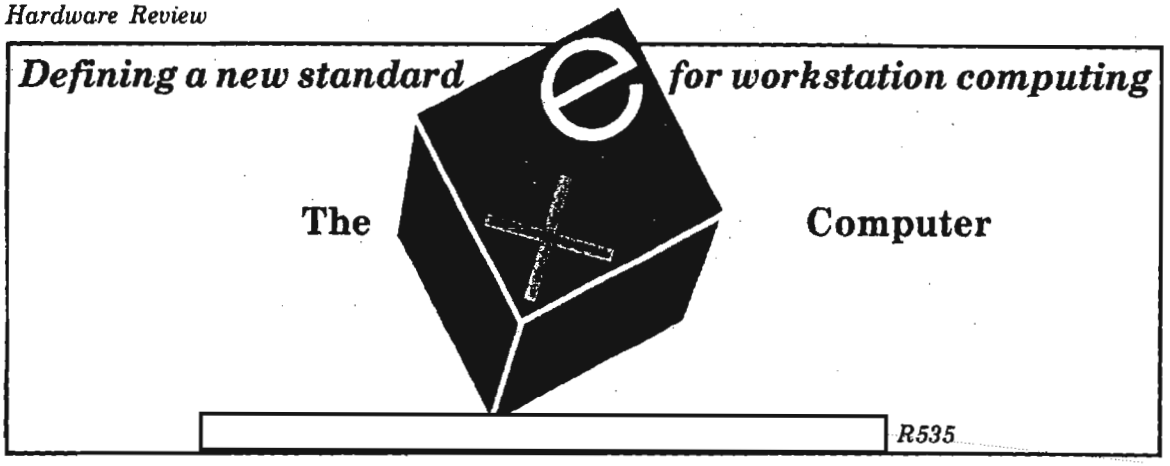
Hardware Review



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The NeXT Computer is the product of Steve Job's endeavors since leaving Apple Computer. It was designed after interviews with numerous universities and research organizations on what their needs and desires were for workstation computing. Initially it was to be offered only to educational institutions; arrangements have since been made to market it commercially through Businessland Computers.

The computer embodies new and diverse technologies which have the potential to define a new standard for high performance, low-cost, interactive workstation computing. In sum, it appears to offers a refreshing alternative to many workstation solutions which seem to stress only computational performance.

This paper discusses the important features of the NeXT Computer and will attempt to assess the impact of this technology on Agency applications. It will present the important hardware features that were designed into the architecture and how they could be exploited; it will the describe robust and dynamic software environment which appears at first glance to be superior to others currently on the market today; and finally, it will speculate on the significance of this technology for NSA computing architecture.

HARDWARE

At first glance, the NeXT Computer looks just like any other UNIX-based technical workstation. It consists of a 25 Mhz. Motorola 68030 CPU with a Motorola 68882 floating point unit, an Ethernet interface with TCP/IP and Network File System (NFS), 4-6 Megabytes of RAM memory, 32-bit NuBus system bus with 4 slots, a high resolution (1120x832), 17", 2-bit deep monochrome display, SCSI peripheral interface, 5.25 winchester disk, and keyboard with mechanical mouse. Though there are many vendors who sell systems with the same basic components, they do not offer the additional hardware features that the NeXT machine provides. These features allow for significant functionality not typically included by competitors in standard units.

MAGNETO-OPTICAL DISK DRIVE

The NeXT Computer incorporates a magneto-optical disk drive which provides a removable optical disk with up to 256 megabytes of data. This is the first instance of optical technology incorporated into the base platform of workstations. The drive is slow by comparison to winchester disk technology, 96-ms average seek time as compared to 18-ms average times for 5.25 winchester drives, but the increased capacity on a random access removable medium is very impressive. The complete operating system, very rich with bundled software is available on one optical disk. The disks are rather expensive, about $50.00 per disk, but that will probably decline as the device becomes more popular.

