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How to Use Android Effectively

This How-To Geek School course aims to teach you how to use Android effectively, showing you the most important settings and methods needed to really become an Android pro and get the most out of your device.

SCHOOL NAVIGATION

Android is the most popular mobile operating system in the world. While Apple's iOS (iPhone and iPad) receives lavish attention and has a devout following, Android continues to rack up impressive numbers. In fact, it holds roughly 88 percent of the global market share.

Part of the reason for this is that Android faces little competition. iOS continues to be its only viable foe, particularly in the United States with where it claims a 43 percent market share. Windows Phone and the ever-fading Blackberry can't come close to stacking up.

All this really means is that a whole lot of people use Android and, time after time, we see people struggling to master it. It's not that Android is hard to use, in fact, it's very easy, but earlier versions are often slow and clunky while newer ones have a lot of features you need to learn to make the most of it. Also, people may simply not know or realize many of the ways you can better manage your device rather than it managing you.

That's what we're here to help with.

Understanding Android Versions

Android has seen *many* versions since version 1.0 was released in 2008. Since 2009 they have been named after desserts or sweets alongside their corresponding version numbers. For example, the first public version of Android was named "Cupcake." Since then we've seen Donut, Eclair, Froyo, Gingerbread, Honeycomb, Ice Cream Sandwich, Jelly Bean, KitKat, Lollipop, Marshmallow, and Nougat.

Unlike the iPhone, however, not all recent phones will necessarily get the latest and greatest version. Depending on your phone, its manufacturer, and the carrier you're on, you could buy a phone that gets stuck on one version while everyone else moves on. That means there are a lot of different versions of Android out there still floating out in the wild.

Given how many versions are out there, it's difficult to write instructions for everyone, but we believe in always having the latest version of any operating system installed. Not simply to take advantage of the latest features, but also because the most recent versions represent a long effort by Google to hone its operating system so that it works on much older hardware than previous Android versions.

If you cannot upgrade to the most recent versions of Android, then it probably means you're stuck with the version you have until you can buy a new phone or tablet. Don't worry, most of the information we cover here can still be applied in some way and, if it cannot, you still have this series as a resource when you do finally upgrade!

What's the Difference between "Pure" Android and Other Distributions?

Handset makers go through a vast array of tricks to make Android more user friendly. But what you often end up with is a convoluted mess of eye candy and unneeded apps that add more bloat than they're worth. Unless you buy a Google Nexus or Pixel phone, your phone will probably have a custom "skin" for Android made by its manufacturer, like Samsung's "TouchWiz" interface and LG's "LG UX". While they each have their own dedicated fans, this problem splinters the Android community even more, and gives everybody a different interface to learn.

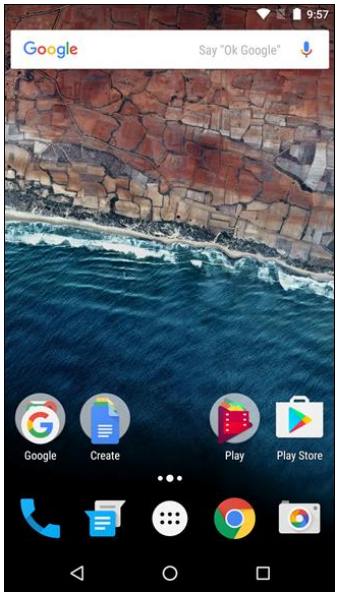
But some phones–particularly Google's Nexus and Pixel line–contain Google's original version of Android, without the extra tweaks. This has attracted its own hardcore following of users who swear by stock, or "pure" Android.

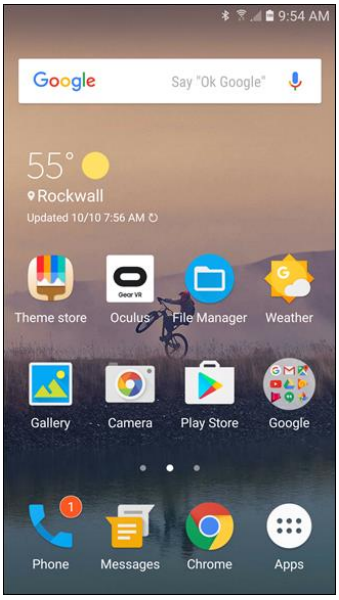
The result of this is an Android distribution as Google intended. For the purposes of this series, we will refer to stock Android and, where necessary, Samsung Touchwiz or LG UX. We include Samsung simply because it is used by 29 percent of US Android users, and worldwide, the company accounted for 23 percent of all smartphone shipments in 2013.

Getting a Lay of the Land

Android is super easy to use. It employs a few consistent UI features and elements that can be found across nearly all Android devices. We'll go on a little tour of these before diving a bit further into many of the settings you will encounter throughout this series.

The Home Screen





Unlock your device and you're greeted by the home screen. Think of this as a desktop of sorts, but unlike a traditional PC, you can have as many home screens as you want, which you simply swipe left or right to access. You can place a whole variety of app shortcuts (which we'll cover in Lesson 2), app groups, and widgets on your home screen(s).

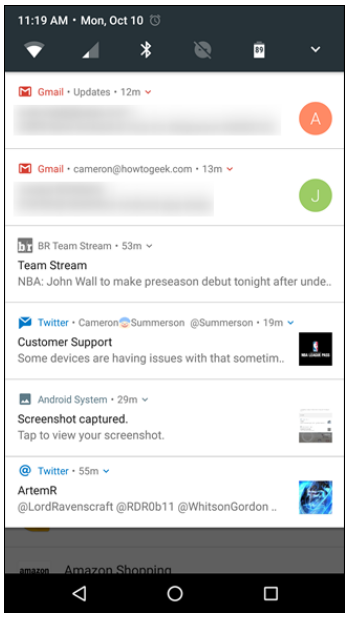
Below is a screenshot of stock Android's home screen on the left, and Samsung Touchwiz on the right.

Note that your home screen will vary according to how your handset manufacturer lays it out or however you customize it.

The Status Bar

At the very top, ever-present, is the status bar. it rarely leaves the display, except in some full-screen applications (like video players or games). The status bar displays important information including the time, how much signal you have (both Wi-Fi and cellular), your battery, and notifications such as texts and e-mails. It will largely look the same across various manufacturer skins, save for some stylistic choices.

Notifications

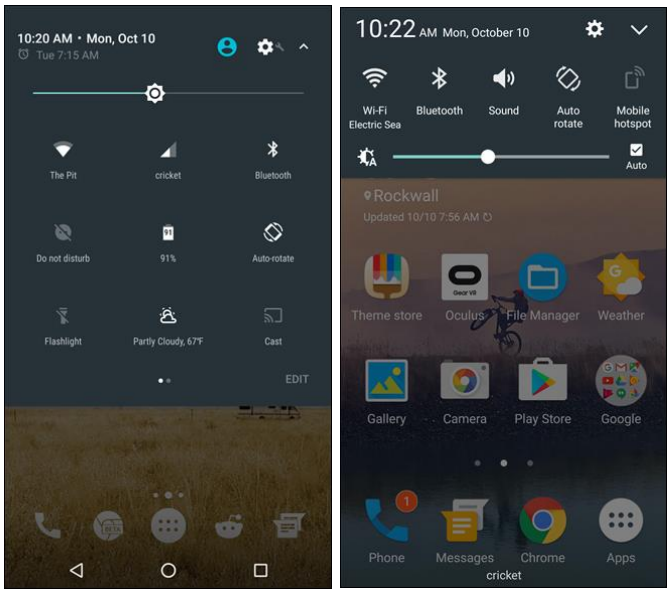


Notifications have always been one of Android's strong points. With notifications, the system and apps can notify you when something needs attention, such as an e-mail, text message, or something app-specific such as a Facebook alert. When you get a notification, you'll see an icon on the left of the status bar at the top of your phone. Pull down on the status bar to see all your notifications, which you can then attend to or clear out.

You can tap a notification to open that email, text message, or whatever it is. If you want to clear it, simply swipe it away, or tap the clear notifications icon at the very top to take care of all of them at once.

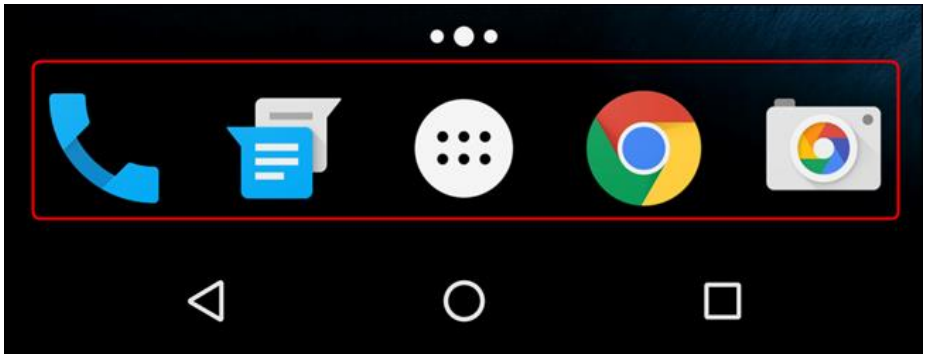
The Quick Settings Panel

In modern versions of Android, you'll find a "Quick Settings" panel nestled within the notification area. On stock Android devices, you pull the shade down twice to expose the Quick Settings, while other devices–like Samsung and LG–condense it into an always-visible part of the shade. Below we have at look at Stock Android on the left, and Samsung's Touchwiz on the right.



The Dock

The Dock–sometimes referred to as the "Favorites Tray"–allows you to pin certain apps such as your contacts and phone dialer, so they show up no matter what home screen you've swiped to. Further, you can stack apps into folders, or if the whim strikes you, remove them altogether.



We'll cover how to create app folders in the next lesson.

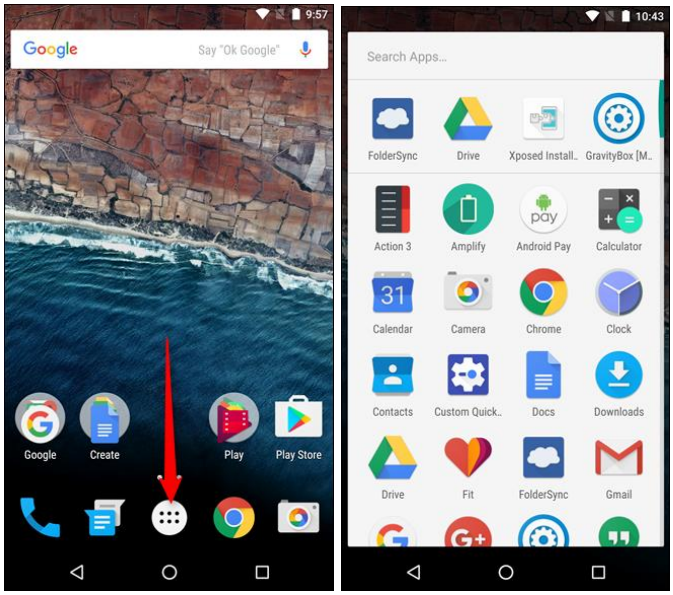
The Navigation Bar

At the bottom of your device is the "Navigation bar," which–like the status bar–is always visible, except in full screen apps or games . The navigation bar almost always displays three symbols (left to right): back, home, and recent apps. Some manufacturers allow you to customize this layout or switch it altogether.

Regardless, you should always see these three navigation elements wherever you are on your device. It's worth noting that Samsung is one of the last manufacturers that still uses physical capacitive buttons, not on-screen navigation like most Android devices.

The App Drawer

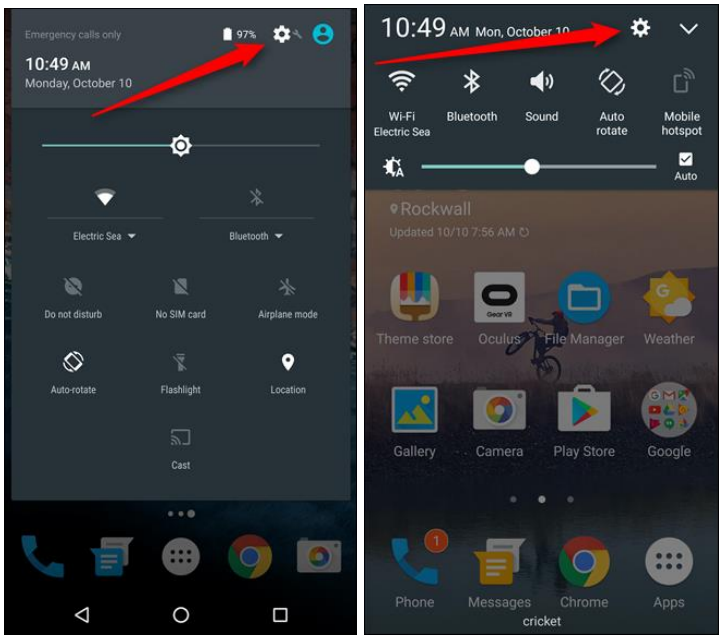
Finally, there's the app drawer. This is where all your apps shortcuts hang out, and is accessed by tapping the circular button with six dots in it. It's *generally* found in the center of the dock, but some manufacturers move it to the far right side in their respective launchers.



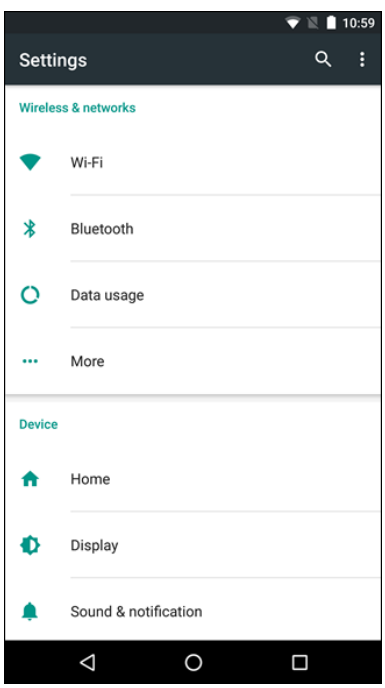
From here you can open apps, uninstall them, or tap and hold to place shortcuts on the home screen.

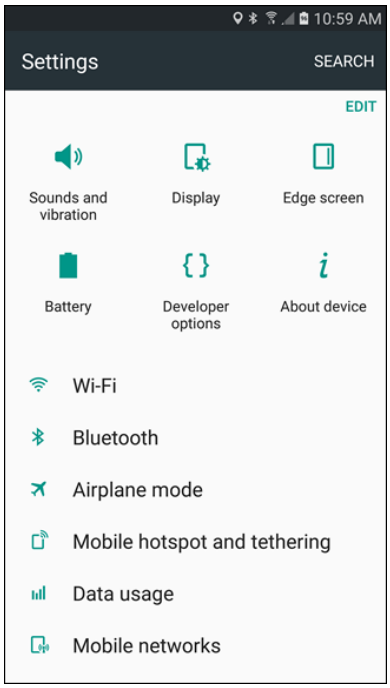
Android's Settings

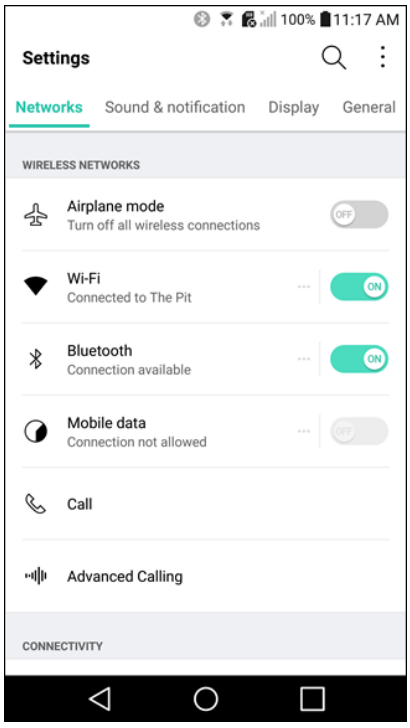
Get to know the settings menu, because this is how you will achieve maximum control over your device. There are two ways to access Android's settings: you can either open the app tray and tap the "Settings" shortcut (not to be confused with the "Google Settings" shortcut, which is different), or you can pull down the "Quick Settings" panel and choose the cog icon in the upper right corner.



While the Quick Settings menu allows you to toggle oft-used settings like Wi-Fi and Bluetooth, you'll find much more granular controls in the main Settings menu. This is the heart and soul of doing more with your Android device.



