

Smartphone Operating Systems

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Key Reference: Prof. Jong-Moon Chung's Lecture Notes at Yonsei University

iPhone Evolution



iOS Evolution

iOS Evolution



iOS Evolution

- iOS

- Steve Jobs introduced the iPhone on January 9, 2007
- The iPhone and iPad started a new era of smart devices, mobile apps, and mobile computing

iOS Evolution

- **iOS 1**
 - Released in **June 2007**
 - **OS of the first iPhone**
 - **Core iOS user interface**
 - Capacitive touchscreen
 - Pinch-to-Zoom
 - Inertial Scrolling
 - **Mobile Safari web browser**
 - **Visual Voicemail**
 - **Google Maps**



iOS Evolution

- **iOS 1.1**
 - Released in **September 2007**
 - iTunes Wi-Fi Music Store
 - iPod Touch compatibility
- **iOS 1.1.3**
 - Released in **January 2008**
 - 'Locate Me' feature
 - Web clips on home screen
 - Re-arrange icons

iOS Evolution

- iOS 2 (1/2)
 - Released in **July 2008**
 - **App Store**
 - Improved app browsing and installation
 - Revolution in mobile app distribution
 - iOS **SDK** (Software Development Kit)
 - More functional apps
 - Improved appearance



iOS Evolution

- **iOS 2 (2/2)**
 - **Contact Search**
 - **Microsoft Exchange support**
 - **MobileMe**
 - A subscription-based collection of online services and software offered by Apple Inc.
 - Later, the services were being gradually transitioned and replaced by iCloud.

iOS Evolution

- **iOS 2.1**
 - Released in **September 2008**
 - Battery life and speed fixes
 - iTunes Genius playlists
 - Dropped call fixes
- **iOS 2.2**
 - Released in **November 2008**
 - **Google street view**
 - Podcast downloads

iOS Evolution

- iOS 3 (1/2)
 - Released in **June 2009**
 - Cut, Copy, and Paste
 - New text-selection metaphor that works well with touch
 - Push notifications for 3rd party apps
 - Voice Control



iOS Evolution

- **iOS 3 (2/2)**
 - **MMS (Multimedia Message Service) functionality including vCards, picture, audio files, video**
 - **Optional Subject line in the Message Settings**
 - **Photos can be taken/sent directly from the Messages app**
 - **MMS messages are played/viewed in the Message app**
 - **USB & Bluetooth tethering**
 - **Landscape keyboard**
 - **Find my iPhone**

iOS Evolution

- **iOS 3.2**
 - Released in **April 2010**
 - **Support for iPad resolution**
 - Initial release on iPad (1st generation)
 - **Allow user to change home screen background**
 - **Location-based services rely on Apple's own databases instead of Google and Skyhook Wireless**
 - **Bluetooth keyboard support**
 - **iBooks**

iOS Evolution

- iOS 4 (1/2)
 - Released in **June 2010**
 - **Multitasking**
 - **Fast App Switching/Saved State** → Allows apps to save current status for easy reuse when returning to app after multitasking
 - Retina Display support

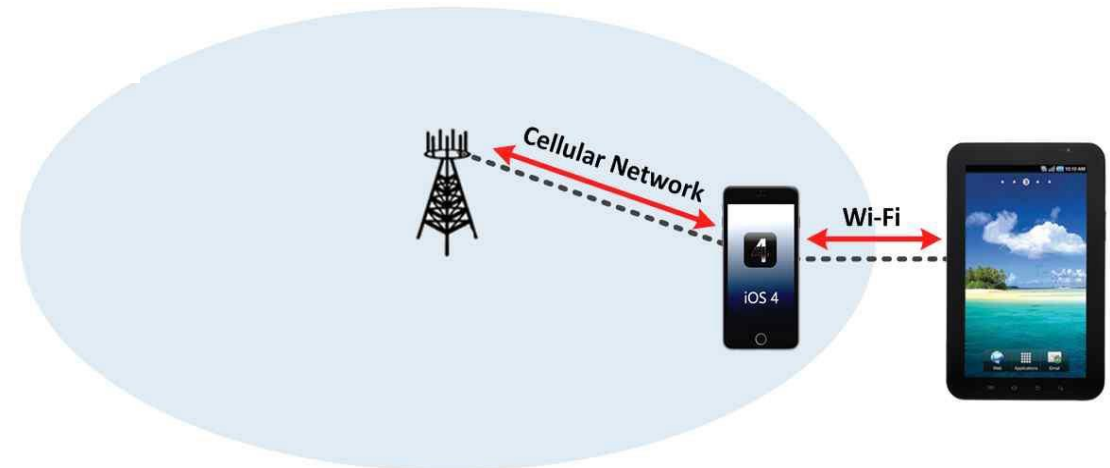


iOS Evolution

- iOS 4 (2/2)
 - **FaceTime** video chat using Wi-Fi
 - **Home Screen Folders**
 - Drag and drop an app icon on top of another app icon to form an **app folder**