INTEGRATED AUDIO

It provides for high quality audio input and playback, with a built-in microphone jack that accepts a high impedance microphone signal. The microphone jack is connected to an analog-to-digital converter known as the CODEC. The CODEC converter produces 8-bit mulaw-encoded samples at a sample rate of 8 kHz. CODEC

input is roughly equivalent to telephone quality speech and is suitable for a number of sound applications such as voice mail where limiting the size of sound objects is important.

The CODEC mu-law encoding is used to save storage space required for storing sound. The mu-law encoding allows a 12-bit dynamic range to be stored in only 8-bits. The 8-bit mu-law encoded sample will yield the same amplitude resolution as a linear 12-bit sample.

The NeXT Computer also integrates a Digital Signal Processor (20 MHz Motorola DSP56001) to process high-quality stereo sound. Its primary function is to minimize system overhead while processing sound, but it can also be programmed to process any type of digital data including signal filtering or image data. The DSP can record and play back up to 44.1 kHz samples per second in both the left and right channels with 16-bit quantization. The DSP can also process 24-bit image data and is able to perform multiple arithmetic functions on data within one instruction cycle of the DSP. Applications which require real-time data capture, such as voice input, can be effectively addressed with this processor.

The types of sound format currently supported under version 0.9 of the operating system are:

16-bit Linear, mono or stereo, 22.5 kHz or 44.1 kHz
16-bit linear, mono 8 kHz
8-bit mu-law, mono 8 kHz
8-bit linear, mono 22.5 kHz
DSP load image

For sound playback, the system contains a speaker built into the NeXT monitor with left and right channel line-out jacks on the back of the monitor. Sounds are sent to both the built-in speaker and to the stereo jacks during playback.

VLSI I/O PROCESSORS

The custom VLSI processors handles I/O between the different system components. NeXT studied workstation architectures and discovered that one significant limitation was in data throughput. In most workstations the CPU is interrupted to perform I/O operations on the system bus, including network transfer and storage medium interactions. In I/O-bound applications this becomes a serious performance problem which vendors usually address by higher bandwidth busses, faster CPU clock cycles and somewhat faster I/O controllers.

While incremental gains are made it still can be a bottleneck, especially when considering signal or image processing applications. NeXT decided that a major emphasis would be to significantly improve sustained system throughput. To accomplish this within the defined architecture required two special I/O processors whose function was to offload as much I/O from the CPU as possible. These two custom VLSI chips manage the SCSI interface, the optical disk drive (including error-correction logic), the serial ports and the Ethernet transfers.

To make efficient use of these components required custom DMA hardware between the CPU board and the I/O processors. There are currently 12 DMA channels on the CPU board to facilitate I/O throughput between devices and processors. To attain designed performance rates required enhancing the RAM memory to CPU data transfer rates. The NeXT computer can perform these transfers in burst mode, twice as fast as other Motorola CPU-based systems.

ERGONOMIC FEATURES

NeXT was very conscious about the system size and ergonomic features. The system consists of a 1-foot cube, a 17" monitor and a keyboard with a mechanical mouse. The system has one power plug which takes standard 110-120V power and is sufficient to supply the complete system. There is one 10 ft. cable from the system cube to the monitor and one cable from the monitor to the keyboard. The cube to monitor cable provides power, the video signal and audio signals for speaker output and microphone input. The limited number of cables makes for quick and easy installation. The keyboard has keys to control power to the system, video display intensity (lighten and darken) and audio volume. This allows all system interaction to take place from the keyboard and for the remoting of the cube away from the desktop if that is desired.

The hardware components are very cleanly integrated into a compact yet expandable cube. Few systems available today offer the powerful

compute platform with the compact packaging that NeXT provides. The ultimate criterion will be the effectiveness of the software interface in developing applications which advantage of the unique hardware.

THE NeXT SOFTWARE ENVIRONMENT

The software environment provides an exciting first glance at the future for operating systems and the users' interaction with the system. NeXT has pushed the state of the industry by providing one of the first commercial offerings of the MACH operating system. It includes several important third party development tools and a user interface with development toolkits to assist in faster application development. The net effect is a dynamic, extensible, and robust environment which will appeal to both programmers and users.

We will discuss the software in three phases: the Mach operating system, the NextStep environment, and two of the application toolkits which are available for development.

