

Smartphone Specifications

Hwajung Lee

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

Smartphone Specifications (1)

	Galaxy S6 edge	G4	iPhone 6 plus
Manufacturer	Samsung	LG	Apple
Released Date	April 2015	April 2015	September 2014
Cellular Network	GSM / HSPA / LTE	GSM / HSPA / LTE	GSM / HSPA / LTE / CDMA / EVDO
WLAN (Wi-Fi)	802.11 a/b/g/n/ac, Dual-Band, Wi-Fi Direct, Hotspot	802.11 a/b/g/n/ac, Dual-Band, Wi-Fi Direct, DLNA, Hotspot	802.11 a/b/g/n/ac, Dual-Band, Hotspot
Bluetooth	v4.1, A2DP, LE, apt-X	v4.1, A2DP, LE, apt-X	v4.0, A2DP, LE

Smartphone Specifications (2)

		Galaxy S6 edge	G4	iPhone 6 plus
Platform	OS	Android OS, v5.0.2 (Lollipop)	Android OS, v5.1 (Lollipop)	iOS 8 upgradable to iOS 8.3
	Chipset	Exynos 7420	Qualcomm MSM8992 Snapdragon 808	Apple A8
	CPU	Quad-core 1.5 GHz Cortex-A53 & Quad-core 2.1 GHz Cortex-A57	Dual-core 1.82 GHz Cortex-A57 & Quad-core 1.44 GHz Cortex-A53	Dual-core 1.4 GHz Cyclone (ARM v8-based)
	GPU	Mali-T760MP8	Adreno 418	PowerVR GX6450 (quad-core graphics)

Smartphone Specifications (3)

		Galaxy S6 edge	G4	iPhone 6 plus
Display	Type	Super AMOLED	IPS LCD	LED-backlit IPS LCD
	Size	5.1 inches	5.5 inches	5.5 inches
	Resolution	2560 x 1440 Pixels	2560 x 1440 Pixels	1920 x 1080 Pixels
	Protection	Corning Gorilla Glass 4	Corning Gorilla Glass 3	Ion-strengthened glass, Oleophobic coating

Smartphone Specifications (4)

		Galaxy S6 edge	G4	iPhone 6 plus
GPS		GPS, A-GPS, GLONASS, Beidou	GPS, A-GPS, GLONASS	GPS, A-GPS, GLONASS
Radio		No	Stereo FM radio with RDS	No
Charging feature		Wireless Charging (Qi / PMA)	Optional Wireless Charging (Qi-enabled)	-
Battery	Capacity	Li-Ion 2600 mAh	Li-Ion 3000 mAh	Li-Po 2915 mAh
Camera	Primary	16 MP 5312 x 2988 pixels	16 MP 5312 x 2988 pixels	8 MP 3264 x 2448 pixels
	Secondary	5 MP 1440p	8 MP 1080p@30fps	1.2 MP 720p@30fps

Quick Peek: Mobile Communication (1)

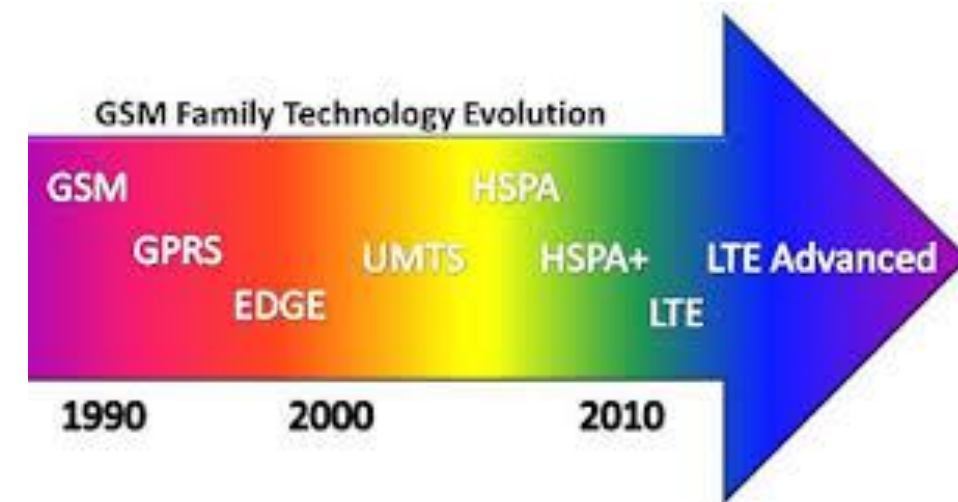
- **Mobile Phone Evolution**
 - **1st Generation (1G)**
 - **AMPS**
 - **2nd Generation (2G)**
 - **GSM, IS-95 (cdmaOne)**
 - **3rd Generation (3G)**
 - **UMTS (WCDMA), CDMA2000**
 - **4th Generation (4G)**
 - **LTE-A**