iOS Evolution

- iOS 4.2.5
 - Released in **February 2011**
 - Personal hotspot using CDMA
- iOS 4.3
 - Released in **March 2011**
 - Personal hotspot using GSM



iOS Evolution

- iOS 5 (1/2)
 - Released in **October 2011**
 - **iCloud**
 - File backup
 - Multiple device sync
 - **Siri**
 - Siri **virtual assistant** replaces Voice Control



iOS Evolution

- **iOS 5 (2/2)**
 - **iMessage**
 - Free multimedia message exchanges
 - **No More PC Activation Requirement**
 - iOS 5 devices do not need to be physically tethered to a computer via USB when activated

iOS Evolution

- iOS 6 (1/2)
 - Released in **September 2012**
 - **Maps**
 - ➔ Departure from Google Maps
 - **FaceTime over mobile cellular networks**
 - Improved Apple ID integration



iOS Evolution

- **iOS 6 (2/2)**
 - **Passbook**
 - Mobile payment (tickets, coupons, boarding passes, etc.) and rewards cards
 - **Siri enhancements**
 - Sports scores, schedules, and player data
 - Restaurant reviews from Yelp
 - Reservations from OpenTable
 - Siri car control (future development): this is still evolving

iOS Evolution

- iOS 7 (1/2)
 - Released in **September 2013**
 - **Touch ID**
 - Fingerprint biometric sensor to unlock phone
 - Password-less purchases from the App Store
 - **AirDrop**
 - Ad-hoc sharing of images, videos, and files



iOS Evolution

- **iOS 7 (2/2)**
 - **FaceTime Audio**
 - **Audio-only version of FaceTime between Apple users via Wi-Fi, 3G, or LTE**

iOS Evolution

- iOS 8 (1/2)
 - Released in **September 2014**
 - Continuity
 - Works with Apple's new Mac OS X 10.10 Yosemite for enhanced **interactivity** between **iPhone** or **iPad** and **Mac** computer
 - Send and receive text messages from a Mac
 - Take phone calls from a Mac



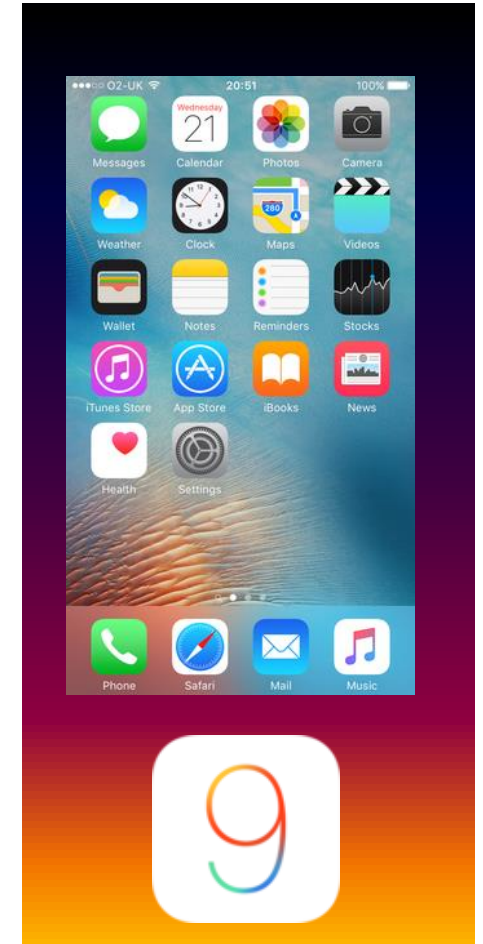
iOS Evolution

- **iOS 8 (2/2)**
 - **Third party keyboard support**
 - **HealthKit**
 - **Hub for third-party fitness trackers data**
 - **HomeKit**
 - **Home automation** (future development)
 - **iPhone can serve as a remote control** for the entire home

iOS Evolution

Any key features of the following iOS?

