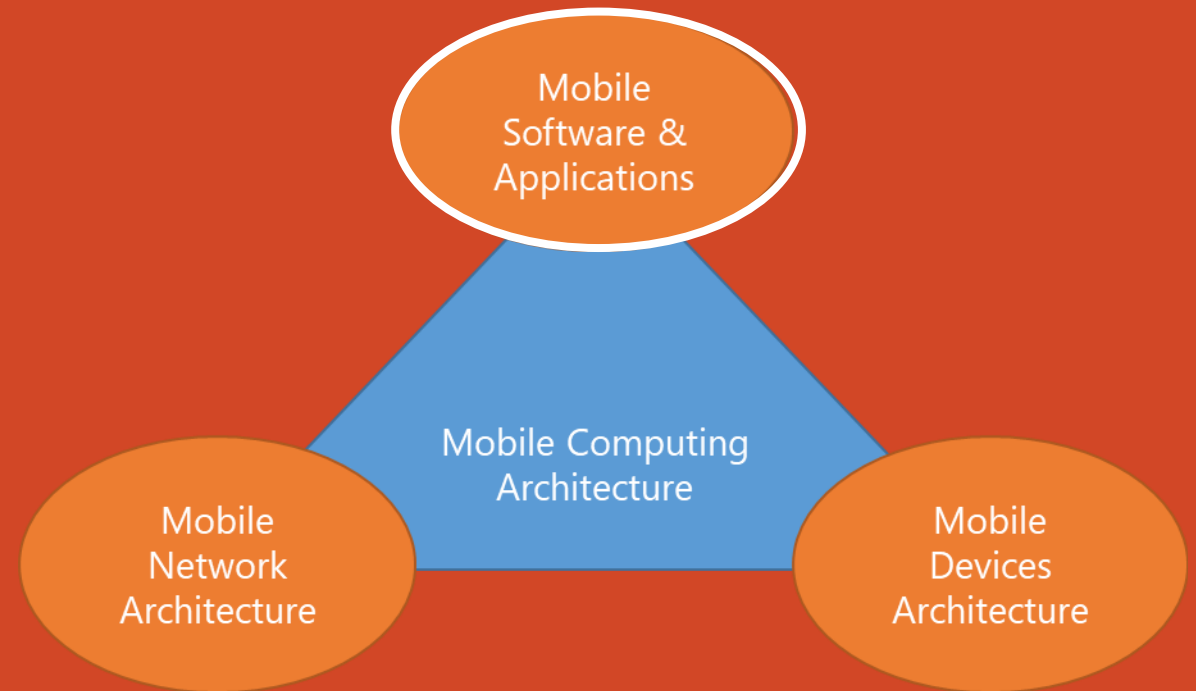


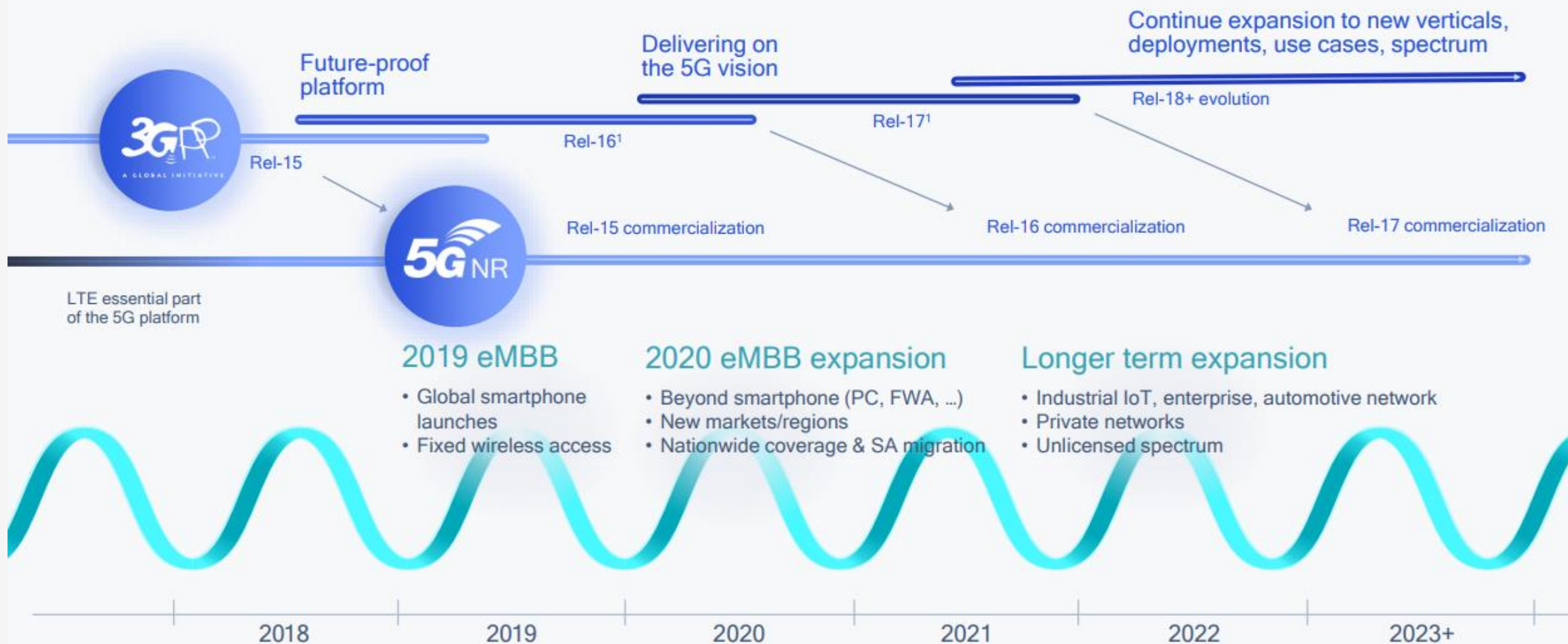
# Mobile Computing Architecture

UW Bothell, WA

Lecture 12: Mobile Devices Architecture



# 5G Standardization Roadmap



# First 5G Modem

Multi-Gigabit over mmWave on working Snapdragon X50 silicon



Oct 2017



Feb 2018

5G NR Interoperability and field trials using form factor mobile test device



2H 2018

First 5G NR mmWave over-the-air data call, with Ericsson



Sep 2018

First 5G NR Sub 6 GHz over-the-air data call, with Ericsson



Oct 2018

Providing Qualcomm Reference Design to accelerate commercial devices



















1H 2019

**Qualcomm**  
snapdragon  
X50 5G modem-RF system




# 5G Phones


5G smartphones

							
Lenovo Z6 Pro 5G	LG V50 ThinQ 5G	Motorola moto z <sup>4</sup> /z <sup>3</sup> + 5G moto mod	Nubia Mini 5G	OnePlus 7 Pro 5G	OPPO Reno 5G	Samsung Galaxy S10 5G	Samsung Galaxy Fold
							
Samsung Galaxy Note10+ 5G	Samsung A90 5G	Vivo iQOO 5G Edition	Vivo NEX 3 5G	Xiaomi Mi MIX 5G	Xiaomi Mi MIX Alpha	Xiaomi Mi 9 Pro 5G	ZTE Axon 10 Pro 5G

