**Experiment No. 1**

PART A

(PART A: TO BE REFFERED BY STUDENTS)

A.1 Aim: **Introduction to android and study android architecture and android versions.**

**A.2 Prerequisite:**

Knowledge of Java programming language

**A.3 Outcome:**

After successful completion of this experiment students will be able to

1. Know in detail each and every block of the android architecture.
2. Have knowledge of all the android version and features.

**A.4 Theory:**

Android is an open source and Linux-based operating system for mobile devices such as smartphones and tablet computers. Android was developed by the *Open Handset Alliance*, led by Google, and other companies.

Android provides a rich application framework that allows you to build innovative apps and games for mobile devices in a Java language environment.

Android Architecture:

Android operating system is a stack of software components which is roughly divided into five sections and four main layers as shown below in the architecture diagram.



PART B

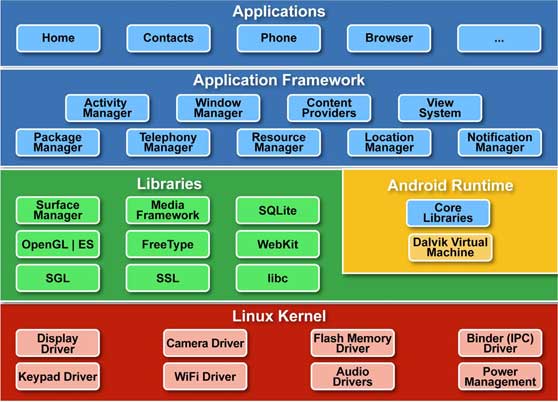
(PART B: TO BE COMPLETED BY STUDENTS)

**(Students must submit the soft copy as per following segments within two hours of the practical. The soft copy must be uploaded on the Blackboard or emailed to the concerned lab in charge faculties at the end of the practical in case the there is no Black board access available)**

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| Roll No. B046 | Name: Pranav Joshi |
| Program: B.tech | Division: B |
| Semester: IV | Batch : B3 |
| Date of Experiment: 16-1-15 | Date of Submission: 16-1-15 |
| Grade : |  |

B.1 Task to be done:

**1) Explain each layer of android architecture.**



Android operating system is a stack of software components which is roughly divided into five sections and four main layers as shown below in the architecture diagram.

Linux kernel

At the bottom of the layers is Linux - Linux 2.6 with approximately 115 patches. This provides basic system functionality like process management, memory management, device management like camera, keypad, display etc. Also, the kernel handles all the things that Linux is really good at such as networking and a vast array of device drivers, which take the pain out of interfacing to peripheral hardware.

Libraries

On top of Linux kernel there is a set of libraries including open-source Web browser engine WebKit, well known library libc, SQLite database which is a useful repository for storage and sharing of application data, libraries to play and record audio and video, SSL libraries responsible for Internet security etc.

Android Runtime

This is the third section of the architecture and available on the second layer from the bottom. This section provides a key component called Dalvik Virtual Machine which is a kind of Java Virtual Machine specially designed and optimized for Android.

The Dalvik VM makes use of Linux core features like memory management and multi-threading, which is intrinsic in the Java language. The Dalvik VM enables every Android application to run in its own process, with its own instance of the Dalvik virtual machine.

The Android runtime also provides a set of core libraries which enable Android application developers to write Android applications using standard Java programming language.

Application Framework

The Application Framework layer provides many higher-level services to applications in the form of Java classes. Application developers are allowed to make use of these services in their applications.

Applications

You will find all the Android application at the top layer. You will write your application to be installed on this layer only. Examples of such applications are Contacts Books, Browser, Games etc.

The main hardware platform for Android is the ARM architecture (ARMv7 and ARMv8-A architectures), with x86 and MIPS architectures also officially supported (the latter two became officially supported in later Android versions). Since Android 5.0 "Lollipop", 64-bit variants of all platforms are supported in addition to the 32-bit variants. Unofficial Android-x86 project used to provide support for the x86 and MIPS architectures ahead of the official support. Since 2012, Android devices with Intel processors began to appear, including phones and tablets. While gaining support for 64-bit platforms, Android was first made to run on 64-bit x86 and then on ARM64.

As of November 2013, Android 4.4 recommends at least 512 MB of RAM, while for "low RAM" devices 340 MB is the required minimum amount that does not include memory dedicated to various hardware components such as the baseband processor. Android 4.4 requires a 32-bit ARMv7, MIPS or x86 architecture processor (latter two through unofficial ports), together with an OpenGL ES 2.0 compatible graphics processing unit (GPU). Android supports OpenGL ES 1.1, 2.0, 3.0 and 3.1. Some applications may explicitly require a certain version of the OpenGL ES, and suitable GPU hardware is required to run such applications.

Android devices incorporate many optional hardware components, including still or video cameras, GPS, orientation sensors, dedicated gaming controls, accelerometers, gyroscopes, barometers, magnetometers, proximity sensors, pressure sensors, thermometers, and touchscreens. Some hardware components are not required, but became standard in certain classes of devices, such as smartphones, and additional requirements apply if they are present. Some other hardware was initially required, but those requirements have been relaxed or eliminated altogether. For example, as Android was developed initially as a phone OS, hardware such as microphones were required, while over time the phone function became optional. Android used to require an autofocus camera, which was relaxed to a fixed-focus camera if it is even present at all, since the camera was dropped as a requirement entirely when Android started to be used on set-top boxes.

In addition to running on smartphones and tablets, several vendors run Android natively on regular PC hardware with a keyboard and mouse. In addition to their availability on commercially available hardware, similar PC hardware–friendly versions of Android are freely available from the Android-x86 project, including customized Android 4.4. Using the Android emulator that is part of the Android SDK, or by using BlueStacks or Andy, Android can also run non-natively on x86. Chinese companies are building a PC and mobile operating system, based on Android, to "compete directly with Microsoft Windows and Google Android". The Chinese Academy of Engineering noted that "more than a dozen" companies were customising Android following a Chinese ban on the use of Windows 8 on government PCs.

Development

Android green figure, next to its original packaging.

Android is developed in private by Google until the latest changes and updates are ready to be released, at which point the source code is made available publicly. This source code will only run without modification on select devices, usually the Nexus series of devices. The source code is, in turn, adapted by OEMs to run on their hardware. Android's source code does not contain the often proprietary device drivers that are needed for certain hardware components.

The green Android logo was designed for Google in 2007 by graphic designer Irina Blok. The design team was tasked with a project to create a universally identifiable icon with the specific inclusion of a robot in the final design. After numerous design developments based on science-fiction and space movies, the team eventually sought inspiration from the human symbol on restroom doors and modified the figure into a robot shape. As Android is open-sourced, it was agreed that the logo should be likewise, and since its launch the green logo has been reinterpreted into countless variations on the original design.

Android's kernel is based on one of the Linux kernel's long-term support (LTS) branches. Since April 2014, Android devices mainly use versions 3.4 or 3.10 of the Linux kernel. The specific kernel version depends on the actual Android device and its hardware platform; Android has used various kernel versions since the version 2.6.25 that was used in Android 1.0.

Android's variant of the Linux kernel has further architectural changes that are implemented by Google outside the typical Linux kernel development cycle, such as the inclusion of components like Binder, ashmem, pmem, logger, wakelocks, and different out-of-memory (OOM) handling. Certain features that Google contributed back to the Linux kernel, notably a power management feature called "wakelocks", were rejected by mainline kernel developers partly because they felt that Google did not show any intent to maintain its own code. Google announced in April 2010 that they would hire two employees to work with the Linux kernel community, but 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. 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.

In August 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". In December 2011, Greg Kroah-Hartman announced the start of Android Mainlining Project, which aims to put some Android drivers, patches and features back into the Linux kernel, starting in Linux 3.3. Linux included the autosleep and wakelocks capabilities in the 3.5 kernel, after many previous attempts at merger. The interfaces are the same but the upstream Linux implementation allows for two different suspend modes: to memory (the traditional suspend that Android uses), and to disk (hibernate, as it is known on the desktop). Google maintains a public code repository that contains their experimental work to re-base Android off the latest stable Linux versions.

The flash storage on Android devices is split into several partitions, such as /system for the operating system itself, and /data for user data and application installations. In contrast to desktop Linux distributions, Android device owners are not given root access to the operating system and sensitive partitions such as /system are read-only. However, root access can be obtained by exploiting security flaws in Android, which is used frequently by the open-source community to enhance the capabilities of their devices, but also by malicious parties to install viruses and malware.