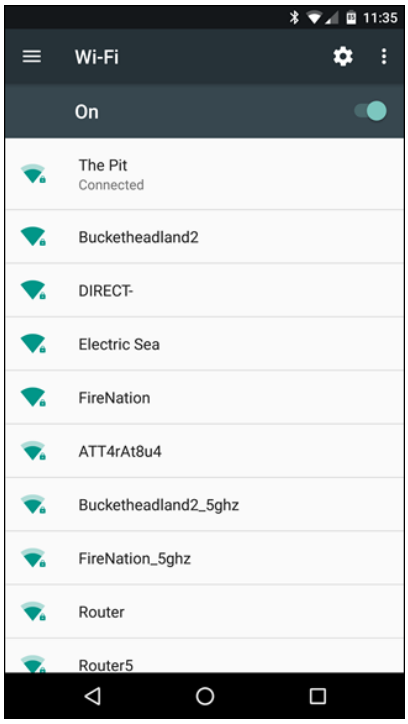




The Settings menu is broken down into several easy-to-follow sections on most devices, with Samsung's most recent offerings being the exception to the rule–where stock Android (and many others) use subsections to break down this menu, Samsung tosses everything into one long list. It's also worth mentioning that some manufacturers–LG comes to mind–will break the Settings menu down into tabs. In all honesty, it makes no sense to do this way–good thing there's a way to fix that.

Let's take a stroll through each of the main options in Android's Settings menu and talk about what you can do.

Wi-Fi



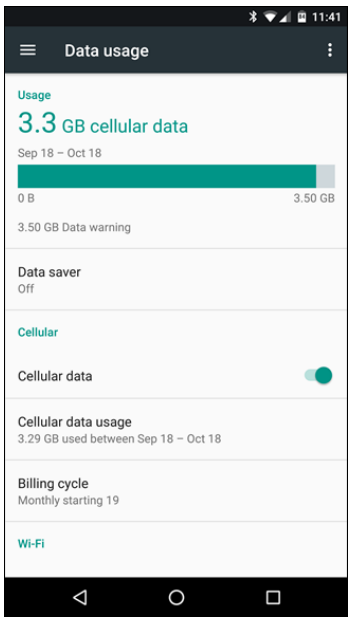
The Wi-Fi menu is where you'll connect to and disconnect from Wi-Fi networks. You can also turn your Wi-Fi off entirely to save battery.

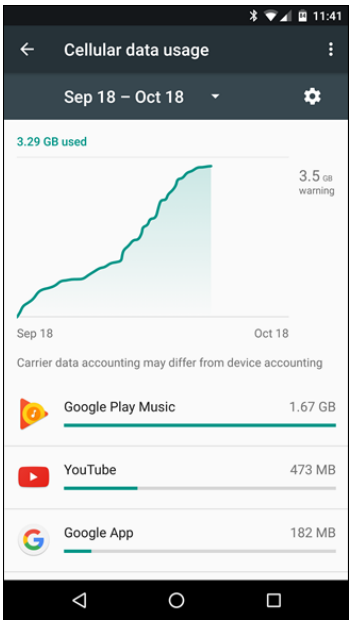
We'll talk more about this in Lessons 3.

Data Usage

If you're on a tight data plan and want to know how much data you're using, or if you want to see how much data certain apps use, then you'll definitely want to learn this setting and use it. Similarly, you may not want to use your phone's mobile data when you have perfectly good Wi-Fi at home.

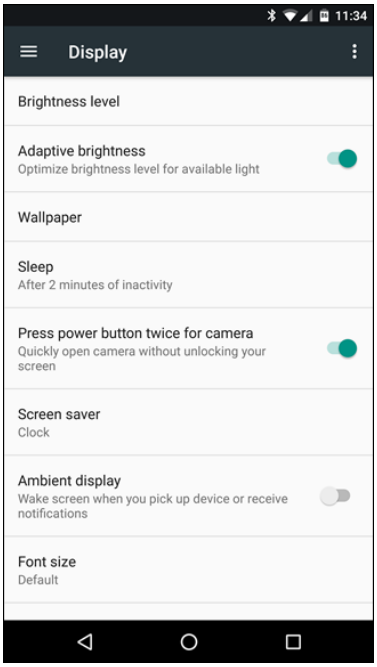
Note, you can turn off mobile data, which will help save your battery, but this may have undesirable side effects, such as the inability to send and receive calls or text messages. So we recommend keeping "Cellular Data" turned on.





More on this in Lesson 3.

Display

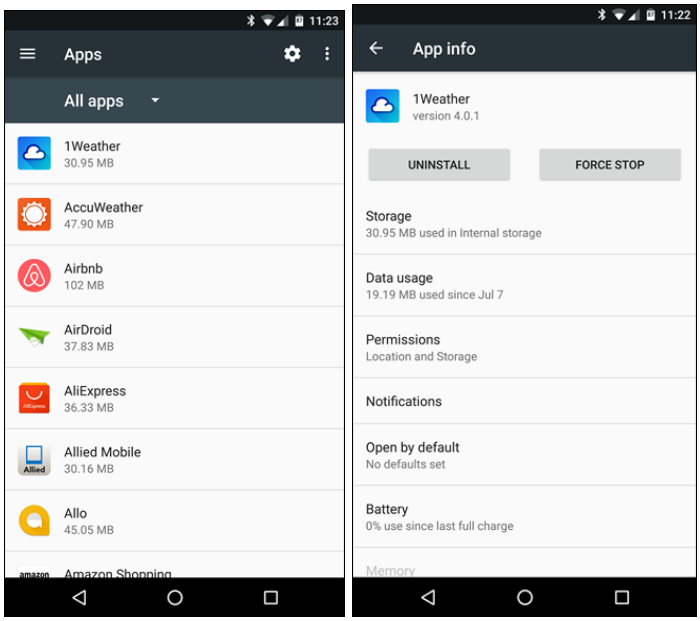


Using the display accounts for the majority of battery use. Simply put, if you never used your phone except when necessary, your battery would probably last for days (plural). But you don't use your phone that way, so you can dial down the brightness and decrease the timeout period to eke a bit more time out of your battery. All this happens in the Display section of the settings.

We go into display settings more in Lesson 3.

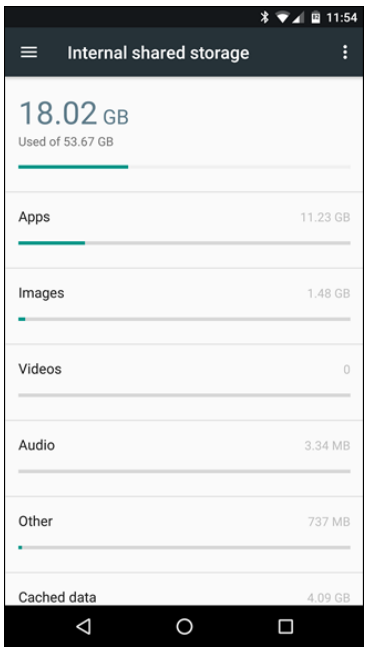
Managing Your Apps

In the Settings menu, under the "Apps" section (or "Applications > Application Manager" on Samsung devices), you can find a list of everything that's installed on your handset. Tapping on an application name will provide a list of useful information: how much storage it uses, how much data it has used since a certain date, any permissions it has been given, notification access, default settings, and how much battery it has used. On Nougat–the most recent version of Android–you can also see how much RAM is being used buy the app, as well as where it was installed from (the Google Play Store or if it was "sideloaded").



If you want to uninstall an app, you can also do that here by tapping the big “Uninstall” button. You can also Force Stop an application if it’s misbehaving, though you shouldn’t have to do this very often.

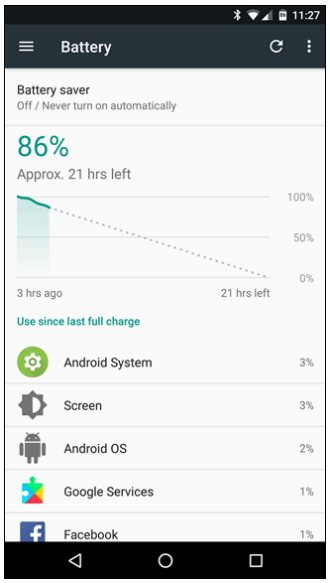
Storage



Your phone has a certain amount of storage for apps, games, photos, videos, music, and other files. If you’re running out of space, the storage settings are an excellent place to determine what is taking up that space, and how much you can reclaim by removing applications and deleting stuff you don’t need. You’d be surprised how much space you get back this way.

We’ll talk a great deal more about this in Lesson 5.

Battery

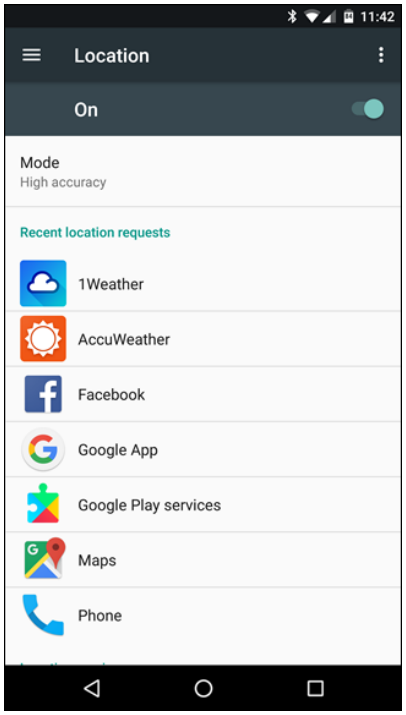


Battery life, or lack thereof, is a huge impasse to our cord-cutting desires. After all, what fun is a mobile device if you have to be near an outlet "just in case?" What's the point of thinness and ultra-portability if you have to cart around a clunky charger and cable with you everywhere?

The battery settings give you an overview of how much battery you've used, how much longer it'll last, and which apps are draining the most battery. You can also adjust Andriod's "Battery Saver" setting here.

We will talk a great deal about this in Lesson 3.

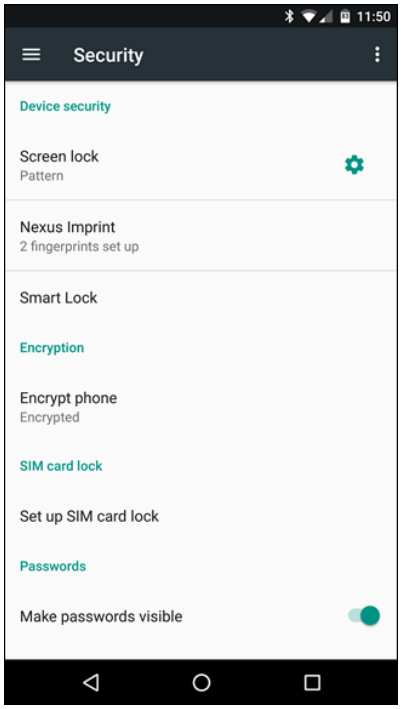
Location

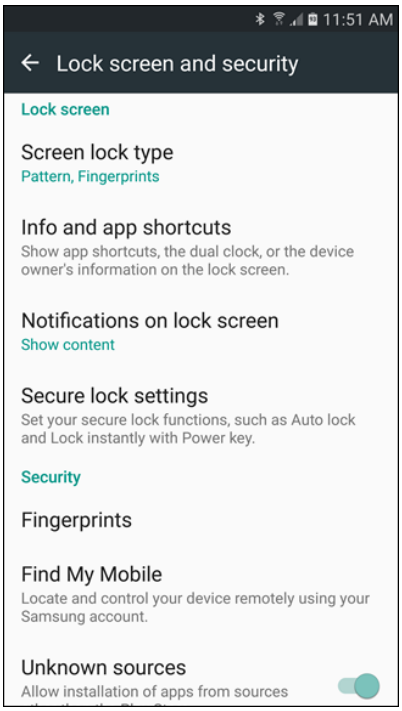


Many of your apps, such as "Camera" and "Facebook," use your location for certain features. This can lead to high battery use, and some people prefer to not give their location away to apps they don't trust. You can adjust your location settings from this section. Generally, we recommend leaving the main setting on and set to "High Accuracy", but you can tap any app on this page to revoke its access to your location.

We'll explain more about this in Lesson 3.

Security

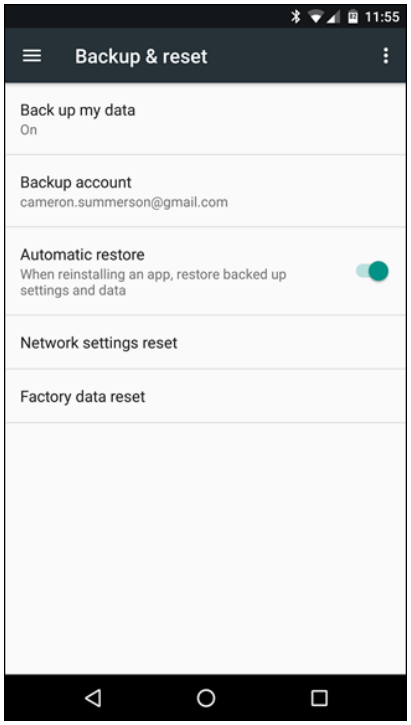




There are a great many ways to protect your device and data on Android, and this subsection of where you'll find the majority of those options. You'll find the security section on "Lock screen and security" on Samsung devices.

We'll go into much greater detail about securing your device in Lesson 4 of this series.

Backup and Reset



Backing up your stuff is pretty important on any computer you use, but it's even more important on your phone. Aside from the everyday disasters that can befall it, it's also really easy to lose–in the back of taxi cabs, in toilets, or even to common thieves. Using your device's backup abilities effectively can save you a lot of awful heartache.

We'll talk a great deal more on this in Lesson 5.

What Else This Series Offers

This series is comprised of five lessons that covers what we believe are keys areas to managing and mastering your Android devices.

Lesson 2: Application Management

Trying out new stuff is fun and it's all too easy to download apps until your phone is crammed with shortcuts and widgets. If you have a bunch of apps on your device you should understand all the ins and outs of shortcuts, Google Play, and the app settings.

Lesson 3: Extending your Battery's Life

You should definitely understand how mobile device batteries work, and the best conditions under which to operate them. Moreover, there's a ton of stuff you can also do in the settings, which can help you get more use out of your battery during the course of a day. We cover all those things including managing your battery's settings and the best ways to help it survive an average day's use.

Lesson 4: Keeping Your Device Secure

Speed things up and lock things down! Truth told, there's a bevy of devices on the market that perform very well even when burdened by whatever you can throw at it but there's also a great many that don't. So we'll discuss possible ways you can improve that.

Also, you should definitely take device security seriously whether it's a pattern lock, password, PIN, encryption, fingerprints, or any of the other ways you can protect your data and self from prying eyes. No worries, we'll take you through all that in this lesson.

Lesson 5: Data Management

Finally, we'll talk about managing your data both in terms of how much space it occupies, and whether it is routinely backed up. After all, you spend a great deal of time on your phone and tablet, shouldn't you understand what your devices are storing, and how much storage that data is taking?

Furthermore, if you're going to keep your most important stuff on on a device the size of deck of cards, shouldn't you at least make sure you can't lose everything in one moment of forgetfulness? We think so and that's why we cover a variety of methods you can always make sure that even if you drop your phone down a sewer grate, everything that's on it can be saved.

That's all for today. We encourage you to familiarize yourself with your device's settings before we get to good stuff tomorrow when we'll talk all about managing your applications and getting to know the Google Play Store's settings.

