Mac OS X for UNIX Users

The power of UNIX and the simplicity of Macintosh:
With Mac OS X, you can have the best of both worlds.

Key Features

Standards-based UNIX foundation
- Based on FreeBSD 4.4 and Mach 3.0
- Support for POSIX and System V APIs
- High-performance math libraries including vector/DSP support
- X11 window server beta release available for UNIX GUIs
- Core operating system available as Open Source via the Darwin project

Standards-based networking
- TCP/IP-based networking architecture
- Interoperability with NFS, AFP, and Windows (SMB/CIFS) file servers
- Powerful web server (Apache)
- Open Directory, an LDAP-compatible directory services architecture
- Kerberos, OpenSSH, personal firewall (ipfw), and other network security technologies

Familiar UNIX environment
- Terminal emulation with full xterm functionality, including VT220 and Unicode support
- Aqua-based Terminal application featuring transparency and drag-and-drop colors
- Comprehensive set of UNIX/Linux utilities (including emacs, vi, tar) and languages (including bash, perl, tcl)
- Bundled gcc 3.1 compiler for fast code compilation and program execution of C, C++, and Objective-C source
- Rich set of command-line C, Java, and UNIX build tools (including make, lex, yacc)

Apple's Mac OS X operating system combines a robust and open FreeBSD foundation with the richness and usability of a Macintosh interface, bringing UNIX technology to the mass market for the first time. There are over 5 million Mac OS X users, including scientists, animators, developers, and system administrators, making Apple the largest vendor of UNIX-based systems. Mac OS X is the first UNIX-based environment to run Microsoft Office, Adobe Photoshop, and thousands of other consumer applications natively—all side by side with traditional command-line and X11 applications. It is also the best UNIX-based environment for portable computers, with full power management and mobility support for Apple's award-winning PowerBook G4.
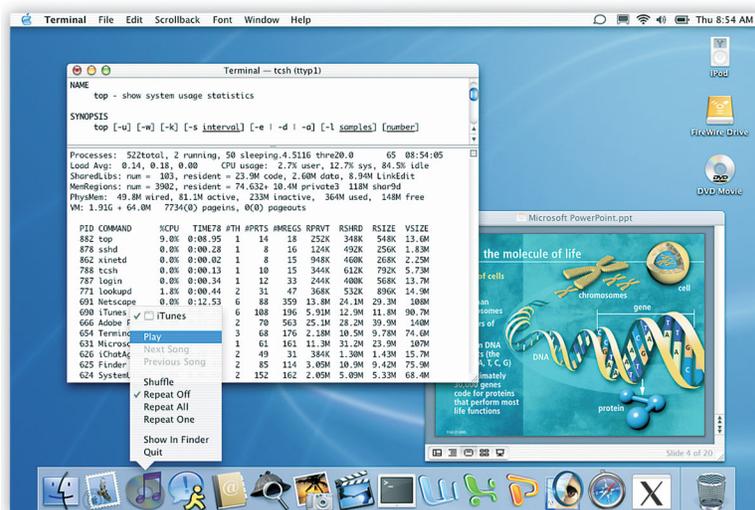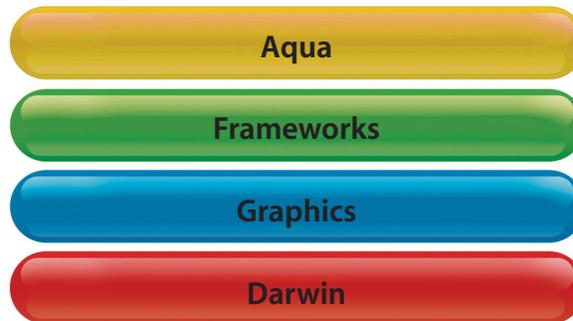

This document provides an in-depth look at the various Open Source and standards-based technologies in Mac OS X of interest to UNIX users. It will help you understand why so many of your peers are choosing Mac OS X as their new UNIX desktop. It is based on Mac OS X v10.2 "Jaguar," the latest industry-leading operating system from Apple. The primary focus is Darwin, the Open Source core underlying Mac OS X v10.2. For more information about other aspects of Jaguar, please visit www.apple.com/macosx/jaguar.

Mac OS X Architecture

Mac OS X has a modular architecture built around four major components: the Darwin core operating system, a diverse suite of application frameworks, standards-based graphics systems, and the Aqua user interface.

Aqua

Frameworks

Graphics

Darwin

Aqua

Aqua is Apple's user interface for Mac OS X, using color, transparency, and animation to enhance the usability and consistency of the system and applications.