Android is a Linux distribution according to the Linux Foundation, Google's open-source chief Chris DiBona, and several journalists. Others, such as Google engineer Patrick Brady, say that Android is not Linux in the traditional Unix-like Linux distribution sense; Android does not include the GNU C Library (it uses Bionic as an alternative C library) and some of other components typically found in Linux distributions.

On top of the Linux kernel, there are the middleware, libraries and APIs written in C, and application software running on an application framework which includes Java-compatible libraries based on Apache Harmony. Development of the Linux kernel continues independently of other Android's source code bases.

Until version 5.0, Android used Dalvik as a process virtual machine with trace-based just-in-time (JIT) compilation to run Dalvik "dex-code" (Dalvik Executable), which is usually translated from the Java bytecode. Following the trace-based JIT principle, in addition to interpreting the majority of application code, Dalvik performs the compilation and native execution of select frequently executed code segments ("traces") each time an application is launched. Android 4.4 introduced Android Runtime (ART) as a new runtime environment, which uses ahead-of-time (AOT) compilation to entirely compile the application bytecode into machine code upon the installation of an application. In Android 4.4, ART was an experimental feature and not enabled by default; it became the only runtime option in the next major version of Android, 5.0.

Android's standard C library, Bionic, was developed by Google specifically for Android, as a derivation of the BSD's standard C library code. Bionic itself has been designed with several major features specific to the Linux kernel. The main benefits of using Bionic instead of the GNU C Library (glibc) or uClibc are its smaller runtime footprint, and optimization for low-frequency CPUs. At the same time, Bionic is licensed under the terms of BSD licence, which Google finds more suitable for the Android's overall licensing model.

Aiming for a different licensing model, toward the end of 2012 Google switched the Bluetooth stack in Android from the GPL-licensed BlueZ to the Apache-licensed BlueDroid.

Android does not have a native X Window System by default, nor does it support the full set of standard GNU libraries. This made it difficult to port existing Linux applications or libraries to Android, until version r5 of the Android Native Development Kit brought support for applications written completely in C or C++. Libraries written in C may also be used in applications by injection of a small shim and usage of the JNI.

Open-source community

Android has an active community of developers and enthusiasts who use the Android Open Source Project (AOSP) source code to develop and distribute their own modified versions of the operating system. These community-developed releases often bring new features and updates to devices faster than through the official manufacturer/carrier channels, albeit without as extensive testing or quality assurance; provide continued support for older devices that no longer receive official updates; or bring Android to devices that were officially released running other operating systems, such as the HP TouchPad. Community releases often come pre-rooted and contain modifications unsuitable for non-technical users, such as the ability to overclock or over/undervolt the device's processor. CyanogenMod is the most widely used community firmware, and acts as a foundation for numerous others.

Historically, device manufacturers and mobile carriers have typically been unsupportive of third-party firmware development. Manufacturers express concern about improper functioning of devices running unofficial software and the support costs resulting from this. Moreover, modified firmwares such as CyanogenMod sometimes offer features, such as tethering, for which carriers would otherwise charge a premium. As a result, technical obstacles including locked bootloaders and restricted access to root permissions are common in many devices. However, as community-developed software has grown more popular, and following a statement by the Librarian of Congress in the United States that permits the "jailbreaking" of mobile devices, manufacturers and carriers have softened their position regarding third party development, with some, including HTC, Motorola, Samsung and Sony, providing support and encouraging development. As a result of this, over time the need to circumvent hardware restrictions to install unofficial firmware has lessened as an increasing number of devices are shipped with unlocked or unlockable bootloaders, similar to Nexus series of phones, although usually requiring that users waive their devices' warranties to do so. However, despite manufacturer acceptance, some carriers in the US still require that phones are locked down, frustrating developers and customers.

**2) Explain various android versions and new features added to it.**

Charts in this section provide breakdowns of Android versions, based on the devices accessing the Play Store in a seven-day period ending on April 6, 2015.[[262]](http://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-android-dev-dashboard-264)[[c]](http://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-265) Therefore, these statistics exclude Android [forks](http://en.wikipedia.org/wiki/Fork_(software_development)) that do not access Google Play, such as Amazon's [Fire tablets](http://en.wikipedia.org/wiki/Kindle_Fire).

| **Version** | **Code name** | **Release date** | [**API**](http://en.wikipedia.org/wiki/Application_programming_interface)**level** | **Distribution**[[d]](http://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-266) |
| --- | --- | --- | --- | --- |
| [**5.1.x**](http://en.wikipedia.org/wiki/Android_Lollipop) | [*Lollipop*](http://en.wikipedia.org/wiki/Android_Lollipop) | March 9, 2015 | 22 | 0.4% |
| [**5.0.0–5.0.2**](http://en.wikipedia.org/wiki/Android_Lollipop) | November 3, 2014 | 21 | 5.0% |
| [**4.4.0–4.4.4**](http://en.wikipedia.org/wiki/Android_KitKat) | [*KitKat*](http://en.wikipedia.org/wiki/Android_KitKat) | October 31, 2013 | 19 | 41.4% |
| [**4.3.x**](http://en.wikipedia.org/wiki/Android_version_history#Android_4.3_Jelly_Bean_.28API_level_18.29) | [*Jelly Bean*](http://en.wikipedia.org/wiki/Android_version_history#Android_4.3_Jelly_Bean_.28API_level_18.29) | July 24, 2013 | 18 | 5.6% |
| [**4.2.x**](http://en.wikipedia.org/wiki/Android_version_history#Android_4.2_Jelly_Bean_.28API_level_17.29) | November 13, 2012 | 17 | 18.6% |
| [**4.1.x**](http://en.wikipedia.org/wiki/Android_version_history#Android_4.1_Jelly_Bean_.28API_level_16.29) | July 9, 2012 | 16 | 16.5% |
| [**4.0.3–4.0.4**](http://en.wikipedia.org/wiki/Android_version_history#Android_4.0.3.E2.80.934.0.4_Ice_Cream_Sandwich_.28API_level_15.29) | [*Ice Cream Sandwich*](http://en.wikipedia.org/wiki/Android_version_history#Android_4.0.E2.80.934.0.2_Ice_Cream_Sandwich_.28API_level_14.29) | December 16, 2011 | 15 | 5.7% |
| [**2.3.3–2.3.7**](http://en.wikipedia.org/wiki/Android_2.3) | [*Gingerbread*](http://en.wikipedia.org/wiki/Android_2.3) | February 9, 2011 | 9 | 6.4% |
| [**2.2**](http://en.wikipedia.org/wiki/Android_Froyo) | [*Froyo*](http://en.wikipedia.org/wiki/Android_Froyo) | May 20, 2010 | 8 | 0.4% |