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Android (operating system)

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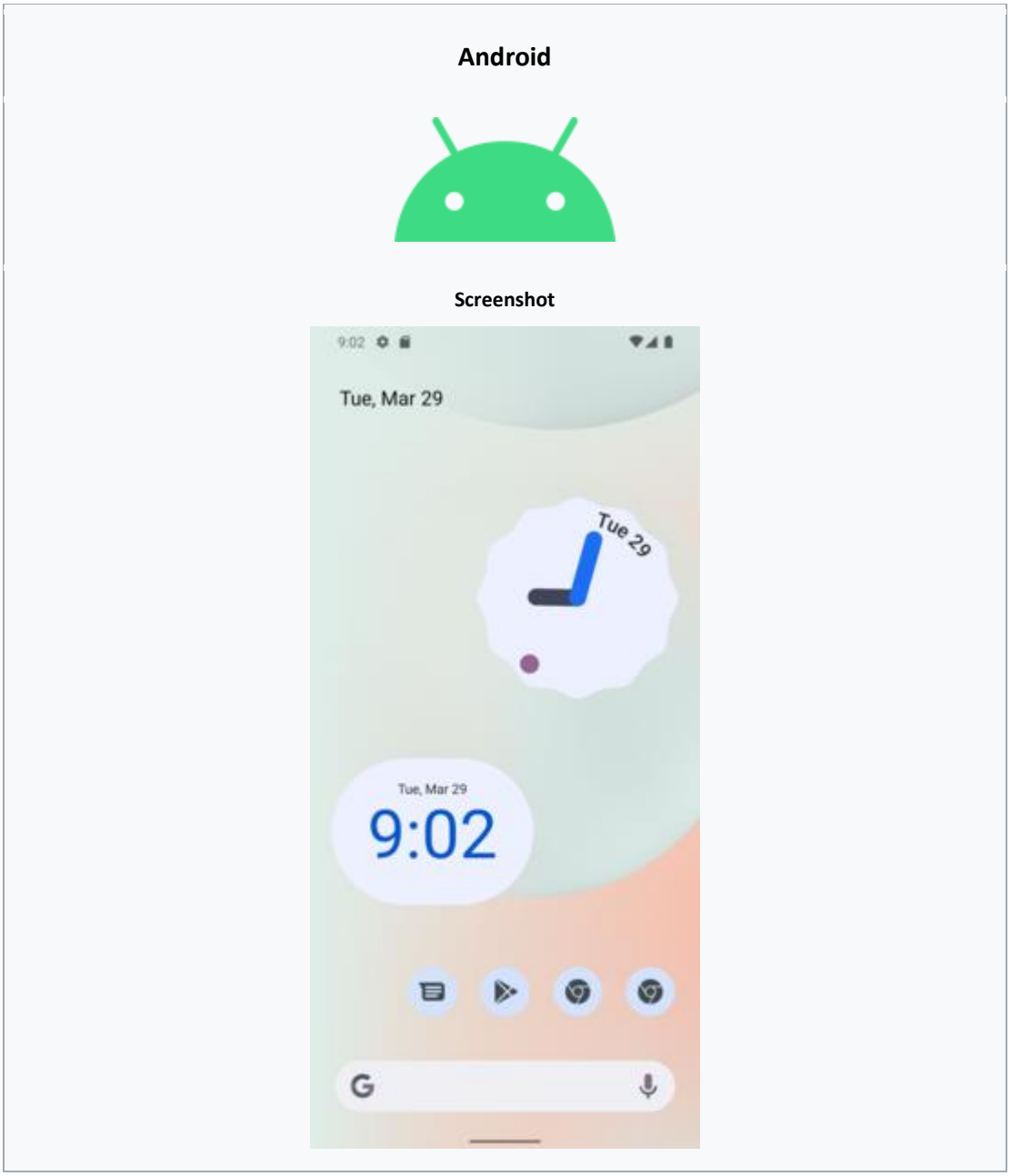

Developer	Various (mostly Google)
Written in	Java (UI), C (core), C++ and others
OS family	Unix-like (modified Linux kernel)
Working state	Current
Source model	Open source (most devices includes proprietary versions of the OS with proprietary components, such as Google Play)
Initial release	September 23, 2008; 13 years ago
Latest release	Android 12 / October 4, 2021; 9 months ago
Latest preview	Android 13: Beta 2 / May 11, 2022; 2 months ago[1]
Repository	android.googlesource.com
Marketing target	Smartphones, tablet computers, smart TVs (Android TV), Android Auto and smartwatches (Wear OS)
Available in	100+ languages
Update method	Over-the-air
Package manager	APK-based
Platforms	64-bit ARM, x86-64, unofficial RISC-V support; 32-bit (for e.g. ARM) was supported[2][3]
Kernel type	Monolithic (Linux kernel)
Userland	Bionic libc, mksh shell, Toybox as core utilities
Default user interface	Graphical (multi-touch)
License	Apache License 2.0 for userspace software GNU GPL v2 for the Linux kernel modifications

Official website	www.android.com
Support status	
Supported	
Articles in the series	
Android version history	

Android is a mobile operating system based on a modified version of the Linux kernel and other open source software, designed primarily for touchscreen mobile devices such as smartphones and tablets. Android is developed by a consortium of developers known as the Open Handset Alliance and commercially sponsored by Google. It was unveiled in November 2007, with the first commercial Android device, the HTC Dream, being launched in September 2008.

Most versions of Android are proprietary. The core components are taken from the Android Open Source Project (AOSP), which is free and open-source software (FOSS) primarily licensed under the Apache License. When Android is installed on devices, ability to modify the otherwise FOSS software is usually restricted, either by not providing the corresponding source code or preventing reinstallation through technical measures, rendering the installed version proprietary. Most Android devices ship with additional proprietary software pre-installed,[4] most notably Google Mobile Services (GMS)[5] which includes core apps such as Google Chrome, the digital distribution platform Google Play, and associated Google Play Services development platform.

Over 70 percent of Android smartphones run Google's ecosystem; some with vendor-customized user interface and software suite, such as *TouchWiz* and later *One UI* by Samsung, and *HTC Sense*.[6] Competing Android ecosystems and forks include Fire OS (developed by Amazon), ColorOS by OPPO, OriginOS by vivo and MagicUI by Honor or custom ROM such as LineageOS. However, the "Android" name and logo are trademarks of Google which imposes standards to restrict the use of Android branding by "uncertified" devices outside their ecosystem.[7][8]

The source code has been used to develop variants of Android on a range of other electronics, such as game consoles, digital cameras, portable media players, PCs, each with a specialized user interface. Some well known derivatives include Android TV for televisions and Wear OS for wearables, both developed by Google. Software packages on Android, which use the APK format, are generally distributed through proprietary application stores like Google Play Store, Amazon Appstore (including for Windows 11), Samsung Galaxy Store, Huawei AppGallery, Cafe Bazaar, and GetJar, or open source platforms like Aptoide or F-Droid.

Android has been the best-selling OS worldwide on smartphones since 2011 and on tablets since 2013. As of May 2021, it has over three billion monthly active users, the largest installed base of any operating system,[9] and as of January 2021, the Google

Play Store features over 3 million apps.[10] Android 12, released on October 4, 2021, is the latest version.[11]

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History

See also: Android version history

First Android logotype (2007–2014)

Second Android logotype (2014–2015)

Third Android logotype (2015–2019)

Fourth Android logotype (2019–present)

Android Inc. was founded in Palo Alto, California, in October 2003 by Andy Rubin, Rich Miner, Nick Sears, and Chris White.[12][13] Rubin described the Android project as having "tremendous potential in developing smarter mobile devices that are more aware of its owner's location and preferences".[13] The early intentions of the company were to develop an advanced operating system for digital cameras, and this was the basis of its pitch to investors in April 2004.[14] The company then decided that the market for cameras was not large enough for its goals, and five months later it had diverted its efforts and was pitching Android as a handset operating system that would rival Symbian and Microsoft Windows Mobile.[14][15]

Rubin had difficulty attracting investors early on, and Android was facing eviction from its office space. Steve Perlman, 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."[16][17]

In 2005, Rubin tried to negotiate deals with Samsung[18] and HTC.[19] Shortly afterwards, Google acquired the company in July of that year for at least $50 million;[13][20] this was Google's "best deal ever" according to Google's then-vice president of corporate development, David Lawee, in 2010.[18] Android's key employees, including Rubin, Miner, Sears, and White, joined Google as part of the acquisition.[13] 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.[13] At Google, the team led by Rubin developed a mobile device platform powered by the Linux kernel. Google marketed the platform to handset makers and carriers on the promise of providing a flexible, upgradeable

system.[21] 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*][22]

Speculation about Google's intention to enter the mobile communications market continued to build through December 2006.[23] An early prototype had a close resemblance to a BlackBerry phone, with no touchscreen and a physical QWERTY keyboard, but the arrival of 2007's Apple iPhone meant that Android "had to go back to the drawing board".[24][25] 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".[26] By 2008, both Nokia and BlackBerry announced touch-based smartphones to rival the iPhone 3G, and Android's focus eventually switched to just touchscreens. The first commercially available smartphone running Android was the HTC Dream, also known as T-Mobile G1, announced on September 23, 2008.[27][28]

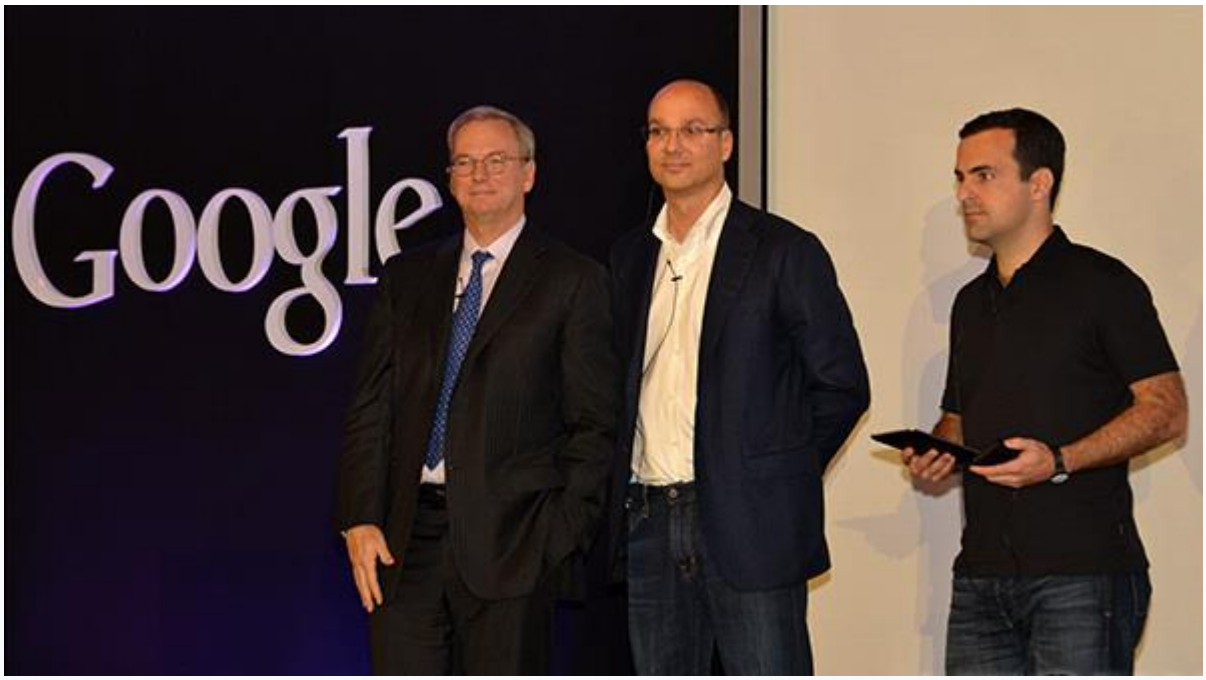
HTC Dream or T-Mobile G1, the first commercially released device running Android (2008)

On November 5, 2007, the Open Handset Alliance, a consortium of technology companies including Google, device manufacturers such as HTC, Motorola and Samsung, wireless carriers such as Sprint and T-Mobile, and chipset makers such as Qualcomm and Texas Instruments, unveiled itself, with a goal to develop "the first truly open and comprehensive platform for mobile devices".[29][30][31] Within a year, the Open Handset Alliance faced two other open source competitors, the Symbian Foundation and the LiMo Foundation, the latter also developing a Linux-based mobile operating system like Google. In September 2007, *InformationWeek* covered an Evalueserve study reporting that Google had filed several patent applications in the area of mobile telephony.[32][33]

Since 2008, Android has seen numerous updates which have incrementally improved the operating system, adding new features and fixing bugs in previous releases. Each major release is named in alphabetical order after a dessert or sugary treat, with the first few Android versions being called "Cupcake", "Donut", "Eclair", and "Froyo", in that order. During its announcement of 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 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".[34]

In 2010, Google launched its 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" software with "timely ... updates".[35] At its developer conference in May 2013, Google announced a special version of the 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.[36] The device would become the start of the Google Play edition program, and was followed by other devices, including the HTC One Google Play edition,[37] and Moto G Google Play edition.[38] In 2015, *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".[39][40]



Eric Schmidt, Andy Rubin and Hugo Barra at a 2012 press conference announcing Google's Nexus 7 tablet

From 2008 to 2013, Hugo Barra served as product spokesperson, representing Android at press conferences and Google I/O, Google's annual developer-focused conference. He left Google in August 2013 to join Chinese phone maker Xiaomi.[41][42] Less than six months earlier, Google's then-CEO 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 would become the new Android lead.[43][44] Pichai himself would eventually switch positions, becoming the new CEO of Google in August 2015 following the company's restructure into the Alphabet conglomerate,[45][46] making Hiroshi Lockheimer the new head of Android.[47][48]

On Android 4.4 *Kit Kat*, shared writing access to 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 *Lollipop* through the backwards-incompatible *Google Storage Access Framework* interface.[49]

In June 2014, Google announced 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.[50][51][52] In September, Google

announced the first set of Android One phones for release in India.[53][54] However, *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".[55] Plans to relaunch Android One surfaced in August 2015,[56] with Africa announced as the next location for the program a week later.[57][58] 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.[59][60] Google introduced the Pixel and Pixel XL smartphones in October 2016, marketed as being the first phones made by Google,[61][62] and exclusively featured certain software features, such as the Google Assistant, before wider rollout.[63][64] The Pixel phones replaced the Nexus series,[65] with a new generation of Pixel phones launched in October 2017.[66]

In May 2019, the operating system became entangled in the trade war between China and the United States involving Huawei, which, like many other tech firms, had become dependent on access to the Android platform.[67][68] In the summer of 2019, Huawei announced it would create an alternative operating system to Android[69] known as Harmony OS,[70] and has filed for intellectual property rights across major global markets.[71][72] 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 devices, rather than for smartphones and tablets.[73]

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).[74][75] 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.[76] Android 10 was released on September 3, 2019, to Google Pixel phones first.

Features

Main article: List of features in Android

Interface

Android's default user interface is mainly based on direct manipulation, 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.[77] Game controllers and full-size physical keyboards are supported via Bluetooth or USB.[78][79] 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 to the user. Internal hardware, such as accelerometers, gyroscopes and proximity sensors 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,[80] or allowing the user to steer a vehicle in a racing game by rotating the device, simulating control of a steering wheel.[81]

Home screen

Android devices boot to the home screen, the primary navigation and information "hub" on Android devices, analogous to the desktop found on personal computers. Android home screens are typically made up of app icons and widgets; app icons launch the associated app, whereas widgets display live, auto-updating content, such as a weather forecast, the user's email inbox, or a news ticker directly on the home screen.[82] A home screen may be made up of several pages, between which the user can swipe back and forth.[83] Third-party apps available on Google Play and other app stores can extensively re-theme the home screen,[84] and even mimic the look of other operating systems, such as Windows Phone.[85] Most manufacturers customize the look and features of their Android devices to differentiate themselves from their competitors.[86]

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, Bluetooth, cellular data), audio mode, and flashlight.[83] Vendors may implement extended settings such as the ability to adjust the flashlight brightness.[87]

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.[88] Beginning with Android 4.1 "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.[89]

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.[83]

The recent list may appear side-by-side or overlapping, depending on the Android version and manufacturer.[90]

Navigation buttons

Front buttons (home, menu/options, go back, search) and optical track pad of an 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 and individual apps' internal search feature.

More recent devices typically allow the former through a long press or swipe away from the home button.[91]

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.[91] 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 view, the latter of which is the default behaviour since stock Android version 7.[92][93][94]

Split-screen view

Native support for split screen view has been added in stock Android version 7.0 *Nougat*.[94]

The earliest vendor-customized Android-based smartphones known to have featured a split-screen view mode are the 2012 Samsung Galaxy S3 and Note 2, the former of which received this feature with the *premium suite* upgrade delivered in TouchWiz with Android 4.1 Jelly Bean.[95]

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.[96]

Audio-coupled haptic effect

Since stock Android version 12, released early 2021, synchronous vibration can be set to complement audio.[97][98] Such feature initially existed under the name "Auto Haptic" on the Android-based 2012 Samsung Galaxy S III, released with a vendor-modified (TouchWiz) installation of Android 4.1 Jelly Bean.[99]

Applications

Many, to almost all, Android devices come with preinstalled Google apps including Gmail, Google Maps, Google Chrome, YouTube, Google Play Music, Google Play Movies & TV, and many more.

