrome display and adapter are not available for the Portable PC. The characters produced by the color/graphics adapter are not as clear as those created by the monochrome adapter, and certain color combinations will produce unreadable text.

Because it uses an IBM PC XT system board, the IBM Portable PC offers the utmost in IBM PC compatibility. The system is well-designed, although it's heavy at 30 pounds.

Name
IBM Portable Personal Computer

Manufacturer
International Business Machines Corporation
Entry Systems Division
POB 1328
Boca Raton, FL 33432
(800) 447-4700

Size
8 by 20 by 17 inches; 30 pounds

Components
Processor: Intel 8088, 4.77-MHz; socket for addition of the 8087 coprocessor
Memory: 40K bytes ROM, 256K bytes RAM standard, 640K bytes RAM maximum with memory-expansion card
Display: 9-inch amber phosphor, built-in monitor; 80 characters by 25 lines
Keyboard: 83-key layout with 10 function keys and numeric/cursor keypad; detachable with 4-foot coil cable; adjustable typing angle
Mass Storage: 360K-byte half-height double-sided 5¼-inch floppy-disk drive
Expansion: Seven expansion slots (two used by floppy-disk drive controller and color/graphics monitor adapter), leaving one full-length slot and four half-length slots

Software
Exploring the IBM Portable Personal Computer. Diagnostics.
Microsoft cassette BASIC interpreter in ROM

Optional Hardware	
64/256K-byte Memory Expansion Card with 64K bytes	\$265
64K-byte Memory Module	\$100
Color Display	\$680
Slimline Disk drive (half-height 5¼-inch floppy)	\$425
Asynchronous Communications Adapter	\$100
8087 Math Coprocessor	\$230
Graphics Printer	\$449
Personal Computer Cluster Adapter	\$400
Personal Computer Cluster cable kit	\$110

Optional Software	
Personal Computer DOS 2.1	\$65
Personal Computer Cluster Program	\$92

Documentation
Guide to Operations. BASIC Reference Manual

Prices	
256K bytes RAM and one half-height floppy-disk drive	\$2595
256K bytes RAM and two half-height floppy-disk drives	\$3020

Circuit-Board-Design Without the Tedium

smARTWORK™ lets the design engineer create and revise printed-circuit-board artwork on the IBM Personal Computer.

Forget tape. Forget ruling. Forget waiting for a technician, draftsman, or the CAD department to get to your project. smARTWORK™ software turns your IBM Personal Computer into a professional, high-quality drafting tool. It gives you complete control over your circuit-board artwork — from start to finish.

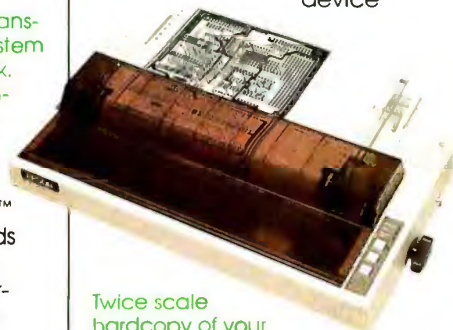


smARTWORK™ transforms your IBM PC into a CAD system for printed-circuit-board artwork. Display modes include both single-layer black and white and dual-layer color.

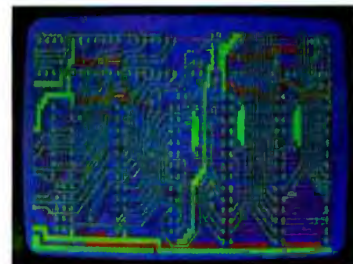
What makes smARTWORK™ so smart is that it understands electrical connections. Conductor spacing is always correct. Lines don't become too narrow, and connecting lines do not intersect other conductors. smARTWORK™ can automatically find and draw the shortest route between two conductors. Or you can specify the route.

smARTWORK™ is the only low-cost printed-circuit-board artwork editor with all these important advantages:

- ☐ Complete interactive control over placement and routing
- ☐ Quick correction and revision
- ☐ Production-quality 2X artwork from pen-and-ink plotter
- ☐ Prototype-quality 2X artwork from dot-matrix printer
- ☐ Easy to learn and operate, yet capable of sophisticated layouts
- ☐ Single-sided and double-sided printed-circuit boards up to 10 x 16 inches
- ☐ Multicolor or black-and-white display
- ☐ 32 user selectable color combinations; coincident points can be displayed in contrasting colors.
- ☐ Can use optional Micro-soft Mouse as pointing device



Twice scale hardcopy of your artwork is produced using the Epson dot-matrix printers or the Houston Instrument DMP-41 pen-and-ink plotter. Quick 1X check plot is also available from Epson printers.



Dual-layer color display of a 2" by 4" section of a 10" by 16" circuit board

The Smart Buy

At \$895, smARTWORK™ is an exceptional value, particularly when compared to conventional engineering workstation costs.

Call or write us for more information on smARTWORK™. We'll be glad to tell you how smARTWORK™ helps us design our own circuit boards and what it can do for your business.

Send a purchase order, or major credit card number, and smARTWORK™ can be working for you next week.

System Requirements

- ☐ IBM PC or XT with 192K RAM, 2 disk drives and DOS Version 2.0
- ☐ IBM Color/Graphics Adapter with RGB color or b&w monitor
- ☐ Epson MX-80/MX-100 or FX-80/FX-100 dot-matrix printer
- ☐ Houston Instrument DMP-41 pen-and-ink plotter (optional)
- ☐ Microsoft Mouse (optional)



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IBM Personal Computer XT/370



The IBM PC XT/370 is actually three systems in one—a workstation for a System/370 mainframe, a 3270-type terminal, and a stand-alone IBM PC XT. When you start the Virtual Machine/Personal Computer (VM/PC) program on the XT/370, you can run most Conversational Monitor System (CMS) programs from a System/370 that will fit into the XT's 4-megabyte virtual-memory space. Uploading and downloading files is supported, as is emulation of a 3277 display terminal. Both these modes require a 3274 control unit connected to the coaxial cable to the mainframe. VM/PC files are stored in the CMS format on disk, but these can be converted from and to PC-DOS format with the CMS Import and Export commands. Most IBM PC hardware options will work with the XT/370 running under VM/PC, and if not (as in the case of the 8087 math coprocessor and the communications adapters), you can use them in the PC mode when not running VM/PC. Switching the XT/370 between these three modes usually requires only two keystrokes.

The XT/370 is made from a standard IBM PC XT with three additional cards. The first card contains three separate processors that execute most System/370 instructions. Two Motorola 68000 microprocessor chips, one standard and the other a custom IBM chip based on the 68000, execute most System/370 fixed-point and non-floating-point instructions. The third microprocessor, a modified Intel 8087, executes System/370 floating-point instructions and contains the floating-point registers.

A second card has 512K bytes for memory expansion, giving you the maximum 640K bytes of usable memory for the PC mode and 480K bytes for System/370 storage in VM/PC mode.

Name

IBM Personal Computer XT/370

Manufacturer

International Business Machines Corporation
Information System Group
900 King Street
Rye Brook, NY 10573

Size

5½ by 20 by 16 inches

Components

Processors: Intel 8088, Motorola MC 68000, Custom IBM/Motorola MC 68000, Custom Intel 8087
Memory: 40K bytes ROM, 768K bytes RAM standard; 640K bytes are addressable in the PC mode, 480K bytes in System/370 mode
Display: 3277 Model 2 emulation card standard
Keyboard: 83-key layout with 10 function keys and numeric/cursor keypad; detachable with 6-foot coil cable; adjustable typing angle
Mass Storage: 360K-byte double-sided 5¼-inch floppy-disk drive and 10-megabyte fixed-disk drive
Expansion: Eight expansion slots, six full-length and two half-length; five slots are already used

Software

Diagnostics, Microsoft cassette BASIC interpreter in ROM

Optional Hardware

Monochrome Display	\$275
Monochrome Display and Printer Adapter	\$250
Color Display	\$680
Color/Graphics Monitor Adapter	\$244
Disk drive (5¼-inch floppy disk)	\$425
Asynchronous Communications Adapter	\$100
8087 Math Coprocessor	\$230
Graphics Printer	\$449
XT/370 Expansion Unit	NA
XT/370 Option Kit for IBM PC XT	NA

Optional Software

Personal Computer DOS 2.1 (with Advanced Disk BASIC)	\$65
Virtual Machine/Personal Computer Program	\$1000

Documentation

Guide to Operations PC XT, Guide to Operations PC XT/370, BASIC Reference Manual

Prices

XT/370 Model 568 with one floppy-disk drive (requires XT/370 Expansion Unit)	\$6230
XT/370 Model 588 with one floppy-disk drive and one fixed-disk drive	\$8085

A NEW WORLD OF SIGNAL PROCESSING FOR THE IBM® PC.



Discover ILS-PC™1. All the most needed programs in one convenient software package.

It's here. True signal processing on the IBM PC. It's called ILS-PC 1, and was developed from our mini-computer ILS, the world standard in signal processing software.

ILS-PC 1 enables you to do signal processing *now* on your own IBM PC or XT. Without writing programs. Without a lot of time or effort. When used with the 8087 coprocessor, it

performs at minicomputer speed.

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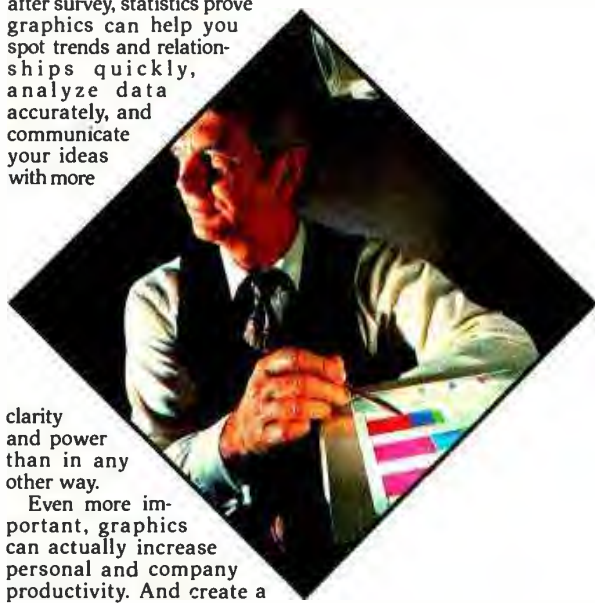
How HP business graphics



Enhance your reputation for being more professional, persuasive, credible and effective than your competition with the new HP 7475A Business Professional's Plotter.

Make a first impression that lasts

The vital importance of graphics to today's business professional cannot be overstated. In survey after survey, statistics prove graphics can help you spot trends and relationships quickly, analyze data accurately, and communicate your ideas with more



clarity and power than in any other way.

Even more important, graphics can actually increase personal and company productivity. And create a first impression of quality and professionalism that lasts and lasts.

Graphics: the end to meetings that go nowhere

In a fascinating research project conducted by The University of Pennsylvania, 123 MBA candidates were involved in a study designed to test the effectiveness of business graphics in meeting situations. The results were startling. In the group where visual aids were used:

- **Meetings were shorter:** The study showed a 28% reduction in meeting length when transparencies were used.
- **Group consensus was faster:** Agreement was reached by 79% of the group using transparencies, compared with only 8% among the control group using no visual aids.
- **The decision process was accelerated:** 64% of study participants said they made their business decisions *immediately after the visual presentation*. When overheads were not used, the control group said they delayed decision-making until *some time after the group*

discussion following the presentation.

- **Presenters with visual aids were perceived as being more professional, persuasive, credible and effective than those not using visual aids.**

Now, with the new HP 7475A Business Professional's Plotter, your meetings can have immediate and productive results like these.

How the quality look of HP graphics can help

The way you present your information can be equally as important as the actual information you're presenting. And that's where the new HP 7475A Business Professional's Plotter lets your professionalism shine through.

Standards unsurpassed in the plotter business

The technical standards of the HP 7475A have no equal for producing quality graphics. With a resolution of one-thousandth-of-an-inch, curved lines are smooth, not jagged, and straight lines are *consistently* straight. Its exceptional repeatability (the ability of a pen to return *precisely* to a given point) assures that intersecting lines and circular shapes will meet *exactly*. The result is *high-quality* charts and graphs you'll be proud to present.

Why 6 pens when experts say 4 will do?

Graphics industry experts maintain that good graphics contain four colors per chart. But Hewlett-Packard goes the experts two better by providing a six-pen carousel, so you can store and use pens of different widths—thick pens for bold headings and thin pens for details. And with six pens, you won't have to waste valuable time changing them. That's important when "the boss wants to see your presentation in twenty minutes!"

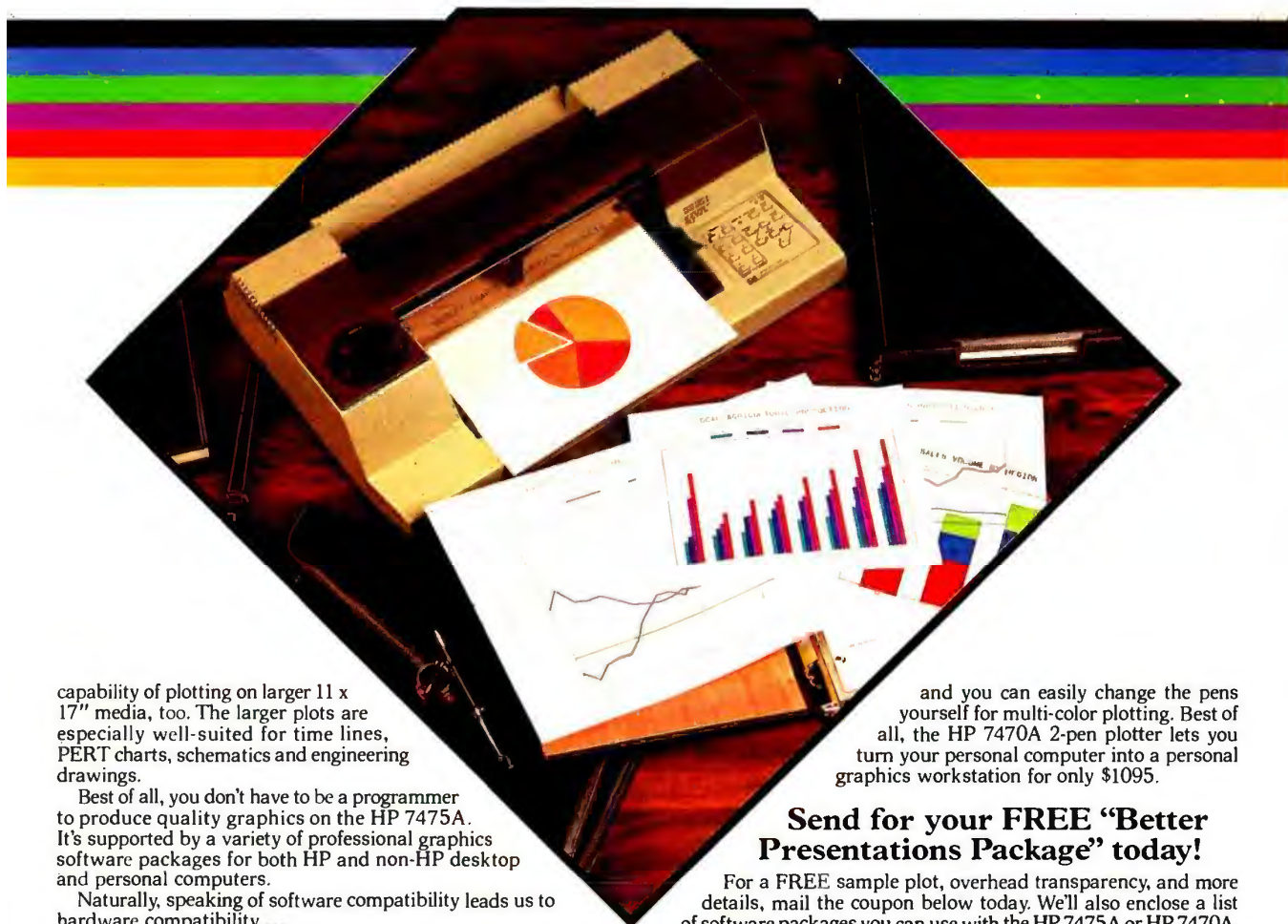
With the HP 7475A, you also get automatic pen capping to prevent pens from drying out between uses, and special "pen damping" (gently lowering the pen to the paper or transparency) to increase pen life and ensure better line quality... use after use after use. You also get a rainbow of 10 colors to choose from, in two line widths.



Your choice: 2 paper sizes and today's most popular graphics software packages

While most professional business applications will be satisfied with standard 8½ x 11" paper or transparencies, the HP 7475A adds the

can be the key to your success.



capability of plotting on larger 11 x 17" media, too. The larger plots are especially well-suited for time lines, PERT charts, schematics and engineering drawings.

Best of all, you don't have to be a programmer to produce quality graphics on the HP 7475A. It's supported by a variety of professional graphics software packages for both HP and non-HP desktop and personal computers.

Naturally, speaking of software compatibility leads us to hardware compatibility...

and you can easily change the pens yourself for multi-color plotting. Best of all, the HP 7470A 2-pen plotter lets you turn your personal computer into a personal graphics workstation for only \$1095.

Send for your FREE "Better Presentations Package" today!

For a FREE sample plot, overhead transparency, and more details, mail the coupon below today. We'll also enclose a list of software packages you can use with the HP 7475A or HP 7470A.

Compatible with almost any personal computer in the marketplace today

With two interfaces available, the HP 7475A quickly "makes friends" with most models of today's most popular personal computers, including IBM® Apple™ Compaq™ Osborne® and Commodore™ --as well as a host of HP computers.

The cost? Surprisingly affordable

The new HP 7475A Business Professional's Plotter is an amazingly affordable \$1895. When you consider that a typical fee for a single five-color transparency from a graphics service is \$50—and that the same transparency can be prepared for about \$1 in materials on the HP 7475A—the return on your investment is almost immediate.

Another choice: HP's low-cost, high performance Personal Computer Plotter

For the "business on a budget," you may also want a look at our 2-pen Personal Computer Plotter, the 7470A. Its low cost (only \$1095) is as remarkable as the quality of its plots. With many of the same features as the new HP 7475A, the HP 7470A plots on a single paper size (8½ x 11"). It stores and caps two pens,

For the name of your nearest Hewlett-Packard dealer call toll-free 800-547-3400.

1101303



YES! I'm ready to gain a reputation for being more professional, persuasive, credible and effective than my competition. Please send me your FREE "Better Presentations Package," so I can learn more about the new HP 7475A Business Professional's Plotter and the HP 7470A Personal Computer Plotter. I understand I will receive this valuable package without cost or obligation.

Name _____ Title _____
 Company _____
 Address _____
 City/State & Zip _____
 Phone Number (____) _____
 My computer is _____

Send to: Hewlett-Packard
 16399 W. Bernardo Drive, San Diego, CA 92127
 Attn: Marketing Communications

11303 8T/8M GUIDE

The IBM 3270 Personal Computer



The IBM 3270 Personal Computer, another in the "workstation" family of PCs, lets you communicate with host computers such as IBM 43XX or 308X series processors, or to work locally in a personal computing session. The 3270 PC can display information in up to seven user-definable windows, including four host windows, one PC-DOS window, and two electronic notepads, all on a high-resolution color display. You need a 3274 control unit to run more than one host computer session at a time, multiplexing four cables to one or more remote mainframes into a single connection to the 3270 PC. Windows can be moved and adjusted easily; a single keystroke takes you from personal computing to host sessions. You can store the layout of windows on the screen in a "profile" and call it up with a few keystrokes. An autokey function can record a sequence of keystrokes, simplifying logging onto multiple sessions.

The 3270 is available in several configurations with different displays, amounts of memory, and mass storage. Most people will choose the inexpensive 5272 color display or 5151 monochrome display. Sophisticated graphics are available with the 3270 PC/G and GX systems and their larger, very high-resolution color displays with up to 960 by 1000 pixels and 16-color resolution.

Name

IBM 3270 Personal Computer

Manufacturer

International Business Machines Corporation
Information Systems Group
900 King Street
Rye Brook, NY 10573

Size

5½ by 20 by 16 inches; 33 pounds

Components

Processor: Intel 8088

Memory: 40K bytes ROM, 256K bytes RAM standard, 640K bytes RAM maximum with memory-expansion card

Keyboard: 122-key layout including function keys for both 3270 and PC functions and a numeric/cursor keypad; detachable with 6-foot coil cable; adjustable typing angle

Mass Storage: 360K-byte double-sided 5¼-inch floppy-disk drive

Expansion: Eight expansion slots (several already used by various adapters)

IBM 3270 PC

5271 Model 2: System Unit with 256K-byte memory, one floppy-disk drive and adapter, 5151/5272 display adapter, 3270 PC keyboard/timer adapter, 3270 system adapter \$3785

5271 Model 4: Model 2 features plus second floppy-disk drive, 64/256K-byte memory-expansion option with 64K bytes, parallel printer adapter \$4650

5271 Model 6: Model 2 features plus one 10-megabyte fixed-disk drive and adapter, 64/256K-byte memory-expansion option with 64K bytes, parallel printer adapter \$6210

5272 Color Display (14-inch, eight-color, 720 by 350 pixels) \$995

All-Points-Addressable Graphics Adapter \$550

Host Graphics Adapter \$800

3270 PC Control Program \$300

3270 PC File Transfer Program \$600

IBM 3270 PC/G and GX

5371 Model 12: System unit with 384K-byte memory, one floppy-disk drive and adapter, 3270 system adapter, parallel printer adapter, and mouse tablet/adapter \$4130

5371 Model 14: Same as Model 12 except for 512K-byte memory and two floppy-disk drives \$4755

5371 Model 16: Same as Model 12 except for 576K-byte memory and 10-megabyte fixed-disk drive and adapter \$6580

5371 Keyboard \$295

5279 Color Display (14-inch, eight-color, 720 by 512 pixels) \$1600

5278 Display Attachment Unit \$3060

5379 Color Display (19-inch, 16-color, 960 by 1000 pixels) \$3600

5379 Monochrome Display (19-inch, four shades, 960 by 1000 pixels) \$2750

5378 Display Attachment Unit (color) \$8310

5378 Display Attachment Unit (monochrome) \$7810

5277 Mouse \$340

Optional Hardware

5151 Monochrome Display \$275

5152 Graphics Printer \$449

5182 Color Printer (dot-matrix) \$1995

3852 Color Printer (seven-color ink-jet) \$900

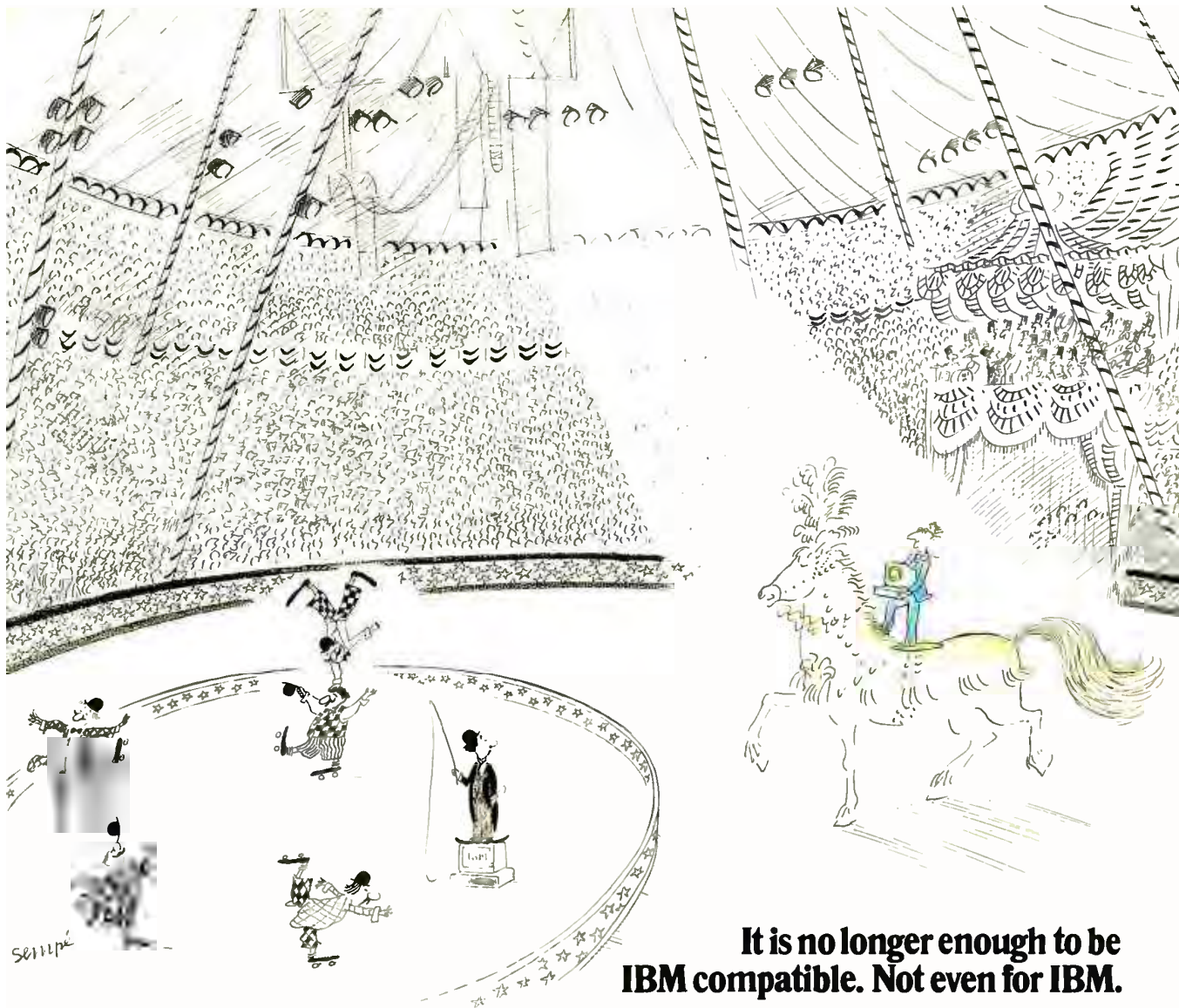
Documentation

Guide to Operations, Reference Manual, Maintenance Information

Prices

3270 PC/G minimum configuration \$9535

3270 PC/GX minimum configuration \$16,785



It is no longer enough to be IBM compatible. Not even for IBM.

It was the personal computer circus. And it had gone on too long.

The crowd grew restless as each new act continued to perform varying degrees of IBM compatibility.

Suddenly, the crowd gasped. It was the unexpected finale — the arrival of Sperry, with a performance no one could have imagined possible.

Ladies and gentlemen, it was the Sperry PC. It ran IBM compatible software.

But that wasn't the show stopper.

Because it soon became quite clear the Sperry PC didn't just *run* the IBM programs, it ran them *better*.

Better because it ran them faster — up to 50% faster.

It ran them with breathtaking graphics, far more dramatic than the IBM PC could provide.

And it ran them from a keyboard that drew roars of approval, for it was not only easier to operate, but far more comfortable than IBM's.

And as the crowd cried out for more, that's just what Sperry gave them: the ability to plug right into a company's main computer, whether that system was IBM or Sperry. Or both.

As the crowd sat stunned by this final flourish, Sperry left all with a most provocative question. Was it possible

that the Sperry PC could do all of this and yet cost less?

Again, the crowd gasped. Could it be?

Come see for yourself. Hands-on, side-by-side. Call 800-535-3232, toll-free. Or write us. Sperry Corporation, Computer Systems, Department 100, P.O. Box 500, Blue Bell, PA 19424-0024.

SPERRY PERSONAL COMPUTER SPECIFICATIONS

OPERATING SYSTEM MS DOS Version 1.25 or 2.0 with G.W.	KEYBOARD 84 keys, 6 ft. cord
BASIC MICRO-PROCESSOR High-Speed 16-bit 8088	AUXILIARY MEMORY Up to two internal 5 1/4" diskettes 10MB
DISPLAY SCREENS High Definition monochrome display	INTERNAL FIXED DISK when configured with single diskette.
IBM compatible graphics.	USER MEMORY Standard 128K bytes, expandable to 640K
COMMUNICATIONS Built-in Asynchronous	DIAGNOSTICS Power-on self test
	CLOCK Time-of-day with battery back-up

SPERRY



The Sperry PC.
What the personal computer should have been in the first place.

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Circle 168 on inquiry card.

Fall 1984 • BYTE Guide to the IBM PC • 25

IBM System 9000



The IBM System 9000 is designed to automate the laboratory as the IBM PC automated the office. For data acquisition, data analysis, and instrument control, the S9000 has a wide range of interfaces: three RS-232C ports, a bidirectional 8-bit parallel port, an IEEE-488 port, three timers, a clock, 32 programmable interrupts, and four DMA channels. The system includes a real-time, multitasking operating system (CSOS) that can simultaneously collect data, store or process it, analyze collected data and display it on the screen, output data to the printer/plotter, or transmit the data to other computers for analysis.

The S9000 comes in two versions—one for the lab, one for the office. The IBM 9001 benchtop model holds the computer, a display, and multicolor printer/plotter in a vertical package that occupies little space. The IBM 9002 is a smaller system with cleaner lines for your desktop. The XENIX operating system (a version of UNIX) is also available for multiuser, multitasking applications in which real-time control is not as critical. You must configure the system with a hard-disk drive, a memory-management card, 640K bytes of memory, and one 8-inch floppy-disk drive in order to run XENIX. Files can be transferred between the two operating systems.

The large membrane keypad with 57 user-programmable keys helps automate laboratory applications by defining single-keystroke commands to control instruments. Keypad overlays let you clearly label the keys. ■

Name

IBM System 9000

Manufacturer

International Business Machines Corporation
IBM Instruments Inc.
Orchard Park
POB 332
Danbury, CT 06810

Size

7 by 18 by 22 inches; 64 pounds

Components

Processor: Motorola 68000, 8-MHz; with four DMA channels
Memory: 128K bytes ROM, 128K bytes RAM standard, expandable to 5.2 megabytes in 256K-byte increments
Processor Board Interfaces: Three RS-232C, one bidirectional 8-bit parallel, one IEEE-488
Display: 12-inch green-phosphor 768- by 480-pixel screen; 80 characters by 30 lines; 10 user-definable keys below screen
Keyboard: 83-key layout with 10 function keys and numeric/cursor keypad; 57-key pressure-sensitive keypad; detachable with 6-foot coil cable
Mass Storage: Optional 640K-byte 5¼-inch or 985K-byte 8-inch floppy-disk drive
Expansion: Optional, five slots on a system bus card

Software

Real-time, multitasking Computer System Operating System (CSOS); diagnostics

Optional Hardware

256K-byte Memory Expansion Card	\$1395
1024K-byte Memory Expansion Card	\$3180
Dual 5¼-inch floppy disks	\$1645
Dual 8-inch floppy disks	\$2470
10-megabyte hard-disk drive	\$2195
Hard-disk controller card	\$1295
Memory-management card	\$1495
Analog sensor card	\$1695
Color Printer	\$1995

Optional Software

CSOS Extensions	\$155
BASIC Interpreter	\$195
Pascal Compiler	\$595
FORTRAN Compiler	\$595
Chromatography Application Program	\$795
XENIX Operating System	\$995

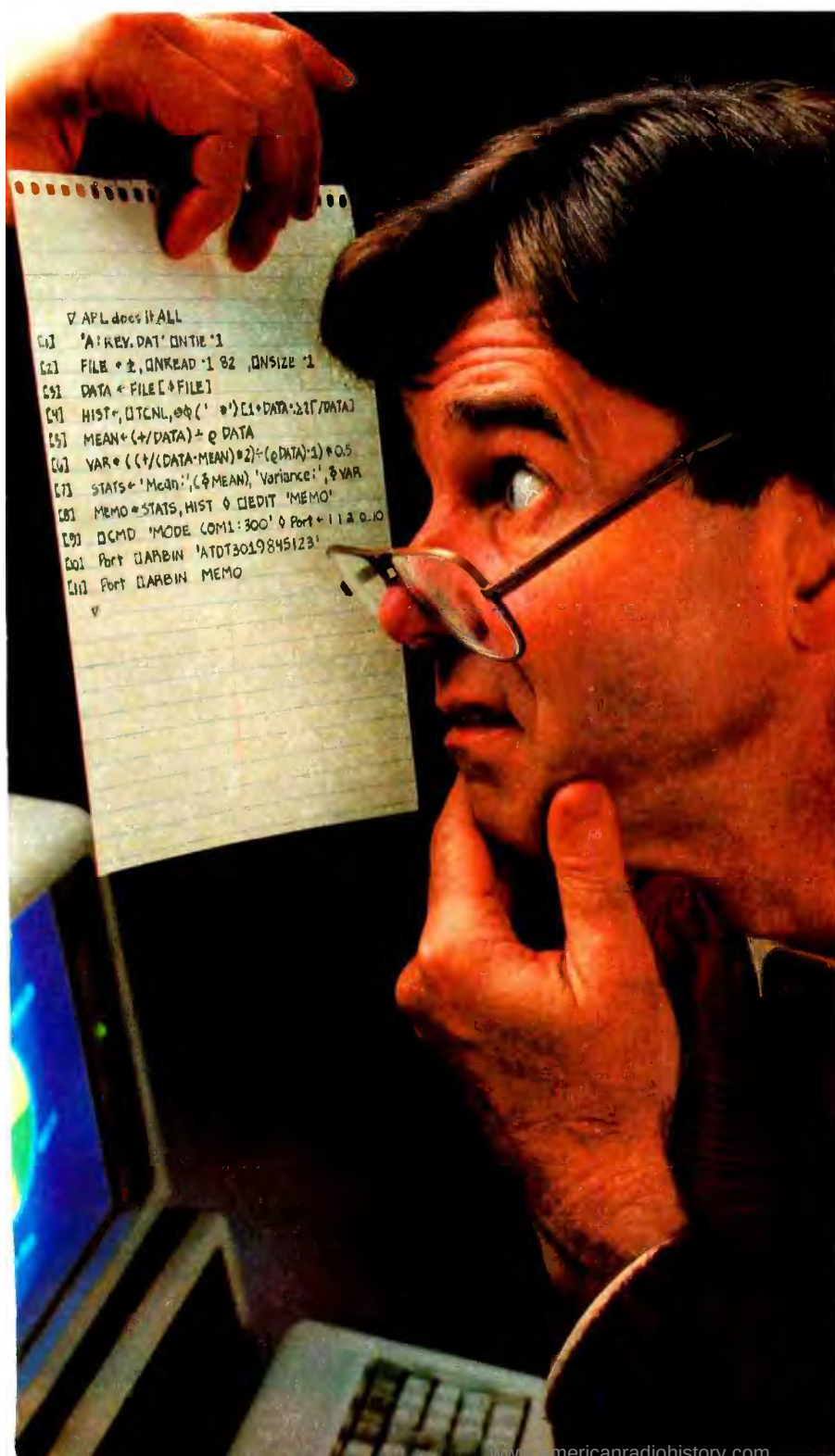
Documentation

Operator's Manual, OS 1.1, Problem Isolation Manual, BASIC Manual

Prices

9001 Benchtop Computer	\$6495
9001 Benchtop Computer with printer/plotter	\$8590
9002 Desktop Computer	\$6495

Tell this to your PC and see what happens.



No, it won't roll over and play dead. While the funny-looking symbols might not make immediate sense to you, to a PC equipped with STSC's APL*PLUS®/PC System they tell an amazing story. In just 11 lines this program describes a sequence of events that can't be accomplished by any other single software package.

The program is written in an application development language called the APL*PLUS/PC System. Briefly, here's what it does. First, it sorts a DOS file containing revenue data and plots the revenues as a histogram. It calculates mean and variance revenues. Then with the help of a full-screen editor, it creates a memo combining the histogram, statistics and descriptive text. Finally the program issues a DOS command to the PC, dials a host computer, and electronically mails the memo. All in just 11 lines. No wonder a *PC Magazine* reviewer reacted to our APL*PLUS/PC System with "awe and delight" (March 1983).

