NeXT and Open Systems Standards

CORPORATE*SALES*

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Standards have become the watchword of the corporate technology manager. And rightly so, because multivendor computing is now the rule. To survive, a computer company must ensure that its products connect and communicate easily with other equipment. With this in mind, *NeXT focuses on adherence to industry standards and multivendor connectivity.* From the start, we built the philosophy of compatibility into all of our products. And we had an advantage. Since the NeXT™ Computer was designed more recently than the products of other major competitors, we saw what standards were actually accepted and which ones truly provided user value. We then incorporated these accepted technologies into NeXT systems. Our view is simple:

- Use standards whenever possible.
- Invent new technologies when users are dissatisfied with current industry offerings.
- Make our new technologies coexist in a heterogeneous world.

This document builds a structured model of where key industry standards are required and discusses where they are incorporated into all NeXT systems. We'll begin with the operating system, the subject of unrelenting UNIX® wars between groups like the Open Software Foundation (OSF) and UNIX International (UI). From there, we'll highlight the additional standards above the operating system that affect users every day.

Before we construct the architectural model we'll use throughout this document, we also want you to know our biases: The ultimate standards-based computer would be a perfect clone of whatever computer system had the largest market share. This product would bring no surprises. Of course it would also provide no added value to its users. The NeXT Computer was never conceived this way. NeXT's goal is to provide the finest possible computing environment in order to allow people to work together creatively and collaboratively. But this does not mean that our extensive use of industry standards was an accident. In today's heterogeneous computing environment, the NeXT system is designed to fit in just as well as it stands out. We hope you agree that we developed the right balance between the exclusive use of established industry standards and the goal of adding additional value and functionality for our users.

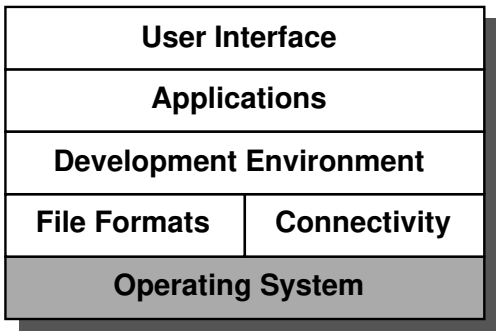
A Structured Look at Standards

A look at broad-based industry standards requires consideration of all parts of a system. As the diagram to the right shows, we begin with the *Operating System*. This is also where most open systems discussions in the UNIX world rage.

On top of this layer lie the key issues of *File Formats*, how data is stored, and *Connectivity*, how information is communicated to other people and other platforms. Next we reach the *Development Environment*. Effectiveness of this layer is critical to assure fast delivery of useful solutions, since on this layer rests the next key component: *Applications*, including both diverse commercial applications and custom internal solutions.

Finally, we reach the *User Interface*, where users actually get their work done. At each level, we discuss the role that open systems play and the way that NeXT builds on established industry standards to provide NeXT users with enhanced productivity and greater opportunity for collaboration.

The Operating System



A great operating system requires five attributes, only the last three of which require standards:

1. Power to conveniently support running the many applications that users desire
2. Flexibility to support increasing hardware performance
3. Support for standard development environments and utilities
4. Powerful networking support
5. Tools for efficient system management

UNIX was created with these strengths in mind. True protected memory multitasking means that users can run as many applications simultaneously as they desire, always confident that a single application crash will not bring down the entire system. Hardware independence allows UNIX to run on system architectures ranging

from Motorola to Intel® to RISC to mainframe. Great utilities assure that UNIX will always boast the finest development environments in the world. An architecture built to allow national networks of users means better networking and communications support than any other operating system. And 20 years of utilities make administration of even these national networks practical.

These last three attributes, development support, communications, and system administration, pinpoint where standards in an operating system are important. Development environment support eases the conversion of software from one platform to another. Communication support in the operating system makes high-speed connectivity more straightforward and reliable. And system administration standards make networks of various sizes feasible while helping encourage the development of comprehensive system administration tools. UNIX supports these three attributes in a far more developed, far more standard way than any other operating environment. Even the additional NeXT tools that make network administration far easier are layered on top of the standard environment. The other two mainstream desktop operating systems, MS-DOS® and Macintosh®, have certainly built up a strong base of development tools. However, neither were designed for today's high speed, wide area networking requirements or system administration demands.

