The TRS-80 Model 16B with Xenix

by Steve Barry and Randy Jacobson

The Radio Shack TRS-80 Model 16B is surprising in at least two ways: first, it appeared later than the company's announcements would have indicated, and second, it has an industry-standard multiuser operating system—Microsoft's Xenix, a derivative of Bell Laboratories' Unix version 7. The Model 16B's Xenix capability is remarkable in that it represents the first use of an outside supplier's operating system in Radio Shack's history. This event is of even more interest because Xenix is to be supplied for several other popular microcomputers.

In this review we'll first present an overview of the 16B's hardware and capabilities, and, because the hardware's effectiveness depends on its ability to run Xenix, we'll also cover that operating system's major features.

The TRS-80 Model 16B is a blend of the old and the new. It is based on a dual-processor architecture (Motorola 68000 and Zilog Z80), and it runs as either a single-user or a multiuser computer. The machine is particularly significant because it has most of the hardware features available on other machines in the $5000 to $16,000 price bracket, and it has the support of an industry powerhouse behind it. Although not innovative in concept, the 16B is more than just a solid high-end engine for Radio Shack's software. The computer performs well for its class of machine and is likely to be a major focus of software houses trying to take advantage of Radio Shack's marketing clout and Xenix program portability. The 16B is compatible with an extensive line of Radio Shack peripheral hardware, and there is also a strong indication that the Model 16B will be a central element in Radio Shack's announced but unmarketed local-area-network (LAN) strategy. Indeed, with its LAN-capability option, the system could become the backbone of an expandable, low-cost, office-wide, multimodel, shared-computer resource.

Background

Starting about a year ago, rumors of Radio Shack's new high-end machine piqued the curiosity of many enthusiasts. The computer was supposed to be a powerful yet inexpensive multiuser machine that employed a proprietary operating system said to be incompatible with the software available on widely distributed multiuser operating systems such as MP/M. When the machine failed to materialize, rumors said its delay was due to myriad hardware and software problems.

In spite of its uncertain beginnings, the Radio Shack TRS-80 Model 16B has hit that all important and all too narrow marketing "window," defined by public acceptance of a combination of price, performance, and features. Once such a window is filled by a few machines, other manufacturers find it difficult to penetrate the market. The target market for this machine is the small business that requires a one-source supplier of multiuser turnkey hardware, software, and service for core business applications. However, the 16B can also serve as a small Unix and Xenix development environment.

Photo 1: *The TRS-80 Model 16B standard system.*

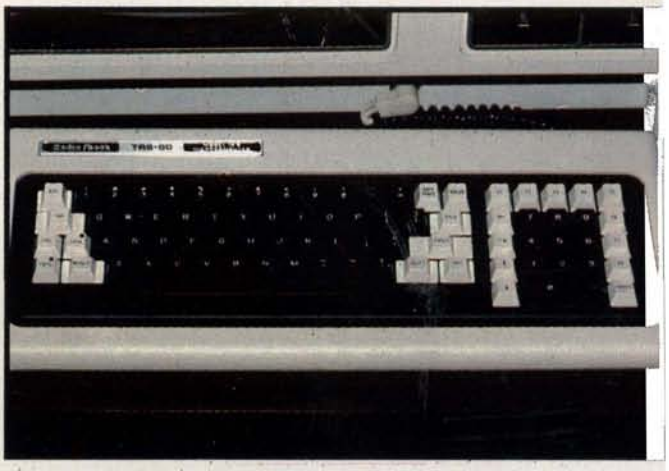

Photo 2: *The 86-key detachable keyboard of the 16B.*

System Summary

The Model 16B (photo 1) runs a large library of single-user software. Moreover, it has multiuser capabilities, and significant multiuser software has become available early in the machine's life (see the At a Glance box).

A minimum three-user system consists of the console with 384K bytes of memory, one 1.25-megabyte 8-inch floppy-disk drive, an 11.6-megabyte hard-disk drive, two user terminals, a printer, and software. The system console has a detached 86-key keyboard (photo 2). The keytops are textured to avoid glare. The standard alphabet, number, and symbol keys and the numeric keypad keys are black with white legends. Other keys—including Shift, Tab, Break, Backspace, eight function keys, and the cursor keys—are white with black legends. A bump is placed on the numeric pad's 5 key to aid manual orientation for touch-typing. Cursor keys are arranged (awkwardly, in our opinion) in a vertical column on the left border of the numeric pad. Keytops are slightly longer vertically than horizontally and have dual-spring action so that the touch is heavier at the bottom of the key travel, but there is no other auditory or tactile feedback for key-switch closure. We felt that the keyboard touch was vague, and this prevented rapid typing during our limited use of the machine. Function keys surround the upper and right side of the numeric keypad. Control keys (such as Return, Tab, Enter, and Shift) that are either the same size or even larger at the base than the character keys have the same raised striking area as an alphanumeric key. Two important symbols for Unix users and programmers can be produced only by pressing Control and another key simultaneously. These symbols are | (for the pipe feature) and \, used primarily in C-language programming.

The system is housed in a large but attractive integrated enclosure containing a seven-slot system card cage, the floppy-disk drive, the console video display (a 12-inch-

Editor's Note: *Since this article was written, Radio Shack has announced a new standard configuration for the Model 16B: a 256K-byte system with one 8-inch floppy-disk drive and a built-in 15-megabyte hard-disk drive for $6999.*

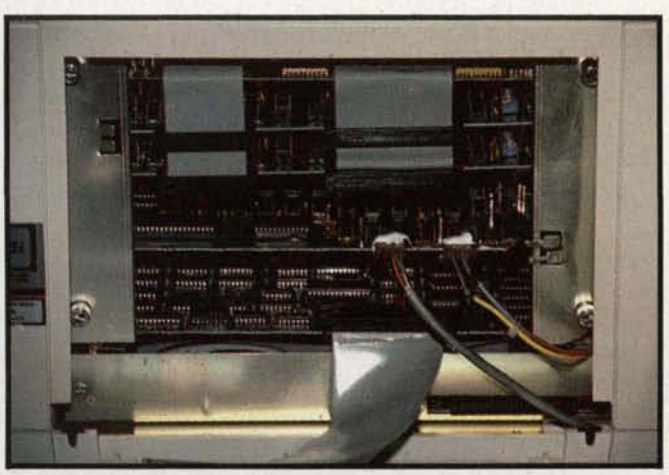

Photo 3: *The Model 16B's card cage.*

At a Glance

Name
TRS-80 Model 16B Computer

Manufacturer
Radio Shack Division
Tandy Corporation
1300 One Tandy Center
Fort Worth, TX 76102

Size
14 by 21¼ by 23½ inches

Weight
Approximately 50 pounds

Components

Processors:	Motorola 68000 running at 6 MHz, Z80A running at 4 MHz
Memory:	Z80A with 64K bytes; M68000 with 256K bytes minimum, 768K bytes maximum (128K-byte memory-expansion board is $699, 128K-byte add-on-chip kit is $299)
Display:	24 lines by 80 columns, green phosphor, brightness and contrast controls, upper- and lowercase characters, 32 symbol graphics characters
Keyboard:	Detached 86-key stepped keyboard with 6-foot coiled cord; keytops are textured to avoid glare
Data Storage:	One 8-inch double-sided double-density 1¼-megabyte floppy-disk drive installed in the console
Expansion:	Seven-slot card cage; three slots are free in a 512K-byte system with a 12-megabyte hard-disk drive

Operating Systems
TRSDOS-II/16 (single user), TRSDOS-12 (single user), TRS-Xenix (multiuser)

Documentation
TRS-80 Model 16B Operator's Manual, 100 pages; *TRSDOS-II Reference Manual*, 326 pages; *TRS-Xenix Operations Guide*, 161 pages; *TRS-80 Model 16B Owner's Manual* (actually the *TRSDOS-16 Operating System Manual*), 256 pages; *Twelve-megabyte Hard Disk Owner's Manual*, 50 pages; *BASIC Reference Manual* (TRSDOS with BASIC interpreter), 235 pages; *Assembler-16 Manual*, 353 pages

Software Available
TRS-Xenix multiuser software: General Ledger ($599); Payroll ($699); Accounts Receivable ($599); Accounts Payable ($599); Order Entry/Inventory Control System ($599); Sales Analysis ($399); Job Costing ($199); Multiplan spreadsheet ($349); COBOL Development System ($699); BASIC interpreter ($299); and TRS-Xenix Development System with C language, electronic mail, text processing, and Xenix utilities and Assembler-16 ($750). The Model 16B also uses Model II and Model 12 software in the Model II compatibility mode (single user)

Optional Features
Second internal 8-inch floppy-disk drive ($799); one ($1299) or two ($2098) external floppy-disk drives; 11.6-megabyte primary hard-disk drive ($3495); 12-megabyte secondary hard-disk drives (three maximum, $2495 each); graphics video adapter board (monochrome 640- by 240-pixel resolution, $499); DT-1 data terminals (two maximum, $699 each)

Prices
256K bytes, one floppy-disk drive: $4999
256K bytes, two floppy-disk drives: $5798
384K bytes, one floppy-disk drive, one 11.6-megabyte hard-disk drive: $9995
512K bytes, one floppy-disk drive, one 11.6-megabyte hard-disk drive (minimum recommended Xenix configuration): $10,294

diagonal green-phosphor tube without antireflection treatment), the Motorola 68000 processor board, a memory board, and the hard-disk interface. This configuration costs in the neighborhood of $16,000, complete with a top-of-the-line Radio Shack letter-quality printer and a complement of multiuser accounting and core business-applications programs. Moderate-resolution (640- by 240-pixel) monochrome-video-graphics hardware is an option for the console terminal but is not yet supported by Xenix software.