If you want to integrate existing software or create custom solutions to problems that can't be handled by the software you're currently using, you need the APL*PLUS/PC System. It costs \$595.00, and runs on the IBM PC with 192 KB of RAM as well as on a number of compatible machines.

To order the APL*PLUS/PC System see your local dealer or contact STSC, Inc., (800) 592-0050, 2115 East Jefferson Street, Rockville, Maryland 20852.

STSC

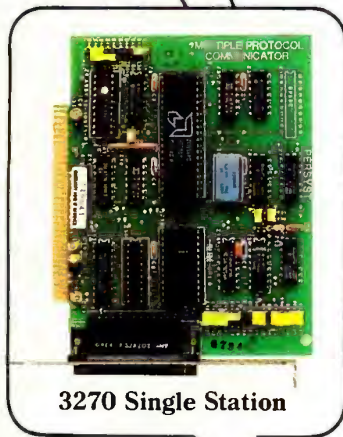
A Contel Company

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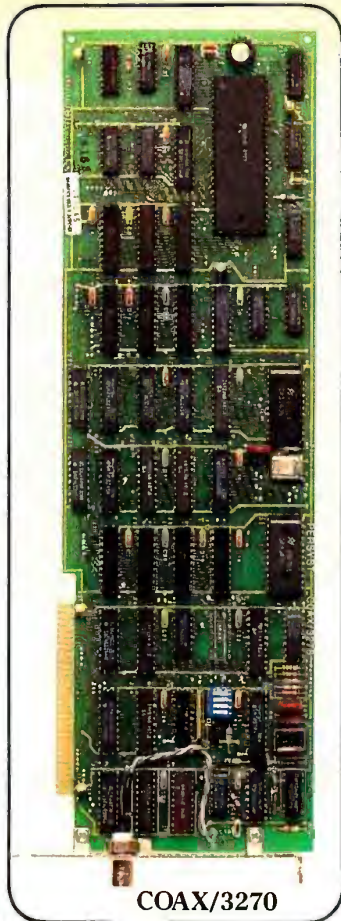
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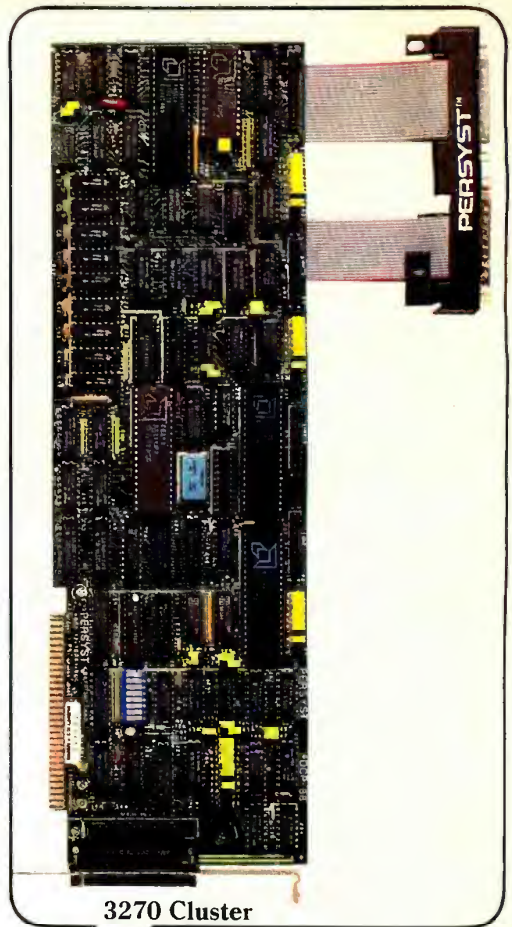
SNA/Bisync



3270 Single Station



COAX/3270



3270 Cluster

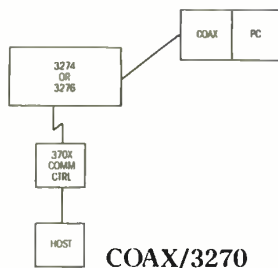


RJE Workstation



Let Persyst get your IBM PC talking to your mainframe, because we have more to talk about.

We have a full range of communication solutions to talk about. That's why Persyst is your single source for the most flexible, the most cost efficient ways to tie your IBM PC to your mainframe computer.



For instance, one solution is our Coax/3270. This single-slot expansion board lets you connect your IBM PC directly into virtually any IBM 3270 environment. And with our 3278/79 emulation software, it's easy to share information between your mainframe and IBM PC.

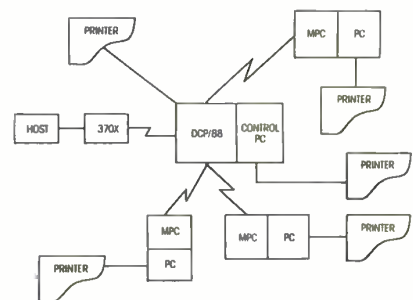
And that's just the start. Persyst has other solutions that will help you incorporate your IBM PC into almost any IBM communications environment, including SNA or Bisync.

With our DCP/88 and our Multiple Protocol Communications controller (MPC), you can create a sophisticated, remote, multi-user 3270 environment. One that can support up to nine devices, including five printers and four PCs functioning as 3278/79 display stations. Or, use either the DCP/88 or MPC to configure 2780/3780 or HASP RJE workstations.

Because Persyst's communication solutions are built on powerful software-controlled multiple protocol hardware, you'll have maximum configuration flexibility. And this means you'll be able to modify your communication strategies as your needs change — without constantly reinvesting in new hardware. It's your guarantee for the future.

And when you're ready to talk about quality and reliability we have plenty to say about that, too. All Persyst products are submitted to one of the most stringent testing and quality assurance programs in the industry. We're so confident in our quality and reliability that we back our products by a 2-year warranty.

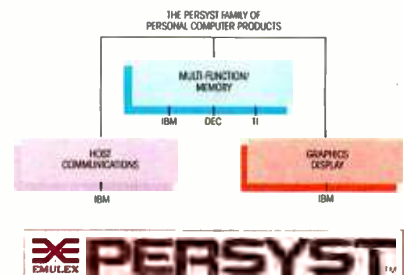
So if you're looking for flexible, low cost and reliable solutions for IBM PC to mainframe communications, talk with Persyst. But be



Cluster Controller

prepared to spend some time, because we have lots to talk about.

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Insist on Persyst.



IBM F ■ REC ■ ST

MARK ■ ■ DOMINANCE

IBM's array of follow-up products and enhancements for the PC means it is here to stay

During 1983, IBM shipped more than 600,000 PC and PC XT microcomputers, making the microcomputer division one of the most startling success stories in IBM's long history. IBM's introduction of low-end computer products has changed the way the corporation approaches the marketplace. Their success will continue to alter Big Blue's development in years to come.

Follow-up products from the corporation's Entry Systems Division in Boca Raton, Florida, and products developed in concert with that division by IBM's Raleigh, North Carolina facility and Endicott, New York operation (the 3270 and XT/370, respectively) indicate that IBM will continue to devote impressive resources to both software and hardware in low-priced computing packages.

Strategic Inc., a high-tech research and market-analysis firm located in San Jose, California, set out to compile user reactions to IBM's new PC from those businesses across the country that have purchased one or more units. *IBM PC User Reactions, Requirements and Plans—1984*, completed in December 1983, also speculates on how businesses will use these computers in the future.

IBM's PC line now includes six products: the original IBM PC, the IBM PC XT, the PCjr, the PC Portable, the 3270 PC, and the XT/370.

Michael Killen (POB 2150, Cupertino, CA 95015-2150) is president of Strategic Inc.

BY MICHAEL KILLEN

THE 16-BIT STANDARD

The 16-bit IBM PC is a flexible, dependable, expandable personal computer with an Intel 8088 central-processing unit, an 8-bit data bus, and one or two 5¼-inch, single- or double-density floppy disks. Its bit-mapped graphics display comes in monochrome or color, and its PC-DOS (disk operating system), a variant of Microsoft's MS-DOS, is now the standard among 16-bit operating systems for personal computers.

The PC and the XT are architecturally identical: PC programs run without modification on the XT, and any PC board can be plugged into the XT. However, the XT, which contains more slots and a larger power supply, is capable of supporting more peripherals and memory. The XT is configured with both a 5¼-inch floppy disk and a 10-megabyte hard disk.

The IBM PC is exceptionally well constructed and provides an excellent diagnostics package that allows customers to

isolate problems. Most microcomputer companies do not provide such a package. It is a reflection of IBM's long-term customer-oriented philosophy.

IBM's personal computer was one of the first to provide "bit-mapped" graphics, meaning that each pixel on the display monitor is represented by a single bit in memory, with specialized hardware to translate the memory "image" into TV signals to drive the monitor. To update any point on the screen, a programmer need only set the appropriate bit in memory. Bit mapping is inexpensive and critical for the "window" features in advanced software.

The Intel 8088 processor provides slightly less arithmetic power than a 4-mHz Z80 by Zilog. However, the 640K-byte maximum address space of the PC allows many significant programs to be run without swapping code or data segments. This often improves performance considerably because disk

(continued)

User Reactions

Strategic Inc. surveyed 70 large companies that currently use both the IBM PC and at least one mainframe and 100 smaller companies that use the IBM PC and some other mini- or microcomputer.

Strategic's findings confirmed several theories on IBM strategies. According to Strategic, IBM has maintained control of its mainframe customers, dissuading most from adding non-IBM equipment. Further, the December 1983 study found that most mainframe customers are using their PCs in conjunction with their mainframes; ultimately, this habit will increase IBM's mainframe revenues.

Specifically, the study found that the large organizations interviewed had an average of 21 IBM PCs installed; the smaller companies had an average of six. According to the survey results, most of the larger companies consider the standard to be IBM products rather than microcomputers from Apple.

The conclusions Strategic reached in its study are as follows:

- Purchase, installation, training, and service are mainly handled by the data-processing departments of large organizations.
- Training is not yet taken very seriously, with most users being self-

taught. Many respondents don't think this is adequate.

- Most of the actual users of IBM PCs are middle managers in both large and small organizations.
- Large organizations purchase more complete systems than smaller companies, with more than 70 percent of these configured with two floppy-disk drives or 10-megabyte hard-disk drives.
- Large and small users cite more than 30 different primary applications for their PCs. Spreadsheet and financial applications are the most common.
- Most users are not developing applications software themselves. Of those who are, BASIC is the most popular language, followed by Pascal and FORTRAN.
- Only 12 percent of the large organizations sampled use a LAN (local-area network), of which only two are standard networks (Corvus and 3COM). The majority of large users are actively considering purchasing a LAN, or will do so in the foreseeable future.
- Approximately two-thirds of the large users use IBM 3270 emulation to access other systems. For one-fourth, the PC is mainly used as a terminal, with another one-

third using both terminal and PC capabilities. One-third use or want to use remote-job-entry capability.

- Most large users need to access IBM mainframes from the PC. Most small users need to access some other computer system.
- Sharing files is the most common reason cited for wanting multiuser versions of a PC.
- Most systems in both large and small companies are shared by at least two different users, and most users have some file-sharing requirement, making a multiuser version of the PC desirable.
- Most small and large organizations are satisfied with their IBM PCs, most citing increased speed, efficiency, quality, and lower cost work as reasons.
- Large organizations in the sample expect to buy at least 32 PCs each during the next year. Sixty percent of the large user organizations plan to make one brand of personal computer standard, and two-thirds have chosen IBM products. Nine percent have chosen Apple.
- Half of the large users expect to buy at least 25 percent more XT systems. Almost 20 percent state they would buy only XT systems.

\$2,490

Great Lakes offers you add-on storage and tape back-up at an unforgettably attractive price

So you're about to outgrow the storage capacity of your IBM PC™ or compatible computer? And now you're biting your nails over the cost of adding more bytes.

No need! Consider the eminently memorable combination price of the Great Lakes Superior 10™ hard disk subsystem and the Great Lakes Quartermaster 23™ tape back-up module.

The Superior 10—\$1495

Not only is our \$1495 price considerably lower than the nearest 10-megabyte competitor, but we offer the best dollar-per-megabyte ratio for the 23mb and 40mb subsystems as well. The ratios? 10mb at \$149 per mb; 23mb at \$98 per mb (retail \$2249); 40mb at \$70 per mb (retail \$2795).

Quartermaster 23—\$995

This optional 23mb tape back-up module is simple to use and efficient as well. Take, for example, our remarkable Selecta-File™ feature. This ¼-inch tape drive module allows you to back up and restore data using selective file-by-file data transfer (or full streaming). And it masters all this for just \$43 per megabyte.

Complete and ready-to-use

When you buy a Superior hard disk subsystem, everything is there, ready to operate at high speed. This includes: high quality fixed hard disk, controller board, software that runs on DOS 1.1 and 2.0 (CP/M 86™ and other operating systems available), host adaptor board, integral power supply, cables, external custom chassis with additional space for our tape back-up, and documentation.

Our line is expansive, not expensive

Need even more storage for your IBM PC or compatible? We offer hard disk subsystems including 65, 110 and 140mb—all designed for superb quality at the very lowest possible prices. And we stand behind all our products with our 90-day warranty. That's because our quality lives up to our first name.

Available at leading dealers everywhere



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The Ven-Tel Half Card.TM

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The Ven-Tel Half CardTM is the only internal 1200/300 baud modem that fits in the small expansion slots of the IBM-XT and the IBM Portable.

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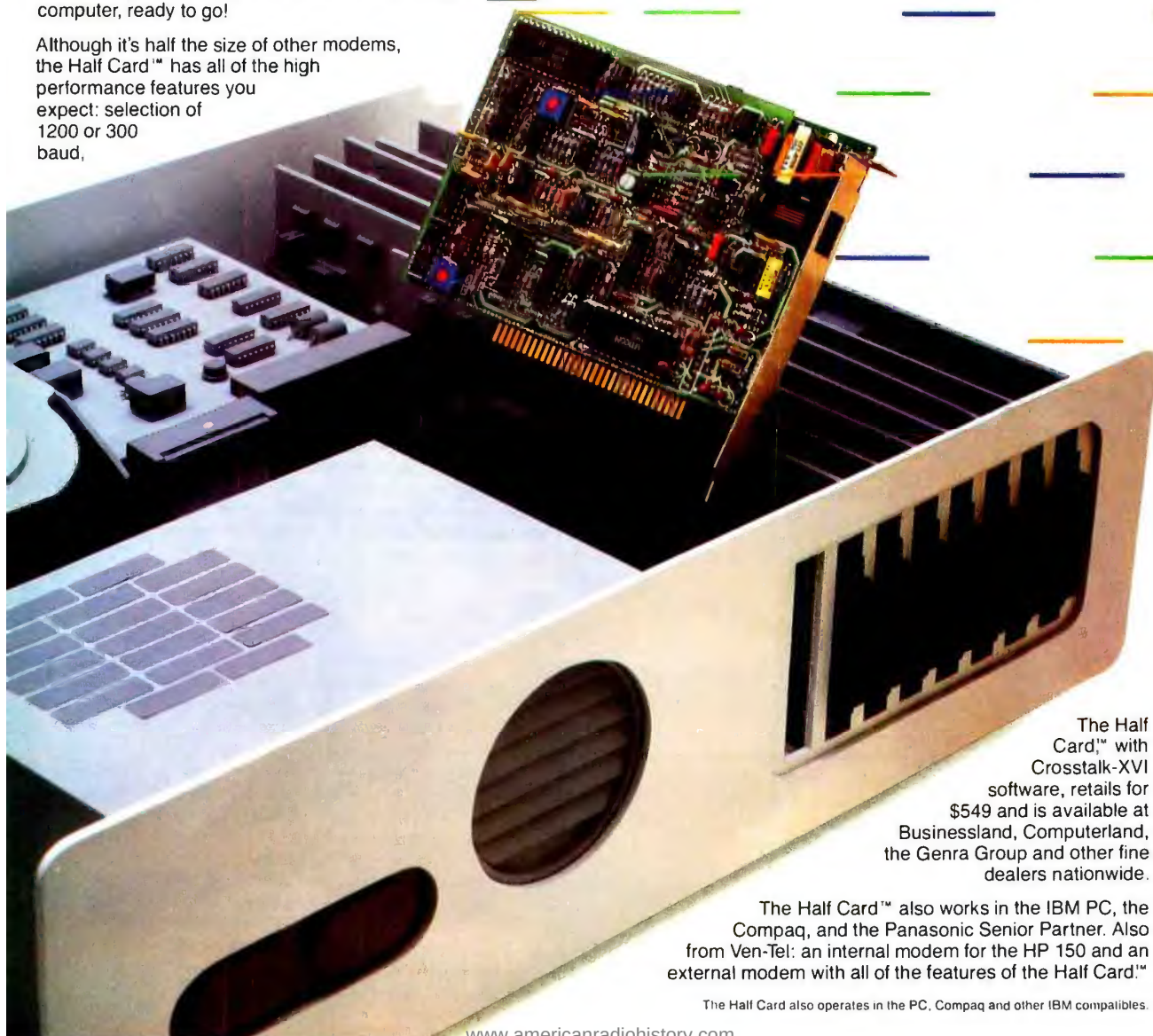
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I/O (input/output) is always time consuming. For instance, on a Z80 even a word processor such as WordStar requires code overlays, and relatively small files must be shuffled to and from the disk. On an IBM PC, the entire program can be resident in memory simultaneously, in addition to very large files.

While 640K bytes of address space is a great improvement over available microcomputer RAM (random-access read/write memory), it is only two-thirds of the 1-megabyte address space available to the 8088 chip. Unfortunately, Microsoft's BASIC Interpreter and the PC disk operating system consume the remaining 360K bytes of memory. Although the remaining memory is adequate for most of today's microcomputer programs, the limit prevents the PC from running large programs, keeping several programs in memory at once, or storing a large amount of data in memory. Each limitation reduces the effectiveness of IBM's PC in some applications and will slow the development of more sophisticated software.

Further, the 8088's 8-bit I/O and memory data bus limit the speed of communication between the PC and its disks or other peripherals to 8-bit levels.

IBM's own feature-by-feature comparison of price and performance shows the PC to be markedly inferior and higher priced than most equivalent systems from other companies. The system is not being sold on either point, but rather as the standard from a corporation that provides strong support, demonstrating, once again, IBM's hegemony in the computer market.

THE IBM 3270 PC

The 3270 PC embodies several IBM tactics. First, it allows IBM to push ahead in the personal computer market and yet maintain its mainframe products at the center of a client's information-processing needs. Second, it bolsters the data-processing department's role in information processing. This is important because IBM's main customers are data-processing managers, not office-automation managers.

Further, the advent of the 3270 PC enhances and protects a line of IBM products (3270/3274) that is now 12 years old. The 3270 PC may be the first step in upgrading the 3274 product. For instance, IBM may merge the 3274 and the yet-to-be-announced local-area network product, or it may use the 3270 PC's program capability to enhance mainframe control of terminals and provide such features as teletext and distributed graphics systems.

Before the advent of the 3270 PC, it was possible to argue that mainframes and their traditional data-processing functions were destined to be overlapped and possibly even superseded by information-processing functions performed by integrated networks of PCs and small multiuser systems. IBM has negated this argument by increasing the capabilities of its mainframes through the integration of more business microcomputer functions. Thus, the information processing functions of business microcomputers are dependent upon the existence and expansion of a mainframe.

The 3270 PC is a superset of the functions of the IBM PC and the IBM 3270 terminal. As a 3270 terminal, it hooks into any of the 3274 control units or serial I/O ports on the various IBM mainframe computers. As a PC, the system provides various configurations comparable to the IBM PC or XT.

IBM has added new functions to this combination, the most

important being the simultaneous display and manipulation on the screen of as many as four "documents" (files or data developed within a program). This kind of integration distinguishes the 3270 PC from a PC with a 3270 emulation adapter.

The 3270 PC will appeal to three classes of customers who currently own IBM mainframes: those who have many management and technical personnel who currently use the mainframe and use, or wish to use, PC functions; microcomputer (and not just IBM PC) users who need to access mainframe data in the course of their work with the microcomputer; and IBM PC users who can't wait for IBM to support the multi-window capabilities on the IBM PC.

Strategic Inc. believes there are many such users. However, even if there were not, IBM has positioned this product to strengthen both the IBM PC and its mainframe lines of equipment.

The 3270 PC multitasking window capabilities represent an entirely new dimension for both the IBM PC and mainframe products. Comparable single-user, stand-alone systems are Apple's Lisa, the Xerox 820, and the IBM PC with a hard disk running VisiOn software. No comparable stand-alone, multiuser products are available to users of IBM mainframe products.

There is, therefore, no direct competition with the 3270 PC. Strategic Inc. knows of none planned, although companies that make 3270-compatible terminals, such as Memorex, are likely to develop equivalent products.

THE XT/370

IBM's XT/370 reaffirms its corporate strategy of maintaining the traditional mainframe as the center of a company's information processing. It is also an attempt to create an industry-standard processor in a new market: the personal workstation arena.

Further, the XT/370 will ultimately force the upgrade of a company's existing mainframe equipment. Adding the XT/370 superficially unloads a company's mainframe 370 of its duties, but the introduction of more XT/370s, spurred by the increased terminal capabilities at relatively low cost, will increase the burden of the mainframe 370. Eventually, this leads a company to invest in additional disks, memory, channel capacity, and probably an upgraded central processor.

Physically, the IBM XT/370 is an XT personal computer with three new boards added, providing 768K bytes of memory, four chips (an 8088, two 68000s, and an 8087), which allow it to execute the 370 instruction set, and an I/O and virtual-memory management unit.

Functionally, the IBM XT/370 combines three systems and allows the user to switch quickly between them. In the PC mode, it is an IBM XT. In terminal mode, it functions as an IBM 3277 display terminal. In workstation mode, it executes a new version of the System/370 VM/CMS (Virtual Memory/Conversational Monitor System) operating system, called VM/PC, enabling the workstation to download VM/CMS applications from the host processor. Thus, only normal file and virtual-memory management are handled by the System/370. As a VM/PC workstation, the XT/370 can call up mainframe programs and access mainframe data in a virtual environ-

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ment of up to 4 megabytes.

Technically, the XT/370 is a weak product: first, there is little integration of the XT/370 with the System/370. For instance, the host treats it like a 3274 terminal, not like a coprocessor. This may be fixed by future software products.

Second, the PC portion of the XT/370 is not well integrated with the MVS (multiple virtual storage) environment.

Third, the XT/370 suffers physical and architectural constraints as a result of IBM's using the XT system as a base. For instance, the PC operating system is always active. The main memory is shared between the 8088 and 370 processors. Further, both I/O and memory share the same 8-bit bus, and, finally, all VM/CMS I/O is run through the PC BIOS (basic input/output system) code.

These limitations, combined with the 70-millisecond access time for the 5¼-inch Winchester disk, which is the paging device, mean that the aggregate performance of the system will be far below the 0.1 millions of instructions per second (MIPS) claimed by IBM. The claim is made for any application with a working set larger than the 416K bytes of physical memory available to the XT/370 processor, while running as a 370. One-tenth of a million instructions per second of 370 processor power is comparable to a 4-mHz Z80 and less than the processor power of an 8086. This is clearly not a price/performance breakthrough compared to other microprocessors.

The XT/370 provides its 0.1 MIPS at a cost of approximately \$12,000, or \$120,000 per 1.0 MIPS. This compares favorably to approximately 1.2 MIPS at \$500,000 for IBM's own 4341 mainframe. Thus, the XT/370 has from two to ten times the absolute processor power available to an average mainframe VM/CMS user, and approximately 3.5 times the price performance ratio of the 4341-12, while allowing you to add the workstations in \$12,000 increments, rather than buying a \$500,000 system.

Finally, IBM's marketing thrust for the XT/370 appears to focus on providing cost-effective higher performance on a per-user basis. However, though favorable relative to IBM's own equipment, the absolute performance of the XT/370 is lower and the price is higher than comparable microcomputers. The per-user cost is unfavorable compared to "super-mini" products.

IBM expects the XT/370 to appeal to several classes of customers who have overloaded mainframes:

- Applications developers. The first software releases for the XT/370 emphasize software development. Undoubtedly the work of the original development team, this software provides an excellent interactive environment.
- Users of small working-set applications. These customers will require considerable processor power relative to that available to a single user under the VM/CMS environment, but relatively little I/O.

If the working set of the application is so large that it cannot fit into the 416K-byte physical memory (when running in 370 mode), or if a large data set is used in the 4 megabytes of virtual memory, the PC's disk I/O will limit performance to a fraction of the 0.1 MIPS. If high-density disk or tape I/O is required and files are so large they cannot fit on the XT disks, the performance advantage of the

XT/370 will likely be dissipated by the increased time necessary to communicate this data between the mainframe and the XT/370 workstation.

- Engineers and scientists. These customers work with relatively small amounts of data (probably in FORTRAN) and will obtain a better turnaround time from a local 0.1 MIPS system than from a shared mainframe.

It is nearly inconceivable, given the number of very high-performance microcomputers aimed at this market, that IBM could sell a single XT/370 for this use without its current dominance in the data-processing market and the power that data-processing departments have in systems acquisition within most companies.

PROBABLE FUTURE PRODUCTS

Obvious and necessary upgrades to the PC and XT are larger memory, larger disks, and a larger variety of printers, plotters, modems, etc. Future versions, compatible at the software but not the hardware level, may feature faster memory and processors, but this is unlikely before 1987 or 1988.

Obvious and necessary upgrades of the 3270 PC include all of the above. Additionally, IBM and other companies will take advantage of the PC's processor power and local disk storage to provide increased integration of other mainframe software environments with the PC. For instance, IBM's interactive environments are not known for simplicity, and a menu-driven TSO (timesharing operation) interface would allow the user to function effectively knowing much less about TSO.

Obvious and necessary upgrades of XT/370 include larger disks, printers, etc., as well as better integration of VM/PC with PC-DOS. Strategic Inc. does not expect a more powerful version of this product, based upon higher performance processors and a 16- or 32-bit bus, until a competitor appears and threatens to gain market share. A more powerful XT/370 would undermine its own 42XX mainframe business.

COMPETITION

Although IBM retains and is extending its market dominance with these PC/workstation products, there is room for competition in terms of performance, cost, features, and market flexibility.

The performance gap between IBM's products and what is technologically possible remains. None of the PC products demonstrates particularly impressive performance, either in absolute terms or relative to price. For instance, the 8088's performance is inherently low, and other companies are already offering PC-compatible systems based on the Intel 8086, a chip with 16-bit access to memory and I/O. Other companies have announced, or soon will announce, systems based on the Intel 80186 and 80286. The 80186 incorporates DMA (direct memory access), bus control, and other functions into the central processor, cutting component cost and allowing more functions on a single board.

Matching the performance of the XT/370 with bit-slice technology or a custom processor would be relatively simple and inexpensive for a competitor.

IBM's PC has no convenient means of sharing peripherals and data with other personal computers. IBM may remedy

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Has IBM Captured the Market?

The Strategic Inc. study, completed in December of 1983, is based on interviews with 170 companies—both large and small—representing every segment of American industry. The complete report covers user reactions to the PC, a market analysis, and an analysis of the technical limits of IBM's new line of computers.

Based partly on the interviews and also on the company's economic modeling, Strategic forecasts that IBM will sell 1.5 to 2.0 million units of the PC, the PC XT, and the XT/370 in 1984. Shipments of these computers should increase to 3.4 million in 1988.

IBM itself claims that it will ship 2.5 million PCs and PCjr's in 1984. Strategic's estimates are very close to that number, provided IBM ships approximately one million PCjr's. Based on Strategic's interviews with 70 large corporations and 100 smaller ones, all currently using IBM PCs, Strategic has come to some general conclusions that its full study, *IBM PC User Reactions, Requirements and Plans—1984*, documents.

Among these conclusions are proposals as to IBM's probable strategies: to set a standard with IBM PCs in a business environment; to design PCs to function with IBM mainframes, thereby bolstering the company's mainframe business; and to merge terminal and PC functions to increase the value of terminal sales.

MARKET ANALYSIS

Each of IBM's latest products is sold to one of three distinct markets. According to estimates published by IBM, approximately 40 percent of its systems will go to large accounts for business use in 1984; 20 percent to scientists and engineers, mostly with large accounts (companies); and the remaining 40 percent to small organizations and home users.

The PC and XT models are sold to both large and small businesses, where they are used as personal computers, as a small company's

main data-processing system, or as a terminal to a mainframe computer. According to Strategic's 1983 findings, IBM now has 50 percent of this business/personal computing market.

The 3270 PC will be sold in the mainframe-based market in large corporations, primarily for use by managers and financial personnel.

The XT/370 will be sold as a workstation for IBM mainframes, which execute VM/CMS (Virtual Memory/Conversational Monitor System), an operating system with the fastest growth rate of any of IBM's line. It can already be found in more than 10,000 installations.

Despite strong sales growth rates for the PC and PC XT in the next few years, Strategic's conclusions take into account the products' technological obsolescence. The 640K-byte limit of physical memory and the 8-bit data bus (which inhibits I/O, for example) will become increasingly severe constraints on sales as more sophisticated software is developed and higher performance peripherals are added to the IBM PC. Strategic's user survey found that, while most clients were happy with the selection of software available for the PC, most said they wanted a faster version of the PC. Strategic projects that the current versions of the PC and XT, as well as the 3270 PC and the XT/370, will be phased out by 1987.

Strategic also concludes that IBM's main focus for 1984 will be the 3270 PC. As a combined terminal and PC, this is a stronger product than the XT/370. Furthermore, the product has no direct competition, and its only indirect competition comes from microcomputer companies that provide 3270 emulation on PC-compatible products. But these do not provide the features of the IBM model.

Although further software developments throughout 1984 may make the XT/370 a more interesting product by integrating it with mainframe systems, Strategic concludes its design has been seriously compro-

mised by IBM's basing it on the XT. The 416K-byte memory limit when running in 370 mode will eliminate many CMS programs that would have been useful to middle managers who use mainframes constantly. Furthermore, the maximum (best-case) performance of only 0.1 million instructions per second (MIPS) and the 4 megabytes of virtual address space will limit its use in some scientific and engineering applications. It will remain useful for developing software on already overloaded systems.

IMPACT OF COMPETITION

Competition from Asia could encroach on 1984 sales of the IBM PC. Already Taiwanese work-alike computers are being delivered to American shores at prices 30 percent lower than IBM's. Furthermore, a number of American companies are manufacturing their computers and products in the Far East. These systems could saturate the personal and small business computer market for IBM's products by the close of 1984, seriously hurting sales in 1985. IBM PC systems with Winchester hard disks are most susceptible to this competition because of a domestic drive shortage. Both Korea and Taiwan are now manufacturing Winchesters.

Strategic does not believe that Far East competition will affect IBM's large accounts or those companies that buy PCs in quantity. But competition will heat up in the small business market, which, according to IBM's own estimates, will account for 40 percent of IBM's business in 1984. However, should foreign firms gain even 50 percent of the U.S. market—a remarkable feat of marketing and sales—IBM's sales would decrease by only 20 percent. The worst effect would be the saturation of the market; that is, supply would grossly exceed demand. This would place severe downward pricing pressure on the entire PC-compatible market and render a majority of the competitors unprofitable.

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FORECAST

IBM has geared up for massive production, which means it is less flexible than competitors in its response to market requirements. Products with a relatively small market won't be handled by IBM.

this with a network in the future, but this will undoubtedly be a high-cost solution. There is certainly room for a "network-in-a-box" system similar in architecture to that of Molecular Computer's 8-bit systems, since this approach will lead to lower cost per user than a standard network.

This system should run both networked CP/M-86 and MS-DOS, since no multiuser software now exists for MS-DOS systems. Several companies have already demonstrated multiple operating systems executing on a single network.

IBM's PC and XT products were introduced while the Boca Raton organization was still an independent business unit (IBU). Within IBM, an IBU is freed of sharing the R&D cost burden imposed by IBM's establishment. Future products, now handled by the Entry Systems Division, will share the R&D costs, increasing its overhead dramatically. This burden will provide a price umbrella for leaner competitors, even though IBM production is highly automated.

IBM's personal computers don't support many desirable features, for instance, Hewlett-Packard's touch screen and NEC's high-resolution color graphics. Hewlett-Packard has done a notable job in this respect, having signed Lotus to enhance its Lotus 1-2-3 package to support the touch screen.

IBM has geared up for massive production, which means it is less flexible than competitors in its response to market requirements. Products with a relatively small market won't be handled by IBM. This leaves room for manufacturers and resellers of add-on and add-in equipment.

More important, the large-scale production, marketing, and future compatibility requirements planned by IBM for the PC line certainly mean that it won't be pushing technological limits. The company is bound by readily available parts. For instance, IBM's marketing requirement for a very low-cost system (the lowest-cost PC and the PCjr) forced the use of the 8088 central processor. This primarily saved IBM the cost of connectors, but permanently limited the computational performance of the system. For a modest cost increase (\$50 to \$100), IBM could install an 8086 and obtain a 50 percent to 100 percent increase in computational power, relative to the 280 or 8088. However, IBM's compatibility requirements will prohibit such a change. ■

This article is based on IBM PC User Reactions, Requirements and Plans—1984, a report prepared by the staff of Strategic Inc., San Jose, California, and used with the company's permission. Copies of the document, released in December 1983, are available through the corporation at 4320 Stevens Creek Blvd., Suite 215, San Jose, CA 95157.

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SYSTEMS	1040S	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439	1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487	1488	1489	1490	1491	1492	1493	1494	1495	1496	1497	1498	1499	1500	1501	1502	1503	1504	1505	1506	1507	1508	1509	1510	1511	1512	1513	1514	1515	1516	1517	1518	1519	1520	1521	1522	1523	1524	1525	1526	1527	1528	1529	1530	1531	1532	1533	1534	1535	1536	1537	1538	1539	1540	1541	1542	1543	1544	1545	1546	1547	1548	1549	1550	1551	1552	1553	1554	1555	1556	1557	1558	1559	1560	1561	1562	1563	1564	1565	1566	1567	1568	1569	1570	1571	1572	1573	1574	1575	1576	1577	1578	1579	1580	1581	1582	1583	1584	1585	1586	1587	1588	1589	1590	1591	1592	1593	1594	1595	1596	1597	1598	1599	1600	1601	1602	1603	1604	1605	1606	1607	1608	1609	1610	1611	1612	1613	1614	1615	1616	1617	1618	1619	1620	1621	1622	1623	1624	1625	1626	1627	1628	1629	1630	1631	1632	1633	1634	1635	1636	1637	1638	1639	1640	1641	1642	1643	1644	1645	1646	1647	1648	1649	1650	1651	1652	1653	1654	1655	1656	1657	1658	1659	1660	1661	1662	1663	1664	1665	1666	1667	1668	1669	1670	1671	1672	1673	1674	1675	1676	1677	1678	1679	1680	1681	1682	1683	1684	1685	1686	1687	1688	1689	1690	1691	1692	1693	1694	1695	1696	1697	1698	1699	1700	1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711	1712	1713	1714	1715	1716	1717	1718	1719	1720	1721	1722	1723	1724	1725	1726	1727	1728	1729	1730	1731	1732	1733	1734	1735	1736	1737	1738	1739	1740	1741	1742	1743	1744	1745	1746	1747	1748	1749	1750	1751	1752	1753	1754	1755	1756	1757	1758	1759	1760	1761	1762	1763	1764	1765	1766	1767	1768	1769	1770	1771	1772	1773	1774	1775	1776	1777	1778	1779	1780	1781	1782	1783	1784	1785	1786	1787	1788	1789	1790	1791	1792	1793	1794	1795	1796	1797	1798	1799	1800	1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	1812	1813	1814	1815	1816	1817	1818	1819	1820	1821	1822	1823	1824	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	1835	1836	1837	1838	1839	1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2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STALWARTS:

THE IBM PERSONAL COMPUTER, PC XT, PORTABLE AND PCjr.