Frameworks

Mac OS X includes a variety of application frameworks to support developers in many different communities.

- **Cocoa** is a set of object-oriented frameworks designed for rapid application development, making it easy to add rich Aqua GUIs to existing UNIX software or to create entirely new applications from scratch.

- **Carbon** is designed to provide a gentle migration path for developers transitioning their applications from Mac OS 9 to Mac OS X.

- **Java** allows development and execution of cross-platform Java 2 Standard Edition programs in Mac OS X, including those written using Java Developer Kit (JDK) 1.4.1.

Graphics

The Mac OS X graphics system consists of three powerful, standards-based technologies that are fully integrated into the operating system to provide seamless system-level services.

- **Quartz 2D.** This high-performance graphics rendering library is based on Adobe's cross-platform Portable Document Format (PDF) standard. It displays and prints high-quality, anti-aliased text and graphics and provides industry-leading support for OpenType, PostScript, and TrueType fonts.

- **OpenGL** is the industry standard for visualizing 3D shapes and textures. Mac OS X features a tightly integrated, highly optimized, and standards-compliant implementation.

- **QuickTime.** Apple's cutting-edge digital media software provides a fully standards-based environment for creating, playing, and delivering video (MPEG-4), audio (AAC, or Advanced Audio Coding), and images (JPEG 2000 and scores of other formats).

Darwin

Beneath the easy-to-use interface and rich graphics of Mac OS X is Darwin, an Open Source UNIX-based foundation built on proven technologies such as FreeBSD, Mach, Apache, and gcc. Darwin is a complete operating system, comparable to Linux or FreeBSD, and provides the usual kernel, libraries, networking, and command-line environment that UNIX users expect. This document reviews each of these components in detail.

Aqua	
Frameworks	**Commands**
Graphics	**Networking**
Darwin	**Libraries**
	Kernel
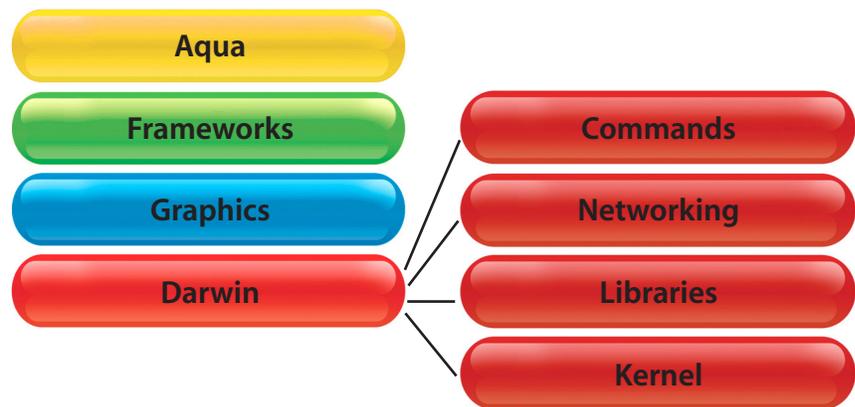
UNIX enhancements in Mac OS X

Mac OS X v10.2 "Jaguar" provides a number of key technologies for UNIX users:

- Kernel and libraries updated to FreeBSD 4.4
- gcc updated to version 3.1
- Updated UNIX libraries, including ncurses and a reentrant C library
- New security APIs such as PAM, pkcs-11, and md5
- Additional scripting languages (python and ruby)
- Common UNIX Printing System (CUPS) printing architecture
- Mach threading enhancements
- Vectorized, optimized math libraries
- Additional POSIX and System V APIs
- Enhanced Terminal application with a richer GUI and full xterm emulation
- LDAP-compatible Open Directory architecture
- A new firewall GUI for safer networking
- A richer set of network services, including IPv6/IPSec and PPTP
- Samba (SMB/CIFS) support for access to Macintosh files from Windows systems
- More than a thousand new man pages

Kernel

Darwin's state-of-the-art BSD kernel is based on FreeBSD 4.4 and Mach 3.0. BSD (the Berkeley Software Distribution, from the University of California, Berkeley) is one of the original flavors of UNIX, and the Open Source FreeBSD distribution is one of the most widely respected UNIX implementations available today. This BSD heritage is what gives Mac OS X the stability, performance, and compatibility you'd expect from UNIX.