Software

The optional single-user software library includes all TRS-80 Model II and 12 programs (nearly 50 from Radio Shack), each targeted at a broad base of business and professional users. The optional multiuser software library is, at this writing, confined to program-development software (available at additional cost; see At a Glance), "big four" accounting packages (General Ledger, Accounts Payable, Accounts Receivable, Payroll), and Microsoft's Multiplan advanced spreadsheet. Other software includes an order-entry/inventory-control system, sales analysis, and small-contractor job-costing programs. COBOL and BASIC languages are sold separately, as is the TRS-Xenix development system, which includes many utilities, the C language, Unix-style communications, Unix-style text processing (*not* word processing in the usual sense), and Unix's basic electronic-mail facilities.

Hardware

The TRS-80 Model 16B has two serial RS-232C ports, a parallel printer port, and a space on the connector panel reserved for the Datapoint/Radio Shack Arcnet LAN interface. In its current configuration, then, the system can handle only three users: two working on dumb terminals, such as Radio Shack's model DT-1, and a third working on the system console. The system card cage has space for seven cards. The maximum RAM (random-access read/write memory) allowable currently is 768K bytes, which is obtained using the M68000 microprocessor's on-board memory and two 256K-byte cards. The 64K bytes of Z80 memory are on a separate card below the card cage (photo 3) in the base of the system unit. The M68000 memory cards are connected to the processor board by two card-edge ribbon cables in a bus configuration, in addition to their interface to the motherboard. One card slot is used for the hard-disk interface, and another is used for the console terminal electronics. Two slots are unused in the configuration we tested. Recent rumors suggest that Radio Shack is planning to announce a six-port terminal multiplexer board, along with a 15-megabyte hard-disk drive. The multiplexer and an Arcnet board would fill the card cage and, according to our system-performance evaluations, provide enough interfaces to cause severe response delays for a full load of users. It is possible that this machine could support only two to four users in a program-development environment, if our previous experience with similar hardware applies to this machine. In fact, with only 384 bytes of memory (one advertised "complete" configuration), Xenix may even be noticeably slow with three users. However, the three-user configuration with 512 or 784K bytes of memory is clearly supported and seems to make the most sense in terms of the speed of the operating system and the memory-segmentation scheme that is implemented.

Local-Area Networking

For larger groups of users, the Arcnet board might be used to interconnect clusters of three users per Model 16B (i.e., a distributed-star network). As a user, you would have access to the 16B to which your terminal is connected and would also have read and/or write access to programs and data for which you have authorization on other 16Bs connected to the network. Typically, in other Unix systems (although there is no official indication that Radio Shack will go this way), networking means you run a program at your terminal that lets you log onto the desired remote system via the physical network facilities. You may then do work on the remote system or transport programs and data back to the system to which your terminal is directly connected. You must have a user account on each networked Unix system that you want to use. Thus, you may have several accounts on several different machines in the office, and it is possible that none of the accounts would have all of the up-to-date information you desire to use in a particular work session. This network architecture itself promotes redundant storage of data on several systems. The software for this type of network access is standard Unix fare: uucp is the Unix-to-Unix copy program (used for file transport and intersystem mail), and cu is the call-Unix program (used to establish a logical user connection over a preexisting physical connection between systems). The cu program lets you log onto the desired system as though your terminal were directly connected to that system. The cu program also allows file transport back to your actual host system. Xenix appears to have the standard Unix networking described above. This is good, but things can get much better.

In contrast, consider two alternative network architectures. The first (and by far the nicest to work on) is the virtual system. In this system, you would typically have your own powerful personal computer (e.g., a 16B) interconnected with other users' 16Bs by a local-area network (e.g., Arcnet). A program called the Network Manager would run on each active system as an invisible background task. All requests for files (i.e., programs, data, or directories) that cannot be satisfied on your system are referred to the Network Manager. The Network Manager then queries all other active systems on the network for the desired item and transports the item to your computer for execution, if that item is a program. If the item is not a program, an access link is created via the network, if you have the correct authorization. You never see all of this activity: you either get access to the file or receive an error message describing why access was

denied (file not found, file found on another file system to which access was not granted, etc.). This type of network reduces data redundancy and, more important, provides you with a transparent network-wide access interface. The Model 16B could be hooked up to this type of network if Radio Shack, Datapoint, or Microsoft creates the right network software.

In the second alternative, the 16B's Arcnet hardware could be used in a simple star network where a central network "server" consists (usually) of a central processor and disk system. Each user workstation would be a Model 16B computer having either no mass-storage system or only a floppy-disk drive. The central server is used for all fast bulk storage and may also be used to route data from one user's workstation or file system to that of another user. It is easy to make this sort of network operate like a virtual system, but such a network is usually slower and is vulnerable to faults in the server. Program execution on each of the workstations might also be slower due to the need to retrieve program or data segments from the central server's disk. The advantages of this type of local-area network are that it is low in cost, it can minimize data storage redundancy, it provides a single integrated and coordinated file system, and, finally, it has relatively good compute performance for processes that are entirely memory resident. Whatever Radio Shack decides to do with the LAN facilities it has in store for us, you can bet that it will be proprietary and will promote the sale of other Radio Shack computer products.

Xenix on the Model 16B

The Xenix implementation on the 16B is an enhancement of Unix version 7 with the addition of several extensions from the University of California, Berkeley, and from Unix System III. (For more information on the Unix operating system, see David Fiedler's three-part article, "The Unix Tutorial," appearing in the August, September, and October 1983 BYTEs. See also the several theme articles in the October 1983 issue on Unix.) The system comes in two pieces. The basic multiuser Xenix operating system and a pretty good collection of utilities comes with the purchase of a Model 16B. The Xenix Development System adds numerous utilities and C, the language in which Unix is written. C is being touted in the industry as the only way to write truly portable fast-executing code. Let it be known, however, that not all versions of C are created equal. Unfortunately, despite a clear definition of what C is and what it's supposed to do by Kernighan and Ritchie in *The C Programming Language* (reference 1), several nonstandard C compilers are available on the market today. Worse, some compilers have subtle differences in their implementations that hinder true portability—code that runs well in some environments gets sick in others. The TRS-Microsoft implementation appears to be reliable and standard. The Xenix Development System adds many useful utilities and commands including the Unix electronic-mail facilities and Unix communications. Xenix is, in comparison

to other manufacturer's offerings, a fairly complete implementation of Unix (minus the languages that come standard with real Unix) at a moderate cost. However, it is possible that Unix System V will be released to end users at a low cost and so offer significant competition to Xenix.

Xenix and Unix System Calls

The most widely distributed and used version of Unix today is version 7. Microsoft Xenix is a derivative of this version with some enhancements and is available as a single or multiuser environment. Like Unix, Xenix requires a good deal of memory (at least 256K bytes for a one-user system) and a lot of hard-disk space (we think that a 10-megabyte disk with an average access time of 95 milliseconds is the minimum practical). Both systems work better with more memory and with faster, bigger disks. Xenix supports all of the version 7 standard system calls (what a program uses to talk with the operating system), plus some extensions that improve multiuser access to the system's resources. The standard system calls (similar to CP/M's BDOS, or basic disk operating system, calls) are shown with brief explanations in table 1. The most notable extensions to Unix are in the kernel; they affect file access and signaling between tasks (called processes in Unix). Unix and Xenix are structured much like an onion; at the center is the kernel, the basic code that makes it all go. Successive layers of code add utilities, features, languages, and the user interface—called the shell. The kernel has the task of making the link between the Unix standard environment and the nitty-gritty of the machine on which the operating system is running. Thus, standard system calls can be issued from programs, and their translation into action on a particular machine is handled by the kernel. This is the key to why Unix is a highly portable system. You only have to rewrite the kernel and a few device drivers to transport the whole system to another machine, using a standard C compiler and an assembler available on the target machine. One of the primary concerns in using Unix in a commercial multiuser environment is how to achieve orderly and centrally-controlled access to disk data at the individual record level. Standard Unix does not support the types of access-permission control and concurrency control (file and record locking) required by business programs. This is one of the first areas addressed by Xenix enhancements to standard Unix.

