

*Has the future of intelligent workstations arrived?
UNIX WORLD reviews this bright spot from Sun.*

The SUN-2

BY BRUCE MACKINLAY

When Bill Joy, one of the founders of Sun Microsystems, recently spoke on the future of the Unix system, he talked of bit-mapped graphics, networking, advanced word processing, and, most important, computer systems designed for people. What he said went over the heads of half the audience, and the other half shook their heads and said, "What a starry-eyed idealist!" or "Right, but what does

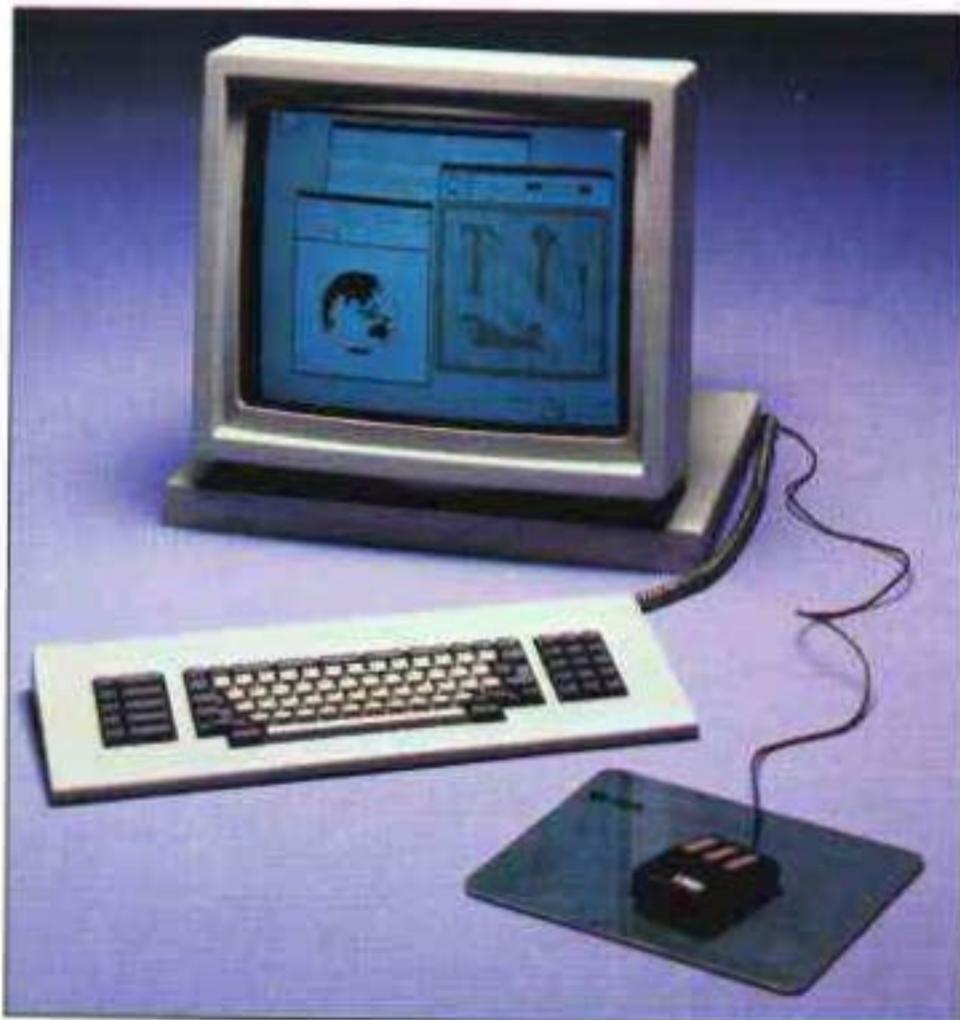
that have to do with today?"

Interleaf asked UNIX WORLD to review its software on the Sun Workstation, and I jumped at the chance to see how the Sun Workstation lives up to Bill Joy's dreams. After working with Interleaf, I chose to do separate reviews of the Sun hardware and Interleaf software.

