Android (operating system)

Android

Home screen displayed by Samsung Galaxy Nexus, running Android 4.0 "Ice Cream Sandwich"

Company / developer	Google Inc, Open Handset Alliance
Programmed in	C (core),[1] Java (UI), C++
Working state	Current
Source model	Open Source[2]
Initial release	20 September 2008
Latest stable release	4.0.3 (Ice Cream Sandwich) / 16 December 2011[3]
Package manager	APK
Supported platforms	ARM, MIPS,[4] x86 [5] [6]
Kernel type	Monolithic (Linux kernel)
Default user interface	Graphical
License	Apache License 2.0 Linux kernel patches under GNU GPL v2[7]
Official website	www.android.com [8]

Android is an operating system for mobile devices such as smartphones and tablet computers. It is developed by the Open Handset Alliance led by Google.[9] [10]

Google purchased the initial developer of the software, Android Inc., on August 17, 2005.[11] The unveiling of the Android distribution on November 5, 2007 was announced with the founding of the Open Handset Alliance, a consortium of 84 hardware, software, and telecommunication companies devoted to advancing open standards for mobile devices.[12] [13] [14] [15] Google released most of the Android code under the Apache License, a free software license.[16] The Android Open Source Project (AOSP) is tasked with the maintenance and further development of Android.[17]

Android consists of a kernel based on the Linux kernel, with middleware, libraries and APIs written in C and application software running on an application framework which includes Java-compatible libraries based on Apache

Harmony. Android uses the Dalvik virtual machine with just-in-time compilation to run Dalvik dex-code (Dalvik Executable), which is usually translated from Java bytecode.[18]

Android has a large community of developers writing applications ("apps") that extend the functionality of the devices. Developers write primarily in a customized version of Java.[19] As of October 2011 there were more than 300,000 apps available for Android, and the estimated number of applications downloaded from the Android Market as of December 2011 exceeded 10 billion.[20] [21] Apps can be downloaded from third-party sites or through online stores such as Android Market, the app store run by Google.

Android was listed as the best-selling smartphone platform worldwide in Q4 2010 by Canalys[22] [23] with over 200 million Android devices in use by November 2011,[24] across the several versions of the operating system. As of December 2011 there are over 700,000 Android devices activated every day.[25]

History

Foundation

Android, Inc. was founded in Palo Alto, California, United States in October, 2003 by Andy Rubin (co-founder of Danger),[26] Rich Miner (co-founder of Wildfire Communications, Inc.),[27] Nick Sears (once VP at T-Mobile),[28] and Chris White (headed design and interface development at WebTV)[29] to develop, in Rubin's words "...smarter mobile devices that are more aware of its owner's location and preferences".[30] Despite the obvious past accomplishments of the founders and early employees, Android Inc. operated secretly, revealing only that it was working on software for mobile phones.[30]

That same year, Rubin ran out of money. Steve Perlman brought him $10,000 in cash in an envelope and refused a stake in the company.[31]

Acquisition by Google

Google acquired Android Inc. in August 2005, making Android Inc. a wholly owned subsidiary of Google Inc. Key employees of Android Inc., including Andy Rubin, Rich Miner and Chris White, stayed at the company after the acquisition.[11] Not much was known about Android Inc. at the time of the acquisition, but many assumed that Google was planning to enter the mobile phone market with this move.[11]

Post-acquisition development

At Google, the team led by Rubin developed a mobile device platform powered by the Linux kernel. Google marketed the platform to handset makers and carriers on the promise of providing a flexible, upgradable system. Google had lined up a series of hardware component and software partners and signaled to carriers that it was open to various degrees of cooperation on their part.[32] [33] [34]

Speculation about Google's intention to enter the mobile communications market continued to build through December 2006.[35] Reports from the BBC and *The Wall Street Journal* noted that Google wanted its search and applications on mobile phones and it was working hard to deliver that. Print and online media outlets soon reported rumors that Google was developing a Google-branded handset.[36] Some speculated that as Google was defining technical specifications, it was showing prototypes to cell phone manufacturers and network operators.