THE MACH OPERATING SYSTEM

The Mach operating system was developed in 1986 at Carnegie Mellon University. It was originally intended as a multiprocessor operating system compatible with Berkeley 4.3 UNIX. It has received significant backing from DARPA (Defense Advanced Research Projects Agency), the major funding source for this effort. It also developed a mechanism for making extensions to UNIX without adding to the kernel. This allows for a smaller kernel base with system-specific functions executing outside the UNIX kernel. It also provides support for sharing memory between processes. This significantly improves performance when multiple processes are accessing large volumes of data. In traditional UNIX these processes would be copying data into each processs' memory space before accessing. In Mach the data is copied once into memory and copied again only when one of the processes attempts to modify it. It has been claimed that Mach outperforms UNIX by 15 to 25 percent because of these modifications.

NeXT adopted Mach for several reasons. First, Mach is based on Berkeley UNIX which is widely used in the academic and scientific research communities. This allows theNeXT Computer access to many existing applications and experienced personnel in these communities. Second, NeXT sought a smaller kernel, eliminating functionality that was not pertinent for their environment. They also preferred having the ability to extend the system without adding to the kernel, which Mach allows. Third, with the major emphasis on maximizing data throughput, the ability to share memory was extremely attractive. And finally, support for multiprocessing provides NeXT with the possibility of adding more processors to its cube (there are three unused bus slots) without having to rewrite the operating system.

Even though the emphasis is placed on Mach, the user's perception will still be that the operating system is UNIX. The many traditional methods for UNIX hackers to interact are provided, including the structure and access to the file system. When interacting with the operating system the commands behave as a Berkeley UNIX system, including the network support for remote operations. NeXT was able to take advantage of the work pioneered at Sun Microsystems with the Network File System and the Yellow Pages utilities to ease the integration into existing network environments.

NeXTStep USER ENVIRONMENT

NeXT believes that powerful user interfaces are critical for systems of the nineties. Its proprietary interface called NextStep uses Display Postscript from Adobe systems for all text and graphics written to the display. It embodies a proprietary window system NeWS, similar to the Apple Macintosh in interaction and behavior, which is currently not compatible with X-windows or any postscript-based window system.

There is a complete graphical interface to the operating system and application toolkits. Applications are invoked by double clicking with the mouse on displayed icons and window manipulation is performed with the mouse pointing to specific areas in the window. The window system supports "hiding" applications which transforms the process into an icon on the lower part of the display where it continues to execute. The application can be recalled by double clicking the icon.