The Sun-2 is primarily a single-user workstation, providing a sophisticated user with a powerful general-purpose environment. Sun is marketing this workstation to what it likes to call the *knowledge worker*. As I understand it, a knowledge worker is anyone who works with difficult intellectual tasks, including engineering, science, technical publishing, artificial intelligence, and all forms of research.

In the past, workers in these areas have either purchased minicomputers or used mainframes, spending \$50,000 or more per researcher. Mainframes provided the researcher with tools and number-crunching, but the price of restrictive centralized control and batch processing was too much to pay. In desperation, many researchers turned to minicomputers, which were not much more than bare computers and which provided researchers with little more than a Teletype and an assembler.

It was from these early minicomputers that the Unix system arose. The high price and the "unintelligibility" of these older sys-



Workstation

tems severely limited the number of researchers able to use them. With the new 16- and 32-bit microcomputers, a number of companies, including Sun Microsystems, Apollo, and Valid Systems, have entered this market with a vengeance, producing "low-cost" research tools.

MULTIPLE WINDOWS AND MICE

The first thing you notice when you see a Sun Workstation is the 19-inch monochrome display, containing multiple windows and a mouse. Underneath the windows is Berkeley 4.2BSD Unix, extending the machine into a local-area network of cooperating Sun Workstations, super-minis, and mainframes. Within the windows runs a wide selection of software, including some of the latest examples of leading-edge research and development.

The Sun workstation is an impressive machine from an impressive group of people. Sun Microsystems was founded in early 1982 by Vinod Khosla, Andreas Bechtolsheim, Bill Joy, and Scott McNealy. The company immediately raised \$4 million from a group of venture-capital firms and created the first Sun Workstation, which made waves in both the business and academic worlds.

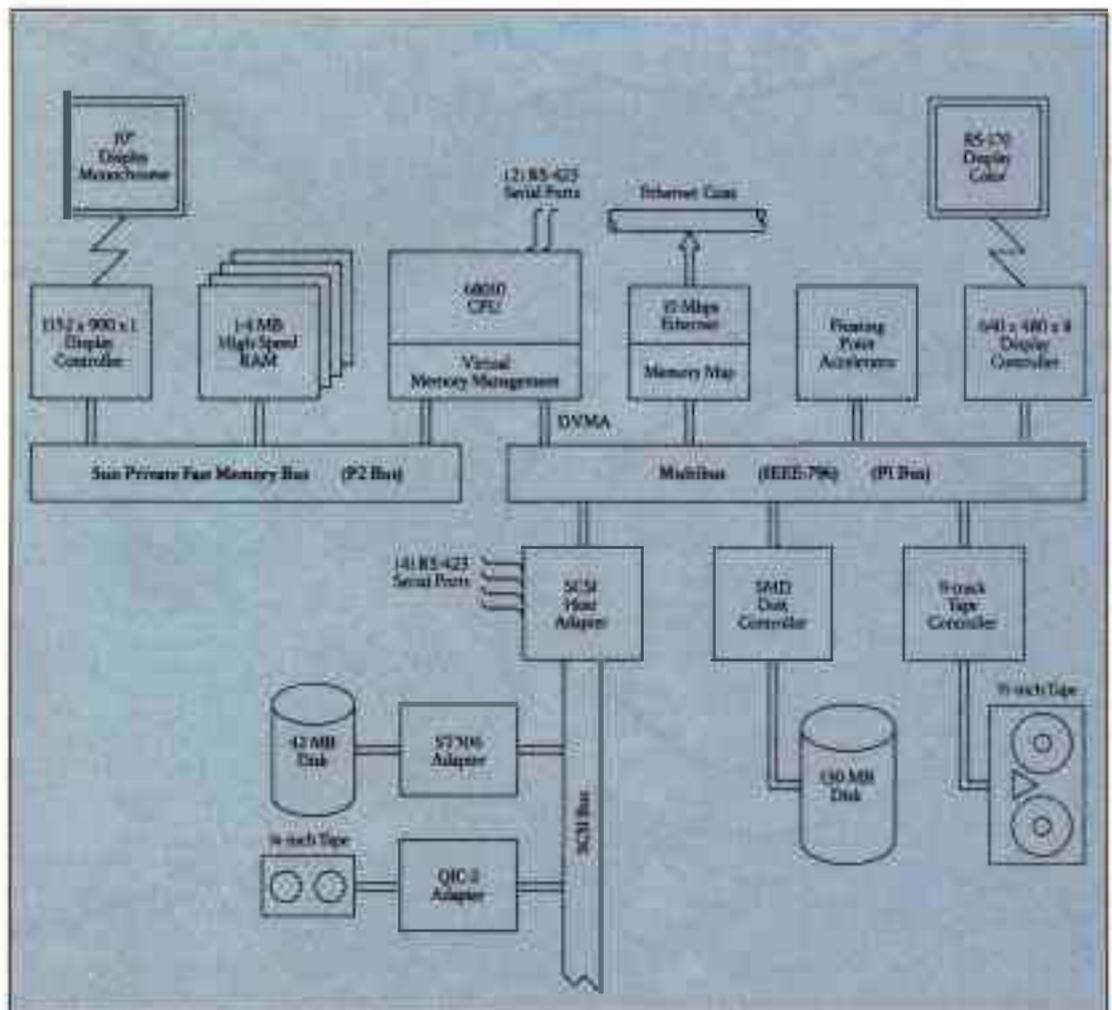
Two of the four co-founders are experienced in electrical CAD/CAM