File Access Control

The Xenix extension routine locking locks or unlocks a specific number of bytes in a file. The process that issues the lock command has read/write access to these bytes and may allow read-only access to other processes. The parameters mode and size control these actions. If the region being locked is already locked by another process, the locking routine requesting access can wait for the entire region to be unlocked or can return with an error code. A Unix/Xenix standard specification for this routine is shown here:

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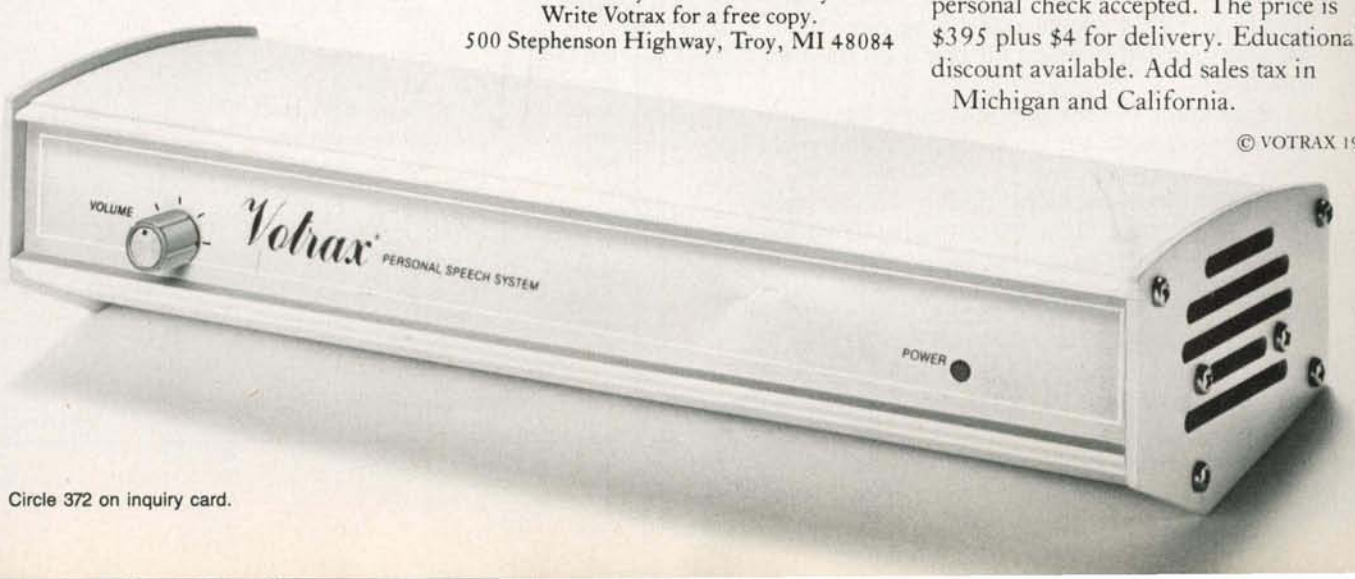


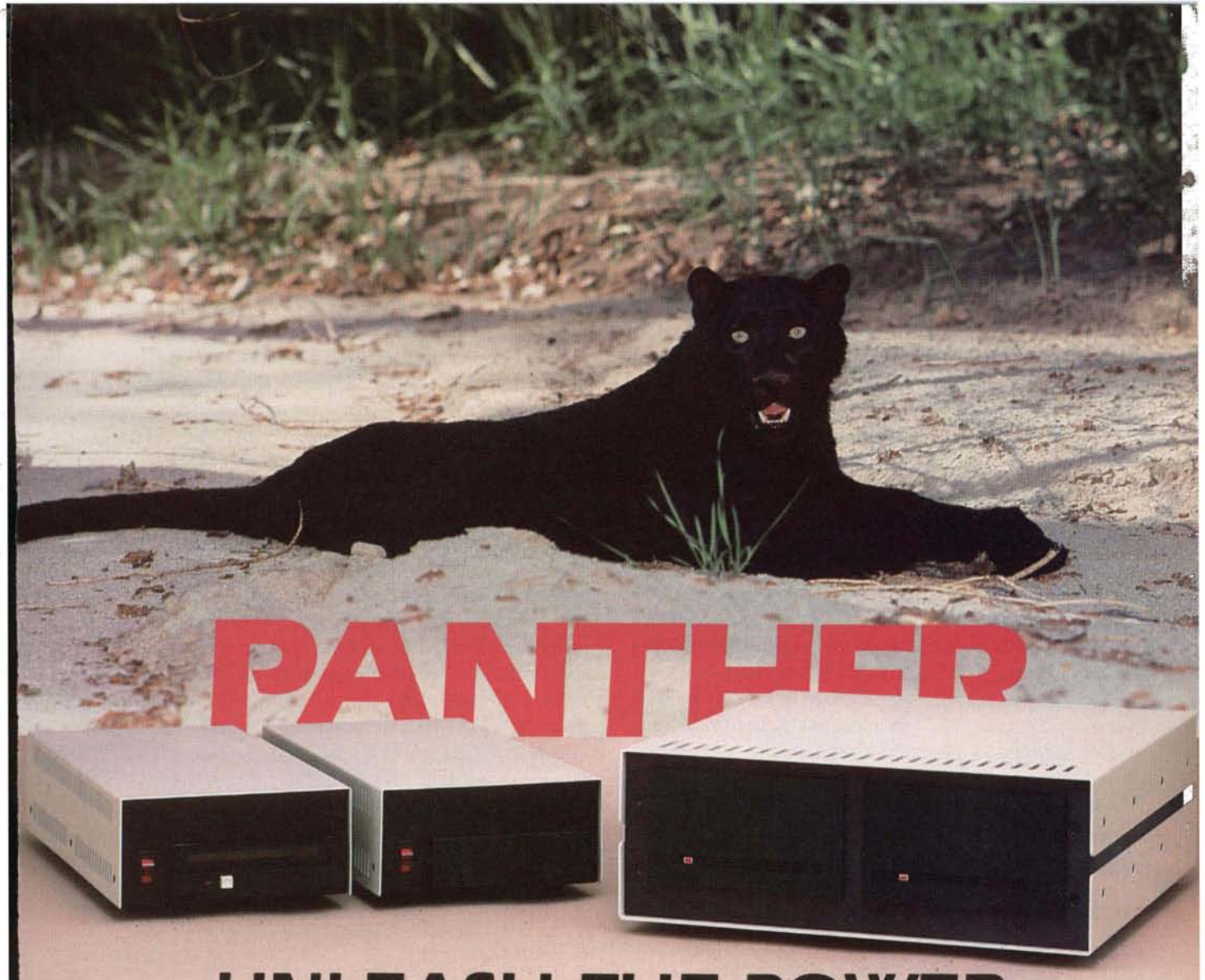
Circle 372 on inquiry card.

```
locking (fildes, mode, size)
int     fildes;
int     mode;
long    size;
```

We'll describe some of the notation as we go along, but a complete specification of the C language is contained in Kernighan and Ritchie's book on C. All Unix and Xenix documentation uses headers such as this one to specify exactly what a routine's calling sequence is.

access	determine accessibility of file
acct	turn accounting on or off
alarm	schedule signal after specified time
brk	change core allocation
chdir	change working directory
chmod	change mode of file
chown	change owner and group of a file
chrrot	change the root directory
close	close a file
creat	create a new file
dup	duplicate an open file descriptor
execl	execute a file
exit	terminate process
fork	create a new process
getgid	get group identity
getpid	get process identity
getuid	get user identity
indir	indirect system call
ioctl	control device
kill	send signal to a process
link	link to a file
lock	lock a process in primary memory
lseek	move read/write pointer
mknod	make a directory or a special file
mount	mount a file system
nice	set program priority
open	open file for reading and writing
pause	stop until signal
pipe	create an interprocess channel
profil	execution time profile
ptrace	process trace
read	read from file
setuid	set user identity
setgid	set group identity
signal	catch or ignore signals
stat	get file status
stime	set time
sync	update super block
time	get date and time
times	get process times
umask	set file creation mode mask
umount	remove a file system
unlink	remove directory entry
utime	set file times
wait	wait for process to terminate
write	write on a file

Table 1: *Standard Xenix system calls.*



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Note that the notation is terse and assumes that you understand both the nuances of the C language and how C was used to implement the function.

The parameter fildes is the file description (i.e., the unique identifier) of the file to be locked. Variables are shown in C-language-type declaration statements as either integer (int) or long integer (long).

Binary semaphores are implemented in Xenix as a special file type having a length of 0. Each semaphore has a name (sem_name) and a mode that specifies permissions. A program creates the semaphore as follows:

```
int     creatsem (sem_name, mode)
char    *sem_name;              /* a character pointer */
int     mode;
```

Execution of the integer function creatsem causes the semaphore to be reset and a unique semaphore identification number to be returned. Other processes can then open the semaphore with a routine open_sem, but access is granted only if the calling process has been given permission by the creating process. The routine wait_sem suspends the calling process until that process is signalled by the routine sigsem. More than one process may wait for a given semaphore to be set. A first-in-first-out (FIFO) queue is maintained by the system for each semaphore. A program that reads a shared file issues sigsem when it is done with the file. The sigsem call awakens the next process on the FIFO stack that is waiting to use the file. The routine nbwaitsem checks to see if the queue for a particular semaphore number is empty.

Thus, the semaphore routines provide the tools with which programmers can construct a binary signaling system between processes. The system is totally maintained by the programmer. A high degree of skill is required to use these facilities. But some such facilities are essential to the implementation of any multiuser application program on a system where one action must be completed before the initiation of the next.