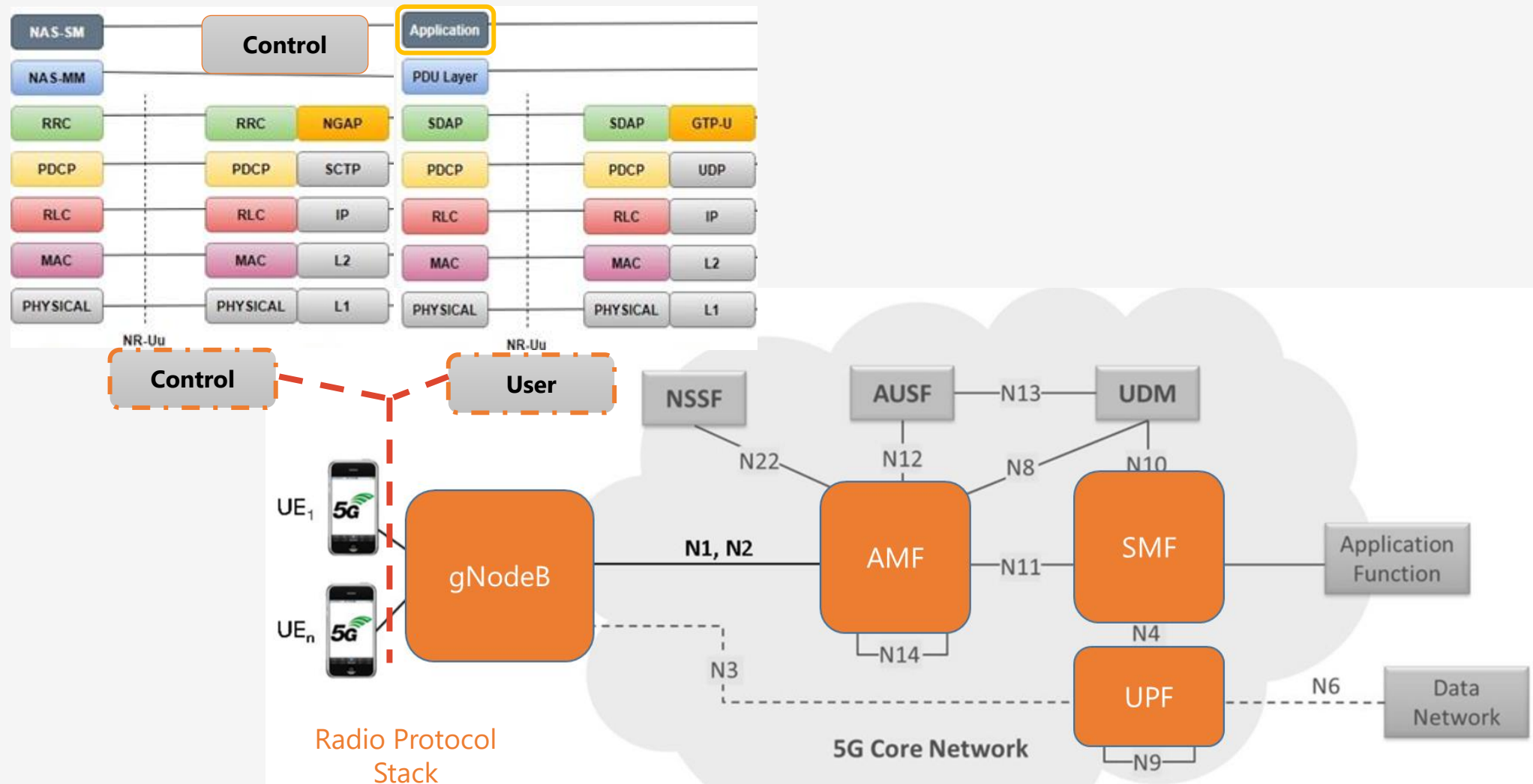
Hotspots and CPEs

	Askey	HTC	Netgear	WNC
	Inseego	Netcomm	Nokia	ZTE

5G modules

	Compal	Longsung	Sierra	SIMcom