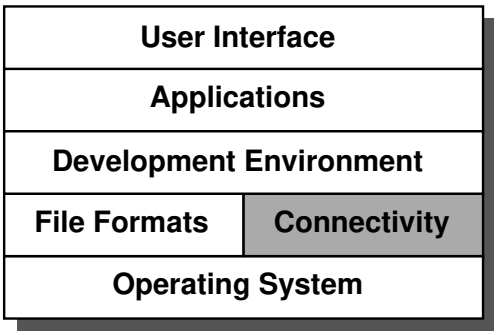
For all the above reasons, it is clear that UNIX will be a standard for many years. In fact, according to numerous studies, it will be the fastest growing system in the computer industry. What is open to more question, however, is what dialects will be dominant. The Open Software Foundation (OSF), led by IBM, Hewlett-Packard, and DEC offer one view of where this standard may go. UNIX International (UI), led by Sun and AT & T, offers another. Motorola is backing both and, so far, Apple Computer is backing neither. No unification of these groups is in sight.

OSF is based on Mach. Developed by researchers at Carnegie-Mellon University, Mach is completely compatible with the industry standard Berkeley UNIX release **4.3BSD**. Further, it offers an efficient, communication-oriented kernel and offers support for multiple processors and multiple threads between applications. We believe OSF's choice of Mach keeps them on the cutting edge of UNIX development.

The decision by OSF to use Mach also ensures alignment with NeXT at this key component in the system. NeXT systems have used Mach since our introduction in 1985. In fact, the principal author of Mach now manages ongoing system software engineering at NeXT. And as described above, this means that NeXT Computers are already fully compatible with Berkeley UNIX **4.3BSD**.

NeXT plans to continue compatibility with industry standard UNIX variations. Perhaps the most important near term example of this is POSIX. And NeXT plans to incorporate POSIX compliance based on Berkeley UNIX Release 4.4, the release now under development.

Connectivity



Although the hottest topic in the computer industry seems to be what flavor of UNIX will be dominant in the '90s, without a doubt the hottest topic by *users* of technology is: How do various systems all *communicate?* Connectivity is one of the two levels in our hierarchy (the other is "File Formats") where standards are critical. And since communication is so often a mission-critical activity, connectivity must work reliably and accurately with extremely little disruption. If the Personal Computing revolution of the 1980's was the decade of personal productivity, the 1990's will be the decade of group productivity and collaboration, the decade of Interpersonal Computing.

NeXT computers were built for this environment. From the standard Ethernet port in every system to the key third party applications we have encouraged, NeXT computers fit a heterogeneous computing environment. And as new communications standards emerge, we will add these to our supported suite. The following are highlights in the NeXT communications story, building up from the physical wiring.

Ethernet

Every NeXT computer includes an Ethernet controller which complies with standard IEEE 802.3a protocols. On the physical layer, each NeXT can connect directly to either thin Ethernet cable or 10baseT twisted pair Ethernet cable installations with no add-on products needed. The system automatically checks both ports at start-up to determine which one is connected, so no configuration of the ports is required.

The result is that every NeXT machine comes ready to connect directly to the organization's current high-speed Ethernet network.

TCP/IP

TCP/IP has become the standard networking protocol for systems ranging from supercomputers to mainframes to the nationwide Internet. It will even be the basis of the proposed National Research and Education Network (NREN). Systems supporting TCP/IP can send and receive mail nationally, get information from a large number of public and private remote databases, and share files with virtually every other mainstream computing platform. On-line services and information products

accessible to systems supporting this protocol are seeing explosive growth.

To ensure compatibility with all of these systems, all NeXT systems are compliant with standard TCP/IP networking as defined by the UNIX version 4.3BSD networking interface, as documented in "Requirements for Internet Hosts -- Communication Layers," R. Braden, Internet Engineering Task Force (RFC-1122, October 1989). Applications can use this interface to communicate with any other computer which uses the TCP/IP protocols.

Network Architectures

NeXT systems support Sun's NFS® (Network File System) version 4.0 as described by the *ONC/NFS Protocol Specifications and Services Manual*. Any NeXT computer can be a client or server to any other computer that implements NFS. Native NFS capability coupled with the NeXT Workspace Manager™ makes NFS accessible to non-technical users and ensures that file sharing and collaboration are smoother than on other platforms.

For large installations where NFS isn't practical, Transarc Corporation provides a complete AFS® 2.0 distributed file system for NeXT computers. It can operate cooperatively with other AFS servers and clients.

Simple Mail Transfer Protocol (SMTP)

Within homogeneous NeXT-only networks, NeXT has optimized its multimedia NeXTmail™ to offer greater capabilities than possible on other mail systems. It supports communication with rich text, graphics, voice, and files. However, NeXTmail is built on industry standard SMTP (Simple Mail Transfer Protocol) mail to assure it can communicate with other systems. This means that NeXT computers can send and receive mail from any other UNIX-based computer or any other PC, Macintosh, mainframe or minicomputer that uses SMTP as its mail protocol or supplies an SMTP gateway. It also means that the various networks and mail gateways throughout the country support full multimedia NeXTmail sent between distant NeXT computers.