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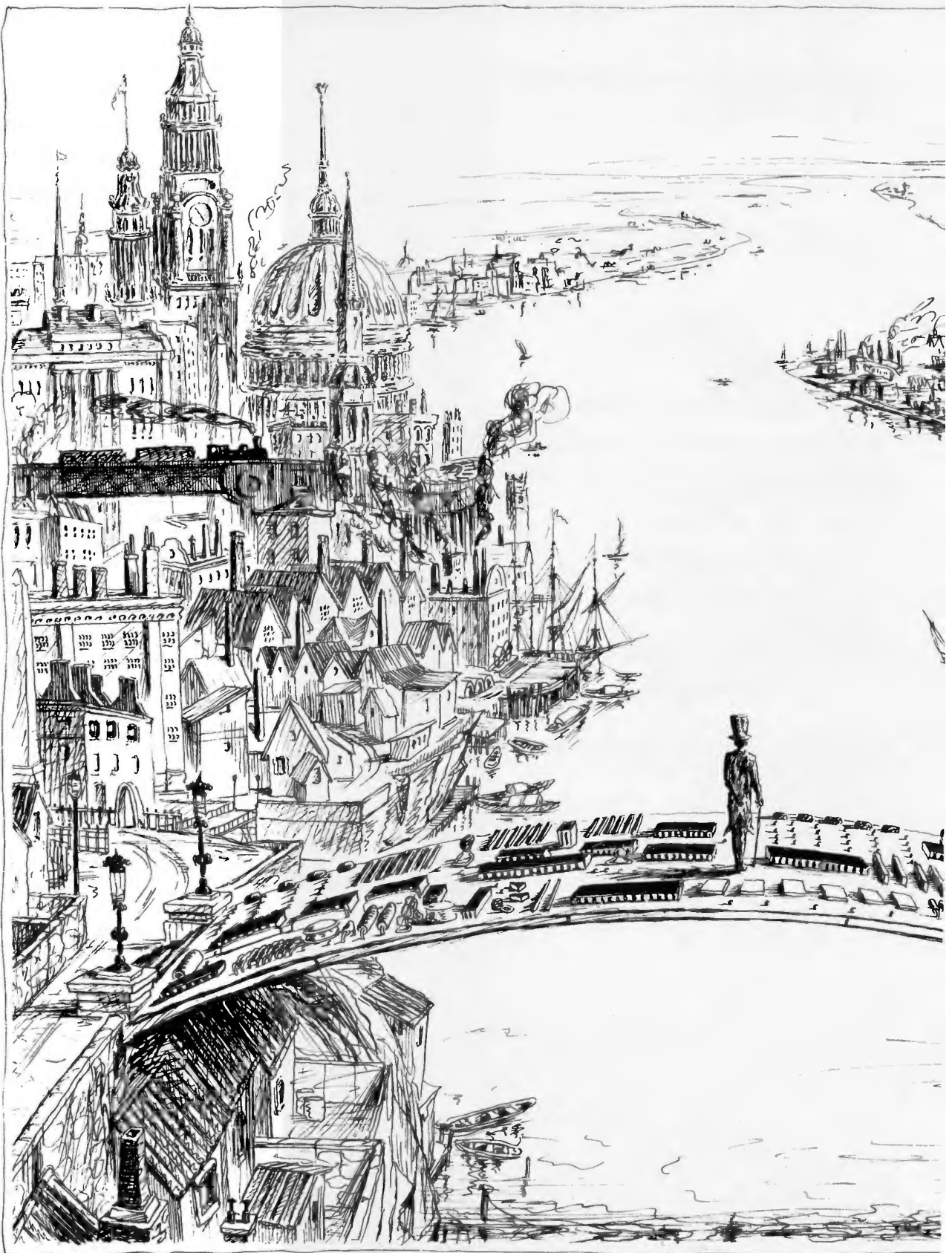
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ILLUSTRATION BY ROBERT TINNEY



BY CHARLES DANNEY AND TOM FOTH

A TALE OF TWO OPERATING SYSTEMS

Confused about the virtual memory operating system in the new XT/370? Compare it to Microsoft's PC-DOS

In October 1983, IBM announced a new member of its personal computer family, the XT/370, the first desktop design of IBM's mainframe 370 architecture. At the same time, IBM introduced the VM/PC (Virtual Machine/Personal Computer) operating system to take advantage of this new hardware.

VM/PC shares many characteristics with the mainframe operating system known as VM/370—and has several new features as well. The main thing that these two operating systems have in common is known as CMS (Conversational Monitor System).

In VM/PC, CMS acts as the user interface and provides application support facilities, just as it has ever since its first incarnation as a part of CP/67, the predecessor of VM/370, nearly 20 years ago.

We'll focus our comparison of CMS and PC-DOS from Microsoft on three different areas: the file system, command procedures, and system modification and extension. Bear in mind, too, that while Microsoft's PC-DOS is always working in your PC XT/370—even if only for I/O (input/output) operations—VM/CMS is invoked only when you are operating as, or networking with, a System/370 mainframe.

(continued)

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ILLUSTRATION BY STEVE SALERNO

*The most important
function of an
operating system
is maintaining
file systems.*

FILE SYSTEMS

Probably the most important function of personal computer operating systems is maintaining file systems. The file system encompasses the conceptual layout and partitioning of disk space, the allocation of data files, the facilities for reading and writing data (sometimes known as "access methods"), and the "catalogs" or "directories" available to the user for keeping track of the files.

PC-DOS assigns letters to disk drives, whether fixed or floppy, as drive identifiers when the system is booted. Although you can change drive letters with the ASSIGN command, the manual specifically recommends against this. Under PC-DOS it's impossible to assign two or more identifiers to distinct parts of the same physical drive.

The mainframe version of VM/CMS assigns virtual disk drives to contiguous portions of disk space on the same physical drive or drives. This space is managed by the control program so that virtual drives appear to be separate devices to CMS, each having its own distinct address. In the 370 architecture, device addresses are three-digit hexadecimal numbers, ranging from 000 to FFF. Hence, 4096 (decimal) possible devices exist, not all of which, of course, are physically present.

Similarly, the VM/PC control program in the XT/370 creates for CMS the illusion of separate devices at specific addresses. These virtual disks are maintained in separate PC-DOS files. Such files can be on either fixed or floppy disks. For example, the virtual disk at address 101 belonging to the user FRED has the name FRED.101.

Because these files are in PC-DOS format and VM/PC actually uses DOS facilities to read and write them, they can be copied, renamed, backed up, and manipulated in general by standard DOS utilities.

CMS data, however, is in a binary format, EBCDIC (Extended Binary-Coded-Decimal Interchange Code), the IBM alternative to ASCII (American Standard Code for Information Interchange), meaningful only to CMS. Therefore, editing or displaying the contents of these files from DOS is not usually productive. But you can very easily move files back and forth between CMS and DOS with the CMS IMPORT and EXPORT commands. These are similar in form to a COPY command except that either the source or the target file is in CMS while the other is in DOS. Options allow for the different end-of-record conventions of CMS and DOS, and conversion between ASCII and EBCDIC is automatic unless suppressed.

As under PC-DOS, these virtual disks are given a file mode letter using the ACCESS command, and the virtual disk cannot be subdivided further with different modes. However, you can change mode assignments any time or assign several different mode letters to the same device. Certain addresses are automatically accessed when CMS is started. For example, the 101 disk becomes the "A" disk by default.

The letter identifier in CMS has a further significance beyond that in PC-DOS: it defines a default "search order." Typically, a command or system utility will search all accessed disks for a requested file whose "mode" is not specified, and the order of search is determined by the alphabetic sequence. This enables the user to keep several versions of the same set of files on different virtual disks and to control which version will be used. Disks "higher" in the search order (toward A) need only contain a subset of all files, consisting of the most recent versions. This function is much like the DOS PATH command, but applies to all file searches.

FILE STORAGE

In both CMS and PC-DOS, files are not stored contiguously on a disk. Instead, a file consists of a number of physical blocks, which can, in principle, be located anywhere on the disk, a definite advantage over earlier operating systems that required a file to be stored as a single segment (or at most a very small number of segments). Files, therefore, need not be preallocated at some fixed size, but can instead grow (or

possibly contract) as required. There is some performance penalty for this, however, in that blocks widely scattered on a disk can cause excessive head movement. In addition, a fair amount of bookkeeping is required to associate disk blocks with files.

In PC-DOS, the most fundamental unit of allocation is the sector, a block of 512 bytes. Different drive types can be formatted with different numbers of sectors per track depending on their physical capacity. For example, PC-DOS on the IBM PC writes either eight or nine sectors per track on floppy disks and 17 sectors per track on a hard disk.

Specific sectors are associated with specific files by means of the file-allocation table (FAT). A FAT is a linear array of entries that are in one-to-one correspondence with space-allocation units on the disk. The space-allocation unit, called a cluster, can be different sizes depending on the type of disk. On a single-sided floppy disk, there is just one sector per cluster, but on a double-sided floppy disks there are two. On a 10-megabyte hard disk, eight sectors per cluster exist. This apportionment is used to keep the total number of clusters, and hence the size of the FAT, small.

The root file directory is a separate table consisting of control blocks, one per file. One field in each control block is the index of an entry in the FAT. This entry corresponds to the first cluster of the file, and it in turn points to another entry of the FAT, which represents the second cluster of the file, and so on.

The PC-DOS design of the FAT places certain limits on the file system. In particular, because each file must have at least one (and usually more) entries in the FAT, there can never be more than 4096 files on a disk, no matter how large it is or how many subdirectories are used.

The FAT design places even more severe limits on the number of files that appear in the root directory. This directory is allocated with a fixed size for a given drive type, and it can never be extended. For instance, on a 10-megabyte disk, the root directory is formatted with just 512 entries. Subdirectories do help to make this limit more flexible, however.

By comparison, the CMS file-allocation

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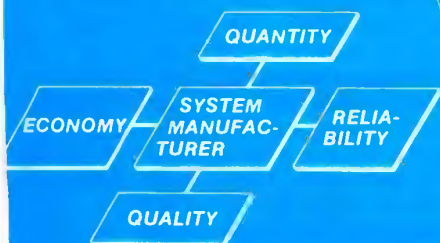
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TWO OPERATING SYSTEMS

tion mechanism is more complex and overcomes most artificial limits on how many files can be stored on a disk (see figure 1). In CMS, the basic allocation unit is called a block. You can select a block size of 512, 1024, 2048, or 4096 bytes when you format your disks. The smaller number allows for many smaller files without much wasted space, while the larger size permits somewhat faster disk access.

The CMS file directory is similar to that of PC-DOS in that it consists of control block entries, called FSTs (file status tables), describing each file. However, in contrast to PC-DOS, the CMS file directory is not fixed in size. Instead, it is itself just a file, and because there are very generous limits on the size of a file, the directory imposes no practical limit on the number of files a disk can contain. Of course, because any file occupies at least 512 bytes, 10 megabytes of disk space could contain at most about 20,000 files.

Unlike PC-DOS, CMS does not use a fixed-size table like the FAT to map the association of blocks with specific files. Instead, it uses a tree structure. Suppose the disk block size is 1024 bytes. If the file consists of only one block, the FST points directly to the block. If the file has more than one block, the FST points instead to something called a pointer block, which will be 1024 bytes long. Blocks are addressed by full 32-bit words. (Because the high-order bit is a sign, the largest positive number is $2^{31} - 1$, so more than 2 billion blocks can be addressed, 1000 times more than enough for today's largest disks.) Thus, one pointer block can refer to 256 additional blocks. For a larger file in excess of 256 blocks, CMS adds a second-level pointer block that in turn points to as many as 256 first-level pointer blocks, which point to the file's actual data blocks. Hence, with two levels of pointer blocks, a file can contain as many as $256 \times 256 = 65,536$ data blocks. With four levels of pointer blocks, a file can contain more than 4 billion data blocks, which exceeds the number that can be addressed.

Given this technique of associating blocks with files, it's confusing to determine which blocks of a disk are in use. Therefore, information about which disk blocks are actually allocated is kept separately in a system file called the

allocation map. In this file, each bit corresponds to exactly one disk block, and the bit is on if and only if the block is in use (as a file, or pointer block, or whatever). Thus one block of 1024 bytes can describe the allocation status of 8192 other blocks, which is a fairly small overhead ratio.

CMS updates its directory information with a dual-directory technique that never overwrites the old directory. It does this without doubling the amount of space that must be reserved permanently for the directory. By reserving just two disk blocks, including the first block of the directory file which contains the FST entry for both itself and the allocation map file, CMS determines the complete allocation and file information for the whole disk. As the very last step of any directory update, a single record is written in the disk label that indicates which of the two possible blocks is the first of the directory. If a directory update should fail at any step before the last record is written, all of the old information is still intact because it has not been overwritten, and the effect is as if no change at all had occurred. Once the label record is written, all of the new information is in effect. This new information indicates, incidentally, that the old directory data blocks are no longer allocated, so their space isn't wasted.

CMS uses exactly the same technique for writing data. That is, when records are updated in a file, they are always rewritten to a different, unallocated disk block. Only when the file is closed and the directory is updated does this new data "officially" become part of the file. This provides some measure of safety against a database being destroyed due to a power failure, for example. But it also requires that more disk space be available whenever files are updated extensively.

READING AND WRITING FILES

The third aspect of an operating system's file management is its facilities for reading and writing files. CMS and PC-DOS have different file structures. In the latter, at least at the operating system level, a file is usually treated as simply a string of bytes. That is, the file itself does not, in the operating system's view, have a structure consisting of individual records. Instead, the file can be read or

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written sequentially a byte at a time, or it can be accessed randomly by absolute or relative byte number. This method was expanded in version 2.0 of PC-DOS, which introduced new function calls without the "file control blocks" that had forced the programmer to treat files somewhat artificially, as if they were grouped into blocks of 128 records. (At an application level, of course, the file may well have a record structure defined in a variety of ways, such as fixed-length records, embedded record delimiters, etc.)

The CMS file system recognizes two kinds of record structures: fixed-length record format and varying-length. As in PC-DOS, it would be possible to simulate a file as a string of bytes by using a fixed-format file with a record length of one, but this is usually impractical. Furthermore, embedded record delimiters are never used to separate varying length records in a file. The file system keeps track, transparently to all programs, of record positions, a great convenience because applications need never scan for delimiters on input or supply them on output.

A number of slightly different system calls are available in PC-DOS for reading and writing files. Many were in existence before version 2.0 of DOS, and an even larger number were added in that version. The older calls used a parameter list called a file control block (FCB), which required the programmer to deal with an artificial block and record structure even if no record structure really existed in the file. Version 2.0 simplified this by eliminating the FCB. Instead, version 2.0 supplies the file's name (together with optional path) to the "open" function call and returns an identifier called a "file handle" if the operation is successful. This file handle identifies the file in subsequent function calls. The function calls are simplified, basically, to read or write some number of bytes starting at the current position in the file or at a designated position. PC-DOS makes a distinction between "opening" a file, which can be done only on an existing file, and "creating" a file. Recreating an existing file resets it to zero length.

CMS makes no such distinction between opening and creating a file. In fact, you don't even need to open a file

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The CMS file system recognizes two kinds of record structures.

explicitly. A file will automatically be opened the first time it is read or written. In keeping with the record-oriented operation of CMS, the file calls specify record numbers rather than byte addresses. Although a parameter list must be supplied with the file calls, CMS provides assembler macros to make life easier.

The concept of fixed or variable record formats and the association of specific logical record lengths with CMS files tend to complicate writing general utility programs that must handle a wide assortment of input files. However, an alternative set of system calls, known as

GET and PUT, mask some of this complexity (while introducing complexities of their own). Although they include a number of somewhat exotic options, in their simplest form they shield programmers from concern with the specific format of the file with which they are working. Some of the more useful options give the programmer control over system buffering, which affects performance.

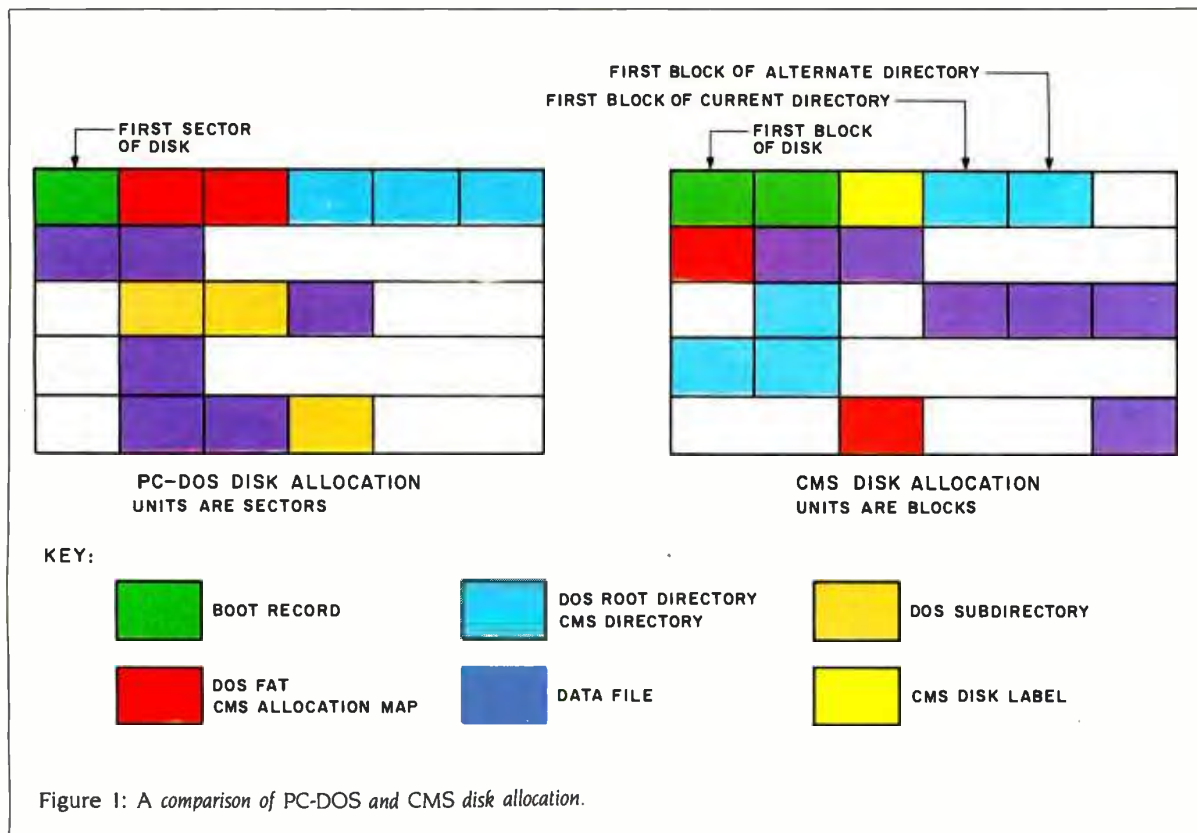
But the most interesting concept that GET and PUT introduce is a level of indirection in file naming. Instead of referring to files in terms of their "real" names, GET and PUT always refer to an eight-character logical name. At run time, this logical name is associated with a real file by means of the FILEDEF command. FILEDEF can also specify other parameters and options, but its most useful function may well be its ability to redirect I/O operations to devices such as the user's console or to a printer. This provides much the same capability that is offered by "standard

input" and "standard output" options in PC-DOS, namely, the ability to write programs that are indifferent to the source or destination of their data. The CMS advantage, of course, is that there can be any number of such "standard" devices instead of just two.

DIRECTORY STRUCTURE

PC-DOS's 2.0 hierarchical directory structure is clearly superior to CMS's. The only advantage of the CMS file directory (apart from its clever implementation) is that it allows file extenders to be eight characters long, instead of the three permitted by PC-DOS. (Each system allows the standard eight-character filename.) Still, 16 characters to fully identify a file is quite meager. In CMS, the only available techniques for logically grouping related files are naming conventions and keeping them on separate virtual disks. Neither approach is particularly satisfactory, either aesthetically or in

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practice.

By contrast, the hierarchical PC-DOS structure gives each physical disk a root directory, created when the disk is formatted. The root directory can contain subdirectories, which can, in turn, contain other subdirectories. The complete list of directories from the root to an actual data file is known as the "path."

Such hierarchical structures tend to be more difficult to use, especially for those not very familiar with computers. By defining multiple subdirectories, finding a file can often become a minor project. But on balance the structure is most useful.

Unfortunately, although the concept is excellent, the programming of hierar-

chical directories in PC-DOS has one glaring deficiency: only one directory at a time is the "current" directory, and only its files are ordinarily visible to programs. The PATH command circumvents this problem for the specific case of finding programs to load by allowing the user to specify which directories should be searched, and in which order. It's too bad that the same concept wasn't applied uniformly to all data files. As a consequence of this oversight, certain data files have to be copied into a number of directories.

COMMAND PROCEDURES

Most operating systems provide some sort of command procedure that enables you to group together in a file sets of commands that are used repeatedly to perform some more complex task. PC-DOS treats this as a minor feature. For example, the IBM DOS manual devotes about 20 pages out of more than 600 to the BAT (batch) facility. The analogous facility in CMS is treated at length because of its greater power. Although the following section of the PC-DOS/CMS comparison is slanted toward CMS, these command groups help to explain much of the popularity of CMS.

You can think about batch facilities in various ways. The simplest is the idea of putting commands that would ordinarily be typed on the console all in one file. The command interpreter then simply reads from the file instead of the console in order to drive the rest of the system. Indeed, this is exactly what "batch" implies: the term evolved from the earliest days of computing, when a sequence of programs could be specified in a "batch job" for unattended execution.

In an interactive, as opposed to a true batch environment, other uses of command groups are possible. For instance, command procedures (as they would more properly be called) can be used to reduce the amount of typing required by associating a complex sequence of operations with a single name.

Though PC-DOS batch files can contain sequences of commands, and one batch file can transfer control to another, one file cannot call another as a subroutine. PC-DOS batch files can deal with parameters passed to them but otherwise do not have variables. PC-

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DOS includes some very primitive forms of IF, FOR, and GOTO control structures. Finally, PC-DOS batch files can display remarks to the user, but they cannot accept input.

In CMS, command procedures are called EXECs. Like the PC-DOS batch language, an EXEC includes system commands, parameters, and a means for communicating with the user (input as well as output). You can use named variables (with as many as 255 characters). Certain variables are predefined, like the date, time, and the return code from the last command executed. An EXEC generally treats variables like character strings unless you are using arithmetic operations. You can, of course, assign and compare variables. EXEC provides a wide range of built-in functions with special emphasis on pattern matching and string manipulation. Certain types of commands control procedure execution, including basic operations like looping, testing, and branching. One EXEC can call another as a subroutine a fair number of times, and recursive calls are permitted. EXEC also enables you to call internal subroutines and provides error handling and debugging.

The only thing EXEC lacks as a general programming language in itself is a provision to handle arrays of one or more dimensions. You can contrive a somewhat clumsy substitute by constructing variable names dynamically. The control structures are not as nice as those found in a language like C (that is, there is no IF-THEN-ELSE or SWITCH, etc.); nevertheless, for a great many purposes, EXEC can be used for general programming. CMS users tend to employ EXEC procedures routinely, just as PC-DOS users employ BASIC, so much so that the EXEC facility is far more analogous to BASIC than it is to BAT.

Problems with EXEC control structures will be eliminated when the latest version of the language, now called REXX (restructured, extended executor) becomes available in VM/PC, as it is already in VM/370. In addition to improved control structures, REXX is capable of even more powerful pattern matching and string manipulation. It also supports "infinite precision" arithmetic on numbers of arbitrary length. For instance, with a single REXX

command you can parse a data string according to a specified model. REXX also includes extensive debugging aids and function libraries.

One final and important difference in command procedures is that you can't use a PC-DOS batch file to override a command of the same name because the executable command will always be called first. On the other hand, in CMS anyone can write EXEC command procedures that will replace ordinary commands of the same name. This gives users a great deal of control over command naming and syntax.

THE CONSOLE STACK

The CMS console stack is an input buffer. Commands can communicate with each other and with EXEC procedures by reading from the buffer. Many of the most common CMS utilities optionally deliver their output to the stack instead of displaying it to the user. This enables EXEC procedures to determine file characteristics, for example, or to query the system flags. A command called EXECIO even enables EXEC procedures to read and write files via the stack.

The "pipe" is the most powerful inter-program communication technique in PC-DOS. A pipe defines the output of one program to be the input of another. By means of pipes many simple utilities (called "filters") can be combined to build useful applications. Unfortunately, PC-DOS pipes are very inefficient because all they do is pass the data through an intermediate disk file. Programs have had that option all along. Pipes, in a UNIX operating system—from which the technique derives—pass data directly from one program to another.

In addition to parameters, return codes, and the stack, programs and EXEC procedures can communicate through global variables. These are simply named character strings maintained by CMS in any number of separately defined sets and are easily accessed from both programs and EXEC procedures. At the user's discretion, these global variables may remain defined during one session only, or across multiple sessions. Yet another interface enables a program to read and write variables in the EXEC that called it.

Again, PC-DOS has a function similar

to CMS global variables, known as "environment strings." These, however, are defined only until DOS is reloaded. Furthermore, their use is restricted, and higher level language programs or BAT files cannot access these strings easily.

Returning to the original idea of a command procedure—a sequence of commands executed from a file instead of being typed at the console—you may realize that this procedure can apply to any command-driven interaction, not just the operating system command handler. Editors, database managers, communication programs, and indeed most other applications of any complexity are driven by their own private set of commands. Many such programs have their own batch processors. With EXEC in CMS, these private command sets are unnecessary because, by using the CMS subcommand interface (SUBCOM), such applications can use the EXEC interpreter to handle their own command language for them. In addition to making it easier to develop applications, the subcommand interface makes life easier for end users by requiring them to learn only one procedure language.

The text editor provided with CMS, called XEDIT, makes good use of SUBCOM (subcommand) in a number of ways. XEDIT EXEC procedures, also known as macros, allow users to tailor the editor command language to their own preferences. Although XEDIT is not a true word processor, many procedures have been written as macros to perform word-processing functions.

You can use XEDIT to manage the display screen because of its built-in full-screen primitives and its interaction with EXEC command procedures. You can also use XEDIT in applications that have little to do with editing. For instance, the CMS FILELIST command, a full-screen file-directory management utility, is built on XEDIT.

OPERATING SYSTEM TAILORING

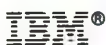
EXEC command procedures, and even BAT files to some extent, are available to all users for customizing an operating system. In both PC-DOS and CMS user-written programs can be used in much the same way as system commands, so extending the operating system by adding new commands is quite easy. In both

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operating systems you can even replace some, but not all, system commands by writing a program of the same name. In PC-DOS, these system commands are the external commands that run as COM or EXEC files, as opposed to those that are part of COMMAND.COM, the command handler. Similarly, you can easily replace CMS system commands that aren't part of the CMS nucleus.

Sometimes, however, you may require more fundamental extensions or changes. In order to modify PC-DOS or CMS, you must first understand the types of interfaces they provide. These interfaces are strongly influenced by processor architecture (8088/8086 and 370, respectively).

In the 8088 architecture, central processor interrupts are generated by various unpredictable events, like I/O events and division by zero. An interrupt can also be generated under program control using the INT instruction. The 8088 assigns a number from 0 to 255 to each type of interrupt it recognizes and maintains a table of 256 four-byte entries starting at location 0, called the interrupt vectors. Each 4-byte entry is the address of a routine that receives program control when its interrupt is generated. Some of these interrupts are defined by the hardware, more are defined by PC-DOS and the IBM PC BIOS (basic input/output system), and some are reserved for use by applications programs.

For defined interrupts, the interrupt vector points to routines in DOS or BIOS. An application can take control of any of these interrupts simply by setting the appropriate address in the interrupt vector, a process called interrupt stealing. If an application wants to modify or replace an existing DOS or BIOS service, it takes over or "front-ends" one of the defined interrupts. An application that does this must be prepared either to do most of what DOS or the BIOS would normally do with the interrupt or to eventually pass the event to DOS or the BIOS. If the application merely requires adding a new service, it takes over an unassigned interrupt. This can, of course, lead to incompatibilities among independent applications that take control of the same interrupt.

Not all DOS functions are mapped to

distinct interrupts because only 256 are available. Indeed, DOS reserves only 32 interrupts for itself, 20 hexadecimal through 3F hexadecimal. One interrupt (21 hexadecimal) acts as the general function call interface; specific DOS functions are usually selected by placing a code in a register and calling INT 21 hexadecimal. In order to take over the DOS function, an applications program has only to trap interrupt 21 hexadecimal and watch for the function code or codes it is interested in; all others are passed on to the usual DOS code.

The 370 architecture has only six types of interrupts: processor restart, external (including timers or other central processors), I/O, programs checks (instruction error), machine checks (hardware trouble), and supervisor call (SVC). A table of six entries contains program status words (PSWs) that are to be loaded when a specific type of interrupt occurs. This transfers control to the appropriate interrupt handler. Just as with the 8088 interrupt vector, programs can replace the system's PSWs with PSWs that point to their own code. This process is called PSW stealing.

The supervisor call instruction is a very close analog of the 8088's INT, and it, too, provides 256 codes. The single significant difference is that the subroutine addresses associated with each code are not located using hardware. Instead, the operating system must look up the addresses in a table, which is not directly accessible from an application. This can take more time and, more important, makes it harder for an application to selectively front-end specific system services. Fortunately, CMS provides an interface to handle selected supervisor call codes that usually meets application needs.

EXTENDING PC-DOS

You can extend PC-DOS by means of exits, interrupt stealing, and device drivers. The distinction among these is roughly as follows. Exit routines are specifically intended to be called by the operating system when certain events occur or during the execution of certain functions. Interrupt stealing applies when an applications program wishes to replace an existing DOS or BIOS service with its own code. Device drivers are usually programs that DOS will call in order to

manage I/O to otherwise unsupported types of hardware.

In PC-DOS, exit routines are just specialized interrupt handlers. They are associated with specific interrupt numbers and are called by DOS using INT. An example of a PC-DOS exit is the Break exit. When you request a "break" or halt in the execution of an applications program, the operating system will first call the application's Break exit, if one was specified. When invoked, the exit routine can determine if the application is in an appropriate state for termination. If not, the exit routine can warn you and return control to the application. It can also do end-of-application processing (such as closing files) and then terminate the application. When the application returns to PC-DOS, these exit routine addresses are reset to default values.

In order to extend the operating system by interrupt stealing, the application simply replaces one of the interrupt vector addresses with the address of its own routine. A common example of this is a disk emulator (RAMdisk). A disk emulator is first invoked as an ordinary command. It then steals the appropriate disk I/O interrupt addresses and returns to DOS in such a way that its code is left resident. When interrupt calls are made for disk services, the disk emulator examines them. If the request is for a disk the routine is not emulating in storage, the routine passes the request on to the operating system routine. If, on the other hand, the request is for one of the emulated disks, the routine maps the request to a read or write operation from memory.

Another interrupt steal might replace the address for interrupt 21 hexadecimal. A routine could intercept all file requests, for example, and, for files where no path is supplied by the caller, search a set of default paths. Finding the file in one of the default paths, the routine would append the appropriate path information to the request (much as the PATH command does for commands) before passing the request on for normal PC-DOS processing. This overcomes the difficulty mentioned earlier of searching for files in multiple sub-directories.

PC-DOS provides several services especially designed to assist applica-

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in PC-DOS.*

tions that do interrupt stealing, such as services that look up the current address of an interrupt or those that replace one interrupt address with another. Memory management is another service required by interrupt-stealing applications.

PC-DOS device drivers, new as of version 2.0, may be the most powerful of the three techniques of system extension. Device drivers are routines that enable applications to replace the PC-DOS logic that handles I/O devices. You can use device drivers as unsupported fixed-disk controllers, as disk emulators, or to read hardware clocks.

Unfortunately, the name of this facility has led users to believe that it is useful only for device handling, but this is simply not the case. Consider a service subroutine (for example, a sort package or database package) that you would like to call from several different languages and, in all cases, use the same calling interface. Rather than trying to interface the routine with several different calling formats, you can call the routine via a sequential I/O request. The same routine will work equally well from any language that supports arbitrary device names.

Device drivers can also ensure data security. You can use a device driver to front-end (take control of) disk I/O. The driver could trap all output commands and first write them to a cartridge tape, providing you with an audit trail. If the disk failed, a utility could restore data from the audit tape to the disk. The beauty of this approach is that the audit feature is completely transparent to the applications program.

EXTENDING CMS

As in PC-DOS, a CMS application can completely take control of one type of

interrupt by replacing the hardware-defined program status word associated with the interrupt. In principle, this enables CMS application programs to do I/O any way they want, alter the meaning of any system service call, etc. But it is rather a brute-force approach, particularly since there are so few distinct interrupt classes, and the applications program becomes obliged to duplicate a lot of system code, even if it later elects not to handle the interrupt.

To surmount this problem, CMS makes much more use of exit routines to handle specific situations. For example, a system call enables an application to handle I/O interrupts for specific I/O devices. You can define another exit routine to handle all external interrupts (so this amounts to little more than front-ending the external interrupt program status word). You can also define individual exit routines for most of the possible supervisor call codes. The exit routine support for program checks (for example, division by zero) is particularly useful, in that the operating system provides services that allow several interrupt routines to be "stacked," making it much easier for multiple applications that use the same sort of interrupt to coexist.

A number of other CMS exit routine interfaces are not associated with specific interrupts. One such routine gets control when a program is terminating abnormally because of a malfunction. This routine can attempt to close files and perform other clean-up chores, or even attempt to recover from an error. Unfortunately, if you cancel a program, you'll get no opportunity to recover or rescind the order as you do with DOS Break exit. You can define another exit routine through the FILEDEF command to receive control in order to handle GET and PUT file requests, so that an exit routine is capable of acting much like a DOS device driver. You can use exit routines of this sort to read and write storage belonging to other programs, and therefore provide another kind of interprogram communication technique. UNIX-like pipes could be programmed in this way.

CMS also provides you with a function called "nucleus extension," enabling you to replace some CMS nucleus commands with your own.

Two special supervisor call codes, 202

and 203 (decimal), invoke CMS functions in a way similar to the way DOS INT 21 hexadecimal does. The specific function being requested is identified to SVC 202 by an eight-character name, and to SVC 203 by a number. Only SVC 202 functions can have nucleus extensions.

To process an SVC 202, CMS first consults an internal table to see whether the function is in the nucleus. If so, CMS calls it. If the function isn't, CMS looks at the accessible disks for a file by the same name as the specified function and whose type is MODULE. If such a file is found, CMS loads and executes it. If no MODULE is found, CMS consults a table of synonyms and abbreviations that the user has supplied to see whether it should try an alias. If CMS finds an alias, the search starts over with the new name.

When an application defines a nucleus extension, its name is added to a special list, which is searched before any of the other lists and tables. The name can even be added to the list more than once (by different applications), and only the first instance will be used. In this way, you can extend CMS nucleus routines, with one unfortunate exception. The CMS file read and write services cannot have nucleus extensions. (Someone decided it was more important to handle files by a very fast path.) However, because these routines are located via addresses that are modifiable by applications, even this situation can be handled.

No such relatively simple techniques are available to replace or enhance PC-DOS internal commands. Because such commands are part of COMMAND.COM, you would have to replace all of COMMAND.COM with an application-supplied module. You can, in fact, do this, using the SHELL command in the CONFIG.SYS file, which is consulted when PC-DOS is loaded. (Device drivers are specified similarly by DEVICE commands in the same file.) However, you must supply a complete replacement COMMAND.COM or (more likely) a shell program that first examines commands for the ones it wants to handle before passing the rest to the real COMMAND.COM. But this requires very sophisticated programming, and the lack of adequate documentation of the interfaces makes it difficult. ■

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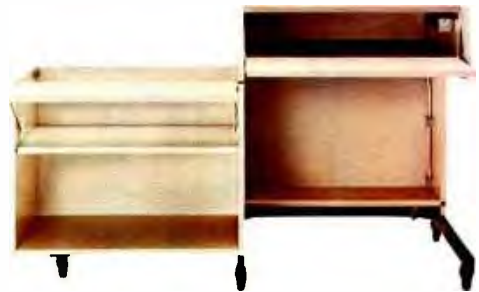
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THE FUTURE OF UNIX ON THE IBM PC

BY RALPH A. PHRANER

*With UNIX available for the XT, the question is not
how to employ it, but how soon*

Microcomputers seem to be moving away from the era where running a separate program for each specific task was considered optimal usage of available computing resources. Manufacturers are offering integrated environments, multitasking operating systems, and hardware enhancements with dedicated software in hopes of gaining a clear position in future markets. The exact nature of the newly emerging working environment is still unclear, but the molding forces of market demand will decide, from many approaches put forward, how to enhance the productivity of the microcomputer workstation.