Quick Peek: Mobile Communication (2)

In mobile communications, frequently, the terms GSM, GPRS, EDGE, UMTS, HSPA and LTE appear. These terms refer to different standards of data transfer and are noticeable for the mobile phone user mainly in a different data transfer rate. In this table, I have contrasted the different standards:

Shortcut Name		Download	Upload	Display
GSM	Global System for Mobile Communications	14.4 Kbit/s	14.4 Kbit/s	2G
GPRS	General Packet Radio Service	53.6 Kbit/s	26.8 Kbit/s	G
EDGE	Enhanced Data Rate for GSM Evolution	217.6 Kbit/s	108.8 Kbit/s	E
UMTS	Universal Mobile Telecommunication Service	384 Kbit/s	128 Kbit/s	3G
HSPA	High Speed Packet Access	7.2 Mbit/s	3.6 Mbit/s	H
HSPA+	Evolved High Speed Packet Access Release 6	14.4 Mbit/s	5.76 Mbit/s	H+
HSPA+	Evolved High Speed Packet Access Release 7	21.1 Mbit/s or 28.0 Mbit/s	11.5 Mbit/s	H+
HSPA+	Evolved High Speed Packet Access Release 8	42.2 Mbit/s	11.5 Mbit/s	H+
HSPA+	Evolved High Speed Packet Access Release 9	84.4 Mbit/s	11.5 Mbit/s	H+
HSPA+	Evolved High Speed Packet Access Release 10	168.8 Mbit/s	23.0 Mbit/s	H+
LTE	Long Term Evolution	100 Mbit/s	50 Mbit/s	4G
LTE-A	LTE Advanced	1 Gbit/s	500 Mbit/s	4G

In the "Name" column, you will find the long name for each abbreviation. Under "Download" and "Upload", the maximum download and upload speeds that can be reached with the standards are listed. Under "Display", you can see how the standard is usually displayed in the status bar of the cell phone, when it is connected to the appropriate network.



Information Source:

Mobile Communication: What are GSM, GPRS, EDGE, UMTS, HSPA and LTE?

<http://www.askingbox.com/info/mobile-communication-what-are-gsm-gprs-edge-umts-hspa-and-lte>

Image Source: www.deadzones.com

Quick Peek: Wi-Fi (1)

IEEE 802.11 Network PHY Standards (1/2)				
802.11 Protocol	Release Date	Frequency	Bandwidth	Stream Data Rate
802.11-1997	Jun. 1997	2.4 GHz	22 MHz	1, 2 Mbps
802.11a	Sep. 1999	5 GHz	20 MHz	6 ~ 54 Mbps
		3.7 GHz		
802.11b	Sep. 1999	2.4 GHz	22 MHz	1 ~ 11 Mbps
802.11g	Jun. 2003	2.4 GHz	20 MHz	6 ~ 54 Mbps
802.11n	Oct. 2009	2.4/5 GHz	20 MHz	7.2 ~ 72.2 Mbps
			40 MHz	15 ~ 150 Mbps

Quick Peek: Wi-Fi (2)

