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1988 in Review

Color Printers Compared

What's Next?

Redefining our expectations of personal computing

by Bruce F. Webster

Five years is a long time in computer development. It was about five years from the Apple II to the IBM PC, and only two more years to the Macintosh. And when you honestly look at it, the Macintosh was the last major advance in the microcomputer industry. The Amiga and the Atari ST were Mac mutants—collateral, specialized descendants, finding and occupying certain niches. The IBM PS/2 and OS/2 projects represent an effort to crossbreed species; they may prove to be evolutionary dead ends. Mac IIs and 386-based systems are the pride of the two major computer phyla, but they represent straight-line extrapolations of systems that existed five years ago. Our industry has been long overdue for a major shift.

The Next computer just might represent that advance, though only time—and the marketplace—will tell. It certainly represents an ambitious leapfrogging over the current flagship systems in the Mac and MS-DOS markets, as well as a definite challenge to workstation manufacturers. Right now, the Next machine is aimed specifically (and solely) at the higher-education market, but the potential exists for it to break out into more general distribution in a year or two. While much of the Next system is a stepwise refinement of what's already out there, several features are truly innovative, and the overall combination at the announced price—$6500—is that evolutionary leap the industry has been waiting for.

I've had a chance to watch some of the development of the Next computer over several months preceding the October product announcement. In this article I've tried to preview the product in its newly announced, not-yet-released state, from the viewpoint of a long-time Macintosh user.

One warning: many of the statements here are based on claims by Next. Some have been verified by direct observation, but since I don't have a Next machine to work on yet, and since it's not due to be generally available until the second quarter of 1989, there's always the possibility of errors and changes.