IBM's Personal Computer brought about a dramatic change in the microcomputer marketplace with its 640K bytes of addressable memory, 16-bit processor, and 10 megabytes of hard-disk storage in the XT model. Backed by IBM's marketing savvy and reputation for reliability, the PC XT captured a large portion of the workstation

*Typically, a concurrent
system maintains
several independent
virtual environments,
each containing a
complete program,
either ready to run or
already executing.*

market of corporate America. Until recently, however, the software available has been limited to memory upgrades of 8-bit microcomputer designs. Single-tasking sequential processes have been the rule.

CONCURRENT FUTURES

Concurrency, the ability of a computer to do two or more projects at once, is both an efficient and an economical approach. The ability of a system to allow

the user to begin another job before a previous one is completed, to suspend one task to work on another, and to automatically transfer data among several independent tasks transparently makes valuable workers, from executives to programmers, much more productive.

Typically, a concurrent system maintains several independent virtual environments, each containing a complete program, either ready to run or already executing. In some cases, the number of concurrent tasks is limited, with all tasks kept resident in RAM (random-access read/write memory). In others, the entire operating environment is written to a reserved area on the system's disk when a higher priority for system resources is recognized by the processor. Each program is guaranteed a

(continued)

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fair share of computing time by operating system scheduling.

THE IBM PC MARKETPLACE

The success of the IBM PC is largely due to its acceptance by the business community. From sole proprietorships to Fortune 500 corporations, the largest market for microcomputers is the business market. Two requirements for many of these systems are that they be able to share data among multiple users, whether across the building or across the country, and that they be able to link to mainframes in existing data-processing environments.

At present, most of the tasks necessary for a microcomputer to be used with a large host computer system are possible—but only one at a time. This sequential nature of task execution creates conditions in which the microcomputer is forced to wait for the mainframe to finish just as if it were a dumb terminal, not a powerful, intelligent workstation. The operator is forced to wait unproductively. To overcome this bottleneck and better integrate into existing computer networks, individual workstations should include these features:

- Transparent communication with different machines and locations
- A consistent command set across different machines and applications
- Local concurrency to allow background processing
- Increased overall combined system performance as a result of off-loading data entry and selected processing tasks to a local workstation

Such a system would let you switch freely from task to task as often as the flow of work required, incurring no penalty in either time or concentration to re-establish a previous work project. You wouldn't have to terminate one task to work on another. You could recall a previous project in exactly the state in which it was left. A major candidate for approaching this ideal is the IBM PC running UNIX.

THE ROLE OF UNIX

The UNIX operating system, pioneered

by Bell Laboratories, is heralded as the answer to increasing the usefulness of microcomputers, both in a large data-processing environment and at individual workstations. A closer look at this concurrent system will help put alternative software solutions in perspective.

There is little doubt that UNIX is destined to play a major role in microcomputers within the next few years. It is estimated that the annual market value of UNIX systems will exceed six billion dollars within two years, with an estimated one million systems running UNIX in service by 1986. From micro to mainframe, UNIX is available on a broader range of computer hardware than any other operating system. Over a thousand different software packages are available for application use under UNIX, including word processors, accounting systems, financial-planning packages, and some of the most powerful database-management software available. Most of these software packages were originally designed to run on minicomputers and are thus powerful and sophisticated migrants to the microcomputer domain.

UNIX was created as a response to a programmer's need for an interactive software-development environment. Since the first PDP-11 release to universities in 1973, UNIX has gained popularity as a result of its use as a computer science research tool. Many of the popular enhancements were initiated in universities, which have provided a whole generation of programmers and computer science professionals who are enthusiastic about UNIX.

Over the years, UNIX has evolved into a sophisticated environment for document creation and management, file manipulation, and communication. It may also be the finest system for software development yet invented. The UNIX style of software development is to generate specialized software tools that speed subsequent applications efforts. For portability, the operating-system interface has been isolated, identified, and grouped by function.

Following are some of the major features and benefits of UNIX:

- Execution with an interactive user interface rather than by batch-job submission. However, interac-

tive users may easily initiate substantial batch-job sequences to be run in the background.

- Operating-system and applications software portability through a relatively small number of standardized function calls.
- Multiuser operation with provision for multiple background processes and facilities for system user accounting.
- A hierarchical file system with directories and removable volumes. Links and aliases let you use several names for one utility program or physical file.
- Stream- rather than record-oriented system I/O (input/output). All files and devices look identical to the user.
- Console input and output redirection to any legal device or file.
- Replaceable command-line interpreters. The UNIX shells provide flexible command language, variables, and commands from files. Any other user-supplied shell may be substituted.
- Security implemented by user name and group protocols. FIPS data-encryption standard (DES) available for user files. Encrypted password security protects operating system access.
- Pipes to pass data between concurrent tasks and group simple modules for accomplishing complex operations.
- Many multiprocessing system utility programs include a wide range of separate capacities.
- Text-processing and office-automation utilities including two powerful calculators, a calendar for reminders and provision for scheduled future program execution, formatting for phototypesetter and line printer, two or more editors, formatters for tables and mathematical equations, spelling and writing style checker.
- File-processing utilities enable combine, split, compare, contrast, search, modify, compression, format translation (including 370/EBDIC), encryption, and tabular data manipulation and processing.
- Software-development tools include translators for various meta-languages (yacc, lex, and m4) and

languages (typically C and FORTRAN 77), subroutine libraries, object-code archiving programs, execution performance profiling, assemblers, linkage editors, debuggers, utilities SCCS and make to manage large numbers of object modules or source/text files, and C language utilities to check source for correctness and print formatted listings.

- Communications utilities for main-frame remote-job entry and dial-up, file transfer, and electronic mail among UNIX facilities.

For a tour of the joys of UNIX, I suggest *The UNIX Tutorial*. David Fiedler's breezy but comprehensive three-part overview (August, September, and October 1983 BYTE).

TRADE-OFFS

Like any operating system, UNIX is a set of compromises made to enhance certain functions at the expense of others. A few of the areas traded off are as follows.

UNIX is poor at real-time tasks such as data acquisition. Task priority is set up to allocate less processor time to jobs that require the most time. The highest priority is given to jobs that use the least amount of the system's central-processor resources. In such a system, designed to be fair across all users and processes, there is no way to guarantee that a time-critical process will get the central processor often enough.

Most of the current UNIX systems permit multiple jobs to simultaneously access the same file, which can bring about such potentially dangerous situations as multiple users updating the same database at the same time. To circumvent this problem, many suppliers of UNIX have implemented file and record locking, generally through the use of such software devices as signals or semaphores, but these are not automatic and must be written into programs. Suppliers of commercial UNIX database programs generally have incorporated file and record locking into their software.

Another drawback is that the user interface can be very difficult to learn. In other systems, the power has been made more explicitly available at a cost of flexibility and command extent.

Often the naming and syntax of commands, options, prompts, error messages, and argument specifications are inconsistent, cryptic, or nonexistent. The concept of a shell to link discrete commands designed for a narrow purpose makes learning difficult, especially for the occasional user.

To overcome these drawbacks, menu systems and other user-interface enhancements are beginning to appear on UNIX systems. It is also worth noting that a competent programmer can create menu facilities, which let new users accomplish tasks usually reserved for experts.

UNIX is vulnerable to problems caused by accidental or intentional overuse of system resources such as jobs, disk space, swap space, and so on. In fact, there are ways to bring a standard UNIX system to a standstill with a single line of commands. The designers assumed that resources are ample to protect against accidental over-allocation and that system users are skilled and benign.

For business uses, there are built-in solutions to the last two issues. Each user should have a login profile, set to execute only the appropriate application program or only given access to a selected safe subset of UNIX commands through the use of shell restrictions. As users become more advanced, these restrictions can be relaxed or rescinded. In addition to the primary goal of ensuring system security, this method implements a configurable learning method—a good set of training wheels. Note, however, that this presupposes someone who knows how to set up and enforce such restrictions.

UNIX AND THE IBM PC

IBM has been increasingly interested in UNIX, as demonstrated by its present commercial offerings in the marketplace. UNIX is presently available from IBM on three of its computer lines, Series 1 (CP/IX), the S9000 (XENIX), and the PC XT (PC/IX). An implementation called TSS/UNIX has also been done for the 370 and 303X mainframes, but it is not commercially available yet.

In a modest configuration of 256K bytes of RAM, the IBM XT is at the bottom of rankings of system resources employed to host UNIX. The addressable memory expanse is

reasonable in comparison to the PDP-11 series of minicomputers that UNIX grew up on, but the Winchester is only marginally adequate. UNIX runs well on hard disks with an average access time of 20 to 40 milliseconds (ms), while the XT's Winchester times are closer to 90 ms.

Excluding user file space, a full UNIX system occupies 6 to 8 megabytes of disk storage space, leaving little space for user files or a DOS partition for hard-disk coresidency. Neither the 8088 nor other on-board hardware provides for memory management and protection. Thus, UNIX must incur extra software overhead to simulate memory management, and the task protection afforded is not sufficient for multiuser software development (due to the likelihood and danger of errant programs) and barely adequate for multiuser application programs. The 8-bit data bus becomes a processing bottleneck in UNIX and C, where most data is manipulated in 16-bit chunks.

On the plus side, the PC family forms the basis for the least expensive UNIX workstation available. That's a potent argument when you recall that only three years ago, the low end of the UNIX market was a minicomputer costing in the middle five figures. The availability of the 8087 coprocessor on the PC is a real boon for floating-point number applications, for example. If usage is restricted to one user doing software development or a maximum of three users at any one time performing tasks such as text entry but not recalculating a large spreadsheet, the system will perform much the same as a terminal on a minicomputer UNIX system under an average load of users. For some applications, then, it's very cost-effective. A general idea of the relative level of performance that can be expected is demonstrated by a computation-intensive benchmark primarily testing central-processor speed and memory-access efficiency. It showed that in tests involving C's long data type, the XT operated at about one-quarter the speed of an 8-MHz 68000-powered supermicro and with C short integers and integers at about one-half that speed.

There are several general reasons why you shouldn't use UNIX on the PC. For

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one, applications software is currently available in a broader spectrum of variety under PC-DOS than UNIX. Second, it takes considerable time for new users to become proficient. Finally, the system is too complex to exist on its own without some rather advanced software-maintenance procedures such as user account creation and administration, file-system administration and maintenance, and the observance of system shut-down protocols.

On the positive side, when considered as a single-user system, PC UNIX is a cost-effective way to trade off some performance for having UNIX available on a widely used hardware configuration. A few hints may help you get the most out of your system. If you want a full UNIX system, keep some of its less used parts on floppy disks and load them into the system only when necessary. If the system has several users or does extensive multitasking, the larger the amount of RAM in the system, the faster UNIX will work because you'll need to swap data less often. In general, the system should have only one user in all but the lightest duty applications, where it can accommodate two to three users at most.

UNIX SYSTEMS FOR THE PC

Several UNIX systems and work-alikes are presently available for the IBM PC, and more are expected shortly. A brief overview follows.

Currently, four Bell-licensed UNIX systems are available for the PC: PC/IX (implemented by Interactive Systems and sold by IBM), XENIX (implemented by Microsoft and sold by Santa Cruz Operation), VENIX (implemented by VenturCom and sold by Unisource Software), and U-II (implemented by Unidos Systems and sold by International Data Services). All of these systems allow file transfer to and from PC-DOS and include additional DOS file-manipulation utilities. The makers of VENIX and Uniform Software Systems are working on DOS emulation capabilities for VENIX and PC/IX, respectively. PC/IX, XENIX, and U-II are based on Bell UNIX system III, while VENIX's ancestry is Bell version 7 UNIX. These are all large, full, licensed UNIX systems. XENIX, U-II, and VENIX contain some utility programs developed at University of California,

Several UNIX systems and work-alikes for the IBM PC are currently available.

Berkeley, including versions of the vi screen editor and the C language-oriented shell, csh. PC/IX includes a screen editor developed by Interactive Systems.

The four UNIX look-alike operating systems for the PC are Idris (White-Smiths Ltd.), QNX (Quantum Software Systems), Coherent (Mark Williams Company), and uNETix (Lantech Systems). None of these systems is based on a Bell Labs UNIX license. The two closest to Bell UNIX are Coherent, a highly compatible UNIX version 7 look-alike, and Idris, which is system-call compatible with version 6 UNIX, but many of its commands differ slightly from their UNIX counterparts. QNX uses an idiosyncratic syntax with functions that bear a close conceptual resemblance to UNIX. To outline some strong points, Idris has an elegant DOS interface, QNX is capable of high performance, and Coherent is nearly equivalent to Bell UNIX. All three systems include excellent C compilers, perhaps better than those supplied with any of the Bell-licensed products.

Two implementations of UNIX are tied to auxiliary processor cards. A Motorola 68000 card runs Xenix, and a National Semiconductor 16032 card runs BSD (Berkeley Standard Distribution) 4.1 UNIX. Both cards are available from SriTek Inc. These systems, intended for the OEM (original equipment manufacturer) market, typically use the PC only as an I/O processor; the auxiliary processor does all other tasks. Although the level of central-processor performance is considerably better in these systems, the hard disk is still slow and small for UNIX. Be sure to evaluate these systems for cost-effectiveness, since either adds roughly \$3000 to the cost of a basic PC host.

Two general levels of PC-DOS interface are evident. The first, DOS emulation, lets users run DOS programs and return to UNIX without sacrificing the

functionality of either operating system. There are several ways this is done. Idris runs as a task under DOS so DOS commands can be executed from within it by an escape mechanism. Moving between Idris and DOS is as simple as invoking Idris from DOS or exiting to DOS. QNX actually brings the binary executable files into its file system and executes DOS function calls by emulating the operating-system routines accessed through interrupts by the guest program. Coherent and uNETix are both developing emulation capability. The second level, for UNIX environments with DOS file-transfer capability, does not allow for any execution of DOS commands from within UNIX. Differing degrees of file-transfer support are provided. Some systems let you delete, rename, and perform other manipulations on PC-DOS 2.0 directories and files, while others only let you copy files to and from UNIX.

COMPETING SOLUTIONS

Three general categories of software products compete with UNIX for a dominant position in the future market for concurrent systems: other multitasking operating systems, proprietary integrated environments, and enhanced hardware environments incorporating mainframe access.

The first category, multitasking operating systems, includes yet to be released MS-DOS 3.0 and Microsoft Windows, Concurrent CP/M-86, and the Pick operating system and its variants.

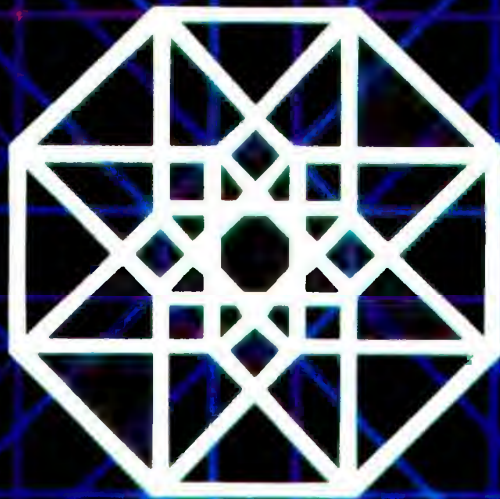
Currently, PC-DOS has a greater variety of general-purpose software available, such as decision support, word processing, utilities, and programming tools. However, it lacks concurrency.

Proprietary integrated environments include Lotus's Symphony, Ashton-Tate's Framework, Quarterdeck's DesQ, and VisiCorp's VisiOn series. Generally, they provide the following enhancements to the operating system:

- It's easy to move data from one application module to others.
- The user can freeze session state and return to DOS or execute DOS commands concurrently without leaving the working environment.
- A concurrent stub allows main-

(continued)

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UNIX ON THE IBM

frame communication.

- The system is user friendly and has menu-driven command structures and extensive help information available on-line.
- Other packages can be added to the same environment.

Environments based on concurrently

integrating a mainframe link refer primarily to the two powerful hardware enhancements to the PC computer family offered by IBM, the PC XT/370 with VM/PC operating system and the 3270 PC with its control and file-transfer programs. The facilities of the XT/370 are limited to a single-tasking VM/CMS session locally under VM/PC, and thus PC

XT and 370 modes are not concurrent. The system does offer file-transfer capabilities between mainframe 370 and XT/370 as well as between XT/370-VM/CMS and PC-DOS, but it really shines when it comes to offloading processing from an IBM mainframe to capable local workstations.

The 3270 PC supports seven concurrent tasks, including four separate interactive 3270 sessions with a host mainframe, two local notepads (with full-screen editing and data-transfer capabilities), and one a standard PC-DOS 2.0 task.

You can obtain data from up to four mainframes, collect it in a notepad area, evaluate it in a PC-DOS spreadsheet, and then pass a set of results back to the mainframe for transmittal by electronic mail.

A UNIX SOLUTION

The growing popularity of UNIX, and the C language in which it is written, in the commercial microcomputer community is largely based on demands for software transportability. The capital investment required by the labor-intensive process of creating software makes increasing the market size and useful life of such new programs imperative. From this standpoint, the alternatives to UNIX become less attractive. Further, the software consumer has to consider the costs of retraining workers. Advances in hardware that invite upgrades for increased performance will appear more rapidly than similar advances in software. None of the alternatives operates on the range of hardware that UNIX does.

While less business-oriented application software is available for UNIX than for some alternatives, DOS emulation can serve as a useful bridge until the new generation of UNIX software, already under development, appears. At present, using the full extent of UNIX capabilities requires some sophistication, but customized shells and restricted environments focused on one task will soon become available to allow the unsophisticated user to take advantage of the system's power.

The wide-ranging transparency and communications transparency that UNIX provides make it an attractive long-term solution to business demands. ■



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At the heart of Enable is a Master Control Module which is similar to supervisory programs that run the most advanced mainframe computers. This Master Control Module (MCM) contains all services and facilities for Enable. And all functions common to all modules—eliminating system redundancies.

Windowing is easier and faster than ever before. "Cut and paste" data from one module to another cleanly, precisely, with a minimum of keystrokes. And do it in a split-second (others can keep you finger-tapping for a small eternity). Up to 8 windows can be moved, shaped, overlapped or zoomed to full screen size.

Integration: So much, so easily.

You can create a graph from a spreadsheet or database. Then insert the graph and the spreadsheet between text in a single word processing document *right on the screen*.

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Using DBMS with word processing, you can automatically include selected DBMS fields—or embed calculated fields—within the text of a letter or report.

Combining word processing with telecommunications, you can write anything from an electronic mail message to an annual report and transmit it across town or around the world.

Since the MCM handles all full-screen text editing, you can use that important feature in any module.

Greek, foreign and special character sets are available—not only in word processing—but for putting labels on top of your graphs, creating DBMS data entry forms and producing customized reports.

Functionality: All you could ask for.

Unlike other integrated software, every one of Enable's modules gives you virtually everything you'd expect from the better stand alone programs. And, often, more than you'd expect.

Enable *e i* is very much like a dedicated word processor. Going beyond all the standard features to include such things as:

- positioned headers and footers • pagination • automatic footnoting • mail merge • multiple character sets • document size limited only by available disk space.

The Enable Spreadsheet is comparable to Lotus 1-2-3™ both in functionality and speed. With such special features as:

- variable column length for loading of DBMS data • highlighting of all related cells • step feature for changing value in target cell • can take advantage of your optional 8087 math co-processor.

Enable Database Management is, without qualification, the most powerful DBMS available in an integrated system. So powerful, you can generate specialized applications *without the need for any programming*. The DBMS includes:

- Menu-driven field definition using an external data dictionary • comprehensive "paint the screen" input and report forms design • full screen data entry with extensive and automatic field editing and validation • over 65,000 records per database • rapid search and retrieval using Boolean logic, arithmetic and relational operators, and "wild cards" • powerful menu-driven report generation including virtual and calculated fields, and up to 16 break conditions with running, break, conditional and grand totals.

Enable Graphics draws *presentation-level* graphs. Its many special features include:

- sizing, shaping and positioning of graphs using

windowing • writing labels right on the graph • 7 graph types with 8 fonts.

Enable Telecommunications gives you easy access to online services, your company's big computer and other personal computers. With automatic sign-on using stored "set-ups" enter your connection protocol just once and then press a few keys to make that connection again and again.

192K? Yes, 192K.

Enable's highly efficient, non-redundant system architecture—which makes use of virtual memory as well as reentrant Assembler coding—gives it the ability to run with as little as 192K and two double-density disk drives. And we do mean *run*. Which means you won't have to add lots of expensive memory or a hard disk to your hardware to enjoy a fully-integrated, full-function system.

Speed you've never seen.

This major shortcoming of many integrators is a major asset of Enable.

With Enable, when a word processing document is revised, the entire document is reformatted in an eyeblink (no "ripples").

In a spreadsheet, even as numbers, formulas, rows and columns grow more complex, Enable re-calculates at lightning speed.

Enable's DBMS can rapidly retrieve records according to even the most complex parameters and sort them on up to 8 fields.

Critical Compatibility.

Here's another enormous advantage: all the time and money you've invested in first generation packages won't go to waste. Files created by dBase II,™ Lotus 1-2-3,™ WordStar,™ VisiCalc,™ EasyWriter I,™ or Volkswriter,™ can be used automatically in Enable without conversion or rekeying. Similarly, Enable can *create* files in the proper format for all the above as well.

Enable = Power.

The MCM internally directs traffic, making it possible to run one main program, one communications program and one printing program concurrently. So you can do spreadsheet analysis, print a monthly report and receive

stock quotes over the wire—all at the same time.

Enable's powerful macro facility saves you time and keystrokes in all modules. Macros may be automatically recorded as the steps are executed; even edited using full word processing capabilities. You can, for instance, create a macro which produces a report containing data selected from your DBMS file. Every time the macro is executed, the resulting report is updated with the latest information from your database.

Ease you've never experienced.

As for being "user-friendly" (the most abused phrase in all of computing), the proof, of course, is in the using. Here, you'll discover, Enable shines. Whether you're a beginner or an expert.

Since the MCM is the sole interface between you and all the modules, you only have to learn one uniform set of commands and menus to use the entire system.

You may not even need to open a manual first. Clear, English language menus—complete with explanatory messages—are available in every module. Menu options may be selected by the traditional cursor method, or with a single keystroke short-cut. As you grow more experienced, expert commands bypass the menus. And there are convenient macro commands for the really sophisticated.

For those just getting started, Enable has a tutorial disk distinguished by its clarity and depth. And the manual teaches you, step-by-understandable-step, how to use all that the system provides. For online assistance, at any time, just push the F1 key to get all the help you need.

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Enable defeats software obsolescence. Your product updates will not only include important new features, but—because of the MCM's flexible design, its "open architecture"—your system will be continually enhanced to take full advantage of changes in micro hardware.

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BY JOHN MARKOFF

FIVE WINDOW MANAGERS FOR THE IBM PC

Multiple windows, mouse pointing devices, and multitasking environments for your IBM PC

The public's acceptance of the Apple Macintosh computer has made it clear that certain user-interface designs are now becoming more universally accepted.

The major elements of these interfaces are bit-mapped graphics monitors, mouse pointing devices, and window-oriented displays with pop-up menus. Together these elements act as a visual shell, insulating the user from the operating system. By using pop-up menus that overlap on the monitor, your computer's screen is supposed to remind you of a cluttered desktop. Often the new interfaces use icons to represent the computer's programs, documents, and resources.

The roots of window-based user interfaces lie in two computer science research developments that emerged during the fifties and sixties. The first is based on the work done around the mainframe graphics systems developed by George Evans and Ivan Sutherland. Sutherland's doctoral dissertation was based on an innovative graphics system he called Sketchpad. The concept of windows seems to have evolved from Sketchpad. Sutherland did his work before the advent of computer time-sharing, so, in effect, he was using a mainframe as a personal computer.

The second development grew out of the investigation of new technologies

for information storage and retrieval done by a group headed by Douglas Englehardt at SRI International. Much of the group's work dealt with viewing and organizing documents and giving the user the ability to rapidly switch between documents.

Both of these research developments were brought together by computer scientists at the Xerox Palo Alto Research Center (PARC) in the early seventies. At PARC, work done by the Smalltalk research group led to the construction of a series of single-user personal computers that employed mouse pointing devices and bit-mapped displays. The first version of Smalltalk offered a bit-mapped screen displaying overlapping windows; it was created on an Alto personal computer (an experimental Xerox computer) by Dan Ingalls in 1975.

These overlapping windows and mouse pointers were striking in contrast to the single-command line and text-oriented questions that faced the user after booting up on the first mainframes and personal computers.

Certain elements of this user interface are still being hotly debated. Some question the efficiency of mouse pointing devices and others ask whether overlapping or "tiled" windows are preferable. (In a tiled interface windows shrink to accommodate other windows that are expanded; however, all windows remain visible. This concept was

also first developed at Xerox PARC and has been used on the Xerox Star.) However, a consensus seems to have emerged that an interface that permits a user to see a command and point at it to execute a task is simpler and more interactive.

Window-oriented user interfaces function best when they are based on high-performance processors and displayed on high-resolution screens. They have (until the introduction of the Apple Macintosh) generally been considered beyond the realm of the low-cost desktop personal computer. However, a number of window-management software programs have been introduced for the IBM PC.

Because two of the five programs I looked at are still undergoing testing and two others were released in their first salable version only weeks before our deadline, this article does not constitute a formal BYTE review. However, I have been able to work with the products, and I will comment on their performance and design with special emphasis on the style of user interaction offered by each program.

The five programs I previewed include

(continued)

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DesQ from Quarterdeck Office Systems in Santa Monica, VisiOn from VisiCorp, Windows from Microsoft, Concurrent DOS from Digital Research, and WindowMaster from Structured Systems Group in Oakland, California.

WINDOW MANAGEMENT ON THE IBM PC

If you attempt to display and integrate a number of discrete applications on an IBM PC, you will face a number of problems that have no obvious solutions. For example, some have approached window management as an application in its own right that intermediates between the operating system and separate applications (DesQ, VisiOn, and Window Master can be considered "operating environments"). Other operating-system developers have extended the operating system up toward the application software (Windows and Concurrent DOS).

In the case of the IBM PC, matters have been complicated a great deal, because the user hardware base has tended not to be standardized (the market is split between those who have either monochrome text-oriented or graphics displays and available system memory ranges from as low as 64K to 600K bytes) and because virtually all major software developers have chosen to circumvent the MS-DOS operating system to display information on the screen.

A second issue is "tight" versus "loose" integration of applications. VisiCorp, the first company to announce a window manager for the IBM PC, insisted on tight integration. To run under VisiOn, an application must be specifically designed for that environment. These applications can exist in display windows as well as pass data to other applications. In contrast, Quarterdeck's DesQ attempts to support as broad a range of MS-DOS applications as possible (see table 1). Quarterdeck has provided "agents" for 12 major application programs. These agents will permit the applications to run in windows under DesQ and to transfer data between windows or applications running in different windows. Applications that don't have a specific agent can generally be installed by the user; however, they will not be able to run in windows. Microsoft's Windows will lie somewhere be-

tween tight and loose integration. To run under Windows an application must be specifically tailored to the program; however, Microsoft has stated that if an application writes directly to the hardware, Windows will gracefully turn the screen and other resources over to that application.

There are other issues at stake in developing window managers for the IBM Personal Computer. Important distinctions between window managers range from style questions, such as whether to use icons, to virtual memory and multitasking.

CONTEXT SHIFTING

The variety of personal computer applications available and the fact that many can be used in conjunction with each other or operate on shared data make it desirable to be able to view applications simultaneously and to move quickly between discrete tasks.

If the operating system of the IBM PC is altered to permit multitasking, an ideal window-oriented interface would permit you to carry on simultaneous communications tasks (electronic mail or database access) while running other programs locally.

PARTITIONS

The large memory-address space of the IBM PC permits several programs to be placed in RAM (random-access read/write memory) at the same time. The simplest approach to partitioning memory is taken by a program called Memory Shift from North American Business Systems. Memory Shift is not a window manager per se, but it allows you to divide the RAM of an IBM PC into up to nine separate partitions. Each partition holds its own application, and you

are permitted to switch between different tasks that are then displayed on the screen. Since Memory Shift does not offer a multitasking extension, only one program is run at a time. Programs in other partitions are suspended.

Of the five window-management programs for the IBM PC, DesQ's and VisiOn's partitioning schemes are the most ambitious. DesQ has added some memory-management capabilities to the IBM PC to allow you to simultaneously display programs whose combined memory requirements extend beyond the limits of your system RAM. (Of course, these programs are not running simultaneously; however, DesQ swaps them back and forth from disk.) VisiOn also uses virtual-memory management to permit you to place more programs on its desktop. The exact makeup of the Windows memory-management scheme isn't available yet, but at a developers' seminar held early this year, Microsoft indicated that both code swapping and compaction would be involved. Concurrent DOS and Window Master partition memory in a manner similar to Memory Shift.

MULTITASKING

Multitasking frequently is held out as the next performance plateau for desktop personal computers. Multitasking is in principle possible on the 8088-based IBM PC, but the consensus is that running several computation-intensive tasks will degrade the performance of the PC below what is acceptable. There are several multitasking operating systems available for the PC, most of them variants of the UNIX operating system. There are also a number of multitasking extensions of DOS available from third parties.

Several of the five window managers also offer multitasking capabilities. WindowMaster, Windows, and Concurrent DOS all offer this feature to varying degrees. In each case there are significant limitations. Both WindowMaster and Concurrent DOS have difficulty handling "misbehaved" applications (those that don't use standard DOS calls to write to the screen) as background tasks. Such programs frequently must be put to sleep when they are in the background to avoid conflict over video memory. Windows steps out of the way in the face of programs that do not

Table 1: The DesQ agent library. These programs can run in resizeable windows within the DesQ environment.

FAST GRAPHS	pfs:report
dBASE II	pfs:write
Lotus 1-2-3	SuperCalc
MultiMate	SuperCalc3
Multiplan	WordStar
pfs:file	VisiCalc

WINDOW MANAGEMENT

meet its design specification. This is not an inconsequential problem, because virtually all of the commercial software available for the IBM PC circumvents MS-DOS for speed reasons.

DATA TRANSFER

Data-transfer capabilities vary in each of the five window managers, ranging from tightly integrated applications (VisiOn and Windows) to a simpler strategy involving only copying screen memory directly or indirectly from one partition to another (Concurrent DOS and WindowMaster). DesQ offers a complex set of transfer options. At one end of the spectrum, with applications that have agent support, DesQ knows enough about how an application formats, marks, and transfers data that it can handle data transfer between dissimilar packages. If agent support isn't available for the programs you are running with DesQ, you can still use a "view" mode transfer option that makes copies from screen memory.

HARDWARE

One obstacle facing the developers of window-management user interfaces for the IBM PC is the lack of standardization among different hardware components.

The most significant split is between the monochrome and color/graphics display. The monochrome display currently available from IBM has a higher resolution than the color/graphics monitor (720 by 350 pixels versus 640 by 200 pixels); however, it supports only a character-mapped display. Developing a window-based user interface has therefore meant choosing to support either one or both of the display options.

There are other hardware-based decisions to make as well. DesQ requires 256K bytes of memory plus enough additional RAM to run the largest application program the user intends to run in addition to a fixed disk. DesQ program files take up over 1 megabyte of disk space. VisiOn requires a minimum of 256K bytes of RAM (VisiCorp claims its applications run faster with more memory) and a fixed disk, and asks the user to clear 5 megabytes of disk space for VisiOn files. Windows, on the other hand, claims that it will run with 256K RAM on a floppy-disk based system.

Finally, there is the issue of the mouse. Both VisiOn and Windows will require mice as pointing and command devices. Mice are optional or not used by the other window managers.

MISBEHAVED APPLICATIONS

The Achilles heel of IBM PC window management is screen management. Only those programs that display textual information on the screen by calling DOS or the ROM BIOS will run in small windows.

Unfortunately, for reasons of performance, almost every software publisher has chosen to write directly to the hardware. DesQ has offered special agents or utilities that permit several popular programs to be run in windows. Still, this probably will remain a major problem until an acceptable standard is set for bit-mapped display graphics and text on the PC's screen.

Other potential sources of incompatibility exist as well, depending on

how individual application programs read the keyboard or how they locate themselves in memory.

STYLE

Entering the debate over the best user interface is hazardous at best. Should your mouse beep, flash, or make no noise at all when you click it? Should your mouse have one, two, or three buttons? Should your windows overlap or be tiled? Should you use icons or have a more staid or serious desktop? The list is virtually endless, yet the questions remain important both from a design and a marketing viewpoint.

DESQ

DesQ was the surprise hit of the 1983 Spring COMDEX computer show in Atlanta. Its strength is that it allows IBM PC users to integrate their already existing applications, and in some cases to display them simultaneously on the

(continued)

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Ex. 1022, Page 78

WINDOW MANAGEMENT

screen and pass information between them. DesQ also automates frequently performed repetitive and complex operations through Learn or Script utilities.

Despite its name, DesQ has kept the use of a desktop metaphor to a minimum; it has no electronic-desktop screen (installed programs appear on a simple menu) and, although the program does support three different mice (Mouse Systems, Microsoft, and Logitech), it is designed to function just as well with menu-based keyboard selections. DesQ does support background color and will run programs that have graphics output (not in windows, however), but it appears to be optimized for use on the IBM monochrome display.

Quarterdeck Office Systems has managed to unhook screen-cursor movement from the individual application software in a number of cases. This means, for example, that it is possible to use a program like WordStar, which is noticeably hostile to mice (quick cursor movement tends to fill a WordStar screen with a series of exclamation marks), with a mouse. However, don't expect the same kind of natural pointing that you experience on a system like Apple's Macintosh. When you move the mouse pointer in WordStar, the DesQ WordStar agent translates your pointer movement into commands. It often

takes several seconds for the WordStar cursor to reach the spot you have pointed at.

Another one of DesQ's strengths is that "shortcuts" have been designed in at every point in the system. This means that, while DesQ is largely menu driven, expert users who have learned commands can frequently get things done using keyboard-control sequences. While novices generally will use menus to move between different windows, experienced users can use a shortcut. To enter a new window (or a new partition of that window), it is only necessary to tap the DesQ key (the Alt key) and then type a number corresponding to the window you wish to activate.

If you are using a mouse with DesQ, one of the mouse buttons becomes the DesQ key. When using a mouse, it is only necessary to point and click in the window to activate it. It is also possible to move or resize the windows with the mouse.

DesQ comes on three floppy disks and uses an install program to create its own directory on a Winchester disk drive. After DesQ is installed, it is necessary to insert the first Starter disk into the floppy-disk drive and then type the command "DesQ" from the operating system prompt each time you start DesQ.