IEEE 802.11 Network PHY Standards (2/2)				
802.11 Protocol	Release Date	Frequency	Bandwidth	Stream Data Rate
802.11ac	Dec. 2013	5 GHz	20 MHz	7.2 ~ 96.3 Mbps
			40 MHz	15 ~ 200 Mbps
			80 MHz	32.5 ~ 433.3 Mbps
			160 MHz	65 ~ 866.7 Mbps
802.11ad	Coming in 2016	60 GHz	2.16 GHz	Up to 7 Gbps

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More Smartphone Specifications (1)

		Galaxy Note 5	Google Nexus 5X	iPhone 6s plus
Manufacturer		Samsung	LG	Apple
Released Date		August 2015	September 2015	September 2015
Platform	Chipset	Exynos 7420	Qualcomm MSM8992 Snapdragon 808	Apple A9
	CPU	Quad-core 1.5 GHz Cortex-A53 & Quad-core 2.1 GHz Cortex-A57	Dual-core 1.82 GHz Cortex-A57 & Quad-core 1.44 GHz Cortex-A53	Dual-core 1.84 GHz Twister
	GPU	Mali-T760MP8	Adreno 418	PowerVR GT7600 (six- core graphics)
	Size*	14 nm	20 nm	14 nm or 16 nm

Size* = Size of semiconductor device fabrication node

More Smartphone Specifications (2)

		Galaxy Note 5	Google Nexus 5X	iPhone 6s plus
Display	Size	5.1 inches	5.2 inches	5.5 inches
	Resolution	2560 x 1440 Pixels	1920 x 1080 Pixels	1920 x 1080 Pixels
Battery	Capacity	Li-Po 3000 mAh	Li-Po 2700 mAh	Li-Po 2750 mAh
Camera	Primary	16 MP	12.3 MP	12 MP
	Secondary	5 MP	5 MP	5 MP

Samsung Exynos 7420

- Samsung Exynos Octa 7420
 - Released in 2015
 - Developed & Manufactured by Samsung
 - Based on the ARMv8-A architecture
 - By using the big.LITTLE heterogenous computing architecture, the Samsung Exynos Octa 7420 has 4 “big” cores and 4 “little” cores



big.LITTLE Technology

- ARM® big.LITTLE™
 - Launched by ARM® in 2011
 - ARM® big.LITTLE™ processing is a power optimization technology where high-performance ARM CPU cores are combined with the most efficient ARM CPU cores to deliver:
 - Peak-performance capacity
 - Higher sustained performance
 - Increased parallel processing performance
 - Significantly lower average power

big.LITTLE Technology

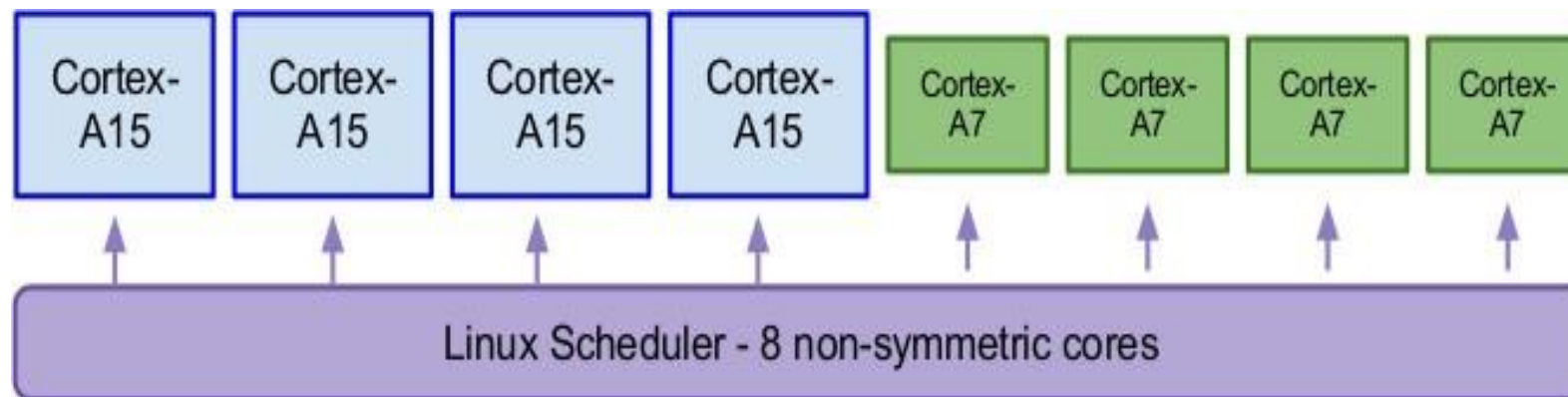
- ARM® big.LITTLE™
 - The "**big**" or faster cores are used for **computation-intensive tasks** such as gaming, whereas the "**little**" or slower cores are used for **less intensive tasks**
 - The latest big.LITTLE software and platforms can **save 75% of CPU energy** in low to **moderate performance scenarios**, and can increase performance by **40%** in **highly threaded workloads**