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| **Android 1.0 (API level 1)** | | | |
| **Android 1.0, the first commercial version of the software, was released on September 23, 2008.**[[20]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-20)**The first commercially available Android device was the**[**HTC Dream**](http://en.wikipedia.org/wiki/HTC_Dream)**.**[[21]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-HTC-21)**Android 1.0 incorporated the following features:** | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 1.0 | September 23, 2008 | * [Android Market](http://en.wikipedia.org/wiki/Android_Market) application download and updates through the Market application * [Web browser](http://en.wikipedia.org/wiki/Web_browser) to show, zoom and pan full [HTML](http://en.wikipedia.org/wiki/HTML) and [XHTML](http://en.wikipedia.org/wiki/XHTML) web pages – multiple pages show as windows ("cards")[[22]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Engadget-22)[[23]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Release_features_.E2.80.93_Android_1.0-23) * Camera support – however, this version lacked the option to change the camera's resolution, white balance, quality, etc.[[24]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-T-Mobile_G1_Google_Android_Phone-24) * Folders allowing the grouping of a number of application icons into a single folder icon on the Home screen[[25]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-25) * Access to web email servers, supporting [POP3](http://en.wikipedia.org/wiki/POP3), [IMAP4](http://en.wikipedia.org/wiki/IMAP4), and [SMTP](http://en.wikipedia.org/wiki/SMTP)[[23]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Release_features_.E2.80.93_Android_1.0-23) * [Gmail](http://en.wikipedia.org/wiki/Gmail) synchronization with the Gmail application * [Google Contacts](http://en.wikipedia.org/wiki/Google_Contacts) synchronization with the People application * [Google Calendar](http://en.wikipedia.org/wiki/Google_Calendar) synchronization with the Calendar application * [Google Maps](http://en.wikipedia.org/wiki/Google_Maps) with [Street View](http://en.wikipedia.org/wiki/Google_Street_View) to view maps and satellite imagery, as well as find local business and obtain driving directions using [GPS](http://en.wikipedia.org/wiki/GPS)[[24]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-T-Mobile_G1_Google_Android_Phone-24) * [Google Sync](http://en.wikipedia.org/wiki/Google_Sync), allowing management of over-the-air synchronization of Gmail, People, and Calendar * [Google Search](http://en.wikipedia.org/wiki/Google_Search), allowing users to search the Internet and phone applications, contacts, calendar, etc. * [Google Talk](http://en.wikipedia.org/wiki/Google_Talk) instant messaging * [Instant messaging](http://en.wikipedia.org/wiki/Instant_messaging), [text messaging](http://en.wikipedia.org/wiki/Text_messaging), and MMS * [Media Player](http://en.wikipedia.org/wiki/Media_player_(application_software)), enabling management, importing, and playback of media files – however, this version lacked video and stereo[Bluetooth](http://en.wikipedia.org/wiki/Bluetooth) support[[23]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Release_features_.E2.80.93_Android_1.0-23)[[24]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-T-Mobile_G1_Google_Android_Phone-24) * Notifications appear in the Status bar, with options to set ringtone, LED or vibration alerts[[22]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Engadget-22)[[23]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Release_features_.E2.80.93_Android_1.0-23)[[26]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-26) * Voice Dialer allows dialing and placing of phone calls without typing a name or number[[23]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Release_features_.E2.80.93_Android_1.0-23) * Wallpaper allows the user to set the background image or photo behind the Home screen icons and widgets * [YouTube](http://en.wikipedia.org/wiki/YouTube) video player[[27]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Android_for_Dummies-27) * Other applications include: Alarm Clock, Calculator, Dialer (Phone), Home screen (Launcher), Pictures (Gallery), and Settings * [Wi-Fi](http://en.wikipedia.org/wiki/Wi-Fi) and Bluetooth support | [Android 1.0 Screenshot.png](http://en.wikipedia.org/wiki/File:Android_1.0_Screenshot.png) Android 1.0 on the old Android SDK emulator |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 1.1 (API level 2)**    **Android 1.1 (API level 2)** | | | |
| **On February 9, 2009, the Android 1.1 update was released, initially for the HTC Dream only. Android 1.1 was known as "**[**Petit Four**](http://en.wikipedia.org/wiki/Petit_four)**" internally, though this name was not used officially.**[[28]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-28)**The update resolved bugs, changed the Android**[**API**](http://en.wikipedia.org/wiki/Application_programming_interface)**and added a number of features:**[[29]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-29) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 1.1 | February 9, 2009 | * Details and reviews available when a user searches for businesses on Maps * Longer in-call screen timeout default when using the speakerphone, plus ability to show/hide dialpad * Ability to save attachments in messages * Support added for marquee in system layouts | [Android 1.1 Beta Screenshot.png](http://en.wikipedia.org/wiki/File:Android_1.1_Beta_Screenshot.png) Android 1.1 on the Android SDK emulator |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 1.5 Cupcake (API level 3)**    **Android 1.5 Cupcake (API level 3)** | | | |
| **On April 27, 2009, the Android 1.5 update was released, based on**[**Linux kernel**](http://en.wikipedia.org/wiki/Linux_kernel)**2.6.27.**[[30]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-cupcake-is-here-30)[[31]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-31)**This was the first release to officially use a codename based on a dessert item ("Cupcake"), a theme which would be used for all releases henceforth. The update included several new features and UI amendments:**[[32]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-cupcake-highlights-32) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 1.5 | April 27, 2009[[30]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-cupcake-is-here-30) | * Support for third-party virtual keyboards with text prediction and user dictionary for custom words * Support for [Widgets](http://en.wikipedia.org/wiki/Widget_engine) – miniature application views that can be embedded in other applications (such as the Home screen) and receive periodic updates[[33]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-33) * Video recording and playback in [MPEG-4](http://en.wikipedia.org/wiki/MPEG-4) and 3GP formats * Auto-pairing and stereo support for Bluetooth (A2DP and AVRCP profiles) * Copy and paste features in web browser * User pictures shown for Favorites in Contacts * Specific date/time stamp shown for events in call log, and one-touch access to a contact card from call log event * Animated screen transitions * Auto-rotation option * New stock boot animation * Ability to upload videos to [YouTube](http://en.wikipedia.org/wiki/YouTube) * Ability to upload photos to [Picasa](http://en.wikipedia.org/wiki/Picasa) | [Android 1.5 Cupcake Screenshot.png](http://en.wikipedia.org/wiki/File:Android_1.5_Cupcake_Screenshot.png) Android 1.5 on the Android SDK emulator |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 1.6 Donut (API level 4)**    **Android 1.6 Donut (API level 4)** | | | |
| **On September 15, 2009, the Android 1.6 SDK – dubbed Donut – was released, based on Linux kernel 2.6.29.**[[34]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Word-highlights-34)[[35]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Word-is-here-35)[[36]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-36)**Included in the update were numerous new features:**[[34]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Word-highlights-34) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 1.6 | September 15, 2009[[35]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Word-is-here-35) | * Voice and text entry search enhanced to include bookmark history, contacts, and the web * Ability for developers to include their content in search results * Multi-lingual [speech synthesis](http://en.wikipedia.org/wiki/Speech_synthesis) engine to allow any Android application to "speak" a string of text * Easier searching and ability to view app screenshots in Android Market * Gallery, camera and camcorder more fully integrated, with faster camera access * Ability for users to select multiple photos for deletion * Updated technology support for [CDMA](http://en.wikipedia.org/wiki/IS-95)/[EVDO](http://en.wikipedia.org/wiki/Evolution-Data_Optimized), [802.1x](http://en.wikipedia.org/wiki/IEEE_802.1X), [VPNs](http://en.wikipedia.org/wiki/Virtual_private_network), and a text-to-speech engine * Support for [WVGA](http://en.wikipedia.org/wiki/Wide_VGA) screen resolutions * Speed improvements in searching and camera applications * Expanded Gesture framework and new GestureBuilder development tool | [Android 1.6 on the Android SDK.png](http://en.wikipedia.org/wiki/File:Android_1.6_on_the_Android_SDK.png) Android 1.6 on the Android SDK emulator |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 2.0 Éclair (API level 5)**    **Android 2.0 Éclair (API level 5)** | | | |