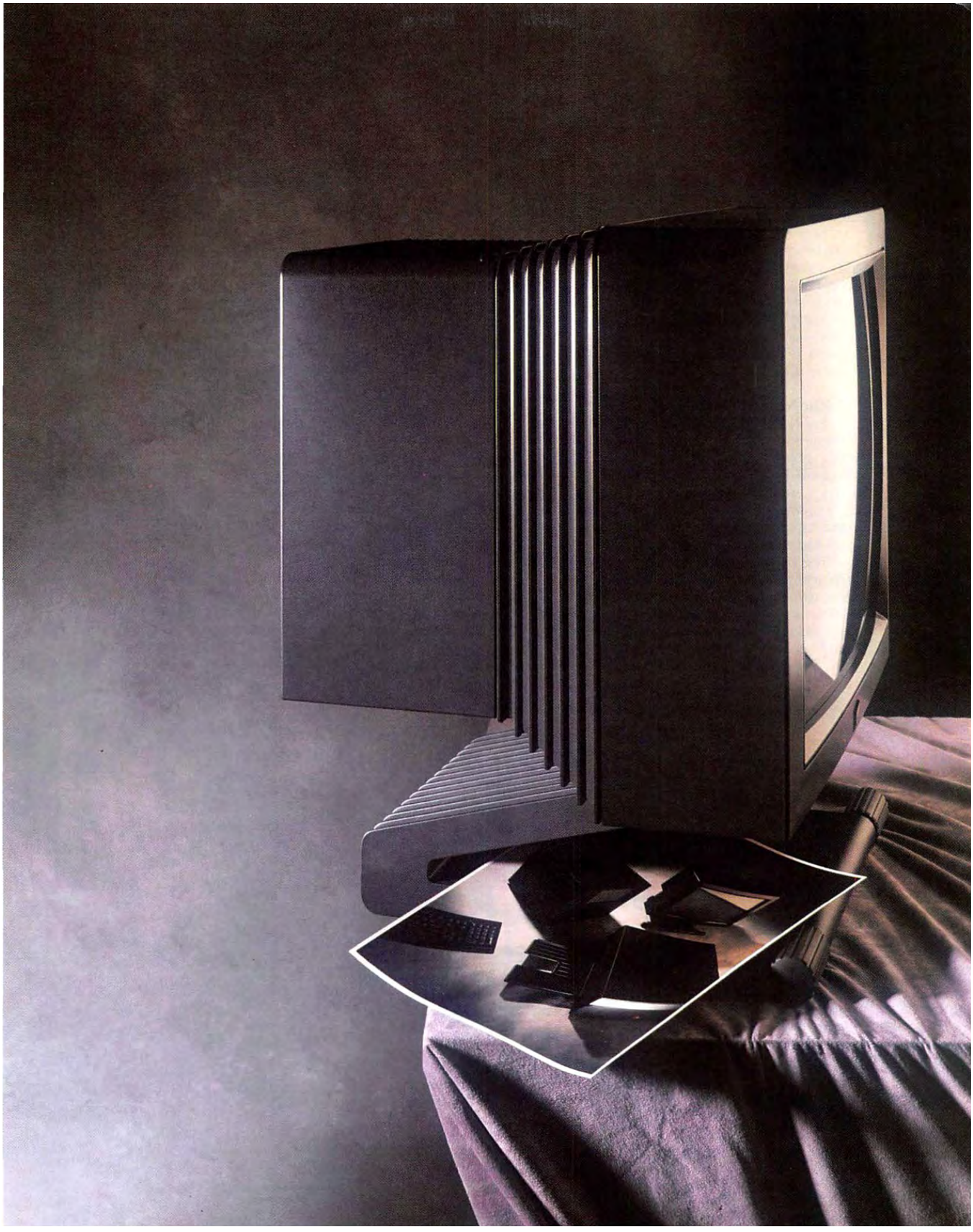
Opening the Cube

As you can see from the photos, the Next computer itself is a black cube, 12 inches on a side, designed to sit under your desk, on a bookshelf, or wherever you want to put it. The cube by itself is mostly empty space: an adaptable power supply, four slots, and space for two 5¼-inch mass storage devices. The case itself is magnesium, which is light and has good radio-frequency shielding properties.

The power supply is a 200-watt, wide-range switching power supply. You can plug it in anywhere in the world, and it automatically adapts to the local current, accepting voltage ranges from 90 v to 270 v and frequencies from 50 Hz to 60 Hz. Each expansion slot gets 25 w of power.

Bruce F. Webster, not surprisingly, is the author of The Next Book, *to be published early in 1989 by Addison-Wesley.*

PHOTOGRAPHS BY PAUL FRANZ-MOORE



The expansion slots are set up to accept 11-by-11-inch circuit boards. The connectors are standard NuBus connectors (like the ones in the Mac II) and use the same pinouts; the major difference is that the bus operates at 25 MHz, as opposed to 10 MHz in the Mac II. In other words, it's not compatible with the Mac II. To make designing for the bus easier, Next has developed a single VLSI (very large scale integration) chip to handle the bus interface and will sell these chips to third-party developers for $25 each.

The standard configuration comes with one board (the system board) and one mass storage device (the optical disk drive) in the cube. In theory, you could put multiple system boards into a single cube, not to support multiple users but to increase the processing power of a single user; however, the current system software doesn't support that yet, so it remains theoretical.

The Next Word in Displays

The Next MegaPixel Display is designed to operate at some distance from the cube. In fact, it comes with a cable 3 meters long (nearly 10 feet) that carries all signals—video, sound, keyboard and mouse input, and power—between the cube and the display. You don't need a separate power cord, and you turn the entire computer system—cube, display, and printer—on and off from the keyboard.

The 17-inch monitor is a high-resolution gray-scale screen: 1120 by 832 pixels at 94 dots per inch (dpi), with four levels of gray (two bits per pixel). The refresh rate is 68 kHz; the result is a fine, crisp, flicker-free display. The video memory itself is on the system board, separate from main memory; the video hardware is also located there. The monitor has a built-in stand that you can adjust for height and tilt angle.

The keyboard plugs into the display. It has 84 keys, including control and cursor keys. There are also (as mentioned) a power on/off key and keys for adjusting display brightness, display contrast, and volume. There are no function keys.