big.LITTLE Technology

	1st Generation: ARMv7	2nd Generation: ARMv8
High-performance CPU (big)	Cortex-A15, Cortex-A17	Cortex-A57, Cortex-A72
High-efficiency CPU (LITTLE)		Cortex-A53
Ultra high-efficiency CPU (LITTLE)	Cortex-A7	Cortex-A35

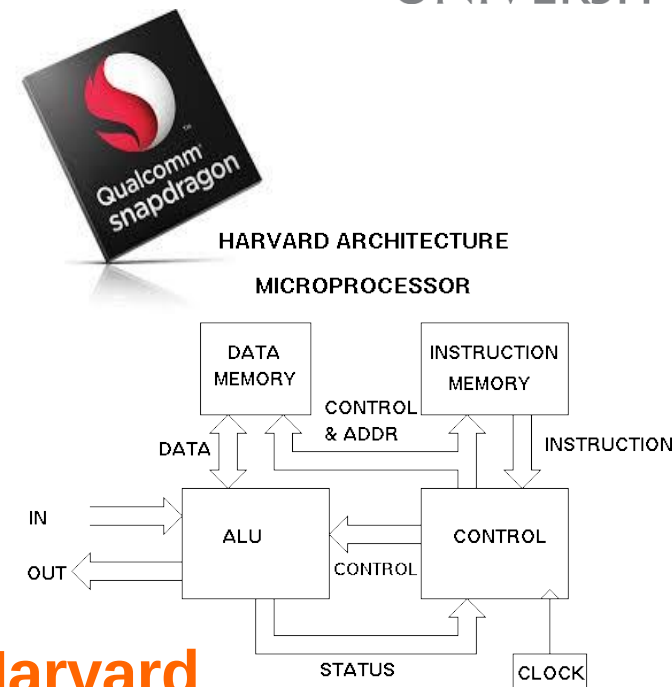
- Threads with **high priority** or **computational intensity** will be allocated to the "**big**" cores while threads with **less priority** or **less computational intensity**, such as background tasks, can be performed by the "**LITTLE**" cores



Qualcomm Snapdragon 808

- Qualcomm MSM8992 Snapdragon 808

- Released in **2014**
- Designed by Qualcomm, Manufactured by TSMC
- Based on the **ARMv8-A** architecture
- Qualcomm MSM8992 Snapdragon 808 uses the **Harvard architecture**, which is a computer architecture with physical **separate storage** and **signal pathways** for instructions and data
- Qualcomm MSM8992 Snapdragon 808 uses the big.LITTLE heterogenous computing architecture and has **2 “big” cores** and **4 “little” cores**



Apple A9



- Apple A9
 - Introduced on Sept. 9, 2015
 - Designed by Apple, Manufactured by Samsung (14 nm) and TSMC (16 nm)
 - Based on the ARMv8-A architecture
 - Compared to the A8, 70% more CPU performance and 90% more graphics performance can be gained
 - Consists of an Apple-designed 64-bit ARM based System-on-Chip (dual-core CPU) called Twister
 - New image processor
 - Better temporal and spatial noise reduction
 - Improved local tone mapping

