Mac OS X

An Overview for Developers

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Introduction

With Mac OS X ("ten"), Apple has asserted its leadership in the advanced technologies and design sensibility that are the hallmarks of any great operating system. While preserving the famed ease of use of its predecessors, Mac OS X is an industrial-strength, modern operating system engineered for reliability, stability, scalability, and phenomenal performance. As such, it lays the foundation for another decade of developer innovation.

Mac OS X is a completely rebuilt implementation of the Macintosh operating system. It expands on Apple's technological strengths, such as industry-standard networking capabilities and industry-leading user interface design. More importantly, Mac OS X combines those strengths with support for a variety of technologies beyond those typically associated with the Macintosh, such as UNIX and Java 2 Standard Edition. This unique combination of technologies offers developers stability, power, and interoperability, beneath a well-designed, elegant, and intuitive user interface. As a result, Mac OS X presents new opportunities for both development and deployment.

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

Apple and Open Source

Apple is the first major computer company to make open source development a key part of its ongoing software strategy. The core of Mac OS X, Darwin, is itself an open source project. This approach to operating system development allows developers and students to view the Darwin source code, learn from it, and submit suggestions and modifications. Developers can participate in the Darwin open source project by signing up at http://developer.apple.com/darwin/.

Stability and Power

Darwin

The stability of Mac OS X begins with Darwin, the open source core of the system. Darwin integrates a number of technologies, including the Mach 3.0 kernel, operating system services based on BSD UNIX (Berkeley Software Distribution), high-performance networking facilities, and support for multiple integrated file systems. Further, Darwin's modular design lets developers dynamically load such things as device drivers, networking extensions, and new file systems.

A key factor in the stability of the system is Darwin's advanced memory protection and management system. Darwin ensures reliability by protecting applications with a robust architecture that allocates a unique address space for each application or process. The Mach kernel augments standard virtual memory semantics with the abstraction of memory objects. This enables Mac OS X to manage separate application environments simultaneously, while presenting users with a seamless experience.

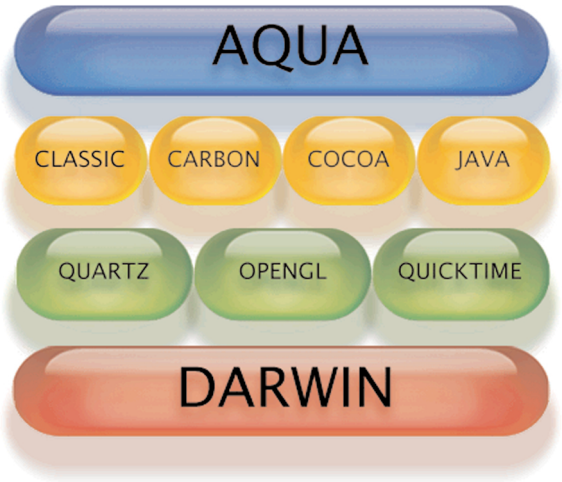
Device drivers are created using an object-oriented programming framework called I/O Kit. Drivers created with I/O Kit easily acquire true plug and play, dynamic device management ("hot plugging"), and power management. I/O kit also provides hardware access to high level application software.

For network protocol developers, Darwin provides the Network Kernel Extension (NKE) facility. This allows 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.

Since Mac OS X is designed to excel in a heterogeneous computing environment, Darwin also offers support for multiple file systems. Based on extensions to BSD and an enhanced Virtual File System (VFS) design, the file system component of Darwin uses a layered architecture in which file systems are stackable. It also introduces several other general features: permissions on removable media including USB and FireWire devices, URL-based volume mount, a unified buffer cache, and long filenames based on UTF-8.

Darwin also supplies the following advanced functionality:

- Preemptive and cooperative multitasking via the Mach kernel.
- Symmetric multiprocessing (SMP) augmented by support for multithreading.
- Real-time support guaranteeing low-latency access to processor resources for time-sensitive media applications.



Mac OS X system architecture

Graphics System

Mac OS X combines three powerful graphics technologies, Quartz, OpenGL and QuickTime, enabling developers to push graphics beyond anything users have seen on a desktop operating system.

Quartz

Quartz is comprised of a high-performance, lightweight window server and a graphics rendering library for two-dimensional (2D) shapes. The window server features such advanced capabilities as device-independent color and pixel depth, layered compositing, and buffered windows for the automatic repair of window damage.