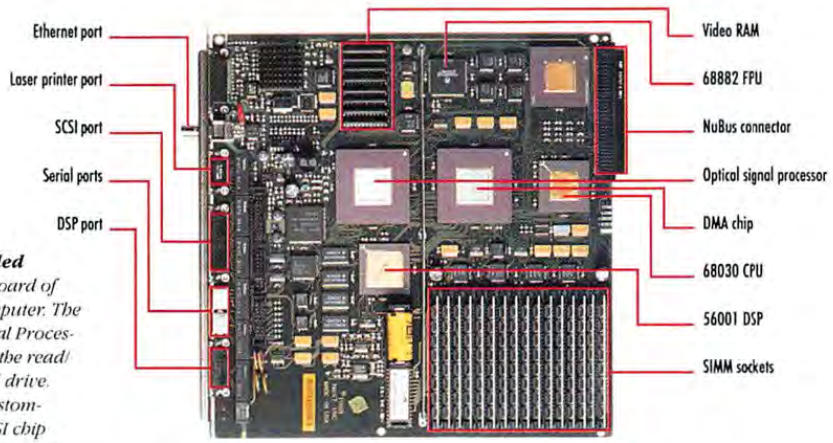
The two-button mouse plugs into the keyboard, much as on the Mac SE and Mac II. Unlike those systems, however, the Next has no desktop bus and there are no plans for other devices. While an application can use the mouse buttons as desired, the user interface works primarily with the left button and reserves the right one for a specific "move the menu here" function.

Since the video RAM and hardware are on the Next system board, you don't have the option (as you do on the Mac II) of buying a display from a third-party company. However, Next says that products will be coming out in the future that will support color and other video options. Since Steve Jobs owns a large chunk of Pixar, the computer graphics firm founded by Lucasfilm, those products could be very interesting.

A Look at the Main Board

As "Next Revealed" shows, the entire electronics of the Next computer fits on a single 11-by-11-inch circuit board. It uses a total of about 45 chips, most of which were designed at Next, and several of which use VLSI technology.

The standard system board comes with three processors: a central processing unit (CPU), a floating-point unit (FPU), and a digital signal processor (DSP). The CPU is a Motorola 68030 processor, and the FPU is a Motorola 68882 chip. These are the same two chips that are found in the Macintosh IIx; however, in the



Next Revealed
The system board of the Next computer. The Optical Signal Processor controls the read/write optical drive. The other custom-designed VLSI chip provides direct memory access to and from the communications ports, video memory, and any external devices.

Behind the Cube
The back of the Next computer, showing the power input and four slots (three of which are empty). The ports on the system board are (from top to bottom): video port (to MegaPixel Display); Ethernet connector; printer port (to 400-dpi laser printer); SCSI port; two Mac-compatible serial ports; DSP port.

Next computer they run at a clock speed of 25 MHz, as opposed to a clock speed of 16 MHz in the Mac IIx.

The DSP is a Motorola 56001, a chip designed for the math operations specific to signal processing, speech and music synthesis, array processing, and other related operations. Average execution speed is about 12.5 million instructions per second (MIPS); the DSP can perform a fast Fourier transform (FFT), an operation common to engineering and scientific applications, on 1024 points of data in 3.2 milliseconds. The DSP has within it 256 bytes of instruction memory and 1024 bytes of data memory; in addition, it has 8K of fast (zero wait state) static RAM for holding both instructions and data.

As for main memory, the system board holds up to 16 megabytes, using 1MB Single Inline Memory Modules (SIMMs). Next says that once 4MB SIMMs are available, you should be able to expand the system to 64MB. A separate section of 256K is used for video RAM.

The system board has a number of ports along the back (see "Behind the Cube"), including the following:

- the video port (to the MegaPixel Display)
- the printer port (to the laser printer)
- the SCSI port, with a Mac-compatible pinout
- two RS-422 serial ports, with Mac-compatible pinouts
- an Ethernet connector
- a special port for communicating directly with the DSP

The SCSI port, while Mac-compatible, is capable of transfer rates two and one-half times that of the Mac. The serial ports are, according to Next, identical to those found on the Mac SE. Also, the Next system board has full 32-bit Ethernet hardware built in, with complete system support for it. All you need to network two (or more) Next cubes is the appropriate cabling.