- iOS 9
- iOS 9.3.5
- iOS 10



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Android Evolution

Android Evolution



Android 1.5 Cupcake



Android 1.6 Donut



Android 2.0 Eclair



Android 2.2 Froyo



Android 2.3 Gingerbread



Android 3.0 Honeycomb



Android 4.0
Ice Cream Sandwich



Android 4.1 Jelly Bean



Android 4.4 KitKat



Android 5.0 Lollipop

Android Evolution



Alpha



Beta



Cupcake



Donut



Eclair



Froyo



Gingerbread

Android Nougat



Honeycomb



Ice Cream Sandwich



Jelly Bean



KitKat



Lollipop



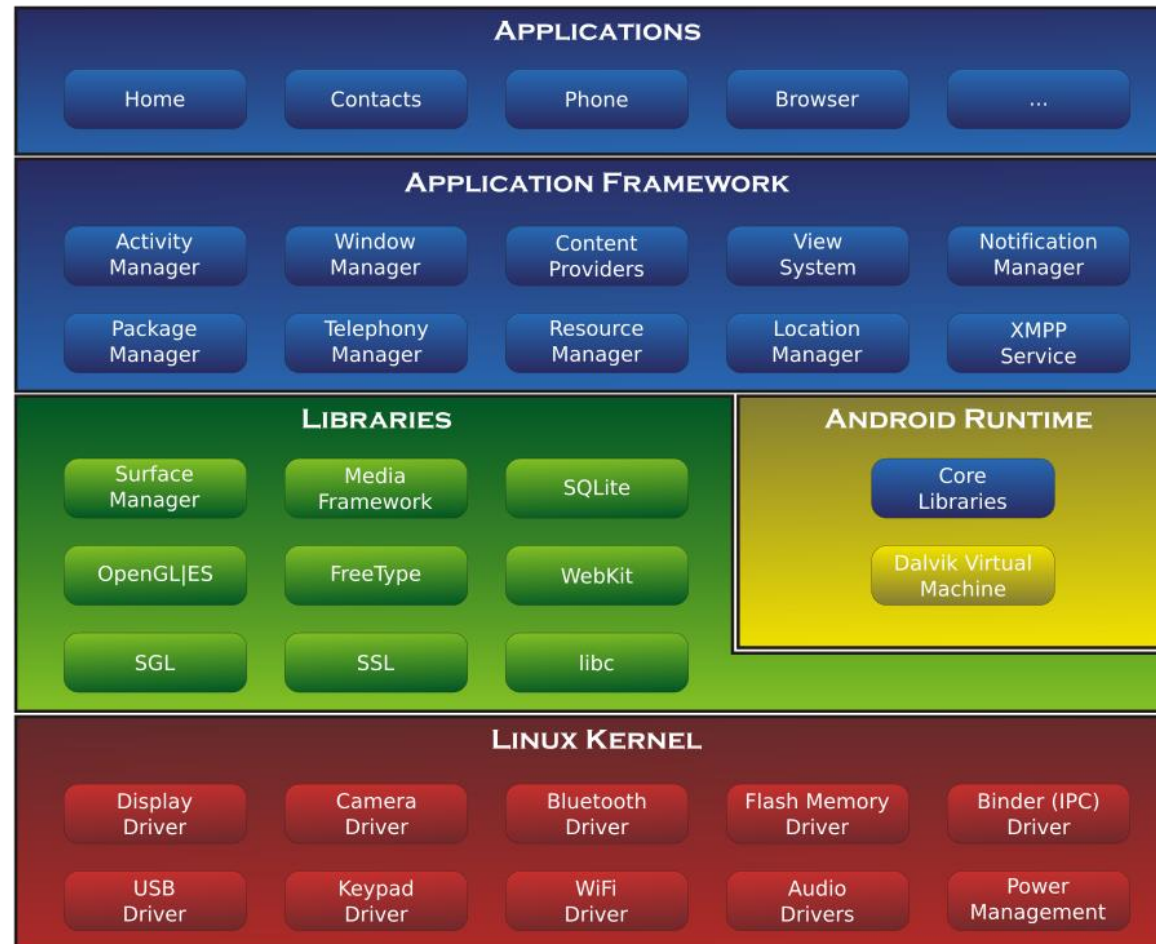
Marshmallow



Nougat

Android Evolution

Android's Architecture Diagram



Android Evolution

Android

- Android Beta
 - Released in **November 2007**
 - Beginning of the Android mobile OS (Operating System)
- Android 1.0
 - Released in **September 2008**
 - First commercial Android OS
- Android versions are linked with **API Levels**