In September 2007, *InformationWeek* covered an Evalueserve study reporting that Google had filed several patent applications in the area of mobile telephony.[37] [38]

Open Handset Alliance

On November 5, 2007, the Open Handset Alliance, a consortium of several companies which include Broadcom Corporation, Google, HTC, Intel, LG, Marvell Technology Group, Motorola, Nvidia, Qualcomm, Samsung Electronics, Sprint Nextel, T-Mobile and Texas Instruments unveiled itself. The goal of the Open Handset Alliance is to develop open standards for mobile devices.[14] On the same day, the Open Handset Alliance also unveiled their first product, Android, a mobile device platform built on the Linux kernel version 2.6.[14]

On December 9, 2008, 14 new members joined, including ARM Holdings, Atheros Communications, Asustek Computer Inc, Garmin Ltd, Huawei Technologies, PacketVideo, Softbank, Sony Ericsson, Toshiba Corp, and Vodafone Group Plc.[39] [40]

Version history

Android has seen a number of updates since its original release, each fixing bugs and adding new features. Each version is named, in alphabetical order, after a dessert.[41]

Android dog model at the Googleplex, 2008

Recent releases

- **2.3 Gingerbread** refined the user interface, improved the soft keyboard and copy/paste features, improved gaming performance, added SIP support (VoIP calls), and added support for Near Field Communication.[42]
- **3.0 Honeycomb** was a tablet-oriented[43] [44] [45] release which supports larger screen devices and introduces many new user interface features, and supports multi-core processors and hardware acceleration for graphics.[46] The first device featuring this version, the Motorola Xoom tablet, went on sale in February 2011.[47] [48]
  - **3.1 Honeycomb**, released in May 2011, added support for extra input devices, USB host mode for transferring information directly from cameras and other devices, and the Google Movies and Books apps.[49]
  - **3.2 Honeycomb**, released in July 2011, added optimization for a broader range of screen sizes, new "zoom-to-fill" screen compatibility mode, loading media files directly from SD card, and an extended screen support API.[50] Huawei MediaPad is the first 7 inch tablet to use this version [51]
- **4.0 Ice Cream Sandwich**, announced on October 19, 2011, brought Honeycomb features to smartphones and added new features including facial recognition unlock, network data usage monitoring and control, unified social networking contacts, photography enhancements, offline email searching, app folders, and information sharing using NFC. Android 4.0.3 Ice Cream Sandwich is the latest Android version that is available to phones. The source code of Android 4.0.1 was released on November 14, 2011.[52]

Licensing

The source code for Android is available under free and open source software licenses. Google published their Linux kernel changes under the GNU General Public License version 2, and the rest of the code (including network and telephony stacks)[53] under the Apache License version 2.0.[54] [55] [56] Google also keeps the reviewed issues list publicly open for anyone to see and comment.[57]

The Open Handset Alliance develops the GPL-licensed part of Android, that is their changes to the Linux kernel, in public, with source code publicly available at all times. The rest of Android is developed in private, with source code released publicly when a major new version is released. Typically Google collaborates with a hardware manufacturer to produce a flagship device featuring the new version of Android, then makes the source code available after that device has been released.[58]

Even though the software is open source, device manufacturers cannot use Google's Android trademark unless Google certifies that the device complies with their Compatibility Definition Document (CDD). Devices must also meet this definition to be eligible to license Google's closed-source applications, including the Android Market.[59]

In September 2010, Skyhook Wireless filed a lawsuit against Google in which they alleged that Google had used the compatibility document to block Skyhook's mobile positioning service (XPS) from Motorola's Android mobile devices.[60] In December 2010 a judge denied Skyhook's motion for preliminary injunction, saying that Google had not closed off the possibility of accepting a revised version of Skyhook's XPS service, and that Motorola had terminated their contract with Skyhook because Skyhook wanted to disable Google's location data collection functions on Motorola's devices, which would have violated Motorola's obligations to Google and its carriers.[61]