One of the drawbacks of Macintosh architecture is that the CPU has to do just about everything, especially when it comes to moving data from one location to another. The Next system alleviates that problem in large part by using 12 I/O processors, implemented in one of the two large VLSI chips on the board. These processors handle transferring data between main memory and the other system components: video RAM, DSP RAM, serial ports, the SCSI port, the printer port, the optical disk drive, and so on (see "Next Hardware Architecture"). This is known as direct memory access (DMA) and lets the CPU go on to other tasks once the transfer has been started. The result, according to Next, is that devices can be transferring data into or out of memory at full speed, and the CPU will still have some 50 percent of its processing power left over for applications.

Mass Storage Goes Optical

Perhaps the most innovative—and certainly the most controversial—feature of the Next computer is its optical disk drive. It uses magneto-optical technology and has full read/write/erase functionality. The drive stores 256MB per disk, which means a single disk holds the same amount as about 328 Macintosh floppies, at 800K each (see "256MB to Go"). And since the disks are removable, you can have as many as you want, at $50 per blank disk. Seek time is about 92 milliseconds, meaning that it takes about 1/10 second for the drive to set up to read from a given sector on the

disk. This isn't great speed; by comparison, the Mac II's internal hard disks have a seek time of 30 milliseconds. However, transfer rate between the disk and main memory is about 1MB per second, the same as in the Mac II. One of the custom I/O processors handles the disk transfer, using DMA to free up the CPU.

The second VLSI chip on the system board is the Optical Storage Processor (OSP), which acts as disk controller for the optical disk drive and also performs Reed-Solomon error correction on the fly as data is coming in from the optical drive. Again, the CPU isn't involved, which increases the overall system performance.

256MB to Go

A magneto-optical disk, capable of holding 256 MB of read-write storage. The disk itself is the same size as a compact disk and is enclosed in a self-opening plastic case, much like 3½-inch floppies.

The question that repeatedly comes up is: Why didn't Next include some sort of floppy drive?

Two reasons, mainly. First, Next is pushing a number of concepts—sound, high-resolution graphics, digital books—that require large amounts of storage. Floppy technology is advancing, but not fast enough. Winchester (hard disk) technology is also advancing, but is usually fixed in the system; if it does come out, it's rather fragile. In fact, both types of storage are susceptible to head crashes and other types of damage, while the optical disk is never touched by anything but a beam of light.

Second, Next wants students to be able to carry their "world" in a backpack. A student can be working on one Next computer, pop out the disk, go across campus, and start working again—with his or her complete set of applications, files, and system configurations—on another Next computer. Likewise, several people can share the same Next computer (albeit at different times) with complete security, since each person has his or her own disk.

The question, mostly from software developers, is: How are software publishers going to distribute their products, especially if blank optical disks cost $50 each? Whether the use of the optical drive turns out to be a brilliant move or a dumb one won't be known for some time, though a lot of people on both sides think they know the answer already. In the meantime, Next is offering internal Winchester hard disks for anyone who wants one, or for use in file servers. Two sizes are available: 330MB for $2000, and 660MB for $4000. But no floppies. Not yet, anyway.

A New Look in Laser Printers

The Next 400-dpi Laser Printer is quite a bit smaller than most laser printers, and has a short, straight paper path from the tray on the right to the tray on the left. The printer uses standard toner cartridges, can handle a wide variety of paper sizes and types, and prints at either 300 or 400 dpi. The former is Next's equivalent of draft mode; 400 dpi offers almost twice the resolution of 300 dpi (160,000 dots versus 90,000 dots).

The printer is not included in the system's $6500 price; it costs another $2000, which is still very inexpensive, given its quality and features. One reason for the low cost is that all imaging is performed within the Next cube, on the system board, as a separate process within the multitasking environment. Once the image is completed, one of the custom I/O processors blasts the bit image from main memory to the laser printer at some 5 megabits per second.

The printer is completely controlled by the Next computer. There are no lights or switches on the printer, just a power cord and a 3-meter cable connecting it with the cube. All signals, error messages, and so on, are handled through the user interface on the screen of the MegaPixel Display.

