Various Mobile Technologies

1G

1G refers to the first generation of wireless cellular technology (mobile telecommunications). These are the analog telecommunications standards that were introduced in the 1980s and continued until being replaced by 2G digital telecommunications. The main difference between the two mobile cellular systems (1G and 2G), is that the radio signals used by 1G networks are analog, while 2G networks are digital.
The first commercially automated 1G cellular network was launched in Japan by Nippon Telegraph and Telephone (NTT) in 1979, initially in the metropolitan area of Tokyo. Within five years, the NTT network had been expanded to cover the whole population of Japan and became the first nationwide 1G network.

In 1981, the NMT system simultaneously launched in Denmark, Finland, Norway and Sweden. NMT was the first mobile phone network to feature international roaming. In 1983, the first 1G network launched in the USA was Chicago-based Ameritech using the Motorola DynaTAC mobile phone.
The antecedent to 1G technology is the mobile radio telephone, or 0G.

2G

2G is short for second-generation cellular technology. Second-generation 2G cellular networks were commercially launched on the GSM standard in Finland by Radiolinja in 1991. Three primary benefits of 2G networks over their predecessors were that phone conversations were digitally encrypted; 2G systems were significantly more efficient on the spectrum enabling far greater wireless penetration levels; and 2G introduced data services for mobile, starting with SMS text messages. 2G technologies enabled the various networks to provide the services such as text messages, picture messages, and MMS (multimedia messages). All text messages sent over 2G are digitally encrypted, allowing the transfer of data in such a way that only the intended receiver can receive and read it.
While radio signals on 1G networks are analog, radio signals on 2G networks are digital. Both systems use digital signaling to connect the radio towers to the rest of the mobile system. With General Packet Radio Service (GPRS), 2G offers a theoretical maximum transfer speed of 50 kbit/s (40 kbit/s in practice).With EDGE (Enhanced Data Rates for GSM Evolution), there is a theoretical maximum transfer speed of 1 Mbit/s (500 kbit/s in practice).

GSM

GSM stands for Global System for Mobile Communication.GSM is nothing but the digital mobile telephony system which is widely used in all over the world. GSM digitizes and compresses the data and then send it to the down channel with two other streams of user data. GSM operates on two frequency bands i.e either 900MHZ or 1800 MHZ .GSM is standard bearer of 2G technologies. GSM used circuit switching traffic

2.5G GPRS - General Packet Radio Service

2.5G is used to describe 2G-systems that have implemented a packet-switched domain in addition to the circuit-switched domain. It doesn't necessarily provide faster service because bundling of

timeslots is used for circuit-switched data services.

GPRS stands for General Packet Radio Service. These is packet-based wireless communication service which provides data rates ranging from 56 to 114kbps The key element of GPRS technology is that it uses packet switched data technique instead of circuit switching, and this technique makes much more efficient use of the available capacity. GPRS operates on one or more frequencies out of frequency bands which supports the radio (850,900,1800,900MHZ).

GPRS is he upgrade over the basic GSM features. It allow the mobile handset to obtain much higher data speed than what standard GSM can offers.

2.75G EDGE - Enhanced Data Rates for GSM Evolution

GPRS networks evolved to EDGE networks with the introduction of 8PSK encoding.

CDMA

Code-division multiple access (CDMA) is a channel access method used by various radio communication technologies. CDMA is an example of multiple access, where several transmitters can send information simultaneously over a single communication channel. This allows several users to share a band of frequencies. To permit this without undue interference between the users, CDMA employs spread spectrum technology and a special coding scheme.

CDMA refers to any of several protocols used in second-generation (2G) and third-generation (3G) wireless communications. As the term implies, CDMA is a form of multiplexing, which allows numerous signals to occupy a single transmission channel, optimizing the use of available bandwidth. The technology is used in ultra-high-frequency (UHF) cellular telephone systems in the 800-MHz and 1.9-GHz bands.

CDMA employs analog-to-digital conversion (ADC) in combination with spread spectrum technology. Audio input is first digitized into binary elements. The frequency of the transmitted signal is then made to vary according to a defined pattern (code), so it can be intercepted only by a receiver whose frequency response is programmed with the same code, so it follows exactly along with the transmitter frequency.