and microcomputers and have M.B.A.'s from Stanford. The other two are Ph.D. candidates from UC Berkeley and Stanford. Stories about Bill Joy abound. The one I like best is how he personally did the first Berkeley software distribution long before DARPA realized that the Unix system could be a valuable research tool.

The Sun Workstation uses the Multibus (IEEE-796) for external peripherals and a high-speed 32-bit

proprietary bus for memory and the bit-mapped graphic display (see Figure 1). The central processor is an M68010 running at 10 MHz with a proprietary virtual memory management unit. Each workstation can support from 1 to 4 Mbytes of real memory and 16 Mbytes of virtual memory per process.

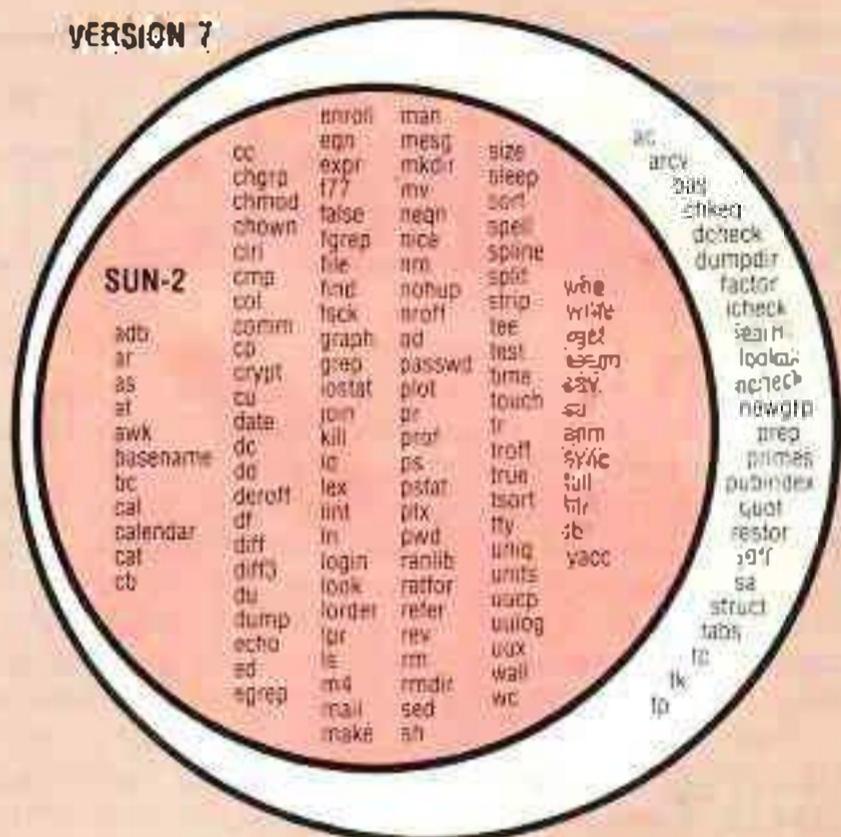
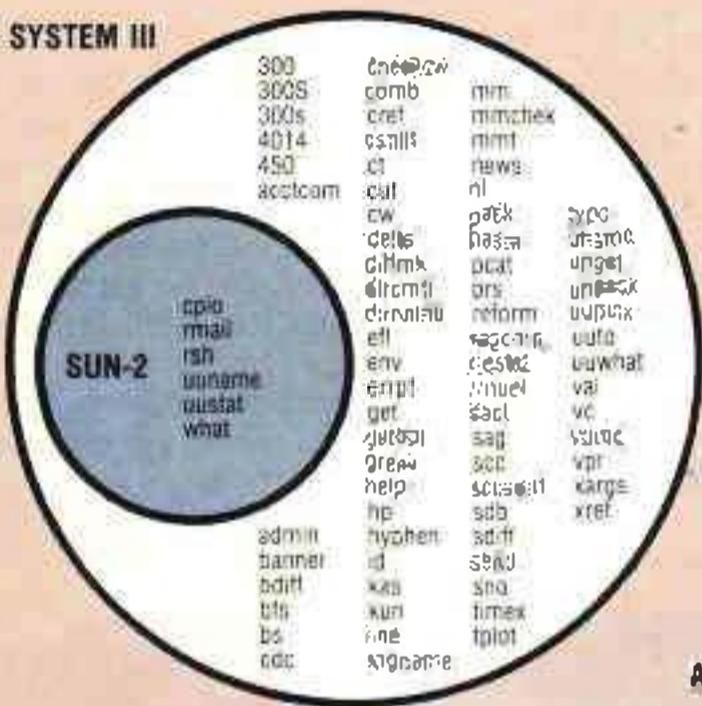
The real memory is high-speed (150-nanosecond) 64K dynamic memory chips. This allows the central processor to run at a full 10 MHz