CD-Quality Sound

Sound has always been an afterthought on most computers, with only occasional exceptions like the Amiga. Even when the basic hardware is included, as with the Mac II, the software support is usually minimal, and it takes a system wizard to get anything impressive out of the machine.

Next's approach was to make high-quality sound an integral, accessible part of the machine. The hardware is certainly in place: the 56001 DSP allows the Next to perform many advanced functions, including true real-time music synthesis, and a software-assisted implementation of FAX and modem functions, reducing the hardware required for the latter two.

The sound software is there, as well. Special libraries in the Application Kit make it easier to use

sound and music in programs, alleviating the need for the program to make direct calls to the DSP. More important, sound input is supported as well as output.

The sound output from the Next computer is, literally, CD quality: 44.1 kHz sampling rate, 16-bit resolution, and stereo. Since stored digitized sound files can get very large very quickly, you can step the sampling rate down to 22.1 kHz, cutting the size of a file in half while losing only the uppermost octave (which is pretty much out of hearing range anyway).

Sound input is telephone-quality and uses an 8-bit CODEC digitizing chip, with an 8 kHz sampling rate. This means that each second of digitized sound takes up about 8K of memory or disk space. A few of the applications bundled with Next take advantage of this hardware; for example, the Mail application has an option for sending voice mail. Remember, though, that a 10-second message takes up 80K of storage.

The MegaPixel Display handles all sound input and output. A speaker is built into the display; there are also left and right gold-plated RCA line-out sockets, as well as a Walkman-type stereo headphone socket. A monaural microphone socket provides input for the CODEC chip.

The Mach Operating System

The foundation of the Next system software is Mach, an operating system developed at Carnegie-Mellon University to help UNIX make it into the '90s. Current versions of UNIX tend to be a good idea grown to disastrous proportions and somewhat out of control. Mach was, in essence, a ground-up rewrite of UNIX, aimed at current and future hardware.

The heart of Mach is its kernel, which performs only three major functions. The first is virtual memory management. This is a technique, common to mainframes, that lets each application think that it has a very large memory space in which to work. Only a portion of memory is used; the rest of the application's "memory" is on the optical disk, being swapped in and out of true memory as needed.

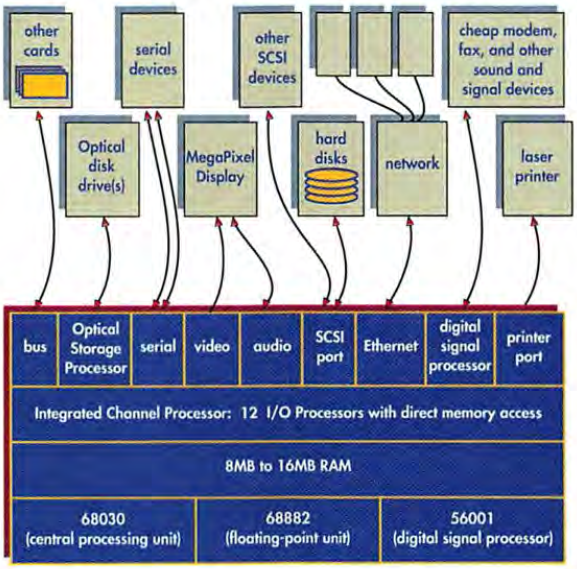
The second function is scheduling, determining which application or task is actually being executed at any given moment. Since this is a true multitasking system, Mach needs to give each task some amount of time to work, in order to maintain several applications running simultaneously.

The third function is intertask communication, which provides a clean, fast, flexible means for tasks (applications and processes within applications) to send messages to one another. This is a key feature of the entire system, and its power shows up in many places, some of which we'll see later.

Built on top of the kernel is an operating system that is completely compatible with the 4.3 BSD (Berkeley) version of UNIX and that includes a fast filing system, TCP/IP networking capabilities, and the Network File Standard (NFS) protocols licensed from Sun.

Taking the Next Step

Mindful of the struggles of Mac developers who find themselves rendering images twice—once for the screen and once for the printer—Next decided to go with a single imaging model for its system: Display



Next Hardware Architecture
The hardware architecture of the Next computer system uses 12 input/output, or channel processors, a concept used in mainframes like the venerable IBM 360. All external data from an Ethernet network, as well as the optical disk drive, SCSI hard disks, and other devices pass through the Integrated Channel Processor chip. Each channel processor has its own direct memory access path to the main memory.