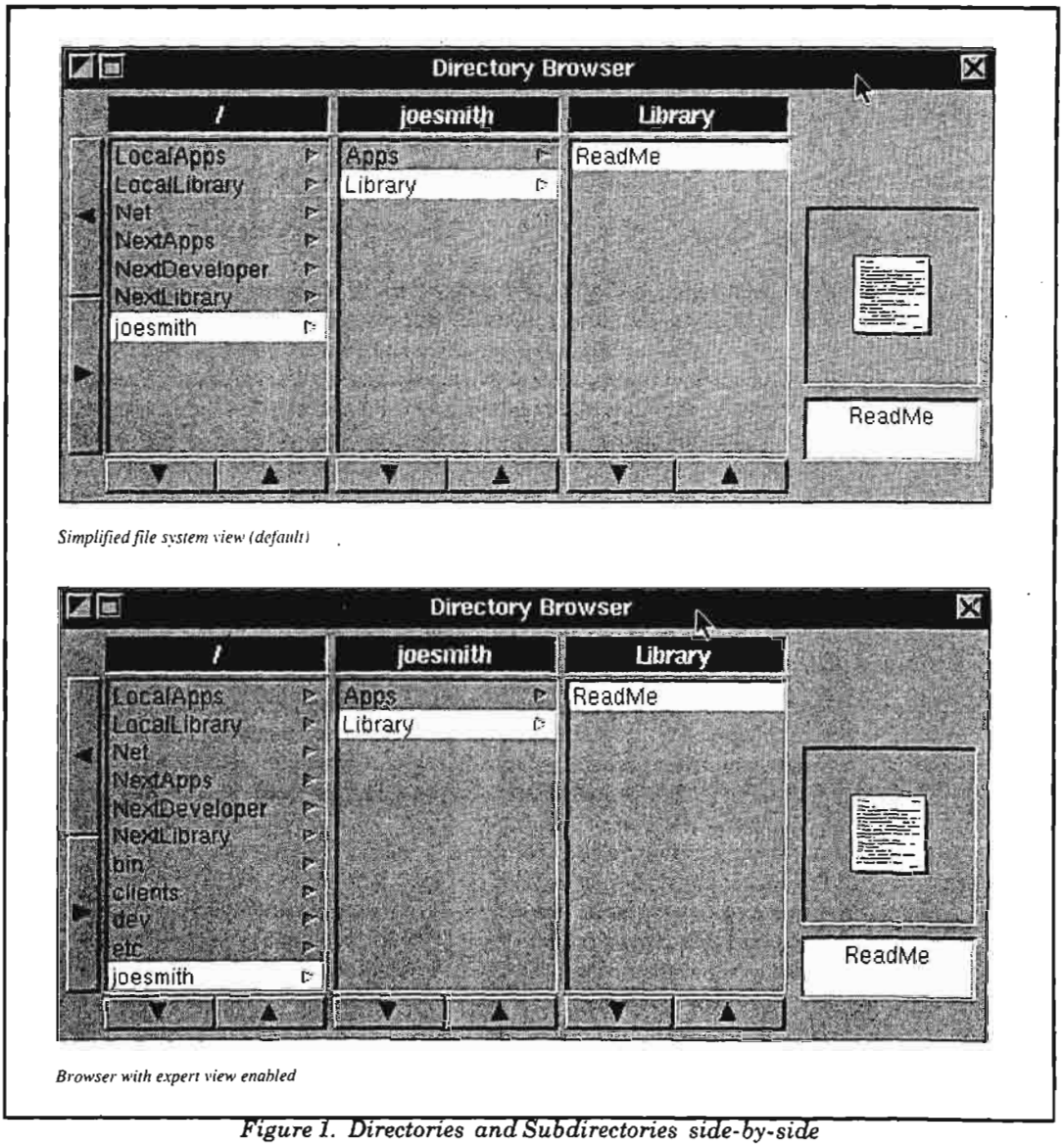

Figure 1. Directories and Subdirectories side-by-side

The NextStep environment also provides a directory browser which displays the contents of directories and subdirectories side-by-side, as shown in Figure 1. The user selects an item with the mouse; if it is a subdirectory its contents will be presented in the column to the right of the current column. A graphical icon depicting the selected item is also displayed in the area immediately to the right of the columns. A user can easily use this tool to navigate through directories looking for files.

Windows are manipulated from the border area along the top edge. There can be several different icons within the border depending on the type of window used. These icons allow for functions like window resizing, moving the entire window pane to a new area on the screen, or terminating the window. Although it is not intuitive for novice users to immediately understand how to manipulate windows, it is easy to learn and users very quickly become adept at window interaction.

The NextStep environment with release 0.9 can be customized by users using the preference tool. This tool allows for setting user preferences for such things as key repeat rates, mouse scaling, etc., through a graphical