(continued)

AT A GLANCE

Name

DesQ

Manufacturer

Quarterdeck Office Systems
1918 Main St., Suite 240
Santa Monica, CA 90405
(213) 392-9851

Application programs

Existing MS-DOS programs and a simple text editor

Consistent command structure

No

Graphics

Character-based

Hardware required

IBM PC or compatible, 256K bytes of RAM plus enough memory for largest application, 5-megabyte hard disk

Support color

Yes

Multitasking

No

CP/M-86

No

Memory management

Yes

Data transfer

Program-level data with agent support

Mouse support

Optional

Price

\$399

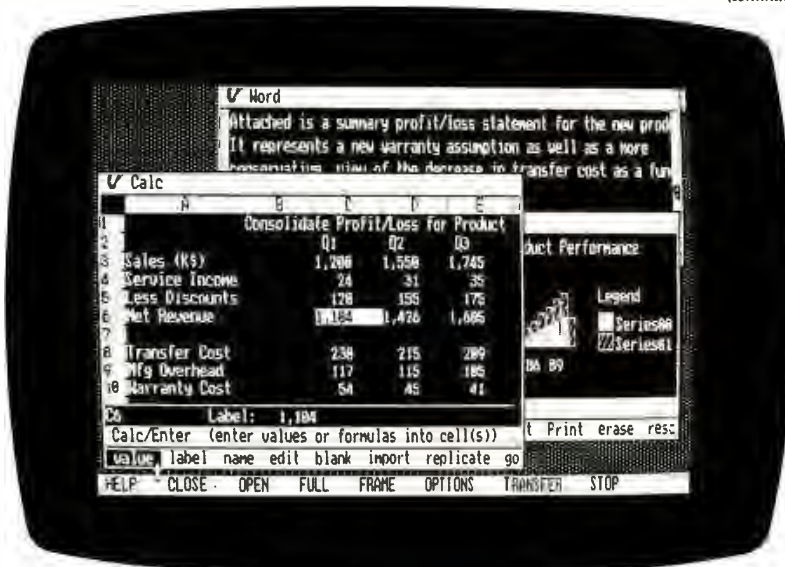


Photo 1: VisiOn from Microsoft.

After the program loads, the first screen of information that appears is the DesQ main menu from which you perform such functions as running programs, rearranging directories, and installing new programs.

To run any program under DesQ, you must first install it as part of the DesQ system. This is done by either loading one of the DesQ-supplied agents for one of the 12 programs that have been tailored for the DesQ environment, or by having DesQ create a new agent for a program that is not in its agent library. After this is done and saved to disk, that program becomes a permanent part of the DesQ menu and can be called directly from that menu.

To create permanent Scripts in DesQ using the Learn facility, select the = key from the DesQ main menu, name the particular Script, and select the keystrokes that will invoke the Script. DesQ then creates a record of all subsequent keyboard input until you suspend the Script by again calling the = key from the DesQ main menu. After the Script has been saved to disk, it can be invoked at any point from a submenu that is specific to a given program. Advanced Script functions also include the ability to let a Script pause for keyboard input or to input data from a pause.

DesQ comes with a series of predefined general Scripts that permit a series of general operations to be performed on any currently active application (see table 2).

The Script command also applies to DesQ's Mark and Transfer function. This feature allows users to automatically generate custom reports that have to be generated regularly from diverse sources.

DesQ claims that if your format can read and write information in DOS text files, DIF format or SYLK (Microsoft's own data format), it will be possible to transfer information in or out of these programs.

DesQ also has a Mark Transfer Forms feature to permit collection of disjointed pieces of information and transfer all the pieces in a group to another program. One example is transferring an entry from an address book in pfs:file to a customer database in dBASE II. Using the Forms capability, the user would show DesQ how to mark each of the pieces of an entry in the pfs:file ap-

plication and then show DesQ where in the dBASE II record to put each piece. After DesQ has been shown the operation once, it can then automatically repeat the process. This is an intriguing capability because it can conceivably provide a method for transferring otherwise incompatible database information between programs.

Creation of Mark Transfer Scripts is considered an advanced task in DesQ. Simpler functions include the MARK TRANSFER command, which will permit transfer of data between programs whether they have DesQ customized agent support or not. At the lowest level DesQ uses a View option to copy information from screen memory. The VIEW command can also be used to circumvent individual application restrictions of cursor movement. In View mode DesQ provides a "snapshot" of the information the program has written to the full screen. This can be manipulated independently of program-imposed restrictions.

The View mode also has several other interesting uses. For example, View can be used to save information from communications programs or other programs that write to the screen as if it were a terminal. View will save this information for later editing or other processing. View also lets you take an application that will not run in a DesQ window and place a snapshot of it in a window so that it can be referred to while using other programs. The program is suspended by DesQ when it is in this

special View window.

Although DesQ insulates the user from DOS, the program does not entirely fence the user away from the operating system. DOS directories and most utility programs can be accessed via a special DesQ window called File Print. A range of DOS commands including BACKUP, COPY, ERASE, RENAME, etc., can all be accessed through this menu.

DesQ also provides a DOS-related feature called Logical Drives that permits programs designed for DOS 1.1 to take advantage of DOS 2.0 directories. The Logical Drives feature lets you associate a drive letter with a DOS 2.0 directory. DesQ then maps this drive assignment to a particular directory path.

USER INTERFACE

DesQ can perhaps be viewed as an extension to the operating system as well as a user interface. Thus the real importance of DesQ may be in the power it gives users to automate repetitive operations.

Although DesQ is designed to permit mouse operation, using a mouse didn't seem to have any particular advantage. Virtually all of the DesQ commands can be given as quickly, if not more quickly, from the keyboard.

Used with the IBM monochrome display, DesQ suffers from the same problem that all character-oriented window managers do: when the display is broken into separate windows, the space available for each window is sig-

Table 2: Predefined DesQ scripts.

Switch to Window (I-9)—switches to windows 1 through 9.
Input from Pause—plays back the last variable information entered when a script performed a Pause for Input command.
Repeat Last Script—displays a menu which allows you to repeat the last script played back.
Mark Begin—marks the beginning of information.
Mark End—marks the end of information.
Put Aside—puts a window aside.
Transfer—transfers marked information.
View—switches the current window in or out of View Mode.
Zoom/Unzoom—zooms the window you are working on to a full screen window, or unzooms it from full screen back to its original window size and position.



Photo 2: WindowMaster from Structured Systems Group.

nificantly limited. Users might find that the ability to shift between different programs or contexts quickly is ultimately of more value than the ability to display several documents or programs at once.

As long as DesQ is able to hold different programs in RAM, context switching between them is virtually instantaneous. However, when DesQ is forced to swap programs between RAM and disk, it doesn't seem to be quicker than the time it would take to perform the same operation from DOS.

Finally, software compatibility seemed higher on DesQ than on any of the other programs I experimented with. DesQ was able to run everything I tried; however, several arcade-style games caused the program to hang when I called the DesQ menu.

WINDOWMASTER

WindowMaster is a recently introduced multitasking window-based user interface. It is optimized for Structured Systems Group's own applications that normally run under CP/M-86: Word Right, NAD (a mailing-list database-management program), and Magic Spreadsheet; however, it will run other applications programs as well. In terms of documentation, WindowMaster is one of the simplest of the five window man-

agers, yet it also has the capability to create script macros similar to DesQ. It will allow several MS-DOS and CP/M-86 programs to run concurrently, and it offers simple interwindow data transfer. Multitasking in WindowMaster is done by time slicing, that is, it allocates each task a small amount of processor time. However, there is no way to control task priorities.

In a sense, WindowMaster has extended MS-DOS to support CP/M-86. (Concurrent DOS is a version of CP/M-86 that has been extended to support MS-DOS calls.) The program includes a copy utility that permits the import of CP/M-86 programs and documents.

Like DesQ, WindowMaster doesn't pretend to give the user a desktop metaphor. The program has no built-in provision for mouse support, and all user interaction with WindowMaster is carried out through pop-up menus containing commands that you can execute with the IBM PC's function keys.

WindowMaster will run on a system with as little as 256K bytes of RAM and two floppy disks; however, it can make use of additional RAM and can be run from a hard disk (see table 3). (The WindowMaster disk must be in the A: drive when the system is loaded.) Window-

(continued)

AT A GLANCE

Name

WindowMaster

Manufacturer

Structured Systems Group
5204 Claremont Ave.
Oakland, CA 94618
(415) 547-1567

Application programs

Existing MS-DOS or CP/M-86 programs

Consistent command structure

No

Graphics

No

Hardware required

IBM PC or compatible, 256K bytes of RAM, two floppy-disk drives

Support color

No

Multitasking

Yes

CP/M-86

Yes

Memory management

No

Data transfer

Screen memory only

Mouse support

No

Price

\$295

Master does not recognize DOS 2.0 hierarchical directories; therefore, in a system using DOS 2.0, all programs must reside in the same directory as WindowMaster in order to run.

WindowMaster functions break down into six categories: program management, window management, script management, interwindow transfer of data,

graphics, and keyboard management.

Program management is a menu item that allows the user to run a program, get information on the current status of different tasks, display a series of "advanced" function options, and copy CP/M-86 program and data files.

When a program is loaded and run, WindowMaster gives it a full screen and

allows the user to decide if he or she wants to place it in a smaller window.

The WindowMaster documentation warns that a multitasking extension to MS-DOS can be dangerous because many programs have bypassed the operating system for speed and other reasons. In practice, I found that most, but not all, MS-DOS programs I tested would run in at least some form under WindowMaster.

In grappling with misbehaved applications that write directly to the display screen hardware, WindowMaster has added a special command `RUN CONCURRENT DMA VIDEO PROGRAM`. When an application is invoked with this command and is not in the active window, WindowMaster suspends the program so that it will not write all over the display screen. WindowMaster additionally gives these programs a full display when they are active.

It is also possible to map a misbehaved application that is only writing to part of the screen into a window so that the portion of the program where output appears will be visible and the rest of the program will be hidden. For example, WindowMaster could place WordStar in a window at the top of a screen while a long document file is being printed. During this time Wordstar only updates the top portion of the screen.

From the program-management menu WindowMaster permits the user to display an information screen that shows a listing of currently running tasks, their status, and available memory. WindowMaster uses the cursor keys on the numeric keypad to size windows on the display screen. It also offers a mode that permits a user to switch quickly between different tasks or windows by pressing the Space Bar. To set a new active task, the user presses the Return key.

A Script in WindowMaster is a group of saved keystrokes. The program differentiates between interwindow and intrawindow Scripts and allows each to be defined by invoking the Script mode, performing the desired task, and saving the Script to disk when finished.

WindowMaster permits the transfer of data from one window to another and will permit manual or automatic filtering of characters that are sent between different tasks. If you choose automatic



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filtering, a filter program creates a file that governs certain aspects of the information transfer, such as the characters to send after each line, the characters that indicate the end of a line, the characters to send before a string field, etc.

A graphics program that permits creation of pie, bar, and line charts on a color display, dot-matrix printer, or the HP 7470A color plotter is also included. However, the program is not integrated with other WindowMaster functions.

Finally, it is possible to define programmable function keys under WindowMaster. This option lets the user define and save single keys for either specific applications or Scripts.

USER INTERFACE

The WindowMaster user interface consists of a Spartan set of menus and makes no provision for either mouse support or an expert mode to permit experienced users to circumvent the menus. However, the multitasking feature of WindowMaster is interesting. I set the program up running WordStar, Crosstalk (a communications program), and a simple BASIC program that displayed elapsed time. When the BASIC program was moved to the background, it was suspended by WindowMaster, yet while Crosstalk was receiving a file through the IBM PC communications port it was possible to run the BASIC program in the foreground while Crosstalk continued to receive the file in the background. When Crosstalk was again made the active task, its screen was updated from the point where it had been frozen as a background task with no loss of information.

Of course, the drawback to a multitasking operating system on the IBM PC is that there is frequently a noticeable effect on individual program performance.

Table 3: Special WindowMaster install files for misbehaved programs.

Crosstalk	Lotus 1-2-3
pfs:file	dBASE II
Multiplan	SuperCalc II
WordStar	TK Solver
BASIC	Word Perfect
BASICA	

WINDOWS

Late last year Microsoft announced that it would be offering a window manager as an extension to the MS-DOS operating system. As the operating-system developer, Microsoft enjoys special advantages because most independent software developers will view the Micro-

soft visual shell as a standard, and because Microsoft has a more intimate working knowledge of the MS-DOS operating system.

To date Microsoft has been able to attract commitments to support Windows from both hardware and software companies. More than 20 IBM PC compati-

(continued)



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(408) 373-4718 / TWX 176786

AT A GLANCE

Name
Windows

Manufacturer
Microsoft
10700 Northup Way
Bellevue, WA 98004
(206) 828-8080

Application programs
Existing MS-DOS and specially designed programs

Consistent command structure
Yes

Graphics
Bit-mapped

Hardware required
IBM PC or PC compatible, 192K bytes, two floppy-disk drives

Support color
No

Multitasking
Yes

CP/M-86
No

Memory management
Yes

Data transfer
High level with specially adapted programs

Mouse support
Yes

Price
To be announced

ble manufacturers were on hand at the initial product announcement to say they would offer Windows with their computers. IBM was noticeably absent from the group, however. It is still not clear whether IBM PC owners will be able to buy Windows as a retail product.

Only demonstration versions of Microsoft Windows are available currently, and at the time of this writing (late April) Microsoft is stating that it will not ship the Windows development toolkit to OEM (original equipment manufacturer) customers until sometime during May. However, in February, Microsoft held a technical seminar on Windows, and a good deal of information about the product can be gleaned from the proceedings.

As was stated previously, Windows falls somewhere between VisiOn and DesQ in its integration strategy. Windows will allow virtually any existing application to run; however, to take advantage of its user interface, programs must be rewritten specially for the system.

Like VisiOn, Windows will work only with a mouse; however, unlike most other window managers, it doesn't offer overlapping windows. Microsoft takes the view that all current windows should be visible on the screen. The company calls this the tiled approach. As you expand one window, other windows automatically adjust to accommodate the growth. The screen is divided into variable-sized columns and rows. A window can be no smaller than its command line. All the windows are simultaneously active and are not suspended until they are clicked closed with the mouse. Windows will have certain multitasking capabilities and Microsoft is billing the Windows environment as a "sneak preview" of things that will be done with MS-DOS in the future.

The anticipated release size of Windows is between 50K and 60K bytes (the current demonstration version takes about 70K bytes). Microsoft is recommending a minimum of 192K bytes of RAM with Windows. This will leave between 120K and 128K bytes of program space in a minimal system.

Each windowpane has several significant sections. The command line across the top of the window contains the window's name. System prompts, command options, and messages can also appear in this area. Additional application com-

mands can reside in a drop-down menu within the window. Each window also can have horizontal and vertical scrollbars for altering the view of the program or document.

Windows will run only on a bit-mapped display (on most systems it will run in the IBM PC high-resolution mode, but it will not offer color windows) and it is the only one of the five window managers to make extensive use of icons to represent programs, documents, and system peripherals. Microsoft claims that icons are the best way to represent applications when screen-display space is scarce.

The question of tiling versus overlapping windows has become something of a theological dispute among user-interface designers. The Microsoft case is that tiling is the metaphor of the "neat" desktop. They claim that a tiled-window manager builds a certain amount of intelligence into the window-display equation. Windows guesses about where to put and how to size a window when it is selected, and it also allows the user to override in case he or she favors another layout. Microsoft hasn't been entirely orthodox on this issue. It will be possible for individual applications to display their own overlapping or "nested" windows for menus, property sheets, or other tasks.

There will be several data-interchange options in Windows. It will be able to pass information in an internal binary format, as ASCII (American National Standard Code for Information Interchange) text, or in SYLK, and possibly in DIF as well.

One of Microsoft's greatest strengths is its contention that by using Windows, application developers will bring portability to new hardware environments. Inasmuch as Windows is designed to function like a "virtual machine" between the application and the hardware, this will be true. For example, Windows is designed so that it can easily be moved to displays with resolution higher than that of the IBM PC.

USER INTERFACE

Of the five window-manager programs discussed here, Windows most closely approximates the group of concepts that comprise the user-interface design first advanced at Xerox PARC and com-

(continued)

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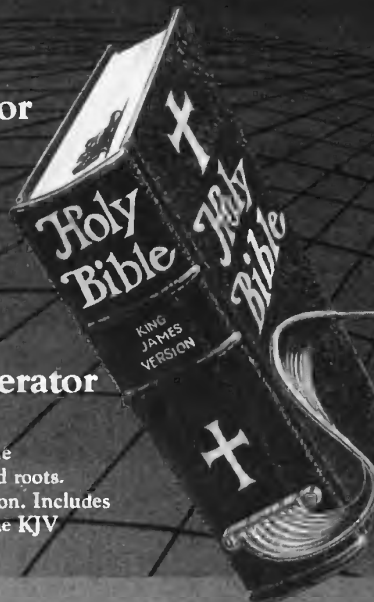
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Name

VisiOn

Manufacturer

VisiCorp

2895 Zanker Rd.

San Jose, CA 95134

(408) 946-9000

Application programs

Calc. Graph. Word. Query

Consistent command structure

Yes

Graphics

Bit-mapped

Hardware required

IBM PC XT, Eagle and Compaq, TI Professional, Wang PC, Honeywell 7900, color/graphics adapter, 512K bytes of RAM, optical mouse

Support color

No

Multitasking

No

CP/M-86 support

No

Memory management

Yes

Data transfer

High level

Mouse

Yes

Price

\$95

mercialized by Apple Computer Inc. Both DesQ and WindowMaster are implemented on character-oriented displays and are therefore better suited for keyboard input. VisiOn has chosen to eschew icons and has built-in interaction concepts that substantially differ from the Star, Lisa, and Macintosh. The final user interface for Concurrent DOS has still not emerged and as such the one currently available should be thought of as an interim design.

Microsoft has stated its commitment to adhere to the Apple Macintosh user interface to ease the design burden on third-party software developers. And although there are substantial differences between the interfaces (such as tiled windows and two mouse buttons instead of one), there are also significant points of compatibility. For example, there will be strong similarities between Microsoft application programs running on Macintosh and the same application running on the IBM PC in the Windows environment.

In the Windows operating environment, both mouse buttons of a two-button mouse function alike. However, in a Windows application program, mouse functions are defined by the application and each button can have a separate purpose.

Another important characteristic of Windows is the degree to which it insulates the user from the operating system. Windows greatly reduces the number of verbs (copy, delete, name, print) the user is faced with to interact directly with the operating system.

VisiOn

VisiCorp first announced VisiOn at the November 1982 COMDEX computer show in Las Vegas. At the time, VisiOn was the first integrated-desktop software environment for personal computers. When VisiOn finally was shipped in early 1984, the market had grown dramatically more competitive. Not only had Apple introduced both Lisa and Macintosh, each with its own integrated-desktop software, but other window managers and a growing variety of integrated programs had also reached the IBM PC marketplace.

Application software must be specially developed to run as part of the VisiOn desktop system. VisiCorp offers

(continued)

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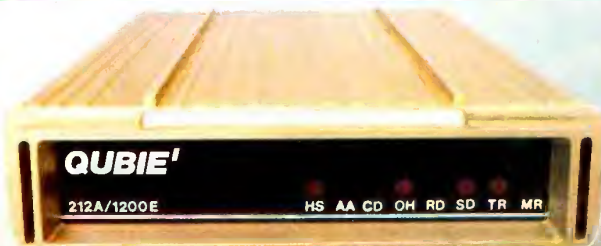
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Ex. 1022, Page 89

Both VisiOn and Windows will require mice as pointing and command devices.

third-party software developers a toolkit for developing applications for \$5500. To date, however, the only applications available for VisiOn are ones VisiCorp itself has developed: VisiOn Word (\$375), VisiOn Graph (\$250), and VisiOn Calc (\$395). A fourth VisiCorp product, VisiOn Query (\$375) will be added shortly. The VisiOn mouse is priced at \$250 and the price of the VisiOn host-applications manager was recently reduced to \$95.

In exchange for tightly specifying the applications that would run in the VisiOn environment, the program achieves both a consistent command structure across all programs running on the desktop and a higher level of program integration (meaning that data can be transferred between programs in context). For example, it is possible to continuously and automatically update a graph of spreadsheet data each time the spreadsheet is altered.

Because the command structure of VisiOn is consistent and because learning how to do something in one application will usually transfer to other applications, the program is relatively easy to learn.

Although VisiOn requires a bit-mapped display, it does not make use of icons. Programs first appear in windows on a gray background (although VisiOn uses the IBM color/graphics adapter card, it currently doesn't have color capabilities) and can be resized and overlapped according to the user's needs. Only one window at a time is active, and this is indicated on the VisiOn desktop by special framing of the active window. The limitation to the number of windows that can be open on the desktop at any one time is available system memory. VisiOn also requires a mouse pointing device that is used to execute system and program commands.

Each VisiOn window consists of three sections, or panes. A large contents

pane is continuously displayed; it contains the program or document itself. Along the bottom of the window is a dialogue pane that supplies prompts and the specific program commands. The third pane is the options pane, which is usually not visible. It gives you control over the default settings for the window or program.

At the bottom of the VisiOn display there is a separate menu consisting of eight commands that are generalized to all VisiOn programs—HELP, CLOSE, OPEN, FULL, FRAME, OPTIONS, TRANSFER, and STOP are available to the user at any point. The HELP command is designed to allow context-sensitive help. The user first points and clicks on the help menu item and then points to whatever it is in the system that he or she needs help with. The CLOSE and OPEN commands function the same way. First you select the command and then you point and click the window you want open or closed. FULL is a zoom command that will cause a selected window to fill the entire screen while FRAME allows you to locate and size the active window. The OPTIONS command will invoke the special hidden pane in each window that permits the user to specially define the default settings of each application. When the TRANSFER command is selected, the VisiOn system will lead you through a series of prompts to outline the source and destination point of data to be transferred between applications. Finally, STOP will permit you to interrupt any operation.

VisiOn filters the user's access to DOS through a special window called Archives. Archives is essentially VisiOn's organizing model, which is placed on top of the DOS 2.0 directory structure. Archives is modeled after the way information is typically stored in an office filing cabinet. In the VisiOn environment, a file is the data that is created with the VisiOn program. A folder is a collection of related files.

The VisiOn Archives has one special folder called the wastebasket folder. This is where files are placed to be disposed of. A file remains in the wastebasket until a second file is added. At that point the first file is permanently deleted. Archives frees the user from some of the file-naming restrictions of DOS and also will provide information

on each folder and file, including its type, and time and date that it was created or modified. It is possible to divide the Archives window into two panes so that the contents of several folders can be examined simultaneously.

Archives does not permit you to examine files that are not in VisiOn, but which may be in your DOS directories. In the future it will be possible, however, to transfer information into and out of the VisiOn system. VisiCorp has stated that independent software developers will be providing programs that modify MS-DOS files into a format that can be transferred into the VisiOn system.

The import and export of files from VisiOn will be done from the TRANSFER command.

VisiCorp claims that VisiOn now runs on the IBM PC XT, Eagle, and Compaq IBM compatibles; the Honeywell 7900, Texas Instruments Professional, and the Wang PC. Each of these systems must have 512K bytes of RAM, a bit-mapped screen, and a 5-megabyte hard-disk drive.

These specifications should be taken literally. I tried installing VisiOn on three separate IBM PCs with half a megabyte of RAM and hard disks that ranged from 5 megabytes to 33 megabytes, and I found that it was possible to install VisiOn on only one of these. A call to VisiCorp revealed that in order to run VisiOn an IBM PC must be "100 percent XT compatible" and that the brand of your memory-expansion card may also affect VisiOn's ability to run your system.

The VisiOn user interface differs significantly from the Star/Lisa and Windows user-interface style. A good example of this difference is the process of closing a window on the screen. On Lisa and Macintosh the user clicks a small "close" box in the upper left-hand corner of the window. An animation effect then shows the window collapsing back into its icon. Reopening a window is done by double-clicking the icon. By contrast, in VisiOn closing (and opening) a window is a two-step process that involves selecting the close (or open) option from the menu bar at the bottom of the screen and then moving the mouse pointer and clicking it in the appropriate window. This involves two separate clicks and, potentially, moving

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AT A GLANCE

Name

Concurrent DOS

Manufacturer

Digital Research
POB 579
Pacific Grove, CA 93950
(408) 649-3896

Application programs

Existing MS-DOS or CP/M-86 programs

Consistent command structure

No

Graphics

Character-based

Hardware required

At least 256K bytes of RAM, two floppy-disk drives

Support color

Yes

Multitasking

Yes

CP/M-86

Yes

Memory management

No

Data transfer

Screen memory only

Mouse support

No

Price

\$295

the pointer back and forth across a great expanse of screen.

Changing the size or moving a window is also a more complex task in VisiOn. To resize a window you must first select the frame command at the bottom of the display screen, then select the window you wish to frame, then select the new upper-left-corner location, and finally select the lower-right-corner location. The multiple steps involved in resizing a window seem to make the whole process awkward and cumbersome.

VisiOn also has chosen to have its mouse-select button beep every time it is clicked. This becomes annoying. It is possible to change the beep to a screen flash at the point of the click; however, this isn't as elegant as the context-sensitive feedback of mice-clicks in Macintosh or Windows.

The VisiOn mouse has two buttons: the left one is a selection button and the right one is a "scroll" button. The addition of the scroll button appears to be an innovative alternative to the traditional window-scroll bars. To move a document in a VisiOn Window you simply hold down the scroll button and move the mouse in the direction you wish the document to scroll. The effect that is gained by this technique is natural and closely akin to holding your finger down on a piece of paper and sliding it along a desktop. It is possible to scroll both vertically and horizontally in this fashion.

CONCURRENT DOS

Although Digital Research's Concurrent CP/M-86 is still a secondary operating system for the IBM PC, the company has

gotten several extensions of its operating system to market before Microsoft. Digital Research is already shipping its graphics, window, and network extensions. The company is now finishing work on an extension to Concurrent CP/M-86 called Concurrent DOS. The new operating system will run both CP/M-86 and MS-DOS software on the IBM PC and will allow the user to display up to four tasks running simultaneously on the same screen or on separate "virtual consoles" that can be arbitrarily selected (see table 4).

The initial release of Concurrent DOS will be a hybrid that will fall somewhere between DOS 1.1 and DOS 2.0. It will be able to read either 8- or 9-sector floppy disks and will access the root directory of an IBM PC hard disk; however, it will not support DOS 2.0 system calls.

Concurrent DOS has some novel aspects. For example, copy utilities (Copy and Pip) that in the past have been the property of each operating system are now both included with Concurrent. The commands that MS-DOS refers to as internal have been replaced with similar external commands. Most MS-DOS commands are available as part of Concurrent DOS; however, for obvious reasons the SYS.COM is not included. Memory allocations for CP/M-86 programs are done dynamically; however, memory must be allocated in each partition by the user for MS-DOS software using a MEM command.

In both Concurrent CP/M-86 and Concurrent DOS, the user can move between any of four different virtual consoles (these can be separate screen or

(continued)

Table 4: Some of the MS-DOS software that runs under Concurrent DOS.

dBASE II	Ashton-Tate
DR Draw	Digital Research Inc.
DR Graph	Peachtree Software Inc.
General Ledger	Continental Software
Home Accountant Plus	Multimate International Corp.
MultiMate	Microsoft Corp.
Multiplan	Lotus Development Corp.
1-2-3	Software Publishing Corp.
pfs:File	Software Publishing Corp.
pfs:Graph	Software Publishing Corp.
pfs:Report	Software Publishing Corp.
pfs:Write	Sorcim
SuperCalc 2	Sorcim
SuperCalc 3	VisiCorp
VisiCalc	Micropro Corp.
WordStar	

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Although Concurrent DOS doesn't support hierarchical files, it does offer 16 different "user areas"; it's possible to copy PC-DOS programs and data to a CP/M disk.

individual windows on the display) by holding down the Control key on the PC keyboard and simultaneously pressing the 0, 1, 2, or 3 key on the numeric keypad. Information about the currently active console is displayed in a status line along the bottom of the screen (if you are running an MS-DOS program in a console, the status line is returned to the program).

Although Concurrent DOS doesn't support hierarchical files, it does offer 16 different "user areas"; to take advantage of this feature it is possible to copy PC-DOS programs and data to a CP/M-formatted disk.

Because there are obvious opportunities for confusion (for example, both WSCOM and WSCMD on the same disk), Concurrent looks for files in a predetermined search path using both drive and file paths as criteria. If you have two files with the same name but different extensions, Concurrent uses that extension as a tie breaker. It will look first for a .cmd file (a CP/M program), then for a .com file (MS-DOS), then .exe (PC-DOS) and finally .bat (a PC-DOS batch file). It is possible to override this search pattern by specifying the extension.

Since many MS-DOS based applications write directly to the screen, Concurrent includes a SUSPEND command that will allow the user to put a program to sleep when its virtual console is not the displayed task. The problem of screen contention is not as great among CP/M applications because most of them are written in a way such that output from the application passes through the operating system before it is displayed. This also means that many CP/M applications will run in windows. A suspended MS-DOS application can continue to be viewed in a window.

USER INTERFACE

Concurrent CP/M handles window management with two utilities. WIN-

DOW is a noninteractive, command-line oriented program. WMENU is an interactive program that allows you to alter the size of windows, determine what portion of the virtual screen console is viewed by the window, hide windows, change their background and foreground color, and copy information from a window to a file or vice versa. After setting up your windows with the WMENU program (which is about 10K bytes in size), you can exit it, freeing that space in memory.

Since Concurrent DOS is limited to four virtual consoles (many more background tasks are running, but an arbitrary limit of four simultaneous applications has been established), it is also possible to display only four windows on the screen. These windows can be moved anywhere on the screen, their size can be changed, and they can overlap or extend off the sides or top and bottom of the display. If you have two monitors, it is even possible to display one virtual console on the color monitor and display three additional windows on the monochrome display.

When CP/M Windows is running, the active window is always designated by having an additional frame around its window area. At any time it is possible to zoom this window by pressing the Control and Delete keys simultaneously, so that it occupies the full screen. Pressing them again will return that window to its former position and display other windows.

There currently is no provision in CP/M Windows for a mouse, so interaction is done by entering commands from the keyboard or by selecting options from the small menu offered by the WMENU program.

CONCLUSION

Current generation graphics-oriented window software technology is literally begging for faster hardware. Either faster processors or the development of personal computers with graphics coprocessors and higher-resolution displays will make it more realistic to run multiple tasks and display them simultaneously.

Window-management software on the IBM PC does offer an interim solution toward a graphics-oriented and more interactive personal computing environment. ■



Photo 3: Concurrent DOS from Digital Research.

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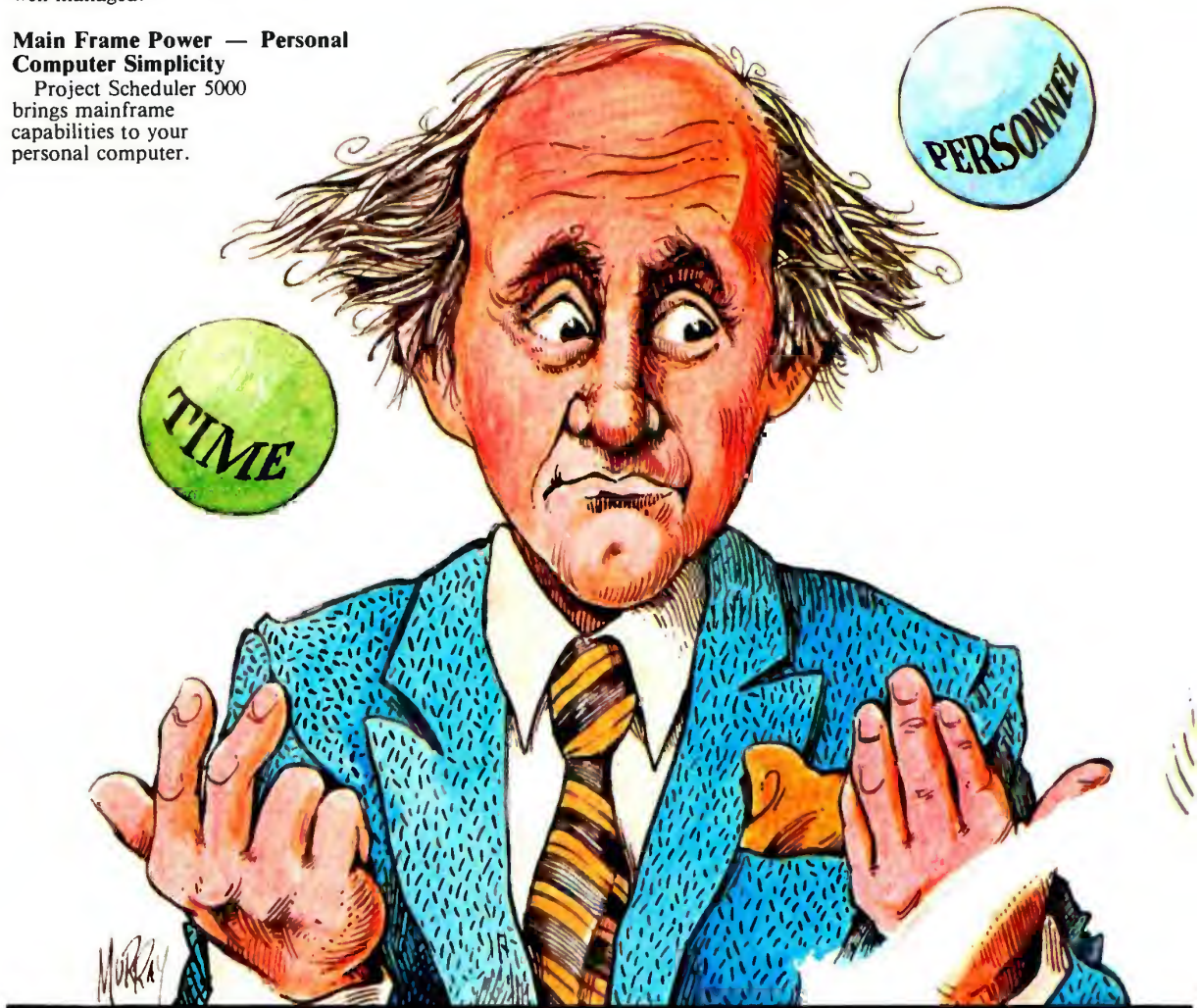
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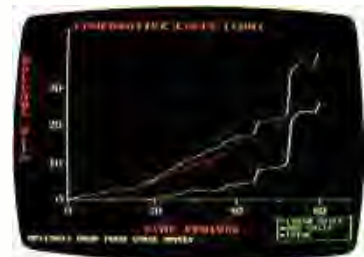
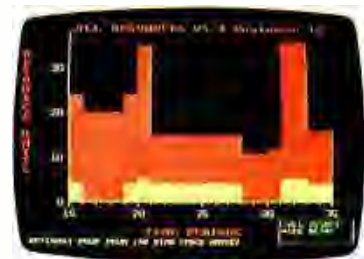
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Project Scheduler 5000 plus Graphics complements the outstanding scheduling and reporting features provided by Project Scheduler 5000. Using presentation quality financial line graphs, resource histograms, resource bar graphs and other high impact displays, Project Scheduler 5000 plus Graphics provides additional insight as you study in depth the effects of resource allocation, labor usage distribution and cost spreads.

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Available for PC or MS DOS:

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*Project Scheduler 5000 plus Graphics available 4th quarter 1984.



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Ex. 1022, Page 98

BY MORTON GOLDBERG

TWO LOGOS FOR THE IBM PC

Two Logos, one by Digital Research and another from IBM, share many features, but choosing the better package proves difficult

I have never been comfortable with BASIC. We get along all right for quick-and-dirty programs, up to 60 lines or so. Beyond that, it's strictly no go. For anything larger, I need a language that lets me work with modules to build a large program from a bunch of small ones. BASIC is hostile to this approach, especially in the case of subroutines. On the other hand, I strongly believe that programs should be coded and tested on an incremental basis. Changes in the program code should be made a little at a time and tested immediately. BASIC, because it is an interpreted language, makes this easy to do. Most modular languages, because they are compiled, are inferior to BASIC in this respect.

For a long time I have been searching for a language that is equally friendly to both modular design and incremental coding and testing. My quest has led me to try FORTH, LISP, and now, Logo. Proponents for each of these languages make similar claims: they all are supposed to have the power of a modular programming language coupled with the productivity of an interpretive language. A description of Logo by its originator, Seymour Papert, follows. (Papert always writes "LOGO;" but just about everyone else writes "Logo.")

Characteristic features of the LOGO family of languages include procedural definitions with local variables to permit recursion. Thus, in LOGO it is possible

*Logo is interactive,
modular, extensible,
recursive, and scoped
—all this and easy
enough
for children too.*

to define new commands and functions which then can be used exactly like primitive ones. LOGO is an interpretive language. This means that it can be used interactively. The modern LOGO systems have full list structure, that is to say, the language can operate on lists whose members can themselves be lists, lists of lists, and so forth.