	Fibocom	Quectel	Wireless	Telit

# 5G Network Architecture



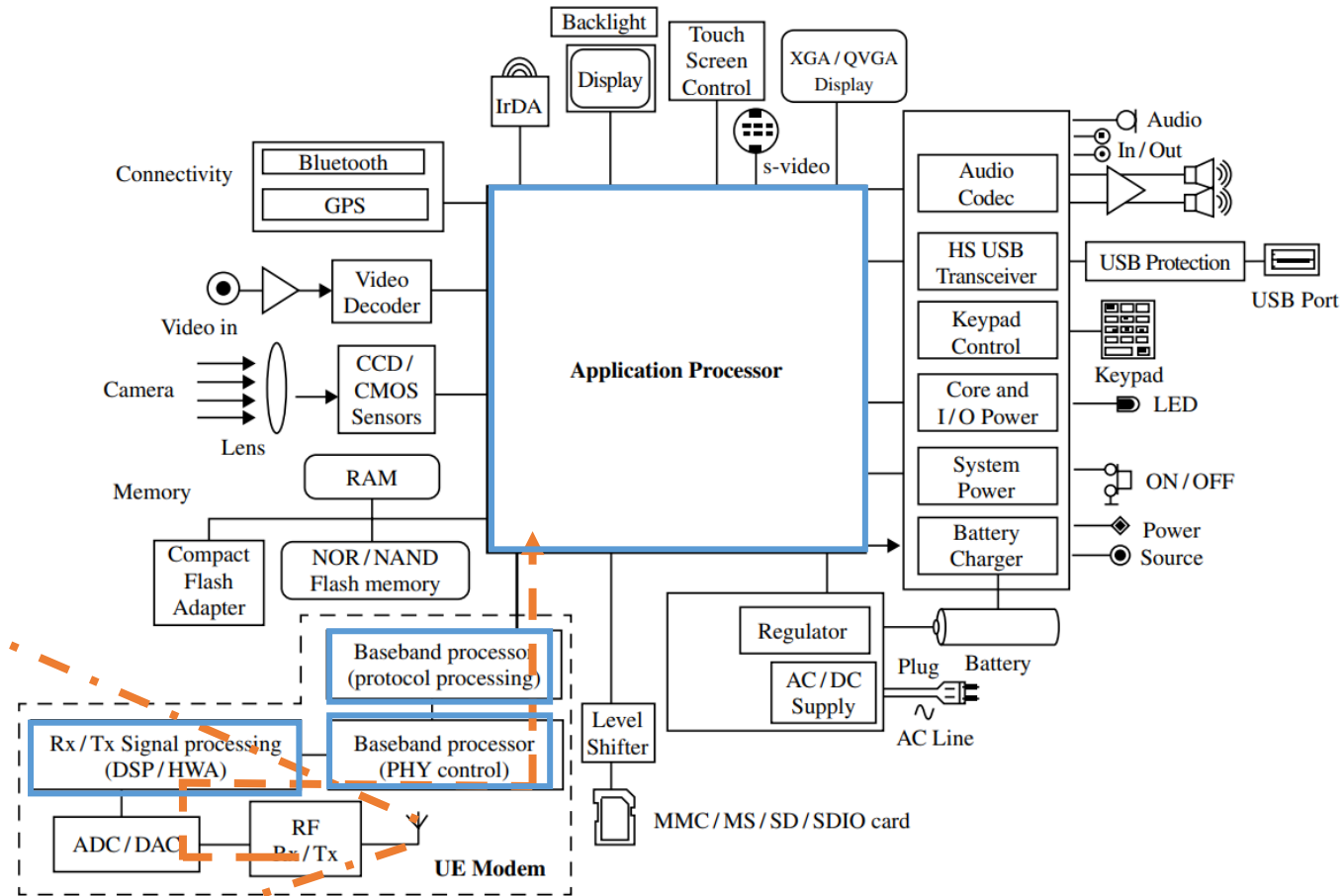
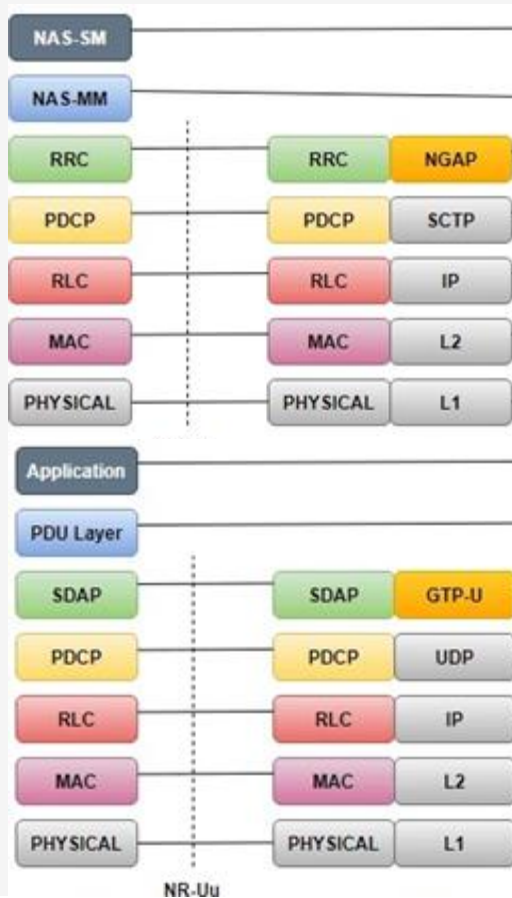