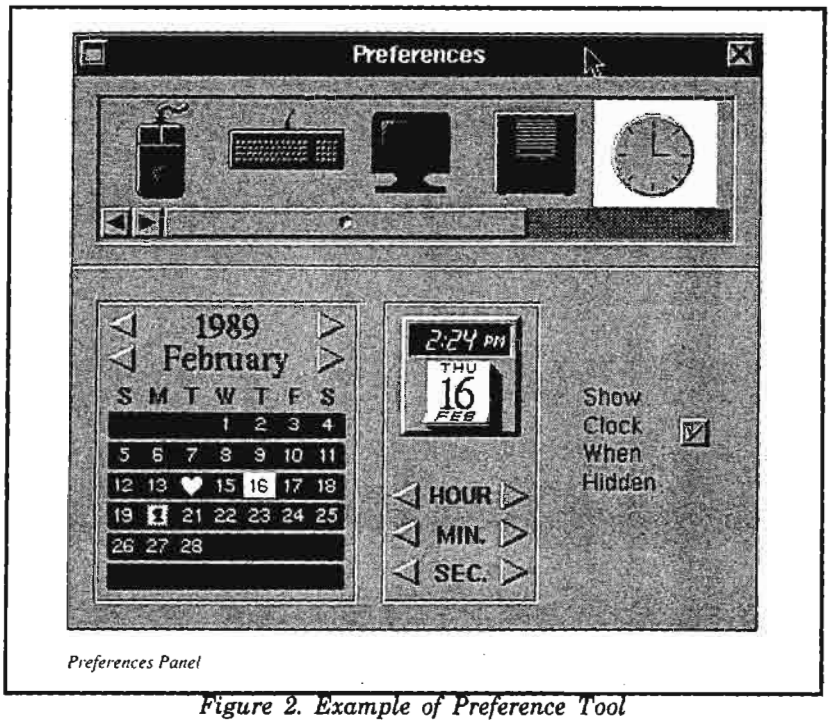

Figure 2. Example of Preference Tool

interface. Examples can be seen in Figures 2 and 3.

APPLICATION TOOLKITS

A major advantage of the NeXT software environment is the inclusion of toolkits to aid developers in building applications on the NeXT Computer. These toolkits consist of object-oriented function libraries which perform low-level object manipulation. Developers use these functions to define new objects required for the application.

This process takes advantage of the desirable features of object-oriented programming, namely extensibility and software reusability. NeXT provides an object-oriented language, Objective-C, as part of the standard environment to encourage development with object-oriented programming. Following are description of two toolkits provided.

Interface Builder

The Interface Builder on the Next machine offers a powerful easy-to-use tool for constructing user interfaces. It allows one to generate the visual component of a user interface without typing a single line of code, yet it does not limit the complexity of interfaces that can be built.

An interface designer builds the visual component of the user interface by picking a graphics object from a set of available objects, and then dragging it to the interface building workspace. Once an object is in the workspace, one can modify it in various ways. For example an object can be resized, moved, copied, cut, pasted, grouped or ungrouped with other objects. Grouped objects can all be set to the same size and can be moved together as a single block. Tools are provided for aligning objects in rows, columns or matrices.

The interface designer selects graphics objects for the interface either from a set of defined objects or by creating a new graphics object. A system for creating and adding new graphical objects is provided, although the method is neither defined nor documented well. Examples of available graphics objects are: buttons, slide bars, text areas, boxes, switches, fields, windows, and panels. A pop-up menu can also be included in a user interface.

The Interface Builder also allows one to associate a sound or an icon with most graphics objects. This can be done by dragging the