... An example of a powerful use of list structure is the representation of LOGO procedures themselves as lists of lists so that LOGO procedures can construct, modify, and run other LOGO procedures. Thus LOGO is not a "toy," a language only for children. The examples of simple uses of LOGO in this book do however illustrate some ways in which LOGO is special in that it is designed to pro-

vide very early and easy entry routes into programming for beginners. ...

—From *Mindstorms: Children, Computers and Powerful Ideas*
(New York: Basic Books,
1980, p. 217)

From the quotation, you can see that Logo must be the very model of a modern major computer language: interactive, modular, extensible, recursive, and scoped—all this and easy enough for children, too.

I have used two of the Logos on the market for approximately 10 weeks: DR Logo by Digital Research Corp. and IBM Personal Computer (PC) Logo by Logo Computer Systems Inc. (which has also produced Apple Logo). I believe I have learned enough during this period to make a fair assessment.

INSIDE THE SLIPCASES

Both Logos come packaged in a shrink-wrapped, 8- by 9.5-inch slipcase holding a binder. Nevertheless, they are easy to tell apart. IBM, showing its marketing skill, has colored the IBM PC Logo slipcase and binder a bright lemon yellow, which certainly stands out on the dealers' shelves. DR Logo comes in the same beige Digital Research uses for all

(continued)

Morton Goldberg (3628 Alpine Dr., Ann Arbor, MI 48104) does numerical analysis and research for the Environmental Research Institute of Michigan.

AT A GLANCE

Name

IBM Personal Computer Logo

Type

Interpretive programming language system

Version tested

1.0

Manufacturer

Logo Computer Systems Inc.
222 Brunswick Blvd.
Pointe Claire, Quebec H9R 1A6
Canada

Publisher and distributor

IBM Corp.
Personal Computer Sales
Boca Raton, FL 33432

Price

\$175

Format

5¼-inch floppy disk

Software required

None—comes complete with PC-DOS 2.0 operating system

Computer

IBM PC or PC XT with 128K bytes of RAM, one floppy-disk drive, color/graphics adapter with monitor (supports but does not require the following: up to 256K bytes of RAM, additional floppy-disk drives, fixed-disk drive, printer, game adapter, light pen, simultaneous use of monochrome adapter if available)

Documentation

Introductory manual, reference manual, quick-reference card

Audience

People who want an easy introduction to programming; educators who want a programming environment also designed to be a learning environment; programmers who would like to use a language supporting modern programming techniques for their personal programming

offerings. With both Logos, along with the 5¼-inch floppy disk containing the Logo interpreter, you get an introductory manual, a reference manual, and a quick-reference guide. They have some minor differences. IBM PC Logo's introductory manual is spiral bound; DR Logo's is not bound but is punched to share the binder with the reference manual. IBM PC Logo's quick-reference guide is an accordion-folded card; DR Logo's is a small, staple-bound book. And they have some not so minor differences. I paid only \$80 for DR Logo because I was able to buy it from a software discount retail store; I paid the full \$175 for IBM PC Logo—it seems IBM doesn't allow software with the IBM label to be sold at a discount. DR Logo comes with two copies of the floppy disk because Digital Research protects the disks from being copied; IBM PC Logo comes with one unprotected disk—you make your own backup copy.

Both Logos come with a license to use what is recorded on their disks. As usual, they lay all responsibility on the buyer, while absolving the software publisher from any responsibility whatsoever. The people at Digital Research ask that you register the license. If you do, they hint you might hear from them occasionally as to bugs, fixes, or updates. IBM requires no registration and makes it perfectly clear that you are on your own.

I think all software should come with a packing slip that tells the buyer exactly what the package includes. The slip would list what files are to be found on the disks, as well as all the tangible properties, such as user manuals. However, such packing slips are more the exception than the rule, and neither of the Logos has one. I had to figure out, as best I could, what it was I had actually bought and whether anything was missing.

The IBM PC Logo floppy disk isn't copy protected. To see what was on it, I booted PC-DOS, popped the floppy into a disk drive, and typed DIR A:. I found:

AUTOEXEC.BAT	starts Logo immediately upon system boot
LOGO.COM	Logo interpreter
COMMAND.COM	PC-DOS 2.0 command interpreter
DISKCOPY.COM	PC-DOS 2.0 disk copy utility
FORMAT.COM	PC-DOS 2.0 disk format utility
GRAPHICS.COM	PC-DOS 2.0 graphics printer driver
TOOLS.LF	a collection of Logo software tools
SAMPLES.LF	menu and loader for Logo demonstration programs
FILE1.LF	demonstration program—random rhyme generator
FILE2.LF	demonstration program—procedure tree generator
FILE3.LF	demonstration program—home inventory
FILE4.LF	demonstration program—tower of Hanoi
FILE5.LF	demonstration program—hangman game
FILE6.LF	demonstration program—recursive curves
FILE7.LF	demonstration program—musical memory game
INVENT.DAT	data file for use with FILE3.LF

I expected to find the Logo interpreter, of course, and I had hoped to find something like the demo programs, but I didn't expect to find so much of PC-DOS on the disk. It's there

(continued)

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Ex. 1022, Page 101

AT A GLANCE

Name

DR Logo

Type

Interpretive programming language system

Version tested

1.0

ManufacturerDigital Research Corp.
Box 579
Pacific Grove, CA 93950**Price**

\$145

Format

Copy-protected, 5¼-inch floppy disk

Software required

None—comes complete with SpeedStart CP/M operating system

Computer

IBM PC or PC XT with 192K bytes of RAM, one floppy-disk drive, color/graphics adapter with monitor (supports but does not require the following: up to 256K bytes of RAM, additional floppy-disk drives, game adapter, light pen, simultaneous use of monochrome adapter if available; limited support of printer)

Documentation

Introductory manual, reference manual, quick-reference guide

Audience

People who want an easy introduction to programming; educators who want a programming environment also designed to be a learning environment; programmers who would like to use a language supporting modern programming techniques for their personal programming

because IBM PC Logo requires PC-DOS 2.0. Rather than make those IBM PC owners who use an earlier version of PC-DOS buy 2.0, IBM has chosen to distribute the PC-DOS needed with IBM PC Logo.

The demonstration programs range in quality from bad to pretty good. The home inventory program is the worst of the lot. An excellent example of how not to design such a program, it is completely user-hostile. Since it is also the only demo program that uses IBM PC Logo's extensive disk I/O (input/output) capabilities, you might want to look at it for this reason. The random rhyme generator is primitive and silly. The hangman game is just primitive. The remaining demos are the ones I rate as being pretty good. Reading the code in SAMPLES.LF, which contains the control program for the whole set of demos, is instructive because it shows how to do menu-driven program chaining in Logo.

I am always pleased when demonstration programs, simple or otherwise, are included with a programming language. Logo Computer Systems has done its customers a favor by their inclusion, especially when it puts TOOLS.LF on the disk. This file comprises a set of useful and, in some cases, extremely powerful extensions to IBM PC Logo, among which I count such things as while-loops, until-loops, and mapping functions. Since such sophisticated extensions are not covered in the books on Logo with which I am familiar, their inclusion in TOOLS.LF is of great value to the neophyte Logo programmer.

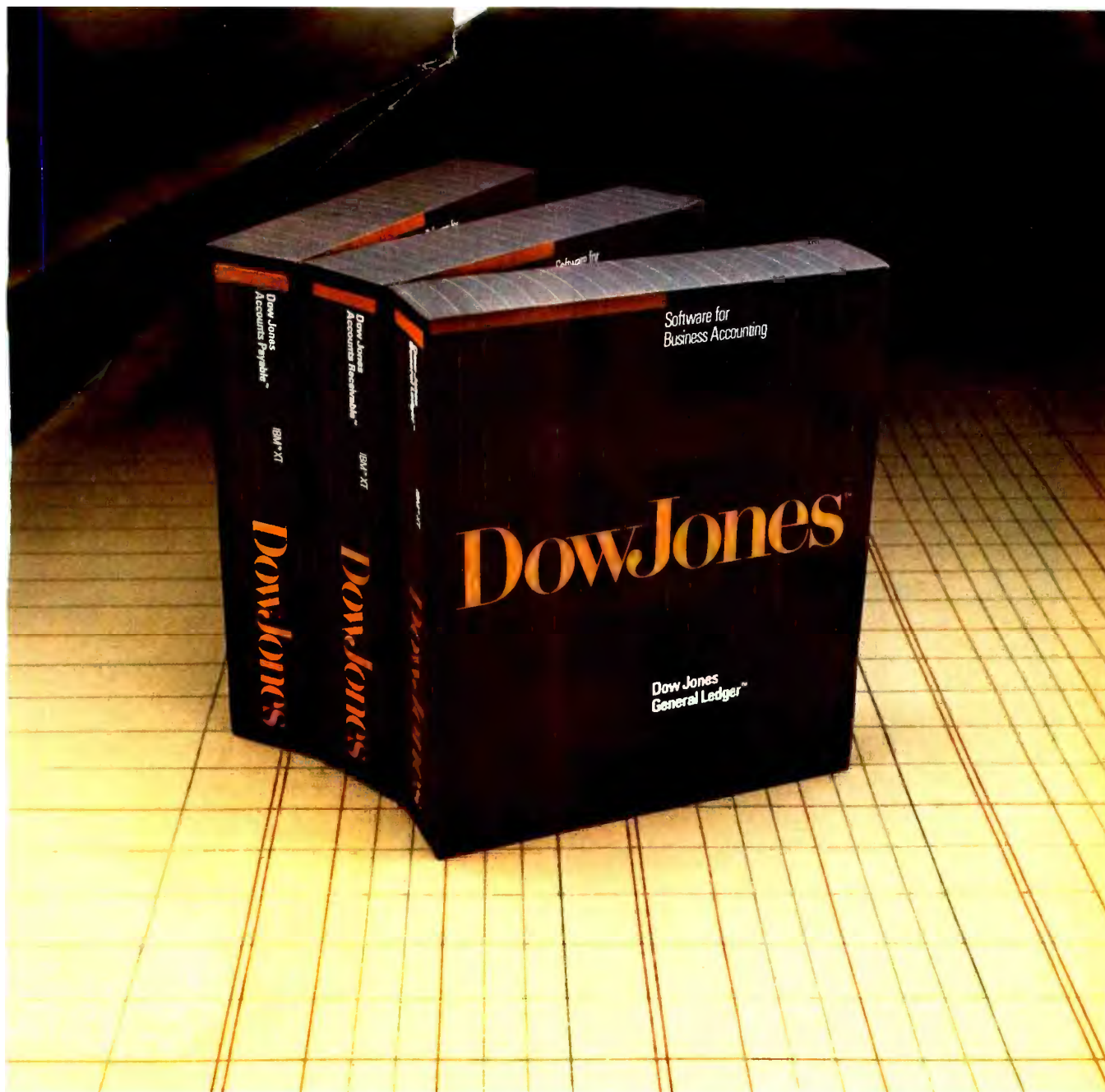
While I had no trouble finding out what was on the IBM PC Logo disk, I cannot say the same for the DR Logo disk. When the DR Logo disk is booted, it puts you right into Logo. Although CP/M-86 is on the disk, I couldn't get at it to use its DIR command, and even if I could, I wouldn't trust the results. Remember, the disk is copy protected, and such disks often have strange directories. I must admit I'm not sure I know exactly what is on the DR Logo disk even now. The documentation says nothing about anything being on the disk similar to the tools or demo programs that come with IBM PC Logo. However, while I was working my way through the DR Logo primitives, I discovered a hidden treasure. When I tried the primitive getfs, the closest DR Logo comes to having a DIR command, I found a file with the suggestive name Blkjak.log. It proved to be a respectable implementation of blackjack with good graphics for the playing cards. The feeling of finding treasure didn't come until later, when I looked at the code. Blkjak is a far better example of Logo code than any of the IBM PC Logo samples. It is strange that Digital Research just leaves it on the disk to be discovered accidentally.

DOCUMENTATION

I have seen great improvements made in software documentation during my six-year involvement with personal computers. Two years ago I would have classified the documentation for both Logos as superior. By my current standards, they have good, say B+, documentation. But each achieves that rating in a different way.

The IBM PC Logo documentation is consistently good; it never rises above that level nor falls below it. It is carefully edited and has no typographical errors. However, the intro-

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Circle 50 on inquiry card.

Fall 1984 • BYTE Guide to the IBM PC • 95

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TWO LOGOS

DR Logo can't read data files created by other software you own.

ductory manual is too simple. The reference manual follows the same pattern as the Microsoft BASIC manual that comes with PC-DOS and is well organized and complete. I have yet to refer to it without being able to find what I am looking for. It gives plenty of examples, but I consider them uninspired. The two appendices are particularly useful: one documenting the tools file found on the floppy disk and another on the Logo primitives that allow assembly language and machine code to be used with IBM PC Logo.

The DR Logo documentation is more uneven. The introductory manual is superb. It sets a faster pace than the IBM PC manual and is able to teach more of the language without being too long. It is written so carefully that it is not likely to lose even a rank beginner. Incorporated into the text are displays from its example programs. The programming projects it presents are slightly more difficult than the IBM PC Logo projects and, consequently, are more interesting to an adult. The DR Logo reference manual shows signs of hasty work, with many typographical errors. The programming examples are more ambitious than those in the IBM PC Logo reference manual, but they are sometimes botched. The manual contains no mention of the blackjack program provided on the language disk. At a certain stage of my development as a Logo programmer, I would have given up my DR Logo backup disk for an appendix with a good discussion of the internals of this program. And no mention is made of the Logo primitives for interfacing to machine-language code. The primitives exist, and they appear to be similar to the ones provided in IBM PC Logo, but they are only mentioned in the quick-reference guide, where the information given is scanty.

PROGRAMMING WITH LOGO

Well-prepared documentation is nice but not much assistance if the Logo interpreter doesn't work properly. For these two Logos, I have good news and bad.

First the good news. I find both Logos satisfy my expectations with regard to expressive power, and those expectations were high. Also, neither exhibits what I call the "Version 1.0 syndrome," the bug-infestation characteristic of newly released programming languages. Both Logos are robust; I have not been able to crash either one. I found one small bug in IBM PC Logo and only a few minor ones in DR Logo.

Both Logos do floating-point computations to a high degree of precision. DR Logo does floating-point arithmetic in accordance with the proposed IEEE standard; its floating-point routines carry approximately 19 digits internally and return 15-digit answers. IBM PC Logo has true variable-precision arithmetic. You can do arithmetic to a hundred digits or more if you have the patience.

Both Logos have built-in full-screen editors. Except for the way keys are assigned to the various editing functions, there

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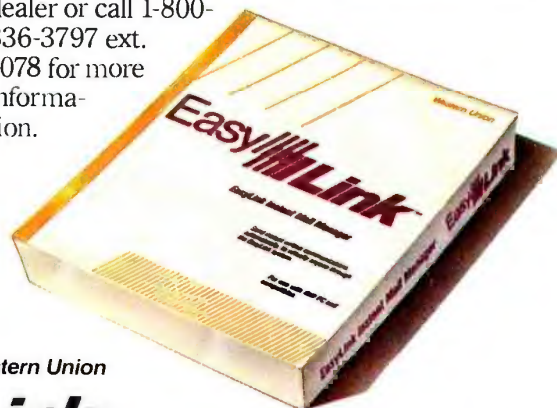
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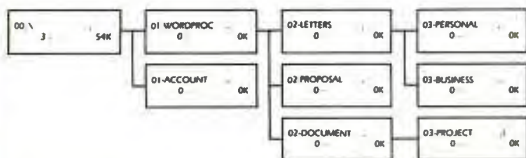
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TWO LOGOS

is almost no difference between them, though I prefer the DR Logo key assignments to those of IBM PC Logo. Because they are so alike, I have adopted below the fiction of a single Logo editor to describe both.

The editor is easy to learn and quite usable. It may lack the power of an editor such as FinalWord or SuperWriter, but it is more powerful than the screen editor built into Microsoft BASIC. You have the choice of editing a file or all or part of the Logo workspace, and I suppose you could use it as a general-purpose text editor, if you should want to. Its main limitations are a lack of any kind of search or search-with-replace command and an absence of commands to move or copy anything larger than a single line of text.

All the in-line editing commands work outside of the editor. If a command results in an error, you can recall it, edit it, and press the Enter key to resubmit it. This feature can be a blessing when you make a mistake in a long command.

Now the bad news. Design defects exist in both implementations. They are frustrating and quite inexplicable—at least to me; they may make perfect sense to the people who did the implementations. I'll list them, and you decide for yourself whether my complaints are legitimate.

The following characteristics of DR Logo bother me most. First, DR Logo uses just a linefeed character (0A hexadecimal) for an end-of-line marker, rather than a carriage-return linefeed pair (0D 0A hexadecimal), the standard end-of-line marker under CP/M. Whether you're doing output to a file with the SAVE command or to a printer with the COPYON and PRINT commands, you don't get carriage returns. The implication is that DR Logo is a Digital Research product that doesn't conform to Digital Research's own CP/M standards.

DR Logo can't perform any kind of stream (character-by-character) or record-oriented file I/O. This means it can't read data files created by other software you own, and it can't write files your other software can read.

And, of course, the copy-protected disk means changing disks—for large editing projects, for instance. If you want to run Logo, you boot the DR Logo disk. Then if you want to do some editing that's too much for the built-in editor, you boot the CP/M-86 disk. But when you've finished editing, you have to boot DR Logo again, and so on.

My complaints about the IBM PC Logo design make up a longer list. IBM PC Logo has only two sets of colors for the turtle's pen (DR Logo has four). While this color choice probably won't bother many people, it bothers me because my favorite graphics color scheme (a yellow turtle drawing bright red lines on a bright blue background) is missing.

This version of Logo doesn't execute an implicit SHOW command at top level. Let me explain the Logo jargon. You're at top level when the Logo interpreter is waiting for you to type something in response to its prompt. Suppose you type "2 + 2." DR Logo would respond with "4." IBM PC Logo responds with "I DON'T KNOW WHAT TO DO WITH 4." In IBM PC Logo, you're expected to type "SHOW 2 + 2." DR Logo automatically supplies the SHOW if you don't type it. This feature is what is meant by executing an implicit SHOW, clearly the right thing for Logo to do.

IBM PC Logo won't switch over to turtle-graphics mode if you are in 80-column text mode. If you try, it prints an error message. As a result, you must manually set the text width

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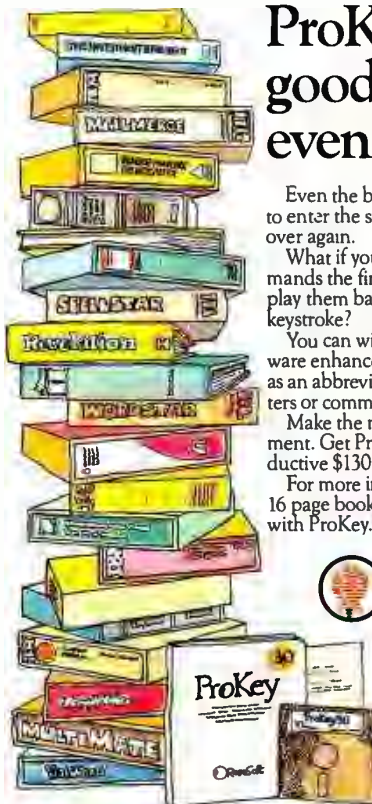
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TWO LOGOS

to 40 columns and retype the graphics command it refused. DR Logo makes the changeover with no fuss at all.

IBM PC Logo has little in the way of primitives to support program debugging, which puzzles me. This lack seems inconsistent with the Logo philosophy. DR Logo has many debugging commands, some of them quite clever (see table 3).

Procedures can't be written in the indented style. Instead, IBM PC Logo forces you to write

```
TO DRAW.STAR :SIDE
RIGHT 18
REPEAT 5 [FORWARD :SIDE RIGHT 144 FORWARD :SIDE
LEFT 72]
LEFT 18
END
```

It won't accept this more readable format:

```
TO DRAW.STAR :SIDE
RIGHT 18
REPEAT 5
[
FORWARD :SIDE
RIGHT 144
FORWARD :SIDE
LEFT 72
]
LEFT 18
END
```

DR Logo allows you to write in either style.

IBM PC Logo doesn't allow comments. The TOOLS.LF file contains a procedure providing a dime-store way to add comments, but it's not a satisfactory substitute for true comment capability.

A LOOK AT LOGO PRIMITIVES

In Logo terms, the verbs that Logo "understands" at start-up are called primitives. You won't be too far off if you think of Logo primitives as being analogous to the keywords and functions of BASIC. The primary job of a Logo programmer is to "teach" the language new verbs by combining primitives and other objects (numbers, words, and lists) into procedures. Thus, the power of a Logo implementation is highly dependent on how many primitives it has. The two Logos under review are comparable by this measure. By my count, DR Logo has 187 primitives, and IBM PC Logo has 183.

Of these, 127 go by the same name and perform the same function in both versions. Fifteen more go by different names but perform functions that are the same or nearly the same. Having this large kernel of primitives in common makes translating a program from one Logo to the other easy. Further, because most of the kernel is mainstream Logo, you can adapt programs written in other Logo dialects to either of these two.

I have compiled tables summarizing all the primitives, and in doing so I have divided the primitives into categories according to their principal use. That wasn't always easy. Is file editing more of a file I/O primitive than it is an editor primitive? In such cases I virtually tossed a coin. Also, I had

(continued)

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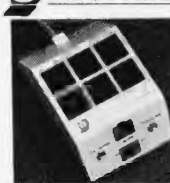
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trouble at times coming up with a description for the action of a primitive that was both accurate and short. If I have botched a description, I apologize.

Tables 1 and 2 list the kernel primitives. Note that I have used the DR Logo names in table 1; the IBM PC Logo names differ only by being expressed in uppercase letters.

Tables 3 and 4 list the 45 or so primitives peculiar to each Logo. Even though they constitute only about a quarter of the total, the effects of these primitives are sufficient to give the two Logos distinct personalities. Clearly, Digital Research and Logo Computer Systems had different ideas on how Logo should be extended from the kernel of mainstream primitives. DR Logo was extended to be more LISP-like and to include more program-development tools. IBM PC Logo was extended to be better integrated into the PC-DOS environment; in particular, it was given primitives to perform file I/O.

I admit I am upset that IBM PC Logo, not DR Logo, has been extended to include file I/O. A BYTE article ("Digital Research's DR Logo," by Gary Kildall and David Thornburg, June 1983, page 208) led me to believe that Digital Research intended to break Logo out of the educational-software mold by implementing it as a serious personal computer applications language. Meeting this goal would have required major extensions to the file-handling capabilities of traditional Logo. I incorrectly assumed Digital Research was doing this. With such extensions, DR Logo might have been the leading edge of a major advance in personal computer programming languages.

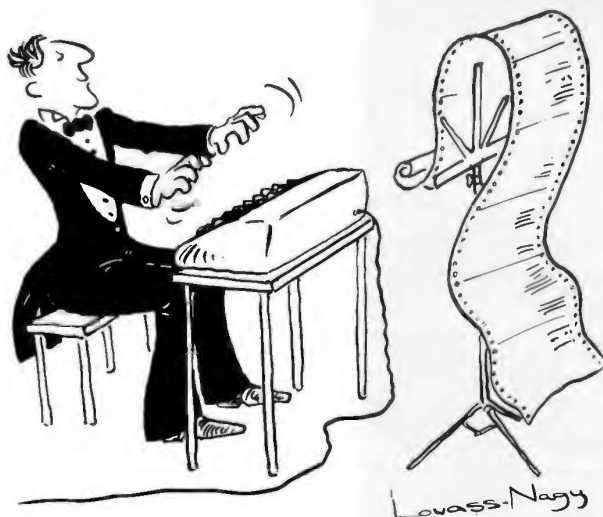
SOME PERFORMANCE MEASUREMENTS

Performance testing, or benchmarking, is the sport of programmers. In this case, I raced DR Logo and IBM PC Logo against each other. I did it mostly for fun and admit I wasn't scientific in the way I went about it. Nevertheless, I got some intriguing results showing that the two implementations must differ much more internally than their surface differences suggest.

Listings 1 through 6 give the programs that I used for my tests. The programs are the IBM PC Logo versions; the DR Logo versions are the same except where noted in the footnotes. Table 5 shows the results. The column headings require no explanation, except the ones labeled Nodes Used, which relate to memory requirements. Both DR Logo and IBM PC Logo take memory as they need it from a memory pool, or workspace. The unit of allocation is called a node. In DR Logo a node is 6 bytes; in IBM PC Logo it is 5. How big a workspace you have depends on your system configuration. In my case, DR Logo's workspace is 10,780 nodes, and IBM PC Logo's is 31,093. Do not conclude from this that IBM PC Logo will run a program three times the size of the largest one DR Logo can run. While a larger workspace is better, maximum program size is not necessarily directly proportional to workspace size. The rate at which workspace is consumed is also important. As table 5 show, IBM PC Logo often consumes workspace at a considerably higher rate than DR Logo.

What happens when a program runs out of workspace? Both Logos stop while workspace is cleaned up by a garbage-collection routine. The pause, called recycling, is quite ap-

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Table 1: Primitives found in both Logos.

Action of Primitive	Logo Name
ASSEMBLY LANGUAGE INTERFACE	
Similar to POKE in BASIC	.deposit
Similar to PEEK in BASIC	.examine
DEBUG SUPPORT	
List of all objects in workspace	.contents
Continue execution after pause	co
Suspend execution	pause
Make random number sequence repeat	rerandom
DISK AND FILE OPERATIONS	
Load file into workspace	load
write contents of workspace/package to disk file	save
EDITOR	
Invoke screen editor to edit procedure	edit (ed)
Invoke screen editor to edit variables	edns
KEYBOARD INPUT	
TRUE if keyboard entry available	keyp
Read in a single character ¹	readchar (rc)
Read in a list ¹	readlist (rl)
LISTS, WORDS, AND VARIABLES	
All of a list/word but the first item/character	butfirst (bf)
All of a list/word but the last item/character	butlast (bl)
Number of items/characters in a list/word	count
TRUE if argument is empty list/word	empty
First item/character in a list/word	first
Append 1st argument to head of 2nd	fput
Select nth item/character from list/word	item
Last item/character in a list/word	last
Make a list	list
TRUE if argument is a list	listp
Declare local variables	local
Append 1st argument to tail of 2nd	lput
Assign value to variable	make
TRUE if 1st argument is member of 2nd	memberp
Assign value to variable	name
TRUE if argument is variable with a value	namep
TRUE if argument is a number	numberp
Print arguments (add newline)	print (pr)
Splice two lists together	sentence (se)
Display argument	show
Value of a variable	thing
Print arguments (no newline)	type
Splice two strings into a word	word
TRUE if argument is a word	wordp
LOGIC FUNCTIONS	
TRUE if 1st argument less than 2nd	<
TRUE if 1st argument equal to 2nd	=
TRUE if 1st argument greater than 2nd	>
TRUE if all arguments are TRUE	and
TRUE if arguments are equal	equalp
TRUE if argument is FALSE	not
TRUE if one argument is TRUE	or

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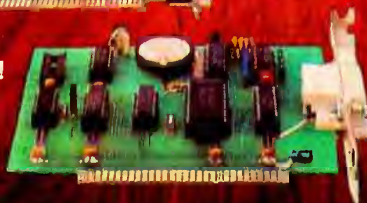


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TWO LOGOS

MATH FUNCTIONS

Multiplication	*
Addition	+
Subtraction	-
Division	/
Arc tangent	arctan
Cosine	cos
Exponential	exp
Truncate to integer	int
3.14159...	pi
Product of arguments ²	product
Division ³	quotient
Pseudorandom integer	random
Remainder from division	remainder
Round argument to nearest integer	round
Sine	sin
Square root	sqrt
Sum of arguments ²	sum

MISCELLANEOUS

Converts character to number	ascii
TRUE if game paddle button is down	buttonp
Converts number to character	char
Illuminates pixel at specified position	dot
Current setting of game paddle	paddle

PROCEDURE DEFINITION AND FLOW CONTROL

Attach a label to a list, execute the list ⁴	catch
Make a list duplicating a procedure definition	copydef
Accept argument as procedure definition	define
TRUE if argument is name of defined procedure	definedp
Signals end of a procedure definition ⁵	end
Current error list	error
Go to label	go
If-else construct ⁶	if
Execute argument if last test was FALSE	iffalse (iff)
Execute argument if last test was TRUE	iftrue (ift)
Make argument target for go	label
Exit procedure, return argument as value	output (op)
Execute list for specified number of times	repeat
Execute argument	run
Exit procedure, no value is returned	stop
Evaluate argument, save result for use by iff and ift	test
Definition list of procedure	text
Jump out of the specified catch list ⁴	throw
Signals start of a procedure definition ⁵	to
Suspend procedure for specified interval	wait

PROPERTY LISTS

Retrieve property from property list	gprop
Return full property list	plist
Add property to property list	pprop
Show all properties in workspace or package	pps
Remove property from property list	remprop

SCREEN CONTROL

Background color of graphics screen	background (bg)
Clear graphics screen	clearscreen (cs)
Clear text screen	cleartext (ct)

(continued)

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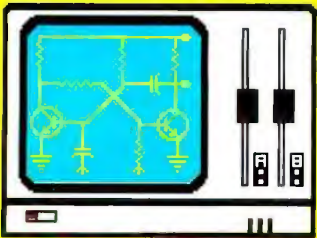


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TWO LOGOS

Cursor position on text screen	cursor
Use full screen for graphics	fullscreen
Set background color of graphics screen	setbg
Set position of text cursor	setcursor
Use full screen for text?	textscreen
TURTLE COMMANDS	
Move backward	back (bk)
Clear screen without changing turtle status	clean
Confine turtle to visible display	fence
Move forward	forward (fd)
Report turtle heading	heading
Make turtle invisible	hideturtle (ht)
Return turtle to origin with heading due north	home
Turn left	left (lt)
Report color of turtle pen	pencolor (pc)
Lower color pen	pendown (pd)
Lower erasing pen	penerase (pe)
Lower XORing pen	penreverse (px)
Raise current pen	penup (pu)
Report pen status	pen
Report turtle position	pos
Turn right	right (rt)
Set turtle heading	setheading (seth)
Set color of turtle pen	setpc
Set state of turtle pen	setpen
Set turtle at specified position	setpos
Set turtle ordinate as specified	setx
Set turtle abscissa as specified	sety
TRUE if turtle is visible	shownp
Make turtle visible	showturtle (st)
Set turtle to point toward specified position	towards
Allow turtle to go outside visible display	window
Apply toroid geometry to graphics display	wrap
Report turtle ordinate	xcor
Report turtle abscissa	ycor
WORKSPACE MANAGEMENT	
Make package invisible to certain primitives	bury
Erase everything in workspace/package	erall
Erase procedure from workspace	erase (er)
Erase variable from workspace/package	ern
Erase all variables from workspace/package	erns
Erase all procedures from workspace/package	erps
Report how much workspace unused	nodes
Put procedure/variable in package	package
Put all unpackaged objects in package	pkgall
Show definition of procedure	po
Combine pops and pons	poall
Show all variables in workspace/package	pons
Show all procedures in workspace/package	pops
Show titles of all procedures in workspace/package	pots
Perform garbage collection on workspace	recycle
Undo action of bury	unbury

¹In IBM PC Logo, these primitives may also be used for file input.

²Not limited to two arguments.

³In DR Logo, quotient truncates its result to an integer.

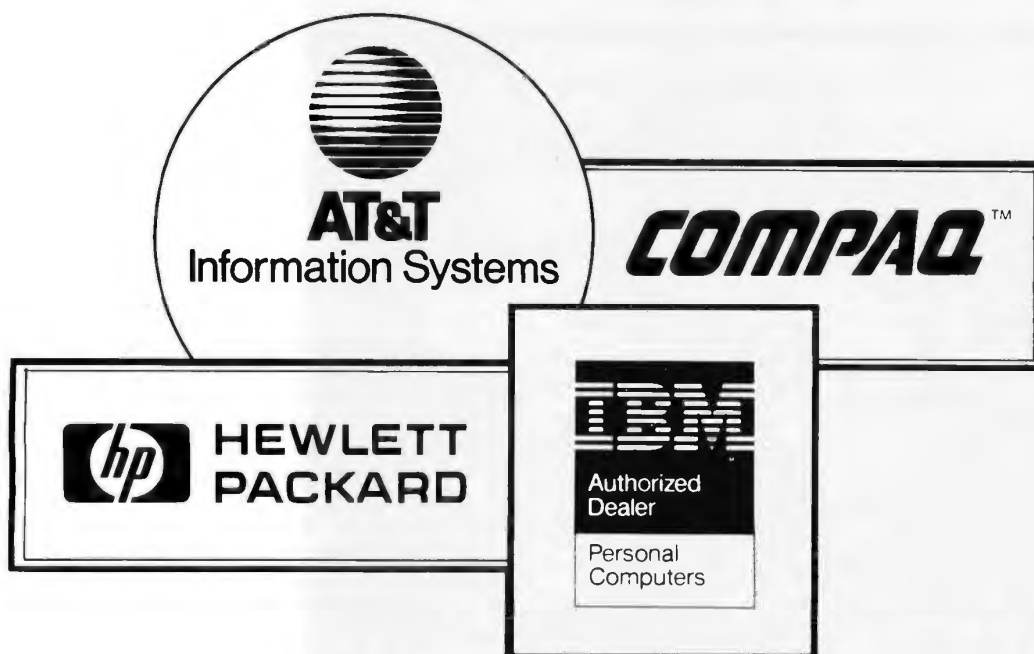
⁴Catch and throw work together in a way similar to the "on condition" and "signal" statements of PL/I.

⁵To and end only function in edit or interactive mode; they are more markers than true primitives.

⁶If 1st argument is TRUE, execute 2nd; otherwise execute 3rd.

⁷May be abbreviated to TS in IBM PC Logo.

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TWO LOGOS

Table 2: Primitives found in both Logos, but under different names.

Action of Primitive	DR Logo Name	IBM PC Logo Name
DISK AND FILE OPERATIONS		
Invoke editor to edit disk file	edf	EDITFILE
Show directory information ¹	getfs, spaced	DIR
Report size of file	sizef	FILELEN
Set default for disk drive	setd	SETDISK
Report default disk drive	defaultd	DISK
Erase file from disk	erf	ERASEFILE
MATH FUNCTIONS		
Number raised to exponent		POWER
Natural logarithm	log	LN
MISCELLANEOUS		
Emit tones from speaker	tones	TONE
PRINTER CONTROL		
Enable copying of text screen ²	copyon	DRIBBLE
Disable copying of text screen	copyoff	NODRIBBLE
Print graphics screen on printer	printscreen (ps)	PrtSc key
SCREEN CONTROL		
Set fore-/background colors for text ¹	textbg, textfg	SETTC
Set space for text on split screen	setsplit	SETTEXT
Mix text and graphics on one screen	splitscreen	MIXEDSCREEN (MS)
Use two monitors	twoscreen	SETSCREEN

¹The combined effect of both DR Logo primitives is more or less equivalent to the IBM PC Logo primitive.

²The IBM PC Logo dribble and nodribble primitives can be used with other output devices besides the printer.

parent, and, if frequent, can hurt a program's performance.

My performance-testing adventure started when I decided to see how the two Logos would perform on David Ahl's simple benchmark from *Creative Computing* ("Creative Computing Benchmark," February 8, 1984), which tests the speed and accuracy of floating-point computations, looping, and random-number generation. Although by no means an exhaustive benchmark, it was a good choice for testing Logo. Listing 1 gives my Logo adaptation of this benchmark.

Surprisingly, DR Logo did considerably better at this benchmark than IBM PC Logo. Normal use had not suggested any such discrepancy in performance. If anything, I had formed the opinion that IBM PC Logo was faster than DR Logo. I decided to investigate this unexpected result further.