Android Evolution

API Level

- **API** (Application Programming Interface)
- API Level is a general indicator of how much the **Programmer** can **communicate** with **built in functions** of a device
- Higher API levels indicate increased functionality control

Android Versions	Name	*Release Date	API Level	Kernel Version
1.5	Cupcake	April 30, 2009	3	2.6.27
1.6	Donut	September 15, 2009	4	2.6.29
2.0–2.1	Eclair	October 26, 2009	5-7	2.6.29
2.2	Froyo	May 20, 2010	8	2.6.32
2.3–2.3.2	Gingerbread	December 6, 2010	9	2.6.35
2.3.3–2.3.7	Gingerbread	February 9, 2011	10	2.6.35
3.0	Honeycomb	Feb 11, 2011	11	2.6.36
3.1	Honeycomb	May 10, 2011	12	2.6.36
3.2	Honeycomb	July 15, 2011	13	2.6.36
4.0-4.0.2	Ice Cream Sandwich	October 11, 2011	14	3.0.1
4.0.3-4.0.4	Ice Cream Sandwich	December 16, 2011	15	3.0.1
4.1.X	Jelly Bean	July 9, 2012	16	3.0.31
4.2.X	Jelly Bean	November 13, 2012	17	3.4.0
4.3	Jelly Bean	July 24, 2012	18	3.4.39
4.4	Kit Kat	September 2013	19, 20	3.10
5.0-5.0.2	Lollipop	November 3, 2014	21	3.16.1
5.1-5.1.1	Lollipop	March 9, 2015	22	
6.0-6.0.1	Marshmallow	October 5, 2015	23	3.18.10
7.0	Nougat	August 22, 2016	24	

*Depending on sources,
the release dates might have
a difference in several days range

Android Evolution

Android 1.0 (API level 1) (1/2)

- Grouping of Folders
→ Single Folder Icon
- Access to web **e-mail** servers
- **Wi-Fi** and **Bluetooth** support
- **Google Sync**
 - Wireless synchronization of Gmail, People, and Calendar



Android Evolution

Android 1.0 (API level 1) (2/2)

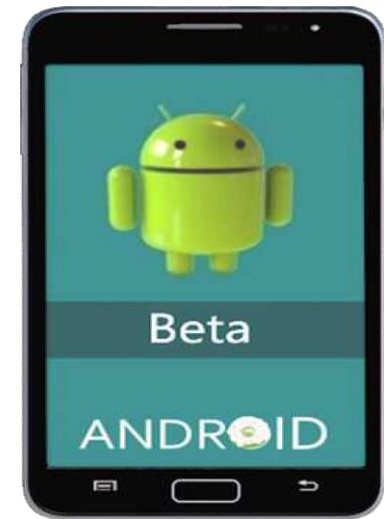
- **Basic Applications**
 - Calendar, Maps, Street View, Talk Voice Dialer, Wallpaper
- **Additional Applications**
 - (Phone) Dialer
 - (Launcher) Home Screen
 - (Gallery) Pictures
 - Alarm Clock
 - Calculator



Android Evolution

Android 1.1 (API level 2)

- Released in **February 2009**
- Released on the HTC Dream smartphone
- Attachments in messages can be saved



Android Evolution

Android 1.5 Cupcake (API level 3) (1/4)

- Released in **April 2009**
- Web Browser **Copy** and **Paste**
- User pictures added for Favorites in Contacts
- Screen Transitions with Animation
- Starting with Android 1.5 "Cupcake," Android versions were each given a confectionery code name in alphabetical order



Android Evolution

Android 1.5 Cupcake (API level 3) (2/4)

- **Auto-pairing** and **stereo support** for Bluetooth **A2DP** and **AVRCP** profiles
 - **A2DP** (Advanced Audio Distribution Profile)
 - Defines how multimedia audio can be streamed from one device (e.g., smartphone) to another device (e.g., wireless headset, hearing aid, car audio) over Bluetooth