| **On October 26, 2009, the Android 2.0 SDK – codenamed Éclair – was released, based on Linux kernel 2.6.29.**[[37]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-37)**Changes included:**[[38]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-eclair-highlights-38) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 2.0 | October 26, 2009 | * Expanded Account sync, allowing users to add multiple accounts to a device for synchronization of email and contacts * [Microsoft Exchange](http://en.wikipedia.org/wiki/Microsoft_Exchange_Server) email support, with combined inbox to browse email from multiple accounts in one page * Bluetooth 2.1 support * Ability to tap a Contacts photo and select to call, SMS, or email the person * Ability to search all saved SMS and MMS messages, with delete oldest messages in a conversation automatically deleted when a defined limit is reached * Numerous new camera features, including flash support, digital zoom, scene mode, white balance, color effect and macro focus * Improved typing speed on virtual keyboard, with smarter dictionary that learns from word usage and includes contact names as suggestions * Refreshed browser UI with bookmark thumbnails, double-tap zoom and support for [HTML5](http://en.wikipedia.org/wiki/HTML5) * Calendar agenda view enhanced, showing attending status for each invitee, and ability to invite new guests to events * Optimized hardware speed and revamped UI * Support for more screen sizes and resolutions, with better contrast ratio * Improved [Google Maps](http://en.wikipedia.org/wiki/Google_Maps) 3.1.2 * MotionEvent class enhanced to track multi-touch events[[39]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-39) * Addition of live wallpapers, allowing the animation of home-screen background images to show movement | [Android 2.0 Screenshot.png](http://en.wikipedia.org/wiki/File:Android_2.0_Screenshot.png) Android 2.0 on the Android SDK emulator |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 2.0.1 Éclair (API level 6)**    **Android 2.0.1 Éclair (API level 6)** | | | |
|  | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 2.0.1 | December 3, 2009[[40]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-2.0.1_SDK-40) | * Minor API changes, bugfixes and framework behavioral changes |  |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 2.1 Éclair (API level 7)**    **Android 2.1 Éclair (API level 7)** | | | |
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| **Version** | **Release date** | **Features** | **Image(s)** |
| 2.1 | January 12, 2010[[41]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-2.1_SDK-41) | * Minor amendments to the API and bugfixes |  |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 2.2–2.2.3 Froyo (API level 8)**    **Android 2.2–2.2.3 Froyo (API level 8)** | | | |
| **On May 20, 2010, the SDK for Android 2.2 (Froyo, short for**[**frozen yogurt**](http://en.wikipedia.org/wiki/Frozen_yogurt)**) was released, based on Linux kernel 2.6.32.**[[42]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-froyo-dev-blog-42) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 2.2 | May 20, 2010 | * Speed, memory, and performance optimizations[[43]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-unofficial-froyo-features-43) * Additional application speed improvements, implemented through [JIT compilation](http://en.wikipedia.org/wiki/Just-in-time_compilation)[[44]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-44) * Integration of [Chrome](http://en.wikipedia.org/wiki/Google_Chrome)'s [V8 JavaScript engine](http://en.wikipedia.org/wiki/V8_(JavaScript_engine)) into the Browser application * Support for the [Android Cloud to Device Messaging](http://en.wikipedia.org/wiki/Android_Cloud_to_Device_Messaging) (C2DM) service, enabling [push notifications](http://en.wikipedia.org/wiki/Push_technology) * Improved [Microsoft Exchange](http://en.wikipedia.org/wiki/Microsoft_Exchange) support, including security policies, auto-discovery, GAL look-up, calendar synchronization and remote wipe * Improved application launcher with shortcuts to Phone and Browser applications * USB tethering and [Wi-Fi hotspot](http://en.wikipedia.org/wiki/Wi-Fi_hotspot) functionality[[45]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-wired_sorrel_2010-45) * Option to disable data access over mobile network. * Updated Market application with batch and automatic update features.[[43]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-unofficial-froyo-features-43) * Quick switching between multiple keyboard languages and their dictionaries. * Support for [Bluetooth](http://en.wikipedia.org/wiki/Bluetooth)-enabled car and desk docks * Support for numeric and alphanumeric passwords * Support for file upload fields in the Browser application[[46]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-46) * The browser now shows all frames of animated GIFs instead of just the first frame only * Support for installing applications to the expandable memory * [Adobe Flash](http://en.wikipedia.org/wiki/Adobe_Flash) support[[47]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-47) * Support for high-[PPI](http://en.wikipedia.org/wiki/Pixel_density) displays (up to 320 ppi), such as 4" 720p screens[[48]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-multiple-screens-48) * Gallery allows users to view picture stacks using a zoom gesture | [Android 2.2 Froyo home.png](http://en.wikipedia.org/wiki/File:Android_2.2_Froyo_home.png) Android 2.2 Froyo home screen |
| 2.2.1 | January 18, 2011 | * Bugfixes, security updates and performance improvements |
| 2.2.2 | January 22, 2011 | * Minor bugfixes, including SMS routing issues that affected the [Nexus One](http://en.wikipedia.org/wiki/Nexus_One)[[49]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-49) |
| 2.2.3 | November 21, 2011[[50]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-50) | * Two security patches |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 2.3–2.3.2 Gingerbread(API level 9)**    **Android 2.3–2.3.2 Gingerbread (API level 9)** | | | |
| **On December 6, 2010, the Android 2.3 (Gingerbread) SDK was released, based on Linux kernel 2.6.35.**[[51]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-gingerbread-highlights-51)[[52]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-gingerbread-dev-blog-52)**Changes included:**[[51]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-gingerbread-highlights-51) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 2.3 | December 6, 2010[[52]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-gingerbread-dev-blog-52) | * Updated user interface design with increased simplicity and speed * Support for extra-large screen sizes and resolutions ([WXGA](http://en.wikipedia.org/wiki/WXGA_(graphics)) and higher)[[48]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-multiple-screens-48) * Native support for [SIP](http://en.wikipedia.org/wiki/Session_Initiation_Protocol) [VoIP](http://en.wikipedia.org/wiki/Voice_over_IP) internet telephony * Faster, more intuitive text input in virtual keyboard, with improved accuracy, better suggested text and voice input mode * Enhanced [copy/paste](http://en.wikipedia.org/wiki/Cut,_copy,_and_paste) functionality, allowing users to select a word by press-hold, copy, and paste * Support for [Near Field Communication](http://en.wikipedia.org/wiki/Near_Field_Communication) (NFC), allowing the user to read an NFC tag embedded in a poster, sticker, or advertisement * New audio effects such as reverb, equalization, headphone virtualization, and bass boost * New [Download Manager](http://en.wikipedia.org/wiki/Download_Manager), giving users easy access to any file downloaded from the browser, email, or another application * Support for multiple cameras on the device, including a front-facing camera, if available * Support for [WebM](http://en.wikipedia.org/wiki/WebM)/VP8 video playback, and [AAC](http://en.wikipedia.org/wiki/Advanced_Audio_Coding) audio encoding * Improved [power management](http://en.wikipedia.org/wiki/Power_management) with a more active role in managing applications that are keeping the device awake for too long * Enhanced support for native code development * Switched from [YAFFS](http://en.wikipedia.org/wiki/YAFFS) to [ext4](http://en.wikipedia.org/wiki/Ext4) on newer devices[[53]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-53)[[54]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-54) * Audio, graphical, and input enhancements for game developers * Concurrent [garbage collection](http://en.wikipedia.org/wiki/Garbage_collection_(computer_science)) for increased performance * Native support for more sensors (such as [gyroscopes](http://en.wikipedia.org/wiki/Gyroscope) and [barometers](http://en.wikipedia.org/wiki/Barometer)) | [Android screenshot.png](http://en.wikipedia.org/wiki/File:Android_screenshot.png) Android 2.3 on the Android SDK emulator |
| 2.3.1 | December 2010 | * Improvements and bugfixes for the Google Nexus S |
| 2.3.2 | January 2011 |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 2.3.3–2.3.7 Gingerbread (API level 10)**    **Android 2.3.3–2.3.7 Gingerbread (API level 10)** | | | |
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| **Version** | **Release date** | **Features** | **Image(s)** |
| 2.3.3 | February 9, 2011 | * Several improvements and API fixes[[55]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-55) |  |
| 2.3.4 | April 28, 2011[[56]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-56) | * Support for voice or video chat using [Google Talk](http://en.wikipedia.org/wiki/Google_Talk)[[57]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-57) * Open Accessory Library support. Open Accessory was introduced in 3.1 (Honeycomb) but the Open Accessory Library grants 2.3.4 added support when connecting to a USB peripheral with compatible software and a compatible application on the device[[58]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-58) * Switched the default encryption for SSL from AES256-SHA to RC4-MD5.[[59]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-59)[[60]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-60) |
| 2.3.5 | July 25, 2011 | * Improved network performance for the [Nexus S](http://en.wikipedia.org/wiki/Nexus_S) 4G, among other fixes and improvements * Fixed Bluetooth bug on [Samsung Galaxy S](http://en.wikipedia.org/wiki/Samsung_Galaxy_S) * Improved Gmail application * Shadow animations for list scrolling * Camera software enhancements[[61]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-61) * Improved battery efficiency |
| 2.3.6 | September 2, 2011[[62]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-62) | * Fixed a voice search bug * The 2.3.6 update had the side-effect of impairing the Wi-Fi hotspot functionality of many Canadian Nexus S phones. Google acknowledged this problem and fixed it in late September.[[63]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-63)[[64]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-64) |