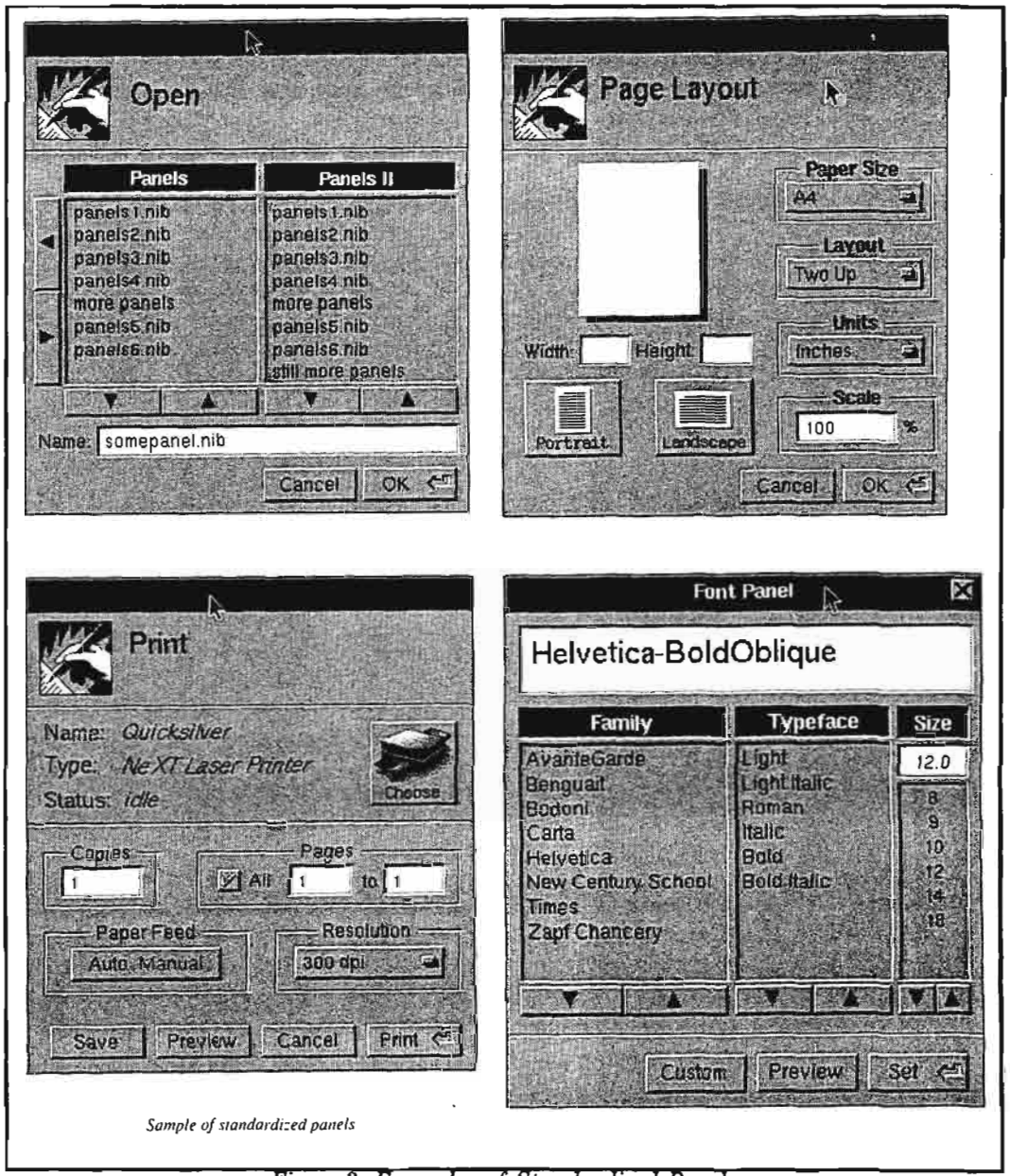

Figure 3. Examples of Standardized Panels

sound or icon object onto the top of the target object. The system comes with a set of predefined sounds and icons which can be customized.

Once an interface has been built, it can be easily tested without the associated application. This allows one to work on the user interface without worrying about the actual application. A programmer and an end user can work together on the user interface for a project. They can completely build and test an interface before formally designing and coding the application. A complex user interface can be built in about five to ten minutes.

Graphical tools are provided for connecting an interface to an application. A programmer specifies how the interface and application components are associated. Then the Interface Builder uses this information to generate header and Objective-C codefiles. These files may be manipulated as the application is debugged. This toolkit (as well as others) automatically generate UNIX "make" files to allow for easy compilation of the finished product. This is

extremely useful for developers as they maintain and rebuild software during the development process.

Sound Toolkit

The Sound Kit for analyzing and manipulating acoustical data consists of two Objective-C classes (Sound and SoundView) and a wide array of C functions to allow software developers to access the NeXT sound facilities with a minimum of effort. The Sound Kit software manages the details of OS communication, data access, and data buffering that are required during recording and playing sounds.

The Sound Kit provides the software developer with full access to the digitized samples of a sound object. Using the C functions provided, simple programs can be written to alter the pitch of a sound or change the playback speed of a sound. In addition, sounds can be played backwards, looped end-to-end, or divided into segments and reassembled in a different order. There are even software tools provided to digitally splice and mix together different sound objects.