3G

3G is the third generation of wireless mobile telecommunications technology. It is the upgrade for 2G and 2.5G GPRS networks, for faster internet speed. 3G finds application in wireless voice telephony, mobile Internet access, fixed wireless Internet access, video calls and mobile TV.

The first 3G networks were introduced in 1998 and fourth generation 4G networks in 2008. 3G telecommunication networks support services that provide an information transfer rate of at least 0.2 Mbit/s. Later 3G releases, often denoted 3.5G and 3.75G, also provide mobile broadband access of several Mbit/s to smartphones and mobile modems in laptop computers.

3G technology was the result of research and development work carried out by the International Telecommunication Union (ITU) in the early 1980s. The communication spectrum between 400 MHz to 3 GHz was allocated for 3G. The first pre-commercial 3G network was launched by NTT DoCoMo in Japan in 1998, branded as FOMA. It was first available in May 2001 as a pre-release (test) of W-CDMA technology.

HSDPA/HSPA

HSDPA(High Speed Downlink Packet Access) is an advanced technology to 3G Technology i.e.,

3.5 Technology. It supports a speed of 7.2 Mbps (Megabits per Second) but its actual speed is 3 Mbps only. It supports to load larger files, MobileTV Streaming and Road Maps etc. HSUPA – High Speed Uplink Packet Access is another technology besides of HSDPA. It is created by Nokia and supports a speed of 5.76 Mbps (Megabits per Second).
HSDPA and HSUPA together called as HSPA.

UMTS

UMTS(Universal Mobile Telecommunications System) is also a 3G Technology i.e., 3rd Generation Technology which is commonly called as WCDMA (Wideband CDMA). It provides faster data transfer rates at 42 Mbps (Megabits per second).

EV-DO

EV-DO(Evolution Data-Only) mainly runs on CDMA Networks for 3G. It supports a speed of 2.4 Mbps (Megabits per Second) but its actual speed is 450 Kbps(Kilobits per Second).

4G

4G is the fourth generation of broadband cellular network technology, succeeding 3G. A 4G system must provide capabilities defined by ITU in IMT Advanced. Potential and current applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing, and 3D television.

The first-release Long Term Evolution (LTE) standard was commercially deployed in Oslo, Norway, and Stockholm, Sweden in 2009, and has since been deployed throughout most parts of the world. In March 2008, the International Telecommunications Union-Radio communications sector (ITU-R) was specified a set of requirements for 4G standards, named the International Mobile Telecommunications Advanced (IMT-Advanced) specification, setting peak speed requirements for 4G service at 100 megabits per second (Mbit/s)(=12.5 megabytes per second) for high mobility communication (such as from trains and cars) and 1 gigabit per second (Gbit/s) for low mobility communication (such as pedestrians and stationary users).

Unlike 3G, which is based on two parallel infrastructures consisting of circuit switched and packet switched network nodes, 4G is based on packet switching only. This requires low-latency data transmission.As IPv4 addresses are (nearly) exhausted, IPv6 is essential to support the large number of wireless-enabled devices that communicate using IP.

Since the first-release versions of Mobile WiMAX and LTE support much less than 1 Gbit/s peak bit rate, they are not fully IMT-Advanced compliant, but are often branded 4G by service providers. According to operators, a generation of the network refers to the deployment of a new non-backward-compatible technology.

An IMT-Advanced cellular system must fulfill the following requirements:
- Be based on an all-IP packet switched network.
- Have peak data rates of up to approximately 100 Mbit/s for high mobility such as mobile access and up to approximately 1 Gbit/s for low mobility such as nomadic/local wireless access.
- Be able to dynamically share and use the network resources to support more simultaneous users per cell.
- Use scalable channel bandwidths of 5–20 MHz, optionally up to 40 MHz.
- Have peak link spectral efficiency of 15-bit/s/Hz in the downlink, and 6.75-bit/s/Hz in the up link (meaning that 1 Gbit/s in the downlink should be possible over less than 67 MHz bandwidth).

- System spectral efficiency is, in indoor cases, 3-bit/s/Hz/cell for downlink and 2.25-bit/s/Hz/cell for up link.
- Smooth handovers across heterogeneous networks.