NeXT also supports UUCP standard serial communications and SLIP via a third-party product from Marble Software, Associates called Teleconnect™.

Touch Communications provides the most universal connection to other mail systems with their WorldTalk™/400 messaging gateway. This product converts NeXTmail, along with most other major electronic mail systems, to and from an X.400 format compliant with the 1984 CCITT X.400 messaging recommendations. It's also completely GOSIP compliant, offering connection to 802.3 and X.25 networks.

NeXT will make more and more use of the X.400 standard as it matures and its acceptance grows. Other critical services related to electronic mail, such as X.500 directory service, are only now being defined by international standards bodies. NeXT, however, looks forward to the day when these can be standardized as well.

FAX

Every NeXT system supports sending and receiving of standard Group 3 FAX as an integrated part of its output capability. Users simply connect one of a variety of widely available FAX modems as a shared device on the network.

The convenience this adds over forcing users to print pages and then send via nearby FAX machine is only the start. In addition, pages produced by conventional FAX machines at the receiving end are remarkably improved.

3270 Terminal Emulation

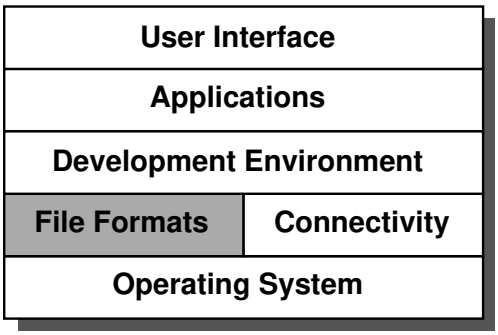
Many customers tell us that while they want the productivity applications and multimedia mail features of the NeXT system, they have critical applications running on their mainframe. For these users, Conextions, Inc. developed 3270Vision™. This product provides full 3270 terminal emulation within a window on the NeXT system. This emulator connects to the mainframe host over either TCP/IP based gateways such as Fibronics K2000 Ethernet Controller or through Conextions 3270Vision Coax. This second product connects to IBM 3174 and 3274 controllers and emulates an SNA Distributed Functions Terminal.

Avatar Corporation will also be shipping a 3270 emulator called InSession 3270™ in mid-1991. InSession 3270 provides an external SCSI device that offers coaxial cable access to IBM mainframes by emulating IBM 3278 and 3279 terminals.

Proprietary Protocols

With available third-party products, NeXT systems connect today to Novell NetWare, AppleTalk, and Token Ring networks. Both NeXT and our third parties continue development to ensure that connection and communication between these networks is simple, efficient and inexpensive.

File Formats



File formats are the second level in our hierarchy (the other is "Connectivity") where standards are absolutely critical. To exchange information between different platforms, or between different applications on a single com-

puter, data must be in a format acceptable to all. For years, the only standard was vanilla (7-bit) ASCII text. If all the user wanted was text, without formatting or graphics, it worked. But that pipeline is no longer sufficient. Formatted text, from font styles to multiple columns, is now common. Graphics intended to make our writing more clear and compelling are widespread. At a more advanced level, we want to transfer information with "intelligence"—from spreadsheets complete with formulas to word processing documents with automatic indexes that change as pages are added.

NeXT actively supports and promotes more of the industry standard formats than any other computing platform. The following highlights, including outlines of how the formats are implemented on other platforms, are the most important:

DOS and Macintosh File Systems

In a heterogeneous computing environment, the most convenient and practical way of transferring data between different platforms is not always a network—sometimes the easiest way is to simply hand a colleague a floppy disk. To make this simple, every NeXT computer can read and write DOS formatted diskettes of 720 KB, 1.4 MB and 2.88 MB. Also, with a third-party software utility from Digital Instrumentation Technology, Inc., called FloppyWorks™, NeXT Computers can also read and write Macintosh floppy disks. These disks show up in the NeXT Workspace Manager just as a native NeXT floppy would, so file manipulation takes no new techniques. Of course, the native format for the NeXT 2.88 MB floppy disks is standard UNIX. We read, write, and format floppy disks from 720KB (double density, "DD") to 2.88 MB (extra density, "ED")

PostScript Language

The Adobe PostScript® language has become the clear standard for managing high quality graphics, as well as font and typographic information. PostScript files are either sent to various output devices or they can be "encapsulated" (EPS) for display on the monitor within various types of documents.

Macintosh applications were among the first to use the PostScript language for printing with the Apple LaserWriter®. However, the Macintosh still uses a "dual-imaging" model requiring PostScript images to carry additional versions in PICT or TIFF format in order to be displayed. DOS applications can include code to support printing of PostScript images; but, they don't usually display these images. Windows applications are beginning to support the file format, but support must be handled by individual applications, so both performance and display capabilities vary. Finally, in the non-NeXT UNIX world, only DEC has begun to use PostScript in system software. On other systems, applications must provide the PostScript language support themselves. On the positive side, so many of them print to PostScript printers that generating PostScript has become standard practice. However, the ability to display the images on the monitor is uncommon, so users rarely work within a "what-you-see-is-what-you-get" environment.