In early 2011, Google chose to temporarily withhold the Android source code to the tablet-only Honeycomb release, creating doubts over Google's commitment to open source with Android.[62] The reason, according to Andy Rubin in an official Android blog post, was because Honeycomb was rushed for production of the Motorola Xoom,[63] and they did not want third parties creating a "really bad user experience" by attempting to put onto smartphones a version of Android intended for tablets.[64] The source code was once again made available in November 2011 with the release of Android 4.0.[65]

Design

Linux

Android's kernel is a fork of the Linux kernel and has further architecture changes by Google outside the typical Linux kernel development cycle.[66] Android does not have a native X Window System nor does it support the full set of standard GNU libraries, and this makes it difficult to port existing Linux applications or libraries to Android.[67]

Certain features that Google contributed back to the kernel, notably a power management feature called wakelocks, were rejected by mainline kernel developers, partly because kernel maintainers felt that Google did not show any intent to maintain their own code.[68] [69] [70] Even though Google announced in April 2010 that they would hire two employees to work with the Linux kernel community,[71] Greg Kroah-Hartman, the current Linux kernel maintainer for the -stable branch, said in December 2010 that he was concerned that Google was no longer trying to get their code changes included in mainstream Linux.[69] Some Google Android developers hinted that "the Android team was getting fed up with the process", because they were a small team and had more urgent work to do on Android.[72]

However, in September 2010 Linux kernel developer Rafael J. Wysocki added a patch that improved the mainline Linux wakeup events framework. He said that Android device drivers that use wakelocks can now be easily merged into mainline Linux, but that Android's opportunistic suspend features should not be included in the mainline kernel.[73] [74] In 2011 Linus Torvalds said that "eventually Android and Linux would come back to a common kernel, but it will probably not be for four to five years."[75] .

On December 23, 2011 Greg Kroah-Hartman announced that some of the android drivers would be included again in Linux 3.3 being this ones maintain by a non-google group [76] . The Android Mainlining Project publicly invited developers interested in helping to integrate Android patches into the mainline kernel to join the project's mailing list.

Features

Current features and specifications:[77] [78] [79]

The Android Emulator default home screen (v1.5)

Handset layouts

The platform is adaptable to larger, VGA, 2D graphics library, 3D graphics library based on OpenGL ES 2.0 specifications, and traditional smartphone layouts.

Storage

SQLite, a lightweight relational database, is used for data storage purposes.

Connectivity

Android supports connectivity technologies including GSM/EDGE, IDEN, CDMA, EV-DO, UMTS, Bluetooth, Wi-Fi, LTE, NFC and WiMAX.

Messaging

SMS and MMS are available forms of messaging, including threaded text messaging and now Android Cloud To Device Messaging (C2DM) is also a part of Android Push Messaging service.

Multiple language support

Android supports multiple languages.[42]

Architecture diagram

Web browser

The web browser available in Android is based on the open-source WebKit layout engine, coupled with Chrome's V8 JavaScript engine. The browser scores 100/100 on the Acid3 test on Android 4.0, however does have some rendering issues.

Java support

While most Android applications are written in Java, there is no Java Virtual Machine in the platform and Java byte code is not executed. Java classes are compiled into Dalvik executables and run on Dalvik, a specialized virtual machine designed specifically for Android and optimized for battery-powered mobile devices with limited memory and CPU. J2ME support can be provided via third-party applications.

Media support

Android supports the following audio/video/still media formats: WebM, H.263, H.264 (in 3GP or MP4 container), MPEG-4 SP, AMR, AMR-WB (in 3GP container), AAC, HE-AAC (in MP4 or 3GP container), MP3, MIDI, Ogg Vorbis, FLAC, WAV, JPEG, PNG, GIF, BMP.[79]

Streaming media support

RTP/RTSP streaming (3GPP PSS, ISMA), HTML progressive download (HTML5 <video> tag). Adobe Flash Streaming (RTMP) and HTTP Dynamic Streaming are supported by the Flash plugin.[80] Apple HTTP Live Streaming is supported by RealPlayer for Mobile,[81] and by the operating system in Android 3.0 (Honeycomb).[46]

Additional hardware support

Android can use video/still cameras, touchscreens, GPS, accelerometers, gyroscopes, barometers, magnetometers, dedicated gaming controls, proximity and pressure sensors, thermometers, accelerated 2D bit blits (with hardware orientation, scaling, pixel format conversion) and accelerated 3D graphics.

