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Mac OS X An Overview for Developers

Introduction

Mac OS X is a mature operating system that combines the power of Unix with the simplicity and elegance of the Macintosh. Released in 2001 and engineered to take the Macintosh platform through the next decade, Mac OS X's robust integration of advanced technologies, reliance on standards, and remarkable user interface make it a compelling platform for developers and users alike.

The latest release, Mac OS X v10.3 Panther, offers significant technological enhancements and presents developers with an unprecedented opportunity to create innovative and compelling applications quickly and easily.

This document presents an overview of Mac OS X technologies, the benefits that these technologies provide for developers, and options for development.

Stability and Performance

Darwin

Superior stability and performance begins with Darwin, the open source, standardsbased core of Mac OS X. Darwin is based on BSD (Berkeley System Distribution) UNIX and provides support for many POSIX, Linux, and System V APIs. Apple integrated the widely used FreeBSD 5 UNIX distribution with the Mach 3.0 kernel to deliver key Darwin functionality, including:

- · Preemptive multitasking via the kernel
- · Symmetric multiprocessing (SMP) augmented by support for multithreading
- Protected memory and advanced virtual memory semantics
- Real-time support guaranteeing low-latency access to processor resources for time-sensitive media applications
- 64-bit support in the kernel for more than 4GB physical memory

Darwin also provides a familiar command-line development environment along with all of the standard Unix utilities and languages: editors such as emacs, vim and pico; file management tools such as cp, mv, ls and gnutar; shell scripts including bash (the default shell), tcsh (csh) and zsh; and scripting languages such as Perl, PHP, tcl, Ruby and Python.

Drivers and Networking

Darwin's modular design lets developers dynamically load device drivers, networking extensions, and new file systems. Device drivers are created using an object-oriented programming framework called I/O Kit. Drivers created with I/O Kit easily acquire true plug and play, dynamic device management ("hot plugging"), and power management. I/O Kit also provides hardware access to high-level application software.

Darwin supports a modern, TCP/IP-based networking architecture, including IPv4, IPv6, and L2TP/IPSec. For network protocol developers, Darwin provides the Network Kernel Extension (NKE) facility. This enables developers to create networking modules and even entire protocol stacks that can be dynamically loaded and unloaded. NKEs also make it possible to configure protocol stacks automatically and easily monitor and modify network traffic. At the data-link and network layers, they can also receive notifications of asynchronous events from device drivers.

Open Source and Apple

Darwin is an open source project whose license is certified by both the Free Software Foundation and the Open Source Initiative. Apple is committed to working with Mac OS X developers and the open source community to enhance Darwin. By pooling its expertise with the open source development community, Apple improves the quality, performance, and feature set of Mac OS X software.

Developers can find the latest Darwin source code at developer.apple.com/darwin/. This site also contains other open source projects from Apple, such as Rendezvous, CDSA, X11 for Mac OS X, and WebCore. In addition, developers can participate in the community-based OpenDarwin project at www.opendarwin.org.

X11 for Mac OS X

Mac OS X provides a complete X Window System implementation for running X11-based applications. X11 for Mac OS X is a rootless X11R6.6 implementation corresponding to XFree86 4.3, the same open source project used for X11 on Linux, BSD, and other UNIX-based systems.

X11 applications run side by side with native applications on the Mac OS X desktop and take full advantage of the Mac OS X graphics system to deliver responsive, hardware-accelerated 2D and 3D graphics performance.

A complete suite of standard X11 display server software, client libraries, and developer toolkits is also available, making it simpler than ever to port Linux and Unix applications to Mac OS X.

Powerful Graphics

The Mac OS X graphics system combines two-dimensional (2D), three-dimensional (3D), and time-based media standards using an industry-leading compositing window system that enables developers to push Mac OS X graphics beyond anything previously seen on a desktop operating system.

Aqua		
Carbon	Cocoa	Java
Quartz	Open GL	QuickTime
Darwin		

Mac OS X system architecture

Quartz and Quartz Extreme

Quartz is a powerful suite of 2D graphics technologies at the foundation of the Mac OS X imaging model, and is comprised of two main parts: Quartz 2D and the Quartz Compositor.