Mobile WiMAX (IEEE 802.16e)

The Mobile WiMAX (IEEE 802.16e-2005) mobile wireless broadband access (MWBA) standard is sometimes branded 4G, and offers peak data rates of 128 Mbit/s downlink and 56 Mbit/s uplink over 20 MHz wide channels.
Data speeds of WiMAX
Peak download 128 Mbit/s
Peak upload 56 Mbit/s

3GPP Long Term Evolution (LTE)

The pre-4G 3GPP Long Term Evolution (LTE) technology is often branded "4G – LTE", but the first LTE release does not fully comply with the IMT-Advanced requirements. LTE has a theoretical net bit rate capacity of up to 100 Mbit/s in the downlink and 50 Mbit/s in the uplink if a 20 MHz channel is used — and more if multiple-input multiple-output (MIMO), i.e. antenna arrays, are used.
Data speeds of LTE
Peak download 100 Mbit/s
Peak upload 50 Mbit/s

LTE Advanced

LTE Advanced (Long Term Evolution Advanced) is a candidate for IMT-Advanced standard, formally submitted by the 4GPP organization to ITU-T in the fall 2009. LTE Advanced is essentially an enhancement to LTE. It is not a new technology, but rather an improvement on the existing LTE network. This upgrade path makes it more cost effective for vendors to offer LTE and then upgrade to LTE Advanced. LTE and LTE Advanced will also make use of additional spectrums and multiplexing to allow it to achieve higher data speeds. Release 10 of LTE is expected to achieve the IMT Advanced speeds. Release 8 currently supports up to 300 Mbit/s of download speeds which is still short of the IMT-Advanced standards.
Data speeds of LTE-Advanced
Peak download   1000 Mbit/s
Peak upload 500 Mbit/s

5G

5G is the fifth generation of cellular mobile communications. It succeeds the 4G (LTE/WiMax), 3G (UMTS) and 2G (GSM) systems. 5G performance targets high data rate, reduced latency, energy saving, cost reduction, higher system capacity, and massive device connectivity. The first phase of 5G specifications in Release-15 will be completed by April 2019 to accommodate the early commercial deployment. The second phase in Release is due to be completed by April 2020 for submission to the International Telecommunication Union (ITU) as a candidate of IMT-2020 technology.
The ITU IMT-2020 specification demands speeds up to 20 gigabits per second, achievable with millimeter waves of 15 gigahertz and higher frequency. 3GPP is going to submit 5G NR (New Radio) as its 5G communication standard proposal. 5G NR can include lower frequencies, from 600 MHz to 6 GHz.

Mobile Operating System

A mobile operating system, also called a mobile OS, is an operating system that is specifically designed to run on mobile devices such as mobile phones, smartphones, PDAs, tablet computers and other handheld devices. Much like the Linux or Windows operating system controls your desktop or laptop computer, a mobile operating system is the software platform on top of which other programs can run on mobile devices. The operating system is responsible for determining the functions and features available on your device, such as thumb wheel, keyboards, WAP, synchronization with applications, email, text messaging and more. While computers such as typical laptops are 'mobile', the operating systems usually used on them are not considered mobile ones, as they were originally designed for desktop computers that historically did not have or need specific mobile features. This distinction is becoming blurred in some newer operating systems that are hybrids made for both uses.

The mobile OS will also determine which third-party applications (mobile apps) can be used on your device.A mobile OS typically starts up when a device powers on, presenting a screen with icons or tiles that present information and provide application access. Mobile operating systems combine features of a personal computer operating system with other features useful for mobile or handheld use; usually including, and most of the following considered essential in modern mobile systems; a wireless inbuilt modem and SIM tray for telephony and data connection, a touchscreen, cellular, Bluetooth, Wi-Fi Protected Access, Wi-Fi, Global Positioning System (GPS) mobile navigation, video- and single-frame picture cameras, speech recognition, voice recorder, music player, near field communication, and infrared blaster.Examples of mobile device operating systems include Apple iOS, Google Android, Research in Motion's BlackBerry OS, Nokia's Symbian, Hewlett-Packard's webOS (formerly Palm OS) and Microsoft's Windows Phone OS.

Android OS (Google Inc.)