Multi-touch

Android has native support for multi-touch which was initially made available in handsets such as the HTC Hero. The feature was originally disabled at the kernel level (possibly to avoid infringing Apple's patents on touch-screen technology at the time).[82] Google has since released an update for the Nexus One and the Motorola Droid which enables multi-touch natively.[83]

Bluetooth

Supports A2DP, AVRCP, sending files (OPP), accessing the phone book (PBAP), voice dialing and sending contacts between phones. Keyboard, mouse and joystick (HID) support is available in Android 3.1+, and in earlier versions through manufacturer customizations and third-party applications.[84]

Video calling

Android does not support native video calling, but some handsets have a customized version of the operating system that supports it, either via the UMTS network (like the Samsung Galaxy S) or over IP. Video calling through Google Talk is available in Android 2.3.4 and later. Gingerbread allows Nexus S to place Internet calls with a SIP account. This allows for enhanced VoIP dialing to other SIP accounts and even phone numbers. Skype 2.1 offers video calling in Android 2.3, including front camera support.

Multitasking

Multitasking of applications is available.[85]

Voice based features

Google search through voice has been available since initial release.[86] Voice actions for calling, texting, navigation, etc. are supported on Android 2.2 onwards.[87]

Tethering

Android supports tethering, which allows a phone to be used as a wireless/wired Wi-Fi hotspot. Before Android 2.2 this was supported by third-party applications or manufacturer customizations.[88]

Screen capture

Android natively supports the ability to capture a screenshot by method of pressing both the power and volume-down buttons at the same time on an Android device. This native support was first included within the Android 4.0 (Ice Cream Sandwich) update, which is first seen on the Galaxy Nexus smartphone.[89] Previously, Android did not feature native support for screen capturing which would have likely been due to security concerns. Furthermore, prior manufacturer and third-party customizations as well as using a PC connection (DDMS developer's tool) were the only known methods of capturing a screenshot on Android.

Uses

The open and customizable nature of the Android operating system allows it to be used on most electronics, including but not limited to: smartphones, laptops, netbooks, tablet computers, Google TV, wristwatches,[90] headphones,[91] Car CD and DVD players[92] and other devices.[93] [94] [95]

The main hardware platform for Android is the ARM architecture. There is support for x86 from the Android-x86 project,[96] and Google TV uses a special x86 version of Android.

The first commercially available phone to run Android was the HTC Dream, released on 22 October 2008.[97] In early 2010 Google collaborated with HTC to launch its flagship[98] Android device, the Nexus One. This was followed later in 2010 with the Samsung-made Nexus S and in 2011 with the Galaxy Nexus.

iOS and Android 2.3.3 'Gingerbread' may be set up to dual boot on a jailbroken iPhone or iPod Touch with the help of OpeniBoot and iDroid.[99] [100]

The Novo 7, manufactured by the Chinese company Ainol Electronics, was the world's first Android 4.0 Ice Cream Sandwich tablet.[101]

Galaxy Nexus, the latest "Google phone"

Applications

Applications are usually developed in the Java language using the Android Software Development Kit, but other development tools are available, including a Native Development Kit for applications or extensions in C or C++, Google App Inventor, a visual environment for novice programmers and various cross platform mobile web applications frameworks .

Android Market

Android Market is the online software store developed by Google for Android devices. An application program ("app") called "Market" is preinstalled on most Android devices and allows users to browse and download apps published by third-party developers, hosted on Android Market. As of October 2011 there were more than 300,000 apps available for Android, and the estimated number of applications downloaded from the Android Market as of December 2011 exceeded 10 billion.[20] [21] The operating system itself is installed on 130 million total devices.[102]

Only devices that comply with Google's compatibility requirements are allowed to preinstall Google's closed-source Android Market app and access the Market.[103] The Market filters the list of applications presented by the Market app to those that are compatible with the user's device, and developers may restrict their applications to particular carriers or countries for business reasons. [104]

Google has participated in the Android Market by offering several applications themselves, including Google Voice (for the Google Voice service), Sky Map (for watching stars), Finance (for their finance service), Maps Editor (for their MyMaps service), Places Directory (for their Local Search), Google Goggles that searches by image, Gesture Search (for using finger-written letters and numbers to search the contents of the phone), Google Translate, Google Shopper, Listen for podcasts and My Tracks, a jogging application. In August 2010, Google launched "Voice Actions for Android",[105] which allows users to search, write messages, and initiate calls by voice.