The Sound class provides the facilities to create and manipulate sound objects. Sound objects are manipulated by sending messages to them. For example, the following lines of code are all that is necessary to create and record 5 seconds of sound:

```
/*  Create  a  new  sound  */
    id  mysound  =  [Sound  new];
    /*  Record  a  sound  */
    [mysound  record];
    /*  wait  5  seconds  */
    sleep(5);
    /*  Stop  recording  */
    [mysound  stop];
```

There are routines to record and play back a sound, as well as to read and write sound files. Facilities are also available for basic editing operations, such as deleting a portion of a sound or inserting part of one sound into another.

The SoundView class is provided to display sound objects in a predefined Soundview window. (Soundview windows can be built using the Interface Builder). Using the SoundView class, sound objects can be displayed as continuous waveforms, such as you would see on an oscilloscope, or as an outline of its maximum and minimum amplitudes. There are also methods provided for scrolling and zooming in and out of a displayed sound object, and selecting portions of a sound with the mouse.

Other Toolkits

Those are just two examples of the powerful toolkits which are available to developers with the NeXT Computer. Others provided are the text search toolkit which allows large bodies of text to be keyword indexed, searched or scanned for pattern matches; the Music Kit which allows for the generation and manipulation of synthesized music: the Application Kit to aid in object-oriented software development; and database management software (Sybase) which provides the tools to build and access relational databases.

CONCLUSIONS

The NeXT Computer has the potential to make significant advances in workstation computing within the Agency. It offers the most sophisticated integration of hardware and the most advanced software environments, all of which are included in the delivered system, in the smallest, cleanest packaging available today. Many of the important tools will be available on final operating system completion. Version 1.0 is expected about mid-summer.

How do we assess this technology? The general feeling of the programmers in R535 who have used the NeXT Computer is very positive. There is an extensive library of robust applications. We believe that rebuilding the prototypes developed on Suns and Apollos would be easier to do and functionally richer because we would begin building the application at a higher level. But to take advantage of these functionally rich libraries probably requires that applications be developed in Objective-C. This may be a problem for those without experience programming with object-oriented languages, though it is easy to learn in the NeXt step environment. A second potential problem might be performance-related if the application is not designed with object-oriented principles. The NeXT software environment continues to evolve, and with that evolution comes changes to the system. Applications being developed with the current 0.9 software release will not be object-code compatible with software release 1.0.

Software releases after 1.0 are supposed to be object-code compatible with applications developed at the 1.0 release. Developers should be aware of that if developing at 0.9.

R535 believes the NeXT Computer is appropriate for many types of applications at the Agency. It clearly competes with Apollo and Sun workstations for applications that do not require color displays. The tools for managing and searching large volumes of text, powerful database support and graphical tools for analysis make it appropriate for most analytic and reporting functions. The DSP processor and audio capabilities with the processing power available make it ideal for signals processing and transcription operations. The numerous tools for the software developer, including automatic generation of "make" files, make it appropriate for software development and maintenance. The unique capabilities it offers allows for innovative concepts and ideas to be explored from the research perspective. For these reasons, the real usefulness of the NeXT Computer has yet to be discovered. Interest in the Agency is growing. In the near future we will have a much better idea of how effective these machines can be within the Agency computing architecture.

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BULLETIN BOARD

WISE NATIONAL CONFERENCE

The Interagency Committee for Women in Science and Engineering will hold its ninth annual National Training Conference Monday through Thursday, 26-29 March 1990 at the Westpark Hotel, Rosslyn, Virginia. This is an excellent opportunity to meet mathematicians, scientists and engineers in other government agencies, to network with them, and to gain some perspective. A highlight of the conference is an exhibit of science projects developed by 9th and 10th grade female students for science fairs held at their schools. These students represent the future. NSA women should encourage them to pursue careers in math, science, and engineering by taking the time to view their projects and yes, even, recruiting!

Concurrent workshops will be held Monday through Wednesday and a science tour is scheduled for Thursday morning. Cost for the full conference, which includes three luncheons and an evening reception, is $275. One-day fee is $135, and two-day fee is $150; both include all events of the day.

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For further information please call or write [redacted] Federal Women's Program Manager, D8, OPS 2B, 963-1103, or your local FWP representative.

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