The Android mobile operating system is Google's open and free software stack that includes an operating system, middleware and also key applications for use on mobile devices, including smartphones. Updates for the open source Android mobile operating system have been developed under "dessert-inspired" version names (Cupcake, Donut, Eclair, Gingerbread, Honeycomb, Ice Cream Sandwich) with each new version arriving in alphabetical order with new enhancements and improvements.

iPhone OS / iOS (Apple)

Apple's iPhone OS was originally developed for use on its iPhone devices. Now, the mobile operating system is referred to as iOS and is supported on a number of Apple devices including the iPhone, iPad, iPad 2 and iPod Touch. The iOS mobile operating system is available only on Apple's own manufactured devices as the company does not license the OS for third-party hardware. Apple iOS is derived from Apple's Mac OS X operating system. Major versions of iOS are released annually. The current version, iOS 12, was released on September 17, 2018.

Windows

A mobile operating system for smartphones and mobile devices from Microsoft based on the Windows CE kernel and designed to look and operate similar to desktop versions of Microsoft

Windows. In 2010 Microsoft announced a new smartphone platform called Windows Phone 7. Windows Phone 7 was first launched in October 2010. Windows Phone 8.1 is the latest public release of the operating system, released to manufacturing on April 14, 2014.

Windows Phone was replaced by Windows 10 Mobile in 2015; it emphasizes a larger amount of integration and unification with its PC counterpart—including a new, unified application ecosystem, along with an expansion of its scope to include small-screened tablets.On October 8, 2017, Joe Belfiore announced that work on Windows 10 Mobile was drawing to a close due to lack of market penetration and resultant lack of interest from app developers

BlackBerry OS (Research In Motion)

The BlackBerry OS is a proprietary mobile operating system developed by Research In Motion for use on the company's popular BlackBerry handheld devices. The BlackBerry platform is popular with corporate users as it offers synchronization with Microsoft Exchange, Lotus Domino, Novell GroupWise email and other business software, when used with the BlackBerry Enterprise Server. Updates to the operating system may be automatically available from wireless carriers that support the BlackBerry over the air software loading (OTASL) service. Third-party developers can write software using the available BlackBerry API classes. BlackBerry OS was discontinued after the release of BlackBerry 10 in January 2013

Palm OS

Palm OS is the computer operating system that provides a software platform for the Palm series of handheld personal digital assistants (PDAs) made by Palm Inc. Palm OS (also known as Garnet OS) is a discontinued mobile operating system initially developed by Palm, Inc., for personal digital assistants (PDAs) in 1996. Palm OS was designed for ease of use with a touchscreen-based graphical user interface. It is provided with a suite of basic applications for personal information management.

Symbian OS (Nokia)

Symbian is a mobile operating system (OS) targeted at mobile phones that offers a high-level of integration with communication and personal information management (PIM) functionality. Symbian OS combines middleware with wireless communications through an integrated mailbox and the integration of Java and PIM functionality (agenda and contacts). Nokia has made the Symbian platform available under an alternative, open and direct model, to work with some OEMs and the small community of platform development collaborators. Nokia does not maintain Symbian as an open source development project.

webOS (Palm/HP)

WebOS is a mobile operating system that runs on the Linux kernel. WebOS was initially developed by Palm as the successor to its Palm OS mobile operating system. It is a proprietary Mobile OS which was eventually acquired by HP and now referred to as webOS (lower-case w) in HP literature. HP uses webOS in a number of devices including several smartphones and HP TouchPads. HP has pushed its webOS into the enterprise mobile market by focusing on improving security features and management with the release of webOS 3.x. HP has also announced plans for a version of webOS to run within the Microsoft Windows operating system and to be installed on all HP desktop and notebook computers in 2012.

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Apple IOS

iOS (formerly iPhone OS) is a mobile operating system created and developed by Apple Inc. exclusively for its hardware. It is the operating system that presently powers many of the company's mobile devices, including the iPhone, iPad, and iPod Touch. It is the second most popular mobile operating system globally after Android.

Originally unveiled in 2007 for the iPhone.The iOS user interface is based upon direct manipulation, using multi-touch gestures. Interface control elements consist of sliders, switches, and buttons. Interaction with the OS includes gestures such as swipe, tap, pinch, and reverse pinch, all of which have specific definitions within the context of the iOS operating system and its multi-touch interface. Internal accelerometers are used by some applications to respond to shaking the device (one common result is the undo command) or rotating it in three dimensions (one common result is switching between portrait and landscape mode).