Apple has turbocharged BSD by adding Mach 3 technology based on the OSF/mk microkernel from the Open Software Foundation. Mach was developed at Carnegie Mellon University during one of the earliest research projects on symmetric multiprocessing and advanced computing architectures. Mach services for memory management, thread control, hardware abstraction, and interprocess communication enable Darwin to provide a number of advanced features, including:

- **Fine-grained multithreading.** Mac OS X uses Darwin technology at the lowest levels to provide superior thread management. Darwin is designed to efficiently handle multithreaded applications whether they're running on one or multiple processors. It also provides precise control of real-time requirements. For example, when a user burns a DVD, Darwin thread handling ensures that the data-burning thread always has just enough cycles to keep the write buffer filled while the computer continues to perform other tasks. Mac OS X implements POSIX threads using true kernel threads rather than user threads, so each thread can be scheduled independently for maximum efficiency.

- **Support for symmetric multiprocessing (SMP).** Mac OS X automatically harnesses both processors in dual processor Macintosh systems, so all applications benefit from the higher performance added by the second processor. Complex tasks such as image transformations, video compression, and audio encoding operations can take a long time to complete when they're done consecutively. With both processors working in parallel, two tasks can be performed in little more than the time it takes to complete each task on a single processor. Because Mac OS X itself is multithreaded, users benefit from multiple processors even with applications that aren't thread-aware.

- **A unified buffer cache** enables the file system and virtual memory subsystem to share kernel buffers. As with most UNIX systems, physical memory and on-disk files are both automatically mapped into 4GB of virtual memory per process. This design uses a single backing mechanism for both, minimizing disk access and the use of wired kernel memory.

- **The I/O Kit** is the device driver subsystem of Mac OS X. This powerful, object-oriented architecture helps device manufacturers rapidly create drivers that run safely in a multiprocessing, preemptive environment. It's specifically designed to support the dynamic plug-and-play capability expected by Mac users, as well as the low latencies required by video and audio applications. The I/O Kit provides a set of C++ classes implementing object-oriented abstractions common to all drivers, as well as specific high-level families such as IONetworkController and IOBlockStorageDevice. This makes it easy to implement SMP/real-time-safe drivers with a minimum of device-specific code. The I/O Kit also allows developers to perform driverlike functions from application code, which in many cases avoids the need to write kernel drivers.

- **Support for mobile computing** includes sophisticated power management and automatic network switching. A feature called multihoming in Mac OS X enables the computer to communicate over all of its network interfaces at the same time. Mac OS X selects the best interface to connect to the Internet. For example, if the user has a PowerBook system connected to an office network via its built-in Ethernet port, then takes the computer to a coffee house that has wireless Internet access, Mac OS X recognizes that the system needs to communicate via AirPort and connects to the Internet accordingly.

- **Loadable file systems,** based on BSD's stackable virtual file system layer (vfs), allow Mac OS X to dynamically mount, read, and write to numerous local file systems, including:

  – HFS+, the default; case insensitive with support for fast Btree-based searches
  – UFS, based on Berkeley FFS, with support for standard POSIX semantics
  – ISO 9660, the standard CD-ROM format
  – UDF, the Universal Disk Format for DVDs
  – FAT32, the standard Windows interchange format

Libraries

Mac OS X provides a robust set of optimized libraries, making it easy to port your existing UNIX code.

Core libraries

- **A standard, multithreaded C library (libc)** that includes support for such capabilities as reentrant variants of standard functions (for example, strtok_r), easing the porting of thread-aware applications to Mac OS X.

- **POSIX API support,** including POSIX thread signaling (for example, pthread_kill and pthread_cancel) and I/O (such as pread/pwrite), for easy porting of POSIX applications.

- **Legacy System V API support,** including semaphores and System V IPC, in a compatibility library, making it easy to port applications from System V–based versions of UNIX (such as Solaris and Linux).

- An **X11 Window System** is available for running cross-platform UNIX applications in Mac OS X. A public beta release of Apple's X11 for Mac OS X is available at www.apple.com/macosx/x11. Based on the Open Source version of X11 (called XFree86), this complete implementation of X11R6.6 is highly optimized for Mac OS X and features Apple's Aqua-compatible Quartz window manager (quartz-wm).

- **GLUT** (OpenGL Utility Toolkit) is a cross-platform toolkit for writing OpenGL programs that supports an Aqua-compatible look and feel on Mac OS X.

- **Extensive security APIs,** including common UNIX security APIs such as PAM, pkcs-11, and md5, let you port and integrate secure versions of UNIX utilities into Mac OS X to improve system security.