Alternatively, users can install apps from third party app stores such as the Amazon Appstore,[106] or directly onto the device if they have the application's APK file.

Application security

Android applications run in a sandbox, an isolated area of the operating system that does not have access to the rest of the system's resources, unless access permissions are granted by the user when the application is installed. Before installing an application, Android Market displays all required permissions. A game may need to enable vibration, for example, but should not need to read messages or access the phonebook. After reviewing these permissions, the user can decide whether to install the application.[107]

Some Android malware incidents have been reported involving rogue applications on Android Market. In August 2010, Kaspersky Lab reported detection of the first malicious program for Android, named Trojan-SMS.AndroidOS.FakePlayer.a, an SMS trojan which had already infected a number of devices.[108] In some cases applications which contained Trojans were hidden in pirated versions of legitimate apps.[109] [110] Google has responded by removing malicious apps from the Android Market, and remotely disabling them on infected devices.[111] Security firms such as AVG Technologies, Avast! and Symantec have released antivirus software for Android devices.

Privacy

Android smartphones have the ability to report the location of Wi-Fi access points, encountered as phone users move around, to build vast databases containing the physical locations of hundreds of millions of such access points. These databases form electronic maps to locate smartphones, allowing them to run apps like Foursquare, Latitude, Places, and to deliver location-based ads.[112]

One design issue is that average users cannot monitor how applications access and use private and sensitive data (e.g. location and hardware ID numbers). Even during installation, permission checks do not often indicate to the user how critical services and data will be used or misused. Third party monitoring software such as TaintDroid,[113] an academic research-funded project, can identify personal information sent from applications to remote servers.[114]

Marketing

The Android logo was designed along with the Droid font family made by Ascender Corporation.[115]

Android Green is the color of the Android Robot that represents the Android operating system. The print color is PMS 376C and the RGB color value in hexadecimal is #A4C639, as specified by the Android Brand Guidelines.[116] The custom typeface of Android is called Norad (cf. NORAD). It is only used in the text logo.[117]

Market share

Research company Canalys estimated in Q2 2009 that Android had a 2.8% share of worldwide smartphone shipments.[118] By Q4 2010 this had grown to 33% of the market, becoming the top-selling smartphone platform. This estimate includes the Tapas and OMS variants of Android.[22] By Q3 2011 Gartner estimates more than half (52.5%) of the smartphone market belongs to Android.[119]

In February 2010 ComScore said the Android platform had 9.0% of the U.S. smartphone market, as measured by current mobile subscribers. This figure was up from an earlier estimate of 5.2% in November 2009.[120] By the end of Q3 2010 Android's U.S. market share had grown to 21.4%.[121]

In May 2010, Android's first quarter U.S. sales surpassed that of the rival iPhone platform. According to a report by the NPD group, Android achieved 25% smartphone sales in the US market, up 8% from the December quarter. In the second quarter, Apple's iOS was up by 11%, indicating that Android is taking market share mainly from RIM, and still has to compete with heavy consumer demand for new competitor offerings.[122] Furthermore, analysts pointed to advantages that Android has as a multi-channel, multi-carrier OS, which allowed it to duplicate the quick success of Microsoft's Windows Mobile.[123] In Q4 2010 Android had 59% of the total installed user base of Apple's iOS in the U.S. and 46% of the total installed user base of iOS in Europe.[124] [125]