Next, I selected two programs that are considered Logo classics: Flower and Tower. Flower is a turtle-graphics program that produces a picture of a flower, found in one form or another in just about every introductory Logo book. I originally wrote the version given in listing 2 as an example of how easy it is to produce a logically structured program with Logo. Tower (listing 3) is another program that appears repeatedly in the Logo literature. For a good analysis of Tower, see Brian Harvey's article in the BYTE special issue on Logo ("Why Logo?" August 1982, page 163). Tower is a classic example of a program that is trivial to write when you use

recursion, but moderately difficult to write when you are restricted to traditional iterative methods.

The results of timing Flower and Tower didn't clear things up at all. They not only conflicted with the Ahl's benchmark timings, they conflicted with each other. Whereas Ahl's benchmark had implied that DR Logo was twice as fast as IBM PC Logo, Flower implied they were about the same speed, and Tower implied IBM PC Logo was four times faster than DR Logo. Taken together, the three tests make a fine lesson in the unreliability of naive benchmarking.

If I hadn't taken data on memory use for Flower and Tower, I would have given the whole thing up as a bad job. That data showed IBM PC Logo was using memory at significantly greater rate than DR Logo. The startling difference in workspace requirements for the Flower program intrigued me enough to press on.

I could think of two ways to explain the conflicting timings: 1) under certain conditions, IBM PC Logo was consuming workspace so fast as to require recycling more often than DR Logo, and 2) some IBM PC Logo primitives were faster than the corresponding DR Logo primitives, while others were slower. Of course, these explanations are not mutually exclusive; both effects could be present.

I knew I would never be able to discriminate between the

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TWO LOGOS

Table 3: Primitives found only in DR Logo.

Action of Primitive	DR Logo Name
DEBUG SUPPORT	
Enable split-screen debug mode	debug
Disable split-screen debug mode	nodebug
Disable trace mode	notrace
Disable single-step mode	nowatch
Show the call tree of a procedure	pocall
Show names of all primitives	poprim
Show names of procedures calling a procedure	poref
Show names of all "top level" procedures	potl
Enable trace mode	trace
Enable single-step mode	watch
DISK AND FILE OPERATIONS	
Rename file	changei
Full disk copy	copyd
Copy file	copyf
Format a disk	initd
EDITOR	
Invoke editor for everything in workspace/package	edall
Invoke editor for all procedures in workspace/package	edps
KEYBOARD INPUT	
Read keyboard line as single word	readquote (rq)
LISTS, WORDS, AND VARIABLES	
Convert word to all lowercase	lowercase (lc)
Extract a substring/sublist	piece
Random permutation of a list	shuffle
Sort a list	sort
Convert a word to all uppercase	uppercase (uc)
Position in list of last match made with memberp	where
Protect argument from evaluation	quote
MATH FUNCTIONS	
Absolute value	abs
Convert from radians to degrees	degrees
Base 10 logarithm	log10
Convert from degrees to radians	radians
Tangent	tan
MISCELLANEOUS	
Code segment	.getcs
Data segment	.getds
Read byte from specified port	.in
Write byte to specified port	.out
Set segment for .deposit and .examine	.setseg
Comment	;
Reboot DR Logo	bye
Assign word to function key	fkey
Read position of light pen	lpen
TRUE if light pen data available	lpenp
PROCEDURE DEFINITION AND FLOW CONTROL	
TRUE if argument is the name of a primitive	primitivep

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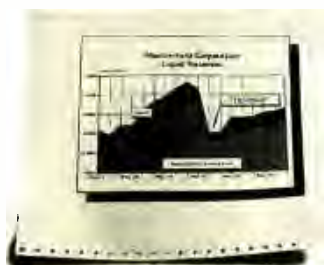


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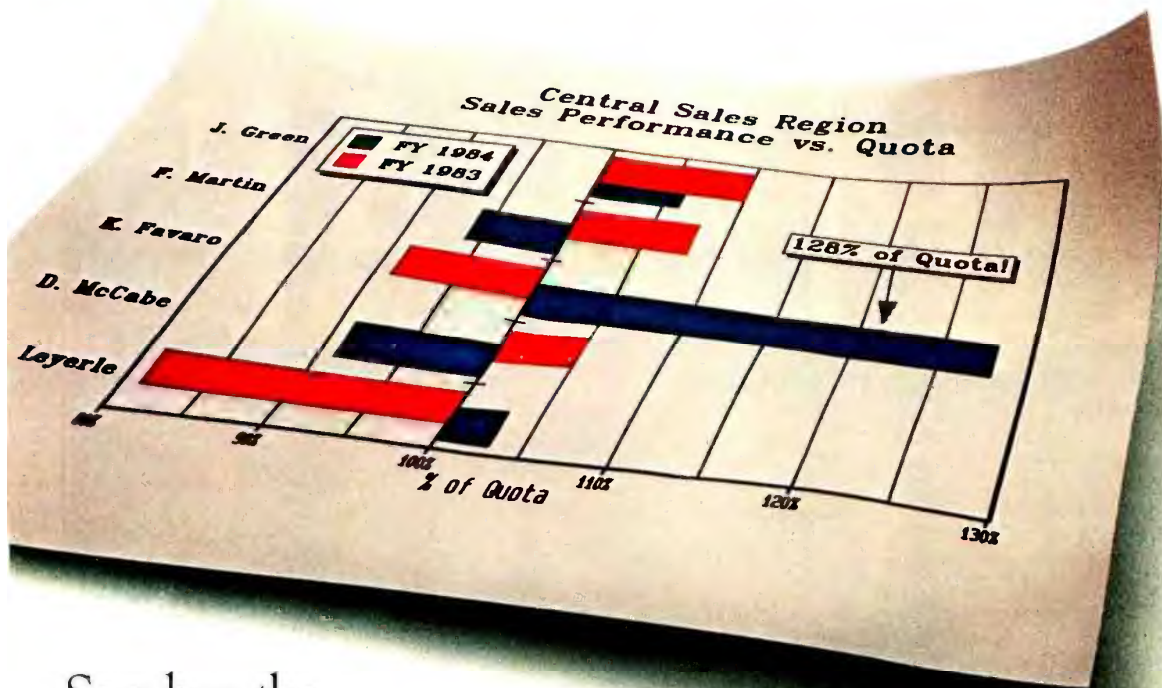
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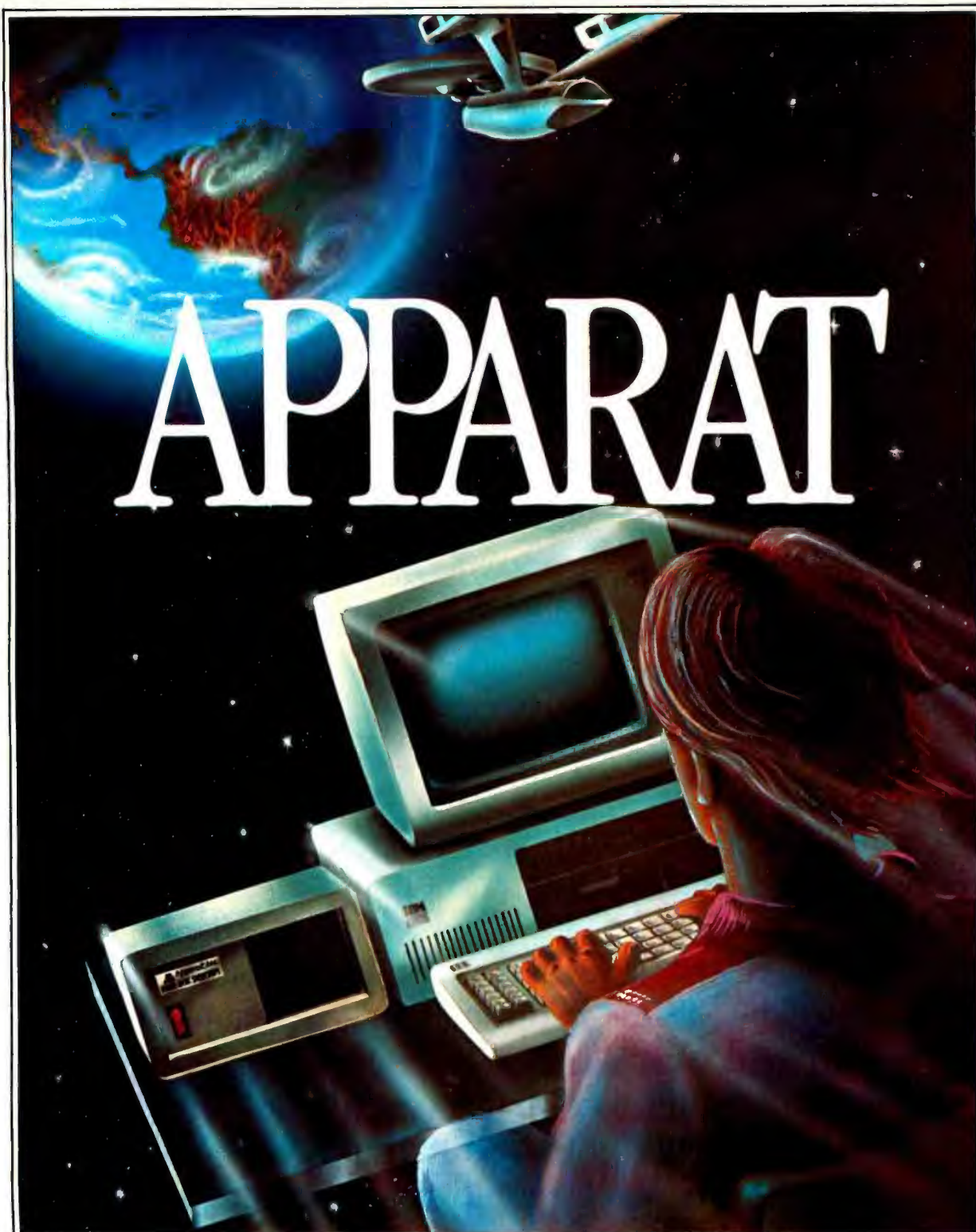


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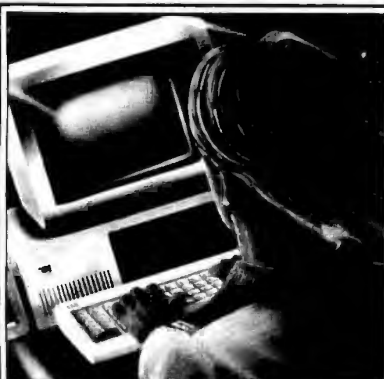
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TWO LOGOS

PROPERTY LISTS

List of all objects having a specified property	glist
---	-------

TURTLE COMMANDS

Write text on graphics screen	turtletext (tt)
-------------------------------	-----------------

WORKSPACE MANAGEMENT

Rearrange order in which procedures are displayed	follow
Disable storing of format information in workspace	noformat
Disable poprim command	poprim
Show all packages and their contents	popkg
List of all procedures in workspace/package	proclist

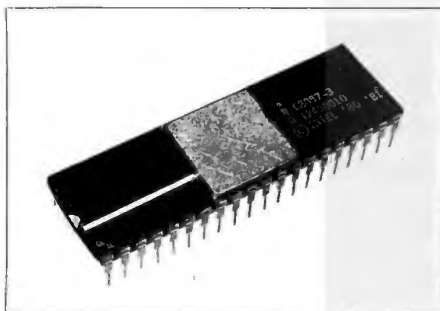
Table 4: Primitives found only in IBM PC Logo.

Action of Primitive	IBM PC Logo Name
ASSEMBLY LANGUAGE INTERFACE	
Call subroutine	.CALL
DISK AND FILE OPERATIONS	
Load binary data from file	.BLOAD
Save binary data to file	.BSAVE
List of all open files	ALLOPEN
Close file	CLOSE
Close all open files	CLOSEALL
TRUE if argument is a file	FILEP
Load a file into display memory	LOADPIC
Open file or device	OPEN
Show contents of file	POFILE
TRUE if end-of-file on read	READEOF
File or device specified by last SETREAD	READER
Current position in input stream	READPOS
Save graphics and text display in a file	SAVEPIC
Attach input stream to open file or device	SETREAD
Position input stream	SETREADPOS
Attach output stream to open file or device	SETWRITE
Position output stream	SETWRITEPOS
TRUE if end-of-file on write	WRITEOFF
Current position in output stream	WRITEPOS
File or device specified by last SETWRITE	WRITER
KEYBOARD INPUT	
TRUE if Caps Lock key reversed	CAPS
Enable/disable reversed Caps Lock operation	SETCAPS
Read in specified number of characters ¹	READCHARS (RCS)
Read in a single word ¹	READWORD (RW)
LISTS, WORDS, AND VARIABLES	
Format a number as scientific	EFORM
Format a number as fixed decimal	FORM
MATH FUNCTIONS	
Difference of arguments, prefix form	DIFFERENCE
Report precision of math operations	PRECISION
Set precision of math operations	SETPRECISION

(continued)

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TWO LOGOS

MISCELLANEOUS

Exit from Logo to PC-DOS	.DOS
Set RS-232C port parameters	.SETCOM
Force parsing of procedure definitions	REPARSE

SCREEN CONTROL

Report number of monitors in use	.SCREEN
Report "scrunch" factor ²	.SCRUNCH
Set "scrunch" factor ²	.SETSCRUNCH
Set width of display (40 or 80)	SETWIDTH
Report color attributes of text display	TEXTCOLOR (TC)
Report width of display	WIDTH

TURTLE COMMANDS

Fill area with color	FILL
Report color palette	PALETTE (PAL)
Select color palette for turtle pen	SETPAL
Set shape of turtle as specified	SETSHAPE
Redefine shape table entry	SNAP
Stamp turtle image at current position ³	STAMP

¹These primitives can also be used for file input.

²The "scrunch" factor is the ratio of vertical turtle steps to horizontal ones—it determines how square a turtle-space square looks on the display.

³A stamped turtle image remains after the turtle moves away.

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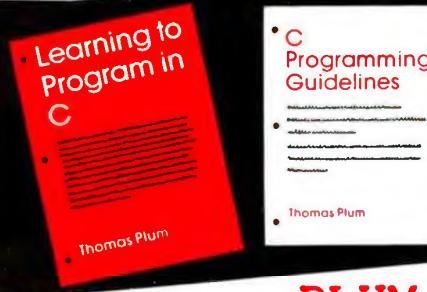
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TWO LOGOS

Table 5: Logo benchmark results.

Program	Loops	IBM PC Logo		DR Logo		Remarks
		Time (sec)	Nodes Used	Time (sec)	Nodes Used	
Ahl.benchmark ¹	1000	690.7		351.5		several recycles executed
Flower	1	15.4	19416	17.4	27	turtle graphics
Tower ²	4	1.4	245	6.2	95	recursion test
	5	3.0	437	12.1	175	
	6	5.8	821	24.2	335	
Loop	500	2.2	59	10.8	11	empty repeat loop
	1000	4.2	59	21.3	11	
	2000	8.4	59	42.5	11	
Cntr	500	4.0	1060	18.2	511	repeat loop with counter
	1000	7.8	2060	36.7	1011	
	2000	15.7	4060	73.2	2011	
IBM PC Logo precision = 10 DR Logo precision = 15						
Fptest						
Add	100	7.0	1589	10.7	824	
	200	13.7	3089	20.6	1624	
	400	27.0	6089	41.2	3224	
Multiply	100	8.2	2971	10.2	824	
	200	16.2	5871	20.6	1624	
	400	32.6	11672	40.3	3224	
Divide	100	8.6	2179	9.8	819	
	200	17.3	4274	19.3	1619	
	400	34.6	8467	38.2	3219	
Square Root	25	11.7	8670	2.8	219	
	50	23.5	17475	5.2	419	
	100	42.6	34842	10.5	819	

¹The floating-point accuracy test results were 3.6e-5 for IBM PC Logo and 1.115e-10 for DR Logo. The random-number test results were 26.06 for IBM PC Logo and 1.62 for DR Logo. For both these tests, the smaller the result the better. ²For Tower benchmark, number shown under Loops is recursion depth.



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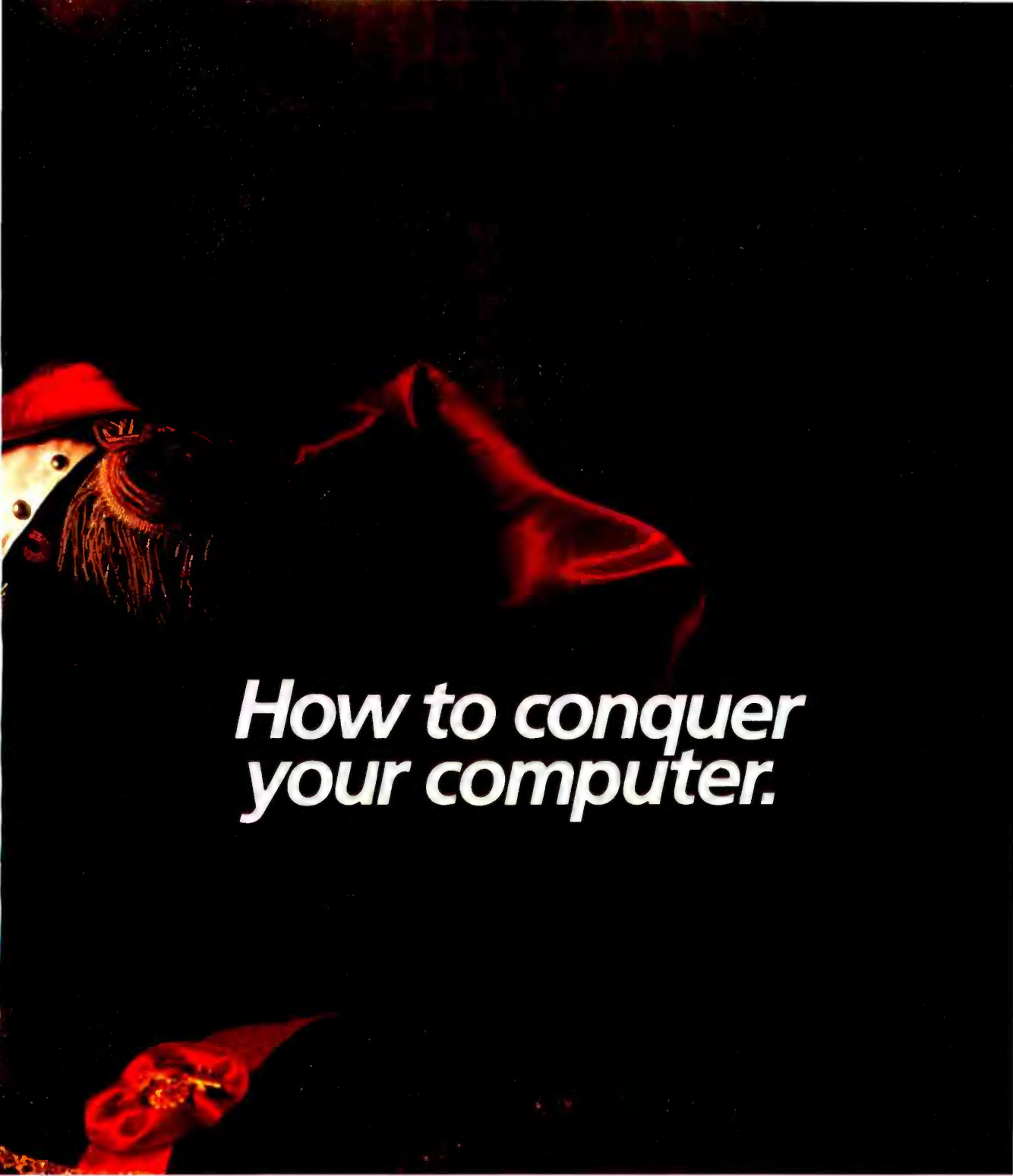
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Ex. 1022, Page 129

Listing 1: My adaptation of Ahl's simple benchmark program.

```

TO AHL.BENCHMARK :M
  (LOCAL "N "A "S "R)
  MAKE "N 1
  MAKE "R 0
  MAKE "S 0
  PRINT [START TIMER]
  REPEAT :M
    |
    MAKE "A :N
    REPEAT 10
      |
      MAKE "A SORT :A
      MAKE "R :R + RN
    |
    REPEAT 10
      |
      MAKE "A :A * :A
      MAKE "R :R + RN
    |
    MAKE "S :S + :A
    MAKE "N :N + 1
    |
  PRINT [STOP TIMER]
  PRINT ABS (1010-:S / 5)
  PRINT ABS (1000-:R)
END

TO RN
  OUTPUT (RANDOM 32768) / 32768
END

TO ABS :X
  IF :X < 0
    [OUTPUT -:X]
  [OUTPUT :X]
END

```

Note: The ABS procedure is not required by the DR Logo version of Ahl.benchmark because abs is a DR Logo primitive.

Listing 2: Flower, a turtle-graphics program.

```

TO FLOWER
  START.UP
  BLOSSOM
  GREENERY
  TITLE
  CLOSE.DOWN
END

TO START.UP
  CLEARSCREEN
  HIDE TURTLE
  FULLSCREEN
  PENUP
  FORWARD 30

```

```

PENDOWN
END

```

```

TO BLOSSOM
  SETPC 2
  CIRCLE
  RIGHT 18
  PETALS
  PENUP
  HOME
  PENDOWN
END

```

```

TO GREENERY
  SETPC 1
  STEM
  LEFT 30
  LEAF
  LEFT 120
  LEAF
END

```

```

TO TITLE
  SETPC 3
  PENUP
  SETHEADING 0
  BACK 15
  SETX XCOR-24
  TURTLETEXT [FLOWER]
END

```

```

TO CLOSE.DOWN
  HOME
  SETPC 2
  PENDOWN
END

```

```

TO CIRCLE
  LOCAL "STEP
  PENUP
  FORWARD 18
  LEFT 90
  PENDOWN
  MAKE "STEP 18 * RADIANS 4
  REPEAT 90
    |
    FORWARD :STEP
    LEFT 4
  |
  PENUP
  RIGHT 90
  BACK 18
  PENDOWN
END

```

```

TO PETALS
  REPEAT 5
    |

```

TWO LOGOS

```

    RIGHT 72
    PETAL
  |
END

TO PETAL
  REPEAT 5
  |
  FORWARD 35
  RIGHT 72
  |
END

TO LEAF
  RIGHT 45
  REPEAT 90
  |
  FORWARD 1
  RIGHT 1
  |
  RIGHT 90
  REPEAT 90
  |
  FORWARD 1
  RIGHT 1
  |
  RIGHT 45
END

TO STEM
  FORWARD 30
  BACK 100
END

TO RADIANS :D
  OP PI * :D / 180
END

TO TURTLETEXT :TXT
  LOCAL "N
  MAKE "N 1
  RIGHT 90
  SHOWTURTLE
  REPEAT COUNT :TXT
  |
  WRTWORD ITEM :N :TXT
  MAKE "N :N + 1
  |
  SETSHAPE "TURTLE
  HIDE TURTLE
END

TO WRTWORD :WD
  IF EMPTY? :WD
  |
  FORWARD 5
  STOP

```

```

  |
  SETSHAPE ASCII FIRST :WD
  STAMP
  FORWARD 5
  WRTWORD BUTFIRST :WD
END

```

Note: RADIANS, TURTLETEXT, and WRTWORD procedures are not required by the DR Logo version of Flower because radians and turtletext are DR Logo primitives.

Listing 3: The Tower of Hanoi program.

```

TO TOWER :N :FROM :TO :EXTRA
  IF :N = 0 [STOP]
  TOWER :N - 1 :FROM :EXTRA :TO
  (PRINT "MOVE :N "FROM :FROM "TO :TO)
  TOWER :N - 1 :EXTRA :TO :FROM
END

```

Listing 4: A simple loop program (Loop).

```

TO LOOP :N
  PRINT "START
  REPEAT :N [IDLE]
  PRINT "STOP
END

TO IDLE
END

```

Listing 5: A simple loop with counter program (Cntr).

```

TO CNT :N
  LOCAL "I
  MAKE "I 1
  PRINT "START
  REPEAT :N [MAKE "I :I + 1]
  PRINT "STOP
END

```

Listing 6: Floating-point arithmetic test program (Fptest).

```

TO FPTEST :N :OPR
  IF OR (:OPR = "+" (:OPR = "*")
  |
  DO.IT :N (SENTENCE [MAKE "I :I] :OPR "I)
  STOP
  |
  IF :OPR = "/"
  |
  DO.IT :N [MAKE "I :I / :I]
  STOP
  |
  IF :OPR = "SQRT"
  |
  DO.IT :N [MAKE "I SQRT :I]
  STOP
  |
  (PRINT [I DON'T KNOW HOW TO TEST] :OPR)
END

```

(continued)

```

TO DO.IT :N :RLIST
  (LOCAL "I ")
  MAKE "I 1.0001
  PRINT "START
  REPEAT :N
  |
  | RUN :RLIST
  | MAKE "I :I + 1.0
  |
  PRINT "STOP
  (PRINT [FOR I = I :I - 1 (I = I :I)]
END

```

two effects if I continued to use typical programs as benchmarks. I needed to write programs simple enough for me to know exactly what was going on. The first of these were Loop and Cntr (listings 4 and 5). As it did with Tower, IBM PC Logo ran both programs four times faster than DR Logo did. For these programs, the Nodes Used results show recycling can never degrade the performance of IBM PC Logo relative to DR Logo. Loop will never recycle because it uses a constant amount of workspace. Cntr will eventually recycle, but DR Logo will be slowed more by this than IBM PC Logo because DR Logo uses up one part in 10,000 of its workspace in every iteration, while IBM PC Logo uses up only one part in 15,000. The tests with Loop and Cntr supported the idea that the speed of primitives determines performance more than the frequency of recycling does.

What primitives could have slowed IBM PC Logo down so much while running Ahl's benchmark? I recalled that IBM PC Logo uses true variable-precision floating-point arithmetic, which has a well-deserved reputation for being slow. Thus the floating-point arithmetic primitives were good candidates. I wrote a program to test them, and the result was Fptest (listing 6). While this program is more elaborate than it needs to be, it shows off Logo's ability to pass an arithmetic operator to a procedure, something most programming languages don't allow. The results from running Fptest strongly support the idea that IBM PC Logo's problem when running Ahl's benchmark is its floating-point arithmetic. However, note that IBM PC Logo's square-root primitive consumes workspace at a rate 40 times faster than DR Logo's, indicating that the recycling effect probably contributes as well.

CAN LOGO REPLACE BASIC?

Let me restate the question in the limited context of the IBM PC. Can either DR Logo or IBM PC Logo replace the Microsoft BASIC that comes with PC-DOS? For some applications it can, for others it cannot. BASIC is used (or abused, if you prefer) to program an incredibly wide range of applications. Indeed, the range is so wide that I am sure I don't know its real dimensions. The best I can do is mention some applications where I think Logo would work better than BASIC and others where I think BASIC would work better.

Since I know Logo was designed to serve education, I wasn't surprised to find that both of the Logos reviewed here live up to Logo's reputation as a superb tool for exploring and demonstrating fundamental concepts in such fields as mathematics, physics, and computer science. Logo is sheer delight when used for this purpose. I imagine it would function just as well when applied to other subject matter, say economics or biology.

A lot of Logo's value in education derives from its excellence as a language in which to write simulations. This area is one in which BASIC is widely used, but where both DR Logo and IBM PC Logo are superior. I find both versions of Logo better than BASIC for numerical computation. Since simulation and numerical computation are two of the most important applications for computers in science and engineering, it follows that either Logo could profitably displace BASIC in these fields.

These Logos should also be of interest to computer scientists and software engineers for rapid prototyping. Rapid prototyping allows you to try out your ideas in a series of small, quickly written programs before you incorporate them into a large and complex one. Prototypes developed in Logo are easy to translate into languages such as C, Pascal, or PL/I. This cannot be said for Microsoft BASIC. When there isn't much need for file handling, DR Logo has the edge over IBM PC Logo for prototyping because it provides the better development environment.

Microsoft BASIC will clearly outdo either of the Logos in most business applications that are mainly of a clerical or financial nature. BASIC's superior capability for handling files ensures this. File-handling superiority will probably tip the balance in BASIC's favor for text-processing applications as well, although both Logos are superior to BASIC in their ability to manipulate text data in memory.

WHICH LOGO IS BETTER?

The choice between Logos is another difficult question. Although the two Logos have much in common, each has strengths and defects not found in the other. Every time I am developing a program in one, I find myself wishing for features the other has. If I were forced to choose between them, I would probably choose DR Logo because it provides the better programming environment. But its I/O limitations would make this a hard decision. The pros and cons are so intertwined that I can easily understand someone else choosing IBM PC Logo instead.

My performance tests do not allow any absolute judgment to be made either. Programs that do a lot of number crunching run faster in DR Logo, but IBM PC Logo has variable-precision floating-point computation. Programs that do a lot of recursive list processing run faster in IBM PC Logo, but DR Logo has the better set of list-processing primitives. For many typical Logo programs, no significant difference will be apparent. The Flower program is a good example.

What I would like is a Logo with all the good features of the two reviewed here and none of the bad. That would be a dynamite programming language. Maybe such a Logo will be available for the IBM PC soon—perhaps even in a subsequent release of either DR Logo or IBM PC Logo. ■

BY JAMES L. WEINER

THE LOGICAL RECORD KEEPER: PROLOG ON THE IBM

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More people are probably "programming" with spreadsheet software than in any traditional programming language. Spreadsheet software allows you to express a large number of real-world problems in terms the computer can understand and solve. After all, how many doctors, lawyers, and people in business need to calculate the factorial of a number? Home or business users deal with objects and relations in the world around them. They want to be able not only to track the deposits and withdrawals in their checking accounts but also to calculate the balance automatically.

The Japanese, who have recognized that computing is no longer reserved for programmers, are developing a new generation of computers to meet the challenge. To complement this new generation of computers, they chose a new logical programming language called PROLOG.

The Japanese effort, termed the "Fifth-Generation Project," is sponsored by both industry and government. The aim of this 10-year undertaking is not only to develop a new generation of computers but to develop integrated systems of software and hardware capable of what the Japanese call "knowledge information processing"—applied artificial intelligence. Because it's based on objects and relations, the stuff of logic, PROLOG is clearly the right language for the project.

How many
doctors, lawyers,
and people in
business need to
calculate the
factorial of a
number?

Initially developed by a group at Marseille, France, headed by Alain Colmerauer, PROLOG is based on ideas proposed by Robert Kowalski, then at the University of Edinburgh, who suggested using logical inference as a form of computation. The most efficient and well-engineered version of PROLOG was developed for the DEC-10 by a group headed by David H. D. Warren and which included Luis Pereira, Fernando Pereira, Lawrence Byrd, and David Bowen. Called the Edinburgh DEC-10 PROLOG, it was the first to support both an interpreter and a compiler as well as a sophisticated debugger.

At the University of New Hampshire, under my direction, a graduate student named Sidney Clark created a portable version of the Edinburgh DEC-10 interpreter for the IBM PC. UNH PROLOG will be available commercially early in the fall of 1984.

USING PROLOG: AN EXAMPLE

PROLOG is a programming language that uses familiar questions and answers in interaction with a common database. A user poses a question to the computer, and the computer, using PROLOG and its database, responds. Programs in PROLOG are rules, stored in the database, for transforming input to output. What makes PROLOG unique is that the system alleviates the need to explicitly state how to use knowledge in the database to answer a question. Thrown out of the vocabulary of programming are such constructs as IF...THEN...ELSE, FOR...LOOPS, and REPEAT...UNTIL. Programmers can focus on describing what a problem is and let the language determine how the database can solve it. While designing a programming example in PROLOG for this article, I have tried to convey both how PROLOG works and how simple it is to use. To some readers my example won't look like sound programming; to others, it will look like the only way.

Suppose we have a large record collection, and we maintain information about it in a three-drawer file cabinet, as shown in figure 1. The first drawer,

(continued)

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PROLOG

labeled "records," contains an entry on an index card for each record in the collection. The entry relates the title of the record with the ensemble that performed it, its conductor, the label on which it was recorded, its catalog number, and its location on the shelves. The index cards used to be ordered, but now they are in disarray. We use the information in this drawer mainly to retrieve a record from the shelf. Sometimes, though, we use the information to answer a question about a record: "Who conducted the Berlin Philharmonic performing Handel's 'Messiah' for RCA?"

Let's assume we enjoy listening to different recordings of the same composition. Another drawer, labeled "performance," relates composition titles to information about the recording. Similarly, we might like listening to a particular composition on a record that features one of our favorite soloists, and thus yet another drawer exists, this one labeled

"solo," that relates record, composition, and soloist. Examples of cards from each drawer are given in figure 2.

Applying PROLOG to this problem is simple. We enter the information on each card into a file that is loaded into PROLOG. (In PROLOG this is called "consulting.") To distinguish between entries from different drawers, we'll use the drawer label. For example, one entry in the "records" drawer might refer to the record entitled "Bach-Orchestral Suites" performed by the Academy of St. Martin in the Fields and conducted by Neville Marriner. The record's label is Argo, and its catalog number is zrg948. In PROLOG this entry might appear as: records ("Bach-Orchestral Suites," Academy of St. Martin in the Fields, marriner, argo, zrg948).

This recording features Bennett on the flute. To indicate the corresponding entry in the "solo" drawer, we must have an entry in the PROLOG file, such as: solo (bennett, argo, zrg948).

A composition performed on this record is Bach's "Orchestral Suite No. 2 in B minor." To indicate this, we need an entry in our PROLOG file such as: performance ("Orchestral Suite No. 2 in B minor," bach, argo, zrg948).

Each entry in our file is a fact about the record collection. For example, we know from our file that there was a performance of Bach's "Orchestral Suite No. 2, in B minor" on the Argo label, catalog number zrg948. Once consulted, these facts will be stored in PROLOG's internal database. Now let's invoke PROLOG:

-- UNH Prolog 1.3 --

| ?-

When invoked, PROLOG responds with a prompt that invites a question. Initially, PROLOG doesn't know much. We must consult our file of facts to add to PROLOG's knowledge. So we ask PROLOG to "consult the file 'records'; if you can":

-- UNH Prolog 1.3 --

| ?- consult(records).
| records consulted |
yes
| ?-

PROLOG responds with the fact that the "records" file was consulted; that is, the facts within it were added to the database. The "yes" indicates it tried to consult the file, and a new prompt invites another question." We can ask, "Did Bennett perform a solo on argo record, catalog number zrg948?":

| ?- solo(bennett,argo,zrg948).
yes
| ?-

PROLOG answers in the affirmative; it knows that Bennett performed a solo on Argo record zrg948. To answer, it has gone through very much the same process that you would go through by hand. In the same way you thumb through your index cards looking for one that matches the information in the question, PROLOG "thumps" through its database looking for a fact that matches the question.

LOGICAL QUESTIONS

If all you could ask were yes/no questions, PROLOG would be relatively useless. But you can ask PROLOG more interesting questions; for example,

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Figure 1: The file cabinet.

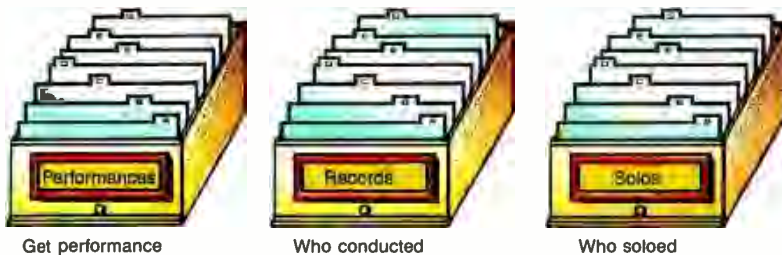


Figure 3: Rephrasing the question.