In contrast to these systems, the PostScript language is entirely central to NeXT's display and printing technology. In fact, NeXT jointly developed the Display PostScript system with Adobe Systems Incorporated. Because NeXT uses PostScript as our "unified imaging model", everything that is displayed on a NeXT computer, printed on a NeXT Laser Printer, or sent to another output device is defined by the PostScript language. The use of the PostScript language throughout NeXT computer offers three major benefits:

- Exceptionally clear, flexible printing and display,
- Precise agreement between printed and displayed information, and
- Unprecedented freedom to move formatted text and graphics between applications.

And because the PostScript and EPS formats can be read by applications on the other platforms mentioned, including Macintosh, Sun®, and DOS/Windows™, PostScript provides an excellent way to transfer information. To ensure compatibility with all other systems using this standard, NeXTstep® is entirely compliant with the PostScript Language as defined in the *Adobe Systems PostScript Language Reference Manual* published by Addison-Wesley. The EPS conventions are documented in *Encapsulated PostScript Files Specification, version 2.0*, by Adobe Systems Incorporated, 1989.

In the future, NeXT will fully implement the newly proposed Level 2 PostScript standard as defined in the *PostScript Language Reference Manual, Second Edition* recently released by Addison-Wesley. The color portability and performance features of PostScript Level 2 will make this industry standard even more successful.

Rich Text Format (RTF)

The Rich Text Format (RTF) was originally created by Microsoft to support the exchange of formatted text. It has been widely adopted in the DOS, Macintosh and Windows 3.0 environments as a format that is more universal than the native file format of any single application.

We often say that "RTF is the ASCII of the NeXT Computer." Since the NeXT development environment makes it trivial for every NeXT application to support RTF, we raise the least common denominator that every user and developer can expect. Users can copy and paste between applications, confident that text formatting is retained. This even includes our most basic bundled text editors. And to assure that information transfers easily to non-NeXT systems, NeXT follows the conventions of RTF as described in the 1988 version of *The Rich Text Format Specification* by Microsoft Corporation.

Tag Image File Format (TIFF)

The Tag Image File Format (TIFF), created by Aldus and Microsoft Corporations, provides a broadly accepted, extensible way to store raster (bit-mapped) images. Like the RTF standard, TIFF (or ".tif" as it is known in the DOS world) is widely supported in the Macintosh, DOS, and Windows environments. While some applications, especially in the DOS world, cannot actually display these images, most can print them.

The NeXT system stores, displays, and prints TIFF images. While virtually every application that uses TIFF also supports EPS, in some situations TIFF is desired. And since TIFF is fundamental to the NeXT Computer rather than simply supported by a few specific software packages, NeXT applications share these images more easily than applications can on any other platform. In addition, applications easily mix and match TIFF images with EPS and RTF. Once again, to ensure compatibility with other computer platforms where TIFF is used, the NeXT version of TIFF follows the *Tag Image File Format Specification* by Aldus Corporation and Microsoft Corporation, 1988. It also incorporates modifications built into the most recent TIFF release, version 5.0.

JPEG Compression/Decompression

Increasingly, users of desktop computers want to incorporate color images into their documents. But as anyone who has tried this knows, those images are enormous. One and two-megabyte images are extremely common. This makes it difficult to save documents to a floppy disk for transporting and adds traffic to a network. The last few years have seen the rise of a standard method, defined by JPEG, to compress and decompress these images by as much as 10 to 30 times. A JPEG compression utility must be purchased, if it is even available, on every other desktop computer. However, every NeXT computer includes this capability. Again, the key here is raising the lowest common denominator. If even one person on the network uses color images, he or she can confidently send the compressed file to any other NeXT computer, knowing that the file can be viewed.

Furthermore, NeXT is preparing to support the follow-on MPEG standard, focused on digitally compressed movies, as it is finalized and as implementations become available.

CD-ROM ISO 9660 and High Sierra Formats

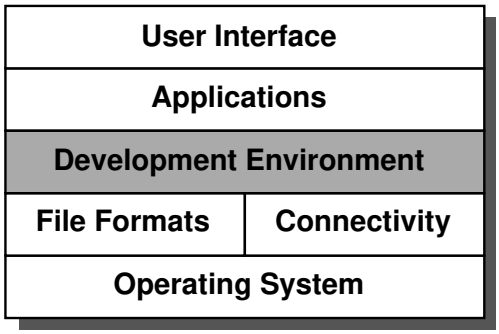
The number of CD-ROM-based applications and databases is exploding. And so are the number of CD-ROM drives available. Like most standard SCSI devices, these drives connect directly to NeXT's standard SCSI-2 port. Or, users can install the internal CD-ROM drive available from NeXT.