See also: Android software development and Google Play

Applications ("apps"), which extend the functionality of devices (and must be 64-bit[100]), are written using the Android software development kit (SDK)[101] and, often, Kotlin programming language, which replaced Java as Google's preferred language for Android app development in May 2019,[102] and was originally announced in May 2017.[103][104] Java is still supported (originally the only option for user-space programs, and is often mixed with Kotlin), as is C++.[105] Java or other JVM languages, such as Kotlin, may be combined with C/C++,[106] together with a choice of non-default runtimes that allow better C++ support.[107] The Go programming language is also supported, although with a limited set of application programming interfaces (API).[108]

The SDK includes a comprehensive set of development tools,[109] including a debugger, software libraries, a handset emulator based on QEMU, documentation, sample code, and tutorials. Initially, Google's supported integrated development environment (IDE) was Eclipse using the Android Development Tools (ADT) plugin; in December 2014, Google released Android Studio, based on IntelliJ IDEA, as its primary IDE for Android application development. Other development tools are available, including a native development kit (NDK) for applications or extensions in C or C++, Google App Inventor, a visual environment for novice programmers, and various cross platform mobile web applications frameworks. In January 2014, Google unveiled a framework based on Apache Cordova for porting Chrome HTML 5 web applications to Android, wrapped in a native application shell.[110] Additionally, Firebase was acquired by Google in 2014 that provides helpful tools for app and web developers.[111]

Android has a growing selection of third-party applications, which can be acquired by users by downloading and installing the application's APK (Android application package) file, or by downloading them using an application store program that allows users to install, update, and remove applications from their devices. 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.[112][113] 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.[10][114] As of July 2013, 50 billion application installations had been performed.[115][116] 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.[117] 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, GetJar, and SlideMe. F-Droid, another alternative marketplace, seeks to only provide applications that are distributed under free and open source licenses.[112][118][119][120]

In October 2020, Google removed several Android applications from 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.[121]

At the Windows 11 announcement event in June 2021, Microsoft showcased the new Windows Subsystem for Android (WSA) that will enable support for the Android Open Source Project (AOSP) and will allow users to run Android apps on their Windows desktop.[122]

Storage

The storage of Android devices can be expanded using secondary devices such as SD cards. 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 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.[123]

Android 4.4 introduced the Storage Access Framework (SAF), a set of APIs for accessing files on the device's filesystem.[124] 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.[125][126][127]

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 so that, while available for immediate use rather than closed, it does not use battery power or CPU resources.[128][129] 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.[130][131] Lifehacker reported in 2011 that third-party task-killer applications were doing more harm than good.[132]

Developer options

Some settings for use by developers for debugging and power users 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, 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.[133][134][135]

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.[136][137][138]

Hardware

See also: Android hardware requirements

The main hardware platform for Android is ARM (the ARMv7 and ARMv8-A architectures), with x86 and x86-64 architectures also officially supported in later versions of Android.[139][140][141] The unofficial Android-x86 project provided support for x86 architectures ahead of the official support.[142][143] Since 2012, Android devices with Intel processors began to appear, including phones[144] and tablets. While gaining

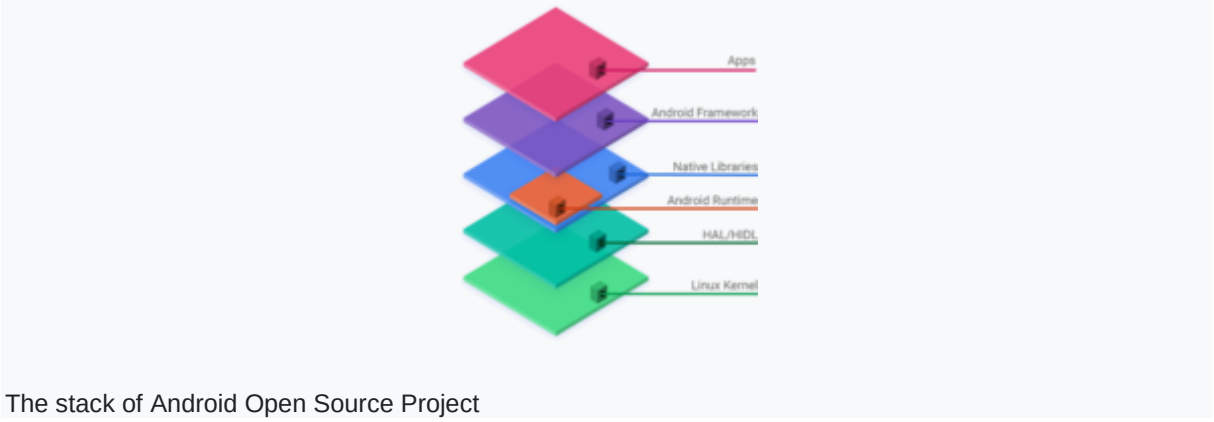
support for 64-bit platforms, Android was first made to run on 64-bit x86 and then on ARM64. Since Android 5.0 "Lollipop", 64-bit variants of all platforms are supported in addition to the 32-bit variants.[139] An unofficial experimental port of the operating system to the RISC-V architecture was released in 2021.[145]

Requirements for the minimum amount of RAM 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 (and version 1.1 available for some devices[146]).

Android devices incorporate many optional hardware components, including still or video cameras, GPS, orientation sensors, dedicated gaming controls, accelerometers, gyroscopes, barometers, magnetometers, proximity sensors, pressure sensors, thermometers, and touchscreens. Some hardware components are not required, but became standard in certain classes of devices, such as smartphones, and additional requirements apply if they are present. Some other hardware was initially required, but those requirements have been relaxed or eliminated altogether. For example, as Android was developed initially as a phone OS, hardware such as microphones were required, while over time the phone function became optional.[116] Android used to require an autofocus camera, which was relaxed to a fixed-focus camera[116] if present at all, since the camera was dropped as a requirement entirely when Android started to be used on set-top boxes.

In addition to running on smartphones and tablets, several vendors run Android natively on regular PC hardware with a keyboard and mouse.[147][148][149][150] 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.[151] Using the Android emulator that is part of the Android SDK, or third-party emulators, Android can also run non-natively on x86 architectures.[152][153] Chinese companies are building a PC and mobile operating system, based on Android, to "compete directly with Microsoft Windows and Google Android".[154] 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.[155][156][157]

Development



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 is made available to the Android Open Source Project (AOSP),[158] an open source initiative led by Google.[159] The AOSP

code can be found with minimal modifications on select devices, mainly the former Nexus and current Android One series of devices.[160]

The source code is, in turn, customized by original equipment manufacturers (OEMs) to run on their hardware.[161][162] Android's source code does not contain the device drivers, often proprietary, that are needed for certain hardware components.[163] As a result, most Android devices, including Google's own, ship with a combination of free and open source and proprietary software, with the software required for accessing Google services falling into the latter category.[*citation needed*]

Update schedule

See also: Android version history

Google provides annual[164] Android releases, both for factory installation in new devices, and for over-the-air updates to existing devices.[165] The latest major release is Android 12.

The extensive variation of hardware[166] in Android devices has caused significant delays for software upgrades and security patches. Each upgrade has had to be specifically tailored, a time- and resource-consuming process.[167] 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.[168] Manufacturers often prioritize their newest devices and leave old ones behind.[169] 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.[169][170] There are also situations in which upgrades are impossible due to a manufacturer not updating necessary drivers.[171]

The lack of after-sale support from manufacturers and carriers has been widely criticized by consumer groups and the technology media.[172][173][174] 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,[175] an attitude described as "insulting".[174] *The Guardian* complained that the method of distribution for updates is complicated only because manufacturers and carriers have designed it that way.[174] 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.[169][176]

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 store independently of the OS. One of those components, Google Play Services, is a closed-source system-level process providing APIs for Google services, installed automatically on nearly all devices running Android 2.2 "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.[177] As a result, Android 4.2 and 4.3 "Jelly Bean" contained relatively fewer user-facing changes, focusing more on minor changes and platform improvements.[178]

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 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 and 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?*] 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'".[179][180][181]

In May 2017, with the announcement of Android 8.0, 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."[182]

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.[183]

In May 2019, with the announcement of 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.[184]

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.[185]

Linux kernel

Android's kernel is based on the Linux kernel's long-term support (LTS) branches. As of 2021, Android uses versions 4.14, 4.19 or 5.4 of the Linux kernel.[186] The actual kernel depends on the individual device.[187]

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 (OOM) handling.[188][189] Certain features that Google contributed back to the Linux kernel, notably a power management feature called "wakelocks",[190] were initially rejected by mainline kernel developers partly because they felt that Google did not show any intent to maintain its own code.[191][192] Google announced in April 2010 that they would hire two employees to work with the Linux kernel community,[193] but Greg Kroah-Hartman, the current Linux kernel maintainer for the stable branch, said in December 2010 that he was concerned that Google was no longer trying to get their code changes included in mainstream Linux.[192] Google engineer Patrick Brady once stated in the company's developer conference that "Android is not Linux",[194] with *Computerworld* adding that "Let me make it simple for you, without Linux, there is no Android".[195] *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".[194]

In August 2011, Linus Torvalds said that "eventually Android and Linux would come back to a common kernel, but it will probably not be for four to five years".[196] In December 2011, Greg Kroah-Hartman announced the start of Android Mainlining Project, which aims to put some Android drivers, patches and features back into the Linux kernel, starting in Linux 3.3.[197] 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).[198] Google maintains a public code repository that contains their experimental work to re-base Android off the latest stable Linux versions.[199][200]

Android is a Linux distribution according to the Linux Foundation,[201] Google's open-source chief Chris DiBona,[202] and several journalists.[203][204] Others, such as Google engineer Patrick Brady, say that Android is not Linux in the traditional Unix-like Linux distribution sense; Android does not include the GNU C Library (it uses Bionic as an alternative C library) and some other components typically found in Linux distributions.[205]

With the release of Android Oreo in 2017, Google began to require that devices shipped with new SoCs 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.[206][207]

Rooting

Main article: Rooting (Android)

The flash storage on Android devices is split into several partitions, such as `/system/` for the operating system itself, and `/data/` for user data and application installations.[208]

In contrast to typical desktop Linux distributions, Android device owners are not given root access to the operating system and sensitive partitions such as `/system/` are read-only. However, root access can be obtained by exploiting security flaws in Android, which is used frequently by the open-source community to enhance the capabilities and customizability of their devices, but also by malicious parties to install viruses and malware.[209] Root access can also be obtained by unlocking the bootloader via the `OEM Unlocking` option on certain devices including most Google Pixel and OnePlus models. The unlocking process resets the system to factory state, erasing all user data.[210]

Software stack

Android's architecture diagram[obsolete source]

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

Android uses Android Runtime (ART) as its runtime environment (introduced in version 4.4), which uses ahead-of-time (AOT) compilation to entirely compile the application bytecode into machine code upon the installation of an application. In Android 4.4, ART was an experimental feature and not enabled by default; it became the only runtime option in the next major version of Android, 5.0.[211] In versions no longer supported, until version 5.0 when ART took over, Android previously used Dalvik as a process virtual machine with trace-based just-in-time (JIT) compilation to run Dalvik "dex-code" (Dalvik Executable), which is usually translated from the Java bytecode. Following the trace-based JIT principle, in addition to interpreting the majority of application code, Dalvik performs the compilation and native execution of select frequently executed code segments ("traces") each time an application is launched.[212][213][214] For its Java library, the Android platform uses a subset of the now discontinued Apache Harmony project.[215] In December 2015, Google announced that the next version of Android would switch to a Java implementation based on the OpenJDK project.[216]

Android's standard C library, Bionic, was developed by Google specifically for Android, as a derivation of the BSD's standard C library code. Bionic itself has been designed with several major features specific to the Linux kernel. The main benefits of using Bionic instead of the GNU C Library (glibc) or uClibc are its smaller runtime footprint, and optimization for low-frequency CPUs. At the same time, Bionic is licensed under the terms of the BSD licence, which Google finds more suitable for the Android's overall licensing model.[214]

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

BlueDroid.[217] A new Bluetooth stack, called Gabeldorsche, was developed to try to fix the bugs in the BlueDroid implementation.[218]

Android does not have a native X Window System by default, nor does it support the full set of standard GNU libraries. This made it difficult to port existing Linux applications or libraries to Android,[205] until version r5 of the Android Native Development Kit brought support for applications written completely in C or C++.[219] Libraries written in C may also be used in applications by injection of a small shim and usage of the JNI.[220]

In current versions of Android, "Toybox", a collection of command-line utilities (mostly for use by apps, as Android does not provide a command-line interface by default), is used (since the release of Marshmallow) replacing a similar "Toolbox" collection found in previous Android versions.[221]

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 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."[222]

Open-source community

Android's source code is released by Google under an 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.[223] 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;[224] provide continued support for older devices that no longer receive official updates; or bring Android to devices that were officially released running other operating systems, such as the HP TouchPad. Community releases often come pre-rooted and contain modifications not provided by the original vendor, such as the ability to overclock or over/undervolt the device's processor.[225] CyanogenMod was the most widely used community firmware,[226] now discontinued and succeeded by LineageOS.[227]

There are, as of August 2019, a handful of notable custom Android distributions (ROMs) of the latest Android version 9.0 Pie, which was released publicly in August 2018. See *List of custom Android distributions*.

Historically, device manufacturers and mobile carriers have typically been unsupportive of third-party firmware development. Manufacturers express concern about improper functioning of devices running unofficial software and the support costs resulting from this.[228] Moreover, modified firmware such as CyanogenMod

sometimes offer features, such as tethering, for which carriers would otherwise charge a premium. As a result, technical obstacles including locked bootloaders and restricted access to root permissions are common in many devices. However, as community-developed software has grown more popular, and following a statement by the Librarian of Congress in the United States that permits the "jailbreaking" of mobile devices,[229] manufacturers and carriers have softened their position regarding third party development, with some, including HTC,[228] Motorola,[230] Samsung[231][232] and Sony,[233] providing support and encouraging development. As a result of this, over time the need to circumvent hardware restrictions to install unofficial firmware has lessened as an increasing number of devices are shipped with unlocked or unlockable bootloaders, similar to Nexus series of phones, although usually requiring that users waive their devices' warranties to do so.[228] However, despite manufacturer acceptance, some carriers in the US still require that phones are locked down, frustrating developers and customers.[234]

Device codenames

Internally, Android identifies each supported device by its **device codename**, a short string,[235] 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 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`.[236]

Security and privacy

See also: Mobile security and Comparison of open-source mobile phones

In 2020, Google launched the Android Partner Vulnerability Initiative to improve the security of Android.[237][238] They also formed an Android security team.[239]

Common security threats

Research from security company 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 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.[240] Security threats on Android are reportedly growing exponentially; however, Google engineers have argued that the malware and virus threat on Android is being exaggerated by security companies for commercial reasons,[241][242] and have accused the security industry of playing on fears to sell virus protection software to users.[241] Google maintains that dangerous malware is actually extremely rare,[242] and a survey conducted by F-Secure showed that only 0.5% of Android malware reported had come from the Google Play store.[243]

In 2021, journalists and researchers reported the discovery of spyware, called Pegasus, developed and distributed by a private company which can and has been used to infect both iOS and Android smartphones often – partly via use of 0-day exploits – 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.[244] Analysis of data traffic by popular smartphones running variants of Android found substantial by-default data collection and sharing with no opt-out by this pre-installed software.[245][246] Both of these issues are not addressed or cannot be addressed by security patches.

Scope of surveillance by public institutions
See also: WARRIOR PRIDE

As part of the broader 2013 mass surveillance disclosures it was revealed in September 2013 that the American and British intelligence agencies, the National Security Agency (NSA) and Government Communications Headquarters (GCHQ), respectively, have access to the user data on iPhone, BlackBerry, and Android devices. They are reportedly able to read almost all smartphone information, including SMS, location, emails, and notes.[247] 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*, which collect personal information of their users for advertising and other commercial reasons. GCHQ has, according to *The Guardian*, a wiki-style guide of different apps and advertising networks, and the different data that can be siphoned from each.[248] Later that week, the Finnish Angry Birds developer Rovio 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.[249]

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.[248] 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."[248]

Leaked documents published by WikiLeaks, codenamed Vault 7 and dated from 2013 to 2016, detail the capabilities of the Central Intelligence Agency (CIA) to perform electronic surveillance and cyber warfare, including the ability to compromise the operating systems of most smartphones (including Android).[250][251]

Security patches

In August 2015, Google announced that devices in the Google Nexus series would begin to receive monthly security patches. 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."[252][253][254] The following October, researchers at the University of Cambridge concluded that 87.7% of Android phones in use had known but unpatched security vulnerabilities due to lack of updates and support.[255][256][257] Ron Amadeo of *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".[258] Following news of Google's monthly schedule, some manufacturers, including Samsung and LG, promised to issue monthly security updates,[259] 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".[260]

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.[261] Furthermore, in a comment to *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.[262]

Patches to bugs found in the core operating system often do not reach users of older and lower-priced devices.[263][264] 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 acquisition to rebuild *Jelly Bean* on top of their hardened microvisor for the "Knox" project.[265][266]

Location-tracking

Android smartphones have the ability to report the location of 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, Google Latitude, Facebook Places, and to deliver location-based ads.[267] Third party monitoring software such as TaintDroid,[268] an academic research-funded project, can, in some cases, detect when personal information is being sent from applications to remote servers.[269]

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. 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.[270] *Avast Threat Labs* also discovered that many pre-installed apps on several hundred new Android devices contain dangerous malware and adware. Some of the preinstalled malware can commit ad fraud or even take over its host device.[271][272]

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.[273]

On August 5, 2020, 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) and Android 9 (Android Pie). Twitter confirmed that updating the app will restrict such practices.[274]

Technical security features

Android applications run in a sandbox, 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.[275]

Since February 2012, Google has used its Google Bouncer malware scanner to watch over and scan apps available in the Google Play store.[276][277] A "Verify Apps" feature was introduced in November 2012, as part of the Android 4.2 "Jelly Bean" operating system version, to scan all apps, both from Google Play and from third-party sources, for malicious behaviour.[278] 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.[279][280]

Before installing an application, the Google Play store displays a list of the requirements an app needs to function. After reviewing these permissions, the user can choose to accept or refuse them, installing the application only if they accept.[281] In Android 6.0 "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 app cannot be uninstalled, nor disabled. Any force stop attempt, result in the app restarting itself.[282][283] The new permissions model is used only by applications developed for Marshmallow using its 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.[284][285]

In September 2014, Jason Nova of *Android Authority* reported on a study by the German security company Fraunhofer AISEC in 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, AVG, Bitdefender, ESET, F-Secure, Kaspersky, Lookout, McAfee (formerly Intel Security), Norton, Sophos, and 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".[286]

In August 2013, Google announced Android Device Manager (renamed Find My Device in May 2017),[287][288] a service that allows users to remotely track, locate, and wipe their Android device,[289][290] with an Android app for the service released in December.[291][292] In December 2016, Google introduced a Trusted Contacts app, letting users request location-tracking of loved ones during emergencies.[293][294] In 2020, Trusted Contacts was shut down and the location-sharing feature rolled into Google Maps.[295]

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.[296][297]

Google Play Services and vendor changes

See also: Behavioral targeting and DeGoogle

Dependence on proprietary Google Play Services and customizations added on top of the operating system by vendors who license Android from Google is causing privacy concerns.[298][299][300]

Licensing

The source code for Android is open-source: 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) under the non-copyleft Apache License version 2.0. which allows modification and redistribution.[301][302] 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 GNU General Public License version 2, developed by the Open Handset Alliance, with the source code publicly available at all times.[303] 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 in an official Android blog post, was because *Honeycomb* was rushed for production of the Motorola Xoom,[304] 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.[305]

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, which includes applications such as Google Play Store, Google Search, and Google Play Services – a software layer that provides APIs 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.[113] Custom, certified distributions of Android produced by manufacturers (such as 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.[112] With the advent of the Google Pixel line of devices, Google itself has also made specific Android features timed or permanent exclusives to the Pixel series.[306][307] There may also be "binary blob" drivers required for certain hardware components in the device.[112][163] The best known fully open source Android services are the LineageOS distribution and MicroG which acts as an open source replacement of Google Play Services.