# Typical Smartphone

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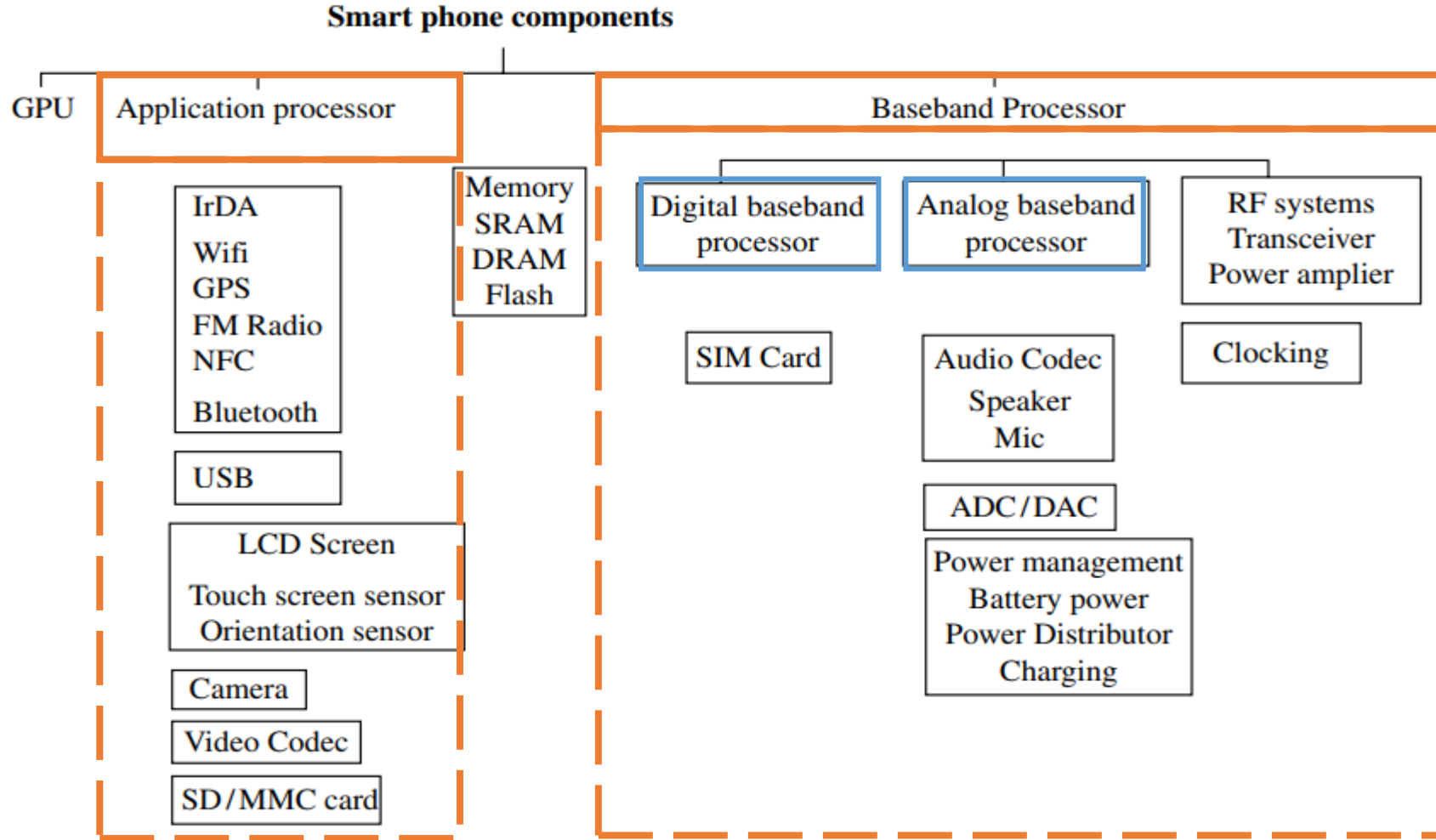


# Smartphone Architecture



[Link to Book](#)