In either type of drive, CD-ROM's created in industry standard ISO 9660 or High Sierra formats show up in the Workspace Manager just like NeXT floppy disks. Any application that can read the data files can then read and manipulate the information. As with recognition of the DOS file system, every NeXT computer has this capability.

Native Application Formats and Translation

While we'll discuss application availability further in the section "Applications," the critical issue related to file formats is the broad selection of native (proprietary) formats that NeXT applications support. Applications on NeXT computers currently read and write the native formats of Lotus® 1-2-3®, WordPerfect®, Microsoft SYLK, Adobe Illustrator™, WriteNow® for Macintosh, FrameMaker® for Macintosh and Sun, *Mathematica*®, T_EX™, and SAS®. In addition, file translators available from DataViz, Inc. make it simple to convert files from Microsoft Word, Microsoft Works, MacWrite (I & II), Microsoft Excel (.wks), MultiMate, OfficeWriter, WordStar®, and Xywrite III to Lotus Improv™, WordPerfect, WriteNow, etc.

Development Environment



The most important aspect of a development environment is to allow developers to create powerful, groundbreaking applications in very little time and with extreme flexibility. Nearly as important is the transportability of the resulting code and the availability of established, standard development tools. Because the issues involved in these two sets of criteria are different, we'll discuss them separately.

Reviews have called the NeXT development environment, NeXTstep, the best, most efficient and most flexible in the world. And NeXT Interface Builder™ is half of the reason. It lets developers design, test and *generate final code* for their application's user interface by simply dragging and dropping the components onto windows in a completely graphical environment. On all other platforms, this is an activity that usually takes over 50% of the development time. The other half of the reason is that NeXTstep is object-oriented. The result is shorter development time, faster debugging, and far more reusable code.

While other platforms have various development tools and integrated development environments, only NeXTstep has been honored with the Fluegelman award for best software environment of the year and *Computer Languages Magazine's* award for the best integrated development environment (surpassing MacApp and

Saber C), as well as awards from *Byte* magazine, *InfoWorld* and others. But even more significantly, leading software developers have chosen NeXTstep to produce their most advanced products. For example, Lotus Development Corporation decided to point the way for all future spreadsheets with their new *Improv* product available only on the NeXT Computer. And WordPerfect Corporation created their best version of WordPerfect yet with a full "what-you-see-is-what-you-get" version, again only for the NeXT computer. Of course, these products are completely file compatible with their DOS, Macintosh and other UNIX versions. The important idea here is that standards are not important to the *user interface* of the development environment, as long as the *output* of the development environment is standard, compatible code. This brings us to the second issue.

The second key aspect of a great development environment involves the transportability of code and the availability of standard development tools. This is where using standards in a development environment offers real benefit, because the same algorithms can run on multiple platforms with less time spent porting.

The critical point is that in all standard platforms, from Windows to Macintosh to Sun to NeXT, a revolution is taking place in the way developers are writing code. To save time and still take advantage of the unique benefits of different environments, *they are breaking their code into two major pieces: back-end algorithms that do the specialized work and the front-end user interface.* Then they reuse the back-end algorithms as they port from platform to platform while modifying the user interface to make users as comfortable and efficient as possible. The keys to a development environment's success, therefore, are a great tool for creating the custom interface and complete industry standard tools for creating (or porting) the underlying algorithms. We'll look separately at the tools a developer uses for these two components of any NeXT application.

Interface Builder

The frustration on platforms other than NeXT is that creating a user interface is exceedingly time consuming. Tools are either non-existent (DOS), or they force the writing of a great deal of code just to have anything to test on a potential user (Macintosh), or they force developers to start over from scratch writing code once they use a prototyping tool to decide on a user interface (Guide on Sun or HyperCard® on Macintosh). However, on NeXT computers, Interface Builder, a tool for just this task, is bundled with every developer system.

Interface Builder allows developers to design, test, refine *and generate all code* for their user interface in a completely graphical environment. Using a set of object-oriented tools called the Application Kit®, developers drag and place user interface items to create the look of their application. When finished, they select a single command to turn their creation into standard code using the Objective-C language. The resulting code is ready to have specialized "back-end" algorithms added.

And to create those back-end algorithms, the development tools are completely standard. With little variation, these are the same tools available and used heavily on Macintosh, Sun, DOS, and Windows platforms. Further, the output of those tools is standard output, ready to be moved to other platforms when needed. The following are the highlights of these tools:

ANSI-C and Objective-C

Like most modern development systems, NeXT chose the ANSI-C language as the basis for our programming language and compiler technology. However, we extended this technology to include both Objective-C and C++ language support. NeXT began with ANSI standard C as found in Appendix A of *The C Programming Language* (second edition, 1988) by Brian W. Kernighan and Dennis M. Ritchie, published by Prentice Hall. The NeXT compiler for the Objective C language is based on GNU CC (gcc), an ANSI-standard C compiler produced by the Free Software Foundation. To this base, NeXT added a small number of additional grammatical terms based on those of the Stepstone Corporation. This combination gives NeXT the full advantages of object-oriented programming while maintaining a close link to ANSI C. It also ensures that developers familiar with standard C programming will have very little to learn as they move to take advantage of the benefits of object-oriented development. NeXT also supplies a complete C++ compiler. This compiler is based on G++ version 1.36.4, which implements version 2.0 of the C++ language, as specified by AT&T ("ANSI Base Document for C++", Ellis and Stroustrup) and published by Addison Wesley (X3.159-1989). Objective-C and C++ can be intermixed and "cross-called" without exception.

FORTRAN

Absoft Corporation offers a full Object-Oriented FORTRAN environment, FORTRAN 77™, compliant with the ANSI X3.9-1978 and MIL-STD 1753 FORTRAN language definitions. It offers complete access to all UNIX tools as well as the NeXT Interface Builder for the addition of a graphical user interface. FORTRAN 77 is also POSIX compliant and able to accept VAX/VMS, IBM/VS, and FORTRAN 90 code.

Oasys Corporation also offers a complete FORTRAN environment which implements the same ANSI and Department of Defense specifications. The Oasys compiler also supports interlanguage calling between Oasys FORTRAN, Pascal, and C compilers.

ISO Pascal

Oasys Corporation has built a complete Pascal compiler system for NeXT that implements the ANSI/IEE 770X3.97-1983 standard as well as the BSI/ISO level 1 standard.

Common LISP

Franz, Inc. offers a full Common LISP programming environment with robust implementations of Flavors and Portable Common LOOPS. This product also provides a full function call interface from LISP into both FORTRAN and C.

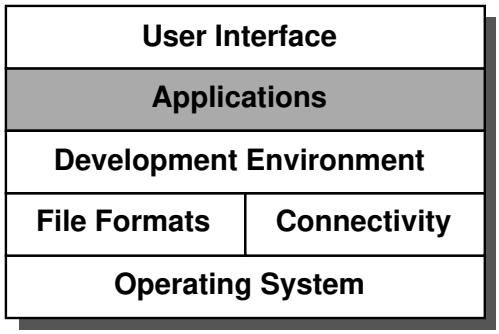
COBOL-85

Acucobol, Inc. has built a COBOL compiler for the NeXT Computer that is compliant with the High 1974 and Intermediate 1985 ANSI COBOL standards. It also supports most features of Data General's ICOBOL.

Structured Query Language—SQL

Two different SQL-based relational databases run on the NeXT system today, Oracle Corporation's ORACLE® DBMS, Sybase, Inc.'s SYBASE SQL™ server. Both of these are completely ANSI-SQL compliant.

Applications



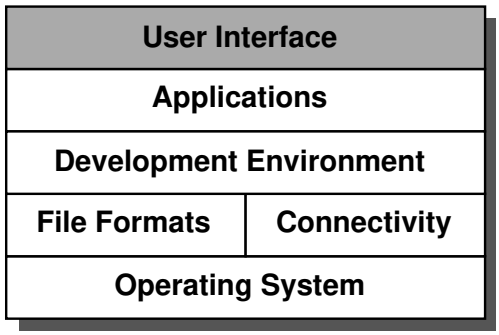
The keys to a world class application base are well-defined. Applications should:

- Be plentiful and diverse
- Be powerful and flexible
- Represent the major software vendors to assure "staying power," effective product support, and an industry of experienced users and consultants
- Consist of the most advanced, most innovative *versions* of the "brand name" software, rather than ports of outdated versions (perhaps the most important criteria when deciding on a platform to use for multiple years)

NeXT has established close partnerships with virtually all leading software developers: Lotus, WordPerfect, Oracle, Novell, Adobe, Informix, Sybase, and many others offer products for the NeXT computer. And the data from every product is compatible with their applications running on other platforms. But unlike the old versions of these products that are ported to other UNIX environments, the products these companies created for NeXT are the best versions they ever developed. Lotus, as we discussed earlier, showed the path of future spreadsheets by, as Lotus says, "reinventing the spreadsheet" on the NeXT platform with their Improv product. Similarly, WordPerfect created their only true "what-you-see-is-what-you-get" version for NeXTstep, and Adobe was able to provide speed and functionality to Illustrator that cannot be found on any other platform.

These key products, plus the hundreds of others from the small companies that will grow to become the Novell's and Adobe's of the coming decade, mean an exceedingly large, diverse, and progressive software base for NeXT computer users. (For more information on applications, ask a NeXT representative for a *Third-Party Software and Peripherals Catalog*.)

User Interface



The user interface of the NeXT Computer, NeXTstep, is indeed unique to NeXT, just as the Macintosh interface is unique to Macintosh, the Microsoft Windows interface is unique to DOS, and the OpenLook™ and SunView™ interfaces are unique to Sun. While some groups, including OSF, are recommending that the Motif interface be used on multiple platforms, few leading application developers are showing interest. In looking at all of these, however, the recurring themes in discussing user interface success are:

- *Successful mainstream platforms must develop superior user interfaces to benefit users and encourage groundbreaking applications*
- *Interface improvements are desirable if standards have been designed appropriately into the rest of the architecture*

The essence of a great user interface has little to do with standards. The user interface, or UI, is simply the way the user tells his or her computer what to do. If the computer is designed appropriately, then "what it does" will be compatible with key industry standards and what matters in the user interface is maximizing personal productivity. Just as NeXT will continue to build accepted standards into our model's layers *below* the user interface, we will continue to innovate in the area of the UI itself. With this philosophy in mind, the UI designer must focus on six key issues:

1. Ease of learning
   Reduce training time and costs
2. Ease of use
   Increase efficiency after techniques are learned
3. Consistency
   Reduce learning time on new applications

4. Great support for systems' advanced functionality
   Provide easy access to more powerful capabilities
5. Metaphors showing similarity to real-world actions
   Intuitiveness–users do many things without "learning"
6. Metaphors showing similarity to other well-known user interfaces
   Similar to intuitiveness–so that users do many things without relearning

Only #6, the idea that similarity with other interfaces reduces the need to learn new techniques, involves standards. This becomes important when a person uses different platforms in the course of their work. However, most people use one type computer for the vast majority of work, so the first five UI goals tend to outweigh the last one.

An institution's system support organization, on the other hand, has mixed desires. If all the platforms are the same, support people need to know fewer details. However, if new platforms are superior in the first five ways, far less support is required in the first place. On balance, *the NeXT goal is to eliminate the need for support as much as possible*, instead of simply making the current support requirements easier.

The most important graphical user interfaces used today are Macintosh and Microsoft Windows/DOS. Both are quite successful at insulating users from the functionality that their platforms offer. Unfortunately, they have no way to support the sort of advanced functionality that was not even considered when Macintosh and DOS were first conceived. Today's users wish to:

- Safely run several applications simultaneously,
- Communicate seamlessly with others across the building or across the country, and
- Navigate quickly among files on large storage devices.

NeXTstep, the NeXT user interface, begins with a system at least as easy to use and as consistent as Macintosh or Windows/DOS. But it goes much further to support the multitasking, high-speed communications, large storage device support, and other advanced functionality available in a true professional workstation. We believe that this combination of strengths makes NeXTstep the finest user interface available.

Bridges to Other User Interfaces

The ability to run alternate user interfaces for a key application is often critical. To ensure that people are not kept from using the NeXT Computer just because they need a single application that runs under another UI, two major environments are available from within NeXTstep.

With SoftPC®, by Insignia Software, users launch standard DOS within a window alongside their other NeXTstep windows. Since NeXT computers read DOS-formatted floppy disks, this means that NeXT users working with DOS users can exchange not only data, but critical applications. SoftPC provides complete PC AT-class emulation for DOS applications, including EGA and CGA graphics support. Files move between the DOS environment and UNIX environment so seamlessly that the NeXT floppy disk drive can even be configured to show up in DOS as drive "A:".

If NeXT users have colleagues using the X Window environment, they can use one of two versions of the standard X window server (X11 release 4) to share critical applications. These servers are available from Pencom Software and White Pine Software, Inc. Each of the packages constitutes an X-Terminal emulator, providing complete X window server functionality, including support of MOTIF, from within a window sharing the display with other NeXTstep application windows.

Peripheral Support

Although peripheral support is not strictly in our hierarchy for building a system architecture, it's clearly critical to efficient, effective computer use. Hundreds of companies in the industry provide essential add-on equipment of all types to standard computer platforms. To let NeXT owners use the vast majority of these products, every NeXT computer has two types of ports for smooth connection. The first is an ANSI standard SCSI-2 bus port for connecting SCSI-based peripherals. These include third-party hard disk drives, scanners, streaming tape drives, CD-ROM drives, etc. Many of the SCSI-based products for Sun and Apple work "out of the box" without any additional software. For example, the NeXT computer automatically formats third-party hard disks so that they appear in the Workspace Manager.