Richard Stallman and the Free Software Foundation have been critical of Android and have recommended the usage of alternatives such as Replicant, 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.[308][309]

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 service.[310]: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.[311] 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.[112] A prominent example of such an Android fork is Amazon's Fire OS, which is used on the Kindle Fire line of tablets, and oriented toward Amazon services.[112] The shipment of Android devices without GMS is also common in mainland China, as Google does not do business there.[312][313][314]

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.[113] 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,[315] and granting a larger share of search revenue to OEMs who agree to not include third-party app stores on their devices.[316] 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.[317]

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 by Google in favor of non-free replacements distributed through Play Store (Google Search, Google Play Music, and Google Calendar) and 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.[112][318][319][320] 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.[321]

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;[112][322] in 2012, Acer Inc. was forced by Google to halt production on a device powered by Alibaba Group's 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 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.[323][324][325]

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.[326] The idea of an open-source, Linux-based development platform sparked interest,[327] 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.[328] 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."[329]

Since then Android has grown to become the most widely used smartphone operating system[330][331] and "one of the fastest mobile experiences available".[332] 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),[333] Amazon (Kindle Fire), Barnes & Noble (Nook), Ouya, Baidu and others to fork the software and release hardware running their own customised version of Android. As a result, it has been described by technology website *Ars Technica* as "practically the default operating system for launching new hardware" for companies without their own mobile platforms.[330] 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.[330][334]

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.[335] *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, 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 instead of Play Store.[112] 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.[113]

Android has suffered from "fragmentation",[336] 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 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.[337] Critics such as *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.[338] 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.[337]

Market share

Main article: 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.[339] 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 shipments.[340] By May 2010, Android had a 10% worldwide smartphone market share, overtaking Windows Mobile,[341] whilst in the US Android held a 28% share, overtaking iPhone OS.[342] By the fourth quarter of 2010, its worldwide share had grown to 33% of the market becoming the top-selling smartphone platform,[343] overtaking Symbian.[344] In the US it became the top-selling platform in April 2011, overtaking BlackBerry OS with a 31.2% smartphone share, according to *comScore*.[345]

By the third quarter of 2011, Gartner estimated that more than half (52.5%) of the smartphone sales belonged to Android.[346] By the third quarter of 2012 Android had a 75% share of the global smartphone market according to the research firm IDC.[347]

In July 2011, Google said that 550,000 Android devices were being activated every day,[348] up from 400,000 per day in May,[349] and more than 100 million devices had been activated[350] with 4.4% growth per week.[348] In September 2012, 500 million devices had been activated with 1.3 million activations per day.[351][352] In May 2013, at Google I/O, Sundar Pichai announced that 900 million Android devices had been activated.[353]

Android market share varies by location. In July 2012, "mobile subscribers aged 13+" in the United States using Android were up to 52%,[354] and rose to 90% in China.[355] During the third quarter of 2012, Android's worldwide smartphone shipment market share was 75%,[347] with 750 million devices activated in total. In April 2013, Android had 1.5 million activations per day.[352] As of May 2013, 48 billion application ("app") installation have been performed from the Google Play store,[356] and by September 2013, one billion Android devices had been activated.[357]

As of August 2020, the Google Play store had over 3 million Android applications published,[10][358] and as of May 2016, apps had been downloaded more than 65 billion times.[359] The operating system's success has made it a target for patent litigation as part of the so-called "smartphone wars" between technology companies.[360][361]

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).[362] At the end of 2013, over 1.5 billion Android smartphones had been sold in the four years since 2010,[363][364] 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.[365] In 2013, it outsold Windows 2.8:1 or by 573 million.[366][367][368] As of 2015, Android has the

largest installed base of all operating systems;[20] Since 2013, devices running it also sell more than Windows, iOS and Mac OS X devices combined.[369]

According to StatCounter, which tracks only the use for browsing the web, Android is the most popular mobile operating system since August 2013.[370] 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 mobile in all African countries, and it stated "mobile usage has already overtaken desktop in several countries including India, South Africa and Saudi Arabia",[371] with virtually all countries in Africa having done so already (except for seven countries, including Egypt), such as Ethiopia and Kenya in which mobile (including tablets) usage is at 90.46% (Android only, accounts for 75.81% of all use there).[372][373]

While Android phones in the 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 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%).[374]

According to a January 2015 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 and OS X combined, and over three times more than Microsoft Windows. Gartner expected the whole mobile phone market to "reach two billion units in 2016", including Android.[375] Describing the statistics, Farhad Manjoo wrote in *The New York Times* that "About one of every two computers sold today is running Android. [It] has become Earth's dominant computing platform."[20]

According to a 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.[376][377][a] Android has the largest installed base of any mobile operating system and, since 2013, the highest-selling operating system overall[366][369][379][380][381] with sales in 2012, 2013 and 2014[382] close to the installed base of all PCs.[383]

In the second quarter of 2014, Android's share of the global smartphone shipment market was 84.7%, a new record.[384][385] This had grown to 87.5% worldwide market share by the third quarter of 2016,[386] leaving main competitor iOS with 12.1% market share.[387]

According to an April 2017 StatCounter report, Android overtook Microsoft Windows to become the most popular operating system for total Internet usage.[388][389] It has maintained the plurality since then.[390]

In September 2015, Google announced that Android had 1.4 billion monthly active users.[391][392] This changed to 2 billion monthly active users in May 2017.[393][394]

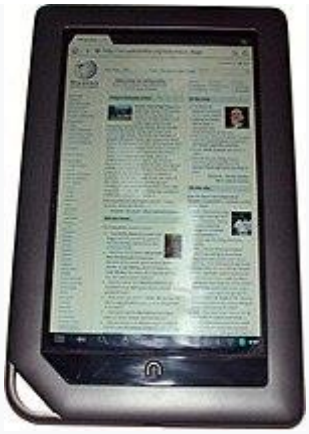
Adoption on tablets

The first-generation Nexus 7 tablet, running Android 4.1 Jelly Bean

Despite its success on smartphones, initially Android tablet adoption was slow,[395] then later caught up with the iPad, in most countries. One of the main causes was the 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.[396][397] The content and app "ecosystem" proved more important than hardware specs 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 was reinforced by the large number of tablet-specific iOS applications.[397][398]

Despite app support in its infancy, a considerable number of Android tablets, like the Barnes & Noble Nook (alongside those using other operating systems, such as the HP TouchPad and BlackBerry PlayBook) were rushed out to market in an attempt to capitalize on the success of the iPad.[397] *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, failed to gain market traction with consumers as well as damaging the early reputation of Android tablets.[399][400] Furthermore, several Android tablets such as the Motorola Xoom were priced the same or higher than the iPad, which hurt sales. An exception was the Amazon Kindle Fire, which relied upon lower pricing as well as access to Amazon's ecosystem of applications and content.[397][401]

This began to change in 2012, with the release of the affordable Nexus 7 and a push by Google for developers to write better tablet applications.[402] According to International Data Corporation, shipments of Android-powered tablets surpassed iPads in Q3 2012.[403]



Barnes & Noble Nook running Android

As of the end of 2013, over 191.6 million Android tablets had sold in three years since 2011.[404][405] This made Android tablets the most-sold type of tablet in 2013, surpassing iPads in the second quarter of 2013.[406]

According to StatCounter's web use statistics, as of 2020, Android tablets represent the majority of tablet devices used in Africa (70%), 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.[407]

In March 2016, Galen Gruman of *InfoWorld* stated that Android devices could be a "real part of your business [..] there's no longer a reason to keep Android at arm's length. It can now be as integral to your mobile portfolio as Apple's iOS devices are".[408] A year earlier, Gruman had stated that Microsoft's own mobile Office apps were "better on iOS and Android" than on Microsoft's own Windows 10 devices.[409]

Platform information

Main article: Android version history

Android 11 is, and was just before the release of Android 12, the most popular Android version, on both smartphones and tablets.

As of May 2022, Android 11 is most popular on smartphones at 35%,[410] with Android 10 2nd at 24%, then Android 12 at 12%. Usage of Android 10 and newer, i.e. supported versions, is at 71%, the rest of users are not supported with security updates. Android 12 is most popular in a few countries including the United States,[411] but Android 11 is most used in most countries, including India, while in many others, including China, Android 10 is the most popular version.[412]

On tablets, Android 11 is most popular at 27%[413][414] overtaking Android 9.0 Pie in July 2021, which is now second at 16% (topped out at over 20%).[415] Usage of Android 10 and newer, i.e. supported versions, is at 34% on Android tablets, with Pie 9.O, until recently supported, at 50.4%. The usage share varies a lot by country: e.g. Android 9.0 Pie is the version with the greatest usage share in the United States (also in the UK) at 34%, while Android 11 is also very popular e.g. most used in India, Canada, Australia, and most European countries, and others all over the world; Oreo 8.1 most used in China.[416]

Version	Marketing name	Release date	API level	Kernel	Runtime	Launched with
13			33	5.x	ART	Pixel 4, Pixel 4 XL, Pixel 5, Pixel 5a, Pixel 6, Pixel 6 Pro, Asus ZenFone 8, Lenovo P12 Pro, OnePlus 10 Pro, Oppo Find X5 Pro, Vivo X80 Pro, Realme GT2 Pro, Xiaomi 12, Xiaomi 12 Pro, Xiaomi Pad 5, Redmi K50 Pro, Sharp AQUOS sense6, Tecno Camon 19 Pro, ZTE Axon 40 Ultra[417]
12L	12	March 7, 2022	32	5.x	ART	Pixel 3, Pixel 3 XL, Pixel 3a, Pixel 3a XL, Pixel 4, Pixel 4 XL, Pixel 4a, Pixel 5, Pixel 5a
12		October 4, 2021	31	5.x	ART	Pixel 3, Pixel 3 XL, Pixel 3a, Pixel 3a XL, Pixel 4, Pixel 4 XL, Pixel 5, Pixel 6, Pixel 6 Pro, Asus ZenFone 8, Nokia X20, OnePlus 9, OnePlus 9 Pro, Oppo Find X3 Pro, iQOO 7 Legend, Realme GT,[418] TCL 20 Pro 5G, Xiaomi Mi 11, Xiaomi Mi 11 Ultra, Xiaomi Mi 11i/Mi 11X Pro,[419] Tecno Camon 17, ZTE Axon 30 Ultra
11	11	September 8, 2020	30	5.x	ART	Pixel 2, Pixel 2 XL, Pixel 3, Pixel 3 XL, Pixel 3a, Pixel 3a XL, Pixel 4, Pixel 4 XL,[420] OnePlus 8, OnePlus 8 Pro, Oppo Find X2, Oppo Find X2 Pro, Vivo NEX 3S, Xiaomi Mi 10, Xiaomi Mi 10

Version	Marketing name	Release date	API level	Kernel	Runtime	Launched with
						Pro, POCO F2 Pro,[421] Realme X50 Pro, Sharp AQUOS Zero 2
10	10	September 3, 2019	29	5.x	ART	Asus ZenFone 5Z, Essential Phone, Pixel, Pixel XL, Pixel 2, Pixel 2 XL, Pixel 3, Pixel 3 XL, Pixel 3a, Pixel 3a XL, OnePlus 6, OnePlus 6T, OnePlus 7, OnePlus 7 Pro, Oppo Reno, Sony Xperia XZ3, Vivo X27, Vivo NEX S, Vivo NEX A, Xiaomi Mi MIX 3 5G, Xiaomi Mi 9, Tecno Spark 3 Pro, Huawei Mate 20 Pro, LG G8, Nokia 8.1, Realme 3 Pro[422]
9	Pie	August 6, 2018	28	4.x	ART	Essential Phone, Pixel, Pixel XL, Pixel 2, Pixel 2 XL, Nokia 7 Plus, OnePlus 6, Oppo R15 Pro, Sony Xperia XZ2, Vivo X21UD, Vivo X21, Xiaomi Mi Mix 2S[423]
8.1	Oreo	December 5, 2017	27	4.x	ART	Pixel, Pixel XL, Nexus 6P, Nexus 5X
8.0		August 21, 2017	26	4.x	ART	—
7.1	Nougat	October 4, 2016	25	4.x	ART	Pixel, Pixel XL

Version	Marketing name	Release date	API level	Kernel	Runtime	Launched with
7.0		August 22, 2016	24	4.x	ART	Nexus 5X, Nexus 6P, LG V20
6.0	Marshmallow	October 5, 2015	23	4.x	ART	Nexus 5X, Nexus 6P
5.1	Lollipop	March 9, 2015	22	3.x	ART	Android One
5.0		November 3, 2014	21	3.x	ART 2.1.0	Nexus 6, Nexus 9
4.4	KitKat	October 31, 2013	19	3.x	Dalvik (and ART 1.6.0)	Nexus 5
4.3	Jelly Bean	July 24, 2013	18	3.x	Dalvik	Nexus 7 2013
4.2		November 13, 2012	17	3.x	Dalvik	Nexus 4, Nexus 10
4.1		July 9, 2012	16	3.x	Dalvik	Nexus 7
4.0	Ice Cream Sandwich	October 19, 2011	15	3.x	Dalvik	Galaxy Nexus
2.3	Gingerbread	February 9, 2011	10	2.6.32	Dalvik 1.4.0	Nexus S

As of July 2021, 66% of devices have Vulkan support (47% on newer Vulkan 1.1),[424] the successor to OpenGL. At the same time 91.5% of the devices have support for OpenGL ES 3.0 or higher (in addition, the rest of devices, 8.50%, use version 2.0), with 73.50% using the latest version OpenGL ES 3.2.

Application piracy

In general, paid Android applications can easily be pirated.[425] In a May 2012 interview with Eurogamer, the developers of *Football Manager* stated that the ratio of pirated players vs legitimate players was 9:1 for their game *Football Manager Handheld*.[426] However, not every developer agreed that piracy rates were an issue; for example, in July 2012 the developers of the game *Wind-up Knight* said that piracy levels of their game were only 12%, and most of the piracy came from China, where people cannot purchase apps from Google Play.[427]

In 2010, Google released a tool for validating authorized purchases for use within apps, but developers complained that this was insufficient and trivial to crack. Google responded that the tool, especially its initial release, was intended as a sample framework for developers to modify and build upon depending on their needs, not as a finished piracy solution.[428] Android "Jelly Bean" introduced the ability for paid applications to be encrypted, so that they may work only on the device for which they were purchased.[429][430]

Legal issues

Further information: Smartphone patent wars and Patent troll

The success of Android has made it a target for patent and copyright litigation between technology companies, both Android and Android phone manufacturers having been involved in numerous patent lawsuits and other legal challenges.