Major versions of iOS are released annually. The current version, iOS 12, was released on September 17, 2018. It is available for all iOS devices with 64-bit processors; On all recent iOS devices, iOS regularly checks on the availability of an update, and if one is available, will prompt the user to permit its automatic installation.
The operating system was unveiled with the iPhone at the [Macworld Conference & Expo](#) on January 9, 2007, and released in June of that year.[13][14][15] At the time of its unveiling in January. In October 2007, Apple announced that a native Software Development Kit (SDK) was under development and that they planned to put it "in developers' hands in February".[21][22][23] On March 6, 2008, Apple held a press event, announcing the iPhone SDK.[24][25] The [iOS App Store](#) was opened on July 10, 2008 with an initial 500 applications available.[26] This quickly grew to 3,000 in September 2008,[27] 15,000 in January 2009,[28] 50,000 in June 2009,[29] 100,000 in November 2009,[30][31] 250,000 in August 2010,[32][33] 650,000 in July 2012,[34] 1 million in October 2013,[35][36] 2 million in June 2016,[37][38][39] and 2.2 million in January 2017.[40][41] As of March 2016, 1 million apps are natively compatible with the [iPad](#) tablet computer. Apple provides major updates to the iOS operating system annually via [iTunes](#) and also, for iOS 5 and later, [over-the-air](#).[50] The latest version is [iOS 12](#), released on September 17, 2018.[51] It is available for [iPhone 5S](#) and later, [iPad Air](#) and later, [iPad Pro](#), [iPad Mini 2](#) and later, and sixth-generation [iPod Touch](#).[

Features

Home screen
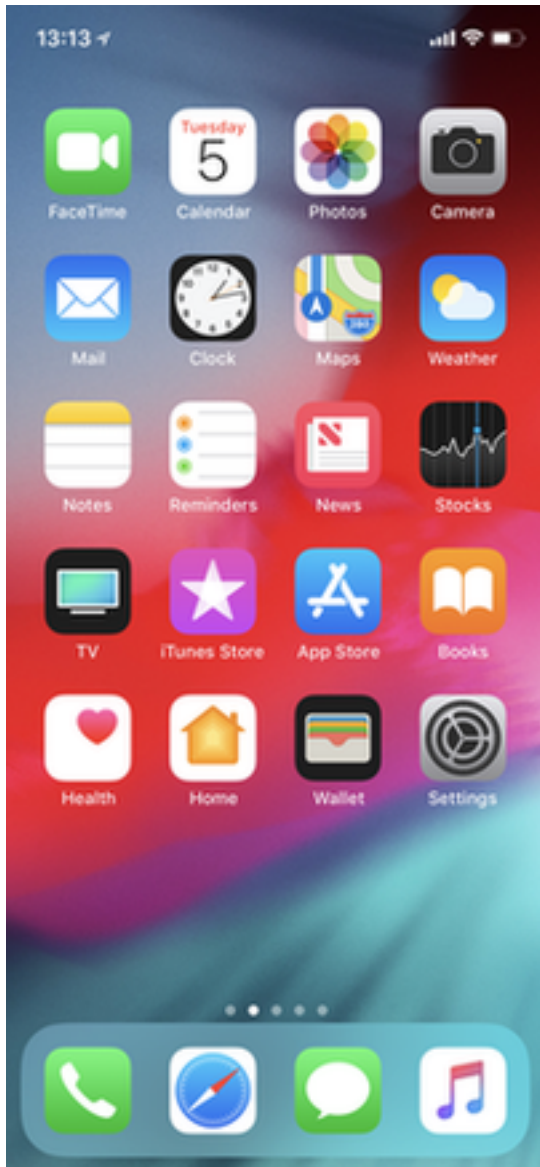
iOS 12 running on an iPhone X

The home screen displays [application](#) icons and a dock at the bottom where users can pin their most frequently used apps. The home screen appears whenever the user unlocks the device or presses the physical "Home" button whilst in another app. The screen has a status bar across the top to display data, such as time, battery level, and signal strength. The rest of the screen is devoted to the current application. When a passcode is set and a user switches on the device, the passcode must be entered at the Lock Screen before access to the Home screen is granted.

Notification Center

Before iOS 5, notifications were delivered in a [modal window](#) and couldn't be viewed after being dismissed. In iOS 5, Apple introduced [Notification Center](#), which allows users to view a history of notifications.