PostScript. This special version of PostScript, developed jointly by Adobe Systems and Next, has been extended to support image modification (such as on a screen), compositing (merging or covering of overlapping images), and working in a multitasking environment. The breakthrough with Display PostScript is that you can use the exact same imaging commands for displaying and for printing. More important, what you see on the screen is truly what you get on the laser printer.

Wrapped around Display PostScript is a process called the Window Server. This is, in effect, the main event loop for every application in the system. The Window Server gets events from the mouse and keyboard, handles any events that it can directly, and passes the rest on to the appropriate application. The Window Server also accepts messages from applications telling it to modify the screen display, and performs any screen update handling that it can.

On top of all this is the Next user interface, called the Workspace Manager. I can't give you a lot of detail about it, since many features were not yet finalized when this article was written. However, it is a mouse/window/icon–type interface. Here are some of the highlights:

- pop-up, hierarchical, and tear-off menus, instead of a menu bar
- window controls that perform the same functions as those on a Mac, but that avoid the Mac's look and feel (too much so, in my opinion)
- an "icon dock" along the right edge of the screen for displaying the standard applications tools
- a black hole instead of a Trash Can for disposing of files
- a disk browser that enables you to quickly navigate the files and folders

Underlying all this is the Application Kit, Next's equivalent of the Mac's Toolbox. The Application Kit

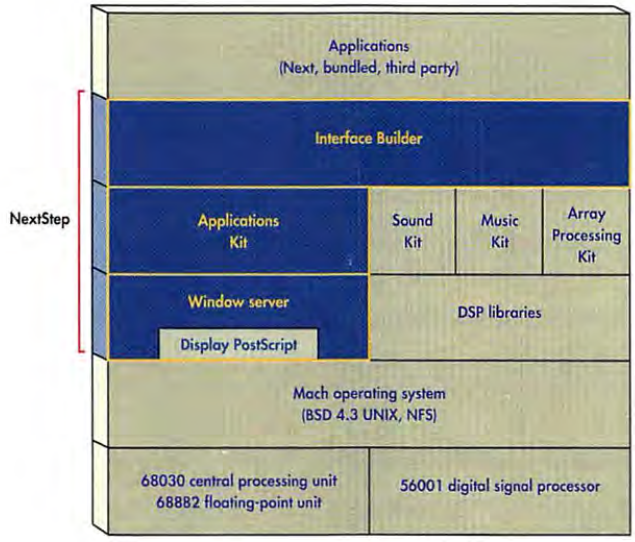
Applications for Free

"But wait—that's not all! If you order now, we'll throw in thousands of dollars' worth of software for free!" Sound familiar? Not since the introduction of the Osborne has a computer manufacturer offered this much software along with the hardware. The products being bundled include:

- Mathematica, from Wolfram Research. This product not only handles sophisticated and complex computations, it also comes (in the Next version only) with an "interactive textbook" user interface for development of mathematical courseware.
- Sybase SQL Server database management system, from Sybase. This is a complete relational database with full network support for up to five simultaneous users.
- WriteNow, the Next version of the popular entry-level word processor that runs on the Mac.
- Allegro Common LISP, from Franz, Inc. This version will provide full access to the Application Kit.
- Digital Library. This is a utility for indexing, searching, and retrieving text and graphics from online documents. Included on the Next master disk for use with Digital Library are: *Webster's Ninth New Collegiate Dictionary*, complete with pronunciation, etymology, definitions, and (in some cases) illustrations; *Webster's Collegiate Thesaurus; The Oxford Dictionary of Quotations; William Shakespeare: The Complete Works* (Oxford University Press edition); and all user manuals and technical documentation.
- Mail, a complete UNIX mail application, supporting both text and voice mail.

All those applications are not only there for each user, they can also be called by other applications, thanks to the generalized event/message handling of Mach and the Window Server. For example, WriteNow can ask Digital Library to look up and display the definition of a highlighted word. Likewise, you can have your own programs call Mathematica to perform computations (such as solutions of simultaneous equations) and then return the answer.