Patent lawsuit with Oracle

Main article: Oracle v. Google

On August 12, 2010, Oracle sued Google over claimed infringement of copyrights and patents related to the Java programming language.[431] Oracle originally sought damages up to $6.1 billion,[432] but this valuation was rejected by a United States federal judge who asked Oracle to revise the estimate.[433] In response, Google submitted multiple lines of defense, counterclaiming that Android did not infringe on Oracle's patents or copyright, that Oracle's patents were invalid, and several other defenses. They said that Android's Java runtime environment is based on Apache Harmony, a clean room implementation of the Java class libraries, and an independently developed virtual machine called Dalvik.[434] In May 2012, the jury in this case found that Google did not infringe on Oracle's patents, and the trial judge ruled that the structure of the Java APIs used by Google was not copyrightable.[435][436] The parties agreed to zero dollars in statutory damages for a small amount of copied code.[437] On May 9, 2014, the Federal Circuit partially reversed the district court ruling, ruling in Oracle's favor on the copyrightability issue, and remanding the issue of fair use to the district court.[438][439]

In December 2015, Google announced that the next major release of Android (Android Nougat) would switch to OpenJDK, which is the official open-source implementation of the Java platform, instead of using the now-discontinued Apache Harmony project as its runtime. Code reflecting this change was also posted to the AOSP source repository.[215] In its announcement, Google claimed this was part of an effort to create a "common code base" between Java on Android and other

platforms.[216] Google later admitted in a court filing that this was part of an effort to address the disputes with Oracle, as its use of OpenJDK code is governed under the GNU General Public License (GPL) with a linking exception, and that "any damages claim associated with the new versions expressly licensed by Oracle under OpenJDK would require a separate analysis of damages from earlier releases".[215] In June 2016, a United States federal court ruled in favor of Google, stating that its use of the APIs was fair use.[440]

In April 2021, the United Supreme Court ruled that Google's use of the Java APIs was within the bounds of fair use, reversing the Federal Circuit Appeals Court ruling and remanding the case for further hearing. The majority opinion began with the assumption that the APIs may be copyrightable, and thus proceeded with a review of the factors that contributed to fair use.[441]

Anti-competitive challenges in Europe

Main article: European Union vs. Google

In 2013, FairSearch, a lobbying organization supported by Microsoft, Oracle and others, filed a complaint regarding Android with the European Commission, alleging that its free-of-charge distribution model constituted anti-competitive predatory pricing. The Free Software Foundation Europe, whose donors include Google, disputed the Fairsearch allegations.[442] On April 20, 2016, the EU filed a formal antitrust complaint against Google based upon the FairSearch allegations, arguing that its leverage over Android vendors, including the mandatory bundling of the entire suite of proprietary Google software, hindering the ability for competing search providers to be integrated into Android, and barring vendors from producing devices running forks of Android, constituted anti-competitive practices.[443] In August 2016, Google was fined US$6.75 million by the Russian Federal Antimonopoly Service (FAS) under similar allegations by Yandex.[444] The European Commission issued its decision on July 18, 2018, determining that Google had conducted three operations related to Android that were in violation of antitrust regulations: bundling Google's search and Chrome as part of Android, blocking phone manufacturers from using forked versions of Android, and establishing deals with phone manufacturers and network providers to exclusively bundle the Google search application on handsets (a practice Google ended by 2014). The EU fined Google for €4.3 billion (about US$5 billion) and required the company to end this conduct within 90 days.[445] Google filed its appeal of the ruling in October 2018, though will not ask for any interim measures to delay the onset of conduct requirements.[446]

On October 16, 2018, Google announced that it would change its distribution model for Google Mobile Services in the EU, since part of its revenues streams for Android which came through use of Google Search and Chrome were now prohibited by the EU's ruling. While the core Android system remains free, OEMs in Europe would be required to purchase a paid license to the core suite of Google applications, such as Gmail, Google Maps and the Google Play Store. Google Search will be licensed separately, with an option to include Google Chrome at no additional cost atop Search. European OEMs can bundle third-party alternatives on phones and devices sold to customers, if they so choose. OEMs will no longer be barred from selling any device running incompatible versions of Android in Europe.[447]

Others

In addition to lawsuits against Google directly, various proxy wars have been waged against Android indirectly by targeting manufacturers of Android devices, with the effect of discouraging manufacturers from adopting the platform by increasing the costs of bringing an Android device to market.[448] Both Apple and Microsoft have sued several manufacturers for patent infringement, with Apple's ongoing legal action against Samsung being a particularly high-profile case. In January 2012, Microsoft said they had signed patent license agreements with eleven Android device manufacturers, whose products account for "70 percent of all Android smartphones" sold in the US[449] and 55% of the worldwide revenue for Android devices.[450] These include Samsung and HTC.[451] Samsung's patent settlement with Microsoft included an agreement to allocate more resources to developing and marketing phones running Microsoft's Windows Phone operating system.[448] Microsoft has also tied its own Android software to patent licenses, requiring the bundling of Microsoft Office Mobile and Skype applications on Android devices to subsidize the licensing fees, while at the same time helping to promote its software lines.[452][453]

Google has publicly expressed its frustration for the current patent landscape in the United States, accusing Apple, Oracle and Microsoft of trying to take down Android through patent litigation, rather than innovating and competing with better products and services.[454] In August 2011, Google purchased Motorola Mobility for US$12.5 billion, which was viewed in part as a defensive measure to protect Android, since Motorola Mobility held more than 17,000 patents.[455][456] In December 2011, Google bought over a thousand patents from IBM.[457]

Turkey's competition authority investigations about default search engine in Android, started in 2017, led to a US$17.4 million fine in September 2018 and a fine of 0.05 percent of Google's revenue per day in November 2019 when Google didn't meet the requirements.[458] In December 2019, Google stopped issuing licenses for new Android phone models sold in Turkey.[458]

Other uses

Ouya, a video game console which runs Android

Google has developed several variations of Android for specific use cases, including Android Wear, later renamed Wear OS, for wearable devices such as wrist watches,[459][460] Android TV for televisions,[461][462] Android Things for smart or Internet of things devices and Android Automotive for cars.[463][464] Additionally, by providing infrastructure that combines dedicated hardware and dedicated applications running on regular Android, Google have opened up the platform for its use in particular

usage scenarios, such as the Android Auto app for cars,[465][466] and Daydream, a Virtual Reality platform.[467]

The open and customizable nature of Android allows device makers to use it on other electronics as well, including laptops, netbooks,[468][469] and desktop computers,[470] cameras,[471] headphones,[472] home automation systems, game consoles,[473] media players,[474] satellites,[475] routers,[476] printers,[477] payment terminals,[478] automated teller machines,[479] and robots.[480] Additionally, Android has been installed and run on a variety of less-technical objects, including calculators,[481] single-board computers,[482] feature phones,[483] electronic dictionaries,[484] alarm clocks,[485] refrigerators,[486] landline telephones,[487] coffee machines,[488] bicycles,[489] and mirrors.[473]

Ouya, a video game console running Android, became one of the most successful Kickstarter campaigns, crowdfunding US$8.5m for its development,[490][491] and was later followed by other Android-based consoles, such as Nvidia's Shield Portable – an Android device in a video game controller form factor.[492]

In 2011, Google demonstrated "Android@Home", a home automation technology which uses Android to control a range of household devices including light switches, power sockets and thermostats.[493] Prototype light bulbs were announced that could be controlled from an Android phone or tablet, but Android head Andy Rubin was cautious to note that "turning a lightbulb on and off is nothing new", pointing to numerous failed home automation services. Google, he said, was thinking more ambitiously and the intention was to use their position as a cloud services provider to bring Google products into customers' homes.[494][495]

Android-x86 running on an ASUS Eee PC netbook

Parrot unveiled an Android-based car stereo system known as Asteroid in 2011,[496] followed by a successor, the touchscreen-based Asteroid Smart, in 2012.[497] In 2013, Clarion released its own Android-based car stereo, the AX1.[498] In January 2014, at the Consumer Electronics Show (CES), Google announced the formation of the Open Automotive Alliance, a group including several major automobile makers (Audi, General Motors, Hyundai, and Honda) and Nvidia, which aims to produce Android-based in-car entertainment systems for automobiles, "[bringing] the best of Android into the automobile in a safe and seamless way."[499]

Android comes preinstalled on a few laptops (a similar functionality of running Android applications is also available in Google's Chrome OS) and can also be installed on personal computers by end users.[500][501] On those platforms Android provides additional functionality for physical keyboards[502] and mice, together with the

"Alt-Tab" key combination for switching applications quickly with a keyboard. In December 2014, one reviewer commented that Android's notification system is "vastly more complete and robust than in most environments" and that Android is "absolutely usable" as one's primary desktop operating system.[503]

In October 2015, *The Wall Street Journal* reported that Android will serve as Google's future main laptop operating system, with the plan to fold Chrome OS into it by 2017.[504][505] Google's Sundar Pichai, who led the development of Android, explained that "mobile as a computing paradigm is eventually going to blend with what we think of as desktop today."[504] Also, back in 2009, Google co-founder Sergey Brin himself said that Chrome OS and Android would "likely converge over time."[506] Lockheimer, who replaced Pichai as head of Android and Chrome OS, responded to this claim with an official Google blog post stating that "While we've been working on ways to bring together the best of both operating systems, there's no plan to phase out Chrome OS [which has] guaranteed auto-updates for five years".[507] That is unlike Android where support is shorter with "EOL dates [being..] at least 3 years [into the future] for Android tablets for education".[508]

At Google I/O in May 2016, Google announced Daydream, a virtual reality platform that relies on a smartphone and provides VR capabilities through a virtual reality headset and controller designed by Google itself.[467] The platform is built into Android starting with Android Nougat, differentiating from standalone support for VR capabilities. The software is available for developers, and was released in 2016.

Mascot

Android robot logo

A giant Android mascot at Googleplex in 2008

The mascot of Android is a green android robot, as related to the software's name. Although it has no official name, the Android team at Google reportedly call it "Bugdroid".[509]

It was designed by then-Google graphic designer Irina Blok on November 5, 2007, when Android was announced. Contrary to reports that she was tasked with a project to create an icon,[510] Blok confirmed in an interview that she independently developed it and made it open source. The robot design was initially not presented to Google, but it quickly became commonplace in the Android development team, with various variations of it created by the developers there who liked the figure, as it was free under a Creative Commons license.[511][512] Its popularity amongst the development team eventually led to Google adopting it as an official icon as part of the Android logo when it launched to consumers in 2008.

See also

- ***Free and open-source software portal***
- ***Computer programming portal***

- Comparison of mobile operating systems
- Index of Android OS articles
- List of Android smartphones

References

Explanatory notes

1. ^ To put the Statistica's numbers in context: by Strategy Analytics estimates, Windows the most popular "desktop" operating system, was estimated to have an installed base of about 1.3 billion at best;[378] they also estimate the overall tablet installed base to be already of comparable size to the PC market and predict tablets will have surpassed them by 2018.

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External links

Wikimedia Commons has media related to ***Android (operating system)***.

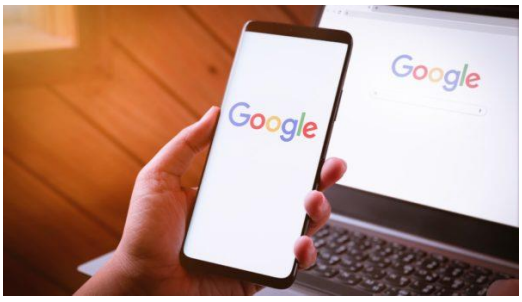
- Official website
- Android Developers
- Android Open Source Project

Android - Overview (tutorialspoint.com) might have some answers for you

Using Android – Beginners guide

- How to use Android [Navigation Basics!] - YouTube
- Android phones 101 / android for dummies. Buttons and functions - YouTube

7 quick ways to get more out of Chrome on your Android phone



Are you taking advantage of everything Google Chrome has to offer on your Android phone? Probably not. We're here to help. We've gathered tips to help you browse faster, organize tabs and even load your favorite websites quicker than ever before.

Tap or click here for better ways to use Google Chrome on Android.

Android - Overview

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

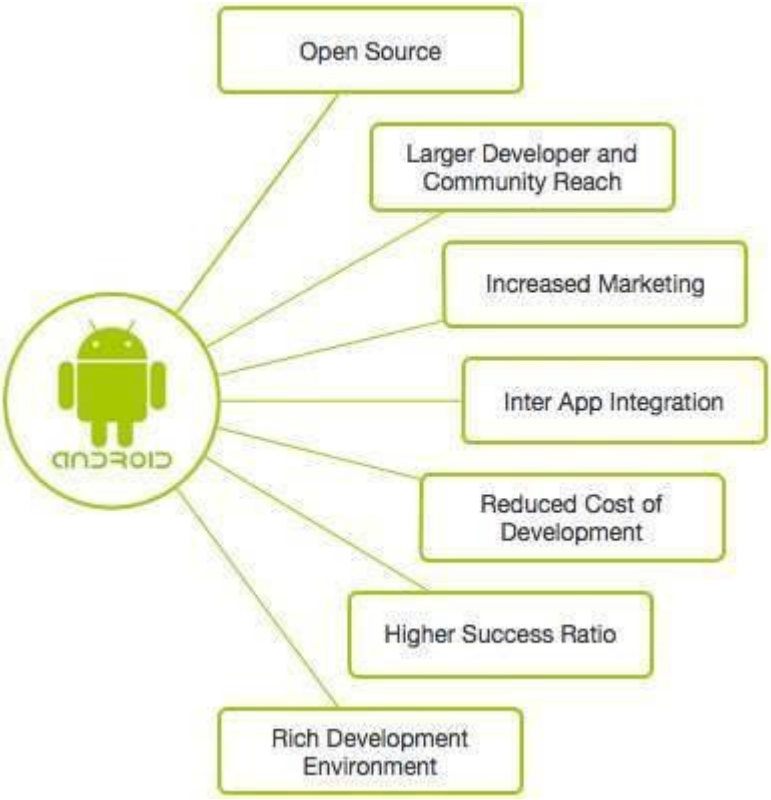
Android offers a unified approach to application development for mobile devices which means developers need only develop for Android, and their applications should be able to run on different devices powered by Android.

The first beta version of the Android Software Development Kit (SDK) was released by Google in 2007 where as the first commercial version, Android 1.0, was released in September 2008.

On June 27, 2012, at the Google I/O conference, Google announced the next Android version, 4.1 **Jelly Bean**. Jelly Bean is an incremental update, with the primary aim of improving the user interface, both in terms of functionality and performance.

The source code for Android is available under free and open source software licenses. Google publishes most of the code under the Apache License version 2.0 and the rest, Linux kernel changes, under the GNU General Public License version 2.

Why Android ?



Features of Android

Android is a powerful operating system competing with Apple 4GS and supports great features. Few of them are listed below −

Sr.No.	Feature & Description
1	**Beautiful UI** Android OS basic screen provides a beautiful and intuitive user interface.
2	**Connectivity** GSM/EDGE, IDEN, CDMA, EV-DO, UMTS, Bluetooth, Wi-Fi, LTE, NFC and WiMAX.
3	**Storage** SQLite, a lightweight relational database, is used for data storage purposes.
4	**Media support** H.263, H.264, MPEG-4 SP, AMR, AMR-WB, AAC, HE-AAC, AAC 5.1, MP3, MIDI, Ogg Vorbis, WAV, JPEG, PNG, GIF, and BMP.

5	**Messaging** SMS and MMS
6	**Web browser** Based on the open-source WebKit layout engine, coupled with Chrome's V8 JavaScript engine supporting HTML5 and CSS3.
7	**Multi-touch** Android has native support for multi-touch which was initially made available in handsets such as the HTC Hero.
8	**Multi-tasking** User can jump from one task to another and same time various application can run simultaneously.
9	**Resizable widgets** Widgets are resizable, so users can expand them to show more content or shrink them to save space.
10	**Multi-Language** Supports single direction and bi-directional text.
11	**GCM** Google Cloud Messaging (GCM) is a service that lets developers send short message data to their users on Android devices, without needing a proprietary sync solution.
12	**Wi-Fi Direct** A technology that lets apps discover and pair directly, over a high-bandwidth peer-to-peer connection.
13	**Android Beam** A popular NFC-based technology that lets users instantly share, just by touching two NFC-enabled phones together.

Android Applications

Android applications are usually developed in the Java language using the Android Software Development Kit.

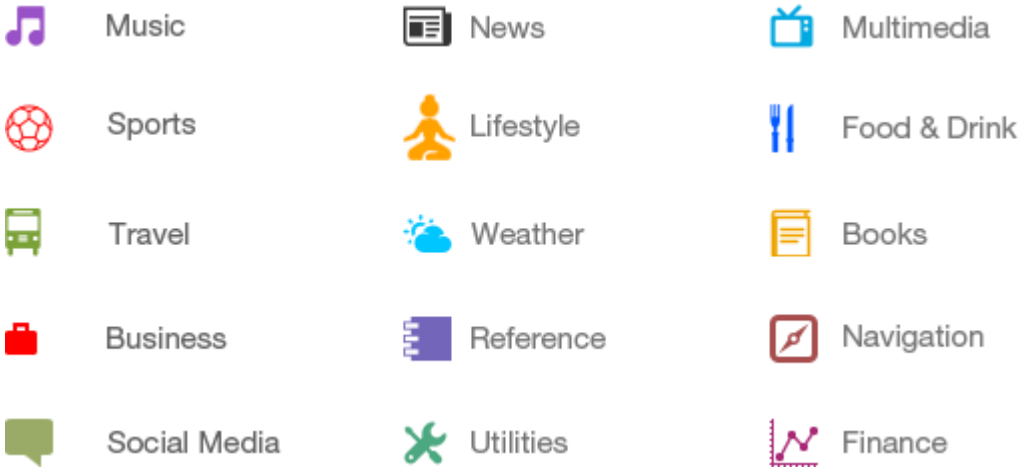
Once developed, Android applications can be packaged easily and sold out either through a store such as **Google Play**, **SlideME**, **Opera Mobile Store**, **Mobango**, **F-droid** and the **Amazon Appstore**.