Accessibility

iOS offers various accessibility features to help users with vision and hearing disabilities. One major feature, [VoiceOver,](#) provides a voice reading information on the screen, including contextual buttons, icons, links and other [user interface](#) elements, and allows the user to navigate the

operating system through gestures. Any apps with default controls and developed with a UIKit framework gets VoiceOver functionality built in.

Multitasking

Multitasking for iOS was first released in June 2010 along with the release of iOS 4. Only certain devices—iPhone 4, iPhone 3GS, and iPod Touch 3rd generation—were able to multitask. Currently, multitasking is supported on iPhone 3GS+, iPod Touch 3rd generation+, and all iPad models.

Implementation of multitasking in iOS has been criticized for its approach, which limits the work that applications in the background can perform to a limited function set and requires application developers to add explicit support for it.]Starting with iOS 4, on third-generation and newer iOS devices, multitasking is supported through seven background APIs:

1. Background audio – application continues to run in the background as long as it is playing audio or video content
2. Voice over IP – application is suspended when a phone call is not in progress[92]
3. Background location – application is notified of location changes[92]
4. Push notifications
5. Local notifications – application schedules local notifications to be delivered at a predetermined time[92]
6. Task completion – application asks the system for extra time to complete a given task[92]
7. Fast app switching – application does not execute any code and may be removed from memory at any time[92]

Switching applications
In iOS 4.0 to iOS 6.x, double-clicking the home button activates the application switcher. A scrollable dock-like interface appears from the bottom, moving the contents of the screen up. Choosing an icon switches to an application. .
With the introduction of iOS 7, double clicking the home button also activates the application switcher. However, unlike previous versions it displays screenshots of open applications on top of the icon and horizontal scrolling allows for browsing through previous apps, and it is possible to close applications by dragging them up
.Ending tasks
In iOS 4.0 to iOS 6.x, briefly holding the icons in the application switcher makes them "jiggle" (similarly to the homescreen) and allows the user to *force* quit the applications by tapping the red minus circle that appears at the corner of the app's icon. As of iOS 7, the process has become faster and easier. In iOS 7, instead of holding the icons to close them, they are closed by simply swiping them upwards off the screen. Up to three apps can be cleared at a time compared to one in versions up to iOS 6.1.6

Task completion

Task completion allows apps to continue a certain task after the app has been suspended. As of iOS 4.0, apps can request up to ten minutes to complete a task in the background. This doesn't extend to background up- and downloads though (e.g. if you start a download in one application, it won't finish if you switch away from the application).

Siri

Siri is an intelligent personal assistant integrated into iOS. The assistant uses voice queries and a natural language user interface to answer questions, make recommendations, and perform actions

by delegating requests to a set of Internet services. The software adapts to users' individual language usages, searches, and preferences, with continuing use.

Game Center

Game Center is an [online](#) [multiplayer](#) "social gaming network" released by Apple. It allows users to "invite friends to play a game, start a multiplayer game through matchmaking, track their [achievements](#), and compare their high scores on a [leaderboard](#)." iOS 5 and above adds support for profile photos

Hardware

The main hardware platform for iOS is the [ARM architecture](#). iOS releases before [iOS 7](#) can only be run on iOS devices with [32-bit](#) ARM processors ([ARMv6](#) and [ARMv7-A](#) architectures). In 2013, [iOS 7](#) was released with full [64-bit](#) support (which includes native 64-bit kernel, libraries, drivers as well as all built-in applications), after Apple announced that they were switching to 64-bit [ARMv8-A](#) processors with the introduction of the [Apple A7](#) chip. 64-bit support was also enforced for all apps in the [App Store](#);

Development

Main article: [iOS SDK](#)

The iOS SDK ([Software Development Kit](#)) allows for the development of [mobile apps](#) on iOS. The SDK is a free download for users of [Mac](#) personal computers. It is not available for [Microsoft Windows](#) PCs. The SDK contains sets giving developers access to various functions and services of iOS devices, such as hardware and software attributes. It also contains an iPhone [simulator](#) to mimic the look and feel of the device on the computer while developing Combined with [Xcode](#), the iOS SDK helps developers write iOS apps using officially supported programming languages, including [Swift](#) and [Objective-C](#). Other companies have also created tools that allow for the development of native iOS apps using their respective programming languages

Kernel

The iOS kernel is the [XNU](#) kernel of [Darwin](#). The original iPhone OS (1.0) up to iPhone OS 3.1.3 used Darwin 9.0.0d1. iOS 12 is based on Darwin 18.