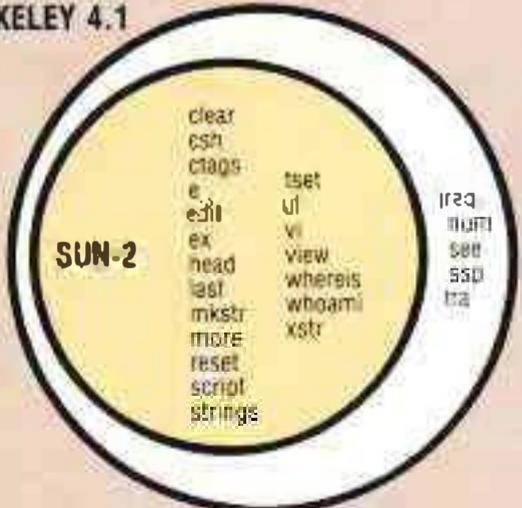
UTILITY COMMAND COMPLETENESS

VERSION 7

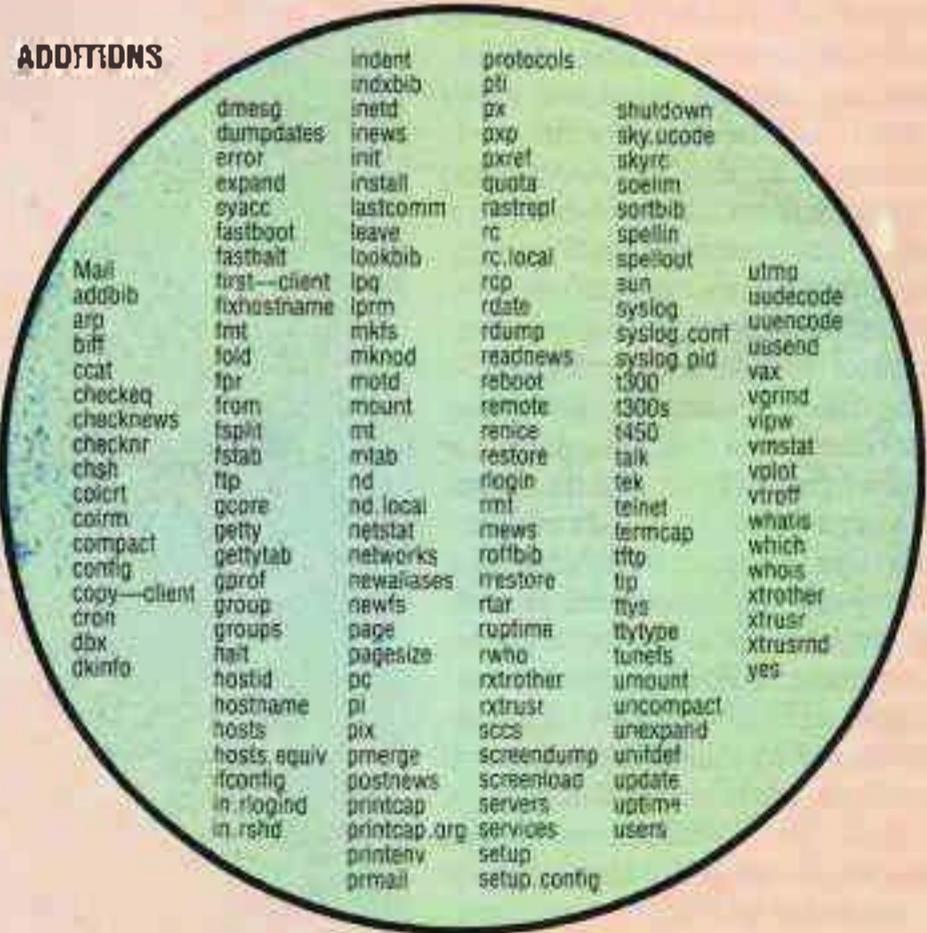
SYSTEM III



BERKELEY 4.1



ADDITIONS



with no wait states and without the complexity or expense of memory caching. The HP 200 has a 16-Kbyte cache to allow the processor to achieve the same performance (see UNIX:WORLD Vol. 1, No. 1).

The processor also supports *direct virtual memory access* so that a peripheral can access a byte anywhere in virtual memory, using the same mapping and protection as any process in the system. The virtual memory management unit uses both segment and page translation.

The Sun is faster than the Apollo in most ways, but the Apollo eats floating-point operations for breakfast.

Segment translation allows the operating system and compilers to organize memory into useful structures and shapes. Page translation improves hardware efficiency, allowing the operating system to easily page in and out virtual memory.

Berkeley 4.2BSD Unix supports these features, allowing users to write and run a program that could use a full 16-Mbyte memory on the M68010.

PERIPHERALS

The Multibus handles all input/output. Among the peripherals supported are Ethernet, an SMD hard disk, an SCSI bus adapter handling both a hard disk and 1/4-inch cartridge tape, a 9-track 1/2-inch tape drive, and a floating-point accelerator. The central processor supports two RS-423 serial lines, and the SCSI adapter supports four RS-423 serial lines. RS-423 is a new standard serial interface that is compatible with the older, slower RS-232, but it will allow the upward movement to RS-449 (which will allow serial communications at speeds

BENCHMARK MEASUREMENTS

Arithmetic Instruction Times Without Floating Point Accelerator (microseconds per op)

	Short	Long	Float	Double
*Add	2	957ns	228	127
*Multiply	23	28	294	182
/ Divide	14	32	417	311

Arithmetic Instruction Times With Floating Point Accelerator (microseconds per op)

	Short	Long	Float	Double
*Add	2	960ns	66	41
*Multiply	23	28	72	50
/ Divide	14	32	103	79

Memory Loop Access Times (nanoseconds per byte)