Quartz 2D is a high-performance graphics rendering library that acts as the primary imaging model for Mac OS X. Since it is based on version 1.4 of the multiplatform Portable Document Format (PDF) specification, developers can easily import, embed, and export PDF data in their applications. Quartz 2D also delivers device-independent and resolution-independent rendering of anti-aliased text, bitmap images, and vector graphics.

The Quartz Compositor is an advanced windowing system that manages the onscreen presentation of Quartz 2D, OpenGL, and QuickTime content. Where other windowing systems merely broker screen real-estate out to an application, the Quartz Compositor acts as a visual mixing board to composite each application's graphic content into Mac OS X's hallmark look and feel. The Quartz Compositor actually "owns" all of the pixels and works in conjunction with each application to gather window content and move it to the frame buffer. This centralized approach allows for full and pervasive support of transparency (alpha), live window dragging, and frees the application from the burden of double buffering animated screen content.

Quartz Extreme

On systems with supported display cards, the Quartz Compositor uses integrated OpenGL technology to push onscreen rendering operations through the display card Graphics Processing Unit (GPU). This functionality, known as Quartz Extreme, frees the system CPU to focus on application code, dramatically improving system performance and responsiveness.

Even without Quartz Extreme-compatible display cards, Mac OS X v10.3 Panther delivers across-the-board graphics optimizations which make all systems appear more responsive. Drawing windows, resizing, moving, scrolling—everything—seems faster in Panther.

OpenGL

For 3D graphics, Mac OS X features an optimized implementation of industry-standard OpenGL. An open standard for visualizing 3D shapes and textures, OpenGL is one of the most widely adopted, multiplatform graphics standards in use today. It is specifically designed for games, animation, CAD/CAM, medical imaging, and other applications that require a rich, robust framework for visualizing shapes in two and three dimensions.

It is Mac OS X's innovative integration of 2D and 3D graphics architectures that enables cutting-edge user interface enhancements such as Exposé. A new feature introduced for Mac OS X v10.3 Panther, Exposé gives users the ability to instantly display all open windows as thumbnails, to view all windows of the current application, or to hide all windows to locate a file on the desktop with a single keystroke. OpenGL and Quartz 2D work hand in hand to deliver the Exposé effect: animated scaling followed by shading and highlighting of high-quality thumbnails.



Exposé instantly tiles all open windows—scaling them down and arranging them, so users can see each one.

QuickTime

Time-based graphics on Mac OS X are provided by QuickTime 6. QuickTime enables developers to manipulate, enhance, and store video, sound, animation, graphics, text, music, and even 360-degree virtual reality. This comprehensive multiplatform multimedia architecture offers tremendous development advantages. Using QuickTime APIs, developers can deliver built-in streaming of either live or stored digital video within any application. And since QuickTime also provides file format converters for more than 250 common image, video, and audio file formats, developers can support and convert new file formats within their applications quickly and easily.

QuickTime supports every major file format for images, including BMP, GIF, JPEG, Photoshop, PNG, and TIFF. QuickTime 6 can be used to author professional-quality, ISO-compliant MPEG-4 audio and video files, and the QuickTime AAC codec brings true variable bit rate (VBR) encoding to the QuickTime platform to deliver sound quality rivaling that of uncompressed CD audio. QuickTime supports every significant professional file format for video, including AVI, AVR, DV, Flash, M-JPEG, MPEG-1, H.263, and OpenDML. For web streaming, QuickTime includes support for HTTP as well as RTP (Real-Time Transport Protocol) and RTSP (Real-Time Streaming Protocol).

QuickTime also features support for 3GPP, a new worldwide standard for third generation cellular telephony. As a result, 3G wireless developers and content providers can use QuickTime to author, playback, and deliver 3GPP-compliant files, extending the reach of rich multimedia to a new generation of handheld wireless devices.

Through the QuickTime plug-in, QuickTime's digital video streaming capability is extended to all popular web browsers, including Safari, Internet Explorer, Netscape Navigator, and America Online. The plug-in supports over thirty different media types and makes it possible to view over 80 percent of all Internet media. QuickTime also features other advanced web streaming capabilities, such as movie "hot spots" and automatic web page launching.