14 nm Technology (1)

- Moore's Law

- **Gordon E. Moore**, co-founder of Intel and Fairchild Semiconductor, 1965 paper
- The **number of transistors** in a dense integrated circuit will **double approximately every two years**, and this rate of growth is projected to continue for **at least another decade**

Annotations:

- Itanium is a family of **64-bit** Intel microprocessors
- Itanium2 was jointly developed by **HP** and **Intel**
- Xeon is targeted at the non-consumer **workstation, server,** and embedded system markets
- Intel Atom is the brand name for a line of **ultra-low-voltage** 32-bit and 64-bit CPUs (or microprocessors)
- K5 was **AMD's first** x86 processor to be developed entirely in-house
- Pentium is a brand used for a series of x86-compatible microprocessors produced by **Intel**
- Pentium processor is an **entry-level** product (e.g., for PCs)

Curve Description: curve shows transistor count doubling every two years

Date of introduction

- Xeon is a brand of x86 microprocessors designed and manufactured by Intel
- Xeon is targeted at the non-consumer **workstation, server,** and embedded system markets

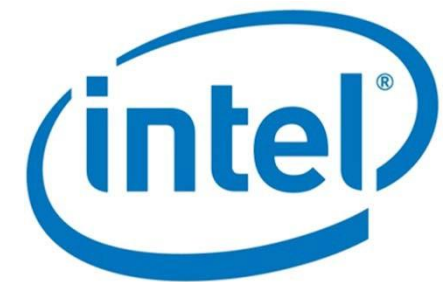
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14 nm Technology (3)

- The **14 nanometer** (14 nm) semiconductor device fabrication node is the technology node **following the 22 nm/(20 nm)** node.
- The **naming** of this technology node as "14 nm" came from the **ITRS** (**International Technology Roadmap for Semiconductors**)
- The **first** 14 nm scale devices were shipped to consumers **by Intel in 2014**



14 nm Technology (4)

- ITRS

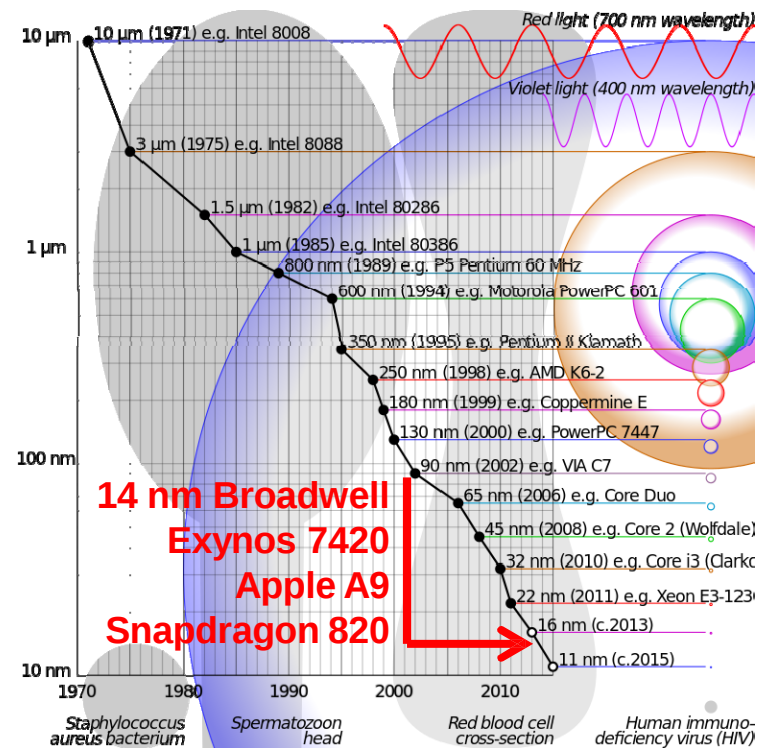
- The ITRS is sponsored by the **five leading chip manufacturing regions** in the world: Europe, Japan, Korea, Taiwan, and the United States
- The **objective** of the ITRS is to ensure **cost- effective** advancements in the **performance** of integrated circuit and **advanced products** and **applications** that employ such devices, to continue consistent growth and success of this industry