Xenix also provides several convenience routines such as a "check" routine, rdchk, which looks to see whether there is any data to be read on an input stream. Programmers can use the routine to avoid annoying "hangs" on inactive input streams. The routine shutdn does all of the housekeeping necessary to shut down the Xenix system in an orderly fashion, including flushing all buffers to disk and halting the central processing unit. The consequences of a disorderly shutdown, caused by a power outage or an inadvertent flick of the power switch on the disk or the processor, are quite uncomfortable. Data and even whole files and file systems can be lost without the possibility of resurrection (unless you really know what you are doing). To reduce the impact of such improprieties, Xenix also supplies a tool that allows some of the worst effects of a damaged file system to be fixed. File-system-repair programs can replace the root file system's "super block" by passing a new super block in stdi

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a structure that contains all of the header declarations for the super block of the file system to be repaired.

The Unix File System

The Unix file system is a hierarchical, or tree, structure. Microsoft has implemented the same general structure in a recent rewrite of its operating system for the IBM Personal Computer, PC-DOS version 2.0. The root directory, /, is where everything starts. Within / are kept data files, files that contain programs, and files that are directories of other files. It also contains a directory called usr, which contains all of the user directories. Let's suppose that a user named Randy has, as his home directory, the file called randy. Randy writes a program called hello. To run that program it is only necessary to type the name of the program. What you type can be the whole name (/usr/randy/hello) or an abbreviation, depending on where you are—that is, what your current directory is. If you type cd /usr/randy, your current directory is randy and you can just type hello to execute the program. If your current directory is /usr, you must type randy/hello.

Files and file systems are held together with a glue made of pointers. Files reside in any blank space available on a disk. If the first space available is too small, the file is written partly in that space and partly in the next free space. Pointers keep track of what is where. Because directories are nothing but files, it is possible that a single bad pointer can lose hundreds or thousands of other files.

Additional problems can occur in relation to another feature of the operating system: to enhance performance, writes to disk are not necessarily done when requested by the user or calling program. This is because Unix I/O is heavily buffered in memory. When some event calls for a write, the write occurs to the buffer and the system decides whether it is time to flush the buffer to the disk. Every 30 seconds or so a housekeeping process (called a daemon) comes along and flushes the buffers so that the disk doesn't get too far out of synchronization. Not surprisingly, this daemon is called sync. Sometimes, due to a power fault, a bad memory location, or some other event, the disk and the memory buffers are left unsynchronized as the system crashes. Even the best-run and best-maintained Unix system will encounter an occasional crash or partial crash. The result is usually a somewhat damaged file system. It is up to the person responsible for system maintenance to repair the damage.

System Maintenance

Unix version 7 supports programs used for file-system maintenance, backup, and system accounting. Xenix has made a number of extensions to the system to make maintenance easier. File systems can be repaired using dcheck, icheck, ncheck, and clri. These utilities give the system maintainer a high degree of flexibility, but to be used effectively they also require a high degree of knowledge about the file system. Xenix includes a Unix System III utility fsck (file system check) to help simplify repairs to the file system.

Program	Unix Version 7	Xenix	TRSDOS
log in accounting	ac	ac*	
turn on system accounting		accton*	
prompt for correct time		asktime*	
clear i-node	clri	clri*	
directory consistency	dcheck	dcheck*	
turn off terminals		disable	
incremental system dump	dump	dump	
directory of dump tape		dumpdir	
turn on terminals		enable	
file system consistency		fsck	
quickly halt system		haltsys	
storage consistency	icheck	icheck*	
test RAM			memtest
make a file system	mkfs	mkfs	format
make a special file	mknod	mknod	
add login ID to system		mkuser	
mount file system	mount	mount	
name for i-numbers	ncheck	ncheck*	
incremental system restore	restor	restor	
remove user from system		rmuser	
system accounting	sa	sa*	
print and set dump dates		sddate*	
gracefully halt system		shutdown	
become super user	su	su	
update super block	sync	sync	
back up script		sysadminn	backup
tape archiver	tar, tp	tar	
dismount file system	umount	umount	

*Available with the optional Radio Shack Development System.

Table 2: *Unix version 7 maintenance programs.*

Backup is a key to the integrity of Unix systems. Invariably, even with expert use of the file-maintenance utilities, files are lost due either to user error or to system error (user error is far more likely). The only effective remedy is a current backup of the file that was lost. Xenix supplies a menu-driven procedure (actually a shell script) called sysadmin to help users maintain an adequate backup of the system, and sddate is used to maintain a backup history for the system.

Normal system maintenance includes authorizing new users, deleting unneeded user accounts, establishing a logical connection between new hardware (e.g., terminals) and the system, and starting and stopping the system. Xenix has made many of these chores easier. The programs mkuser and rmuser establish (make) a user account and remove one in a far easier way than Unix, where the manager must edit the /etc/passwd file. In Unix version 7 the terminals were enabled and disabled by editing the /etc/ttys file. In Xenix the programs enable and disable simplify this process. The program shutdown is used to warn other users that the manager intends to shut the system down. The haltsys program accomplishes the shutdown quickly.

Table 2 is a brief description of the maintenance programs available in Unix version 7, Xenix, and, for com-

parison, TRSDOS (an operating system that we perceive to be similar in scope—if not in structure or detail—to most of the common single-user operating systems in the microcomputer market today). Entries in tables 2 through 15 marked with an asterisk (*) in the Xenix column are available with the optional Development System from Radio Shack or Microsoft. Entries in tables 3 through 15 marked with the † symbol are from the Berkeley implementation of Unix.

Program Development

Unix version 7 supports the program-development environment with a standard set of languages (included in the operating system package): f77 (FORTRAN 77), RATFOR (Rational FORTRAN preprocessor), a rudimentary BASIC interpreter, and, of course, C, as well as a host of useful utilities such as an assembler, a debugger, and library management. Table 3a shows the program support utilities available in several operating systems. Table 3b lists the programming languages, utilities, and related programs available in Unix and Xenix. Note that language software for Xenix is available only in the Development System or as a separate package. The arcv utility converts an archive from PDP-11 format (most of Unix was originally developed on PDP-11s) to one suitable for the Motorola M68000. Another utility, ctags, is used with vi, a full-screen (visual) editor of considerable power and complicated syntax, to edit programs using more than one source file. With ranlib you can convert an archive to a randomized library that can be used with the link editor—a program that takes the output of compilers or assemblers (i.e., object programs) and puts them together to form a single runnable program (thus, a "fix" in one program module requires only short recompilation and linkage editing to have the program running again). The Berkeley extensions mkstr, strings, and xstr minimize the storage space required for strings used in C programs.

Unix/Xenix Text Processing

The Unix community has spawned a number of editors and text processing systems. Xenix makes many of the text processors and two editors available to users. The Unix line-oriented editor ed is easier to use on a printing terminal than on a screen, but it is simple and quick and, for short texts, very effective. The vi editor has a manual nearly an inch thick and is a very powerful screen-oriented character editor. Each of these editors can be used to prepare text that can be subsequently processed by one of the formatting programs. Note that what you see is *not* what you get in the system. The text-processing formatters such as nroff, troff, and neqn provide tremendous flexibility and handle chores such as typesetting, mathematical equations, tables, and reference sections. The problem is that this is a multistep process. You place formatting commands into the text during text editing. To see the effect of these commands, you submit them to the proper formatter and print the result. You then proof the output, noting typographical errors, editorial changes, and format goofs. Back to the

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(3a)

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debugger	adb	adb*	debug	ddt, save
archive/library manager	ar	ar*		
convert archive format		arcv*		
assembler	as	as*		asm
create a tags file		ctags*†		
link editor	ld	ld*		load
ordering for library	lorder	lorder*		
maintain program group	make	make*		
message file from C		mkstr*†		
print name list	nm	nm*		
octal dump	od	od*	list	dump
display profile data	prof	prof*		
size of an object file	size	size*		stat
remove object file parts	strip	strip*		
time a command	time	time*		
randomize library		ranlib*		
extract objects strings		strings*†		
extract C strings		xstr*†		

*Available with the optional Radio Shack Development System.
†From the Berkeley implementation of Unix.

(3b)

Program	Unix Version 7	Xenix
BASIC interpreter	bas	
unlimited precision	bc	bc*
C program beautifier	cb	cb*
C compiler	cc	cc*
desk calculator	dc	dc*
FORTRAN 77 compiler	f77	
lexical analyzer generator	lex	lex*
C program verifier	lint	lint*
macro processor	m4	m4*
rational FORTRAN dialect	ratfor	ratfor*
structure FORTRAN	struct	struct*
parser generator	yacc	yacc*

*Available with the optional Radio Shack Development System.

Table 3: *Support utilities of four operating systems (3a) and languages and utilities available for Unix and Xenix (3b).*

editor. The typos and changes are easy, but figuring out how to get the formatting just right is a matter of considerable effort for those of us who haven't had the foresight to get a Ph.D. in nroff. Tabel 4 shows what text utilities are available in Unix and Xenix.