Numerical computing resources
Languages
- GNU g77 FORTRAN compiler:
  gravity.psu.edu/~khanna/hpc.html
- Metrowerks CodeWarrior (C++ development):
  www.metrowerks.com/products/macos
- NAGWare f95 compiler:
  www.nag.com/nagware.asp
- Absoft Pro Fortran:
  www.absoft.com/newosxproductpage.html
- PSR/Veridian VAST Optimizer:
  www.psrv.com
- Perl Data Language:
  fink.sourceforge.net/pdb/package.php/pdl
- Numerical Python (NumPy):
  ftp.cwi.nl/jack/python/mac

Environments
- Mathematica:
  www.wolfram.com/products/mathematica
- MATLAB:
  www.mathworks.com
- LabVIEW:
  www.ni.com/mac
- SPSS:
  www.spss.com/spssbi/spss_mac
- JMP Discovery:
  www.jmpdiscovery.com
- The R Project:
  cran.r-project.org
- Stata:
  www.stata.com

Clustering/Grid computing
- Platform LSF:
  www.platform.com/products/index.asp
- SGE (Sun's Grid Engine):
  wwws.sun.com/software/gridware/sge.html
- Pooch (based on UCLA's AppleSeed):
  www.daugerresearch.com
- MPICH (message-passing API standard):
  www.sdsc.edu/~tkaiser/mac_stuff/
  mpi_osx.html
- OpenPBS:
  www.openpbs.org

- **The BSD SDK** contains popular UNIX libraries and headers (including tcl, OpenSSL, ruby, and curl) that let you compile many common UNIX applications "out of the box."

- **The ncurses library** is included for advanced cursor control in terminal-based applications, especially useful for newer applications that expect it.

Numerical libraries

Mac OS X v10.2 is designed to support a wide range of numerical computation tools for desktop supercomputing, making it possible for developers to get optimal perfor-mance without using assembly language or platform-specific coding.

Mac OS X includes a robust suite of hand-optimized standard math libraries, plus high-performance, state-of-the-art libraries for digital signal processing and large number operations. Wherever possible, these libraries take advantage of the PowerPC G4 processor and its Velocity Engine. Best of all, unlike the costly comparable solutions for other platforms, these libraries are included free with every copy of Mac OS X. They include the following:

- **Optimized, C99-compliant libm.** The C math library in Mac OS X is compliant with C99 and IEEE 754, providing the fastest performance ever on the Mac for basic double-precision transcendental functions (including sin, cos, exp, and log), even when using standard cross-platform C code.

- **Vectorized digital signal processing (vDSP).** Built-in double- and single-precision operations accelerate Fast Fourier Transforms (FFTs), convolutions, and squares. These functions allow you to use high-performance routines to manipulate audio and other signal data, without needing to write Velocity Engine assembly code or distinguish between single and double precision.

- **BLAS (Basic Linear Algebra Subprograms) Levels I, II, and III.** These high-quality "building block" routines for performing basic vector and matrix operations include Level 1 BLAS for vector-vector operations, Level 2 BLAS for matrix-vector operations, and Level 3 BLAS for matrix-matrix operations. They enable you to perform standard, cross-platform vector and matrix mathematics with optimal performance, taking advantage of the Velocity Engine where possible.

- **LAPACK (Linear Algebra Package).** Written on top of BLAS, LAPACK provides routines for solving systems of simultaneous linear equations, least-squares solutions of linear systems of equations, eigenvalue problems, and singular-value problems. Cross-platform FORTRAN and C routines written to industry-standard LAPACK run at full native performance, using the Velocity Engine where possible.

- **vMathLib.** These basic vectorized transcendental functions provide a version of libm optimized for the Velocity Engine, enabling you to perform standard math functions on many operands at once.

- **vBigNum.** These basic arithmetic operations for manipulating large integers enable you to perform math operations on 128-bit integers, for applications such as cryptography.

Networking

Mac OS X supports a wealth of popular networking and file system standards, allowing Macintosh computers to fit easily into any computing environment.

TCP/IP

Networking in Mac OS X is based entirely on Internet-standard TCP/IP protocols. Specifically, Mac OS X networking is built on a full BSD TCP/IP stack—the first open implementation of TCP/IP, and the one that gave birth to the Internet we know today.

Important networking capabilities in Mac OS X include the following:

- **IPv6/IPSec,** the next generation of Internet protocols. Apple's implementation is based on the highly respected KAME IPv6 project for BSD, which also includes IPSec, a standards-based, secure networking technology that forms the foundation for many popular VPN solutions.

- **DNS** (Domain Name Services), the standard Internet service for mapping host names to IP addresses. Mac OS X implements DNS services using BIND, the Berkeley Internet Name Daemon.

- **DHCP.** Support for the Network Address Translation (NAT) protocol and the Dynamic Host Configuration Protocol (DHCP) allows multiple computers to connect to the Internet through a single Macintosh system.

- **inetd.** This Internet "super-server" listens for connections on certain sockets. When a connection occurs, inetd decides which service the socket corresponds to and invokes the appropriate program to service the request. inetd reduces system loads by eliminating the need to have many different daemons running to detect incoming requests.

- **Rendezvous** is a powerful, standards-based protocol, developed by Apple, that makes it easy to find systems and services on a local network without requiring a network administrator. Rendezvous appeared first in Mac OS X v10.2 and is already supported by a wide range of devices (printers, webcams), servers (Apache, ftpd), and other network-enabled services. It leverages existing IETF (Internet Engineering Task Force) standard protocols such as DNS service discovery and is designed to fit seamlessly into today's IP-based networks. Rendezvous is part of the IETF's ongoing standardization work; Apple has submitted Rendezvous as a Working Draft to the IETF's ZeroConf working group and has released it both as an open standard and as Open Source for use on other platforms.

File sharing

Mac OS X enables Macintosh systems to work smoothly with a wide range of file systems on networks of Macintosh, Windows, and other UNIX computers. Mac OS X can act as either a client or a server for the following file system protocols:

- **NFS** (Network File System) is the dominant file sharing protocol among UNIX variants.

- **AFP** (Apple File Protocol), running over TCP/IP, remains the principal file sharing protocol for Macintosh systems.

- **SMB/CIFS,** Microsoft's proprietary Server Message Block/Common Internet File System file service, is the primary file sharing protocol for Windows. Mac OS X bundles Samba, the popular Open Source SMB implementation, to enable Windows users to access files on Macintosh computers. In the other direction, the BSD-based SMB client support in Mac OS X gives Macintosh users the ability to browse and connect to Windows file servers and volumes.
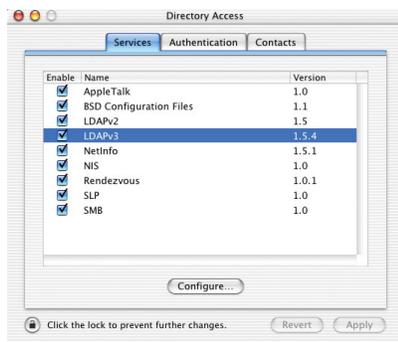

One-click file and Internet sharing

Internet sharing

With its powerful Apache web server and other essential Internet services, Mac OS X is the platform of choice for developing and serving Internet content.

- **HTTP.** Apache is the world's most popular web server, providing reliable, high-performance delivery of both static and dynamically generated web content. Mac OS X includes a fully native port of the standard Apache httpd server, providing Apache performance better than or equal to that of any other system in its class. Sharing Preferences lets users configure a basic Apache server with a single click, or they can edit the configuration files using a text editor just as with any other UNIX imple-mentation of Apache. Both mod_perl and the PHP server-side scripting language are included with Mac OS X for easy creation of dynamic web pages and CGIs.

- **WebDAV.** Web Distributed Authoring and Versioning, or WebDAV, allows people to collaboratively edit and manage files on remote web servers via the HTTP protocol. Mac OS X includes the Apache mod_dav module, enabling it to act as a DAV server, and a DAV file system, allowing it to mount other DAV servers on the desktop.

- **FTP** (File Transfer Protocol). FTP is the standard protocol used to move files between computers on TCP/IP networks. Mac OS X lets users activate an FTP server with a single click. In addition, FTP servers can be mounted as Mac OS X file systems.

Open Directory

Open Directory is Apple's directory services architecture built around LDAP, the IETF standard Lightweight Directory Access Protocol. Open Directory enables a computer running Mac OS X to authenticate users, find their home directories on the network, and provide file and print services using a centralized directory server. The Open Directory client is designed to use LDAP v2/3 and can be extended to work with legacy directories, allowing it to access data from services such as:

- OpenLDAP (the Open Source LDAP server)
- Sun's SunOne Directory Server (formerly iPlanet)
- Microsoft's Active Directory
- Novell's eDirectory (formerly NDS)
- Sun's Network Information System (NIS)
- Apple's NetInfo
- Traditional BSD configuration files (such as /etc/passwd)

Apple also provides an Open Directory server as part of Mac OS X Server, which can provide directory services over either LDAP or NetInfo.

Access to multiple directory services

Network security

Mac OS is the first operating system designed for the Internet, and Apple built proven security techniques into the core operating system from day one, where they can pro-tect both client and server systems. This fits into Apple's philosophy of helping users do the right thing, rather than expecting them to be experts on network security in order to manage their own systems safely.

- **Role-based administration.** Unlike other multiuser systems, Mac OS X does not require users to deal with an all-powerful Administrator or root account to manage the system. Instead, the initial user (and potentially other authorized users) authenticate into the Administrator role, which allows them to perform one specific privileged func-tion at a time. This negates whole categories of attacks that target the root account and reduces the ability of malicious programs to attack the system from within.

• **Network services turned off by default.** Unlike many systems, Mac computers are shipped with all ports closed (sometimes called "prehardened"). It takes only one click for authorized users to enable the services they actually need, but this approach avoids unnecessary exposure resulting from open network ports.

• **Fast, reliable software updates.** To ensure that Mac OS X users are always running the most secure systems possible, Apple provides rapid-response software updates to address CERT/FIRST alerts and other security concerns. The user is prompted to install these updates after connecting to the Internet. The majority of security alerts are unlikely to affect most users, since Apple disables most relevant services in Mac OS X.

• **Kerberos.** With Kerberos, authorized users can access multiple network services securely without repeatedly typing in their passwords. A full implementation of the MIT Kerberos client authentication services allows Mac OS X to participate on secure networks protected by Kerberos v4 and v5 servers. In addition to a kerberized login, Mac OS X includes kerberized applications such as Mail, ftp, telnet, and the AFP client. The Kerberos services in Mac OS X are also compatible with those in Microsoft Active Directory.

• **SSH** (Secure Shell). Mac OS X uses OpenSSH as its default protocol for secure command-line access between computers. SSH encrypts remote command-line traffic (including passwords) to effectively eliminate eavesdropping, connection hijacking, and other network-level attacks to which rlogin and telnet are susceptible. Mac OS X includes the full suite of OpenSSH client and server functionality, including ssh (command execution), sftp (file transfer), and scp (file copies).

• **VPN/PPTP.** Mac OS X v10.2 includes a Virtual Private Network (VPN) client that supports the Internet-standard Point-to-Point Tunneling Protocol (PPTP). This allows users to create a secure, encrypted connection to a private network, such as those often found in corporations and educational institutions. Users can securely access files from home through any compatible Internet service provider (including AOL or EarthLink) using any standard dial-up, DSL, or cable modem connection. Because PPTP is the same protocol used by Windows VPN servers, users on networks secured by Windows-based VPN solutions can access those networks remotely using Mac OS X. PPTP is also used in a number of UNIX/Linux and Cisco VPN products.

Integrated Virtual Private Networks

• **Firewall.** The built-in firewall in Mac OS X, based on FreeBSD's ipfw, protects a Macintosh system from Internet hackers by sealing off the computer's vulnerabilities. To provide a high level of security right out of the box, the firewall closes all ports by default. Ports that are subsequently opened can be filtered by the firewall to ensure that the system is not compromised. The firewall is easy to use; it has simple on/off checkboxes and human-readable names, and can be managed from System Preferences.

• **CDSA.** Mac OS X uses the Common Data Security Architecture (CDSA), an open standard from the Open Group, to provide a foundation for strong cryptography and a public key infrastructure. Apple created the first industrial-strength Open Source implementation of CDSA, and Mac OS X is the only major operating system with the CDSA built in. The CDSA provides a layered set of security services, as well as a cryptographic framework for creating security-enabled applications, including support for Secure Sockets Layer (SSL) v2/v3 and Transport Layer Security (TLS) v1. Apple also includes OpenSSL, a security library for use by legacy Open Source applications.

• **PAM.** Mac OS X integrates the Linux Pluggable Authentication Modules (PAM) into Apple's CDSA architecture, allowing UNIX applications to access CDSA services through a PAM API, and UNIX services to export functionality to CDSA-based applications via PAM modules.

Standards-based printing

CUPS printing

Mac OS X features a comprehensive, standards-compliant printing architecture based on the Open Source Common UNIX Printing System (CUPS v1.1)—making it easy to render documents faithfully on a wide range of printers. Features include:

· **PDF printing.** Mac OS X applications can print directly to PDF, which is based on the same imaging model as PostScript. This ensures that what users see on the screen is what they get on the printed page.

· **Internet Printing Protocol (IPP).** CUPS uses the IETF's Internet Printing Protocol, based on HTTP, to provide remote print spooling services. Mac OS X systems can print to any IPP-enabled print spool, and provide IPP spooling on port 631 to local printers when Printer Sharing is selected in Sharing preferences.

· **UNIX compatibility.** In addition to full GUI-based printing services, CUPS allows users to print files using traditional BSD (lpr, lprm, lpc) and SysV (lp, cancel, lpmove, lpstat) commands. It also accepts lpd print spooling requests.

· **Broad printer support.** Mac OS X v10.2 includes hundreds of built-in raster drivers and Adobe PostScript Printer Description (PPD) files. Other drivers from vendors and Open Source developers are readily available on the web, such as those at www.linuxprinting.org/macosx.

Communications

Mac OS X provides connectivity to both wired and wireless networks through Ethernet, AirPort, and Bluetooth.

· **Ethernet.** Mac OS X supports Gigabit (1000BASE-T) Ethernet as well as 10BASE-T and 100BASE-T Ethernet. It determines and defaults to the highest speed that can be used on a given connection.

· **AirPort.** AirPort, Apple's implementation of the 802.11 wireless networking technology, is easy to set up, easy to use, and inexpensive.* It lets users get on the Internet from almost anywhere in their home, school, or office—without cables, additional phone lines, or complicated networking hardware. AirPort enables wireless communications within a radius of approximately 150 feet from a base station. Apple's AirPort Extreme Base Stations support both the widely used Wi-Fi certified 802.11b protocol, providing data transfer at up to 11 megabits per second (Mbps), and the cutting-edge IEEE 802.11g specification at up to 54 Mbps. Best of all, since 802.11g is compatible with 802.11b, AirPort-enabled Mac systems automatically use whichever version is available.

· **Bluetooth.** Mac OS X v10.2 includes support for Bluetooth software and hardware. Bluetooth is a short-range, low-power wireless technology designed for automatic discovery of and easy access to handheld devices such as mobile phones and PDAs.

Command-Line Environment

UNIX users will quickly recognize the robust UNIX environment that underlies Mac OS X. That environment is accessible at any time from the Terminal application, which ships in the /Applications/Utilities folder with every copy of Mac OS X. With thousands of man pages included in Mac OS X, you can quickly find all your favorite UNIX tools.

UNIX utilities and scripting languages

All of the standard UNIX utilities and scripting languages you're familiar with are ready to use in Mac OS X. They include editors such as emacs, vi, and pico; file management tools such as cp, mv, ls, and tar; shell scripts including bash (the default /bin/sh) and tcsh (the default user shell); and scripting languages such as perl, php, tcl, ruby, and python.

Terminal emulation functionality

Terminal emulation in Mac OS X leverages ncurses for terminal emulation functionality on par with xterm, the most popular UNIX terminal. Mac OS X includes support for:

• VT100/VT220 emulation for cursor control, animation, and drawing

• Unicode (UTF-8) and VT220 fonts to enable the display of multiple languages and special characters, including tall and wide characters (type "ls -v /System/Library/Fonts" to see Japanese font names)

• Input and display of multibyte and bidirectional fonts

• Standard escape sequences that set ISO-6429 colors, highlighting, and blinking

Terminal application

These functions are implemented in the Mac OS X Terminal application, which makes command-line operations more versatile than ever. With Mac OS X, command-line users can enjoy a rich Aqua experience through these and other features:

• Split-view scrollback lets you view the entire history of the terminal session while entering new text.

• Drag-and-drop copying enables you to drag text from one window into a clip file, another window, or a different application—without having to touch the keyboard. You can even drag files onto a Terminal window from the Finder and have the path-names properly quoted.

• Full transparency support lets you watch other applications in the background while working at the command line.

• Fine-grained font control allows you to turn anti-aliasing on and off and adjust character and line spacing for optimum readability.

Developer tool resources
• UNIX Developer resources:
developer.apple.com/unix
• Open Source resources:
developer.apple.com/darwin
• Developer documentation:
developer.apple.com/techpubs/index.html
• Getting started tutorial for Mac OS X:
developer.apple.com/macosx/gettingstarted
• Developer tools downloads:
connect.apple.com (free login required)
• O'Reilly Mac Developer center:
mac.oreilly.com
• Stepwise developer portal:
www.stepwise.com

Developer Tools

Every copy of Mac OS X includes a free, professional-quality suite of developer applications, making it easier than ever for anyone to create Mac OS X–native applications. These applications are all built on the standard command-line developer tools familiar to the UNIX community.