Android Evolution

Android 1.5 Cupcake (API level 3) (3/4)

- **AVRCP** (Audio/Video Remote Control Profile)
 - Enables a single remote controller to control all local A/V equipment (e.g., TVs, Hi-Fi equipment)
 - Can be used with **A2DP**
- Third-Party **Virtual Keyboards**
 - Text Prediction
 - Custom Words User Dictionary

Android Evolution

Android 1.5 Cupcake (API level 3) (4/4)

- **Widget**
 - Miniature application that can be inserted into another application
 - Receives periodic updates
 - Used in **home screen customization**
 - Touching leads to direct app access
 - Widget Examples
 - Weather widgets
 - Clock widgets
 - Sports score trackers

Android Evolution

Android 1.6 Donut (API level 4) (1/3)

- Released in **September 2009**
- Text-to-Speech Engine
- **Multi-Lingual** Speech Synthesis Engine
 - Android applications can “Speak” a string of text
- Enhanced fully integrated Gallery, Camera, and Camcorder
 - Faster camera access



Android Evolution

Android 1.6 Donut (API level 4) (2/3)

- Multiple photo selection for deletion
- CDMA/EVDO and 802.1x support
- **VPN** (Virtual Private Network) support
 - **Virtual** point-to-point **private** dedicated network connection setup in a **public** network
 - Virtual **tunneling** protocols and packet traffic **encryption** commonly used

Android Evolution

Android 1.6 Donut (API level 4) (3/3)

- **WVGA** (Wide Video Graphics Array) Screen support
 - Wider VGA screen with same **480** Pixel Height
 - Aspect Ratio 3:2
 - 720x**480**
 - Aspect Ratio 5:3
 - 800x**480**
 - Approximate Aspect Ratio 16:9
 - 848x**480**, 852x**480**, 853x**480**, 854x**480**

Android Evolution

Android 2.0 Éclair (API level 5) (1/4)

- Released in **October 2009**
- Account Sync
 - Multiple User Accounts on a single device
 - Synchronization of e-mail and contacts
- **Bluetooth 2.1** support



Android Evolution

Android 2.0 Éclair (API level 5) (2/4)

- Can **search** all saved SMS and MMS messages
- New Camera Features
 - Flash Support
 - Digital Zoom
 - Scene Mode
 - White Balance
 - Color Effect
 - Macro Focus



Android Evolution

Android 2.0 Éclair (API level 5) (3/4)

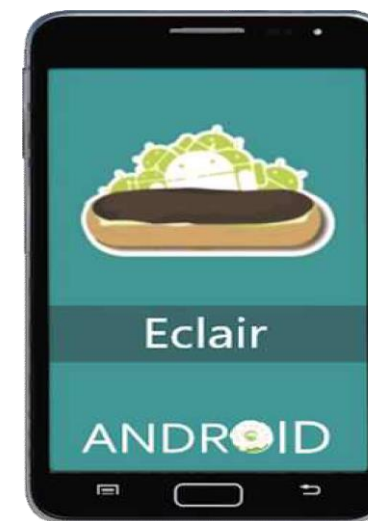
- Enhanced **Google Maps**
- Enhanced **Virtual Keyboard**
 - Improved Typing Speed using dictionary suggestions
 - Includes words used by the user
 - Includes user contacts names



Android Evolution

Android 2.0 Éclair (API level 5) (4/4)

- Motion Event class
 - ➔ Track multi-touch events
- Live Wallpapers
 - Home-Screen Background Animation
- Microsoft Exchange e-mail support



Android Evolution

Android 2.2~2.2.3 Froyo (API level 8) (1/2)

- Released in **May 2010**
- Android **C2DM** (Cloud to Device Messaging) support
 - Enables **push** notification for third-party developers
 - Used in E-mail, Contacts, and Calendar



Android Evolution

Android 2.2~2.2.3 Froyo (API level 8) (2/2)

- Adobe Flash support
- USB Tethering
- Wi-Fi Hotspot
- Multiple Keyboard Languages and Dictionary Quick switching



Android Evolution

Android 2.3~2.3.2 Gingerbread (API level 9) (1/3)

- Released in **December 2010**
- Front and Back Camera support
- Improved Virtual Keyboard
 - Intuitive text input
 - Improved accuracy
 - Improved suggested text and voice input mode