Android powers hundreds of millions of mobile devices in more than 190 countries around the world. It's the largest installed base of any mobile platform and growing fast. Every day more than 1 million new Android devices are activated worldwide.

This tutorial has been written with an aim to teach you how to develop and package Android application. We will start from environment setup for Android application programming and then drill down to look into various aspects of Android applications.

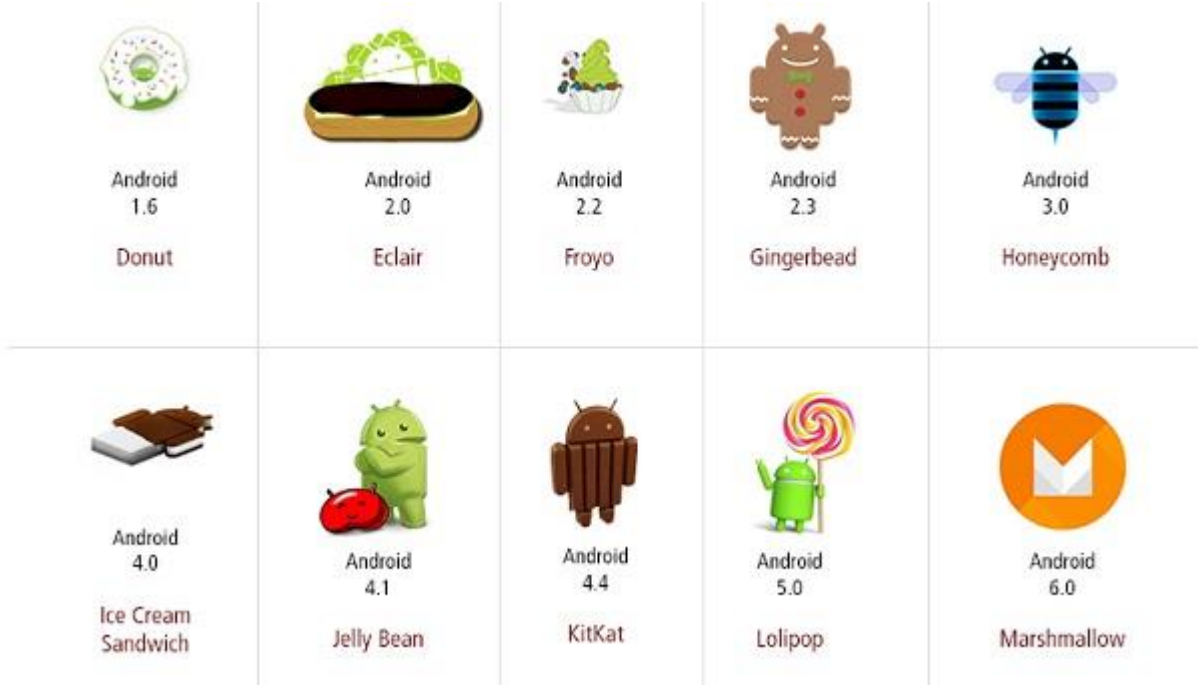
Categories of Android applications

There are many android applications in the market. The top categories are −



History of Android

The code names of android ranges from A to N currently, such as Aestro, Blender, Cupcake, Donut, Eclair, Froyo, Gingerbread, Honeycomb, Ice Cream Sandwitch, Jelly Bean, KitKat, Lollipop and Marshmallow. Let's understand the android history in a sequence.



What is API level?

API Level is an integer value that uniquely identifies the framework API revision offered by a version of the Android platform.

Platform Version	API Level	VERSION_CODE	
Android 6.0	23	MARSHMALLOW	
Android 5.1	22	LOLLIPOP_MR1	
Android 5.0	21	LOLLIPOP	
Android 4.4W	20	KITKAT_WATCH	KitKat for Wearables Only
Android 4.4	19	KITKAT	
Android 4.3	18	JELLY_BEAN_MR2	
Android 4.2, 4.2.2	17	JELLY_BEAN_MR1	
Android 4.1, 4.1.1	16	JELLY_BEAN	
Android 4.0.3, 4.0.4	15	ICE_CREAM_SANDWICH_MR1	

Android 4.0, 4.0.1, 4.0.2	14	ICE_CREAM_SANDWICH	
Android 3.2	13	HONEYCOMB_MR2	
Android 3.1.x	12	HONEYCOMB_MR1	
Android 3.0.x	11	HONEYCOMB	
Android 2.3.4 Android 2.3.3	10	GINGERBREAD_MR1	
Android 2.3.2 Android 2.3.1 Android 2.3	9	GINGERBREAD	
Android 2.2.x	8	FROYO	
Android 2.1.x	7	ECLAIR_MR1	
Android 2.0.1	6	ECLAIR_0_1	
Android 2.0	5	ECLAIR	
Android 1.6	4	DONUT	
Android 1.5	3	CUPCAKE	
Android 1.1	2	BASE_1_1	
Android 1.0	1	BASE	

Advantages

The **advantages of the Android operating system** include the following.

- Android is a Linux based open-source operating system, it can be developed by anyone
- Easy access to android apps
- You can replace the battery and mass storage, disk drive, and UDB option
- Its supports all Google services

- The operating system is able to inform you of a new SMS and Emails or the latest updates.
- It supports Multitasking
- Android phone can also function as a router to share the internet
- It’s free to customize
- Can install a modified ROM
- Its supports 2D and 3D graphics
- We can install Millions of apps-
- Backup and restore of apps can be possible
- It supports Third-party apps
- Addition & removal of unwanted features:-
- High job demands for Android developers
- Notifications can be displayed very clearly
- Huge community support
- The Internet can be shared from device to device
- It is an Open source
- Different types of mobile models you can select
- Add/ Remove Unwanted
- Internal memory is Expandable
- Cloud storage
- It supports big screens at a reasonable price
- Foldable Android devices
- Different apps can run at the same time
- Several widgets on display

Dis-advantages

The **disadvantages of the Android operating system** include the following.

- Apps work in the background
- Battery discharges easily due to a lot of processes within the background.
- Requires Google account
- Less security, so fake apps can be easily installed to steal your data from strange resources
- Mobiles with low specification run very slow
- Generally, you require additional code on Java language as compared to Objective-C.
- Android developers have a critical time
- Difficult layouts & animations are tough to code within Android.
- Protection of Virus is required
- For developers of the app, Google is strict
- Several ads within apps
- Some apps quality is not good
- For elders, it is not friendly

Android Operating System vs. Apple iOS

Differences between the android operating system and apple iOS include the following.

Android	iOS
The developer of Android was mostly Google & Open Handset Alliance	The developer of iOS was Apple Inc.
The initial release was Sep23, 2008	The initial release was July 29, 2007
The latest version is Android 11	Latest version of iOS is14.1 & iPadOS 14.1
It is an open-source model	The source model is closed including open source components.
As compared to iOS, file transfer is easy	File transfer is more difficult in iOS but transferring media files can be done through the iTunes desktop app.
The browser used in Android is Google Chrome	The browser used in iOS is Safari
Web mapping used in this is Google maps	Web mapping used in this is Apple maps
Available languages are nearly 100	Available languages are nearly 40
Video calling can be possible through different apps.	For video calling, face time & other third-party apps are used.
Google assistant is used as a virtual assistant	Siri is used as a virtual assistant
This OS supports different smartphones like Samsung, Xiaomi, OnePlus, Honor, Vivo, etc	This OS supports only Apple products like iPad, iPhone, iPod Touch & Apple TV
Battery life is good	Battery life is not good as compared to Android
Biometric Authentication used in Android OS is Fingerprint or Face recognition	Biometric Authentication used in iOS is Fingerprint or Face recognition
OS family is Linux	OS family is Linux OS X, UNIX

Comparison of mobile operating systems

From Wikipedia, the free encyclopedia

This is a comparison of mobile operating systems. Only the latest versions are shown in the table below, even though older versions may still be marketed.

Contents

About OS

About OS										
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**	**Mobian**[1]	**Plasma Mobile**	**PureOS**	**PostmarketOS**	**KaiOS**
Developed by	Google, Open Handset Alliance	Apple Inc.	Linux Foundation, Tizen Association, Samsung, Intel	Sailfish Alliance, Mer, Jolla and Sailfish community contributors	UBports and Ubuntu community contributors (previously Canonical Ltd.)	Debian on Mobile Team	KDE and Blue Systems	Purism	PostmarketOS community	KaiOS Technologies Inc.(TCL)

Market share[2][3]	71.90%	27.33%	0.22%	N/A	N/A	N/A	N/A	N/A	N/A	0.14%
License	Base system is Free and open-source. Closed-source drivers are often needed for hardware support.	Proprietary, open source kernel and core	Partial; both proprietary and open-source components, assorted licenses	Free and open-source, but the UI and the SDK are proprietary and closed source	Free and open-source, mainly the GPL[4]	Free and open-source, mainly the GPL	Free and open-source, mainly the GPL	Free and open-source, mainly the GPL	Free and open-source, GPL	Proprietary except for open source kernel patches (formerly the MPL 2.0 B2G OS)
Current version	12L	15.5	4.0.0.7	4.3.0.15	16.04 OTA-22	20210516	5.24.3	10.0	21.12 Service Pack 3	2.6.0
Development version	13	16.0	6.0 M2	Unknown	Unknown	20220612	Unknown	Unknown	N/A	
Current version release dates	March 7, 2022; 4 months ago	May 16, 2022; 59 days ago	May 30, 2020; 2 years ago[5]	February 16, 2022; 4 months ago[6]	February 18, 2022; 4 months ago	May 16, 2021	March 8, 2022; 4 months ago	October 2, 2021; 9 months ago	March 13, 2022; 4 months ago	
OS family	Modified Linux kernel based	Darwin	Linux (based on a combination of Linux MeeGo and Samsung Bada)	Linux	Linux (based on Ubuntu)	Linux (based on Debian)	Linux (mainly based on KDE neon)	Linux (based on Debian)	Linux (based on Alpine Linux)	Firefox OS / Open Web (based on Linux kernel)
Supported CPU architecture	ARM (32-bit ARMv7-A and 64-bit ARMv8-A only), x8	64-bit ARMv8-A only	ARM, x86, x86-64	ARM, x86-64	ARM, x86-64	ARM	ARM, ?	Convergence operating system	ARM, ARM64, x86, x86-64	ARM

	6, x86-64[7]									
Programmed in	C, C++, Java, Kotlin	C, C++, Objective-C, Swift	C++, Xamarin.Forms (.NET C#, F#, VB[8])	C++, QML, Python	Apps: HTML5, QML, Go, JavaScript, C++ System: C, C++, QML	C, C++	C++, QML		Python install tool and shell script packages	HTML5, JavaScript
Public issues list	Yes[9]	3rd party[10]	Yes[11]	Yes[12]	Yes[13]	No[*citation needed*]	Yes[14]	Yes[15]	Yes[16]	No[*citation needed*]
DRM-free[17]	No[18] since Android 4.1[19] and Android 4.3[20] and more restrictions on Android 4.4[21]	No – FairPlay	Yes	Yes	Yes	Yes	Yes[*citation needed*]	Yes[*citation needed*]	Yes	?
Device independent system updates	Partial system updates since Oreo[22] 3rd party software like LineageOS[23]	Yes[24]	No	Yes	Yes[25]	?			Yes.[26] Intended for use on old mobile devices	For feature phones, not smart phones
Wireless system updates	Yes	5+[27]	No	Yes	Yes	?				
GPU accelerated GUI	3+[28]	Yes	Yes	Yes	Yes	?				
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**	**Mobian**[1]	**Plasma**	**PureOS**	**PostmarketOS**	**KaiOS**

							Mobile			

Advanced controls [edit]

Advanced controls					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
While-in-use permissions	10+	11+: Location only[29]	No	No	Yes
Per-app Internet access	No,[30] 3rd party software[31]	7+: Cellular only;[32] 3rd party software on jailbroken devices[33]	No	No	No
Per-app identity access	8+[34]	6+[35][36]	No	No	Yes
Per-app user data access	6+[37]	6+[38]	No	No	Yes
Per-app background execution	No,[39] 3rd party apps available[40]	7+[41]	No	No	Background execution not allowed
Per-app notifications	4.1+[42]	5+[43][44]	No	No	Yes
Per-app location access	6+[37]	4+[45]	No	No	Yes
Per-app camera access	6+[37]	8+[46]	No	No	Yes

Per-app microphone access	6+[37]	7+[47]	No	No	Yes
Per-app shared files access	6+[37]	8+[48]	No	No	Yes
Per-app network data usage auditing	4+[49]	Yes[50]	?	No[51]	No
Fine grained storage usage	Yes[52]	5+[53]	?	No	Yes
Parental controls	4.3+ or 3rd party software[54]	Yes[55]	?	No	No
Screen orientation lock	Yes[56]	Yes[57]	?	1.0.4+[58]	Yes
File manager	6.0+[59]	11+[60]	3rd party software[61]	Yes[62]	Yes
File manager write access to external storage	6+ Or 3rd party software like LineageOS	13+	Yes	Yes	Yes
Multi-user	4.2+, including phones 5+[63][64]	9.3+: Education use only on iPad[65]	No	3.4.0+	No
Guest mode	5+[66]	6+[67]	No	3.4.0+	No
Guided Access	No	Yes[68]	No	No	No
Do not disturb mode	5+[69]	6+[70]	No	No	No

App groups	Yes	4+[71]	?	1.0.7+[72]	Yes

Accessibility features [edit]

Accessibility features					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
System wide base text size	Yes	Yes[73][74][75]	?	2.1.0+: Set text size[76]	3rd party software[77]
Monaural output	Yes	Yes	No	No	No
Always visible scrollbar	No	No	No	No	No
Reduced Animations	Yes	Yes	No	No	No

App ecosystem [edit]

App ecosystem					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
Official app store	Google Play	App Store	Tizen Store	Jolla Store	OpenStore
Non-discriminatory stores	No, Some apps like Ad blockers are censored on Google Play[78][79] but developers can	No, Apple discriminates based on country[80] and own Apple policies[81]	?	Openrepos.[82] Developers can distribute apps from their own sources, supports multiple app stores	Yes

	distribute apps from their own sources				
Common APIs for smartphones, tablets, and PCs	Yes[83]	Smartphone and tablet only[84]	No	Yes	Yes
Official SDK platform(s)	Linux, macOS and Windows[85]	macOS using iOS SDK	Linux, Windows, macOS[86]	Windows, macOS and Linux[87]	Yes
Cost to develop for the mobile OS	Free	No, Requires Apple hardware.[88]	Free	Free	Free
Cost to publish app to official store	US$25 once to offer it on Google Play[89]	US$99/year	Free	Free[90]	Free

Basic features [edit]

Basic features					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
Cut, copy, and paste	Yes[91]	3+[92]	Yes[93]	Yes	Yes
Multi-Device clipboard	Chrome OS[94]	10+[95]	No	No	No
Undo	No[96]	3+[97]	No	No[98]	Yes

Custom home and lock screen wallpaper	Yes	4+[57]	Yes	Yes (incl. Ambience)	Yes
Desktop sync	No,[99] but available using the vendor's companion/PC suite application such as Samsung Smart Switch & HTC Sense[100]	Yes	Yes	?	Yes
Local full backup	Yes, via external computer[101]	Yes, using external computer or iCloud[102]	No[103]	Yes	Yes
Core data missing sync	Bookmarks[104] (before 4), SMSs and Settings[105]		?	?	?
Notification center	Yes	5+[106]	2+[107]	Yes	Yes
Push notifications	Yes[108]	Yes (Apple Push Notification Service)	2+[109]	Yes	Yes
Screenshot	4+ also available on earlier versions with customized firmware, such as Cyanogen Mod and on older Samsung Galaxy smartphones[110]	Yes[57][111]	Yes	2.0.2+[112]	Yes
iCalendar import	No,[113] but 3rd party app available[114]	Yes[115]	?	1.1.6+[116]	No
Text/document support (read only; creating using third-party apps)	Microsoft Office, PDF, TXT/RTF	Microsoft Office,[117][118][119] iWork, PDF, Images, TXT/RTF, VCF	Read only: text files, PDF, HTML,	Microsoft Office, OpenDocument, PDF, Text	Yes

			Multiple office formats		
Printer support	4.4+ using Google Cloud Print[120] but not over USB unless proprietary vendor solutions such as HP Print Service are used[121]	Yes (AirPrint)[122]	No	yes, cups package is available	Beta
Show remembered Wi-Fi connections	Yes	No, 3rd party software on jailbroken devices[123]	?	Yes	Yes

Browser[edit]

Browser					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
Default web browser/engine	Blink	WebKit	WebKit	Gecko[124]	Qt WebEngine (based on Blink)
Major web browsers available[125]	Chrome for Android, Opera, Firefox, Microsoft Edge, Samsung Internet	Safari, Chrome for iOS, Opera Touch, Firefox, Microsoft Edge	Tizen Browser (Based on UC Browser)	Sailfish Browser (Gecko), Webcat (WebKit), Web Pirate (WebKit), others via Android (Firefox, Chrome, Opera)	Morph Browser
Browser can use its own engine	Yes	No[126]	Yes	Yes	Yes