As of June 2011, Google said that 550,000 new Android devices were being activated every day[126] — up from 400,000 per day a month earlier — and more than 100 million devices had been activated.[127] Android hit 300,000 activations per day back in December 2010. By the 14th of July 2011, 550,000 Android devices were being activated by Google each day, with 4.4% growth per week.[128] On the 1st of August 2011, Canalys estimated that Android had about 48% of the smartphone market share.[129] On October 13, 2011, Google announced that there were 190 million Android devices in the market.[130] As of November 16, 2011, during the Google Music announcement "These Go to Eleven", 200 million Android devices had been activated.[131] Based on this number, with 1.9% of Android devices being tablets, approximately 3.8 million Android Honeycomb Tablets have been sold.[132] On December 20, 2011. Andy Rubin announced that Google was activating 700,000 new Android devices daily.[25]

Usage share

Usage share of the different versions, by December 1, 2011.[133]

Distribution	API level	%
4.0 *Ice Cream Sandwich*	14-15	0%
3.x.x *Honeycomb*	11-13	2.4%
2.3.x *Gingerbread*	9-10	50.6%
2.2 *Froyo*	8	35.3%
2.1 *Eclair*	7	9.6%
1.6 *Donut*	4	1.3%
1.5 *Cupcake*	3	0.8%

There were two more internal releases, called "Astro" and "Bender". The code names are in alphabetical order, and were allegedly changed from robots to desserts to avoid trademark issues.[134]

Retail Stores

The carrier Telstra opened the world's first Android store on Bourke Street, Melbourne in December 2011.[135]

Intellectual property infringement claims

Both Android and Android phone manufacturers have been the target of numerous patent lawsuits. On 12 August 2010, Oracle sued Google over claimed infringement of copyrights and patents related to the Java programming language.[136] Specifically, the patent infringement claim references seven United States patents including US 5966702 [137] "Method and apparatus for pre-processing and packaging class files", and US 6910205 [138] "Interpreting functions utilizing a hybrid of virtual and native machine instructions".[139]

In response, Google submitted multiple lines of defense, counterclaiming that Android did not infringe on Oracle's patents or copyright, that Oracle's patents were invalid, and several other defenses. They said that Android is based on Apache Harmony, a clean room implementation of the Java class libraries, and an independently developed virtual machine called Dalvik.[140] [141] [142]

Microsoft has also sued several manufacturers of Android devices for patent infringement, and collects patent licensing fees from others. In October 2011 Microsoft said they had signed license agreements with ten Android device manufacturers, accounting for 55% of worldwide revenue for Android devices.[143] These include Samsung and HTC.[144]

Former Apple Inc. CEO Steve Jobs claimed that Android copied major elements of Apple's iPhone and iOS operating system. According to his biography, Jobs stated that Android is a "stolen product," and vowed to destroy it. “I will spend my last dying breath if I need to, and I will spend every penny of Apple's $40 billion in the bank, to right this wrong,” said Jobs.[145]

Google has publicly expressed its dislike for the current patent landscape in the United States, accusing Apple, Oracle and Microsoft of trying to take down Android through patent litigation, rather than innovating and competing with better products and services.[146] In August 2011, Google started the process of purchasing Motorola Mobility for US$12.5 billion, which was viewed in part as a defensive measure to protect Android, since Motorola Mobility holds 17,000 patents.[147]

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External links

- Official website (http://www.android.com/)
- Android (operating system) (http://www.dmoz.org/Computers/Systems/Handhelds/Android/) at the Open Directory Project
- Sergey Brin introduces the Android platform (https://www.youtube.com/watch?v=1FJHYqE0RDg) on YouTube
- Android Mainlining Project (http://elinux.org/Android_Mainlining_Project/)
- Android: Building a Mobile Platform to Change the Industry (http://www.stanford.edu/class/ee380/Abstracts/071128.html): lecture given by Google Mobile Platforms Manager, Richard Miner at Stanford University (video archive (http://ee380.stanford.edu/cgi-bin/videologger.php?target=071128-ee380-300.asx))
- Android Internals: Fragment of a course detailing the architecture of Android and interaction of its components (http://technologeeks.com/Courses/Android-Excerpt.pdf)
- Diagram of Android internals (http://www.makelinux.net/android/internals/)

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