# Smartphone Processors





# Baseband Processor

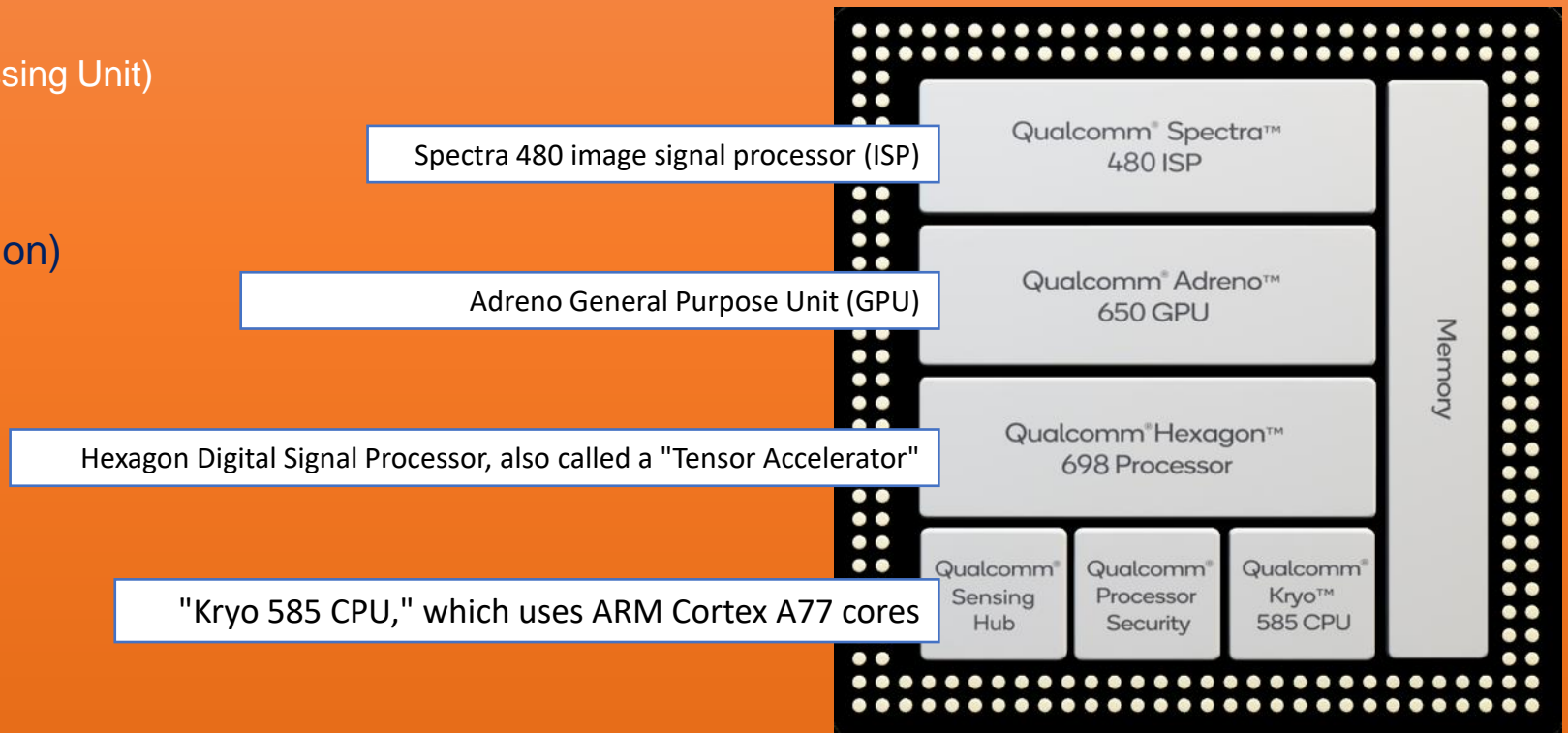
- Manages radio communications
- Performs radio signal processing
- To support receiver signal processing-related tasks, generally one Digital Signal Processor (DSP) is used along with several hardware accelerators (HWA),
- Protocol stack processing to enable the smartphone to access different types of wireless network technologies
- For protocol stack execution, one or more processors, like ARM, are used
- Apart from the modem signal processing-related tasks, a DSP is also used for noise suppression, echo cancellation or other such signal processing-related tasks
- Majority of smartphone processing units are based on the Advanced RISC Machines (ARM) Architecture. An ARM processor based on the RISC (reduced instruction set computer) architecture.
- It was designed for power-efficiency ARM also grants a license, known as an architectural license, to other companies to design ARM architecture compatible cores. Companies like Qualcomm, Samsung, MediaTek and Huawei take the core designs from ARM and incorporate them into their **System on a Chip (SoC)**