Browser extensions	No[127] 3rd party software[128]	8+[129]	No	No	No
Browser direct Internet connection (increased resilience to outages)	Yes	Yes	Yes	?	?
Browser undo close tab	Google Chrome for Android[130]	8+[131]	No	No	No
Browser keeps windows open on shutdown or crash	2.3+ Google Chrome[132] but not on the deprecated AOSP browser[133]	Yes	No	Yes	Yes
Browser keeps windows open when cleaning cookies	Yes	3rd party software[134]	?	Yes	Yes
Browser search engine options	Many[135]	Bing, Google, Yahoo! Search, DuckDuckGo, Ecosia	Bing, Google, Yahoo! Search	Bing, Google, Yahoo, Yandex. Baidu, DuckDuckGo, StartPage, Searx, ixquick, Swisscows, Qwant, Seznam, Hulbee via openrepos[136]	Baidu, Bing, DuckDuckGo, Ecosia, Google, lilo, Peekier, Qwant, Wikipedia, Yahoo[137]
Browser find on page	1.5+[138]	Yes[139]	Yes	1.1.2+[140]	Yes

Browser–email save images	Yes	Yes[141]	?	Yes	Yes
Browser–email save PDFs	Yes	Yes[57]	Yes	Yes	Yes
Browser save audio/video	Yes, but only links, not embedded media	13+;[142] 5+: 3rd party software[143]	Yes	Yes	Yes
Browser save page	Yes, Google Chrome 55+[144]	6+: Offline Reading List;[145] 3rd party software[146]	Yes	4.0.1.48+	Yes
Browser save any file	Yes, Chrome for Android.	13+;[142] 5+: When an app that can handle/open the filetype is installed (excluding audio/video – requires 3rd party software[147]);[148]	?	Yes	Yes
Browser force enable zoom	Yes, Chrome for Android	Yes[149]	?	?	?
Browser text reflow[150]	No, removed on Android 4.4[151][152]	5+: Only on pages with reader mode available[153][154] 3rd party browsers on prior versions[155]	No	No	No
Browser Reader Mode	No,[156] 3rd party software[157][158]	5+[153][154]	Yes	No[159]	No
Browser open PDFs	No	Yes	No	No	No

without storing					
Browser file upload	2.2+[160]	9+; 6–8: Limited	Yes	1.0.7+[161]	Yes
Browser form navigation	Next button[162]	Previous, Next, AutoFill, and Done buttons[163]	?	?	?
Browser private browsing mode	3.0+ with AOSP browser[164] or with Chrome for Android	5+[165]	Yes	1.1.6+[166]	Yes
Offline web apps	Yes[167]	Yes[168][169][170]	No	?	Yes
HTTP Live Streaming	3+[171]	3+[172]	No	?[173]	Yes
WebRTC	Yes[174]	11+[175]	No	No	Yes

Communication and connectivity[edit]

Communication and connectivity					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
Unified Inbox	No,[176] but 3rd party apps available[177]	Yes	Yes	Yes	?

Email sync protocols supported	POP3, IMAP, MAPI	POP3, IMAP, MAPI, ActiveSync[178]	POP3, IMAP	POP3, IMAP, ActiveSync	?
Non-carrier-based integrated messaging	Google Hangouts	5+ (iMessage)[179]	?	3rd party software	3rd party software
Visual voicemail	2.1+[180]	Yes	?	?	?
Call log duration	Yes[181]	Yes[182]	?	Yes	Yes
Multiple mobile phones per contact	Yes	Yes	?	Yes	Yes
Contact groups	4+[183] or 3rd party software[184]	Via iCloud or 3rd party software[185]	Yes	No[186]	?
Voice over IP	Yes (SIP)[187] or 3rd party software[188]	FaceTime; 3rd party software[189]	No[190]	3rd party software	3rd party software
NFC payment software	Available on any device that supports the hardware. Android Pay for NFC payments available in Play Store.[191]	8+: iPhone 6/6 Plus and later (iPhone 5 and later if used with Apple Watch), via Apple Pay	Samsung Pay	No	No

Tethering	Mobile Wi-Fi Hotspot, USB, Bluetooth	4.3+: Personal Hotspot (Wi-Fi, Bluetooth, USB; carrier dependent)	microUSB, Bluetooth 3.0, Mobile Wi-Fi Hotspot	Mobile Wi-Fi Hotspot, USB, Bluetooth	Mobile Wi-Fi Hotspot
USB On-The-Go	3.1+[192][193]	13+;[194] 9+: Only for connecting cameras	No	Yes	Yes
Direct file transfer over Wi-Fi Direct	4+[49] and selected devices[195][196]	No, 3rd party software on jailbroken devices	No, was available on bada 2+,[197] but removed on Tizen	No[198]	No
DHCP v4	Yes	Yes	?	?	?
DHCP v6	No	Yes	?	?	?
Direct file transfer over Bluetooth	2+[199]	AirDrop: 7+: Between iOS only; 8+: Between Mac/iOS only. (Note: AirDrop utilizes Wi-Fi as well)	No, was available on bada,[200] but removed on Tizen	Yes[201] but limited to images, videos and contacts	No
Direct file transfer over NFC	No, removed on Android 10	No	2+[197]	No	No

Language and inputs [edit]

Language and inputs					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
Non-English languages support	Partial[202]	Yes[203][204][205]	Limited (Search is not diacritical mark-insensitive)	Yes	Yes

Underlining spell checker	2.3+[206][207]	Yes[208]	No	?	No
Built-in system-wide dictionary	Built into keyboard app. Available on every device.[209]	5+[210]	No	Yes	Yes
Autoexpanding text replacements	Yes	5+[211]	?	?	?
Keyboard next word prediction	No,[212] 3rd party software[213]	8+[214]	No	Yes	Yes
Keyboard cursor controller	Google Keyboard;[215][216]	12+;[217] 9-11: Only on devices with 3D Touch;[218]	No	No	Yes
Optical character recognition input method	No[219]	15+;[220] 11+: Notes app;[221] 8+: Only for inputting credit card details[222]	No	No	No
Third party input methods	Yes[223]	8+	?	?	?
Gesture text input	4+[224]	13+;[225] 8+: 3rd party software like SwiftKey	?	No[226]	No
Emoji support	4.4+[227]	Yes[228]	?	2.2.0+[229] 3rd party software[230]	Yes

Maps and navigation[edit]

Maps and navigation					
Feature	Android	iOS	Tizen	Sailfish OS	Ubuntu Touch
Safe driving mode	3rd party software	11+[231]	?	?	?
Turn-by-turn navigation	2+[232]	6+[233]	?	Yes	3rd party software
Offline maps	3rd party software Google Maps,[234] Here WeGo	6+[235]	?	3rd party software	3rd party software
Alternative routes in maps	Yes[236]	5+[237][238]	?	3rd party software	3rd party software

Media playback and controls[edit]

Media playback and controls					
Feature	Android	iOS	Tizen	Sailfish OS	Ubuntu Touch
Audio playback	AAC LC/LTP 3GPP, HE-AACv1 (AAC+), HE-AACv2 (enhanced AAC+) AMR-NB, AMR-WB, MP3, MIDI (Type 0 and 1, DLS versions 1 and 2), Ogg Vorbis, PCM/WAVE, FLAC, WAVE, Opus[239]	AAC, protected AAC (from iTunes Store), HE-AAC, MP3, MP3 VBR, Audible (formats 2, 3, 4, Audible Enhanced Audio, AAX, and AAX+), Apple Lossless, AIFF, WAV[240]	AAC, AAC+, eAAC+, AMR-NB, AMR-WB, MP3, Vorbis, WAV[241]	MP3, FLAC, AAC, eAAC, eAAC+, ALAC, AC3, DTS, Opus, Vorbis	?

Video playback	H.263, H.264 (up to Baseline Profile), H.265 HEVC, MPEG-4 SP, DivX, XviD, VP8, VP9[239] (WMV on 3rd party software like VLC media player)	H.264 (up to High Profile), MPEG-4, M-JPEG[240]	H.263, H.264, MPEG-4 Part 2[241]	MPEG-4, H264, H263,[242] although audio in recorded videos is out of sync[243]	?
Wired video out	4K on 6+[244]	Up to 1080p via HDMI[245] or VGA,[246] 576p/480p via component[247] or composite;[248]	No	No[249]	Yes
Wired digital audio output	5+ USB Audio[250]	7+: USB Audio[251]	No	No	Yes
Wireless video/audio streaming to set top boxes/TVs/speakers	4.2+ Miracast,[252] but DLNA[253] only available on selected devices	AirPlay[254]	DLNA[255]	?	Yes
Media player on-device playlist creation	Yes[256]	Yes[57]	?	Yes	Yes
Media player video scrubbing	Yes	Yes	?	?	?
Media player audio scrubbing	Yes	Yes	?	?	?
Media player fine scrubbing	No,[257] 3rd party software like VLC media player, basic fine scrubbing removed on 4+[258]	Yes[259]	?	?	?
Media player double speed playing	6+[260]	Only Podcasts[261]	?	?	?

Peripheral support[edit]

Peripheral support					
Feature	Android	iOS	Tizen	Sailfish OS	Ubuntu Touch
Bluetooth keyboard	2.3+;[262] previous versions via 3rd party software[263]	Yes[264]	No	Yes[265][266]	Yes
USB keyboard	3.1+[262]	With Camera Connection Kit[267]	No	Yes	Yes
Interchangeable external memory cards	Yes[268]	Only for photo/video import with an optional accessory	Yes[269]	Yes	Yes

Photo and video[edit]

Photo and video					
Feature	Android	iOS	Tizen	Sailfish OS	Ubuntu Touch
Camera focus at specified point	2.3+[270]	Yes[57]	?	1.0.4+[271]	Yes
Camera exposure metering from specified point	No,[272] available on some phones.[273][274]	Yes[275]	No	?	No
On device picture info (including Exif data)	Only date and location; more with 3rd party software[276]	Only date and location; more with 3rd party software[277]	No	?	Yes

On device picture categorization	No[278] 3rd party software like TouchWiz[279]	5+[280]	No	?	No
On device picture description and search	No[281]	10+: Items/objects in picture;[282] 7+: Only date and location[283]	No	?	No
Turn off shutter sound	In silent mode[284]	In silent mode[285]	In silent mode	In silent mode[286]	No
Picture crop	Yes	5+[287]	No	Yes	Yes
Photo rotation	Yes	5+[287]	No	Yes	Yes
Photo red-eye reduction	2.3+[288]	5+[287]	No	No[289]	No
HDR photos option	4.2+, some manufacturers earlier[290]	Yes[291]	No	No[292]	Yes
Photo/video import from memory cards	Yes	With Camera Connection Kit[267]	Yes	Yes	Yes
Video trim	2.3+	Yes	No	?	No

Productivity[edit]

Productivity					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**

Multitasking	Yes	7+;[293] 4–6: Limited[294]	2+[109]	Yes	Yes
Quick app switching	7+[295]	9+: via 3D Touch;[296] 5+: only on iPad[297]	No	No	Yes
Document-centric multitasking	5+[298]	13+: can open different views of same app side by side[299]	No	No	No
Split-screen app usage	7+, some manufacturers earlier[300]	9+: only on iPad with 2 GB RAM or more[301]	Yes[302]	No [303]	Tablet-only
Desktop interactive widgets	Yes	10+: App icons via 3D Touch and/or dedicated widget screen[304]	No	Yes	No
Lock screen widgets	Yes (Notifications and settings). Full Widgets on Android 4.2–4.4 only.[305][306]	Media player, voicemail, camera;[307] 5+: Notifications; 7+: Control Center 8+: Interactive Notifications[308] 10+: Full widgets[304]	Media player; Notifications (SMS, call)	Yes	No
Notification view widgets	4.1+: Google Now and possible with 3rd party apps	8+	No	Yes	No
Quick settings toggles	2+[309]	7+[310]	No	Via the Patchmanager app[311]	Yes

Search multiple internal apps at once	Yes	Yes	Yes	No[312]	Yes
Settings search	5+ or 3rd party software like LineageOS[313]	9+[314]	No	No	Yes
Search all fields of internal objects	Only search Contacts name field but not any other field[315]	6+[316]	Only searches contacts by name	First name, last name, nickname, also the multiple field called "Details"[317]|?	
Core apps missing search	Calendar[318] (available since 3+ and HTC Sense)	Bookmarks[319]	?	?	?
Phone number links to dialer	Available in stock Android, but not all devices enable it.[320]	Yes	Yes, but not in browser	Yes	Yes
Addresses links to maps	In Contacts, but not in Calendar[321] nor in Gmail[322]	Yes[323]	?	Yes	?
Dates links to calendar	No	Yes[324]	Yes	Yes	?

Ringtones and alerts[edit]

Ringtones and alerts					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
Custom ringtones	Yes	Yes[325]	Yes	Yes	Yes

Custom SMS/MMS tones	Yes[326]	5+[327]	?	Yes	No
Custom vibrate alert patterns	No,[328] possible on some Samsung devices such as Galaxy S III, but limited[329]	5+[330][331]	?	API available for 3rd party apps	No
Dismiss repeating alarm clock before trigger	4.4+[332]	No[333]	No	?	Yes
Tap to snooze[334]	3rd party apps[335]	Yes	No	Swipe down	Yes

Security and privacy[edit]

Security and privacy					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
Proxy server	3.1+[336] but only global, not per connection[337] and only works for the browser[338] 3rd party apps available[339]	Yes	Yes	Yes[340]	No
On-device encryption	3+[341] but insecure on Qualcomm devices[342]	Yes[343] (3rd party software may attempt brute-force attacks on password[344])	No	3.3.0+[345]	No
External storage encryption	6+	External storage not available	No	Yes	No

Zero knowledge encryption[346]	No, data is accessible by Google[347] and shared with the American PRISM surveillance program.[348]	No, data stored on iCloud is accessible by Apple[349] and shared with the American PRISM surveillance program.[348]	?	?	No
Privacy of synchronization[350]	3rd party software like ownCloud[351]	When synchronizing locally and not using iCloud	?	?	?
Sync to cloud communication encryption	2.3.4+[352]	Yes[353]	?	?	?
Wireless anti-tracking[354]	Developer Options (9+)[355]	8+[356]	No	?	No
Remote device location tracking	Yes[357]	Yes[358]	?	?	No
Remote device locking and/or data wipe	2.2+[359]	Yes[358]	?	?	No
End-to-end encrypted push notifications	Possible, notifications are handled by the app that can decrypt it[108]	Possible since iOS 7, where the app can handle the notification and decrypt it[360]	?	?	Yes
SSH Client	Yes	Yes[361][362]	?	Yes	Yes
VPN	Yes[363]	Yes[364]	?	Yes	Yes
OpenVPN	No, but possible with 3rd party firmware[365]	Yes[366]	?	Yes	Yes[*citation needed*]

WPA PEAP	Yes[367]	Yes[368]	?	In developer mode[369]	Yes[citation needed]

Sound and voice[edit]

Sound and voice					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
Separate volume for ringtone and media	Yes	Yes	?	Yes	Yes
Voice commands	Yes[370]	5+ (Siri)	?	3rd party software, such as Saera[371]	No
Offline voice commands	6+[372]	Yes[373]	?	No	No
Voice recognition	Yes	5+ (Siri)	?	No	No
Offline voice recognition	4.1+[374]	15+;[375]	No	No	No
Non-English voice recognition	Yes	Yes[205]	?	No	No
Sound recorder	Very limited (Doesn't work in background[376] and not voice controlled)	3+: Limited (Not voice controlled)[377][378]	Partial	3rd party software[379]	3rd party software

Call recorder	Yes, Phone by Google,[380] but also possible with 3rd party firmware[381]	3rd party software[382]	No	Disabled by default, must be interactively switched on during a call when enabled / 3rd party software[383]	?
Sound trim	No,[384] but 3rd party software available[385]	Yes[386]	?	?	?

Other features[edit]

Other features					
Feature	**Android**	**iOS**	**Tizen**	**Sailfish OS**	**Ubuntu Touch**
Non-intrusive incoming calls	5+[387] or 3rd party software[388]	14+[389]	No	No[390]	?
Non-intrusive notifications	Yes[391]	5+[106]	?	?	?
Move apps to external storage	2.2+[392]	External storage not allowed for apps	No	No	No
Remote Frame Buffer (RFB) protocol	Yes[393]	3rd party software[394]	?	?	?
Screencast on device	11+[395]	9+[396]	No	No	Yes
Screencast over USB	4.4+ over USB,[120] for prior versions root	8+: on OS X[398]	No	?	No

	required for 3rd party app[397]				
Screen share	On select devices using vendor's implementation[399][400][401]	3rd party software[402]	No	No	No

See also[edit]

- List of custom Android firmware
- List of GPS software for mobile phones

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