User Experience

The most visible expression of Mac OS X's integration and power is its Aqua user interface. Aqua incorporates the visual appearance of icons, menus, windows and controls with high-quality graphics and user-centric design to produce a user experience that is as functional as it is appealing. Consistent with Apple's design philosophy, visual enhancements such as color, transparency and animation serve not just as beautiful images, but as cues to the functionality and operation of the system and its applications.

Fast User Switching is an example where Aqua uses the sophisticated graphics system in Mac OS X v10.3 Panther to provide strong visual cues and user feedback. Fast User Switching lets two or more users make a secure switch between user accounts on a single Mac without quitting applications and logging out.



Fast User Switching utilizes a vivid and graceful visual cue to notify the user about a significant environment change.

Panther uses Quartz 2D and OpenGL to animate transitions from one user account to another. The current desktop becomes a texture placed on a 3D cube that rotates out of view while the incoming account desktop rotates into view on another side of the cube.

Apple offers developers a definitive guide to Mac OS X user experience design with the Mac OS X Human Interface Guidelines. These guidelines provide detailed instructions on how to create an intuitive interface that enables users to accomplish tasks quickly and efficiently, while maintaining the consistency and ease of learning that character-izes most successful Macintosh applications.

Interoperability

Mac OS X makes unprecedented use of technologies and standards that allow interaction among applications and with other platforms. This affords both developers and users the opportunity to use Macintosh computers in new places and in new ways.

Extensions to BSD and an enhanced Virtual File System (VFS) design allow Mac OS X to dynamically mount, read, and write to numerous local file systems, including:

- HFS Plus, the default journaled file system for Mac OS X (ships case insensitive with option for case sensitivity)
- UFS, based on Berkeley FFS
- ISO 9660, the standard format for CD-ROM volumes
- UDF, the Universal Disk Format for DVDs
- FAT32, the standard Windows interchange format
- NTFS (read-only), the high-end Microsoft file system format

Standard protocols supported by Mac OS X.

- Active Directory
- BOOTP
- CUPS
- DHCP
- DNS
- FTP
- HTTP
- IMAP
- IPv4
- IPv6
- IPSec
- Kerberos
- L2TP
- LDAP
- NIS
- NTP
- PPP
- PPTP
- SLP
- SMB/CIFS
- SSH
- SSL
- TCP/IP

Mac OS X provides support for network file services such as AFP, SMB/CIFS, WebDAV and NFS. It also includes extensive support for Windows, including Personal File Services for Windows, dynamic browsing for volumes, secure remote access using VPN, and interoperability with Active Directory, so that Mac OS X user volumes can appear as SMB volumes on a Windows network.

In Mac OS X, hardware connectivity for peripheral support is provided through USB (Universal Serial Bus), USB 2.0, FireWire 400/800 (IEEE 1394), and Fibre Channel. Wireless services are provided through AirPort Extreme (IEEE 802.11g) and Bluetooth. And standardized network connectivity is delivered through Ethernet (10/100/1000Base-T) and through serial connections for modems, ISDN, and DSL.

In addition, Mac OS X features Rendezvous, which uses industry-standard IP protocols to allow devices to automatically find each other without the need to enter IP addresses or configure DNS servers. Also known as Zero Configuration Networking, Rendezvous is an open protocol that Apple has submitted to the IETF as part of the ongoing standards creation process.

Easy Internationalization

Every major release of Mac OS X ships simultaneously in sixteen languages, including Japanese, French, German, Spanish, Italian, Dutch, Swedish, Danish, Norwegian, Finnish, Traditional Chinese, Simplified Chinese, Korean, and Brazilian Portuguese. Mac OS X also offers broad support for many additional languages, including Thai, Korean, Arabic, Hebrew, Russian, and Greek.

Mac OS X provides conversion utilities to manage locales, dates, currencies, and measurement systems in a consistent manner along with an array of technology to handle text systems used around the world.

Unicode is an international standard that combines the characters for all commonly used writing systems into a single, coded character set, based upon a 16-bit characterencoding standard. With a universal character encoding such as Unicode, the character sets of separate writing systems do not overlap. Mac OS X v10.3 Panther supports Unicode 4.

Apple Type Services for Unicode Imaging (ATSUI) is a set of services for rendering Unicode-encoded text. ATSUI is used by many parts of Mac OS X, including the Finder, making Mac OS X a truly international system that respects the display of complex languages and double-byte scripts. Using ATSUI enables applications to be internationaltext compliant, accommodating left-to-right text entry.

Lastly, the Multilingual Text Engine (MLTE) is a full-featured API for creating and editing Unicode text, providing services such as document-wide tabs, full justification of text, support for more than 32 KB of text, built-in scroll bar handling, built-in printing support, support for inline input, and support for multiple levels of undo.

Another way Mac OS X makes it easy to internationalize software is with application packaging. Using application packages, developers can group an application's executable with multiple libraries and resource files in what users view as a single binary. Thus, internationalized and localized software versions can launch dynamically from a single application icon.





Mac OS X Server

The server version of Mac OS X, known as Mac OS X Server, simplifies network administration by integrating services for file sharing, Web serving, networking, client management, email, and more.

Mac OS X Server comes with everything required to host dynamic web sites, stream audio and video, or develop and deploy powerful J2EE applications. The Apache web server, QuickTime Streaming Server, JBoss application server (including Enterprise Java Bean components), Tomcat, Apache Axis, Samba 3, and MySQL 4 are built-in. The Panther version of Mac OS X Server also features new application deployment tools with a graphical user interface, making it easier to configure existing J2EE applications for hosting on Mac OS X Server.

Mac OS X Server ships with a Server Admin application that provides a single-window interface for managing and monitoring network services. System administrators can start and stop services with a single button, modify settings, view real-time logs and activity graphs, monitor disk space, and even check networking and CPU activity. Server Admin plug-in APIs make it possible for developers to create administrative tools for their own applications that can be incorporated directly into the Server Admin window view.

Development Options

There are multiple ways to develop for Mac OS X. Individual skills, preferred programming languages and development tools, target user base, and time to market concerns will influence a developer's approach. The following development environments are available:

Carbon

Carbon is a set of procedural C APIs for developing full-featured, high-performance, highly reliable applications for Mac OS X. The Carbon API set is based on earlier Macintosh APIs, but expanded and enhanced to take advantage of the power of Mac OS X.

Сосоа

Cocoa is a rich object-oriented framework designed specifically for developing Mac OS X-only native applications. When coupled with Interface Builder, Apple's interface design tool, developers can create full-featured, object-oriented applications on Mac OS X in a fraction of the time they would need using procedural languages.

Developers coming from UNIX and other OS platforms often use Cocoa to a build state-of-the-art Aqua user interface on top of a core of portable, platform-agnostic code.

Java

Every copy of Mac OS X ships with a highly optimized and tightly integrated implementation of Java 2 Standard Edition (J2SE) version 1.4.1, including the Java Developer Kit (JDK) and the HotSpot virtual machine. Since pure Java applications and applets often run on Mac OS X without modification, developers are beginning to realize how easy it is to deploy Java applications on a new high-volume desktop platform. Building on Sun's HotSpot technology, the Mac OS X Java VM shares significant runtime data between processes, reducing memory usage and startup time when running multiple Java applications. In addition, Mac OS X treats JAR files as shared libraries, which improves the speed of execution and reduces the RAM footprint of applications which rely on the same archive, such as applications within suites.

Other benefits of Apple's Java implementation include access to Aqua user interface elements "for free" through AWT and Swing, OpenGL hardware-accelerated graphics for Java2D, and Java Web Start support to enable remote deployment and web-based launching of applications.

BSD Unix

Because Mac OS X is built atop a Mach/BSD kernel and provides a robust set of optimized libraries and routines, developers of multiplatform UNIX applications often find they can port libraries and applications to Mac OS X with minimal change to their existing applications. Supported Unix APIs and libraries include:

- A standard, multithreaded C library that includes support for such capabilities as reentrant variants of standard functions, easing the porting of thread-aware applications to Mac OS X.
- POSIX API support, including POSIX thread signaling and I/O, for easy porting of POSIX applications.
- UNIX/Linux portability APIs, including System V semaphores, making it easy to port applications from System V-based versions of UNIX such as Linux and Solaris.
- The BSD SDK, which contains popular UNIX libraries and headers that help developers compile common UNIX applications right out of the box.

Developer Tools

Xcode Tools is a complete suite of developer tools that combines a high-performance, UNIX-based development environment with a groundbreaking user interface that delivers a new level of developer productivity and ease of use.

The suite is available for free from Apple and due to several unique productivity features, it delivers significantly faster turn around times for developers creating applications on Mac OS X. With Xcode Tools, Apple has streamlined the most common and time-consuming developer tasks.

Xcode

Xcode is a full-featured integrated development environment (IDE) that provides project editing, search and navigation, file editing, project building and debugging facilities for all types of Mac OS X software projects.

Xcode is designed to facilitate development of applications, tools, frameworks, libraries, plug-in bundles, kernel extensions and device drivers. Xcode supports developers using C, C++, Objective C, AppleScript and Java.

The easy-to-navigate user interface in Xcode presents all the information and tools developers need in a streamlined interface. The Fix and Continue feature enables developers to make live code changes to a running application and see their effect immediately without recompiling the application. Zero Link acheives dramatically reduced turnaround times by removing the linking stage for all development builds. And project build times are minimized through a Rendezvous-enabled Distributed Build feature allowing developers to compile applications using multiple networked systems.

Interface Builder

Interface Builder is the graphical user interface design tool for Mac OS X applications. Interface Builder's graphical editing environment ensures easy adherence to the Mac OS X Human Interface Guidelines.

AppleScript Studio

AppleScript is the versatile and powerful natural language scripting system for Mac OS X. It provides direct control of scriptable Macintosh applications, such as databases, networks, and Web services—even the operating system itself. Scriptable applications enable users to build automated workflows. AppleScript Studio enables users to build individual scripts and workflows into complete Aqua-compliant applications.

GNU Compiler Collection 3.3 (GCC 3.3)

Xcode Tools includes an enhanced version of GCC 3.3 that provides significantly faster compile times and code optimizations, as well as features that assist in debugging. GCC 3.3 can generate optimized code for the Power Mac G5, as well as code that executes efficiently on G4 and G3-based systems.

Performance Optimization

The Xcode Tools suite provides an extremely robust collection of performance analysis tools, which fall into two categories: non-invasive tools, both command-line and graphical, that operate at the process level; and the Computer Hardware Understanding Development (CHUD) tools, which rely upon dedicated hardware features to operate.

Command-Line Tools

Xcode Tools also includes many familiar command-line development tools, such as:

- distcc, a front-end to GCC that distributes builds of C, C++, Objective-C, or Objective-C++ code across several computers on a network
- A full suite of Java compilation and debugging tools (javac, rmic, java, and jdb) based on JDK 1.4.1
- Two versions of make (the default GNU make as well as BSD make)
- Parsing tools (lex, flex, yacc, and bison)
- CVS and RCS, the standard UNIX source code management tools

Conclusion

This document provides a brief overview of the unique combination of industryleading technologies found within Mac OS X. The development options highlighted here represent opportunities for developers from many different backgrounds to port and to build innovative and compelling Mac OS X applications.

Further Reading

For complete documentation, tutorials, and business information about developing for Mac OS X, please visit the Apple Developer Connection website at developer.apple.com/.

Become a free Online member of the Apple Developer Connection and receive the ADC News, an electronic newsletter featuring weekly updates about available software, tutorials, and documentation. For complete information, please visit developer.apple.com/membership/.

To learn more about the architecture and features of Mac OS X, refer to "Inside Mac OS X: System Overview." A free copy of this and other technical documentation is available in html and PDF format at developer.apple.com/macosx/.

To learn complete details about the Mac OS X's Unix underpinnings, refer to "Mac OS X for Unix Users." A free copy of this technical brief is available in PDF format at www.apple.com/macosx/techspecs/.

To read the Aqua Human Interface Guidelines, please visit developer.apple.com/documentation/MacOSX/Conceptual/SystemOverview/.

To learn more about developing for Mac OS X Server, please visit www.apple.com/server/macosx/.

To learn complete details about Xcode Tools, refer to "Xcode: The Fastest Way to Create Mac OS X Applications." A free copy of this technical brief is available in PDF format at www.apple.com/macosx/techspecs/.

To download Xcode Tools, please visit the Apple Developer Connection website at developer.apple.com/tools/.

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