Several other firms, including Lotus, Frame, Cricket Software, Adobe, and Mark of the Unicorn, have announced plans for, or interest in, developing for the Next computer. The developers' introduction, held the day after the rollout, attracted a paying crowd of over 700 people; how many of those end up developing for the Next computer remains to be seen.



Next System Software

The system software resides on top of the hardware: central processing unit, floating-point processing unit, and digital signal processor. NextStep, which resides above the Mach operating system, is the portion of the Next software that IBM has licensed for its AIX systems (AIX/PS, AIX/RT, AIX/370). The DSP libraries—Sound Kit, Music Kit, and Array Processing Kit—are proprietary to the Next machine.

not only implements all the standard user interface features, such as windows, menus, buttons, and so on, but it does so in a way that greatly aids programmers, which I'll discuss shortly.

The Window Server, Interface Builder, Workspace Manager, and Application Kit together are collectively known as NextStep (see "Next System Software").

Workspace Manager

The Workspace Manager user interface. Note the icon dock along the right side, the black hole at the bottom right (for file disposal), the Directory Browser, the Digital Library application showing a definition from Webster's Ninth New Collegiate Dictionary.

Next has licensed NextStep to IBM "for use on their RISC- and Intel-based platforms," specifically the AIX-PS/2, AIX-RT, and AIX-370 systems. This greatly increases the appeal of NextStep for developers, since the market for applications developed under NextStep is going to be much larger. It also gives IBM a club to hold over Microsoft's head, which may explain why Bill Gates's response to the Next machine has been less than enthusiastic, and why Microsoft isn't developing for it, despite Steve Jobs's statement that "we'd love to have Microsoft products on our system."

Programming the Next Machine

Given the complexity of the Next system, programming it could be a real nightmare, as those who have developed programs on the Macintosh can imagine. However, after programming on the machine, I feel Next has taken an approach that tremendously simplifies and speeds the task of developing applications.

The first solution, already mentioned, is the Application Kit. It's a code library implementing a number of objects—windows, menus, controls, buttons—from which you can build an application. As you might guess, this means that the Next system uses an object-oriented programming approach.

As you develop new objects or extend old ones, you can make these part of your standard library and use them in other programs.

Programming can be done in Objective C, a full ANSI C compiler with some object-oriented extensions done via a preprocessor. This approach lets you mix normal C routines with defined (or predefined) objects, so you can use as little or as much of the Application Kit as you desire. Objective C was developed by the Stepstone Corporation; Next has included with it a source-level debugger and several other program-development utilities.

Mac–Next Price Comparison

	Mac IIx			Next		
		List price	Consortium Price (approximate)		List price	University Price
	Mac IIx A/UX Development System	$9852	$5525	**Next Computer System**	not available retail	$6500
CPU	16-MHz 68030			25-MHz 68030		
FPU	16-MHz 68882			25-MHz 68882		
DSP/sound	Apple Sound Chip			25-MHz 56001 digital signal processor		
I/O processors	none			Integrated Channel Processor (12 direct memory access I/O processors)		
Disk controller	Integrated Woz Machine disk controller			Optical Storage Processor (optical disk controller with error-correction code)		
RAM	8MB (4MB+ 4MB expansion kit)	$2399	$1675	8MB		
ROM	256K (Toolbox, Mac OS routines)			64K (diagnostics and boot code)		
Removable storage	1.44MB 3½" floppy drive			256MB 5¼" optical disk drive		
Fixed storage	three 80MB hard disks (2 external)	$4398	$2640	optional		
Serial ports	RS-422 with Mini-8 connector (2)			RS-422 with Mini-8 connector (2)		
SCSI ports	DB-25; internal			DB-25; internal		
Other ports	Apple Desktop Bus (2)			DSP, video, printer		
Sound output ports	speaker, headphone			speaker, headphone, dual line-outs		
Sound input ports	none			microphone port, 8-bit 8kHz CODEC chip		
Slots	6 slots; 4.0" × 12.9" cards			4 slots (3 available); 11" × 11" cards		
Bus	10-MHz NuBus (bipolar)			25-MHz modified NuBus (CMOS)		
Display	640 × 480 pixels, 72 dpi, 16 gray levels	$898	$625	1132 × 820 pixels, 92 dpi, 4 gray levels		
Keyboard	81 keys	$129	$90	84 keys		
Mouse	1 button			2 buttons		
Networking	Network File System; Mac II EtherTalk board	$699	$490	NFS; built-in 32-bit Ethernet with port		
Operating system	A/UX (AT&T System V compatible)			Mach (BSD 4.3 compatible)		
Imaging models	QuickDraw (screen, dot matrix printer) PostScript (laser printer)			Display PostScript (all devices)		
Libraries	Mac Toolbox			Application Kit, Music Kit, Sound Kit, and Array Processing Kit		
User interface	UNIX shell			Workspace Manager, UNIX shell		
Bundled software	HyperCard, UNIX utilities and tools			Mathematica, SYBASE SQL database, Mail, Objective C, Interface Builder, WriteNow, UNIX utilities and tools, the Digital Library		
Total price		$18,375	$11,045			$6500