| 2.3.7 | September 21, 2011 | * [Google Wallet](http://en.wikipedia.org/wiki/Google_Wallet) support for the Nexus S 4G |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 3.0 Honeycomb (API level 11)**    **Android 3.0 Honeycomb (API level 11)** | | | |
| **On February 22, 2011, the Android 3.0 (Honeycomb) SDK – the first**[**tablet**](http://en.wikipedia.org/wiki/Tablet_computer)**-only Android update – was released, based on Linux kernel 2.6.36.**[[65]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-honeycomb-highlights-65)[[66]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-honeycomb-sneak-peek-66)[[67]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-3.0-release-67)[[68]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-68)**The first device featuring this version, the**[**Motorola Xoom**](http://en.wikipedia.org/wiki/Motorola_Xoom)**tablet, was released on February 24, 2011.**[[69]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-69)**The update's features included:**[[65]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-honeycomb-highlights-65) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 3.0 | February 22, 2011[[67]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-3.0-release-67) | * Optimized tablet support with a new “holographic” user interface * Added System Bar, featuring quick access to notifications, status, and soft navigation buttons, available at the bottom of the screen * Added Action Bar, giving access to contextual options, navigation, widgets, or other types of content at the top of the screen * Simplified multitasking – tapping Recent Applications in the System Bar allows users to see snapshots of the tasks underway and quickly jump from one application to another * Redesigned keyboard, making typing fast, efficient and accurate on larger screen sizes * Simplified, more intuitive copy/paste interface * Multiple browser tabs replacing browser windows, plus form auto-fill and a new “incognito” mode allowing anonymous browsing * Quick access to camera exposure, focus, flash, zoom, front-facing camera, time-lapse, and other camera features * Ability to view albums and other collections in full-screen mode in Gallery, with easy access to thumbnails for other photos * New two-pane Contacts UI and Fast Scroll to let users easily organize and locate contacts * New two-pane Email UI to make viewing and organizing messages more efficient, allowing users to select one or more messages * Hardware acceleration * Support for [multi-core processors](http://en.wikipedia.org/wiki/Multi-core_processor) * Ability to encrypt all user data * HTTPS stack improved with [Server Name Indication](http://en.wikipedia.org/wiki/Server_Name_Indication) (SNI) * [Filesystem in Userspace](http://en.wikipedia.org/wiki/Filesystem_in_Userspace) (FUSE; kernel module) * Applications' write access to secondary storage (memory cards on devices with internal primary storage) is disabled outside of designated, app-specific directories, while full access to internal primary storage is still allowed through a separate application-level permission.[[70]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-anandtech-sdkitkat-70)[[71]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-androidpolice-sdcards-71) | [Android3.0.png](http://en.wikipedia.org/wiki/File:Android3.0.png) Android 3.0 on the [Motorola Xoom](http://en.wikipedia.org/wiki/Motorola_Xoom) tablet |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 3.1 Honeycomb (API level 12)**    **Android 3.1 Honeycomb (API level 12)** | | | |
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| **Version** | **Release date** | **Features** | **Image(s)** |
| 3.1 | May 10, 2011[[72]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-72) | * UI refinements * Connectivity for USB accessories ([USB On-The-Go](http://en.wikipedia.org/wiki/USB_On-The-Go)). * Expanded Recent Applications list * Resizable Home screen widgets * Support for external keyboards and pointing devices * Support for joysticks and gamepads * Support for [FLAC](http://en.wikipedia.org/wiki/Free_Lossless_Audio_Codec) audio playback[[73]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Android-Media-Formats-73)[[74]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-74) * High-performance Wi-Fi lock, maintaining high-performance Wi-Fi connections when device screen is off * Support for HTTP proxy for each connected Wi-Fi access point |  |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 3.2 Honeycomb (API level 13)**    **Android 3.2 Honeycomb (API level 13)** | | | |
| **Most first- and second-generation**[**Google TV**](http://en.wikipedia.org/wiki/Google_TV)**-enabled devices utilize Honeycomb 3.2.**[[75]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-75) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 3.2 | July 15, 2011[[76]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-76) | * Improved hardware support, including optimizations for a wider range of tablets * Increased ability of applications to access files on the SD card, e.g. for synchronization * Compatibility display mode for applications that have not been optimized for tablet screen resolutions * New display support functions, giving developers more control over display appearance on different Android devices[[77]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-77) |  |
| 3.2.1 | September 20, 2011 | * Bugfixes and minor security, stability and Wi-Fi improvements * Update to [Android Market](http://en.wikipedia.org/wiki/Android_Market) with automatic updates and easier-to-read Terms and Conditions text * Update to [Google Books](http://en.wikipedia.org/wiki/Google_Books) * Improved [Adobe Flash](http://en.wikipedia.org/wiki/Adobe_Flash) support in browser * Improved [Chinese](http://en.wikipedia.org/wiki/Chinese_language) handwriting prediction |
| 3.2.2 | August 30, 2011 | * Bugfixes and other minor improvements for the Motorola Xoom 4G |
| 3.2.3 |  | * Bugfixes and other minor improvements for the Motorola Xoom and Motorola Xoom 4G |
| 3.2.4 | December 2011 | * "Pay as You Go" support for 3G and 4G tablets |
| 3.2.5 | January 2012 | * Bugfixes and other minor improvements for the Motorola Xoom and Motorola Xoom 4G |
| 3.2.6 | February 2012 | * Fixed data connectivity issues when coming out of airplane mode on the US 4G Motorola Xoom |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  [**Android 4.0–4.0.2 Ice Cream Sandwich**](http://en.wikipedia.org/wiki/Android_4.0)**(API level 14)**    [**Android 4.0–4.0.2 Ice Cream Sandwich**](http://en.wikipedia.org/wiki/Android_4.0)**(API level 14)** | | | |
| **The SDK for Android 4.0.1 (Ice Cream Sandwich), based on Linux kernel 3.0.1,**[[78]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-78)**was publicly released on October 19, 2011.**[[79]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-79)**Google's Gabe Cohen stated that Android 4.0 was "theoretically compatible" with any Android 2.3.x device in production at that time.**[[80]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-80)**The**[**source code**](http://en.wikipedia.org/wiki/Source_code)**for Android 4.0 became available on November 14, 2011.**[[81]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-81)**Ice Cream Sandwich was the last version to officially support**[**Adobe Systems**](http://en.wikipedia.org/wiki/Adobe_Systems)**'**[**Flash player**](http://en.wikipedia.org/wiki/Flash_player#Mobile_platforms)**.**[[82]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-82)**The update introduced numerous new features:**[[83]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-ics-release-83)[[84]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-84)[[85]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-85) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 4.0 | October 18, 2011[[83]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-ics-release-83) | * Major refinements to the "Holo" interface with new [Roboto](http://en.wikipedia.org/wiki/Roboto) font family * Soft buttons from Android 3.x are now available for use on phones * Separation of widgets in a new tab, listed in a similar manner to applications * Easier-to-create folders, with a drag-and-drop style * Improved visual voicemail with the ability to speed up or slow down voicemail messages * Pinch-to-zoom functionality in the calendar * Integrated screenshot capture (accomplished by holding down the Power and Volume-Down buttons) * Improved error correction on the keyboard * Ability to access applications directly from [lock screen](http://en.wikipedia.org/wiki/Lock_screen) * Improved copy and paste functionality * Better voice integration and continuous, real-time speech to text dictation * Face Unlock, a feature that allows users to unlock handsets using facial recognition software * Automatic syncing of browser with users' Chrome bookmarks * Data Usage section in settings that lets users set warnings when they approach a certain usage limit, and disable data use when the limit is exceeded * Ability to shut down applications from the recent apps list with a swipe.[[86]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-86) * Improved camera application with zero shutter lag, time lapse settings, panorama mode, and the ability to zoom while recording * Built-in photo editor * New gallery layout, organized by location and person * Refreshed "People" application with social network integration, status updates and hi-res images * Android Beam, a [near-field communication](http://en.wikipedia.org/wiki/Near-field_communication) feature allowing the rapid short-range exchange of web bookmarks, contact info, directions, YouTube videos and other data * Support for the [WebP](http://en.wikipedia.org/wiki/WebP) image format[[73]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Android-Media-Formats-73) * Hardware acceleration of the UI[[87]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-87) * [Wi-Fi Direct](http://en.wikipedia.org/wiki/Wi-Fi_Direct)[[88]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-88) * [1080p](http://en.wikipedia.org/wiki/1080p) video recording for stock Android devices * Android VPN Framework (AVF), and TUN (but not TAP) kernel module. Prior to 4.0, VPN software required rooted Android. | [Android 4.0.png](http://en.wikipedia.org/wiki/File:Android_4.0.png) Android 4.0 on the Samsung[Galaxy Nexus](http://en.wikipedia.org/wiki/Galaxy_Nexus) |