# Application Processor

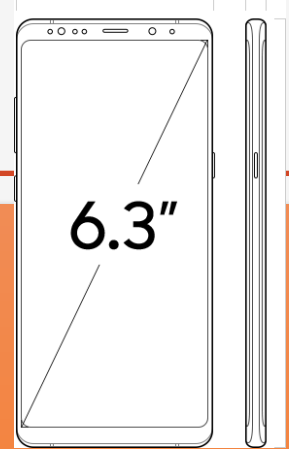
- The application unit relies mainly on a general-purpose processor (GPP). Typically a RISC processor, which provides the processing needed by the applications and provides user interfaces and overall command-and-control functions.
- A dedicated processor which enables smartphone to run mainstream OS such as Android, iOS and Windows Mobile etc.
- Optimized to run a number of user applications
- Emphasize multimedia processing (audio/video/still image/2D/3D)
- Multimedia engine which is hardware implementation of one or more multimedia standards (e.g. JPEG module, MPEG module, Audio module)
- Device interfaces which are used to communicate with peripheral device (e.g. USB, camera, display)
- However, nowadays, to drive application functionalities, special types of application processor or **SoC** are used, which can support a number of multimedia-related features such as Web browsing, e-mail, multimedia entertainment, and games, and also employs customized user applications.

# System on a Chip (SOC)

- System-on-a-Chip (SoC) – An integrated circuit (IC) that integrates all components of a computer or other electronic system into a single chip or package.
- Low power consumption – Typically used for mobile or embedded devices • A mobile SoC typically integrates
  - CPU
  - GPU (General Purpose Processing Unit)
  - Digital Signal processor
  - Multimedia processor
  - Major suppliers –
    - Qualcomm (Snapdragon)
    - Apple
    - MediaTek
    - Samsung
    - Nvidia



# Smartphone Screens

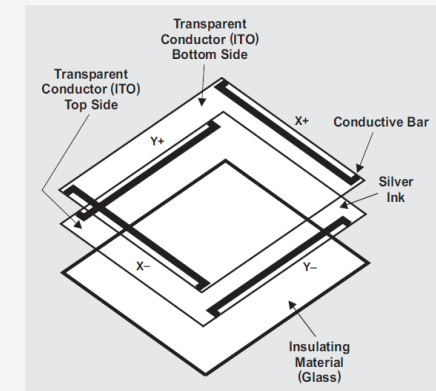
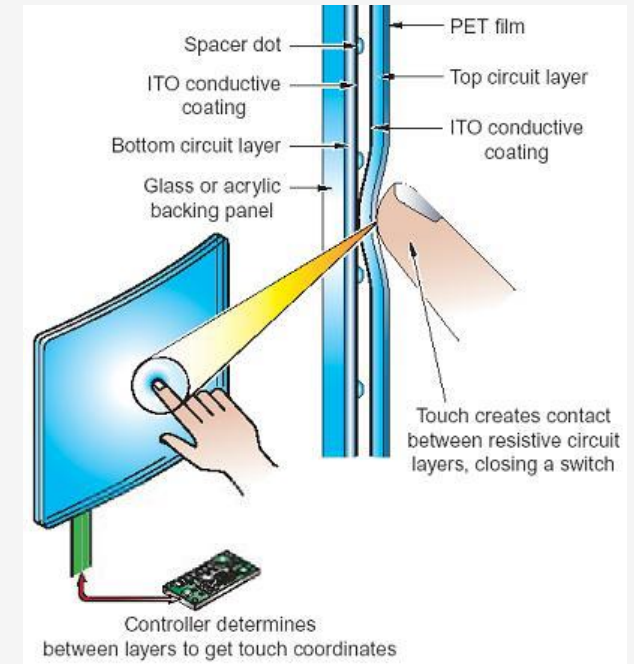


## Major specifications for screens

- Size: The screen size of mobile cell phones is given as the diagonal measurement of the phones screen.
- Resolution: Number of pixels of the screen. Expressed as the width x height of the screen. Typical phone resolution
  - HD ready (720x1280) – 720P
  - Full HD (1920x1080) – 1080P
  - Quad HD (1440x2560)
- Density: DPI (dot per inch) or PPI (pixel per inch) is a measure of pixel density (how many pixels are in one inch?). The higher density the better image quality
- Screen types:
  - LCD (Liquid Crystal Display): LCD panels utilize one backlight for the entire screen. Cheaper. Last longer.
  - AMOLED (Active-Matrix Organic Light-Emitting Diode). In AMOLED, each of the pixels are made up from groups of Light Emitting Diodes, which makes them the source of the light. As a result, pixels can be turned completely on or off. Vibrant colors. Higher Contrast. Shortest life.