Security

iOS utilizes many security features in both hardware and software. Below are summaries of the most prominent features.

Secure Boot

Before fully booting into iOS, there is low-level code that runs from the Boot [ROM](#). Its task is to verify that the Low-Level [Bootloader](#) is signed by the Apple [Root](#) [CA](#) public [key](#) before running it. This process is to ensure that no malicious or otherwise unauthorized software can be run on an iOS device. After the Low-Level Bootloader finishes its tasks, it runs the higher level bootloader, known as [iBoot](#). If all goes well, iBoot will then proceed to load the iOS kernel as well as the rest of the operating system

Secure Enclave

The Secure Enclave is a [coprocessor](#) found in iOS devices that contain [Touch ID](#) or [Face ID](#). It has

its own secure boot process to ensure that it is completely secure. A hardware random number generator is also included as a part of this coprocessor. Each device's Secure Enclave has a unique ID that is given to it when it is made and cannot be changed. This identifier is used to create a temporary key that encrypts the memory in this portion of the system. The Secure Enclave also contains an anti-replay counter to prevent brute force attacks

Passcode

iOS devices can have a passcode that is used to unlock the device, make changes to system settings, and encrypt the device's contents. Until recently, these were typically four numerical digits long. However, since unlocking the devices with a fingerprint by using Touch ID has become more widespread

Touch ID

Touch ID is a fingerprint scanner that is embedded in the home button and can be used to unlock the device, make purchases, and log into applications among other functions. When used, Touch ID only temporarily stores the fingerprint data in encrypted memory in the Secure Enclave, as described above. There is no way for the device's main processor or any other part of the system to access the raw fingerprint data that is obtained from the Touch ID sensor

Address Space Layout Randomization

Address Space Layout Randomization (ASLR) is a low-level technique of preventing memory corruption attacks such as buffer overflows. It involves placing data in randomly selected locations in memory in order to make it harder to predict ways to corrupt the system and create exploits.

Non-Executable Memory

iOS utilizes the ARM architecture's Execute Never (XN) feature. This allows some portions of the memory to be marked as non-executable, working alongside ASLR to prevent buffer overflow attacks including return-to-libc attacks

Encryption

As mentioned above, one use of encryption in iOS is in the memory of the Secure Enclave. When a passcode is utilized on an iOS device, the contents of the device are encrypted. This is done by using a hardware AES 256 implementation that is very efficient because it is placed directly between the flash storage and RAM. iOS, in combination with its specific hardware, uses crypto-shredding when erasing all content and settings by obliterating all the keys in 'effaceable storage'. This renderes all user data on the device cryptographically inaccessible

Keychain

The iOS keychain is a database of login information that can be shared across apps written by the same person or organization. This service is often used for storing passwords for web applications

App Security

Third-party applications such as those distributed through the App Store must be code signed with an Apple-issued certificate. Applications are also sandboxed, meaning that they can only modify the data within their individual home directory unless explicitly given permission to do otherwise. There is a very extensive set of privacy controls contained within iOS with options to control apps ability to access a wide variety of permissions such as the camera, contacts, background app refresh, cellular data, and access to other data and services. Most of the code in iOS, including

third-party applications, run as the "mobile" user which does not have [root privileges](). This ensures that system files and other iOS system resources remain hidden and inaccessible to user-installed applications.

Network Security

iOS supports [TLS]() with both low- and high-level [APIs]() for developers. By default, the App Transport Security framework requires that servers use at least TLS 1.2. However, developers are free to override this framework and utilize their own methods of communicating over networks. When Wi-Fi is enabled, iOS uses a randomized [MAC address]() so that devices cannot be tracked by anyone [sniffing]() wireless traffic

Two-Factor Authentication

Two-factor authentication is an option in iOS to ensure that even if an unauthorized person knows an [Apple ID]() and password combination, they cannot gain access to the account. It works by requiring not only the Apple ID and password, but also a verification code that is sent to a device that is already known to be trusted.[169] If an unauthorized user attempts to sign in using another user's Apple ID, the owner of the Apple ID receives a notification that allows them to deny access to the unrecognized device.[173]