| 4.0.1 | October 21, 2011 | * Fixed minor bugs for the Samsung Galaxy Nexus. |
| 4.0.2 | November 28, 2011 | * Fixed minor bugs on the Verizon Galaxy Nexus, the US launch of which was later delayed until December 2011 * For Canadian consumers, 4.0.2 reportedly created a bug on the Galaxy Nexus that crashed the application market when users attempted to view details of any Android application. It also inadvertently reduced the [NFC](http://en.wikipedia.org/wiki/Near_Field_Communication) capabilities of the Nexus phone.[[89]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-89)[[90]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-90) |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  [**Android 4.0.3–4.0.4 Ice Cream Sandwich**](http://en.wikipedia.org/wiki/Android_4.0)**(API level 15)**    [**Android 4.0.3–4.0.4 Ice Cream Sandwich**](http://en.wikipedia.org/wiki/Android_4.0)**(API level 15)** | | | |
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| **Version** | **Release date** | **Features** | **Image(s)** |
| 4.0.3 | December 16, 2011[[91]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-ICS16Dec2011-91) | * Numerous bugfixes and optimizations * Improvements to graphics, databases, spell-checking and Bluetooth functionality * New APIs for developers, including a social stream API in the Contacts provider * Calendar provider enhancements * New camera applications enhancing video stabilization and [QVGA](http://en.wikipedia.org/wiki/Quarter_Video_Graphics_Array) resolution * Accessibility refinements such as improved content access for screen readers[[92]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-92) |  |
| 4.0.4 | March 29, 2012[[93]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-InqMar2012-93) | * Stability improvements * Better camera performance * Smoother screen rotation * Improved phone number recognition[[94]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-ICS29mar2012-94) |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  [**Android 4.1 Jelly Bean**](http://en.wikipedia.org/wiki/Android_Jelly_Bean)**(API level 16)**    [**Android 4.1 Jelly Bean**](http://en.wikipedia.org/wiki/Android_Jelly_Bean)**(API level 16)** | | | |
| **Google announced Android 4.1 (Jelly Bean) at the**[**Google I/O**](http://en.wikipedia.org/wiki/Google_I/O)**conference on June 27, 2012. Based on Linux kernel 3.0.31, Jelly Bean was an incremental update with the primary aim of improving the functionality and performance of the user interface. The performance improvement involved "Project Butter", which uses touch anticipation,**[**triple buffering**](http://en.wikipedia.org/wiki/Multiple_buffering)**, extended**[**vsync**](http://en.wikipedia.org/wiki/Vsync)**timing and a fixed frame rate of 60**[**fps**](http://en.wikipedia.org/wiki/Frames_per_second)**to create a fluid and "buttery-smooth" UI.**[[95]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Android-4.1-devs-95)**Android 4.1 Jelly Bean was released to the**[**Android Open Source Project**](http://en.wikipedia.org/wiki/AOSP#Android_Open_Source_Project)**on July 9, 2012,**[[96]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-96)**and the**[**Nexus 7**](http://en.wikipedia.org/wiki/Nexus_7_(2012_version))**tablet, the first device to run Jelly Bean, was released on July 13, 2012.** | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 4.1 | July 9, 2012 | * Smoother user interface:   + Vsync timing across all drawing and animation done by the Android framework, including application rendering, touch events, screen composition and display refresh   + Triple buffering in the graphics pipeline * Enhanced [accessibility](http://en.wikipedia.org/wiki/Accessibility) * Bi-directional text and other language support * User-installable keyboard maps * Expandable notifications * Ability to turn off notifications on an application-specific basis * Shortcuts and widgets can automatically be re-arranged or re-sized to allow new items to fit on home screens * Bluetooth data transfer for Android Beam * Tablets with smaller screens now use an expanded version of the interface layout and home screen used by phones.[[97]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-android41-differentlayouts-97) * Improved camera application * Multichannel audio[[95]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Android-4.1-devs-95) * The [Fraunhofer FDK AAC](http://en.wikipedia.org/wiki/Fraunhofer_FDK_AAC) codec becomes standard in Android, adding AAC 5.1 channel encoding/decoding. * USB audio (for external sound [DACs](http://en.wikipedia.org/wiki/Digital-to-analog_converter))[[95]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Android-4.1-devs-95) * Audio chaining (also known as [gapless playback](http://en.wikipedia.org/wiki/Gapless_playback))[[95]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Android-4.1-devs-95)[[98]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-98)[[99]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-99) * Ability for other launchers to add widgets from the application drawer without requiring root access | [Android 4.1 on the Galaxy Nexus.jpeg](http://en.wikipedia.org/wiki/File:Android_4.1_on_the_Galaxy_Nexus.jpeg) Android 4.1 on the Samsung[Galaxy Nexus](http://en.wikipedia.org/wiki/Galaxy_Nexus) |
| 4.1.1 | July 11, 2012[[100]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-100) | * Fixed a bug on the Nexus 7 regarding the inability to change screen orientation in any application |
| 4.1.2 | October 9, 2012[[101]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Jelly_Bean_4.1.2-101) | * Lock/home screen rotation support for the Nexus 7[[102]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-102) * One-finger gestures to expand/collapse notifications[[103]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-103) * Bugfixes and performance enhancements |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  [**Android 4.2 Jelly Bean**](http://en.wikipedia.org/wiki/Android_Jelly_Bean)**(API level 17)**    [**Android 4.2 Jelly Bean**](http://en.wikipedia.org/wiki/Android_Jelly_Bean)**(API level 17)** | | | |
| **Google was expected to announce Jelly Bean 4.2 at an event in**[**New York City**](http://en.wikipedia.org/wiki/New_York_City)**on October 29, 2012, but the event was cancelled due to**[**Hurricane Sandy**](http://en.wikipedia.org/wiki/Hurricane_Sandy)**.**[[104]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-104)**Instead of rescheduling the live event, Google announced the new version with a press release, under the slogan "A new flavor of Jelly Bean". Jelly Bean 4.2 was based on Linux kernel 3.4.0, and debuted on Google's**[**Nexus 4**](http://en.wikipedia.org/wiki/Nexus_4)**and**[**Nexus 10**](http://en.wikipedia.org/wiki/Nexus_10)**, which were released on November 13, 2012.**[[105]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-New4.2And-105)[[106]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-106) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 4.2 | November 13, 2012[[107]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Jelly_Bean_4.2-107) | * [Lock screen](http://en.wikipedia.org/wiki/Lock_screen) improvements, including widget support and the ability to swipe directly to camera[[108]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-108) * Notification power controls ("Quick Settings") * "Daydream" [screensavers](http://en.wikipedia.org/wiki/Screensaver), showing information when idle or docked * Multiple user accounts (tablets only) * Rewritten [Bluetooth stack](http://en.wikipedia.org/wiki/Bluetooth_stack), switching from [Bluez](http://en.wikipedia.org/wiki/Bluez) to [Broadcom](http://en.wikipedia.org/wiki/Broadcom) open source [BlueDroid](http://en.wikipedia.org/wiki/BlueDroid),[[109]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-anand1-109) allowing improved support for multiple displays and wireless display ([Miracast](http://en.wikipedia.org/wiki/Miracast)) * Native [right-to-left](http://en.wikipedia.org/wiki/Right-to-left), always-on [VPN](http://en.wikipedia.org/wiki/Virtual_Private_Network) and application verification.[[110]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-aosp-jb1-110) A new [NFC](http://en.wikipedia.org/wiki/Near_field_communication) stack was added at the same time.[[109]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-anand1-109) * Accessibility improvements: triple-tap to magnify the entire screen, pan and zoom with two fingers. Speech output and Gesture Mode navigation for blind users * New clock application with built-in world clock, stop watch and timer * All devices now use the same interface layout, previously adapted from phones on 4.1 for smaller tablets (with centered software buttons, the system bar at the top of the screen, and a home screen with a dock and centered application menu), regardless of screen size * Increased number of extended notifications and Actionable Notifications for more applications, allowing users to respond to certain notifications within the notification bar and without launching the application directly * [SELinux](http://en.wikipedia.org/wiki/SELinux) * Premium [SMS](http://en.wikipedia.org/wiki/SMS) confirmation[[111]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Android_Police_4.2_Alpha_Teardown-111) * Group Messaging | [Android 4.2 on the Nexus 4.png](http://en.wikipedia.org/wiki/File:Android_4.2_on_the_Nexus_4.png) Android 4.2 on the [Nexus 4](http://en.wikipedia.org/wiki/Nexus_4) |
| 4.2.1 | November 27, 2012[[112]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Jelly_Bean_4.2.1-112) | * Fixed a bug in the People application where December was not displayed on the date selector when adding an event to a contact[[113]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-December_bug-113) * Added Bluetooth gamepads and joysticks as supported [HID](http://en.wikipedia.org/wiki/Human_interface_device) (Human interface device) |