Android Evolution

Android 2.3~2.3.2 Gingerbread (API level 9) (2/3)

- Easy-to-use **Copy & Paste**
 - Word selection by **Press-Hold** → Copy → Paste
- **SIP** based **VoIP** (Voice over IP) support
 - SIP (Session Initiation Protocol) supports signaling and controlling of IP multimedia communication sessions
 - VoIP, Video Call, Instant Messaging

Android Evolution

Android 2.3~2.3.2 Gingerbread (API level 9) (3/3)

- More **Sensor** support
 - Gyroscope, Barometer, etc.
- **NFC** (Near Field Communication)
 - Used to exchange small information segments
 - Application examples
 - Payments, Posters, Stickers, Advertisement



Android Evolution

Android 2.3.4 Gingerbread (API level 10)

- Released in April 2011
- Support for **Voice** or **Video Chat** using **Google Talk**
 - Google Talk is an **Instant Messaging** service
 - Provides text and voice communication



Android Evolution

Android 3.0 Honeycomb (API level 11) (1/4)

- Released in **February 2011**
- Simplified multitasking
- First **Tablet only** Android OS
 - Optimized for Smart Tablets



Android Evolution

Android 3.0 Honeycomb (API level 11) (2/4)

- **Action Bar**
 - Top of the Screen Access
 - Contextual options, Navigation, Widgets, etc.
- **System Bar**
 - Bottom of the Screen Access
 - Notifications, Status, and Soft Navigation Buttons, etc.



Android Evolution

Android 3.0 Honeycomb (API level 11) (3/4)

- **Improved Tablet Keyboard**
 - Improvements for faster, more efficient, and more accurate typing on larger Tablet screens
- **Camera Features Quick Access**
 - Camera exposure, focus, flash, zoom, front-facing camera, time-lapse, etc.

Android Evolution

Android 3.0 Honeycomb (API level 11) (4/4)

- **Multi-Core Processor** support
- **External I/O Device** support (3.1 Honeycomb, API level 12, May 10, 2011)
 - Keyboards, Pointing Devices, Joysticks, Gamepads, etc.



Android Evolution

Android 4.0~4.0.2 Ice Cream Sandwich (API level 14) (1/3)

- Released in **October 2011**
- **Easier-to-Crete Folders**
 - **Drag-and-Drop creation**
- **Enhanced Visual Voicemail**
 - **Controllable Speed-Up or Slow-Down Voicemail messages**



Android Evolution

Android 4.0~4.0.2 Ice Cream Sandwich (API level 14) (2/3)

- **Face Unlock**
 - Facial recognition based smartphone unlocking
- Improved **Camera** functionality
 - Zero shutter lag, time lapse settings, panorama mode, zoom control during recording



Android Evolution

Android 4.0~4.0.2 Ice Cream Sandwich (API level 14) (3/3)

- Location and Person based gallery layout
- Built-in Photo Editor
- **Wi-Fi Direct**



Android Evolution

Android 4.1 Jelly Bean (API level 16) (1/3)

- Released in **July 2012**
- Bi-directional text and other language support
- Bluetooth data transfer



Android Evolution

Android 4.1 Jelly Bean (API level 16) (2/3)

- **Android Beam**
 - Instant file sharing of two NFC enabled phones by touching each other
- **Keymaps (Keyboard maps)**
 - Additional international keymaps and special layout keyboard types can be installed



Android Evolution

Android 4.1 Jelly Bean (API level 16) (3/3)

- **Multi-Channel Audio**
 - Supported on smartphones with Multi-Channel Audio output through HDMI
 - For non-equipped devices, Android automatically down-mixes the audio to fit the number of audio channels supported by the smartphone

Android Evolution

Android 4.3 Jelly Bean (API level 18)

- **BLE** (Bluetooth Low Energy) support
- **AVRCP 1.3** support
 - **AVRCP** (Bluetooth Audio/Video Remote Control Profile)



Android Evolution

Android 4.4 KitKat (API level 19) (1/3)

- Released in **October 2013**
- **Wireless Printing**
- Step detector and counter
- NFC Host Card emulation
 - Smartphones are capable of **replacing smart cards**
- Sensor batching
 - Collects and delivers sensor events efficiently in batches



Android Evolution

Android 4.4 KitKat (API level 19) (2/3)