File Processing

File processing was an area of considerable concern to the Unix system designers. An efficient program-development environment requires all sorts of neat ways to get at things, to see if one thing is the same as another or to sort things into some reasonable order. Xenix provides the complete Unix version 7 file-processing set and extends the set by a considerable margin. Table 5 shows the file-processing capabilities of Unix, Xenix, TRSDOS,

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and CP/M. The copy utility is a handy extension tha copies groups of files, whereas cp does so only wit some fairly arcane manipulation. A Berkeley enhance ment called more displays files a screenful at a time Members of the grep family, including look, are used to

Program	Unix Version 7	Xenix
simple text formatter	roff	
text typesetting	troff	troff*
text formatter	nroff	nroff*
typeset mathematics	eqn	eqn*
format mathematics	neqn	neqn*
format nroff/troff	tbl	tbl*
format references	refer	refer*
insert references		lookbib*
simulate typesetter	tc	tc*
greek letters print	greek	
reverse line feeds	col	col*
remove format constructs	deroff	deroff*
check eqn usage	checkeq	checkeq*
prepare for statistics		prep*
format output		sp*

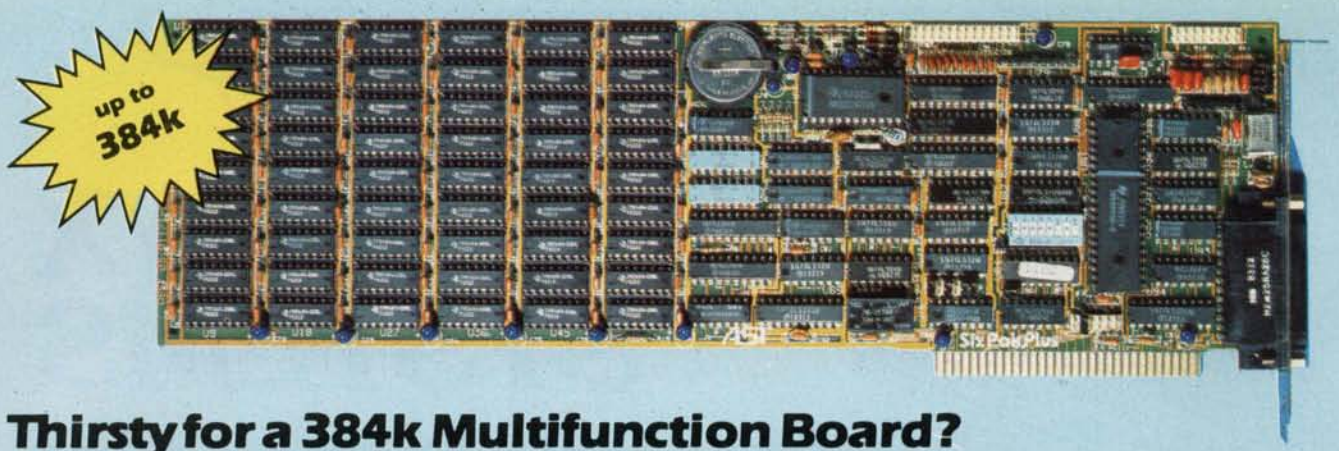
*Available with the optional Radio Shack Development System.

Table 4: *Unix and Xenix text utilities.*

Program	Unix Version 7	Xenix	TRSDOS	CP/M
pattern processing	awk	awk		
append file to file	cat	cat	append	
catenate and print	cat	cat		type
compare two files	cmp	cmp*		
choose common lines	comm	comm*		
copy groups of files		copy	move	
copy	cp	cp	copy	pip
convert and copy a file	dd	dd		
differences in two files	diff	diff		
differences in three files		diff3*		
full expression search		egrep*		
string search		fgrep		
limited expression search	grep	grep		
print beginning of file		head*†		
relational database join	join	join*		
find lines in sorted list	look	look*		
browse file		more†		
print page headings	pr	pr		
reverse lines		rev*		
stream editor	sed	sed		
sort or merge files	sort	sort		
split file	split	split*		
checksum of file	sum	sum*		
print end of file	tail	tail		
translate characters	tr	tr*		
topological sort	tsort	tsort*		
duplicate lines	uniq	uniq*		
word count	wc	wc*		

*Available with the optional Radio Shack Development System.
†From the Berkeley implementation of Unix.

Table 5: *File-processing capabilities of four operating systems.*



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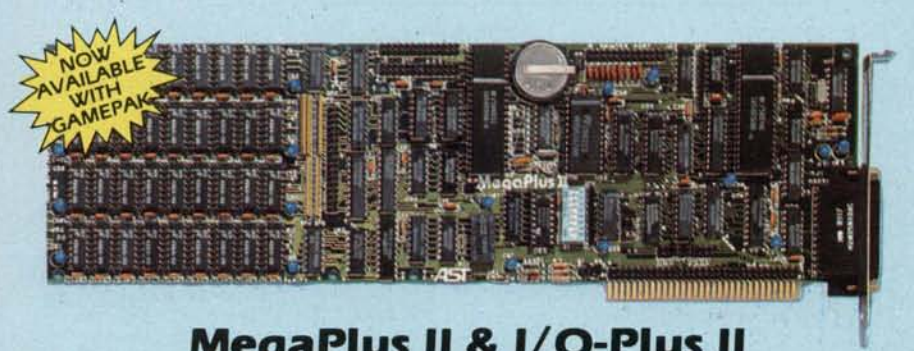

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Program	Unix Version 7	Xenix	TRSDOS	CP/M
repeat last command		!(csh)	again	
execute command at time	at	at*		
execute on log-in	.profile	.profile	auto	
create shell script	ed	ed	build	ed
schedule programs	cron	cron		
shell with C-like syntax		csh†		
echo arguments	echo	echo		
evaluate expression	expr	expr		
return false		false		
fix last command line			fc	
get string from input		gets*		
signal process	kill	kill		
run command with priority	nice	nice*		
run immune to hangups	nohup	nohup*		
return a random number		random*		
read line from terminal	read	read		
execute a shell script	sh	sh	do	submit
suspend for interval	sleep	sleep		
return true		true		
duplicate output	tee	tee*	dual	
condition command	test	test		
shell with TRSDOS syntax		tsh		
wait for completion	wait	wait		
output unit end of pipe		yes		

*Available with the optional Radio Shack Development System.
†From the Berkeley implementation of Unix.

Table 6: *Program-control interface facilities available on four operating systems.*

search files for patterns or words, and cmp, diff, and diff3 are file-content comparison programs.

Xenix Shells

The program control interface for Unix systems is implemented by a shell program. This shell is the outermost skin of the operating system onion. Xenix has three shells available. You are assigned a shell when your user account is created on the system. Changing shells is a simple matter. It is possible, but not easy, to write a whole new shell and use it instead of one of the shells provided. An easier matter is to write "shell scripts" within either the standard Bourne shell or the Berkeley C-shell. Shell scripts can help make user environments that are much easier for unsophisticated users than the standard environments. Menu interfaces, for example, can be implemented without excessive difficulty. Radio Shack has also provided tsh, which implements an emulation of the TRSDOS environment and its commands (such as dir) for users familiar with that interface and unwilling to tackle the standard Unix fare. Table 6 is a comparison of the program-control interface facilities available on Unix, Xenix, TRSDOS, and CP/M.

Communication

Unix has supported intersystems communication for some time and as a standard part of the system. Xenix has expanded the complement of communications programs available. Of particular note is uux, a program that lets you specify separate systems for program input, execution, and output. Naturally, these systems must be linked by auto-dial modems or by a local-area network. Table 7 is a comparison of utilities available within Unix version 7, Xenix, and TRSDOS.

Program	Unix Version 7	Xenix	TRSDOS
reminder service	calendar	calendar*	
call up Xenix (terminal emulation)	cu	cu*	terminal
send or receive mail	mail	mail*	
permit or deny messages	mesg	mesg*	
write to user	write	write*	
Unix-to-Unix copy (file transfer)	uucp	uucp*	host
uucp log summary		uulog*	
Unix-to-Unix execution		uux*	
write to all users	wall	wall	

*Available with the optional Radio Shack Development System.

Table 7: *Communication utilities. Note that Unix supports both communications among users on one system and communications among separate systems.*

File-Access Control

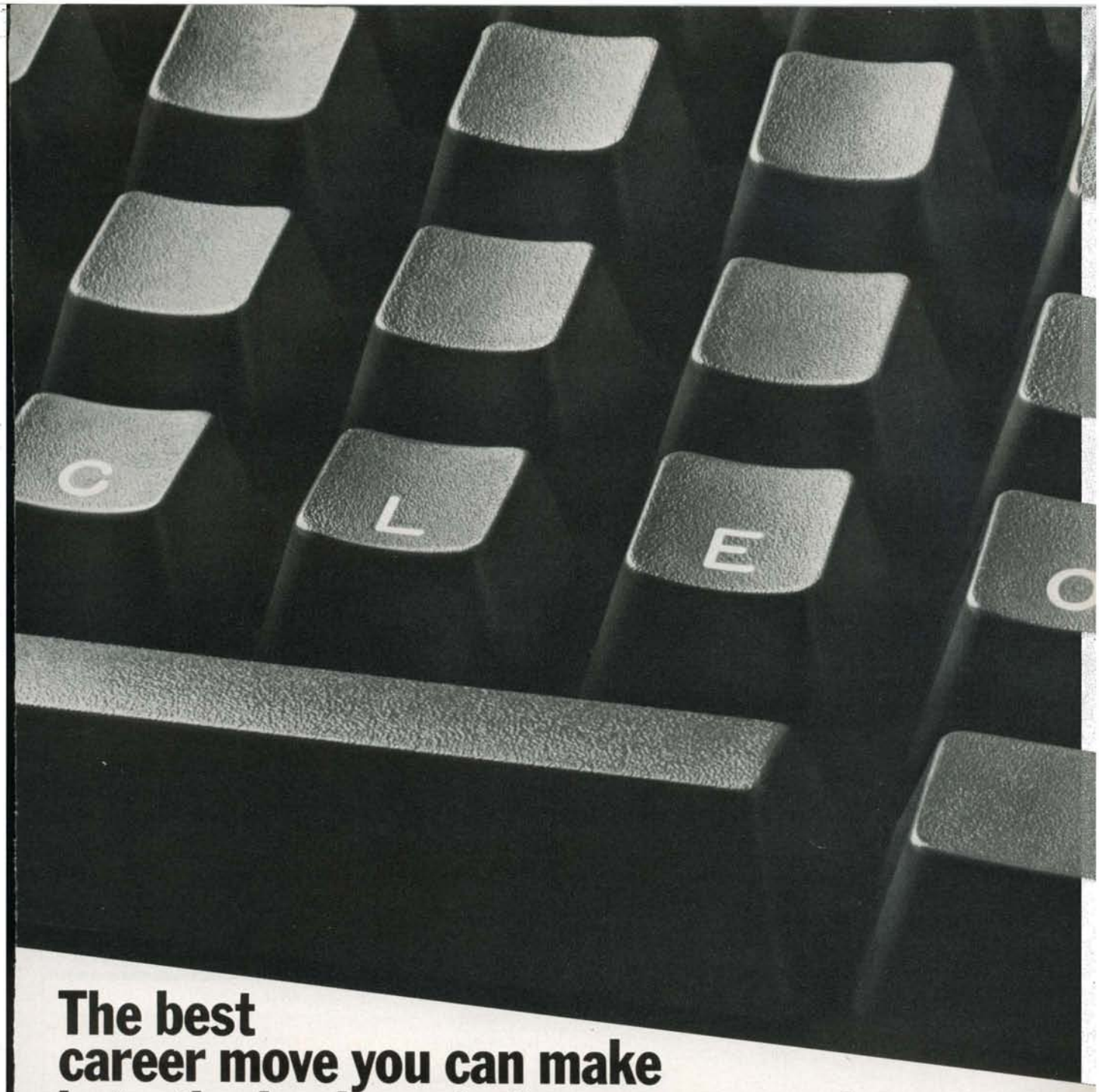
Unix files have sophisticated access controls. Each named file has an owner who, in turn, belongs to a group. The file has a set of access permissions and is marked with the date created and the date last modified.

Changing shells is a simple matter: it is possible to write a whole new shell and use it instead of one of the shells provided.

The utilities mv (move a file—the same as renaming it), chown (change owner), chmod (change mode—the same as changing access attributes), chgrp (change file group), settime, and touch are all used to change these access attributes. A directory is a special file that has special attributes and that contains references to other files. Thus, several of the listings in table 8 are directory-control functions. The utility ln (link) allows a file to appear in more than one directory under different names. Table 8 presents a comparison of Unix, Xenix, TRSDOS, and CP/M on file-access control.

Terminal Handling

Unix provides an easy method for handling nearly any terminal in a way that is (usually) transparent to users and their application programs. Settings include speed (data rate), parity, echo (i.e., full or half duplex), the characters to use for backspace and kill, and the end-of-file characters. The Berkeley enhancement tset uses the terminal-capabilities database /etc/termcap to set terminal modes. Note that in Xenix, it is impossible to set terminal



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Program	Unix Version 7	Xenix	TRSDOS	CP/M
change working directory	cd	cd		
change file group	chgrp	chgrp		
change file owner	chown	chown		
change file mode	chmod	chmod	atrib	stat
find files	find	find*		
make a link	ln	ln		
make a directory	mkdir	mkdir		
move files, directories	mv	mv	rename	ren
remove files	rm	rm	kill,purge	era
remove directories	rmdir	rmdir		
change file dates		settime*		
change modified date		touch*		

*Available with the optional Radio Shack Development System.

Table 8: *File-access control functions of four operating systems.*

Program	Unix Version 7	Xenix	TRSDOS
set key click			click
clear screen			cls
set terminal options	stty	stty	setcom
set terminal tabs	tabs	tabs*	
set terminal modes		tset†	

*Available with the optional Radio Shack Development System.
†From the Berkeley implementation of Unix.

Table 9: *Terminal commands.*

Program	Unix Version 7	Xenix	TRSDOS	CP/M
line editor	ed	ed		ed
encode/decode	crypt	crypt*		
permuted index	ptx	ptx*		
find spelling errors	spell	spell*		
non-English spelling	typo			
screen editor		vi*†		

*Available with the optional Radio Shack Development System.
†From the Berkeley implementation of Unix.

Table 10: *Text-manipulation facilities of four operating systems.*

Program	Unix Version 7	Xenix	CP/M
sign on	login	login	
log in to a new group	newgrp	newgrp	
change log-in password	passwd	passwd	user

Table 11: *Access-protection facilities.*

tab stops unless you purchase the optional Development System. See table 9 for terminal commands.

Much program development time is spent in an editor. A good editor makes program development much easier and much less error-prone. Note, however, that an editor is not a word processor. The vi editor is a very powerful screen-oriented editor that comes from the Berkeley Computer Science Labs. It relies on the termcap file to tell it how to make magic things happen, even with comparatively dumb terminals. This editor takes considerable effort to learn, but once you know it well, it allows very fast text manipulation. Table 10 compares editing text-manipulation facilities on four operating systems.

System Access

Unix was conceived as a timesharing system. Accordingly, the access-protection facilities on Unix and Xenix are far better developed than on either of the single-user operating systems shown in table 11. Users have a password that may be changed by use of the passwd command. Files are protected by user (the file owner) and by group. A user may belong to more than one group. As a safety measure, on some systems repeated unsuccessful attempts to log into a Unix system may trigger a software disable of the terminal port being accessed.

Unix has for some time had standard support for limited line and curve drawing on a number of different graphic devices. Although not very comprehensive and not nearly as user-friendly as some current commercial packages, simple graphics can be done on a basic Unix or Xenix system. Table 12 shows the three routines generally available (in the Development System for Xenix).

Unix/Xenix has a general-purpose printer spooler that works on whatever has been set up as the system's printer. In contrast, TRSDOS has several explicit and useful individual commands. These are shown in table 13.

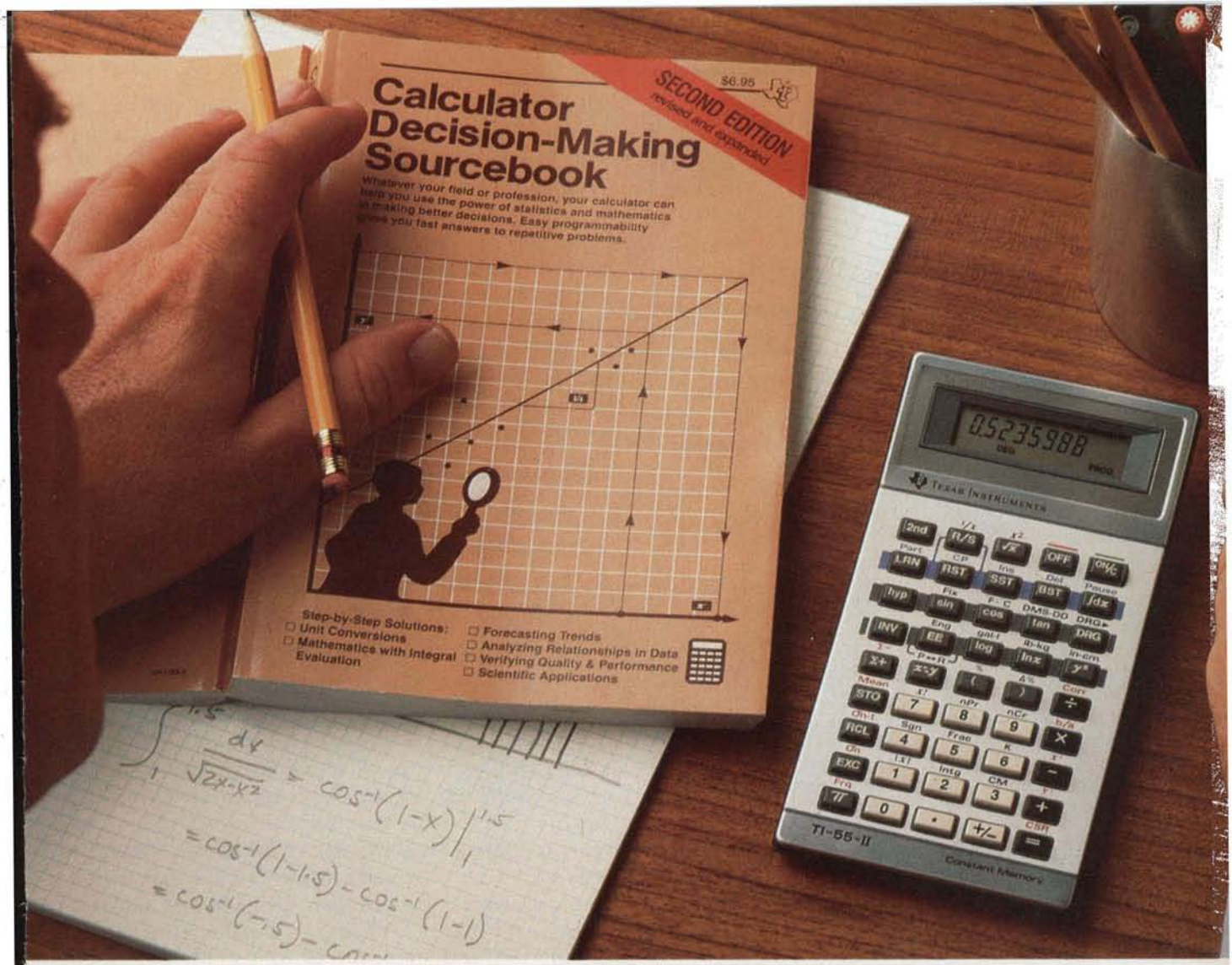
Program	Unix Version 7	Xenix
draw a graph	graph	graph*
interpolate smooth curve	spline	spline*
graphics filters	plot	plot*

*Available with the optional Radio Shack Development System.

Table 12: *Unix and Xenix graphics routines.*

Program	Unix Version 7	Xenix	TRSDOS
line-printer spooler	lpr	lpr	print
print current screen			screen
controls spooler			spool
set to top of form			t

Table 13: *Printer-handling commands.*



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Program	Unix Version 7	Xenix	TRSDOS
print calendar	cal	cal*	
CAI	learn	learn*	
system manual	man	man*	help
conversion program	units	units*	

*Available with the optional Radio Shack Development System.

Table 14: *Miscellaneous software features of Unix version 7, Xenix, and TRSDOS.*

Program	Unix Version 7	Xenix	TRSDOS	CP/M
current date and time	date	date	date, time	
disk free space	df	df	free	stat
disk usage summary	du	du		
determine file type	file	file*		
information on user		finger*†		
input/output statistics	iostat			
directory contents		l	dir	dir, stat
directory by column		lc†	files	
directory contents	ls	ls		
file system ownership	quot	quot		
print out environment		printenv*†		
process status	ps	ps		
system statistics		pstat*	status	
working directory name	pwd	pwd		
terminal name	tty	tty		
logged-in users	who	who		

*Available with the optional Radio Shack Development System.
†From the Berkeley implementation of Unix.

Table 15: *Status utilities of four operating systems.*

		Real	User	System
compile sieve	cc –O sieve.c –o sieve	33.0	5.4	5.9
execute sieve	sieve	10.0	9.0	0.2
simultaneous sieves	sieve&sieve&sieve&time sieve	38.0	9.0	0.2
compile terminal	cc –O terminal.c –o terminal	34.0	6.8	6.5
one terminal	terminal 1	16.0	0.4	7.5
two terminals	terminal 2	31.0	1.2	13.5
three terminals	terminal 3	46.0	1.9	19.7
compile disk	cc –O disk.c –o disk	36.0	6.4	6.4
one file	disk 1	5.0	2.0	0.5
two files	disk 2	8.0	3.7	1.2
four files	disk 4	13.0	7.5	2.1
eight files	disk 8	32.0	15.4	4.0
simultaneous sorts	sort f1>f1s&sort f2>f2s&sort f3>f3s&time sort f4>f4s	63.0	6.7	2.8
multifile sort	sort f1 f2 f3 f4 > sorted.file	97.0	37.9	12.8

Table 16: *Model 16B benchmark results. Entries in the Real column represent total elapsed time; entries in the User column represent time in the user process; and entries in the System column represent kernel time. Times are given in seconds.*

Miscellaneous Features

Because Unix is a fairly mature system, a lot of software has been written for it that is generally useful but hard to classify. Among the nice things available are those shown in table 14. The on-line system manual is handy for those who need access to specific manual pages fairly quickly. Note, however, that you need to know the name of the function you want to read about—you can't say, "Tell me about the utility that changes ownership of a file." The on-line computer-aided instruction (CAI) on Unix is nice, but using it tends to be a bit tedious. The conversion program for units is useful for those of us who have trouble converting from one measurement system to another in our heads.

Informal comparisons on other systems have shown the Model 16B to be about what you'd expect of a 6-MHz M68000-based machine running Unix and using the C language.

Unix and Xenix provide a number of valuable utility programs that inform you about system status and certain other data. Table 15 compares the facilities in Unix version 7, Xenix, TRSDOS, and CP/M in these areas. The finger utility from Berkeley retrieves information from your password file in a more readable format than contained in the file itself. You can list the status of processes running on the system with ps. This utility is useful in general but is especially useful to the system manager. Used in combination with the kill command, the ps utility allows the manager to free hung terminals or terminate runaway processes and unwanted processes. (Some microcomputer manufacturers don't make this feature available to their customers, claiming that their system software security scheme could be broken if it were available. However, this feature is an essential part of any Unix-style system and we applaud Microsoft and Radio Shack for making it available.) A System III utility called pstat prints out the kernel tables, which are loaded with useful information, if you know what you are doing.

TRS-80 Model 16B Performance

We subjected the Radio Shack TRS-80 Model 16B to an extensive list of performance tests. One of these tests was a compute-bound microprocessor speed test (the Sieve of Eratosthenes, used by Jim and Gary Gilbreath in "Eratosthenes Revisited: Once More through the Sieve," January 1983 BYTE, page 283), and others were designed by us for this article. We have done some informal comparisons on other systems available to us and have found the Model 16B to be about what you would expect of a 6-MHz M68000-based machine running Unix and using the C language. The Model 16B we tested had

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512K bytes of memory and the 12-megabyte hard disk. Terminal I/O was, according to Radio Shack literature, done by the second processor in the system, a 4-MHz Zilog Z80. The kernel seems to be particularly slow, especially as it attends to terminal I/O. In contrast, the kernel is rather efficient on disk I/O, but the overall system is hampered by slow hardware. Note, however, that long average disk-access times are a consequence of efforts to keep the system price down—you have to pay for the speed you get. Performance times were collected by executing the test using the Unix time command. This command monitors the time it takes to execute a process. Tabel 16 shows the results of the benchmarks in seconds. Total elapsed time ("Real"), time in the user process ("User"), and kernel time ("System" are reported individually. The Sieve program is shown in listing 1. The disk and terminal programs are shown in listings 2 and 3, respectively. The disk program is designed to provide a disk-intensive I/O load while the terminal program is designed to provide a serial-port I/O

Text continued on page 31

Listing 1: *The Sieve of Eratosthenes program used as a compute-bound microprocessor speed test on the Model 16B.*

```
#define TRUE    1
#define FALSE   0
#define SIZE    8190

char flags [SIZE + 1];

main ()
{
        int     count;
        int     i;
        int     iter;
        int     k;
        int     prime;

        printf ("10 iterations\n");
        for (iter = 1; iter <= 10; iter++)
        {
                count = 0;
                for (i = 0; i <= SIZE; i++)
                        flags [i] = TRUE;
                for (i = 0; i <= SIZE; i++)
                        if (flags [i])
                        {
                                prime = i + i + 3;
                                for (k = i + prime; k <= SIZE; k += prime)
                                        flags [k] = FALSE;
                                count++;
                        }
        }
        printf ("%d primes.\n", count);
}
```

Listing 2: *The disk benchmark program.*

```
#include <stdio.h>

FILE    *fp [8];
char    *file [] =
{
        "f1",
        "f2",
        "f3",
        "f4",
        "f5",
```

Listing 2 continued on page 31

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SuperSoft FORTRAN is the answer to the growing need for a high quality FORTRAN compiler running under CP/M-86 and IBM PC DOS. It has major advantages over other FORTRAN compilers for the 8086. For example, consider the benchmark program used to test the IBM FORTRAN in InfoWorld, p. 44, Oct. 25, 1982. (While the differential listed will not be the same for all benchmark programs, we feel it is a good indication of the quality of our compiler.) Results are as follows:

IBM FORTRAN:	38.0 Seconds
SuperSoft FORTRAN:	2.8 Seconds

"At last, a FORTRAN compiler that works great on my 8086, 8087, and 8088 and Z-80 based systems!"

In its first release SuperSoft FORTRAN offers the following outstanding features:

1. Full ANSI 66 standard FORTRAN with important extensions
2. Standard data types, double precision, varying string length, complex numbers
3. Free format input and free format string output
4. Compact object code and run time support
5. Special functions include string functions, dynamic allocation, time/date, and video access
6. Debug support: subscript checking, good runtime messages
7. Full IEEE floating point
8. Full 8087 support-available as option ($50.00).

Program developers:

SuperSoft's family of FORTRAN compilers means you can write your programs once and they will run under CP/M-80, CP/M-86, and MS DOS. This lets you get your applications running fast no matter what the environment.

The current compiler allows 64K code space and 64K data space with expansion anticipated in future releases.

SuperSoft FORTRAN: available NOW and working great!

Requires:	128K with CP/M-86 or MS DOS, 32K with CP/M-80
Price:	$425 (in each environment)

In conjunction with SuperSoft, SuperSoft FORTRAN was developed by Small Systems Services, Urbana, IL, a leader in FORTRAN development.

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Circle 342 on inquiry card.

Listing 2 continued:

```
        "f6",
        "f7",
        "f8"
};

main (argc, argv)
int     argc;
char    *argv [];
{
        int     num;
        int     x;
        int     y;

        num = *argv [1] - '0';
        for (x = 0; x < num; x++)
                fp [x] = fopen (file [x], "w");
        for (y = 500; y > 0; y--)
                for (x = 0; x < num; x++)
                        fprintf (fp [x], "%50d\n", y);
        for (x = 0; x < num; x++)
                fclose (fp [x]);
```

Listing 3: *The terminal benchmark program.*

```
#include <stdio.h>

FILE    *fp [8];
char    *dev [] =
{
        "/dev/console",
        "/dev/tty01",
        "/dev/tty02",
        "/dev/tty03",
        "/dev/tty04",
        "/dev/tty05",
        "/dev/tty06",
        "/dev/tty07"
};

main (argc, argv)
int     argc;
char    *argv [];
{
        int     num;
        int     x;
        int     y;

        num = *argv [1] - '0';
        for (x = 0; x < num; x++)
                fp [x] = fopen (dev [x], "w");
        for (y = 0; y < 500; y++)
                for (x = 0; x < num; x++)
                        fputs ("how fast are your terminals\n", fp [x]);
        for (x = 0; x < num; x++)
                fclose (fp [x]);
}
```

SuperSoft BASIC Compiler

for CP/M-86®, MS DOS, and PC DOS

Compatible with Microsoft BASIC

The SuperSoft BASIC compiler, available under CP/M-86 and MS DOS, is compatible with Microsoft* BASIC and follows the ANSI standard. If you want to compile BASIC programs under CP/M-86, PC DOS, and MS DOS, SuperSoft's BASIC compiler is the answer.

Greater accuracy with BCD math routines

If you have used other languages without BCD math, you know how disconcerting decimal round off errors can be. For example:

With IBM PC* BASIC	With SuperSoft BASIC with BCD math
10 A=.99	10 A=.99
20 PRINT A	20 PRINT A
30 END	30 END
Output: .9899999	Output: .99

As you can see, SuperSoft BASIC with BCD provides greater assurance in applications where accuracy is critical.

SuperSoft's BASIC is a true native code compiler, not an intermediate code interpreter. It is a superset of standard BASIC, supporting numerous extensions to the language. Important features include:

- Four variable types: Integer, String, and Single and Double Precision Floating Point (13 digit)
- Full PRINT USING for formatted output
- Long variable names
- Error trapping
- Matrices with up to 32 dimensions
- Boolean operators OR, AND, NOT, XOR, EQV, IMP
- Supports random and sequential disk files with a complete set of file manipulation statements
- IEEE floating point available soon as an option

In addition, SuperSoft BASIC has no run time license fee. SuperSoft's line of fine language compilers includes FORTRAN, BASIC, C, and Ada.

Requires: 128K memory
BASIC compiler: $300.00

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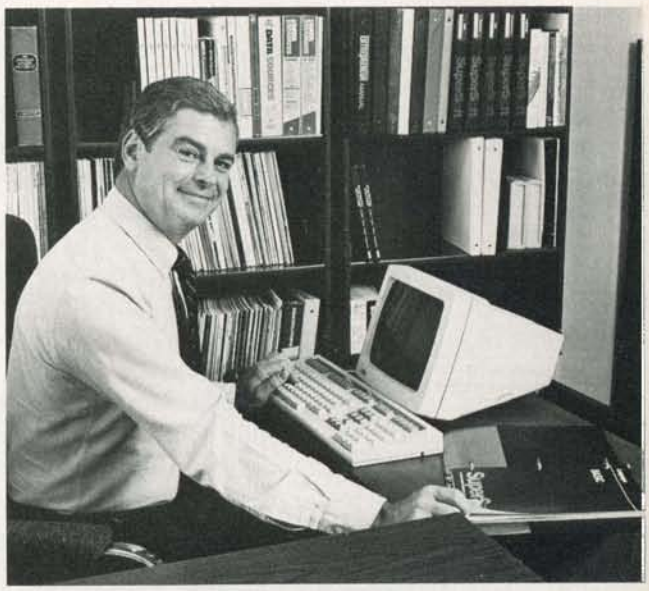

SuperSoft BASIC lets me run compiled BASIC programs under either CP/M-86 or MS DOS.

*SuperSoft BASIC is compatible with Microsoft BASIC interpreter and IBM PC BASIC. Due to version differences and inherent differences in compilers and interpreters some minor variations may be found. Machine dependent commands may not be supported. The vast majority of programs will run with no changes.

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Text continued from page 314:

load. We noted the compile times for each program and for various conditions of execution of each program. These times and conditions are shown in table 16. The Sieve was executed alone and as four background tasks, the last of which was executed under time. The terminal program used the console and either one or both of the terminal ports, each set to 9600 bps (bits per second), full duplex. The disk program wrote data to one, two, four, or eight files simultaneously. The Unix sort facility was then used to sort the resultant files under two conditions: a simultaneous sort of each file to its own destination file, and a multifile sort of each file to a single destination file. We believe these benchmarks to be a fair and accurate picture of the various activities that combine to form "system performance."

Analysis

The Radio Shack TRS-80 Model 16B is a fairly well-implemented and apparently well-supported Xenix system. Business-oriented software is available from the manufacturer, and it should be possible to get third-party "Unix-compatible" software for the machine in the near future. The machine we tested was not as reliable as we would have hoped. On several occasions, the display screen seemed to roll like a TV with a maladjusted vertical-hold control. We let the display roll for 5 to 10 minutes and the problem corrected itself on every occasion. More seriously, for unknown reasons, the 12-megabyte hard disk went down for an afternoon. After a couple of attempts to reformat the disk (23 minutes per attempt), we finally succeeded and were able to reload the operating system and development software. Everything went fine after that. This incident illustrates the three cardinal rules to be followed by all users of nonremovable hard disks: 1) back up your data and software, 2) back them up again, and 3) back them up a third time and put the media in another room.

When we opened the back of the system unit to look at the card cage, we found that one of the rivets used to attach a card-edge guide to the card cage wall had come loose, leaving the card in that slot partly unsupported. Such mechanical strain could result in premature board failure.

Despite these problems (we regard them as new-product teething pains), we thought the system was a useful and well-executed product. Radio Shack has come a long, long way from the TRS-80 Models I and III. With Radio Shack's customary attention to providing software and a wide variety of compatible peripherals, this system could become one of the more interesting offerings in its price class. It has already met and exceeded some of its competition in the area of available business software. Its only failing in addressing its target market is its use of the standard Unix shells. A turnkey business user expects a gentler user interface, such as has been provided by some of Radio Shack's competitors. We also have to

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comment on the system manuals. There are eleven of them: six for Xenix and the Development System, and five for the single-user operating systems, the assembler, and hardware owner's manuals. The manuals are long, neat, well indexed, illustrated, and index-tabbed. They are, however, rather difficult to use, especially for the intended purchasers of the machine. The documentation for the hardware and single-user software is moderately informative, but tends to brush the surface of topics that require detailed treatment. There is no clear documentation path, either. One manual says to read it first (the 16B's Operator's Manual); it deals entirely with the single-user operating systems and basic use of the machine. Although it is relatively lengthy, the Xenix documentation is only a mild improvement over standard Unix manuals. There are some custom-written sections, and the organization and indexing of the manuals is much better than for standard Unix manuals. However, we feel that naive purchasers could not use this machine without a lot of careful handholding from their dealers. We hope that Radio Shack dealers are better able to handle the complexities of Unix than are most computer retail stores today.

Conclusions

The Radio Shack TRS-80 Model 16B computer is a good competitor in the race to computerize America's small businesses. Its drawbacks for an unsophisticated user relate to the traditional Unix user interface and the lack of any real help to a novice from the large stack of manuals shipped with the system. Its advantages include good initial software offerings and the support of a very large company with many dealers and service centers. While there is certainly better executed hardware and software available in the same price category, Radio Shack has a significant potential advantage in its extensive support capabilities. It's not clear whether Radio Shack can or will invest in the educational program necessary to make sure its dealers can cope with the very sophisticated Xenix environment. The Microsoft implementation of Xenix is fairly complete and has many useful extensions to the basic Unix software set. Surprisingly, to us, the Model 16B appears to be a very good choice for people who need a small Unix development environment. Radio Shack has done a good job on this machine, and it deserves serious consideration.■

References

1. Kernighan B. W. and D. M. Ritchie. *The C Programming Language*. Englewood Cliffs, New Jersey: Prentice-Hall, 1978.
2. Weinberg, P. N. "The Multiuser UNIX Benchmark." *UNIQUE*. June 1983, pages 3–8.

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