| 4.2.2 | February 11, 2013[[114]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Jelly_Bean_4.2.2-114) | * Fixed Bluetooth audio streaming bugs[[115]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-115) * Long-pressing the Wi-Fi and Bluetooth icons in Quick Settings now toggles the on/off state * New download notifications, which now shows the percentage and estimated time remaining for active application downloads * New sounds for wireless charging and low battery * New Gallery application animation allows faster loading * USB debug whitelist * Bugfixes and performance enhancements |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  [**Android 4.3 Jelly Bean**](http://en.wikipedia.org/wiki/Android_Jelly_Bean)**(API level 18)**    [**Android 4.3 Jelly Bean**](http://en.wikipedia.org/wiki/Android_Jelly_Bean)**(API level 18)** | | | |
| **Google released Jelly Bean 4.3 under the slogan "An even sweeter Jelly Bean" on July 24, 2013, during an event in**[**San Francisco**](http://en.wikipedia.org/wiki/San_Francisco)**called "Breakfast with**[**Sundar Pichai**](http://en.wikipedia.org/wiki/Sundar_Pichai)**". Most Nexus devices received the update within a week, although the**[**second-generation Nexus 7**](http://en.wikipedia.org/wiki/Nexus_7_(2nd_generation))**tablet was the first device to officially ship with it.**[[116]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-TomsJuly2013-116)**A minor bugfix update was released on August 22, 2013.**[[117]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-117) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 4.3 | July 24, 2013[[118]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Jelly_Bean_4.3-118) | * [Bluetooth low energy](http://en.wikipedia.org/wiki/Bluetooth_low_energy) support[[119]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-OfficialAndroidBlog4.3-119) * [Bluetooth Audio/Video Remote Control Profile (AVRCP) 1.3](http://en.wikipedia.org/wiki/AVRCP) support * [OpenGL ES 3.0](http://en.wikipedia.org/wiki/OpenGL_ES#OpenGL_ES_3.0) support, allowing for improved game graphics[[119]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-OfficialAndroidBlog4.3-119) * Restricted access mode for new user profiles[[119]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-OfficialAndroidBlog4.3-119) * Filesystem write performance improvement by running [fstrim](http://en.wikipedia.org/wiki/Trim_(computing)) command while device is idle[[120]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-EngdtTRIM-120) * Dial pad auto-complete in the Phone application[[119]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-OfficialAndroidBlog4.3-119) * Volume for incoming calls (ringtone) and notification alerts is no longer adjustable separately * Improvements to Photo Sphere[[121]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-APPhotosphere-121) * Reworked camera UI, previously introduced on Google Play edition phones[[122]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-4.3Camera-122) * Addition of "[App Ops](http://en.wikipedia.org/wiki/App_Ops)", a fine-grained application permissions control system (hidden by default)[[123]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-AppOps-123) * [4K resolution](http://en.wikipedia.org/wiki/4K_resolution) support[[124]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Engdt4K-124) * Many security enhancements, performance enhancements, and bugfixes[[125]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-AP4.3-125) * System-level support for [geofencing](http://en.wikipedia.org/wiki/Geo-fence) and Wi-Fi scanning APIs   + Background Wi-Fi location still runs even when Wi-Fi is turned off * Developer logging and analyzing enhancements * Added support for five more languages * Changed [digital rights management](http://en.wikipedia.org/wiki/Digital_rights_management) (DRM) APIs * [Right-to-left](http://en.wikipedia.org/wiki/Right-to-left) (RTL) languages now supported[[119]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-OfficialAndroidBlog4.3-119) * Clock in the status bar disappears if clock is selected as lockscreen widget | [Android 4.3 on Nexus 7 (2013).jpg](http://en.wikipedia.org/wiki/File:Android_4.3_on_Nexus_7_(2013).jpg) Android 4.3 on the [Nexus 7 (2013 version)](http://en.wikipedia.org/wiki/Nexus_7_(2013_version)) |
| 4.3.1 | October 3, 2013[[126]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Jelly_Bean_4.3.1-126) | * Bugfixes and small tweaks for the Nexus 7 LTE[[127]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-4.3.1changelog-127) |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 4.4 KitKat (API level 19)**    **Android 4.4 KitKat (API level 19)** | | | |
| **Google announced Android 4.4**[**KitKat**](http://en.wikipedia.org/wiki/Kit_Kat)**on September 3, 2013. Although initially under the "Key Lime Pie" ("KLP") codename, the name was changed because "very few people actually know the taste of a**[**key lime pie**](http://en.wikipedia.org/wiki/Key_lime_pie)**."**[[128]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-KitkatBBC-128)**Some technology bloggers also expected the "Key Lime Pie" release to be Android 5.**[[129]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-129)**KitKat debuted on Google's**[**Nexus 5**](http://en.wikipedia.org/wiki/Nexus_5)**on October 31, 2013, and was optimised to run on a greater range of devices than earlier Android versions, having 512 MB of RAM as a recommended minimum; those improvements were known as "Project Svelte" internally at Google.**[[130]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Nexus_5_review-130)**The required minimum amount of RAM available to Android is 340 MB, and all devices with less than 512 MB of RAM must report themselves as "low RAM" devices.**[[131]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-cdd-4.4-131) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 4.4 | October 31, 2013[[132]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Android_4.4_KitKat-132)[[133]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-androiddev-44-133) | * Refreshed interface with white elements instead of blue * Clock no longer shows bold hours; all digits are thin. The H, M, and S markings for the stopwatch and timer have been removed, leaving just the numbers. * Ability for applications to trigger translucency in the navigation and status bars[[134]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-verge-n5handson-134) * Ability for applications to use "immersive mode" to keep the navigation and status bars hidden while maintaining user interaction[[135]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-135) * Action overflow menu buttons are always visible, even on devices with a "Menu" key, which was officially deprecated by Android 4.0.[[136]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-phonearena-overflowgone-136) * Restriction for applications when accessing external storage, except for their own directories * Optimizations for performance on devices with lower specifications, including [zRAM](http://en.wikipedia.org/wiki/Zram) support and "low RAM" device API[[130]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Nexus_5_review-130) * Wireless printing capability[[130]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Nexus_5_review-130) * NFC [host card emulation](http://en.wikipedia.org/wiki/Host_card_emulation), enabling a device to replace [smart cards](http://en.wikipedia.org/wiki/Smart_card)[[130]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Nexus_5_review-130) * WebViews now based on [Chromium](http://en.wikipedia.org/wiki/Chromium_(web_browser)) engine (feature parity with [Chrome for Android](http://en.wikipedia.org/wiki/Google_Chrome_for_Android) 30) * Expanded functionality for notification listener services[[130]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Nexus_5_review-130) * Public API for developing and managing [text messaging](http://en.wikipedia.org/wiki/Short_Message_Service) clients[[137]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-adb-kitkatsms-137) * Storage Access Framework, an API allowing apps to retrieve files in a consistent manner. As part of the framework, a new system file picker allows users to access files from various sources (including those exposed by apps, such as online storage services).[[70]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-anandtech-sdkitkat-70) * New framework for UI transitions * Sensor batching, step detector and counter APIs[[130]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Nexus_5_review-130) * Settings application now makes it possible to select default text messaging and home (launcher) application * Audio tunneling, audio monitoring and loudness enhancer[[138]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-138) * Built-in screen recording feature (primarily for developers, as usage of [ADB](http://en.wikipedia.org/wiki/Android_Debug_Bridge) is required)[[139]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-139) * Native [infrared blaster](http://en.wikipedia.org/wiki/Infrared_blaster) API * Expanded accessibility APIs and system-level [closed captioning](http://en.wikipedia.org/wiki/Closed_captioning) settings * [Android Runtime](http://en.wikipedia.org/wiki/Android_Runtime) (ART) introduced as a new experimental application [runtime environment](http://en.wikipedia.org/wiki/Runtime_environment), not enabled by default, as a replacement for the [Dalvik](http://en.wikipedia.org/wiki/Dalvik_(software)) virtual machine[[140]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-140) * [Bluetooth Message Access Profile](http://en.wikipedia.org/wiki/Message_Access_Profile) (MAP) support[[141]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-141) * Disabled access to battery statistics by third-party applications[[142]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-142) * Settings application no longer uses a multi-pane layout on devices with larger screens * Wi-Fi and mobile data activity (TX/RX) indicators are moved to quick settings[[143]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-143) * Browser text wrap is disabled.[[144]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-144) | [Android 4.4.2.png](http://en.wikipedia.org/wiki/File:Android_4.4.2.png) Android 4.4.2 ([OmniROM](http://en.wikipedia.org/wiki/OmniROM), [AOSP](http://en.wikipedia.org/wiki/AOSP)-based) |
| 4.4.1 | December 5, 2013[[145]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-145) | * Improvements to auto focus, white balance and HDR+ for the Nexus 5 camera[[146]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-146)[[147]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-147) * Better application compatibility for the experimental Android Runtime (ART) * Camera application now loads Google+ Photos instead of Gallery when swiping away from the camera view * Miscellaneous improvements and bugfixes |