To compare apples to apples, you must compare the price of the Next computer to Apple's University Consortium prices. Because the Next machine will be sold only to universities, no retail price for that machine is given. Items shown without prices are included in the system.

The back of the Mega-Pixel Display, showing (left to right): the stereo headphone output; standard RCA stereo line-out ports; connector for cable from Next computer; standard microphone input.

There's an even easier way to program, though. Interface Builder, a remarkable utility written by Jean-Marie Hullot at Next, lets you build the user interface for a program by arranging objects (such as windows, buttons, menus, and so forth) together in graphical form. It even lets you connect objects (such as sliders and buttons to fields) to one another. And once you're done, it will (at your request) generate full Objective C source code, as well as a makefile to compile it. You can then add in the main routines of the program, filling it out as needed. And as you create your own objects, you can use them within Interface Builder, too.

The combination of these three tools—the Application Kit, Objective C, and Interface Builder—significantly increases programmer productivity and reduces programming time. This isn't just according to Next. I've actually programmed using an early prototype of the development software, porting a simple version of my Go board program from the Mac to the Next, and I was amazed at how quickly and easily I brought it up. Given the current state of these tools, I know I could accomplish it in even shorter time.

Survival of the Fittest

When Apple announced the Macintosh IIx, with its 16-MHz 68030 and its $10,000 price for a system with no monitor or printer, common wisdom in the industry was that this was to preempt the impact of the Next computer. If anything, the IIx served to heighten the impact. In fact, the entire Apple price increase was a generous gift to Next; with higher DRAM prices, the base price of the Next computer had undoubtedly been pushed up from where Next wanted it.

"Mac–Next Price Comparison" shows an attempt to equip a Mac IIx to the level of a Next system, using only Apple equipment. Both list and consortium prices are given for the IIx. There are some obvious gaps—no DSP, no optical disk, no large-screen display, and most of all, no software bundled with the machine—so you can adjust the price upwards to include these items on your own. As you can see, even at consortium prices, the Mac IIx can't compete with the Next system.

As far as features go, the Next computer has it over the Mac IIx (not to mention the rest of the Mac product line) in almost every area. The one area where the Next machine falls short is in the availability of third-party software, but then the Macintosh also started with a similar handicap. On paper, the Next computer has more raw power; whether or not Mach and Display PostScript slow that down to something closer to Mac performance remains to be seen.

Steve Jobs has a good industry track record: two successes out of three attempts, with the one failure (the Lisa) spawning the greater success (the Mac). The ultimate test of the Next computer's fitness is not its personal survival, but its impact and influence on the rest of the industry—its genetic heritage, so to speak. In that regard, Jobs and the other folks at Next have already succeeded; moments after its introduction, the Next computer became the new standard against which competing systems will be compared, and it or its progeny may replace the Mac II (or its progeny) as the power user's system of choice. Whatever the outcome, the true winners will be you, the users, who will have more choices and better solutions.

As a friend once said, think of it as evolution in action. □