GNU compiler collection

The popular gcc 3.1 compiler boasts fast C++ build times and superb standards compliance. Apple's gcc 3.1 is in sync with the Free Software Foundation's upstream source code, making it easy to rapidly incorporate new bug fixes and enhancements. Other major features of gcc 3.1 on Mac OS X include:

• Excellent support for C99, ANSI C++, and the C++ Standard Template Library (STL), providing great compatibility and portability, especially for newer C++ code

• A persistent front end with an integrated preprocessor for faster build times

• A forward-compatible C++ ABI (binary interface) that improves binary compatibility for C++ libraries across gcc 3.x versions

• Apple-created PowerPC code generation improvements, making gcc-generated code 25 percent faster overall than with gcc 2.95

Other developer tools

In addition to gcc and gdb, Mac OS X includes the other compilation and build tools you would expect from a UNIX operating system:

• A full suite of Java tools (javac, rmic, java, and jdb) based on JDK 1.4.1

Solutions resources
• MATLAB (MathWorks):
  www.mathworks.com
• Oracle 9i:
  www.oracle.com/start/apple/intro.html
• Sybase Adaptive Server:
  www.sybase.com/mac
• Fink package management:
  fink.sourceforge.net
• BSD Mall:
  www.bsdmall.com/darwin.html
• OpenOSX:
  www.openosx.com

Mac OS X by the numbers
• More than 40 built-in, easy-to-use graphical
  applications
• 5987 command-line utilities
• 21 visual developer tools
• 3822 man pages
• Over 2300 Open Source projects that have
  been ported to and packaged for Mac OS X

For More Information

Now that you've had an introduction to
the robust UNIX functionality of Mac OS X,
visit these Apple web pages to find out
more about specific topics:
• UNIX features in Mac OS X:
  www.apple.com/macosx/jaguar/unix.html
• Mac OS X in general:
  www.apple.com/macosx
• PowerBook G4, the world's best portable
  UNIX workstation:
  www.apple.com/powerbook
• Xserve, Apple's 1U rackmount server:
   www.apple.com/xserve
• Other Apple hardware products:
  www.apple.com/hardware
• Developer resources:
  developer.apple.com
• Open Source code releases:
  developer.apple.com/darwin
• Web development:
  developer.apple.com/internet

To purchase Apple products, visit the
Apple Store online (www.apple.com or
800-MY-APPLE), an Apple Store near
you, or an Apple Authorized Reseller.

• Two versions of Make (the default GNU make as well as BSD make)

• jam, the Open Source build system used by Apple's developer tools

• lex, flex, yacc, and bison parsing tools

• CVS and RCS, the standard UNIX source code management tools

Other Sources of UNIX Software

Of course, you don't always want to build your own software. Fortunately, you'll
discover that the most popular Open Source software has already been ported to
Mac OS X. For example, you can easily find such favorite command-line utilities as
a pine mail client, trn news reader, lynx web browser, TeX formatting package, and
even vim, a popular vi-based editor. In addition, there are both native and X11 ports
of major Open Source applications such as OpenOffice, the GIMP, and Mozilla.

Popular commercial UNIX applications are also available for Mac OS X. MATLAB from
MathWorks joins Wolfram's Mathematica to provide advanced analytical tools for Mac
users; Sybase is already shipping its Adaptive Server for Mac OS X, while Oracle has
released a developer preview of its database and other developer tools. Many other
key commercial applications are already available or in development.

To find out about these and the thousands of other applications available for Mac OS
X, you can visit one of the following sites:

• The Mac OS X Downloads page (www.apple.com/downloads/macosx) offers a wealth
  of links to Open Source and commercial Mac OS X applications.

• The Fink packaging tool (at fink.sourceforge.net) tracks all the dependencies of source
  code, libraries, and binaries, enabling you to download, build, and install thousands of
  Open Source UNIX applications with just a single click each.

• If you don't want to download all the software you use, check out one of the Open
  Source compilation CDs available for Mac OS X. BSD Mall offers a collection of UNIX
  utilities for Mac OS X, and OpenOSX provides user-friendly Mac OS X versions of UNIX
  solutions for databases, graphics, and word processing.

Mac OS X v10.2 "Jaguar": Wildly Innovative

There's much more to Mac OS X than described here. With its powerful Open Source
code and modular architecture, Mac OS X delivers the power and stability of UNIX
with the legendary simplicity of the Macintosh. The latest release, Mac OS X v10.2,
delivers more than 150 new features. They include the Quartz Extreme hardware-
accelerated graphics engine, QuickTime 6 media technology, industry-leading
networking technologies (including Rendezvous automatic device discovery), and
innovative applications such as iChat, iCal, and Sherlock. For information on these and
other Apple innovations, see "For More Information" at left or visit www.apple.com.