Bach Orchestra Suites
Academy of St. Martin in the Fields
Marriner
Argo zrg948
Shelf 6

Orchestra Suite No. 2 in B Major
Bach
Argo zrg948

Bennett
Argo zrg948

Figure 2: Sample index cards.

| ?- solo(Soloists,philips,6727).
Soloists = nicklin;
Soloists = davis;
no
| ?-

"What soloist performed on Argo record zrg948?"

| ?- solo(Soloist,argo,zrg948).
Soloist = bennett.
yes

Questions like the above involve a concept similar to that of "variables" in other languages. Variables in PROLOG are distinguished from other words by starting with an uppercase letter. (Other versions of PROLOG use different variable conventions. For example, MicroPROLOG allows variables X, Y, XO, YO, XI, YI, etc. MicroProlog is available from Programming Logic Systems, 31 Crescent Dr., Milford, CT 06460.) In this case, as PROLOG thumbs through its database, it is looking for an entry that matches all items except the one describing the soloist's name. When it finds a component of an entry that matches, it "sets" the variable "Soloist" to that matching component. For example, in the above, the variable "Soloist" is set to "bennett." PROLOG then responds with values of all the variables used. The period in "Soloist = bennett." is entered by the user, and it means, "This is the soloist that I was looking for." If the response had been a semicolon (;), which means, "This isn't the soloist I was looking for," PROLOG would have continued to search for another entry that

matched. In this case, since Bennett is the only soloist on the record, PROLOG would have eventually answered "no" to your ":" response.

If the file PROLOG originally consulted had information about another recording performed by the Academy of St. Martin in the Fields, this one entitled "Handel-Orchestral Works," two soloists would have been found. Both Nicklin and Davis performed oboe solos on this Philips recording, catalog number 6727. Let's exit PROLOG and add this information to the file:

records('Handel-Orchestal Works;
'Academy of St. Martin in the
Fields;' marriner, philips, 6727).
performance('Water Music;' handel,
philips, 6727).
performance('Music for the Royal
Fireworks;' handel, philips, 6727).
solo(nicklin, philips, 6727).
solo(davis, philips, 6727).

Then reinvoke PROLOG and reconsult the file:

| ?- consult(collection).
| collection consulted |
yes
| ?-

Now that we've these new facts, we can ask, "Who are the soloists on Philips record 6727?"

PROLOG finally responds with "no" only because we didn't accept the two possible answers. If we had typed a period (.) in response to any of the two choices, PROLOG would have responded with "yes."

Suppose we want to ask, "Did Bennett perform Handel's 'Water Music' on a recording conducted by Marriner?" No entries relate a soloist directly to music that he or she performed, only to the record on which he performed. To find out what compositions were performed, we have to search the "performances" drawer. If we want to find out who conducted that performance, we have to search the drawer labeled "records."

To answer the above question, we must rephrase it in terms that apply to our filing system. One way to rephrase this question is, "On what recording did Bennett perform such that that recording was of Handel's 'Water Music' and that recording was conducted by Marriner?" The information needed to answer this question is stored in three different drawers—the "performance" drawer, the "solo" drawer, and the "records" drawer. We need some way to go from one drawer to another (see figure 3). Clearly, the "link" between drawers is information about the recording, specifically the record label and catalog number.

(continued)

THE PROCESS BY HAND

Now let's run through the process of answering this question by hand. First, we thumb through the "performance" drawer for a performance of Handel's "Water Music." (See figure 4a.) When we find one, we note the record label and catalog number and thumb through the "records" drawer looking for that recording. (See figure 4b.) If he wasn't, then we have to go back to the "performance" drawer again, forget about the recording we last noted, and find another recording of that piece. (See figure 4c.)

If the recording was conducted by Marriner, we head for the "solo" drawer, seeking the same recording, and check to see if it featured Bennett. (See figures 4d and 4e.) If it did, we have our answer; otherwise, we have to return to the "solo" drawer and find another entry for that recording—there could be more than one soloist on a recording. If there isn't another entry, we go back to the "records" drawer and look for another entry for that recording. Clearly, there won't be one, because the "records" drawer has only one entry per recording. So we have to go back to the "performance" drawer and start the process again.

With any luck, we remembered to mark each card in the "performance" drawer as we found a pertinent entry. If we didn't, then each time we have to go back to it, we must start thumbing from the beginning.

This process, called backtracking, is analogous to the way PROLOG processes questions. We can view each time we thumb through a drawer, go from one drawer to another, or go back to a previous drawer as part of a path through the filing system. PROLOG guarantees that if there is a path that leads to a solution to the question, it will find it. In this way, unlike with a conventional programming language, we don't have to tell PROLOG how to find a solution. In PROLOG, the above query would be expressed as follows:

```
| ?-performance('Water
Music',_,Label,Number),
| records(____,marriner,Label,
Number),
| solo(nicklin,Label,Number).
```

Label= philips.
Number = 6727.
yes

The underscore character (____) is used to represent some variable that we don't care to name, because we never need to refer to it again. These variables

refer to parts of an entry on which there are no restrictions; we don't care who composed the piece, what the title of the record was, or what ensemble performed it. Although the record label and catalog number are unimportant, PROLOG must use the same ones to link the three drawers together, so you must

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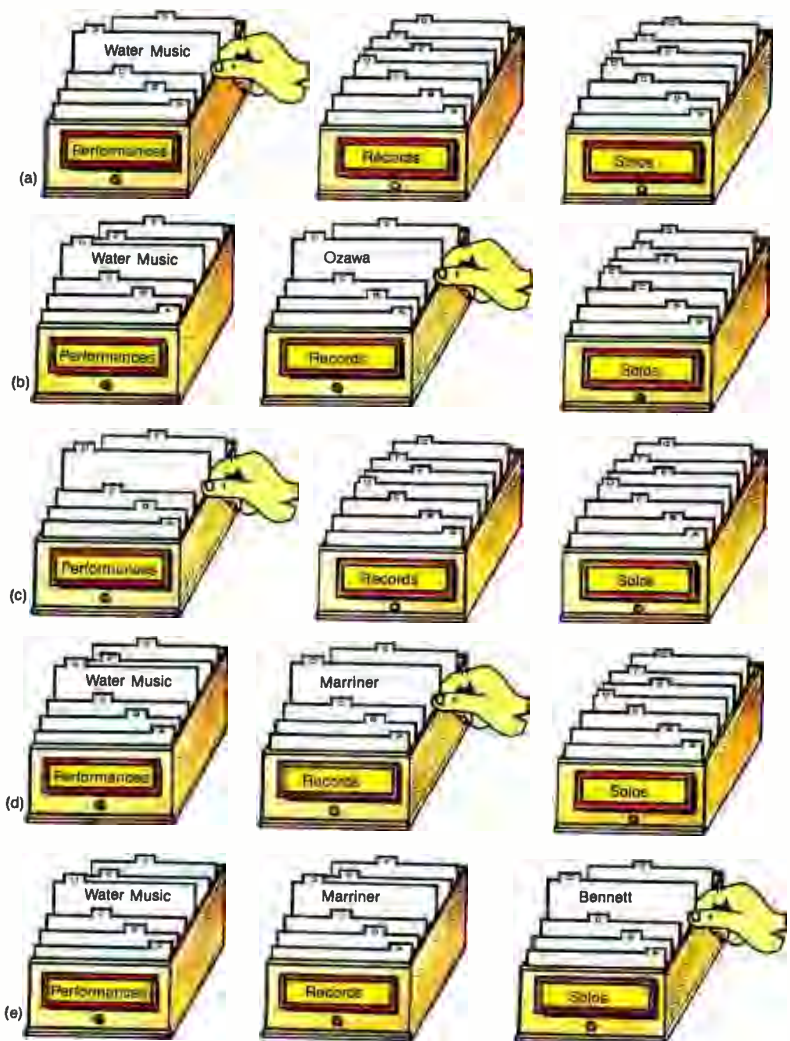


Figure 4: The process of answering the question.

PROLOG

*guarantees that if
there is a path
that leads to a
solution to the
question, it will
find it.*

name them. Unfortunately, PROLOG doesn't understand that the specific record label and catalog number are used temporarily to answer the question, so it displays them as part of the response.

REPHRASING A QUESTION

It's easy for the record collector to rephrase a question, but for others, it may be difficult. For them, the collector has written a small pamphlet containing possible general questions such as, "Who has conducted on recordings featuring some soloist?" The collector has included instructions on how to use the file system. An example of a page in the pamphlet is given in figure 5. To answer a question that needs rephrasing, we thumb through the pamphlet, looking for a page with our question, and then thumb through the file drawers following the instructions in the pamphlet.

Because we have rewritten each entry in our file drawers in PROLOG, we can do the same with each page in the pamphlet. Instead of being facts about the record collection, the entries are rules for finding out new facts using the record collection. The page shown in figure 5 would be rewritten in PROLOG as follows:

```
conductor__soloist(Conductor,
Soloist) :-
records(__,Conductor,Label,
Number),
solos(Soloist,Label,Number).
```

In PROLOG, the colon/hyphen (:-) is used to separate the "goal" of finding the conductor of a recording that features a specific soloist from the

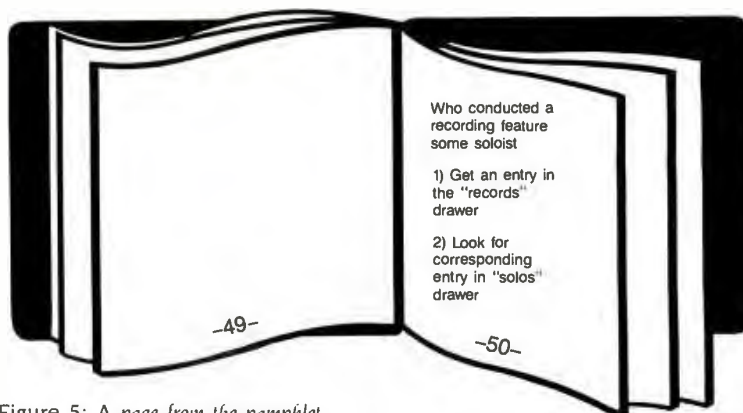


Figure 5: A page from the pamphlet.

"method" PROLOG must use for finding this information. Because the rule is given in a general form, we can ask several variations on it. For example, we ask, "Did Marriner conduct a recording featuring Bennett?"

```
|?- conductor__soloist
(marriner.bennett).
```

Or, "What soloist was featured on a recording conducted by Marriner?"

```
|?- conductor__soloist
(marriner.Soloist).
```

Or, "Was Bennett featured on a recording conducted by some conductor?"

```
|?- conductor__soloist
(Conductor.bennett).
```

Finally, we can ask just the general question, "Who conducted a recording featuring some soloist?"

```
|?- conductor__soloist
(Conductor.Soloist).
```

For each question, PROLOG thumbs through its database trying to match either a fact or the goal part of a rule. If it matches a rule, the method part, functioning as the rephrased question, is posed to PROLOG with the appropriate substitution of variables. That is, for the question

```
|?- conductor__soloist
(marriner.bennett).
```

the rephrased question posed to PROLOG would be

```
records(__,marriner,Label,
Number),
solos(bennett,Label,Number),
```

This process is called "pattern-directed invocation."

The pamphlet also comes in handy when you're answering questions about what people work together. For example, having heard a rumor that Neville Marriner and Robert Davis are feuding, we may want to know if it is true. It couldn't be possible if the two have never worked together, so we want to know if they have. Picking up the pamphlet, we thumb through it to find a method for figuring out if the two have ever worked together. We find the following:

Do PersonA and PersonB work together

1) See if PersonA soloed on a recording. If so, then see if PersonB soloed on the same recording.

In PROLOG this would appear as:

```
work_together(PersonA,PersonB) :-
solos(PersonA,Label,Number),
solos(PersonB,Label,Number).
```

The rephrased question would be:

```
solos(marriner,Label,Number),
solos(davis,Label,Number).
```

Clearly, this approach will not succeed, because Marriner is a conductor, not a soloist. Going back to the pamphlet, we look for another method to answer our question. On page 55 we find:

Do PersonA and PersonB work together

1) See if PersonB soloed on a recording conducted by PersonA.

(continued)

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PROLOG

This method is similar to the first, but it does not have the same flaw. In PROLOG, a method can consist of either rules or facts interspersed. This rule would appear as:

```
work__together(PersonA,PersonB) :-
  conductor__soloist(PersonB,
    PersonA).
```

From what we know, they do work together. Maybe the feud is still on!

If we exit PROLOG again, add the rules we encountered in the pamphlet to our file "collection." reinvok PROLOG, and reconsult the file. we can ask PROLOG for an answer to the above questions.

CONCLUSIONS

Owners of a personal computer need a language such as PROLOG that allows them to solve common but interesting problems without having to devote an inordinate amount of time to programming. One might think that a language like LISP, which is widely used in the Artificial Intelligence community, might be as effective as PROLOG for common real-world problems, but that's not the case. LISP is a much lower-level language. The main advantage that PROLOG has over LISP is the fact that patterns and pattern matching are so fundamental to PROLOG. The problem of representing knowledge in LISP is casting that knowledge into lists that LISP can process. ■

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AN INTRODUCTION TO PC ASSEMBLY- LANGUAGE PROGRAMMING

How to program the 8088

This is a guide for writing assembly-language programs or routines on the IBM PC. It is necessary to program in assembly language when an application must be as fast as possible or when the high-level language being used cannot perform the desired operation. High-level languages are also easier to comprehend when you understand assembly-language concepts. This article is not a primer. I am assuming that you have read a primer or manual and are left with unanswered questions. I hope this article will answer some of those questions and that, with one or more of the references listed at the end of the article, you will become a more polished assembly-language programmer. I will present specifics of the 8088 first, followed by a sample program and routine. The program is a useful utility illustrating DOS (disk operating system) function calls and string manipulation. The routine introduces a new technique for writing code to be called from BASIC.

THE 8088 CENTRAL PROCESSING UNIT

Figure 1 shows an elementary block diagram of the 8088. This processor has two separate processing units: the execution unit (EU), which executes instructions, and the bus interface unit (BIU), which is responsible for the 8088's communication with the outside world. The BIU is capable of coor-

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ordinating multiple EUs such as the 8087 numeric data processor (NDP) and the 8089 I/O processor. The only difference between the 8088 and the 8086 is their BIUs.

The BIU sits between the EU and the outside world. An EU provides a logical address to the BIU, which translates it into a physical address. This translation, called the physical-address computation, uses two 16-bit quantities: a segment register and an offset. The notation used for logical addresses is segment:offset. The segment registers (parts of the BIU) are code segment (CS), stack segment (SS), data segment (DS), and extra segment (ES). The offset is usually supplied by the EU.

The physical address is computed by shifting the segment register left 4 bits and adding the offset in the BIU's dedicated adder. Segments are 64K-

byte relocatable pieces of the 1-mega-byte physical-address space. They are located on 16-byte boundaries called paragraphs. Assembly-language programs are written in logical segments. Placement of these segments in memory is a function of the linker and the DOS. They can be overlapped, contiguous, or disjointed.

The address of the next instruction to be executed is CS:IP, (code segment: instruction pointer). For increased efficiency, the BIU pipelines bytes (prefetches them and puts them into a queue). To facilitate this calculation, the offset instruction pointer is kept in the BIU.

The EU contains eight 16-bit registers, any of which can be used in computations. Four of these registers comprise the data group. They are the accumulator (AX), base (BX), count (CX), and data (DX) registers. The high and low 8 bits of each data register also can be accessed. The two halves of the accumulator register are AH (accumulator high) and AL (accumulator low). The halves of the base, count, and data

(continued)

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registers are similarly named.

Two other general registers, the source index (SI) and the destination index (DI), comprise the index group. These registers are used primarily in string operations. Two segment registers are required to perform moves or comparisons on memory more than 64K bytes apart. This is why there is an extra segment in addition to the data segment. The destination in a string operation is always ES:DI (extra segment: destination index).

The last two general registers, the stack pointer (SP) and the base pointer (BP), comprise the pointer group. These registers manipulate the stack that holds subroutine return information. When a subroutine is invoked, SS:SP (stack segment: stack pointer) is used to store the return address on the stack. Stack pointer points to the top of the stack and is automatically decremented by calls and incremented by returns. The stack also is used to pass subroutine parameters. The base-pointer register is used to access these parameters.

Many of the registers in the EU have special uses. Table 1 shows these registers and their uses.

ADDRESSING

An offset is also known as an effective address. The EU generates an effective address using one of several methods called addressing modes. An effective address has one or more of the following: base, index, and displacement. A base can be either a base register or base pointer; an index can be either a source index or destination index; and the displacement is a 16-bit signed number.

If no segment register is specified, the data-segment register will be used. If the base-pointer register is specified as the base, the stack-segment register is used. Supplying a segment register that is not the default is called a segment-override prefix. The segment cannot be overridden for an instruction pointer, stack pointer, or destination-index registers in string operations. Figure 2 shows how the various addressing modes in the EU and the BIU combine to form the physical address.

There are three types of addresses: Short, Near, and Far. Short addressing is used for looping, conditional jumps,

and for some unconditional jumps. Near and Far addressing are used in calls and unconditional jumps that do not qualify for Short addressing. Short and Near addresses affect only the instruction-pointer register and are always relative.

Far addresses affect code-segment and instruction-pointer registers and are absolute. When the value of the code-segment register does not change, you have intrasegment addressing. When

(continued)

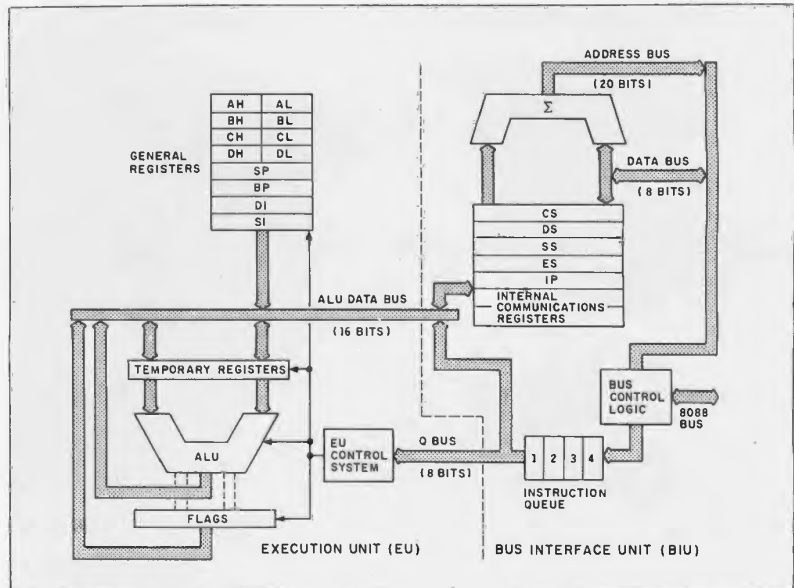


Figure 1: A block diagram of the 8088's two processing units (see reference 3).

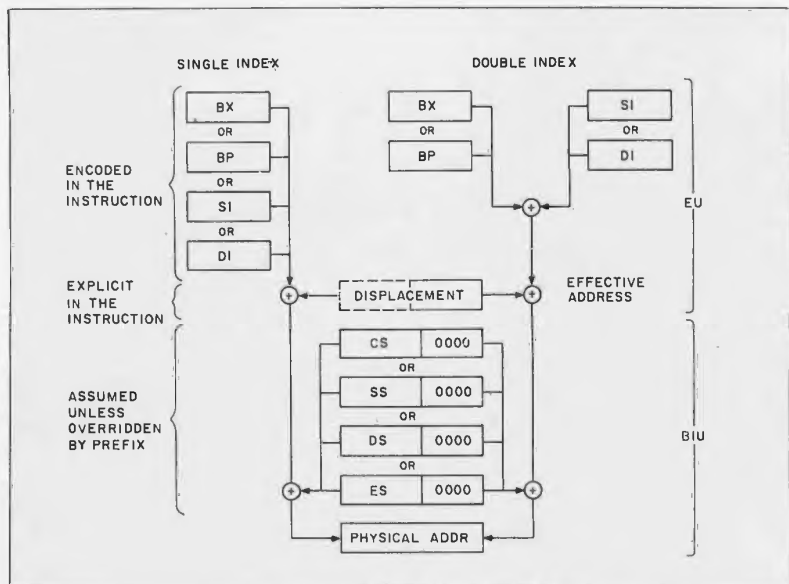


Figure 2: Addressing modes in the execution unit and bus-interface unit combine to form the physical address (see reference 4).

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The segmented addressing scheme of the 8088 differs from the traditional linear addressing scheme. . . It shortens the instruction length. . . of data items.

the value of the code-segment register does change, you have intersegment addressing. A Near call puts only the instruction-pointer register for the return on the stack. A Far call puts both code-segment and instruction-pointer registers for the return on the stack. Consequently, there are different Near and Far returns. A Near call to a Far procedure, or vice-versa, is a disaster.

The segmented-addressing scheme of the 8088 differs from the traditional linear-addressing scheme in several ways. Segmented addressing shortens the instruction length and the size of data items required for addresses. This saves memory and speeds execution because fewer fetches are required. It also allows you to easily relocate logical segments. Linear addressing is superior for processing data that is larger than 64K bytes.

INTERRUPTS

The 8088 does not distinguish between

interrupts invoked with the assembly-language instruction INT or by the hardware. There are 256 interrupts, vectored through a table of double words located at hexadecimal 00000H:00000H (all locations mentioned in this article are hexadecimal). Each double-word entry in the table corresponds to the CS:IP (code segment: instruction pointer) of the subroutine that is invoked for that interrupt.

An interrupt is handled like a Far call except that the flags are also pushed on the stack before the return CS:IP (code segment: instruction pointer). In addition to Near and Far returns, there is an interrupt return. The 8088 uses interrupts 000H through 004H for division by zero, single stepping, nonmaskable interrupts, breakpoints, and overflows. Hardware interrupts IRQ0 through IRQ7 are mapped into interrupts 008H through 00FH by the 8259A interrupt controller.

MEMORY USAGE

The interrupt vector table is an example of a fixed portion of memory that is used in a particular way. To program the IBM PC effectively, you have to have an understanding of all such fixed areas.

The 8088 begins execution at 0FFFFH:00000H. On the IBM PC, this is an entry point into the BIOS (basic input/output system). This code is in ROM (read-only memory) at 0FE00H:00000H; therefore, it is called the ROM BIOS. It contains the basic code necessary to interface with all of the hardware devices. You can reach the subroutines of the ROM BIOS through software interrupts 010H through 01FH. The ROM BIOS

also uses memory at 00040H:00000H through 00040H:000FFH. Some of the values kept in this area include the current video mode and the keyboard buffer.

There is a version of ROM BASIC located at 0F600H:00000H. This BASIC and the disk-based BASICs also use memory at 00050H:00000H through 00050H:000FFH, as do some DOS functions.

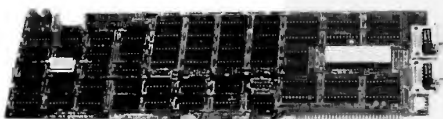
The memory from 00060H:00000H through 00060H:000FFH is used under DOS 2.0 and DOS 2.1 to store various disk variables. When DOS is booted, the boot code loads the hidden files IBMBIOS.SYS and IBMDOS.SYS into memory directly above these reserved areas. IBMBIOS is also known as the RAM (random-access read/write memory) BIOS. It moves IBMDOS down to recover unused space and transfers control to DOS. DOS functions are invoked through interrupts 020H to 027H. DOS initializes devices, loads COMMAND.COM into memory directly above itself, and transfers control to COMMAND. To make more memory available to the user, COMMAND relocates a portion of itself, the transient portion, into high memory.

COMMAND is responsible for executing internal or external commands. For example, DIR is an internal command (the code for DIR is inside COMMAND), while CHKDSK is an external command (the code for CHKDSK is in a file called CHKDSK.COM). The macro-assembler, MASM (found in a file called MASM.EXE), is also an external command.

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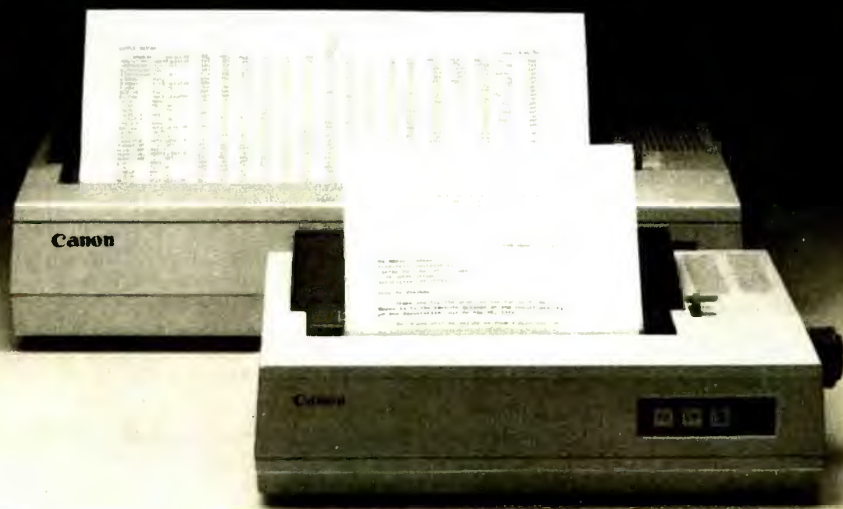
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PROGRAM EXECUTION

When COMMAND loads code to execute an external command to perform a task, it first builds a 256-byte program segment prefix (PSP). The program segment, which has its origins in CP/M, contains important information about the task. Listing 1, PSP.INC, shows the layout of the program-segment prefix.

If the code is in a command (.COM) file, the contents of the file are put into memory at CS:00100H, where the code segment points to the program-segment prefix. A .COM file contains exactly one logical segment. When execution begins, CS=DS=ES=SS=PSP (code segment = data segment = extra segment = stack segment = program-segment prefix), IP (instruction pointer) = 00100H, SP (stack pointer) = 000FEH, and there is a zero word on the top of the stack.

If the code is in an executable (.EXE) file, then the file contains relocation information and one or more logical segments. In this case, when execution begins, DS=ES=PSP (data segment = extra segment = program-segment prefix) and CS:IP (code segment:instruction pointer) and SS:SP (stack segment:stack pointer) depend on the assembly and link conditions. It is common for the code segment to be PSP (program-segment prefix) + 00010H and IP (instruction pointer) to be 00000H.

A Near return is used to terminate execution of .COM files. A zero word is placed on the top of the stack, and the code at PSP (program-segment prefix) :00000H is an INT 020H instruction. INT 020H is the DOS terminate function. A jump to 00000H or an INT 020H will also terminate the program. I prefer INT 020H because it does not depend on the state of the stack.

For .EXE files, none of the .COM file methods work. INT 020H assumes that CS=PSP (code segment = program-segment prefix) because the original DOS, developed by Tim Patterson at Seattle Computer Products, supported only .COM files. To terminate an .EXE file, you have to transfer control to the INT 020H instruction in the program-segment prefix with CS=PSP (code segment = program-segment prefix). One common method is to push the initial data segment value and a 0 on the stack and do a Far return to terminate.

Listing 1: This program shows the layout of the program-segment prefix.

```

.....
:PROGRAM SEGMENT PREFIX
.....
TOP_OF_MEMORY    DB  2 DUP(?)    :int20
                  DW  ?
                  DB  ?
                  DB  5 DUP(?)    :ioct1
                  DD  ?           :dos__jmp
TERMINATE         DD  ?
CTRL__BREAK       DD  ?
CRITICAL__ERROR   DD  ?
                  DB  22 DUP(?)   :used by dos
ENVIRONMENT       DW  ?
                  DB  46 DUP(?)   :used by dos
FORMATTED__AREA__1 DB  16 DUP(?)
FORMATTED__AREA__2 DB  16 DUP(?)
                  DB  4 DUP(?)
UNFORMATTED__AREA DB  128 DUP(?)

```

Because the stack may not be in the desired state, I prefer to store the initial data segment value and a 0 in a double word and to jump indirect through this double word to terminate.

PROGRAM WALKTHROUGH

Listing 2, MAKEBAT.ASM, shows a program that is executed with two parameters: an output filename and a search filename. The program creates a batch file with the output filename and writes a line in for each file that meets the search criteria. Each line has the form

```
%1 filename
```

For example, if we enter

```
MAKEBAT ALLASM.BAT *.ASM
```

this would create a batch file called ALLASM.BAT that might contain the lines

```
%1 MAKEBAT.ASM
%1 SEARCH.ASM
```

Entering the command ALLASM TYPE would cause each .ASM file to be typed in turn.

PROGRAMMING CONVENTIONS AND COMMENTS

Like most programmers, I follow certain rules to make my programs more understandable and maintainable. These rules are my own and I do not contend that everyone else should use them, but I do feel that each programmer should develop his or her own conventions. You are welcome to adopt or adapt mine as you see fit. You may already

have noticed one convention I use regarding hexadecimal numbers—I use leading zeroes so that word values are always five digits and byte values are always three digits.

A semicolon (;) indicates the beginning of a comment. A comment continues to the end of a line. In my programs the characters after the ; indicate the level of comment. The highest level begins ;=====, Major comments begin ;***** and minor comments start with ;-----, I don't generally make remarks on individual lines of code because the scope of such comments is usually too limited. I precede groups of lines with a minor comment concerning their function. Major comments precede groups of minor comments.

PROGRAM STRUCTURE

The 8088's assembly language is strongly typed. Each named item, data, or label has a type, and the assembly language will not let you misuse the item, data, or label. If you declare a variable to be a byte, the assembly language will not let you move that value into a word register. If you declare a label to be a Near procedure, the assembly language will not let you make a Far call to that label. You help the assembly language make these decisions by declaring data before its use.

There are two major classes of declarations—those that reserve memory and those that do not. I place definitions that do not reserve memory at the top of my programs.

Listing 2: This program creates a batch file and is executed with two parameters—an output filename and a search filename.

```

=====STRUCTURES
-----FILE CONTROL BLOCK
FCB          STRUC
DRIVE__NUMBER DB    ?
FILE__NAME    DB    8 DUP(?)
FILE__EXTENSION DB  3 DUP(?)
CURRENT__BLOCK DW    ?
REC__SIZE     DW    ?
FILE__SIZE__LO DW    ?
FILE__SIZE__HI DW    ?
FILE__DATE    DW    ?
              DB    10 DUP(?)
CURRENT__REC  DB    ?
RANDOM__REC__LO DW    ?
RANDOM__REC__HI DW    ?
FCB          ENDS

=====PROGRAM SEGMENT PREFIX
PSP          SEGMENT AT 0
              INCLUDE PSP INC
PSP          ENDS

=====SSEG SEGMENT
SSEG         SEGMENT PARA STACK 'STCK'
              DW    256 DUP (?)
SSEG         ENDS

=====DSEG SEGMENT
DSEG         SEGMENT 'DATA'

-----FILE CONTROL BLOCKS
FCBOUT       FCB    <>
FCBRES       FCB    <>
FCBSEA       FCB    <>

-----ERROR MESSAGES
MSGCRE       DB    'UNABLE TO CREATE THE OUTPUT FILE:00DH,00AH:'S'
MSGWRI       DB    'ERROR DURING WRITE TO THE OUTPUT FILE:00DH,00AH:'S'

-----OUTPUT LINE TEMPLATE
OUTLINE      DB    '%1 ?;????????;???'00DH,00AH

-----DOUBLEWORD FOR RETURN
RETURN       LABEL DWORD
RETIP        DW    0
RETCS        DW    ?

-----SEARCH FUNCTION. 011H FIRST TIME THEN 012H.
VARFUN       DB    011H
DSEG         ENDS

=====CSEG SEGMENT
CSEG         SEGMENT 'CODE'
;.....PROCEDURES
ASSUME CS:CSEG,DS:DSEG,ES:DSEG,SS:SSEG
TRAIL        PROC NEAR
TRAILL       LABEL NEAR
              CMP    BYTE PTR ES:[DI]-1,
              JNE    TRAILX
              DEC    DI
              JMP    TRAILL
TRAILX       LABEL NEAR
              RET
TRAIL        ENDP
;.....MAIN PROGRAM
ASSUME CS:CSEG,DS:PSP,ES:PSP,SS:SSEG
CONDSEG      DW    DSEG
;-----ENTRY-POINT
IP           LABEL NEAR
;.....INITIAL AND PSP PROCESSING
;-----ES=DSEG
MOV          ES,CONDSEG
ASSUME ES:DSEG
;-----FORM DOUBLEWORD FOR TERMINATE
MOV          RETCS,DS

```

MAKEBAT begins with the definition of FCB, a structure that documents the layout of a file-control block. Later, the fields in this definition will allow easy access to quantities such as the REC__SIZE within a particular FCB. The definition starts with the STRUC statement and ends with the ENDS statement. DB and DW stand for define byte and define word. DUP is used to specify a repeating value. A question mark (?) means there is no default value.

The information I need from the command line is stored in the program segment prefix. All segments start with the SEGMENT statement and end with an ENDS statement. The INCLUDE statement brings in the PSP.INC file that was listed earlier. Declaring the segment to be AT 0 tricks the linker into not reserving any memory for this segment in the .EXE file.

The SSEG SEGMENT declares the amount of stack for the program. If there is no stack segment declaration, the linker will generate an error message. This message is really a warning because a stack is still created and usually no harm is done.

The DSEG SEGMENT declares all of the variables. Some variables, such as MSGCRE, have initial values. FCBOUT, FCBRES, and FCBSEA use the FCB definition. The empty angle brackets indicate that none of the fields are to be given initial values different from the defaults in the definition. I list my variables alphabetically so they are easier to find.

The first statement in the CSEG SEGMENT is an ASSUME. This promises the assembly language that each segment register listed will point to the logical segment named after that register. This information will help the assembly language generate segment-prefix overrides where appropriate.

For the same reason that I declare all data before code, I declare procedures before the main code. This should be familiar to Pascal programmers. In this program there is only one procedure, TRAIL. TRAIL is a Near procedure that decrements the destination index, while the byte before the destination index is the blank character. This is used in the main program to remove trailing blanks from the output line. Note the type override, BYTE PTR, in the compare

text continued on page 144



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ASSEMBLY LANGUAGE

```

:----- GET DRIVE,FILENAME AND EXTENSION OF OUTPUT FILE
MOV     CX,(SIZE DRIVE__NUMBER) + (SIZE FILE__NAME) + (SIZE
        FILE__EXTENSION)
MOV     SI,OFFSET FORMATTED__AREA__1
MOV     DI,OFFSET FCBOUT
REP     MOVSB
:----- GET DRIVE,FILENAME AND EXTENSION OF SEARCH CRITERIA
MOV     CX,(SIZE DRIVE__NUMBER) + (SIZE FILE__NAME) + (SIZE
        FILE__EXTENSION)
MOV     SI,OFFSET FORMATTED__AREA__2
MOV     DI,OFFSET FCBSEA
REP     MOVSB
:----- DS=DSEG
MOV     DS,CONDSEG
ASSUME  DS:DSEG
:----- CREATE THE OUTPUT FILE
MOV     AH,016H
MOV     DX,OFFSET FCBOUT
INT     021H
OR      AL,AL
JZ      CREATED
:----- FAILED
MOV     AH,009H
MOV     DX,OFFSET MSGCRE
INT     021H
JMP     EXIT
:----- SUCCESS
CREATED LABEL  NEAR
MOV     FCBOUT.REC__SIZE,I
MOV     FCBOUT.CURRENT__REC,0
MOV     FCBOUT.RANDOM__REC__LO,0
MOV     FCBOUT.RANDOM__REC__HI,0
:----- SEARCH FOR FILENAMES
NEXT LABEL  NEAR
:----- SET DISK TRANSFER ADDRESS FOR RESULT OF SEARCH
MOV     AH,01AH
MOV     DX,OFFSET FCBRES
INT     021H
:----- PERFORM THE SEARCH
MOV     AH,VARFUN
MOV     DX,OFFSET FCBSEA
INT     021H
OR      AL,AL
JNZ     DONE
:----- BUILD OUTLINE FROM RESULT
:----- '%I '
MOV     DI,OFFSET OUTLINE
MOV     AL,'% '
STOSB
MOV     AL,'I'
STOSB
MOV     AL,' '
STOSB
:----- DRIVE & ':'
MOV     AL,FCBRES.DRIVE__NUMBER
ADD     AL,'@'
STOSB
MOV     AL ':'
STOSB
:----- FILENAME & ':'
:----- MOVE ENTIRE FILENAME
MOV     CX,(SIZE FILE__NAME)
MOV     SI,OFFSET FCBRES.FILE__NAME
REP     MOVSB
:----- REMOVE TRAILING BLANKS
CALL    TRAIL
:----- '
MOV     AL:'
STOSB

```