- **Loudness Enhancer**
 - Increase the loudness of speech in media playback apps
- **Built-in Screen Recording**
 - Primarily for developers → Use of ADB (Android Debug Bridge) is required
- **Bluetooth MAP** (Message Access Profile)
 - Apps can exchange messages with a nearby device

Android Evolution

Android 4.4 KitKat (API level 20) (3/3)

- Released in June 2014
- **Wearable** Extensions
 - Android Wear platform for **smartwatches**



Android Evolution

Android 5.0~5.0.2 Lollipop (API level 21) (1/3)

- Released in **November 2014**
- **64 bit CPU** support
- **Audio Input and Output through USB devices**



Android Evolution

Android 5.0~5.0.2 Lollipop (API level 21) (2/3)

- 3rd-party applications can read and modify data on external storages (e.g., SD cards)
- Memory of recently used applications
 - Even after restarting the device the memory of recently used apps is maintained

Android Evolution

Android 5.0~5.0.2 Lollipop (API level 21) (3/3)

- Addition of **15 new languages**
 - Basque, Bengali, Burmese, Chinese (Hong Kong), Galician, Icelandic, Kannada, Kyrgyz, Macedonian, Malayalam, Marathi, Nepali, Sinhala, Tamil, and Telugu



Android Evolution

- **Android 6.0 Marshmallow**
- **Android 7.0 Nougat Cheesecake**

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Android vs. iOS

Android vs. iOS

	Android	iOS
Developer	Google	Apple
OS family	Linux	OS X, UNIX
Customizability	High	Low
Initial release	Sept. 23, 2008	July 29, 2007
Programming Language	C, C++, Java	C, C++, Objective-C, Swift

Android vs. iOS

	Android	iOS
Source model	Open Source	Closed but has Open Source components
Internet Browsing	Google Chrome	Mobile Safari
Voice Commands	Google Now	Siri
Video Chat	Google Hangouts	Facetime
App Store	Google Play & other app stores (e.g., Amazon)	Apple App Store

Android vs. iOS

	Android	iOS
Latest Release	Android 5.1.1 (Lollipop) April 2015	iOS 8.3 April 2015
Device Manufacturer	Google, LG, Samsung, HTC, Sony, ASUS, Motorola, and many more	Apple
Website	android.com	apple.com

Android vs. iOS

Apps Available on iOS vs. Android

- Most popular apps are available on both Android & iOS
- Google's app store is more open and tends to include some apps that are not available in iOS (e.g., Adobe Flash Player and BitTorrent)

Android vs. iOS

Apps Available on iOS vs. Android

- **iPad** has an advantage in tablets, as more apps are designed specifically iPads
- Many Android tablet apps are **scaled up versions** of apps that were made for Android smartphones
- Developers at smaller companies may first develop their app for an iPhone or iPad and then conduct development in Android

Android vs. iOS

Mobile Payments

- **Google Wallet** is used in Android
 - Supported on smartphones equipped with **NFC** (Near-Field Communication)
- **Apple Pay** is used in iOS
 - Integrated with **fingerprint identification**

Android vs. iOS

Building & Publishing Apps

- Android
 - Android apps are programmed in **C**, **C++**, and **Java**
 - Free download of Android source code and Android SDK
 - One-time **\$25 registration fee** for app developers that need to publish an app

Android vs. iOS

Building and Publishing Apps

- iOS
 - iOS apps are programmed using **Objective-C** and **Swift**
 - Developers need to annually pay **\$99** for access to the **iOS SDK** and **publish** in Apple's App store
 - iOS SDK is **only available** for the **Mac** platform

Android vs. iOS

Android Pros & Cons

- **Variety in Hardware selection**
 - Various Android devices are available
 - Various hardware capabilities, screen sizes and features
 - Various prices
- **Customizable User Interface**
 - Easy to customize Home screen
 - Adjustable app icons and widgets

Android vs. iOS

iOS Pros & Cons

- **Massive App Ecosystem**
 - Very Large Apple App store
 - App quality check
- **Locked Down Interface**
 - No third-party apps can be pre-installed by the mobile operator
 - Limited home screen customization options
 - Rows of app icons

Android vs. iOS

iOS Pros & Cons

- **Software Upgrades**
 - Very good software upgrade system
 - Good upgrade notifications and reminders
 - Device capability considered in upgrades
- **Privacy Control**
 - iOS provides good control of user private information (e.g., contacts and location)

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