14 nm Technology

- Why 14 nm?
 - The smaller the transistors, the **more** transistors in the same area, the **faster** they switch, the **less energy** they require, and the cooler the chip runs (given equal numbers of transistors)
 - By reducing the distance between transistors you **decrease** the amount of power required to activate transistors and to get a signal from one to the next. The results make for **slimmer** and **lighter** products that have **longer battery life**

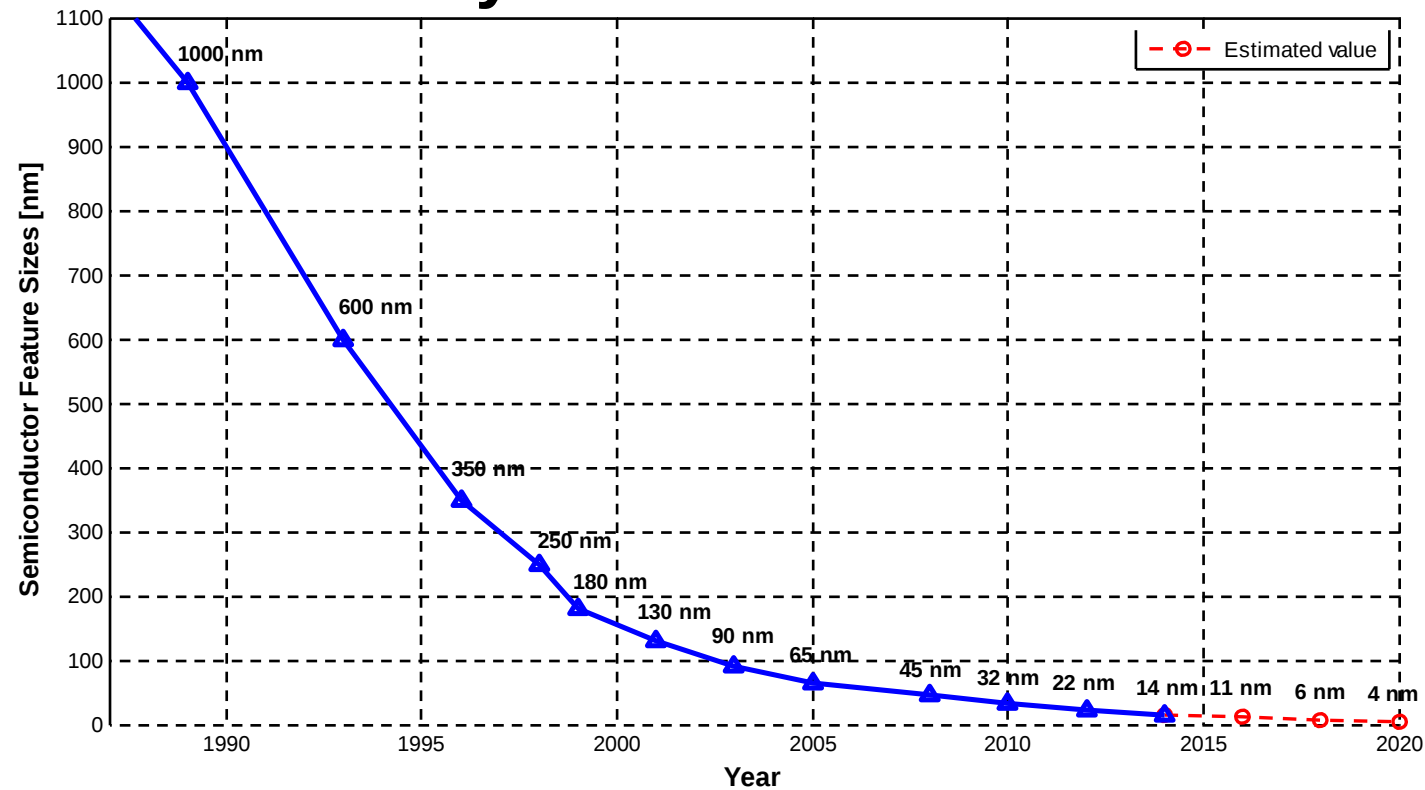
14 nm Technology

- How much smaller?
 - A normal red blood cell is **6~8 μm** in diameter
 - A typical human eye will respond to wavelengths from about **390 to 700 nm**
 - Bacterial ribosome is about **20 nm**



14 nm Technology

► Size History of Semiconductors



Recap: More Smartphones

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GPS

- **GPS (Global Positioning System)**
 - Created by the U.S. Army in **1978**
 - GPS device communicates with **4 or more satellites** to determine its exact location
 - Location Coordinates
 - Longitude, Latitude

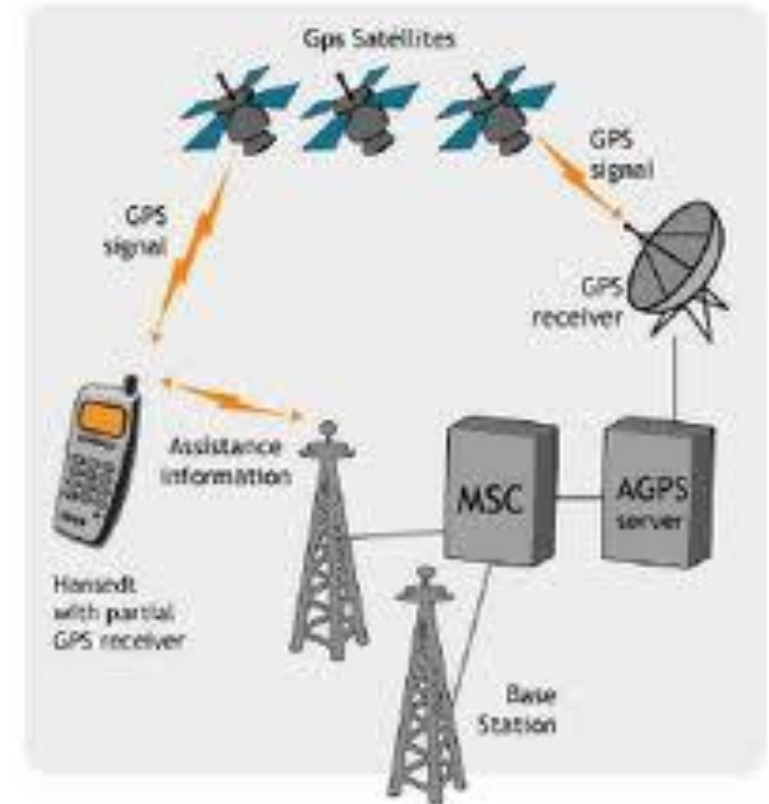


A-GPS

- **A-GPS (Assisted GPS)**
 - Uses information from GPS satellites by using position information from the **mobile network** assistant servers
 - Works the same way as GPS
 - Location Coordinates: Longitude, Latitude
 - Accurate time information of the mobile network can be used

A-GPS

- A-GPS (Assisted GPS)
- Assistance Types
 - **MSB** (Mobile Station Based)
 - Mobile station **helps in acquiring** GPS satellite information quickly
 - **MSA** (Mobile Station Assisted)
 - Mobile server **helps calculation** of position by using GPS receiver signal information



GPS vs. A-GPS

	A-GPS	GPS
Signal Information	GPS satellite signals & assistance servers	GPS satellite signals
Speed	Faster location coordinate determination (by using connectivity with cellular base stations)	May take several minutes to determine location (requires connectivity with 4 or more satellites)

GPS vs. A-GPS

	A-GPS	GPS
Reliability	A-GPS could be slightly less accurate than GPS	Can achieve within 1 meter accuracy (with sufficient GPS signals)
Cost	Cost of mobile network usage	No cost
Usage	Mobile phones	Cars, planes, ships, boats