| 4.4.2 | December 9, 2013[[148]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-148) | * Further security enhancements and bugfixes * Removal of the "[App Ops](http://en.wikipedia.org/wiki/App_Ops)" application permissions control system, introduced in Android 4.3[[149]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-149) |
| 4.4.3 | June 2, 2014[[150]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-150) | * Refreshed Dialer app interface[[151]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-151) * Updated the Chromium based WebView to version 33 (screencasting to DevTools, HTML5 Canvas hardware acceleration performance improvements, vibration API, HTML5 form validation, HTML5 datalist)[[152]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-152) * Miscellaneous improvements and bugfixes |
| 4.4.4 | June 19, 2014[[153]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-153) | * [CVE-2014-0224](http://en.wikipedia.org/wiki/CVE-2014-0224) fixed, eliminating an [OpenSSL](http://en.wikipedia.org/wiki/OpenSSL) [man-in-the-middle](http://en.wikipedia.org/wiki/Man-in-the-middle) vulnerability[[154]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-154) |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  **Android 4.4 KitKat with wearable extensions (API level 20)**    **Android 4.4 KitKat with wearable extensions (API level 20)** | | | |
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| **Version** | **Release date** | **Features** | **Image(s)** |
| 4.4W[[155]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Wear_source_code-155) | June 25, 2014[[156]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-156) | * Initial release of Android Wear platform for [smartwatches](http://en.wikipedia.org/wiki/Smartwatch): the same as Android 4.4 "KitKat", but with wearable extensions added |  |
| 4.4W.1 | September 6, 2014[[157]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-157) | * UI updates for Google Maps navigation and alarms |
| 4.4W.2 | October 21, 2014[[158]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-158) | * Offline music playback * GPS support |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  [**Android 5.0–5.0.2 Lollipop**](http://en.wikipedia.org/wiki/Android_Lollipop)**(API level 21)**    [**Android 5.0–5.0.2 Lollipop**](http://en.wikipedia.org/wiki/Android_Lollipop)**(API level 21)** | | | |
| **Android 5.0 "Lollipop" was unveiled under the codename "Android L" on June 25, 2014, during**[**Google I/O**](http://en.wikipedia.org/wiki/Google_I/O)**. It became available as official**[**over-the-air**](http://en.wikipedia.org/wiki/Over-the-air_programming)**(OTA) updates on November 12, 2014, for select devices that run distributions of Android serviced by Google, including**[**Nexus**](http://en.wikipedia.org/wiki/Google_Nexus)**and**[**Google Play edition**](http://en.wikipedia.org/wiki/Google_Play_edition)**devices. Its source code was made available on November 3, 2014.**[[159]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-PCWorldJun2014-159)[[160]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-160)  **Lollipop features a redesigned user interface built around a responsive**[**design language**](http://en.wikipedia.org/wiki/Design_language)**referred to as "**[**material design**](http://en.wikipedia.org/wiki/Material_design)**". Other changes include improvements to the notifications, which can be accessed from the lockscreen and displayed within applications as top-of-the-screen banners. Furthermore, Google made internal changes to the platform, with the**[**Android Runtime**](http://en.wikipedia.org/wiki/Android_Runtime)**(ART) officially replacing**[**Dalvik**](http://en.wikipedia.org/wiki/Dalvik_virtual_machine)**for improved application performance, and with changes intended to improve and optimize battery usage, known internally as**[**Project Volta**](http://en.wikipedia.org/wiki/Project_Volta)**.**[[161]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-161)[[162]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-162)[[163]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-163)[[164]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-164) | | | |
| **Version** | **Release date** | **Features** | **Image(s)** |
| 5.0[[165]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Api_level_21-22-165) | November 12, 2014[[166]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-lollipop-blog-166) | * [Android Runtime](http://en.wikipedia.org/wiki/Android_Runtime) (ART) with [ahead-of-time (AOT) compilation](http://en.wikipedia.org/wiki/Ahead-of-time_compilation) and improved garbage collection (GC), replacing [Dalvik](http://en.wikipedia.org/wiki/Dalvik_(software)) that combines bytecode [interpretation](http://en.wikipedia.org/wiki/Interpreter_(computing)) with [trace-based just-in-time (JIT) compilation](http://en.wikipedia.org/wiki/Tracing_just-in-time_compilation)[[165]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-Api_level_21-22-165)[[167]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-167) * Support for [64-bit](http://en.wikipedia.org/wiki/64-bit_computing) CPUs * [OpenGL ES](http://en.wikipedia.org/wiki/OpenGL_ES) 3.1 and Android Extension Pack (AEP) on supported GPU configurations * Recent activities screen with tasks instead of applications, up to a configured maximum of tasks per application * [Vector drawables](http://en.wikipedia.org/wiki/Vector_graphics), which scale without losing definition * Support for print previews * [Material design](http://en.wikipedia.org/wiki/Material_design), bringing a restyled user interface * Refreshed lock screen, no longer supporting widgets[[168]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-168) * Refreshed notification tray and quick settings pull-down * [Project Volta](http://en.wikipedia.org/wiki/Project_Volta), for battery life improvements * Searches can be performed within the system settings for quicker access to particular settings * Lock screen provides shortcuts to application and notification settings[[169]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-IndiaTimes-169) * Guest logins and multiple user accounts are available on more devices, such as phones.[[170]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-170) * Audio input and output through USB devices * Third-party applications regain the ability to read and modify data located anywhere on external storage, such as on [SD cards](http://en.wikipedia.org/wiki/SD_card).[[171]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-android-police01-171)[[172]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-android-police02-172) * Pinning of an application's screen for restricted user activity.[[169]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-IndiaTimes-169) * Recently used applications are remembered even after restarting the device.[[169]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-IndiaTimes-169) * WebViews receive updates independently through [Google Play](http://en.wikipedia.org/wiki/Google_Play) for security reasons, instead of relying on system-wide vendor updates[[173]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-173) * Addition of 15 new languages: Basque, Bengali, Burmese, Chinese (Hong Kong), Galician, Icelandic, Kannada, Kyrgyz, Macedonian, Malayalam, Marathi, Nepali, Sinhala, Tamil and Telugu[[174]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-AndroidLollipop-174) * *Tap and Go* allows users to quickly migrate to a new Android device, using NFC and Bluetooth to transfer Google Account details, configuration settings, user data and installed applications.[[169]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-IndiaTimes-169) * A flashlight-style application is included, working on supported devices with a camera flash.[[169]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-IndiaTimes-169) * User-customizable priorities for application notifications.[[175]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-CNET-priority-175) * Smart lock feature[[176]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-176) | [Android 5.0-en.png](http://en.wikipedia.org/wiki/File:Android_5.0-en.png) Android 5.0 "Lollipop" homescreen. |
| 5.0.1 | December 2, 2014[[177]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-177) | * A few bugfixes, including resolving issues with video playback and password failures handling |
| 5.0.2 | December 19, 2014[[178]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-178) | * Fixes a bug with [TRIM](http://en.wikipedia.org/wiki/TRIM) support, which prevented devices from the nightly on-charger cleanups of file system allocations if the device was turned off while being charged, or if it was charged during the day * Changes how alarms wake the CPU, and how alarms compete for system resources[[179]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-179) |

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| [[hide](http://en.wikipedia.org/wiki/Android_version_history)]  [**Android 5.1 Lollipop**](http://en.wikipedia.org/wiki/Android_Lollipop)**(API level 22)**    [**Android 5.1 Lollipop**](http://en.wikipedia.org/wiki/Android_Lollipop)**(API level 22)** | | | |
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| **Version** | **Release date** | **Features** | **Image(s)** |
| 5.1 | March 9, 2015[[180]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-180) | * Ability to join Wi-Fi networks and control paired Bluetooth devices from quick settings * Support for [multiple SIM cards](http://en.wikipedia.org/wiki/Dual_SIM) * [Device protection](http://en.wikipedia.org/wiki/Anti-theft_system): if a device is lost or stolen it will remain locked until the owner signs into their Google account, even if the device is reset to factory settings. * [High-definition voice calls](http://en.wikipedia.org/wiki/Wideband_audio), available between compatible devices running Android 5.1 * Improvements to the notification priority system, to more closely replicate the [silent mode](http://en.wikipedia.org/wiki/Silent_mode) that was removed in Android 5.0.[[181]](http://en.wikipedia.org/wiki/Android_version_history#cite_note-181) |  |

B.3 Conclusion: