**Android** is an [operating system](https://en.wikipedia.org/wiki/Operating_system) based on a modified version of the [Linux kernel](https://en.wikipedia.org/wiki/Linux_kernel) and other [open-source](https://en.wikipedia.org/wiki/Open-source_software) software, designed primarily for [touchscreen](https://en.wikipedia.org/wiki/Touchscreen)-based mobile devices such as [smartphones](https://en.wikipedia.org/wiki/Smartphone) and [tablets](https://en.wikipedia.org/wiki/Tablet_computer). Android has historically been developed by a consortium of developers known as the [Open Handset Alliance](https://en.wikipedia.org/wiki/Open_Handset_Alliance), but its most widely used version is primarily developed by [Google](https://en.wikipedia.org/wiki/Google). First released in 2008, Android is the world's [most widely used operating system](https://en.wikipedia.org/wiki/Usage_share_of_operating_systems); the latest version, released on October 15, 2024, is [Android 15](https://en.wikipedia.org/wiki/Android_15).[[4]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-4)

At its core, the operating system is known as the **Android Open Source Project** (**AOSP**)[[5]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-5) and is [free and open-source software](https://en.wikipedia.org/wiki/Free_and_open-source_software) (FOSS) primarily licensed under the [Apache License](https://en.wikipedia.org/wiki/Apache_License). However, most devices run the [proprietary](https://en.wikipedia.org/wiki/Proprietary_software) Android version developed by Google, which ships with additional proprietary closed-source software pre-installed,[[6]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-6) most notably [Google Mobile Services](https://en.wikipedia.org/wiki/Google_Mobile_Services) (GMS),[[7]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-7) which includes core apps such as [Google Chrome](https://en.wikipedia.org/wiki/Google_Chrome), the [digital distribution](https://en.wikipedia.org/wiki/Digital_distribution) platform [Google Play](https://en.wikipedia.org/wiki/Google_Play), and the associated [Google Play Services](https://en.wikipedia.org/wiki/Google_Play_Services) development platform. [Firebase Cloud Messaging](https://en.wikipedia.org/wiki/Firebase_Cloud_Messaging) is used for push notifications. While AOSP is free, the "Android" name and logo are [trademarks](https://en.wikipedia.org/wiki/Trademark) of Google, who restrict the use of Android branding on "uncertified" products.[[8]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-8)[[9]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-9) The majority of smartphones based on AOSP run Google's ecosystem—which is known simply as Android—some with [vendor](https://en.wikipedia.org/wiki/Vendor)-customized user interfaces and software suites,[[10]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-10) for example [One UI](https://en.wikipedia.org/wiki/One_UI). Numerous [modified distributions](https://en.wikipedia.org/wiki/List_of_custom_Android_distributions) exist, which include competing [Amazon Fire OS](https://en.wikipedia.org/wiki/Fire_OS), community-developed [LineageOS](https://en.wikipedia.org/wiki/LineageOS); the source code has also been used to develop a variety of Android distributions on a range of other electronics, such as [Android TV](https://en.wikipedia.org/wiki/Android_TV) for televisions, [Wear OS](https://en.wikipedia.org/wiki/Wear_OS) for [wearables](https://en.wikipedia.org/wiki/Wearable_computer), and [Meta Horizon OS](https://en.wikipedia.org/wiki/Meta_Horizon_OS) for [VR headsets](https://en.wikipedia.org/wiki/Virtual_reality_headset).

Software packages on Android, which use the [APK](https://en.wikipedia.org/wiki/Apk_(file_format)) format, are generally distributed through a proprietary [application store](https://en.wikipedia.org/wiki/Application_store); non-Google platforms include vendor-specific [Amazon Appstore](https://en.wikipedia.org/wiki/Amazon_Appstore), [Samsung Galaxy Store](https://en.wikipedia.org/wiki/Samsung_Galaxy_Store), [Huawei AppGallery](https://en.wikipedia.org/wiki/Huawei_AppGallery), and third-party companies [Aptoide](https://en.wikipedia.org/wiki/Aptoide), [Cafe Bazaar](https://en.wikipedia.org/wiki/Cafe_Bazaar), [GetJar](https://en.wikipedia.org/wiki/GetJar) or open source [F-Droid](https://en.wikipedia.org/wiki/F-Droid). Since 2011 Android has been the most used operating system worldwide on smartphones. It has the largest [installed base](https://en.wikipedia.org/wiki/Installed_base) of any operating system in the world[[11]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-11) with over three billion [monthly active users](https://en.wikipedia.org/wiki/Monthly_active_users)[[a]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-12) and accounting for 46% of the global operating system market.[[b]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-13)[[12]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-14)

**History**

*See also:*[*Android version history*](https://en.wikipedia.org/wiki/Android_version_history)

**2000s**

**Android Inc.** was founded in [Palo Alto, California](https://en.wikipedia.org/wiki/Palo_Alto,_California), in October 2003 by [Andy Rubin](https://en.wikipedia.org/wiki/Andy_Rubin) and Chris White, with [Rich Miner](https://en.wikipedia.org/wiki/Rich_Miner) and Nick Sears[[13]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-15)[[14]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Google_Buys_Android-16) joining later. Rubin and White started out to build an Operating System for [digital cameras](https://en.wikipedia.org/wiki/Digital_camera) viz *FotoFrame*. The company name was changed to *Android* as Rubin already owned the [domain name](https://en.wikipedia.org/wiki/Domain_name) android.com. After having built a prototype internally known as the "Fadden demo" predominantly by purchasing licensing agreements for most of the software components built around a custom [JavaScript](https://en.wikipedia.org/wiki/JavaScript) front-end, the company failed to convince investors, and so in April 2004 they pivoted to building an Operating System for Phones at the suggestion of Nick Sears,[[15]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-hasse1-17)[[16]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-pcworld-camera-os-18) as a rival to [Symbian](https://en.wikipedia.org/wiki/Symbian) and Microsoft [Windows Mobile](https://en.wikipedia.org/wiki/Windows_Mobile).[[17]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-19) Rubin pitched the Android project as having "tremendous potential in developing smarter mobile devices that are more aware of its owner's location and preferences".[[14]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Google_Buys_Android-16) Due to difficulty attracting investors early on, Android faced potential eviction from its office space. [Steve Perlman](https://en.wikipedia.org/wiki/Steve_Perlman_(entrepreneur)), a close friend of Rubin, brought him $10,000 in cash in an envelope, and shortly thereafter wired an undisclosed amount as seed funding. Perlman refused a stake in the company, and has stated "I did it because I believed in the thing, and I wanted to help Andy."[[18]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-20)[[19]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-21)

In 2005, Rubin tried to negotiate deals with [Samsung](https://en.wikipedia.org/wiki/Samsung)[[20]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-MPC-22) and [HTC](https://en.wikipedia.org/wiki/HTC).[[21]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-23) Shortly afterwards, [Google](https://en.wikipedia.org/wiki/Google) acquired the company in July of that year for at least $50 million;[[14]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Google_Buys_Android-16)[[22]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Murky_road_despite_dominance-24) this was Google's "best deal ever" according to Google's then-vice president of corporate development, [David Lawee](https://en.wikipedia.org/wiki/David_Lawee), in 2010.[[20]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-MPC-22) Android's key employees, including Rubin, Miner, Sears, and White, joined Google as part of the acquisition.[[14]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Google_Buys_Android-16) Not much was known about the secretive Android Inc. at the time, with the company having provided few details other than that it was making software for mobile phones.[[14]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Google_Buys_Android-16) At Google, the team led by Rubin developed a mobile device platform powered by the [Linux kernel](https://en.wikipedia.org/wiki/Linux_kernel). Google marketed the platform to [handset makers](https://en.wikipedia.org/wiki/Original_equipment_manufacturer) and [carriers](https://en.wikipedia.org/wiki/Mobile_network_operator) on the promise of providing a flexible, upgradeable system.[[23]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-25) Google had "lined up a series of hardware components and software partners and signaled to carriers that it was open to various degrees of cooperation".[[*attribution needed*](https://en.wikipedia.org/wiki/Wikipedia:Attribution_needed)][[24]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-26)

Speculation about Google's intention to enter the mobile communications market continued to build through December 2006.[[25]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-27) An early [prototype](https://en.wikipedia.org/wiki/Prototype) had a close resemblance to a [BlackBerry](https://en.wikipedia.org/wiki/BlackBerry) phone, with no touchscreen and a physical [QWERTY](https://en.wikipedia.org/wiki/QWERTY) [keyboard](https://en.wikipedia.org/wiki/Computer_keyboard), but the arrival of [Apple's](https://en.wikipedia.org/wiki/Apple_Inc.) 2007 [iPhone](https://en.wikipedia.org/wiki/IPhone) meant that Android "had to go back to the drawing board".[[26]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-28)[[27]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-29) Google later changed its Android specification documents to state that "Touchscreens will be supported", although "the Product was designed with the presence of discrete physical buttons as an assumption, therefore a touchscreen cannot completely replace physical buttons".[[28]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-30) By 2008, both [Nokia](https://en.wikipedia.org/wiki/Nokia) and BlackBerry announced touch-based smartphones to rival the [iPhone 3G](https://en.wikipedia.org/wiki/IPhone_3G), and Android's focus eventually switched to just touchscreens. The first commercially available smartphone running Android was the [HTC Dream](https://en.wikipedia.org/wiki/HTC_Dream), also known as T-Mobile G1, announced on September 23, 2008.[[29]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-31)[[30]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-32)

[](https://en.wikipedia.org/wiki/File:HTC_Android_T-Mobile_G1.jpg)[HTC Dream](https://en.wikipedia.org/wiki/HTC_Dream) or T-Mobile G1, the first commercially released device running Android (2008)

On November 5, 2007, the [Open Handset Alliance](https://en.wikipedia.org/wiki/Open_Handset_Alliance), a [consortium](https://en.wikipedia.org/wiki/Consortium) of technology companies including Google, device manufacturers such as HTC, [Motorola](https://en.wikipedia.org/wiki/Motorola_Mobility) and Samsung, wireless carriers such as [Sprint](https://en.wikipedia.org/wiki/Sprint_Corporation) and [T-Mobile](https://en.wikipedia.org/wiki/T-Mobile_US), and chipset makers such as [Qualcomm](https://en.wikipedia.org/wiki/Qualcomm) and [Texas Instruments](https://en.wikipedia.org/wiki/Texas_Instruments), unveiled itself, with a goal to develop "the first truly open and comprehensive platform for mobile devices".[[31]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Announcement_of_OHA-33)[[32]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-34)[[33]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-35) Within a year, the Open Handset Alliance faced two other [open source](https://en.wikipedia.org/wiki/Open-source_software) competitors, the [Symbian Foundation](https://en.wikipedia.org/wiki/Symbian_Foundation) and the [LiMo Foundation](https://en.wikipedia.org/wiki/LiMo_Foundation), the latter also developing a [Linux](https://en.wikipedia.org/wiki/Linux)-based mobile operating system like Google. In September 2007, Google had filed several [patent](https://en.wikipedia.org/wiki/Patent) applications in the area of mobile telephony.[[34]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-36)[[35]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-37)[[36]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-38)

On September 23, 2008, Android was introduced by Andy Rubin, Larry Page, Sergey Brin, Cole Brodman, Christopher Schlaeffer and Peter Chou at a press conference in a [New York City](https://en.wikipedia.org/wiki/New_York_City) [subway station](https://en.wikipedia.org/wiki/Subway_station).[[37]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-39)

Since 2008, Android has seen [numerous updates](https://en.wikipedia.org/wiki/Android_version_history) which have incrementally improved the operating system, adding new features and fixing [bugs](https://en.wikipedia.org/wiki/Software_bug) in previous releases. The first two Android versions were internally codenamed [Astro Boy](https://en.wikipedia.org/wiki/Astro_Boy) and [Bender](https://en.wikipedia.org/wiki/Bender_(Futurama)) but licensing issues meant subsequent releases were named after dessert or sugary treat in an alphabetical order, with the first few Android versions being called "[Petit Four](https://en.wikipedia.org/wiki/Petit_Four)", "[Cupcake](https://en.wikipedia.org/wiki/Cupcake)", "[Donut](https://en.wikipedia.org/wiki/Donut)", "[Eclair](https://en.wikipedia.org/wiki/Eclair)",[[38]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-hasse27-40) and "[Froyo](https://en.wikipedia.org/wiki/Frozen_yogurt)", in that order. During its announcement of [Android KitKat](https://en.wikipedia.org/wiki/Android_KitKat) in 2013, Google explained that "Since these devices make our lives so sweet, each Android version is named after a dessert", although a Google spokesperson told [CNN](https://en.wikipedia.org/wiki/CNN) in an interview that "It's kind of like an internal team thing, and we prefer to be a little bit—how should I say—a bit inscrutable in the matter, I'll say".[[39]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-41)

**2010s**

In 2010, Google launched its [Nexus](https://en.wikipedia.org/wiki/Google_Nexus) series of devices, a lineup in which Google partnered with different device manufacturers to produce new devices and introduce new Android versions. The series was described as having "played a pivotal role in Android's history by introducing new software iterations and hardware standards across the board", and became known for its "[bloat-free](https://en.wikipedia.org/wiki/Software_bloat)" software with "timely ... updates".[[40]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-42) At its [developer conference](https://en.wikipedia.org/wiki/Google_I/O) in May 2013, Google announced a special version of the [Samsung Galaxy S4](https://en.wikipedia.org/wiki/Samsung_Galaxy_S4), where, instead of using Samsung's own Android customization, the phone ran "stock Android" and was promised to receive new system updates fast.[[41]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-43) The device would become the start of the [Google Play edition](https://en.wikipedia.org/wiki/List_of_Google_Play_edition_devices) program, and was followed by other devices, including the [HTC One](https://en.wikipedia.org/wiki/HTC_One_(M7)) Google Play edition,[[42]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-44) and [Moto G](https://en.wikipedia.org/wiki/Moto_G_(1st_generation)) Google Play edition.[[43]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-45) In 2015, [*Ars Technica*](https://en.wikipedia.org/wiki/Ars_Technica) wrote that "Earlier this week, the last of the Google Play edition Android phones in Google's online storefront were listed as "no longer available for sale" and that "Now they're all gone, and it looks a whole lot like the program has wrapped up".[[44]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-46)[[45]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-47)

[](https://en.wikipedia.org/wiki/File:A_Press_Conference_for_the_Launch_of_Nexus_7_on_September_27,_2012_in_Seoul_from_acrofan_3.JPG)[Eric Schmidt](https://en.wikipedia.org/wiki/Eric_Schmidt), [Andy Rubin](https://en.wikipedia.org/wiki/Andy_Rubin) and [Hugo Barra](https://en.wikipedia.org/wiki/Hugo_Barra) at a 2012 press conference announcing Google's Nexus 7 tablet

From 2008 to 2013, [Hugo Barra](https://en.wikipedia.org/wiki/Hugo_Barra) served as product spokesperson, representing Android at press conferences and [Google I/O](https://en.wikipedia.org/wiki/Google_I/O), Google's annual developer-focused conference. He left Google in August 2013 to join Chinese phone maker [Xiaomi](https://en.wikipedia.org/wiki/Xiaomi).[[46]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-48)[[47]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-49) Less than six months earlier, Google's then-[CEO](https://en.wikipedia.org/wiki/CEO) [Larry Page](https://en.wikipedia.org/wiki/Larry_Page) announced in a blog post that Andy Rubin had moved from the Android division to take on new projects at Google, and that [Sundar Pichai](https://en.wikipedia.org/wiki/Sundar_Pichai) would become the new Android lead.[[48]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-50)[[49]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-51) Pichai himself would eventually switch positions, becoming the new CEO of Google in August 2015 following the company's restructure into the [Alphabet](https://en.wikipedia.org/wiki/Alphabet_Inc.) conglomerate,[[50]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-52)[[51]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-53) making [Hiroshi Lockheimer](https://en.wikipedia.org/wiki/Hiroshi_Lockheimer) the new head of Android.[[52]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-54)[[53]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-55)

On [Android 4.4](https://en.wikipedia.org/wiki/Android_4.4), *KitKat*, shared writing access to [MicroSD](https://en.wikipedia.org/wiki/MicroSD) memory cards has been locked for user-installed applications, to which only the dedicated directories with respective package names, located inside Android/data/, remained writeable. Writing access has been reinstated with [Android 5](https://en.wikipedia.org/wiki/Android_5) *Lollipop* through the [backwards-incompatible](https://en.wikipedia.org/wiki/Backwards_compatibility) *Google Storage Access Framework* [interface](https://en.wikipedia.org/wiki/API).[[54]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-56)

In June 2014, Google announced [Android One](https://en.wikipedia.org/wiki/Android_One), a set of "hardware reference models" that would "allow [device makers] to easily create high-quality phones at low costs", designed for consumers in developing countries.[[55]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-57)[[56]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-58)[[57]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-59) In September, Google announced the first set of Android One phones for release in India.[[58]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-60)[[59]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-61) However, [*Recode*](https://en.wikipedia.org/wiki/Recode) reported in June 2015 that the project was "a disappointment", citing "reluctant consumers and manufacturing partners" and "misfires from the search company that has never quite cracked hardware".[[60]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-62) Plans to relaunch Android One surfaced in August 2015,[[61]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-63) with Africa announced as the next location for the program a week later.[[62]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-64)[[63]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-65) A report from *The Information* in January 2017 stated that Google is expanding its low-cost Android One program into the United States, although *The Verge* notes that the company will presumably not produce the actual devices itself.[[64]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-66)[[65]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-67) Google introduced the [Pixel and Pixel XL smartphones](https://en.wikipedia.org/wiki/Pixel_(smartphone)) in October 2016, marketed as being the first phones made by Google,[[66]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-68)[[67]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-69) and exclusively featured certain software features, such as the [Google Assistant](https://en.wikipedia.org/wiki/Google_Assistant), before wider rollout.[[68]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-70)[[69]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-71) The Pixel phones replaced the Nexus series,[[70]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-72) with a new generation of Pixel phones launched in October 2017.[[71]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-73)

In May 2019, the operating system became entangled in the [trade war between China and the United States](https://en.wikipedia.org/wiki/China%E2%80%93United_States_trade_war) involving [Huawei](https://en.wikipedia.org/wiki/Huawei), which, like many other tech firms, had become dependent on access to the Android platform.[[72]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-74)[[73]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-75) In the summer of 2019, Huawei announced it would create an alternative operating system to Android[[74]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-76) known as [Harmony OS](https://en.wikipedia.org/wiki/Harmony_OS),[[75]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-77) and has filed for intellectual property rights across major global markets.[[76]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-78)[[77]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-79) Under such sanctions Huawei has long-term plans to replace Android in 2022 with the new operating system, as Harmony OS was originally designed for [internet of things](https://en.wikipedia.org/wiki/Internet_of_things) devices, rather than for smartphones and tablets.[[78]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-verge-harmony-80)

On August 22, 2019, it was announced that Android "Q" would officially be branded as Android 10, ending the historic practice of naming major versions after desserts. Google stated that these names were not "inclusive" to international users (due either to the aforementioned foods not being internationally known, or being difficult to pronounce in some languages).[[79]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-81)[[80]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-82) On the same day, *Android Police* reported that Google had commissioned a statue of a giant number "10" to be installed in the lobby of the developers' new office.[[81]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-83) Android 10 was released on September 3, 2019, to [Google Pixel](https://en.wikipedia.org/wiki/Google_Pixel) phones first.

**2020s**

In late 2021, some users reported that they were unable to dial emergency services.[[82]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-84)[[83]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-85) The problem was caused by a combination of bugs in Android and in the [Microsoft Teams](https://en.wikipedia.org/wiki/Microsoft_Teams) app; both companies released updates addressing the issue.[[84]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-86)

On December 12, 2024 [Google](https://en.wikipedia.org/wiki/Google) announced [Android XR](https://en.wikipedia.org/wiki/Android_XR). It is a new operating system developed by Google, designed for [virtual reality](https://en.wikipedia.org/wiki/Virtual_reality) and [augmented reality](https://en.wikipedia.org/wiki/Augmented_reality) devices, such as VR headsets and smart glasses. It was built in collaboration with [Samsung](https://en.wikipedia.org/wiki/Samsung) and [Qualcomm](https://en.wikipedia.org/wiki/Qualcomm). The platform is also focused on supporting developers with tools like [ARCore](https://en.wikipedia.org/wiki/ARCore) and Unity to build applications for upcoming XR devices.[[85]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-87)

**Features**

*Main article:*[*List of features in Android*](https://en.wikipedia.org/wiki/List_of_features_in_Android)

**Interface**

Android's default user interface is mainly based on [direct manipulation](https://en.wikipedia.org/wiki/Direct_manipulation_interface), using touch inputs that loosely correspond to real-world actions, like swiping, tapping, pinching, and reverse pinching to manipulate on-screen objects, along with a [virtual keyboard](https://en.wikipedia.org/wiki/Virtual_keyboard).[[86]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-88) [Game controllers](https://en.wikipedia.org/wiki/Game_controller) and full-size physical keyboards are supported via [Bluetooth](https://en.wikipedia.org/wiki/Bluetooth) or [USB](https://en.wikipedia.org/wiki/USB).[[87]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-89)[[88]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-90) The response to user input is designed to be immediate and provides a fluid touch interface, often using the vibration capabilities of the device to provide [haptic feedback](https://en.wikipedia.org/wiki/Haptic_technology) to the user. Internal hardware, such as [accelerometers](https://en.wikipedia.org/wiki/Accelerometer), [gyroscopes](https://en.wikipedia.org/wiki/Gyroscope) and [proximity sensors](https://en.wikipedia.org/wiki/Proximity_sensor) are used by some applications to respond to additional user actions, for example adjusting the screen from portrait to landscape depending on how the device is oriented,[[89]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-91) or allowing the user to steer a vehicle in a [racing game](https://en.wikipedia.org/wiki/Racing_game) by rotating the device, simulating control of a [steering wheel](https://en.wikipedia.org/wiki/Steering_wheel).[[90]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-92)

**Home screen**

Android devices boot to the [home screen](https://en.wikipedia.org/wiki/Home_screen), the primary navigation and information "hub" on Android devices, analogous to the [desktop](https://en.wikipedia.org/wiki/Desktop_metaphor) found on personal computers. Android home screens are typically made up of app icons and [widgets](https://en.wikipedia.org/wiki/Software_widget); app icons launch the associated app, whereas widgets display live, auto-updating content, such as a [weather forecast](https://en.wikipedia.org/wiki/Weather_forecast), the user's email inbox, or a [news ticker](https://en.wikipedia.org/wiki/News_ticker) directly on the home screen.[[91]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-93) A home screen may be made up of several pages, between which the user can swipe back and forth.[[92]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Design_info-94) Third-party apps available on [Google Play](https://en.wikipedia.org/wiki/Google_Play) and other app stores can extensively re-[theme](https://en.wikipedia.org/wiki/Theme_(computing)) the home screen,[[93]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-95) and even mimic the look of other operating systems, such as [Windows Phone](https://en.wikipedia.org/wiki/Windows_Phone).[[94]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-96) Most manufacturers customize the look and features of their Android devices to differentiate themselves from their competitors.[[95]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-97)

**Status bar**

Along the top of the screen is a status bar, showing information about the device and its connectivity. This status bar can be pulled (swiped) down from to reveal a notification screen where apps display important information or updates, as well as quick access to system controls and toggles such as display brightness, connectivity settings ([WiFi](https://en.wikipedia.org/wiki/WiFi), Bluetooth, cellular data), audio mode, and [flashlight](https://en.wikipedia.org/wiki/Flashlight).[[92]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Design_info-94) Vendors may implement extended settings such as the ability to adjust the flashlight brightness.[[96]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-98)

**Notifications**

Notifications are "short, timely, and relevant information about your app when it's not in use", and when tapped, users are directed to a screen inside the app relating to the notification.[[97]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-99) Beginning with [Android 4.1 "Jelly Bean"](https://en.wikipedia.org/wiki/Android_Jelly_Bean), "expandable notifications" allow the user to tap an icon on the notification in order for it to expand and display more information and possible app actions right from the notification.[[98]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-100)

**App lists**

An "All Apps" screen lists all installed applications, with the ability for users to drag an app from the list onto the home screen. The app list may be accessed using a gesture or a button, depending on the Android version. A "Recents" screen, also known as "Overview", lets users switch between recently used apps.[[92]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Design_info-94)

The recent list may appear side-by-side or overlapping, depending on the Android version and manufacturer.[[99]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-101)

**Navigation buttons**

[](https://en.wikipedia.org/wiki/File:HTC_Desire_-_optic_navigation.jpeg)Front buttons (home, menu/options, go back, search) and [optical track pad](https://en.wikipedia.org/wiki/Smartphone#Alternative_input_methods) of an [HTC Desire](https://en.wikipedia.org/wiki/HTC_Desire), a 2010 smartphone with Android OS

Many early Android OS smartphones were equipped with a dedicated search button for quick access to a [web search engine](https://en.wikipedia.org/wiki/Web_search_engine) and individual apps' internal search feature. More recent devices typically allow the former through a long press or swipe away from the home button.[[100]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-MenuKey-102)

The dedicated option key, also known as menu key, and its on-screen simulation, is no longer supported since Android version 10. Google recommends mobile application developers to locate menus within the user interface.[[100]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-MenuKey-102) On more recent phones, its place is occupied by a task key used to access the list of recently used apps when actuated. Depending on device, its long press may simulate a menu button press or engage [split screen](https://en.wikipedia.org/wiki/Split_screen_(computing)) view, the latter of which is the default behaviour since stock Android version 7.[[101]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-103)[[102]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-104)[[103]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-NougatSplit-105)

**Split-screen view**

Native support for split screen view has been added in stock Android version 7.0 *Nougat*.[[103]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-NougatSplit-105)

The earliest vendor-customized Android-based smartphones known to have featured a split-screen view mode are the 2012 [Samsung Galaxy S3](https://en.wikipedia.org/wiki/Samsung_Galaxy_S3) and [Note 2](https://en.wikipedia.org/wiki/Samsung_Galaxy_Note_II), the former of which received this feature with the *premium suite* upgrade delivered in [TouchWiz](https://en.wikipedia.org/wiki/TouchWiz) with Android 4.1 Jelly Bean.[[104]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-106)

**Charging while powered off**

When connecting or disconnecting charging power and when shortly actuating the power button or home button, all while the device is powered off, a visual battery meter whose appearance varies among vendors appears on the screen, allowing the user to quickly assess the charge status of a powered-off without having to boot it up first. Some display the battery percentage.[[105]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-107)

**Desktop mode**

|  |  |
| --- | --- |
| [[icon]](https://en.wikipedia.org/wiki/File:Wiki_letter_w_cropped.svg) | **This section is empty.** You can help by [adding to it](https://en.wikipedia.org/w/index.php?title=Android_(operating_system)&action=edit&section=). *(February 2025)* |

**Applications**

*See also:*[*Android software development*](https://en.wikipedia.org/wiki/Android_software_development)*and*[*Google Play*](https://en.wikipedia.org/wiki/Google_Play)

Most Android devices come with preinstalled Google apps including Gmail, Google Maps, Google Chrome, YouTube, Google Play Movies & TV, and others.

Applications ("[apps](https://en.wikipedia.org/wiki/Mobile_app)"), which extend the functionality of devices (and must be 64-bit[[106]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-108)), are written using the [Android software development](https://en.wikipedia.org/wiki/Android_software_development) kit (SDK)[[107]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-109) and, often, [Kotlin](https://en.wikipedia.org/wiki/Kotlin_(programming_language)) programming language, which replaced [Java](https://en.wikipedia.org/wiki/Java_(programming_language)) as Google's preferred language for Android app development in May 2019,[[108]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-110) and was originally announced in May 2017.[[109]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-111)[[110]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-112) Java is still supported (originally the only option for user-space programs, and is often mixed with Kotlin), as is [C++](https://en.wikipedia.org/wiki/C%2B%2B).[[111]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-113) Java or other JVM languages, such as Kotlin, may be combined with [C](https://en.wikipedia.org/wiki/C_(programming_language))/C++,[[112]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-114) together with a choice of non-default [runtimes](https://en.wikipedia.org/wiki/Runtime_library) that allow better C++ support.[[113]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-115)

The SDK includes a comprehensive set of development tools,[[114]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-116) including a [debugger](https://en.wikipedia.org/wiki/Debugger), [software libraries](https://en.wikipedia.org/wiki/Software_library), a handset [emulator](https://en.wikipedia.org/wiki/Emulator) based on [QEMU](https://en.wikipedia.org/wiki/QEMU), documentation, sample code, and tutorials. Initially, Google's supported [integrated development environment](https://en.wikipedia.org/wiki/Integrated_development_environment) (IDE) was [Eclipse](https://en.wikipedia.org/wiki/Eclipse_(software)) using the Android Development Tools (ADT) plugin; in December 2014, Google released [Android Studio](https://en.wikipedia.org/wiki/Android_Studio), based on [IntelliJ IDEA](https://en.wikipedia.org/wiki/IntelliJ_IDEA), as its primary IDE for Android application development. Other development tools are available, including a [native development kit](https://en.wikipedia.org/wiki/Native_development_kit) (NDK) for applications or extensions in C or C++, [Google App Inventor](https://en.wikipedia.org/wiki/Google_App_Inventor), a visual environment for novice programmers, and various cross platform mobile web applications frameworks. In January 2014, Google unveiled a framework based on [Apache Cordova](https://en.wikipedia.org/wiki/Apache_Cordova) for porting [Chrome](https://en.wikipedia.org/wiki/Google_Chrome) [HTML 5](https://en.wikipedia.org/wiki/HTML_5) [web applications](https://en.wikipedia.org/wiki/Web_app) to Android, wrapped in a native application shell.[[115]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-117) Additionally, [Firebase](https://en.wikipedia.org/wiki/Firebase) was acquired by Google in 2014 that provides helpful tools for app and web developers.[[116]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-118)

Android has a growing selection of third-party applications, which can be acquired by users by downloading and installing the application's [APK](https://en.wikipedia.org/wiki/APK_(file_format)) (Android application package) file, or by downloading them using an [application store](https://en.wikipedia.org/wiki/Application_store) program that allows users to [install, update, and remove applications](https://en.wikipedia.org/wiki/Package_manager) from their devices. [Google Play Store](https://en.wikipedia.org/wiki/Google_Play_Store) is the primary application store installed on Android devices that comply with Google's compatibility requirements and license the Google Mobile Services software.[[117]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars-irongrip-119)[[118]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-geek-poweredby-120) Google Play Store allows users to browse, download and update applications published by Google and third-party developers; as of January 2021, there are more than three million applications available for Android in Play Store.[[119]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-3_million_apps-121)[[120]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-122) As of July 2013, 50 billion application installations had been performed.[[121]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Google_Play_Hits_1_Million_Apps-123)[[122]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-android-compatibility-124) Some carriers offer direct carrier billing for Google Play application purchases, where the cost of the application is added to the user's monthly bill.[[123]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-125) As of May 2017, there are over one billion active users a month for Gmail, Android, Chrome, Google Play and Maps.

Due to the open nature of Android, a number of third-party application marketplaces also exist for Android, either to provide a substitute for devices that are not allowed to ship with Google Play Store, provide applications that cannot be offered on Google Play Store due to policy violations, or for other reasons. Examples of these third-party stores have included the [Amazon Appstore](https://en.wikipedia.org/wiki/Amazon_Appstore), [GetJar](https://en.wikipedia.org/wiki/GetJar), and SlideMe. [F-Droid](https://en.wikipedia.org/wiki/F-Droid), another alternative marketplace, seeks to only provide applications that are distributed under [free and open source](https://en.wikipedia.org/wiki/Free_and_open_source) [licenses](https://en.wikipedia.org/wiki/Free-software_license).[[117]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars-irongrip-119)[[124]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-wired_alt_app_stores-126)[[125]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-127)[[126]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-128)

In October 2020, Google removed several Android applications from [Play Store](https://en.wikipedia.org/wiki/Play_Store), as they were identified breaching its data collection rules. The firm was informed by International Digital Accountability Council (IDAC) that apps for children like *Number Coloring*, *Princess Salon* and *Cats & Cosplay*, with collective downloads of 20 million, were violating Google's policies.[[127]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-129)

At the [Windows 11](https://en.wikipedia.org/wiki/Windows_11) announcement event in June 2021, [Microsoft](https://en.wikipedia.org/wiki/Microsoft) showcased the new [Windows Subsystem for Android](https://en.wikipedia.org/wiki/Windows_Subsystem_for_Android) (WSA) to enable support for the [Android Open Source Project](https://en.wikipedia.org/wiki/Android_Open_Source_Project) (AOSP), but it has since been deprecated. It was meant to allow users running [Android apps](https://en.wikipedia.org/wiki/Android_app) and games in Windows 11 on their Windows desktop.[[128]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-130) On March 5, 2024, Microsoft announced deprecation of WSA with support ending on March 5, 2025.[[129]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-131)

**Storage**

The storage of Android devices can be expanded using secondary devices such as [SD cards](https://en.wikipedia.org/wiki/SD_card). Android recognizes two types of secondary storage: *portable* storage (which is used by default), and *adoptable* storage. Portable storage is treated as an external storage device. Adoptable storage, introduced on Android 6.0, allows the internal storage of the device to be [spanned](https://en.wikipedia.org/wiki/Non-RAID_drive_architectures#Concatenation_(SPAN,_BIG)) with the SD card, treating it as an extension of the internal storage. This has the disadvantage of preventing the memory card from being used with another device unless it is [reformatted](https://en.wikipedia.org/wiki/Disk_formatting).[[130]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Ars_Technica_review-132)

Android 4.4 introduced the Storage Access Framework (SAF), a set of APIs for accessing files on the device's filesystem.[[131]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-anandtech-sdkitkat-133) As of Android 11, Android has required apps to conform to a data privacy policy known as *scoped storage*, under which apps may only automatically have access to certain directories (such as those for pictures, music, and video), and app-specific directories they have created themselves. Apps are required to use the SAF to access any other part of the filesystem.[[132]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-:32-134)[[133]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-135)[[134]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-136)

**Memory management**

Since Android devices are usually battery-powered, Android is designed to manage processes to keep power consumption at a minimum. When an application is not in use the system [suspends its operation](https://en.wikipedia.org/wiki/Process_state) so that, while available for immediate use rather than closed, it does not use battery power or CPU resources.[[135]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-phonedogtask-137)[[136]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-138) Android manages the applications stored in memory automatically: when memory is low, the system will begin invisibly and automatically closing inactive processes, starting with those that have been inactive for the longest amount of time.[[137]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-phandroidtask-139)[[138]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-140) Lifehacker reported in 2011 that third-party task-killer applications were doing more harm than good.[[139]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-lifehackertask-141)

**Developer options**

Some settings for use by [developers](https://en.wikipedia.org/wiki/Android_app_development) for [debugging](https://en.wikipedia.org/wiki/Debugging) and [power users](https://en.wikipedia.org/wiki/Power_user) are located in a "Developer options" sub menu, such as the ability to highlight updating parts of the display, show an overlay with the current status of the touch screen, show touching spots for possible use in [screencasting](https://en.wikipedia.org/wiki/Screencast), notify the user of unresponsive background processes with the option to end them ("Show all ANRs", i.e. "App's Not Responding"), prevent a Bluetooth audio client from controlling the system volume ("Disable absolute volume"), and adjust the duration of transition animations or deactivate them completely to speed up navigation.[[140]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-142)[[141]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-143)[[142]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-144)

Developer options are initially hidden since Android 4.2 "Jelly Bean", but can be enabled by actuating the operating system's build number in the device information seven times. Hiding developers options again requires deleting user data for the "Settings" app, possibly resetting some other preferences, or in recent Android versions, turning off the Developer options master switch.[[143]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-145)[[144]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-146)[[145]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-147)

**Hardware**

*See also:*[*Android hardware requirements*](https://en.wikipedia.org/wiki/Android_hardware_requirements)

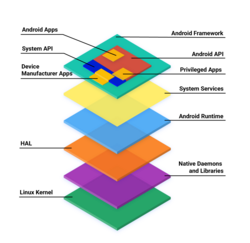
The main hardware platform for Android is [ARM](https://en.wikipedia.org/wiki/ARM_architecture_family) (i.e. the 64-bit [ARMv8-A](https://en.wikipedia.org/wiki/ARMv8-A) architecture and previously 32-bit such as [ARMv7](https://en.wikipedia.org/wiki/ARMv7)), and [x86](https://en.wikipedia.org/wiki/X86) and [x86-64](https://en.wikipedia.org/wiki/X86-64) architectures were once also officially supported in later versions of Android.[[146]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Android_Lollipop_platform_support-148)[[147]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-149)[[148]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-150) The unofficial [Android-x86](https://en.wikipedia.org/wiki/Android-x86) project provided support for x86 architectures ahead of the official support.[[149]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ARMAN-4.0-on-x86-151)[[150]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-auto-152) Since 2012, Android devices with [Intel](https://en.wikipedia.org/wiki/Intel) processors began to appear, including phones[[151]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-153) and tablets. While gaining support for 64-bit platforms, Android was first made to run on 64-bit x86 and then on [ARM64](https://en.wikipedia.org/wiki/ARM64). An unofficial experimental port of the operating system to the [RISC-V](https://en.wikipedia.org/wiki/RISC-V) architecture was released in 2021.[[152]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-154)

Requirements for the minimum amount of [RAM](https://en.wikipedia.org/wiki/Random-access_memory) for devices running Android 7.1 range from in practice 2 GB for best hardware, down to 1 GB for the most common screen. Android supports all versions of OpenGL ES and [Vulkan](https://en.wikipedia.org/wiki/Vulkan) (and version 1.1 available for some devices[[153]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-155)).

Android devices incorporate many optional hardware components, including still or video cameras, [GPS](https://en.wikipedia.org/wiki/Global_Positioning_System), [orientation sensors](https://en.wikipedia.org/wiki/Orientation_sensing), dedicated gaming controls, accelerometers, gyroscopes, barometers, [magnetometers](https://en.wikipedia.org/wiki/Magnetometer), proximity sensors, [pressure sensors](https://en.wikipedia.org/wiki/Pressure_sensor), thermometers, and [touchscreens](https://en.wikipedia.org/wiki/Touchscreen). 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.[[122]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-android-compatibility-124) Android used to require an [autofocus](https://en.wikipedia.org/wiki/Autofocus) camera, which was relaxed to a [fixed-focus](https://en.wikipedia.org/wiki/Fixed-focus_lens) camera[[122]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-android-compatibility-124) if present at all, since the camera was dropped as a requirement entirely when Android started to be used on [set-top boxes](https://en.wikipedia.org/wiki/Set-top_box).

In addition to running on smartphones and tablets, several vendors run Android natively on regular PC hardware with a keyboard and mouse.[[154]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-156)[[155]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-157)[[156]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-158)[[157]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-159) 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.[[158]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-160) Using the Android emulator that is part of the [Android SDK](https://en.wikipedia.org/wiki/Android_SDK), or third-party emulators, Android can also run non-natively on x86 architectures.[[159]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-161)[[160]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-162) Chinese companies are building a PC and mobile operating system, based on Android, to "compete directly with Microsoft Windows and Google Android".[[161]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-163) The Chinese Academy of Engineering noted that "more than a dozen" companies were customizing Android following a Chinese ban on the use of Windows 8 on government PCs.[[162]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-164)[[163]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-165)[[164]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-166)

**Development**

[](https://en.wikipedia.org/wiki/File:AOSP_Android_Stack.png)The stack of Android Open Source Project

Android is developed by Google until the latest changes and updates are ready to be released, at which point the [source code](https://en.wikipedia.org/wiki/Source_code) is made available to the Android Open Source Project (AOSP),[[165]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-167) an open source initiative led by Google.[[166]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-168) The first source code release happened as part of the initial release in 2007. All releases are under the [Apache License](https://en.wikipedia.org/wiki/Apache_License).[[167]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-169)

The AOSP code can be found with minimal modifications on select devices, mainly the former Nexus and current Android One series of devices.[[168]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-170) However, most original equipment manufacturers (OEMs) customize the source code to run on their hardware.[[169]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-171)[[170]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-172)

Android's source code does not contain the [device drivers](https://en.wikipedia.org/wiki/Device_driver), often proprietary, that are needed for certain hardware components,[[171]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Building_for_devices-173) and does not contain the source code of [Google Play Services](https://en.wikipedia.org/wiki/Google_Play_Services), which many apps depend on. As a result, most Android devices, including Google's own, ship with a combination of [free and open source](https://en.wikipedia.org/wiki/Free_and_open-source_software) and [proprietary](https://en.wikipedia.org/wiki/Proprietary_software) software, with the software required for accessing Google services falling into the latter category.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] In response to this, there are some projects that build complete operating systems based on AOSP as free software, the first being [CyanogenMod](https://en.wikipedia.org/wiki/CyanogenMod) (see section [Open-source community](https://en.wikipedia.org/wiki/Android_(operating_system)#Open-source_community) below).

**Update schedule**

*See also:*[*Android version history*](https://en.wikipedia.org/wiki/Android_version_history)

| **Summary of versions** | |
| --- | --- |
| **Version** | **Release date** |
| 1.0 | September 23, 2008 |
| 1.1 | February 9, 2009 |
| [1.5 (Cupcake)](https://en.wikipedia.org/wiki/Android_Cupcake) | April 27, 2009 |
| [1.6 (Donut)](https://en.wikipedia.org/wiki/Android_Donut) | September 15, 2009 |
| [2.0−2.1 (Eclair)](https://en.wikipedia.org/wiki/Android_Eclair) | October 26, 2009 |
| [2.2 (Froyo)](https://en.wikipedia.org/wiki/Android_Froyo) | May 20, 2010 |
| [2.3 (Gingerbread)](https://en.wikipedia.org/wiki/Android_Gingerbread) | December 6, 2010 |
| [3.0 (Honeycomb)](https://en.wikipedia.org/wiki/Android_Honeycomb) | February 22, 2011 |
| [4.0 (Ice Cream Sandwich)](https://en.wikipedia.org/wiki/Android_Ice_Cream_Sandwich) | October 18, 2011 |
| [4.1−4.2−4.3 (Jelly Bean)](https://en.wikipedia.org/wiki/Android_Jelly_Bean) | July 9, 2012 |
| [4.4 (KitKat)](https://en.wikipedia.org/wiki/Android_KitKat) | October 31, 2013 |
| [5.0−5.1 (Lollipop)](https://en.wikipedia.org/wiki/Android_Lollipop) | November 12, 2014 |
| [6.0 (Marshmallow)](https://en.wikipedia.org/wiki/Android_Marshmallow) | October 5, 2015 |
| [7.0−7.1 (Nougat)](https://en.wikipedia.org/wiki/Android_Nougat) | August 22, 2016 |
| [8.0−8.1 (Oreo)](https://en.wikipedia.org/wiki/Android_Oreo) | August 21, 2017 |
| [9 (Pie)](https://en.wikipedia.org/wiki/Android_Pie) | August 6, 2018 |
| [10](https://en.wikipedia.org/wiki/Android_10) | September 3, 2019 |
| [11](https://en.wikipedia.org/wiki/Android_11) | September 8, 2020 |
| [12−12L](https://en.wikipedia.org/wiki/Android_12) | October 4, 2021 |
| [13](https://en.wikipedia.org/wiki/Android_13) | August 15, 2022 |
| [14](https://en.wikipedia.org/wiki/Android_14) | October 4, 2023 |
| [15](https://en.wikipedia.org/wiki/Android_15) | October 15, 2024 |

Google provides annual[[172]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-174) Android releases, both for factory installation in new devices, and for [over-the-air](https://en.wikipedia.org/wiki/Over-the-air_programming) updates to existing devices.[[173]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-175) The latest major release is [Android 15](https://en.wikipedia.org/wiki/Android_15).

The extensive variation of [hardware](https://en.wikipedia.org/wiki/Computer_hardware)[[174]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-176) in Android devices has caused significant delays for software upgrades and [security patches](https://en.wikipedia.org/wiki/Patch_(computing)). Each upgrade has had to be specifically tailored, a time- and resource-consuming process.[[175]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-177) Except for devices within the Google Nexus and Pixel brands, updates have often arrived months after the release of the new version, or not at all.[[176]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-178) Manufacturers often prioritize their newest devices and leave old ones behind.[[177]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-alliance-179) Additional delays can be introduced by wireless carriers who, after receiving updates from manufacturers, further customize Android to their needs and conduct extensive testing on their networks before sending out the upgrade.[[177]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-alliance-179)[[178]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-180) There are also situations in which upgrades are impossible due to a manufacturer not updating necessary [drivers](https://en.wikipedia.org/wiki/Device_driver).[[179]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-181)

The lack of after-sale support from manufacturers and carriers has been widely criticized by consumer groups and the technology media.[[180]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-182)[[181]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-183)[[182]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-The_Guardian_upgrades-184) Some commentators have noted that the industry has a financial incentive not to upgrade their devices, as the lack of updates for existing devices fuels the purchase of newer ones,[[183]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-185) an attitude described as "insulting".[[182]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-The_Guardian_upgrades-184) [*The Guardian*](https://en.wikipedia.org/wiki/The_Guardian) complained that the method of distribution for updates is complicated only because manufacturers and carriers have designed it that way.[[182]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-The_Guardian_upgrades-184) In 2011, Google partnered with a number of industry players to announce an "Android Update Alliance", pledging to deliver timely updates for every device for 18 months after its release; however, there has not been another official word about that alliance since its announcement.[[177]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-alliance-179)[[184]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-186)

In 2012, Google began de-coupling certain aspects of the operating system (particularly its central applications) so they could be updated through the [Google Play](https://en.wikipedia.org/wiki/Google_Play) store independently of the OS. One of those components, [Google Play Services](https://en.wikipedia.org/wiki/Google_Play_Services), is a [closed-source](https://en.wikipedia.org/wiki/Closed-source) system-level process providing [APIs](https://en.wikipedia.org/wiki/API) for Google services, installed automatically on nearly all devices running [Android 2.2 "Froyo"](https://en.wikipedia.org/wiki/Android_Froyo) and higher. With these changes, Google can add new system functions and update apps without having to distribute an upgrade to the operating system itself.[[185]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-187) As a result, [Android 4.2 and 4.3 "Jelly Bean"](https://en.wikipedia.org/wiki/Android_Jelly_Bean) contained relatively fewer user-facing changes, focusing more on minor changes and platform improvements.[[186]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-188)

[HTC](https://en.wikipedia.org/wiki/HTC)'s then-executive Jason Mackenzie called monthly security updates "unrealistic" in 2015, and Google was trying to persuade carriers to exclude security patches from the full testing procedures. In May 2016, [Bloomberg Businessweek](https://en.wikipedia.org/wiki/Bloomberg_Businessweek) reported that Google was making efforts to keep Android more up-to-date, including accelerated rates of security updates, rolling out technological workarounds, reducing requirements for phone testing, and ranking phone makers in an attempt to "shame" them into better behavior. As stated by *Bloomberg*: "As smartphones get more capable, complex and hackable, having the latest software work closely with the hardware is increasingly important". Hiroshi Lockheimer, the Android lead, admitted that "It's not an ideal situation", further commenting that the lack of updates is "the weakest link on security on Android". Wireless carriers were described in the report as the "most challenging discussions", due to their slow approval time while testing on their networks, despite some carriers, including [Verizon Wireless](https://en.wikipedia.org/wiki/Verizon_Wireless) and [Sprint Corporation](https://en.wikipedia.org/wiki/Sprint_Corporation), already shortening their approval times. In a further effort for persuasion, Google shared a list of top phone makers measured by updated devices with its Android partners, and is considering making the list public.[[*when?*](https://en.wikipedia.org/wiki/Wikipedia:Manual_of_Style/Dates_and_numbers#Chronological_items)] Mike Chan, co-founder of phone maker Nextbit and former Android developer, said that "The best way to solve this problem is a massive re-architecture of the operating system", "or Google could invest in training manufacturers and carriers 'to be good Android citizens'".[[187]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-189)[[188]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-190)[[189]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-191)

In May 2017, with the announcement of [Android 8.0](https://en.wikipedia.org/wiki/Android_Oreo), Google introduced Project Treble, a major re-architect of the Android OS framework designed to make it easier, faster, and less costly for manufacturers to update devices to newer versions of Android. Project Treble separates the vendor implementation (device-specific, lower-level software written by silicon manufacturers) from the Android OS framework via a new "vendor interface". In Android 7.0 and earlier, no formal vendor interface exists, so device makers must update large portions of the Android code to move a device to a newer version of the operating system. With Treble, the new stable vendor interface provides access to the hardware-specific parts of Android, enabling device makers to deliver new Android releases simply by updating the Android OS framework, "without any additional work required from the silicon manufacturers."[[190]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-192)

In September 2017, Google's Project Treble team revealed that, as part of their efforts to improve the security lifecycle of Android devices, Google had managed to get the Linux Foundation to agree to extend the support lifecycle of the Linux Long-Term Support (LTS) kernel branch from the 2 years that it has historically lasted to 6 years for future versions of the LTS kernel, starting with Linux kernel 4.4.[[191]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-193)

In May 2019, with the announcement of [Android 10](https://en.wikipedia.org/wiki/Android_10), Google introduced Project Mainline to simplify and expedite delivery of updates to the Android ecosystem. Project Mainline enables updates to core OS components through the Google Play Store. As a result, important security and performance improvements that previously needed to be part of full OS updates can be downloaded and installed as easily as an app update.[[192]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-194)

Google reported rolling out new amendments in Android 12 aimed at making the use of third-party application stores easier. This announcement rectified the concerns reported regarding the development of Android apps, including a fight over an alternative in-app payment system and difficulties faced by businesses moving online because of [COVID-19](https://en.wikipedia.org/wiki/COVID-19).[[193]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-195)

**Linux kernel**

Android's [kernel](https://en.wikipedia.org/wiki/Kernel_(operating_system)) is based on the [Linux kernel](https://en.wikipedia.org/wiki/Linux_kernel)'s [long-term support](https://en.wikipedia.org/wiki/Long-term_support) (LTS) branches. As of 2024, Android (14) uses versions 6.1 or 5.15 (for "Feature kernels", can be older for "Launch kernels", e.g. android12-5.10, android11-5.4, depending on Android version down to e.g. android11-5.4, android-4.14-stable, android-4.9-q), and older Android versions, use version 5.15 or a number of older kernels.[[194]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-196) The actual kernel depends on the individual device.[[195]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-197)

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 device trees, ashmem, ION, and different [out of memory](https://en.wikipedia.org/wiki/Out_of_memory) (OOM) handling.[[196]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-198)[[197]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-199) Certain features that Google contributed back to the Linux kernel, notably a power management feature called "wakelocks",[[198]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-200) were initially rejected by [mainline kernel](https://en.wikipedia.org/wiki/Mainline_Linux) developers partly because they felt that Google did not show any intent to maintain its own code.[[199]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-201)[[200]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-hartman-202) Google announced in April 2010 that they would hire two employees to work with the Linux kernel community,[[201]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-203) but [Greg Kroah-Hartman](https://en.wikipedia.org/wiki/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.[[200]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-hartman-202) Google engineer Patrick Brady once stated in the company's developer conference that "Android is not Linux",[[202]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars_introduction_developer-204) with [*Computerworld*](https://en.wikipedia.org/wiki/Computerworld) adding that "Let me make it simple for you, without Linux, there is no Android".[[203]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-205) [*Ars Technica*](https://en.wikipedia.org/wiki/Ars_Technica) wrote that "Although Android is built on top of the Linux kernel, the platform has very little in common with the conventional desktop Linux stack".[[202]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars_introduction_developer-204)

In August 2011, [Linus Torvalds](https://en.wikipedia.org/wiki/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".[[204]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-206) (that has not happened yet, while some code has been [upstreamed](https://en.wikipedia.org/wiki/Upstream_(software_development)), not all of it has, so modified kernels keep being used). In December 2011, Greg Kroah-Hartman announced the start of Android Mainlining Project, which aims to put some Android [drivers](https://en.wikipedia.org/wiki/Device_driver), patches and features back into the Linux kernel, starting in Linux 3.3.[[205]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-207) Linux included the autosleep and wakelocks capabilities in the 3.5 kernel, after many previous attempts at a 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).[[206]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-208) Google maintains a public code repository that contains their experimental work to [re-base](https://en.wikipedia.org/wiki/Rebasing) Android off the latest stable Linux versions.[[207]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-209)[[208]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-210)

Android is a [Linux distribution](https://en.wikipedia.org/wiki/Linux_distribution) according to the [Linux Foundation](https://en.wikipedia.org/wiki/Linux_Foundation),[[209]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-211) Google's open-source chief [Chris DiBona](https://en.wikipedia.org/wiki/Chris_DiBona),[[210]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-212) and several journalists.[[211]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-213)[[212]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-214) Others, such as Google engineer Patrick Brady, say that Android is not Linux in the traditional [Unix-like](https://en.wikipedia.org/wiki/Unix-like) Linux distribution sense; Android does not include the [GNU C Library](https://en.wikipedia.org/wiki/GNU_C_Library) (it uses [Bionic](https://en.wikipedia.org/wiki/Bionic_(software)) as an alternative C library) and some other components typically found in Linux distributions.[[213]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-APIs-215)

With the release of [Android Oreo](https://en.wikipedia.org/wiki/Android_Oreo) in 2017, Google began to require that devices shipped with new [SoCs](https://en.wikipedia.org/wiki/System_on_a_chip) had Linux kernel version 4.4 or newer, for security reasons. Existing devices upgraded to Oreo, and new products launched with older SoCs, were exempt from this rule.[[214]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-216)[[215]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-217)

**Rooting**

*Main article:*[*Rooting (Android)*](https://en.wikipedia.org/wiki/Rooting_(Android))

The [flash storage](https://en.wikipedia.org/wiki/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.[[216]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-218)

In contrast to typical [desktop Linux](https://en.wikipedia.org/wiki/Desktop_Linux) distributions, Android device owners are not given [root](https://en.wikipedia.org/wiki/Superuser) access to the operating system and sensitive partitions such as /system/ are partially [read-only](https://en.wikipedia.org/wiki/Read-only_memory). However, [root access](https://en.wikipedia.org/wiki/Filesystem_Hierarchy_Standard) can be obtained by exploiting [security flaws](https://en.wikipedia.org/wiki/Vulnerability_(computing)) in Android, which is used frequently by the [open-source community](https://en.wikipedia.org/wiki/Android_(operating_system)#Open-source_community) to enhance the capabilities and customizability of their devices, but also by malicious parties to install [viruses](https://en.wikipedia.org/wiki/Computer_virus) and [malware](https://en.wikipedia.org/wiki/Malware).[[217]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-219) Root access can also be obtained by [unlocking the bootloader](https://en.wikipedia.org/wiki/Bootloader_unlocking) which is available on most Android devices, for example on most [Google Pixel](https://en.wikipedia.org/wiki/Google_Pixel), [OnePlus](https://en.wikipedia.org/wiki/OnePlus) and [Nothing](https://en.wikipedia.org/wiki/Nothing_(company)) models OEM Unlocking option in the developer settings allows the user to unlock the bootloader with [Fastboot](https://en.wikipedia.org/wiki/Fastboot), afterward, custom software may be installed. Some OEMs have their own methods. The unlocking process [resets the system to factory state](https://en.wikipedia.org/wiki/Factory_reset), erasing all user data.[[218]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-220) Proprietary frameworks like [Samsung Knox](https://en.wikipedia.org/wiki/Samsung_Knox) limit or block attempts at rooting. Google's [Play Integrity API](https://en.wikipedia.org/w/index.php?title=Play_Integrity&action=edit&redlink=1) allows developers to check for any signs of tampering,[[219]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-221) although the fairness of the tests have been criticized.[[220]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-222)

**Software stack**

[](https://en.wikipedia.org/wiki/File:Android-System-Architecture.svg)Android's architecture diagram [[*obsolete source*](https://en.wikipedia.org/wiki/Wikipedia:AGE_MATTERS)]

On top of the Linux kernel, there are the [middleware](https://en.wikipedia.org/wiki/Middleware), [libraries](https://en.wikipedia.org/wiki/Software_library) and [APIs](https://en.wikipedia.org/wiki/API) written in [C](https://en.wikipedia.org/wiki/C_(programming_language)), and [application software](https://en.wikipedia.org/wiki/Application_software) running on an [application framework](https://en.wikipedia.org/wiki/Application_framework) which includes [Java](https://en.wikipedia.org/wiki/Java_(software_platform))-compatible libraries. Development of the Linux kernel continues independently of Android's other source code projects.

Android uses [Android Runtime](https://en.wikipedia.org/wiki/Android_Runtime) (ART) as its runtime environment (introduced in version 4.4), which uses [ahead-of-time (AOT) compilation](https://en.wikipedia.org/wiki/Ahead-of-time_compilation) to entirely compile the application bytecode into [machine code](https://en.wikipedia.org/wiki/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.[[221]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-223) In versions no longer supported, until version 5.0 when ART took over, Android previously used [Dalvik](https://en.wikipedia.org/wiki/Dalvik_(software)) as a [process virtual machine](https://en.wikipedia.org/wiki/Process_virtual_machine) with [trace-based just-in-time (JIT) compilation](https://en.wikipedia.org/wiki/Tracing_just-in-time_compilation) to run Dalvik "dex-code" (Dalvik Executable), which is usually translated from the [Java bytecode](https://en.wikipedia.org/wiki/Java_bytecode). Following the trace-based JIT principle, in addition to [interpreting](https://en.wikipedia.org/wiki/Interpreter_(computing)) the majority of application code, Dalvik performs the compilation and [native execution](https://en.wikipedia.org/wiki/Machine_code) of select frequently executed code segments ("traces") each time an application is launched.[[222]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-224)[[223]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-225)[[224]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-brady_dissects_android-226) For its Java library, the Android platform uses a subset of the now discontinued [Apache Harmony](https://en.wikipedia.org/wiki/Apache_Harmony) project.[[225]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars-njdk-227) In December 2015, Google announced that the next version of Android would switch to a Java implementation based on the [OpenJDK](https://en.wikipedia.org/wiki/OpenJDK) project.[[226]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-vb-openjdk-228)

Android's [standard C library](https://en.wikipedia.org/wiki/C_standard_library), [Bionic](https://en.wikipedia.org/wiki/Bionic_(software)), was developed by Google specifically for Android, as a derivation of the [BSD](https://en.wikipedia.org/wiki/Berkeley_Software_Distribution)'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](https://en.wikipedia.org/wiki/GNU_C_Library) (glibc) or [uClibc](https://en.wikipedia.org/wiki/UClibc) are its smaller runtime footprint, and optimization for low-frequency CPUs. At the same time, Bionic is licensed under the terms of the [BSD licence](https://en.wikipedia.org/wiki/BSD_licence), which Google finds more suitable for the Android's overall licensing model.[[224]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-brady_dissects_android-226)

Aiming for a different licensing model, toward the end of 2012, Google switched the Bluetooth stack in Android from the GPL-licensed [BlueZ](https://en.wikipedia.org/wiki/BlueZ) to the Apache-licensed BlueDroid.[[227]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-229) A new Bluetooth stack, called Gabeldorsche, was developed to try to fix the bugs in the BlueDroid implementation.[[228]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-230)

Android does not have a native [X Window System](https://en.wikipedia.org/wiki/X_Window_System) by default, nor does it support the full set of standard [GNU](https://en.wikipedia.org/wiki/GNU) libraries. This made it difficult to port existing Linux applications or libraries to Android,[[213]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-APIs-215) until version r5 of the [Android Native Development Kit](https://en.wikipedia.org/wiki/Android_NDK) brought support for applications written completely in [C](https://en.wikipedia.org/wiki/C_(programming_language)) or [C++](https://en.wikipedia.org/wiki/C%2B%2B).[[229]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-231) Libraries written in C may also be used in applications by injection of a small [shim](https://en.wikipedia.org/wiki/Shim_(computing)) and usage of the [JNI](https://en.wikipedia.org/wiki/Java_Native_Interface).[[230]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-sdlandroid-232)

In current versions of Android, "[Toybox](https://en.wikipedia.org/wiki/Toybox)", a collection of command-line utilities (mostly for use by apps, as Android does not provide a [command-line interface](https://en.wikipedia.org/wiki/Command-line_interface) by default), is used (since the release of Marshmallow) replacing a similar "Toolbox" collection found in previous Android versions.[[231]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-toyboxmarsmallow-233)

Android has another operating system, Trusty OS, within it, as a part of "Trusty" "software components supporting a Trusted Execution Environment (TEE) on mobile devices." "Trusty and the Trusty API are subject to change. [..] Applications for the Trusty OS can be written in C/C++ (C++ support is limited), and they have access to a small C library. [..] All Trusty applications are single-threaded; multithreading in Trusty userspace currently is unsupported. [..] Third-party application development is not supported in" the current version, and software running on the OS and processor for it, run the "[DRM](https://en.wikipedia.org/wiki/Digital_rights_management) framework for protected content. [..] There are many other uses for a TEE such as mobile payments, secure banking, full-disk encryption, multi-factor authentication, device reset protection, replay-protected persistent storage, wireless display ("cast") of protected content, secure PIN and fingerprint processing, and even malware detection."[[232]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-234)

**Open-source community**

*See also:*[*List of custom Android distributions*](https://en.wikipedia.org/wiki/List_of_custom_Android_distributions)

Android's [source code](https://en.wikipedia.org/wiki/Source_code) is released by Google under an [open-source license](https://en.wikipedia.org/wiki/Open-source_license), and its open nature has encouraged a large community of developers and enthusiasts to use the open-source code as a foundation for community-driven projects, which deliver updates to older devices, add new features for advanced users or bring Android to devices originally shipped with other operating systems.[[233]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-235) These community-developed releases often bring new features and updates to devices faster than through the official manufacturer/carrier channels, with a comparable level of quality;[[234]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-236) 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](https://en.wikipedia.org/wiki/HP_TouchPad). Community releases often come pre-[rooted](https://en.wikipedia.org/wiki/Android_rooting) and contain modifications not provided by the original vendor, such as the ability to [overclock](https://en.wikipedia.org/wiki/Overclock) or [over/undervolt](https://en.wikipedia.org/wiki/Dynamic_voltage_scaling) the device's processor,[[235]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-237) or security enhancements beyond what is included in the stock OS.[[236]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-:2-238)

[CyanogenMod](https://en.wikipedia.org/wiki/CyanogenMod) was the most widely used community firmware;[[237]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-239) after its abrupt discontinuation in 2016, a community [fork](https://en.wikipedia.org/wiki/Fork_(software_development)) known as [LineageOS](https://en.wikipedia.org/wiki/LineageOS) was established as a spiritual continuation of the project.[[238]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-240)

Historically, device manufacturers and mobile carriers have typically been unsupportive of third-party [firmware](https://en.wikipedia.org/wiki/Firmware) development. Manufacturers express concern about improper functioning of devices running unofficial software and the support costs resulting from this.[[239]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-htcdev-241) Moreover, modified firmware such as CyanogenMod sometimes offer features, such as [tethering](https://en.wikipedia.org/wiki/Tethering), for which carriers would otherwise charge a premium. As a result, technical obstacles including locked [bootloaders](https://en.wikipedia.org/wiki/Bootloader) 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](https://en.wikipedia.org/wiki/Librarian_of_Congress) in the [United States](https://en.wikipedia.org/wiki/United_States) that permits the "[jailbreaking](https://en.wikipedia.org/wiki/IOS_jailbreaking)" of mobile devices,[[240]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-242) manufacturers and carriers have softened their position regarding third party development, with some, including [HTC](https://en.wikipedia.org/wiki/HTC),[[239]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-htcdev-241) [Motorola](https://en.wikipedia.org/wiki/Motorola),[[241]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-243) [Samsung](https://en.wikipedia.org/wiki/Samsung)[[242]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-244)[[243]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-245) and [Sony](https://en.wikipedia.org/wiki/Sony_Mobile_Communications),[[244]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-246) 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](https://en.wikipedia.org/wiki/Bootloader), similar to [Nexus](https://en.wikipedia.org/wiki/Google_Nexus) series of phones, although usually requiring that users waive their devices' warranties to do so.[[239]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-htcdev-241) However, despite manufacturer acceptance, some carriers in the US still require that phones are locked down.[[245]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-247)

**Device codenames**

Internally, Android identifies each supported device by its **device codename**, a short string,[[246]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-248) which may or may not be similar to the model name used in marketing the device. For example, the device codename of the [Pixel smartphone](https://en.wikipedia.org/wiki/Pixel_(1st_generation)) is *sailfish*.

The device codename is usually not visible to the end user, but is important for determining compatibility with modified Android versions. It is sometimes also mentioned in articles discussing a device, because it allows to distinguish different hardware variants of a device, even if the manufacturer offers them under the same name. The device codename is available to running applications under android.os.Build.DEVICE.[[247]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-249)

**Security and privacy**

*See also:*[*Mobile security*](https://en.wikipedia.org/wiki/Mobile_security)*and*[*Comparison of open-source mobile phones*](https://en.wikipedia.org/wiki/Comparison_of_open-source_mobile_phones)

In 2020, Google launched the Android Partner Vulnerability Initiative to improve the security of Android.[[248]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-250)[[249]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-251) They also formed an Android security team.[[250]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-252)

**Common security threats**

Research from security company [Trend Micro](https://en.wikipedia.org/wiki/Trend_Micro) lists premium service abuse as the most common type of Android malware, where text messages are sent from infected phones to [premium-rate telephone numbers](https://en.wikipedia.org/wiki/Premium-rate_telephone_number) without the consent or even knowledge of the user. Other malware displays unwanted and intrusive advertisements on the device, or sends personal information to unauthorised third parties.[[251]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-253) Security threats on Android are reportedly growing exponentially; however, Google engineers have argued that the malware and virus threat on Android is being [exaggerated](https://en.wikipedia.org/wiki/Fear,_uncertainty_and_doubt) by security companies for commercial reasons,[[252]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-exaggeration-254)[[253]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-extremely-255) and have accused the security industry of playing on fears to sell virus protection software to users.[[252]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-exaggeration-254) Google maintains that dangerous malware is actually extremely rare,[[253]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-extremely-255) and a survey conducted by [F-Secure](https://en.wikipedia.org/wiki/F-Secure) showed that only 0.5% of Android malware reported had come from the Google Play store.[[254]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-256)

In 2021, journalists and researchers reported the discovery of [spyware](https://en.wikipedia.org/wiki/Spyware), called [Pegasus](https://en.wikipedia.org/wiki/Pegasus_(spyware)), developed and distributed by a private company which can and has been used to infect both [iOS](https://en.wikipedia.org/wiki/IOS) and Android smartphones often – partly via use of [0-day exploits](https://en.wikipedia.org/wiki/Zero-day_(computing)) – without the need for any user-interaction or significant clues to the user and then be used to exfiltrate data, track user locations, capture film through its camera, and activate the microphone at any time.[[255]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-257) Analysis [of data traffic](https://en.wikipedia.org/wiki/Packet_analyzer) by popular smartphones running variants of Android found substantial by-default data collection and sharing with no opt-out by this [pre-installed software](https://en.wikipedia.org/wiki/Pre-installed_software).[[256]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-258)[[257]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-259) Both of these issues are not addressed or cannot be addressed by security patches.

**Scope of surveillance by public institutions**

*See also:*[*WARRIOR PRIDE*](https://en.wikipedia.org/wiki/WARRIOR_PRIDE)

As part of the broader [2013 mass surveillance disclosures](https://en.wikipedia.org/wiki/2013_mass_surveillance_disclosures) it was revealed in September 2013 that the American and British intelligence agencies, the [National Security Agency](https://en.wikipedia.org/wiki/National_Security_Agency) (NSA) and [Government Communications Headquarters](https://en.wikipedia.org/wiki/Government_Communications_Headquarters) (GCHQ), respectively, have access to the user data on iPhone, BlackBerry, and Android devices. They were reportedly able to read almost all smartphone information, including SMS, location, emails, and notes.[[258]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-spiegel20130907-260) In January 2014, further reports revealed the intelligence agencies' capabilities to intercept the personal information transmitted across the Internet by social networks and other popular applications such as [*Angry Birds*](https://en.wikipedia.org/wiki/Angry_Birds), which collect personal information of their users for advertising and other commercial reasons. GCHQ has, according to [*The Guardian*](https://en.wikipedia.org/wiki/The_Guardian), a [wiki](https://en.wikipedia.org/wiki/Wiki)-style guide of different apps and advertising networks, and the different data that can be siphoned from each.[[259]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-angrybirdsatgchq-261) Later that week, the Finnish Angry Birds developer [Rovio](https://en.wikipedia.org/wiki/Rovio_Entertainment) announced that it was reconsidering its relationships with its advertising platforms in the light of these revelations, and called upon the wider industry to do the same.[[260]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-262)

The documents revealed a further effort by the intelligence agencies to intercept Google Maps searches and queries submitted from Android and other smartphones to collect location information in bulk.[[259]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-angrybirdsatgchq-261) The NSA and GCHQ insist their activities comply with all relevant domestic and international laws, although the Guardian stated "the latest disclosures could also add to mounting public concern about how the technology sector collects and uses information, especially for those outside the US, who enjoy fewer privacy protections than Americans."[[259]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-angrybirdsatgchq-261)

Leaked documents codenamed [Vault 7](https://en.wikipedia.org/wiki/Vault_7) and dated from 2013 to 2016, detail the capabilities of the [Central Intelligence Agency](https://en.wikipedia.org/wiki/Central_Intelligence_Agency) (CIA) to perform electronic surveillance and [cyber warfare](https://en.wikipedia.org/wiki/Cyber_warfare), including the ability to compromise the operating systems of most smartphones (including Android).[[261]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-263)[[262]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-264)

**Security patches**

In August 2015, Google announced that devices in the [Google Nexus](https://en.wikipedia.org/wiki/Google_Nexus) series would begin to receive monthly security [patches](https://en.wikipedia.org/wiki/Patch_(computing)). Google also wrote that "Nexus devices will continue to receive major updates for at least two years and security patches for the longer of three years from initial availability or 18 months from last sale of the device via the [Google Store](https://en.wikipedia.org/wiki/Google_Store)."[[263]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-265)[[264]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-266)[[265]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-267) The following October, researchers at the [University of Cambridge](https://en.wikipedia.org/wiki/University_of_Cambridge) concluded that 87.7% of Android phones in use had known but unpatched [security vulnerabilities](https://en.wikipedia.org/wiki/Security_vulnerabilities) due to lack of updates and support.[[266]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-268)[[267]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-269)[[268]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-270) Ron Amadeo of [*Ars Technica*](https://en.wikipedia.org/wiki/Ars_Technica) wrote also in August 2015 that "Android was originally designed, above all else, to be widely adopted. Google was starting from scratch with zero percent market share, so it was happy to give up control and give everyone a seat at the table in exchange for adoption. [...] Now, though, Android has around 75–80 percent of the worldwide smartphone market—making it not just the world's most popular mobile operating system but arguably the most popular operating system, period. As such, security has become a big issue. Android still uses a software update chain-of-command designed back when the Android ecosystem had zero devices to update, and it just doesn't work".[[269]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-271) Following news of Google's monthly schedule, some manufacturers, including Samsung and LG, promised to issue monthly security updates,[[270]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-272) but, as noted by Jerry Hildenbrand in *Android Central* in February 2016, "instead we got a few updates on specific versions of a small handful of models. And a bunch of broken promises".[[271]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-273)

In a March 2017 post on Google's Security Blog, Android security leads Adrian Ludwig and Mel Miller wrote that "More than 735 million devices from 200+ manufacturers received a platform security update in 2016" and that "Our carrier and hardware partners helped expand deployment of these updates, releasing updates for over half of the top 50 devices worldwide in the last quarter of 2016". They also wrote that "About half of devices in use at the end of 2016 had not received a platform security update in the previous year", stating that their work would continue to focus on streamlining the security updates program for easier deployment by manufacturers.[[272]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-274) Furthermore, in a comment to [*TechCrunch*](https://en.wikipedia.org/wiki/TechCrunch), Ludwig stated that the wait time for security updates had been reduced from "six to nine weeks down to just a few days", with 78% of flagship devices in North America being up-to-date on security at the end of 2016.[[273]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-275)

Patches to bugs found in the core operating system often do not reach users of older and lower-priced devices.[[274]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-276)[[275]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-277) However, the open-source nature of Android allows security contractors to take existing devices and adapt them for highly secure uses. For example, Samsung has worked with General Dynamics through their [Open Kernel Labs](https://en.wikipedia.org/wiki/Open_Kernel_Labs) acquisition to rebuild *Jelly Bean* on top of their hardened microvisor for the "Knox" project.[[276]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-278)[[277]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-279)

**Location-tracking**

Android smartphones have the ability to report the location of [Wi-Fi](https://en.wikipedia.org/wiki/Wi-Fi) access points, encountered as phone users move around, to build 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](https://en.wikipedia.org/wiki/Foursquare_City_Guide), [Google Latitude](https://en.wikipedia.org/wiki/Google_Latitude), [Facebook Places](https://en.wikipedia.org/wiki/Facebook_Places), and to deliver location-based ads.[[278]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-280) Third party monitoring software such as TaintDroid,[[279]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-281) an academic research-funded project, can, in some cases, detect when personal information is being sent from applications to remote servers.[[280]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-282)

**Further notable exploits**

In 2018, Norwegian security firm Promon has unearthed a serious Android security hole which can be exploited to steal login credentials, access messages, and track location, which could be found in all versions of Android, including [Android 10](https://en.wikipedia.org/wiki/Android_10). The vulnerability came by exploiting a bug in the multitasking system enabling a malicious app to overlay legitimate apps with fake login screens that users are not aware of when handing in security credentials. Users can also be tricked into granting additional permissions to the malicious apps, which later enable them to perform various nefarious activities, including intercepting texts or calls and stealing banking credentials.[[281]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-283) [*Avast*](https://en.wikipedia.org/wiki/Avast)*Threat Labs* also discovered that many pre-installed apps on several hundred new Android devices contain dangerous malware and [adware](https://en.wikipedia.org/wiki/Adware). Some of the preinstalled malware can commit ad fraud or even take over its host device.[[282]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-284)[[283]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-285)

In 2020, the Which? watchdog reported that more than a billion Android devices released in 2012 or earlier, which was 40% of Android devices worldwide, were at risk of being hacked. This conclusion stemmed from the fact that no security updates were issued for the Android versions below 7.0 in 2019. Which? collaborated with the AV Comparatives anti-virus lab to infect five phone models with malware, and it succeeded in each case. Google refused to comment on the watchdog's speculations.[[284]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-286)

On August 5, 2020, [Twitter](https://en.wikipedia.org/wiki/Twitter) published a blog urging its users to update their applications to the latest version with regards to a security concern that allowed others to access direct messages. A hacker could easily use the "Android system permissions" to fetch the account credentials in order to do so. The security issue is only with Android 8 ([Android Oreo](https://en.wikipedia.org/wiki/Android_Oreo)) and Android 9 ([Android Pie](https://en.wikipedia.org/wiki/Android_Pie)). Twitter confirmed that updating the app will restrict such practices.[[285]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-287)

**Technical security features**

Android applications run in a [sandbox](https://en.wikipedia.org/wiki/Sandbox_(computer_security)), an isolated area of the system that does not have access to the rest of the system's resources, unless access permissions are explicitly granted by the user when the application is installed, however this may not be possible for pre-installed apps. It is not possible, for example, to turn off the microphone access of the pre-installed camera app without disabling the camera completely. This is valid also in Android versions 7 and 8.[[286]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-288)

Since February 2012, Google has used its [Google Bouncer](https://en.wikipedia.org/wiki/Google_Bouncer) malware scanner to watch over and scan apps available in the Google Play store.[[287]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-289)[[288]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-290) A "Verify Apps" feature was introduced in November 2012, as part of the [Android 4.2 "Jelly Bean"](https://en.wikipedia.org/wiki/Android_Jelly_Bean) operating system version, to scan all apps, both from Google Play and from third-party sources, for malicious behaviour.[[289]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-291) Originally only doing so during installation, Verify Apps received an update in 2014 to "constantly" scan apps, and in 2017 the feature was made visible to users through a menu in Settings.[[290]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-292)[[291]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-293)

In former Android versions, before installing an application, the [Google Play](https://en.wikipedia.org/wiki/Google_Play) store displayed a list of the requirements an app needs to function. After reviewing these permissions, the user could choose to accept or refuse them, installing the application only if they accepted.[[292]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-294) In [Android 6.0 "Marshmallow"](https://en.wikipedia.org/wiki/Android_Marshmallow), the permissions system was changed; apps are no longer automatically granted all of their specified permissions at installation time. An opt-in system is used instead, in which users are prompted to grant or deny individual permissions to an app when they are needed for the first time. Applications remember the grants, which can be revoked by the user at any time. Pre-installed apps, however, are not always part of this approach. In some cases it may not be possible to deny certain permissions to pre-installed apps, nor be possible to disable them. The [Google Play Services](https://en.wikipedia.org/wiki/Google_Play_Services) app cannot be uninstalled, nor disabled. Any force stop attempt, result in the app restarting itself.[[293]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-295)[[294]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-296) The new permissions model is used only by applications developed for Marshmallow using its [software development kit](https://en.wikipedia.org/wiki/Software_development_kit) (SDK), and older apps will continue to use the previous all-or-nothing approach. Permissions can still be revoked for those apps, though this might prevent them from working properly, and a warning is displayed to that effect.[[295]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-297)[[296]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-298)

In September 2014, Jason Nova of *Android Authority* reported on a study by the German security company Fraunhofer AISEC in [antivirus software](https://en.wikipedia.org/wiki/Antivirus_software) and malware threats on Android. Nova wrote that "The Android operating system deals with software packages by sandboxing them; this does not allow applications to list the directory contents of other apps to keep the system safe. By not allowing the antivirus to list the directories of other apps after installation, applications that show no inherent suspicious behavior when downloaded are cleared as safe. If then later on parts of the app are activated that turn out to be malicious, the antivirus will have no way to know since it is inside the app and out of the antivirus' jurisdiction". The study by Fraunhofer AISEC, examining antivirus software from [Avast](https://en.wikipedia.org/wiki/Avast), [AVG](https://en.wikipedia.org/wiki/AVG_AntiVirus), [Bitdefender](https://en.wikipedia.org/wiki/Bitdefender), [ESET](https://en.wikipedia.org/wiki/ESET), [F-Secure](https://en.wikipedia.org/wiki/F-Secure), [Kaspersky](https://en.wikipedia.org/wiki/Kaspersky_Lab), [Lookout](https://en.wikipedia.org/w/index.php?title=Lookout_(company)&action=edit&redlink=1), [McAfee](https://en.wikipedia.org/wiki/McAfee) (formerly Intel Security), [Norton](https://en.wikipedia.org/wiki/Norton_(software)), [Sophos](https://en.wikipedia.org/wiki/Sophos), and [Trend Micro](https://en.wikipedia.org/wiki/Trend_Micro), revealed that "the tested antivirus apps do not provide protection against customized malware or targeted attacks", and that "the tested antivirus apps were also not able to detect malware which is completely unknown to date but does not make any efforts to hide its malignity".[[297]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-299)

In August 2013, Google announced Android Device Manager (renamed Find My Device in May 2017),[[298]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-300)[[299]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-301) a service that allows users to remotely track, locate, and wipe their Android device,[[300]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-302)[[301]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-303) with an Android app for the service released in December.[[302]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-304)[[303]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-305) In December 2016, Google introduced a Trusted Contacts app, letting users request location-tracking of loved ones during emergencies.[[304]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-306)[[305]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-307) In 2020, Trusted Contacts was shut down and the location-sharing feature rolled into Google Maps.[[306]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-308)

On October 8, 2018, Google announced new Google Play store requirements to combat over-sharing of potentially sensitive information, including call and text logs. The issue stems from the fact that many apps request permissions to access users' personal information (even if this information is not needed for the app to function) and some users unquestionably grant these permissions. Alternatively, a permission might be listed in the app manifest as required (as opposed to optional) and the app would not install unless user grants the permission; users can withdraw any, even required, permissions from any app in the device settings after app installation, but few users do this. Google promised to work with developers and create exceptions if their apps require Phone or SMS permissions for "core app functionality". The new policies enforcement started on January 6, 2019, 90 days after policy announcement on October 8, 2018. Furthermore, Google announced a new "target API level requirement" (targetSdkVersion in manifest) at least Android 8.0 (API level 26) for all new apps and app updates. The API level requirement might combat the practice of app developers bypassing some permission screens by specifying early Android versions that had a coarser permission model.[[307]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-309)[[308]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-310)

**Verified Boot**

The Android Open Source Project implements a [verified boot](https://en.wikipedia.org/wiki/UEFI#Secure_Boot) chain with intentions to [verify](https://en.wikipedia.org/wiki/Data_verification) that executed code, such as the [kernel](https://en.wikipedia.org/wiki/Kernel_(operating_system)) or [bootloader](https://en.wikipedia.org/wiki/Bootloader), comes from an official source instead of a malicious actor. This implementation establishes a full chain of trust, as it initially starts at a hardware level. Subsequently, the boot loader is verified and system partitions such as system and vendor are checked for [integrity](https://en.wikipedia.org/wiki/Data_integrity).[[309]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-verifiedboot-311)[[310]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-312)

Furthermore, this process verifies that a previous version of Android has not been installed. This effectively provides rollback protection, which mitigates exploits that are similar to a [downgrade attack](https://en.wikipedia.org/wiki/Downgrade_attack).[[309]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-verifiedboot-311)

**dm-verity**

*See also:*[*Device mapper*](https://en.wikipedia.org/wiki/Device_mapper)

Android (all supported versions, as far back as version 4.4 of the Android Open Source Project) has the option to provide a [verified boot](https://en.wikipedia.org/wiki/UEFI#Secure_Boot) chain with [dm-verity](https://en.wikipedia.org/wiki/Device_mapper#Applications). This is a feature in the [Linux kernel](https://en.wikipedia.org/wiki/Linux_kernel) that allows for transparent integrity checking of [block devices](https://en.wikipedia.org/wiki/Device_file#Block_devices).[[311]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-313)[[312]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-314)

This feature is designed to mitigate persistent [rootkits](https://en.wikipedia.org/wiki/Rootkits).

**Google Play Services and vendor changes**

*See also:*[*Behavioral targeting*](https://en.wikipedia.org/wiki/Behavioral_targeting)*and*[*DeGoogle*](https://en.wikipedia.org/wiki/DeGoogle)

Dependence on proprietary [Google Play Services](https://en.wikipedia.org/wiki/Google_Play_Services) and customizations added on top of the operating system by vendors who license Android from Google is causing privacy concerns.[[*clarification needed*](https://en.wikipedia.org/wiki/Wikipedia:Please_clarify)][[313]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-315)[[314]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-316)[[315]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-317)

**Criticism and controversy**

**Privacy and GDPR compliance**

**France**

In 2019, [Google](https://en.wikipedia.org/wiki/Google) was fined €50 Million by the French [CNIL](https://en.wikipedia.org/wiki/Commission_nationale_de_l%27informatique_et_des_libert%C3%A9s) for a lack of information regarding their users.[[316]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-318)

Two years later, in 2021, [researcher](https://en.wikipedia.org/wiki/Research) Douglas Leith, using a sort of data interception, showed that several data are sent from Android device to [Google](https://en.wikipedia.org/wiki/Google)'s servers, even when the phone is sleeping (IDLE) with no [Google](https://en.wikipedia.org/wiki/Google) account registered into it.[[317]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-319) Several [Google](https://en.wikipedia.org/wiki/Google) [applications](https://en.wikipedia.org/wiki/Application_software) send data, such as [Chrome](https://en.wikipedia.org/wiki/Google_Chrome), [Message](https://en.wikipedia.org/wiki/Google_Messages) or [Docs](https://en.wikipedia.org/wiki/Google_Docs), however [Youtube](https://en.wikipedia.org/wiki/YouTube) is the only one to add a unique identifier data.[[318]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-320)

In 2022, Leith showed that an Android [phone](https://en.wikipedia.org/wiki/Telephone) sent various data related to communications, including [phone](https://en.wikipedia.org/wiki/Telephone) and [text messages](https://en.wikipedia.org/wiki/Text_messaging) to Google. [Timestamp](https://en.wikipedia.org/wiki/Timestamping_(computing)), sender and receiver, plus several other data, are sent to [Google Play Services](https://en.wikipedia.org/wiki/Google_Play_Services) infrastructure, even if the "Usage and Diag" feature is disabled. Those data are marked with a Unique Identifier of an Android device, and don't comply with [GDPR](https://en.wikipedia.org/wiki/General_Data_Protection_Regulation).[[319]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-321)

**Australia**

Google was sanctioned about [A$](https://en.wikipedia.org/wiki/Australian_dollar)60 Million (approx 40Million [USD](https://en.wikipedia.org/wiki/United_States_dollar)) in [Australia](https://en.wikipedia.org/wiki/Australia) for having misled its Android customers. It concerns the 2017–2018 period where the issue regarding misleading location tracking settings was discovered, and the case came under Australia’s Competition & Consumer Commission responsibility. The trial concluded in 2021 when the court decided Google broke [Consumer law](https://en.wikipedia.org/wiki/Consumer_law) for about 1.3 million of Google account owners.[[320]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-322)

**United States of America**

A similar case to the 2019 French case regarding location tracking, was brought in the U.S. in a privacy lawsuit filed by a coalition of attorneys general from 40 U.S. states. A penalty of [USD](https://en.wikipedia.org/wiki/United_States_dollar) 391 Million was agreed between Google and the [DoJ](https://en.wikipedia.org/wiki/Ministry_of_justice).[[321]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-323) [The New York Times](https://en.wikipedia.org/wiki/The_New_York_Times) released at that time a long-term [investigation](https://en.wikipedia.org/wiki/Investigative_journalism) about those [privacy](https://en.wikipedia.org/wiki/Privacy) concerns.[[322]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-324)

**Short software support lifespans**

*See also:*[*European Ecodesign Directive § Smartphones, mobile phones, cordless phones and tablets*](https://en.wikipedia.org/wiki/European_Ecodesign_Directive#Smartphones,_mobile_phones,_cordless_phones_and_tablets)

Android devices, particularly low-end and mid-range models, have been criticized for their short software support lifespans.[[323]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-325) Starting in the 2010s, many users found that their devices received only one or two major updates and a limited number of security patches. This lack of long-term support stemmed from manufacturers’ unwillingness to invest in costly software upgrades,[[324]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-326) which were often tied to contractual agreements with chipset suppliers like [Qualcomm](https://en.wikipedia.org/wiki/Qualcomm). As a result, Android developed a reputation for rapid device obsolescence.[[325]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-327)[[326]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-328)

To address this concern, Google introduced [Project Treble](https://en.wikipedia.org/wiki/Project_Treble), a framework designed to streamline the development and deployment of Android updates via [Google Play Services](https://en.wikipedia.org/wiki/Google_Play_Services), reducing manufacturers’ involvement in the update process.

However, for many devices, significant improvements were still limited by the chipset manufacturers. [Fairphone](https://en.wikipedia.org/wiki/Fairphone), a company focused on sustainability, explained that its inability to extend software support was due to Qualcomm’s policies rather than its own.[[327]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-329) [Apple](https://en.wikipedia.org/wiki/Apple_Inc.) executives also highlighted Android’s fragmented update ecosystem in their critiques of the platform, while quietly admitting that Qualcomm had also made it difficult for them to offer updates to the iPhone.[[328]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-330)

In response problem, several community-driven initiatives emerged to provide alternatives operating systems for unsupported devices including, like [LineageOS](https://en.wikipedia.org/wiki/LineageOS), [Sailfish OS](https://en.wikipedia.org/wiki/Sailfish_OS), [Ubuntu Touch](https://en.wikipedia.org/wiki/Ubuntu_Touch) and [PostmarketOS](https://en.wikipedia.org/wiki/PostmarketOS).[[329]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-331)

Starting in 2022, Samsung, the largest Android smartphone manufacturer, announced extended software support from previous two years, first to four years, followed by five years in 2023 and six years in 2024.[[330]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-332)

Shortly thereafter, Qualcomm followed suit, offering extending support timelines for OEM building phones with its chipsets, first to seven years in 2024,[[331]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-333) followed by eight years in 2025. However, the support commitment was only for its most powerful chipsets, and did not make a similar commitment for chipsets used in low-end and mid-range phones.[[332]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-334)

These changes bring Samsung and potentially some Qualcomm-powered devices closer to competing platforms, such as Apple, whose iPhones have received four to eight years of support.[[333]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-335)

**Licensing**

The [source code](https://en.wikipedia.org/wiki/Source_code) for Android is [open-source](https://en.wikipedia.org/wiki/Open-source_software): it is developed in private by Google, with the source code released publicly when a new version of Android is released. Google publishes most of the code (including network and telephony [stacks](https://en.wikipedia.org/wiki/Solution_stack)) under the [non-copyleft](https://en.wikipedia.org/wiki/Non-copyleft) [Apache License](https://en.wikipedia.org/wiki/Apache_License) version 2.0. which allows modification and redistribution.[[334]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-336)[[335]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-337) The license does not grant rights to the "Android" trademark, so device manufacturers and wireless carriers have to license it from Google under individual contracts. Associated Linux kernel changes are released under the [copyleft](https://en.wikipedia.org/wiki/Copyleft) [GNU General Public License](https://en.wikipedia.org/wiki/GNU_General_Public_License) version 2, developed by the [Open Handset Alliance](https://en.wikipedia.org/wiki/Open_Handset_Alliance), with the source code publicly available at all times.[[336]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-338) The only Android release which was not immediately made available as source code was the tablet-only 3.0 *Honeycomb* release. The reason, according to [Andy Rubin](https://en.wikipedia.org/wiki/Andy_Rubin) in an official Android blog post, was because *Honeycomb* was rushed for production of the [Motorola Xoom](https://en.wikipedia.org/wiki/Motorola_Xoom),[[337]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-339) 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.[[338]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-340)

Only the base Android operating system (including some applications) is open-source software, whereas most Android devices ship with a substantial amount of proprietary software, such as [Google Mobile Services](https://en.wikipedia.org/wiki/Google_Mobile_Services), which includes applications such as [Google Play Store](https://en.wikipedia.org/wiki/Google_Play_Store), Google Search, and [Google Play Services](https://en.wikipedia.org/wiki/Google_Play_Services) – a software layer that provides [APIs](https://en.wikipedia.org/wiki/Application_programming_interface) for the integration with Google-provided services, among others. These applications must be licensed from Google by device makers, and can only be shipped on devices which meet its compatibility guidelines and other requirements.[[118]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-geek-poweredby-120) Custom, certified distributions of Android produced by manufacturers (such as [Samsung Experience](https://en.wikipedia.org/wiki/Samsung_Experience)) may also replace certain stock Android apps with their own proprietary variants and add additional software not included in the stock Android operating system.[[117]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars-irongrip-119) With the advent of the [Google Pixel](https://en.wikipedia.org/wiki/Google_Pixel) line of devices, Google itself has also made specific Android features timed or permanent exclusives to the Pixel series.[[339]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-341)[[340]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-342) There may also be "[binary blob](https://en.wikipedia.org/wiki/Binary_blob)" [drivers](https://en.wikipedia.org/wiki/Driver_(software)) required for certain hardware components in the device.[[117]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars-irongrip-119)[[171]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Building_for_devices-173) The best known fully open source Android services are the [LineageOS](https://en.wikipedia.org/wiki/LineageOS) distribution and [MicroG](https://en.wikipedia.org/wiki/MicroG) which acts as an open source replacement of Google Play Services.

[Richard Stallman](https://en.wikipedia.org/wiki/Richard_Stallman) and the [Free Software Foundation](https://en.wikipedia.org/wiki/Free_Software_Foundation) have been critical of Android and have recommended the usage of alternatives such as [Replicant](https://en.wikipedia.org/wiki/Replicant_(operating_system)), because drivers and firmware vital for the proper functioning of Android devices are usually proprietary, and because the Google Play Store application can forcibly install or uninstall applications and, as a result, invite non-free software. In both cases, the use of closed-source software causes the system to become vulnerable to [backdoors](https://en.wikipedia.org/wiki/Backdoor_(computing)).[[341]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-stallman2011-343)[[342]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-344)

It has been argued that because developers are often required to purchase the Google-branded Android license, this has turned the theoretically open system into a [freemium](https://en.wikipedia.org/wiki/Freemium) service.[[343]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-JemielniakPrzegalinska2020-345): 20

**Leverage over manufacturers**

Google licenses their Google Mobile Services software, along with the Android trademarks, only to hardware manufacturers for devices that meet Google's compatibility standards specified in the Android Compatibility Program document.[[344]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-AndroidCompatibility-346) Thus, forks of Android that make major changes to the operating system itself do not include any of Google's non-free components, stay incompatible with applications that require them, and must ship with an alternative software marketplace in lieu of Google Play Store.[[117]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars-irongrip-119) A prominent example of such an Android fork is [Amazon](https://en.wikipedia.org/wiki/Amazon.com)'s [Fire OS](https://en.wikipedia.org/wiki/Fire_OS), which is used on the [Kindle Fire](https://en.wikipedia.org/wiki/Kindle_Fire) line of tablets, and oriented toward Amazon services.[[117]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars-irongrip-119) The shipment of Android devices without GMS is also common in mainland [China](https://en.wikipedia.org/wiki/China), as Google does not do business there.[[345]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-347)[[346]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-348)[[347]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-349)

In 2014, Google also began to require that all Android devices which license the Google Mobile Services software display a prominent "Powered by Android" logo on their boot screens.[[118]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-geek-poweredby-120) Google has also enforced preferential bundling and placement of Google Mobile Services on devices, including mandated bundling of the entire main suite of Google applications, mandatory placement of shortcuts to Google Search and the Play Store app on or near the main home screen page in its default configuration,[[348]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-350) and granting a larger share of search revenue to OEMs who agree to not include third-party app stores on their devices.[[349]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-351) In March 2018, it was reported that Google had begun to block "uncertified" Android devices from using Google Mobile Services software, and display a warning indicating that "the device manufacturer has preloaded Google apps and services without certification from Google". Users of custom ROMs can register their device ID to their Google account to remove this block.[[350]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-352)

Some stock applications and components in AOSP code that were formerly used by earlier versions of Android, such as Search, Music, Calendar, and the location API, were [abandoned](https://en.wikipedia.org/wiki/Deprecation) by Google in favor of [non-free](https://en.wikipedia.org/wiki/Proprietary_software) replacements distributed through Play Store (Google Search, YouTube Music, and Google Calendar) and [Google Play Services](https://en.wikipedia.org/wiki/Google_Play_Services), which are no longer open-source. Moreover, open-source variants of some applications also exclude functions that are present in their non-free versions.[[117]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars-irongrip-119)[[351]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-353)[[352]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-354)[[353]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-355) These measures are likely intended to discourage forks and encourage commercial licensing in line with Google requirements, as the majority of the operating system's core functionality is dependent on proprietary components licensed exclusively by Google, and it would take significant development resources to develop an alternative suite of software and APIs to replicate or replace them. Apps that do not use Google components would also be at a functional disadvantage, as they can only use APIs contained within the OS itself. In turn, third-party apps may have dependencies on Google Play Services.[[354]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-356)

Members of the Open Handset Alliance, which include the majority of Android OEMs, are also contractually forbidden from producing Android devices based on forks of the OS;[[117]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars-irongrip-119)[[355]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Compatibility_FAQ-357) in 2012, [Acer Inc.](https://en.wikipedia.org/wiki/Acer_Inc.) was forced by Google to halt production on a device powered by [Alibaba Group](https://en.wikipedia.org/wiki/Alibaba_Group)'s [Aliyun OS](https://en.wikipedia.org/wiki/Aliyun_OS) with threats of removal from the OHA, as Google deemed the platform to be an incompatible version of Android. Alibaba Group defended the allegations, arguing that the OS was a distinct platform from Android (primarily using [HTML5](https://en.wikipedia.org/wiki/HTML5) apps), but incorporated portions of Android's platform to allow backwards compatibility with third-party Android software. Indeed, the devices did ship with an application store which offered Android apps; however, the majority of them were [pirated](https://en.wikipedia.org/wiki/Software_piracy).[[356]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-358)[[357]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-359)[[358]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-360)

**Reception**

Android received a lukewarm reaction when it was unveiled in 2007. Although analysts were impressed with the respected technology companies that had partnered with Google to form the Open Handset Alliance, it was unclear whether mobile phone manufacturers would be willing to replace their existing operating systems with Android.[[359]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-361) The idea of an open-source, Linux-based [development platform](https://en.wikipedia.org/wiki/Computing_platform) sparked interest,[[360]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-362) but there were additional worries about Android facing strong competition from established players in the smartphone market, such as Nokia and Microsoft, and rival Linux mobile operating systems that were in development.[[361]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-363) These established players were skeptical: Nokia was quoted as saying "we don't see this as a threat", and a member of Microsoft's Windows Mobile team stated "I don't understand the impact that they are going to have."[[362]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-364)

Since then Android has grown to become the most widely used smartphone operating system[[363]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars5th-365)[[364]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-reisinger2015-366) and "one of the fastest mobile experiences available".[[365]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-syrup-367) Reviewers have highlighted the open-source nature of the operating system as one of its defining strengths, allowing companies such as Nokia (Nokia X family),[[366]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-368) Amazon (Kindle Fire), [Barnes & Noble](https://en.wikipedia.org/wiki/Barnes_%26_Noble) ([Nook](https://en.wikipedia.org/wiki/Barnes_%26_Noble_Nook)), [Ouya](https://en.wikipedia.org/wiki/Ouya), [Baidu](https://en.wikipedia.org/wiki/Baidu) and others to [fork](https://en.wikipedia.org/wiki/Fork_(software_development)) the software and release hardware running their own customised version of Android. As a result, it has been described by technology website [*Ars Technica*](https://en.wikipedia.org/wiki/Ars_Technica) as "practically the default operating system for launching new hardware" for companies without their own mobile platforms.[[363]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars5th-365) This openness and flexibility is also present at the level of the end user: Android allows extensive customisation of devices by their owners and apps are freely available from non-Google app stores and third party websites. These have been cited as among the main advantages of Android phones over others.[[363]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars5th-365)[[367]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-369)

Despite Android's popularity, including an activation rate three times that of iOS, there have been reports that Google has not been able to leverage their other products and web services successfully to turn Android into the money maker that analysts had expected.[[368]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-370) [*The Verge*](https://en.wikipedia.org/wiki/The_Verge) suggested that Google is losing control of Android due to the extensive customization and proliferation of non-Google apps and services – Amazon's Kindle Fire line uses [Fire OS](https://en.wikipedia.org/wiki/Fire_OS), a heavily modified fork of Android which does not include or support any of Google's proprietary components, and requires that users obtain software from its competing [Amazon Appstore](https://en.wikipedia.org/wiki/Amazon_Appstore) instead of Play Store.[[117]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-ars-irongrip-119) In 2014, in an effort to improve prominence of the Android brand, Google began to require that devices featuring its proprietary components display an Android logo on the boot screen.[[118]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-geek-poweredby-120)

Android has suffered from "fragmentation",[[369]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-371) a situation where the variety of Android devices, in terms of both hardware variations and differences in the software running on them, makes the task of developing applications that work consistently across the ecosystem harder than rival platforms such as iOS where hardware and software varies less. For example, according to data from [OpenSignal](https://en.wikipedia.org/wiki/OpenSignal) in July 2013, there were 11,868 models of Android devices, numerous screen sizes and eight Android OS versions simultaneously in use, while the large majority of iOS users have upgraded to the latest iteration of that OS.[[370]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-guardianfrag-372) Critics such as [*Apple Insider*](https://en.wikipedia.org/wiki/Apple_Insider) have asserted that fragmentation via hardware and software pushed Android's growth through large volumes of low end, budget-priced devices running older versions of Android. They maintain this forces Android developers to write for the "lowest common denominator" to reach as many users as possible, who have too little incentive to make use of the latest hardware or software features only available on a smaller percentage of devices.[[371]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-373) However, OpenSignal, who develops both Android and iOS apps, concluded that although fragmentation can make development trickier, Android's wider global reach also increases the potential reward.[[370]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-guardianfrag-372)

**Market share**

*Main article:*[*Usage share of operating systems*](https://en.wikipedia.org/wiki/Usage_share_of_operating_systems)

Android is the most used operating system on phones in virtually all countries, with some countries, such as India, having over 96% market share.[[372]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-374) On tablets, usage is more even, as iOS is a bit more popular globally.

Research company Canalys estimated in the second quarter of 2009, that Android had a 2.8% share of worldwide [smartphone](https://en.wikipedia.org/wiki/Smartphone) shipments.[[373]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Insider_1-375) By May 2010, Android had a 10% worldwide smartphone market share, overtaking [Windows Mobile](https://en.wikipedia.org/wiki/Windows_Mobile),[[374]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-376) whilst in the US Android held a 28% share, overtaking [iPhone OS](https://en.wikipedia.org/wiki/IPhone_OS).[[375]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-377) By the fourth quarter of 2010, its worldwide share had grown to 33% of the market becoming the top-selling smartphone platform,[[376]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-canalysQ42010-378) overtaking [Symbian](https://en.wikipedia.org/wiki/Symbian).[[377]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-379) In the US it became the top-selling platform in April 2011, overtaking [BlackBerry OS](https://en.wikipedia.org/wiki/BlackBerry_OS) with a 31.2% smartphone share, according to *comScore*.[[378]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-380)

By the third quarter of 2011, [Gartner](https://en.wikipedia.org/wiki/Gartner) estimated that more than half (52.5%) of the smartphone sales belonged to Android.[[379]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-381) By the third quarter of 2012 Android had a 75% share of the global smartphone market according to the research firm IDC.[[380]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-idcQ3-382)

In July 2011, Google said that 550,000 Android devices were being activated every day,[[381]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-a550-383) up from 400,000 per day in May,[[382]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-384) and more than 100 million devices had been activated[[383]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-i/o_2011_stats-385) with 4.4% growth per week.[[381]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-a550-383) In September 2012, 500 million devices had been activated with 1.3 million activations per day.[[384]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Google_Team-386)[[385]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Eric_Schmidt-387) In May 2013, at Google I/O, Sundar Pichai announced that 900 million Android devices had been activated.[[386]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-388)

Android market share varies by location. In July 2012, "mobile subscribers aged 13+" in the United States using Android were up to 52%,[[387]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-389) and rose to 90% in China.[[388]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-390) During the third quarter of 2012, Android's worldwide smartphone shipment market share was 75%,[[380]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-idcQ3-382) with 750 million devices activated in total. In April 2013, Android had 1.5 million activations per day.[[385]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Eric_Schmidt-387) As of May 2013, 48 billion application ("app") installation have been performed from the Google Play store,[[389]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-48bn-391) and by September 2013, one billion Android devices had been activated.[[390]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-1bn-392)

As of August 2020, the [Google Play](https://en.wikipedia.org/wiki/Google_Play) store had over 3 million Android applications published,[[119]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-3_million_apps-121)[[391]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-393) and as of May 2016, apps had been downloaded more than 65 billion times.[[392]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-394) The operating system's success has made it a target for patent litigation as part of the so-called "[smartphone wars](https://en.wikipedia.org/wiki/Smartphone_patent_wars)" between technology companies.[[393]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-395)[[394]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-396)

Android devices account for more than half of smartphone sales in most markets, including the US, while "only in Japan was Apple on top" (September–November 2013 numbers).[[395]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-397) At the end of 2013, over 1.5 billion Android smartphones had been sold in the four years since 2010,[[396]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-398)[[397]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-399) making Android the most sold phone and tablet OS. Three billion Android smartphones were estimated to be sold by the end of 2014 (including previous years). According to Gartner research company, Android-based devices outsold all contenders, every year since 2012.[[398]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-400) In 2013, it outsold Windows 2.8:1 or by 573 million.[[399]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-more_than_Windows-401)[[400]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-402)[[401]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-403) As of 2015, Android has the largest [installed base](https://en.wikipedia.org/wiki/Installed_base) of all operating systems;[[22]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Murky_road_despite_dominance-24) Since 2013, devices running it also sell more than Windows, iOS and Mac OS X devices combined.[[402]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-best_selling-404)

According to [StatCounter](https://en.wikipedia.org/wiki/StatCounter), which tracks only the use for browsing the web, Android is the most popular mobile operating system since August 2013.[[403]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-405) Android is the most popular operating system for web browsing in India and several other countries (e.g. virtually all of Asia, with Japan and North Korea exceptions). According to StatCounter, Android is most used on phones in all African countries, and it stated "mobile usage has already overtaken desktop in several countries including India, South Africa and Saudi Arabia",[[404]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-406) with all countries in Africa having done so already in which mobile (including tablets) usage is at 90.46% (Android only, accounts for 75.81% of all use there).[[405]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-407)[[406]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-408)

While Android phones in the [Western world](https://en.wikipedia.org/wiki/Western_world) almost always include Google's proprietary code (such as Google Play) in the otherwise open-source operating system, Google's proprietary code and trademark is increasingly not used in emerging markets; "The growth of [AOSP](https://en.wikipedia.org/wiki/Android_Open_Source_Project) Android devices goes way beyond just China [..] ABI Research claims that 65 million devices shipped globally with open-source Android in the second quarter of [2014], up from 54 million in the first quarter"; depending on country, percent of phones estimated to be based only on AOSP source code, forgoing the Android trademark: Thailand (44%), Philippines (38%), Indonesia (31%), India (21%), Malaysia (24%), Mexico (18%), Brazil (9%).[[407]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-409)

According to a January 2015 [Gartner](https://en.wikipedia.org/wiki/Gartner) report, "Android surpassed a billion shipments of devices in 2014, and will continue to grow at a double-digit pace in 2015, with a 26 percent increase year over year." This made it the first time that any general-purpose operating system has reached more than one billion end users within a year: by reaching close to 1.16 billion end users in 2014, Android shipped over four times more than [iOS](https://en.wikipedia.org/wiki/IOS) and [OS X](https://en.wikipedia.org/wiki/OS_X) combined, and over three times more than [Microsoft Windows](https://en.wikipedia.org/wiki/Microsoft_Windows). Gartner expected the whole mobile phone market to "reach two billion units in 2016", including Android.[[408]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-410) Describing the statistics, Farhad Manjoo wrote in [*The New York Times*](https://en.wikipedia.org/wiki/The_New_York_Times) that "About one of every two computers sold today is running Android. [It] has become Earth's dominant computing platform."[[22]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-Murky_road_despite_dominance-24)

According to a [Statistica](https://en.wikipedia.org/wiki/Statistica)'s estimate, Android smartphones had an installed base of 1.8 billion units in 2015, which was 76% of the estimated total number of smartphones worldwide.[[409]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-411)[[410]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-412)[[c]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-414) Android has the largest installed base of any [mobile operating system](https://en.wikipedia.org/wiki/Mobile_operating_system) and, since 2013, the highest-selling operating system overall[[399]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-more_than_Windows-401)[[402]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-best_selling-404)[[412]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-mahapatra1-415)[[413]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-elmer1-416)[[414]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-sammobile1-417) with sales in 2012, 2013 and 2014[[415]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-418) close to the installed base of all PCs.[[416]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-419)

In the second quarter of 2014, Android's share of the global smartphone shipment market was 84.7%, a new record.[[417]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-420)[[418]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-421) This had grown to 87.5% worldwide market share by the third quarter of 2016,[[419]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-422) leaving main competitor [iOS](https://en.wikipedia.org/wiki/IOS) with 12.1% market share.[[420]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-423)

According to an April 2017 [StatCounter](https://en.wikipedia.org/wiki/StatCounter) report, Android overtook Microsoft Windows to become the most popular operating system for total Internet usage.[[421]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-424)[[422]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-425) It has maintained the plurality since then.[[423]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-426)

In September 2015, [Google](https://en.wikipedia.org/wiki/Google) announced that Android had 1.4 billion monthly active users.[[424]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-427)[[425]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-428) This changed to 2 billion monthly active users in May 2017.[[426]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-429)[[427]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-430)

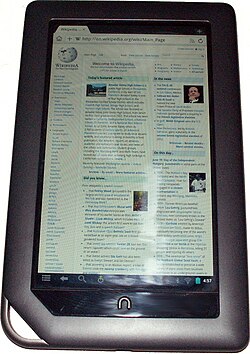
**Adoption on tablets**

[](https://en.wikipedia.org/wiki/File:Front_view_of_Nexus_7_(cropped).png)The [first-generation Nexus 7](https://en.wikipedia.org/wiki/Nexus_7_(2012_version)) tablet, running Android 4.1 Jelly Bean

Despite its success on smartphones, initially Android tablet adoption was slow,[[428]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-431) then later caught up with the iPad, in most countries. One of the main causes was the [chicken or the egg](https://en.wikipedia.org/wiki/Chicken_or_the_egg) situation where consumers were hesitant to buy an Android tablet due to a lack of high quality tablet applications, but developers were hesitant to spend time and resources developing tablet applications until there was a significant market for them.[[429]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-432)[[430]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-tabs-433) The content and app "ecosystem" proved more important than hardware [specs](https://en.wikipedia.org/wiki/Specification_(technical_standard)) as the selling point for tablets. Due to the lack of Android tablet-specific applications in 2011, early Android tablets had to make do with existing smartphone applications that were ill-suited to larger screen sizes, whereas the dominance of Apple's [iPad](https://en.wikipedia.org/wiki/IPad) was reinforced by the large number of tablet-specific [iOS](https://en.wikipedia.org/wiki/IOS) applications.[[430]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-tabs-433)[[431]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-434)

Despite app support in its infancy, a considerable number of Android tablets, like the [Barnes & Noble Nook](https://en.wikipedia.org/wiki/Barnes_%26_Noble_Nook) (alongside those using other operating systems, such as the [HP TouchPad](https://en.wikipedia.org/wiki/HP_TouchPad) and [BlackBerry PlayBook](https://en.wikipedia.org/wiki/BlackBerry_PlayBook)) were rushed out to market in an attempt to capitalize on the success of the iPad.[[430]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-tabs-433) *InfoWorld* has suggested that some Android manufacturers initially treated their first tablets as a "Frankenphone business", a short-term low-investment opportunity by placing a smartphone-optimized Android OS (before Android 3.0 *Honeycomb* for tablets was available) on a device while neglecting user interface. This approach, such as with the [Dell Streak](https://en.wikipedia.org/wiki/Dell_Streak), failed to gain market traction with consumers as well as damaging the early reputation of Android tablets.[[432]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-435)[[433]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-436) Furthermore, several Android tablets such as the [Motorola Xoom](https://en.wikipedia.org/wiki/Motorola_Xoom) were priced the same or higher than the [iPad](https://en.wikipedia.org/wiki/IPad), which hurt sales. An exception was the [Amazon](https://en.wikipedia.org/wiki/Amazon.com) [Kindle Fire](https://en.wikipedia.org/wiki/Kindle_Fire), which relied upon lower pricing as well as access to Amazon's ecosystem of applications and content.[[430]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-tabs-433)[[434]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-437)

This began to change in 2012, with the release of the affordable [Nexus 7](https://en.wikipedia.org/wiki/Nexus_7_(2012_version)) and a push by Google for developers to write better tablet applications.[[435]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-438) According to International Data Corporation, shipments of Android-powered tablets surpassed iPads in Q3 2012.[[436]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-439)

[](https://en.wikipedia.org/wiki/File:Nook_Color_Showing_Wikipedia_Index_On_Dolphin_Browser_HD.jpg)[Barnes & Noble Nook](https://en.wikipedia.org/wiki/Barnes_%26_Noble_Nook) running Android

As of the end of 2013, over 191.6 million Android tablets had sold in three years since 2011.[[437]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-440)[[438]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-441) This made Android tablets the most-sold type of tablet in 2013, surpassing iPads in the second quarter of 2013.[[439]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-442)

According to StatCounter's web use statistics, as of 2020, Android tablets represent the majority of tablet devices used in [Africa](https://en.wikipedia.org/wiki/Africa) (70%), [South America](https://en.wikipedia.org/wiki/South_America) (65%), while less than half elsewhere, e.g. Europe (44%), Asia (44%), North America (34%) and Oceania/Australia (18%). There are countries on all continents where Android tablets are the majority, for example, Mexico.[[440]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-443)

**Platform information**

*Main article:*[*Android version history*](https://en.wikipedia.org/wiki/Android_version_history)

Android has 71% market share vs Apple's iOS/iPadOS at 29% (on tablets alone Apple is slightly ahead, i.e. 48% vs 52%, though Android is ahead in virtually all countries). Android 14 is the most popular Android version on smartphones and on tablets.

As of May 2025, Android 14 is most popular Android version on smartphones at 34%,[[441]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-444) (down from 37% peak, Android 15 at 12% has been eating away at it, about to get to be 3rd most popular version) followed by Android 13, and 12. Android is more used than iOS is virtually all countries, with few exceptions such as iOS has a 58% share in the US. Android 14 is the most-used single version on all countinents, and most countries, including India, the US and all European countries, with the exception of China (and there Android 15 is well ahead of it[[442]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-445)). Usage of Android 12 and newer, i.e. supported versions, is at 73%, the rest of users are not supported with security updates, with recently unsupported Android 11, use is at 83%.

On tablets, Android 14 is again the most popular version overall (also in e.g. India, Russia, Australia, Europe and South America), at 27%.[[443]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-446)[[444]](https://en.wikipedia.org/wiki/Android_(operating_system)#cite_note-447) Usage of Android 12 and newer, i.e. supported versions, is at 48% on Android tablets, and with Android 11, until recently supported, at 64%. The usage share varies a lot by country.