	Read	Write	Copy
Char type	1	2	2
Short type	575ns	924ns	815ns
Long type	414ns	671ns	645ns

Input/Output Rates (bytes/sec)

	Read	Write	Copy
Disk	233K	188K	69K
Disk-less	117K	109K	40K
Pipe			171K
TTY 1		702	
TTY 1+2		725	
RAM 1-byte			621K
RAM 4-byte			1592K

Array Subscript References (microseconds)

short[]	long[]
4	4

Function References (microseconds/ref)

0-parameters funct()	1-parameter funct(i)	2-parameters funct(i,i)
13	19	24

C Compiler Performance

1301 symbols, maximum
CPU estim: 8.5 sec + .25 lines/sec
Real estim: 1 X CPU

up to 1 million bits per second).

The RS-449 standard maximum rate is 50 times faster than that of the RS-232. There are a lot of advantages in the RS-449 interface, but the major disadvantage is the large pool of existing RS-232 terminals and computers. These serial lines can be used as terminals, with the workstation acting as a traditional supermicro. The benchmarks show that a Sun could support terminals on all six of these lines without producing unacceptable slowness; none of the benchmarks showed any evidence of thrashing.

The Sun workstation is more than just a pretty toy (like the Macintosh).

The SMD hard-disk controller can support disks in three sizes: 65 Mbyte, 130 Mbyte, and 380 Mbyte. The SCSI adaptor supports only a 12-Mbyte disk. The SCSI is slow, with an average access time of 41.3 milliseconds (ms) and a maximum data transfer rate of 5 Mbit/sec. The SMD disk is much faster, having an access time of 28.3ms and a maximum data transfer rate of 15 Mbit/sec. SMD disk controllers support very efficient direct memory access, further reducing the demands on the processor and operating system.

The Sun Workstation also supports a "disk-less mode" in which all disk I/O goes through Ethernet. We were able to benchmark a disk-less workstation, and the disk-less system showed only 10 to 20 percent reduction of performance. In fact, a disk-less system going to an SMD file server is faster than a direct SCSI hard disk.

Comparing the Sun Workstation to the Apollo, we see that the Sun is faster in most respects, but the Apollo eats floating-point operations for breakfast (see UNIXWORLD Vol. 1, No. 4). Even when the Sun is augmented with a floating-point ac-

COMPANY OVERVIEW		
Company name:	Sun Microsystems	
Public/Private:	Privately held	
In Business for:	2 years	
Headquarters:	2475 Garcia Avenue Mountain View, Calif. 94043 415/906-1300	
CEO:	Scott McNealy	
ve Marketing:	Carol Barz;	
General Sales Contact:	Joe Roebuck, vice-president sales 415/906-1300	
Gross Revenue:	This Year	Last Year
Net Income:	\$39 Million	\$9 Million
Employees:	\$2.5 Million	\$700,000
% of total expense spent on R&D:	400 plus	100
Units Shipped:	12%	12%
	1500	400
Major support centers:	Palo Alto, Calif. Lexington, Mass. Frankfurt, West Germany Plus 14 other field sales/support offices	
Major funding:	1st round -- \$4.5 million Kleiner Perkins, TOL U.S. Venture Partners, West Coast Venture Capital. 2nd round -- \$11 million Numerous institutional investors	

celerator, it does not touch the Apollo's raw floating-point speed. Sun Microsystems used the SKY floating-point accelerator. I benchmarked the Sun Workstation with and without the floating-point accelerator.

The floating-point accelerator improved floating-point operations on the Sun by as much as 400 percent, but even with these improvements, the floating-point operations on the Apollo are from 3 to 21 times faster than on the Sun. Even the

short and long operations are faster on the Apollo. Sun is faster in both memory I/O (about 2 times faster) and disk I/O (about 2 to 3 times faster), and in most other aspects the Sun outperformed the Apollo.

NETWORKING

The Sun Workstation supports TCP/IP networking over Ethernet at 10 million bits per second because it supports Unix 4.2. Unix 4.2 provides the best networking env-

ronment in the Unix world, with remote log-in, remote shells, and a whole set of remote utilities. Sun is working on the next step, the remote file system. This will allow a person to mount a remote file system onto the local file system.

This capability was planned for the Berkeley 4.2 release, but Bill Joy did not have the time to write the code. I was told that Sun has finished the code and that all that needs to be done is to integrate the code into the kernel. A number of other leading-edge computer manufacturers are rushing to produce this remote file system. AT&T plans this capability for a future Unix VI or VII. The only question now is who will produce a good, deeply integrated network file system.

I was very pleased to see the depth of integration of the network on the Sun Workstation. The laser printer I was using was on its own workstation shared by over 100 different Sun Workstations. The list of machines on the different networks at Sun world headquarters contained over 300 machines.

The other advantage of 4.2 networking is compatibility with other 4.2 machines including VAXs, the interesting new Pyramid RISC machine, and soon the IBM 3081 mainframe. When Sun finishes the remote file system, they plan to give the software to these other noncompetitive machines. Soon we will see the realization of the dream of a network of workstations and background number-crunchers.

WINDOWS AND GRAPHICS

There is more to good graphics than just a large bit-mapped display and laser printers; these are just the raw materials that good graphics are built upon. To have good graphics requires software, lots of software, much more than a low-level subroutine library. The Sun Workstation provides a lot of

HARDWARE OVERVIEW	
Model:	Sun-2/120 Workstation
Price:	\$16,900 + \$3,300 + \$3,300 + \$13,900 + \$4,000 + \$3,500
Configuration:	3 Mbyte of RAM, 130 Mbyte hard disk, black and white 900 x 1152 high-resolution XBN, mouse, Ethernet LAN, floating point
Related Models:	Sun-2/170 rack mountable
First Delivered:	1982
Processor CPU:	M68010
Cycle Time:	12.5 MHz
Bus:	New-style IEEE-796 (Multibus)
Min. Memory:	1MB DRAM
Max. Memory:	4MB DRAM
Floating Point:	IEEE co-processor.
STORAGE MEMORY	
Floppy:	none
Winchester:	13-30MB (several can be placed on one machine)
Backup:	1/4-inch cartridge tape 1/2-inch nine-track reel tape
NETWORK HARDWARE	
LAN:	Ethernet
Software:	Unix 4.2 (BSD) Suntools (windows) Remote file system Bourne, csh, suntools
Shell:	Complete
Libraries:	Complete
Utilities:	Complete
Languages:	Pascal, C, FORTRAN-77

software, and the independent software provides tools. The Interleaf Office Publishing System software provides very pretty word-processing and very advanced graphic presentation tools. Q-CALC is a spreadsheet with graphics, similar to Lotus 1-2-3.

Donald Knuth's TeX and

MetaFont typesetting allows very advanced typesetting of technical and foreign language composition. There are also a number of different CAD/CAM/CAE software systems with extensive graphics and windows. Sun provides these third-party software developers extensive tools to develop graphic and window soft-

ware. The content of these tools raises bloody debates between enthusiasts of different approaches. I have always believed that graphics tools should insulate the programmer from the messy hardware details.

The tools are fairly high level, with very few hardware details showing through. What most impressed me was the ease with which graphics designed for the large resolution display could be displayed

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on the medium-resolution color display. The window tools are also fairly high level. The drive-less workstation I reviewed had both monochrome and color displays. John Gage of Sun Microsystems demonstrated the ability to move from one display to the other as if they were one screen. He could open a window on the left screen and then move the mouse to the right and open a window in the right screen.

UTILITIES AND OTHER SOFTWARE

As you can see from the list of third-party software, the Sun workstation is more than just a pretty toy (like the Macintosh). There is a full set of 4.2 Unix utilities, including `cp`, `date`, `rdump`, `login`, `rsh`, `rnews`, `rrestore`, `rjar`, `rupdate`, and `rwho`. `rjar` was used to download the Aim benchmarks from a tape drive on a remote machine, creating files and directories on the local machine. Most of the System III commands were missing.

The only useful System III command included is `opt`. Missing

SOFTWARE OVERVIEW

Sun Microsystems has a very aggressive third-party software program, and the following software packages are currently available from Sun Microsystems:

OFFICE AUTOMATIONS

C-CALC	Electronic spreadsheet
CCA-EMACS	Full-screen editor
EMACS	Full-screen editor
Horizon	Office automation software
Interleaf	Text and graphics document
LEX	Menu-driven word processing
MISTRESS	Relational DBMS
Q-CALC	Spreadsheet with graphics
RAPID/USE	Prototype constructions
SCRIBE	Document formatter
MicroIngres	Relational DBMS and application tools
TeX82 & TeX	Technical composition and typesetting
Troll/USE	Relational DBMS
WordMARC	Word processing
XED	Document processing
XDE	Data entry and data edit facility

GENERAL ENGINEERING

MACSYMA	Computer algebra
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ELECTRICAL ENGINEERING

CADToid	Logic design system
HSPICE	Circuit simulator
REDUCE	Logic reduction
SILOS	Logic simulator

LANGUAGES AND SOFTWARE TOOLS

DYALOG APL	APL interpreter
FRANZ LISP	LISP interpreter and compiler
Lattice C	Lattice C cross-compiler for Apx86
MAINSAIL	MAINSAIL compiler
Pascal-2	Optimizing Pascal compiler
Q'Nail	Interactive programming environment
RM/COBOL	GSA-certified ANSI standard COBOL compiler
Telesoft-Ada	Partial implementation of Ada

MECHANICAL DESIGN

Amethyst	Interactive solid modeling
CatSolid	Computer-aided engineering

GENERAL GRAPHICS

Dataviews	Interactive Color Graphics Package
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Version 7 commands are unimportant, except for `dumpdir` (which has been replaced by the `-t` option of `restore`) and `learn`. I was surprised that some Berkeley 4.1 commands were missing, but the missing commands were of very little importance. I like the `see` and `nam` commands, but these are very easy to duplicate.

The list of additions includes a large number of useful commands. The Sun includes C, FORTRAN (F77), and Pascal. Third-party languages include APL, LISP (FRANZ LISP), MAINSAIL, GENIAL, REXX, DBCOL,

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and Telesoft-Ada. Sun also has an aggressive third-party software program and will extend its software base even further.

In the Sun Workstation I can see the future Bill Joy described, but much work will have to be done before we can reach this future. The system is much more integrated than its predecessors, but it is still very fragmented. Major work needs to be done connecting the Sun to other systems. The cost is still very high—I won't have a Sun Workstation on my desk for a number of years. If the price of a drive-less workstation dropped to \$5,000 or less, then we would see a real beginning of the intelligent workstation.

I don't believe that Sun Microsystems has the resources to fund the level of research and development necessary to reach this future. AT&T has the resources, but does it have the needed guts and insight. I get the feeling that AT&T is just flitting around, and IBM has too many irons in too many fires. In this class of machines, IBM has always been a follower, not a leader. Sun

ERGONOMIC EVALUATIONS		
Packaging:	Console System Box Printer Fan noise	Good, but large for desk Good, desk side Separate (Imagen laser printer) Ok, noticeable
Monochrome:	Graphics Characters Brightness Grays	Excellent Excellent Excellent Excellent
Color:	Graphics Characters Brightness Colors	Good, medium resolution Good Good Excellent
Keyboard:	Action Special Keys Weight Mouse	Good Excellent Good Excellent, optional
Mass Storage:	Hard Disk Noise Backup Tape Access	Ok, noticeable Excellent
Software:	Languages Kernel Version 7 Commands System III Berkeley Commands Additions Applications Games Debuggers	Excellent Good, 4.2BSD Ok, some missing Poor, many missing Excellent Many for network and windows Excellent, aggressive third party none adh

hopes that cooperation among a number of noncompeting companies and government researchers will forge this future.

This is why Sun is willing to license out its jewel—its remote file system—because in exchange the company would receive important research that it cannot afford to do. DARPA could change this, however, by getting back into the funding of Unix system research on a large scale. ■

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