The second key connections are the two RS-423 serial ports. They provide unbalanced RS-423 connectivity fully compatible with RS-232C. NeXT systems support flow control on the serial ports via the RTS and CTS modem signals. These serial ports are used to connect modems, Type 2 fax modems, serial printers of all types, and other specialized serial devices. The following products highlight some of the most important groups of peripheral products available today for NeXT systems:

Scanners

Abaton, Canon, HSD, and Visus all provide SCSI-based scanners for NeXT computers. These devices offer resolution up to 2400 dots per inch and up to 24-bit color. Like scanners used on other platforms, all can produce standard TIFF images for manipulation in one of many NeXT applications or for transfer to other environments.

Printers

In addition to the NeXT 400 dpi LaserPrinter, a NeXT computer can print to any black-and-white or color PostScript output device (PostScript raster image processor). Among those supported are the Apple LaserWriter, Linotype and Agfa-Compugraphic imagesetters, HP LaserJet®, IBM 4019, OceColor™ Printer, and a variety of QMS, NEC, and Varityper devices.

External Data Storage

A wide variety of external hard disks are compatible "out of the box" with NeXT computers. These range in size from 20 MB to 1.4 GB and more. There is no practical limit to the size of a disk that can be used on NeXT computers. In addition, SCSI devices can be daisy-chained for greater flexibility. There are also several models of external disk drives that read and write floppy disks formatted on other systems. With these products NeXT computers can directly read and write both DOS and Macintosh formatted floppy disks. With both 3.5-inch and 5.25-inch formats available, these drives support all of the standard sizes: 400 KB, 720 KB, 800 KB, 1.4 MB, and 2.88 MB. Finally, a variety of other storage devices from streaming tape back-ups to CD-ROM drives to removable magnetic cartridge drives are also available from various third parties. (For more information on these products, ask a NeXT representative for a *Third-Party Software and Peripherals Catalog*.)

IEEE488 Instrument Control

IOtech, Inc. offers an interface for up to 14 IEEE 488 devices. Provided with the interface is software that can control these devices from inside an Objective-C language application.

Contacts for additional information on products discussed

NeXT Computer, Inc.
900 Chesapeake Drive
Redwood City, CA 94063
1-800-848-NeXT

Abaton
48431 Milmont Drive
Fremont, CA 94538
1-800-444-5321

Absoft Corporation
2781 Bond Street
Rochester Hills, MI 48309
313-853-0050

Acucobol, Inc.
7950 Silverton Avenue
Suite 201
San Diego, CA 92126
619-271-7097

Adobe Systems Inc.
1585 Charleston Road
Mountain View, CA 94039
415-961-4400

Agfa-Compugraphic Division
200 Ballardvale Street
Wilmington, MA 01887
508-658-5600

Avatar Corporation
65 South Street
Hopkinton, MA 02748
1-800-282-3270

Canon USA, Inc.
One Canon Plaza
Lake Success, NY 11042
1-800-848-4123

Conextions, Inc.
79 Wildwood Road, Suite 200
Andover, MA 01810
508-475-5411

Digital Instrumentation Technology, Inc.
901 18th Street, #11000
Los Alamos, NM 87544

505-622-1459

Franz, Inc.
1995 University Avenue
Berkeley, CA 94704
415-548-3600

HSD U.S., Inc.
1350 Pear Avenue, Suite C
Mountain View, CA 94043
415-964-1400

Insignia Solutions Inc.
254 San Geronimo Way
Sunnyvale, CA 94086
408-522-7600

IOtech, Inc.
25971 Cannon Road
Cleveland, Oh 44146
216-439-4091

Lotus Development Corp.
55 Cambridge Parkway
Cambridge, MA 02142
617-577-8500

Marble Associates, Inc.
38 Edge Hill Road
Waltham, MA 02154
617-891-5555

Oasys
230 Second Avenue
Waltham, MA 02154
617-890-7889

Oce Graphics, USA Inc.
385 Ravendale Drive
P.O. Box 7169
Mountain View, CA 94039
1-800-545-5445

Oracle Corporation
20 Davis Drive
Belmont, CA 94002
1-800-345-DBMS

Pencom Software, Inc.
9050 Capital of Texas Highway
Suite 300
Austin, TX 78759
512-343-1111

Sybase, Inc.
6475 Christie Avenue
Emeryville, CA 94608
415-596-3500
1-800-879-2273

Touch Communications
250 East Hacienda Avenue
Campbell, CA 95008
408-374-2500

Transarc Corporation
The Gulf Tower
707 Grant Street
Pittsburgh, PA 15219
412-338-4400

VISUS
3400 Forbes Avenue
Pittsburgh, PA 15213
412-687-3800

White Pine Software, Inc.
94 Route 101A
P.O. Box 1108
Amherst, NH 03031
603-886-0950

WordPerfect Corporation
1555 N. Technology Way
Orem, UT 84057
801-225-5000

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