The rendering model of Quartz is based on the cross-platform Portable Document Format (PDF) standard, enabling developers to easily embed and manipulate PDF data within any Mac OS X application. This yields such benefits as automatic PDF generation and save-as-PDF, automatic onscreen preview of graphics, conversion of PDF data to printer raster data or PostScript, and a consistent feature set for all printers.

The layered compositing engine used by Quartz allows developers to create unique onscreen effects. It replaces the "switch model" of traditional windowing systems with a "video mixer" model in which every pixel on the screen can be shared among windows in real time. This model allows for smooth transitions between the states of the graphical user interface.

Another important feature of Quartz is its ability to do window bitmap buffering. In Mac OS X, each window is represented as a bitmap that includes both translucency (alpha channel) and anti-aliasing information. This bitmap is buffered, allowing the window server to "remember" an application's window contents and to recomposite it without the application's involvement, providing improved graphics performance without additional developer effort.

Quartz also provides developers with these advantages:

- On the fly anti-aliasing of graphics and text enabled by the use of a floating-point coordinate system and high-precision vector processing.
- Direct access to the video frame buffer.
- Automatic detection of and benefit from the floating-point coprocessing performed by the Velocity Engine in PowerPC G4 microprocessors.
- High-quality screen rendering.

OpenGL

For three-dimensional (3D) graphics, Mac OS X features an optimized implementation of industry-standard OpenGL. OpenGL is one of the most widely adopted graphics standards today, making code written to OpenGL extremely portable and making generated visual effects highly consistent. It is specifically designed for games, animation, CAD/CAM, medical imaging, and other applications that need a rich, robust framework for visualizing shapes in two and three dimensions.

The Darwin foundation of Mac OS X ratchets up OpenGL performance. For applications that manage OpenGL resources like large textures, Mac OS X is very efficient at moving texture memory from applications to 3D graphics cards, ensuring maximum quality and frame rates.

QuickTime

Mac OS X comes packaged with the latest version of QuickTime, a powerful multimedia technology for manipulating, enhancing, and storing video, sound, animation, graphics, text, music, and even 360-degree virtual reality. It also allows streaming of either live or stored digital video. As a cross-platform technology, QuickTime can deliver content on Mac OS X, as well as Mac OS 8, Mac OS 9, Windows 95, Windows 98, Windows NT, Windows 2000, and Windows XP.

Augmenting its cross-platform capabilities, QuickTime supports every major file format for images, including BMP, GIF, JPEG, Photoshop, PNG, and TIFF. It also 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).

Through the QuickTime plug-in, QuickTime's digital video streaming capability is extended to all popular web browsers, including 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.

Rapid Interface Development with Interface Builder

Interface Builder is Apple's user interface design tool for applications. Developers using its graphical editing environment can manage virtually every aspect of creating a well-designed user interface that adheres to the Mac OS X user interface guidelines. This allows developers to create and test application interface elements quickly, so that a programmer's time can be spent developing application logic rather than learning interface code.

Interface Builder works with Project Builder (Apple's Integrated Development Environment) to make application design and development more productive and to create highly reliable, good-looking applications.

User Interface

The most visible expression of Mac OS X power and technology is its new user interface, Aqua. Apple applies its leadership in user interface design to Aqua, incorporating many of the qualities and characteristics Macintosh users expect, while adding advancements to benefit expert and novice users alike. Ease of use is factored into every feature and capability. Consistent with Apple's design philosophy, visual enhancements serve not just as beautiful images, but as cues to the functionality and operation of the system.

A prime example of this user-focused design is the use of "sheets." These non-modal dialog boxes attach directly to the title bar of the relevant document, intuitively linking document and action. The non-modal nature of sheets prevents applications from hijacking the system and interrupting user workflow.

A non-modal save dialog in Mac OS X remains linked to its parent window.

One of the Mac OS X user interface features that benefits developers is its application packaging method. Using application packages, developers can group an application's executable with multiple libraries and resource files in what end users view as a single icon. Thus, developers can simplify the installation process for users, while packaging internationalized and localized software versions in the same bundle.

Interoperability

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

Networking and File Systems

Mac OS X manages multiple file and networking formats and protocols. Based on an enhanced VFS design, the file system supports the following local formats:

- Universal File System (UFS), similar to the standard volume format of most UNIX operating systems and supporting POSIX file system semantics, important for many server applications.
- NFS (Network File System), used for sharing volumes over TCP/IP networks.
- Universal Disk Format (UDF) for DVD volumes.
- ISO 9660, the standard format for CD-ROM volumes.
- Mac OS Standard (HFS), the format used on Macintosh systems prior to Mac OS 8.1.
- Mac OS Extended (HFS Plus), the default format on systems from Mac OS 8.1 through Mac OS X.

Mac OS X supports the following industry-standard protocols:

- WebDAV (Web Distributed Authoring and Versioning), which allows users to collaboratively edit and manage files on remote web servers.
- SMB (Server Message Block), a protocol designed to allow file and printer sharing across a small network.
- TCP/IP (Transmission Control Protocol) and UDP/IP (User Datagram Protocol), transmission-layer protocols that function with the network-layer Internet Protocol.
- PPP (Point to Point Protocol), used for dialup (modem) access.
- PAP (Printer Access Protocol), used for spooling print jobs and printing to network printers.
- HTTP (Hypertext Transport Protocol), the standard protocol for transferring web pages between a web server and a browser.
- FTP (File Transfer Protocol), used to move files between computers on TCP/IP networks.
- DNS (Domain Name Services), the standard Internet service for mapping host names to IP addresses.
- SLP (Service Location Protocol), designed for the automatic discovery of resources (printers, servers, fax machines, etc.) on an IP network.
- DHCP (Dynamic Host Configuration Protocol) and BOOTP (Bootstrap Protocol) automate the assignment of IP addresses in a particular network.
- LDAP (Lightweight Directory Access Protocol), used to locate organizations, individuals, and resources such as files and devices in a network.
- NTP (Network Time Protocol), used for synchronizing client clocks.

Mac OS X provides standard support for hardware connectivity through Ethernet (10/100/1000Base-T), and serial connections for modems, ISDN, DSL, etc. Wireless networking through AirPort (IEEE 802.11) is built into Mac OS X, and peripheral interconnectivity is provided through USB (Universal Serial Bus) and FireWire (IEEE 1394).

Macintosh Systems

Darwin's ability to manage multiple application environments simultaneously makes Mac OS X interoperable with previous versions of the Mac OS. Two Mac OS X environments, Classic and Carbon, are specifically designed for such interoperability.

The Classic environment is actually a full version of Mac OS 9.1 running in a protected memory space under Mac OS X. As a result, most Mac OS 9 compatible applications will run side-by-side with Mac OS X applications. This allows users to upgrade to Mac OS X without fear of application incompatibility. Carbon is a native Mac OS X environment that allows programmers to take advantage of advanced Mac OS X features while retaining compatibility with the installed base of Macintosh computers running Mac OS 8.1 and later.

Java Platform

Mac OS X ships with a complete implementation of Java 2 Standard Edition (J2SE) version 1.3.1, including the HotSpot virtual machine. Benefits of Apple's Java implementation include access to Aqua user interface elements "for free" through Swing, native preemptive multitasking, multiprocessing support (with no additional coding required), and treatment of JAR files as shared libraries. This last advance improves the speed of execution and reduces the RAM footprint of applications which rely on the same archive, such as applications within suites. Additionally, Mac OS X plugs the Java windowing toolkit directly into the Mac's native windowing toolkit, giving Java applications and applets the graphics performance benefits of Quartz.

Development Options

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

Carbon

The Carbon APIs are based on earlier Mac OS APIs. While Carbon allows applications to take advantage of Mac OS X features such as multiprocessing support and the Aqua user interface, Carbon is specifically designed to allow compatibility with older versions of the Mac OS.

Cocoa

The Cocoa application environment runs natively under Mac OS X. For those who wish to develop for Mac OS X using rapid application development (RAD) tools and object-oriented techniques, the Cocoa frameworks provide a fast and complete way to do so. These frameworks offer both Java and Objective-C APIs.

Java

The Java application environment allows development and execution of Java programs on Mac OS X. The J2SE implementation in Mac OS X is designed to allow maximum Java application portability while delivering the performance benefits of Mac OS X. Developers can also use the Java development language to write a Cocoa application, allowing Java programmers to use a familiar language to develop for a new platform.

Unix

Since Mac OS X is built atop a Mach/BSD kernel, porting UNIX-based applications to the platform is relatively easy and enables enterprise-level UNIX products to enjoy parity with consumer and business applications on a commercial desktop platform.

Conclusion

This document provides only a cursory view of the unique combination of industry-leading 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.

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

For further documentation, tutorials, or business information about developing for Mac OS X, please visit the Apple Developer Connection website at http://developer.apple.com/macosx/.

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