GLONASS & BeiDou

- **GLONASS (Global Navigation Satellite System)**
 - Satellite navigation system for vehicle and aviation navigation
 - Operated by the Russian Aerospace Defense Force
- **BeiDou Navigation Satellite System**
 - Second generation satellite navigation system of China

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DLNA

- **DLNA (Digital Living Network Alliance)**
 - Supports wireless networking service applications
 - DLNA Service Examples
 - Video streaming from PC/laptop to a TV
 - Play music on a Hi-Fi system directly from a MP3 in a smartphone
 - Print a photo directly to a printer from a smartphone
 - etc.

RDS & Shatterproof Glass



- **RDS (Radio Data System)**
 - Protocol standard that enables small amounts of **digital information** transfer (e.g., program information, time, station ID) in conventional FM broadcast radios
- **Shatterproof Glass**
 - Shatterproof Glass serves as the best surface for smartphones as it provides a very smooth (luxurious) seamless surface

Gorilla Glass & Oleophobic Coating

- **Gorilla Glass**

- Specialized toughened shatterproof glass that is **scratch-resistant** to prevent deep scratches that can weaken glass
- Introduced at CES 2013 by Corning

- **Oleophobic Coating**

- Physical property of a molecule that is repelled from Oil (means “**fear of oil**”)
- Used on the smartphone’s surface for **fingerprint-resistance & anti-smudging**

AMOLED

- **AMOLED (Active-Matrix Organic Light-Emitting Diode)**
 - AMOLED display technology is used in TVs and smartphones
 - OLED (Organic Light-Emitting Diode) is a thin-film-display technology that uses organic compounds to form the electro luminescent material

Super AMOLED

- Super AMOLED
 - Super AMOLED is an AMOLED display with an **integrated digitizer**
 - Touch detection layer is (not overlaid) integrated into the smartphone screen
 - Characteristics
 - **Thinner** Display
 - Lower Power Consumption
 - Improves the **sunlight reflection** characteristics to improve the screen's **outdoor viewing** properties

IPS

- IPS (In-Plane Switching)

- LCD (Liquid Crystal Display) screen technology used for **liquid crystal layer** molecule orientation (arranging and switching between the glass substrates)
- Characteristics
 - Accurate color and consistent image from **wide viewing angles**
 - When screen is **touched** there is **no tailing or lighten** effect on the screen
 - Clear images and stable response time



LED-Backlit LCD Display

- LED-Backlit LCD Display
 - LED backlighting flat panel display tech.
 - Improvements Compared to CCFL (Cold Cathode Fluorescent) Backlit LCDs (which was commonly used in LCDs)
 - Improved images with **greater dynamic contrast & wider dimming range**
 - **Slimmer screen** → **Reduced weight**
 - and more...

LED-Backlit LCD Display

- More Improvements
 - RGB-LED backlighting results in **wider color gamut** (range of colors identifiable by the human eye)
 - **Reduced heat** emission
 - **Reduced power** consumption
 - More reliable and longer product lifespan

Qi

- Qi (氣 = Natural Energy [in Chinese])
 - **WPC** (Wireless Power Consortium) standard for inductive electrical power transfer over distances **up to 4 cm**
 - Low power for inductive transfer commonly uses power delivery **below 5 W**
 - Qi System
 - Power Transmission Pad
 - Power Receiver (commonly in a Mobile Device)



WPC

- **WPC (Wireless Power Consortium)**
 - Established December 17, 2008
 - WPC Objective
 - Create a universal wireless power charging standard
 - ➔ Various mobile electronics placed on top of a **single power transfer pad** can be recharge by magnetic induction
 - Uses the **Qi** standard



PMA

- **PMA (Power Matters Alliance)**
 - Global non-profit industry organization founded by Procter & Gamble and Powermat Technologies in March 2012
 - PMA's mission is to advance standards and protocols for **wireless power transfer**



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