# Smartphone Touch Screens I

- The touch panel is on top of the screen to capture input
- Mainly captive touch screens – Commonly known as “hard screen”.  
(1) Resistance (2) Capacitive
- Resistance screens
  - Composed of multiple layers separated by thin spaces.
  - Using indium tin oxide (ITO) layers. Different standards
  - 4, 5, and 8 wire types
  - Uniform voltages on two screens. Touch produces voltage gradient
  - Once screen for X and the other for Y



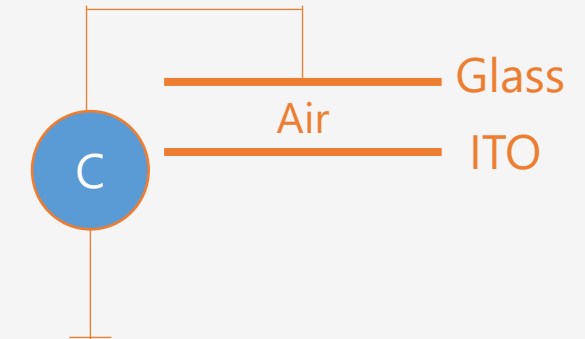
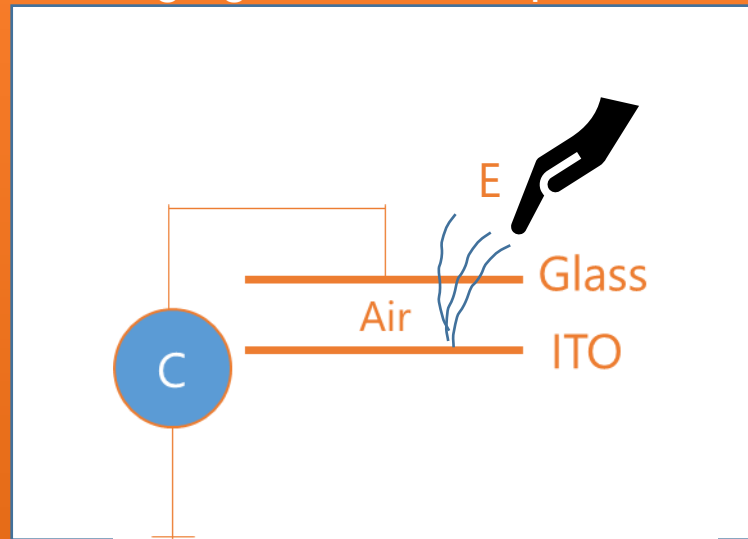
# Smartphone Touch Screens II

## Capacitive screens

- Insulator (glass or Air); conductive coating (ITO)
- Two types: Surface and Projected (commonly used)

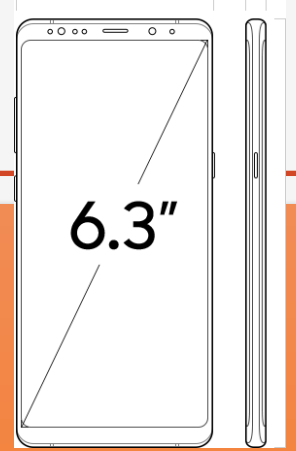
## Projected Capacitance

- Two layers
- Simple Capacitor on each point of the surface
- Electromagnetic field is projected through glass, and couples with Finger.
- Changes capacitance
- Detected as electrical signal
- High Resolution
- Indirect touch





# Smartphone Sensors



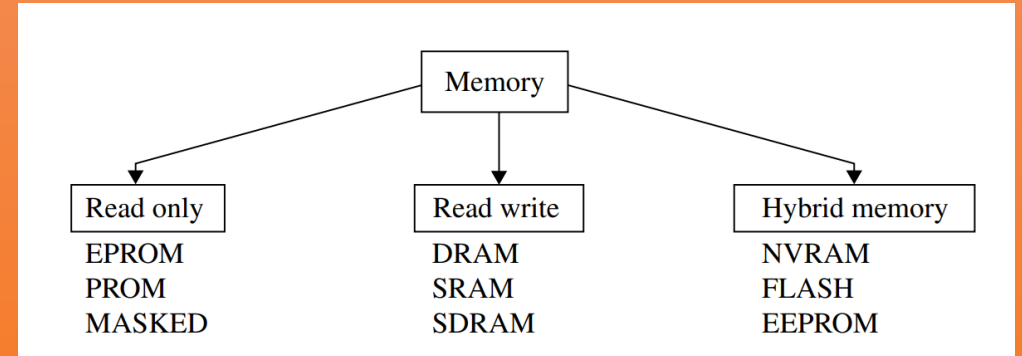
## Various integrated sensors

- Motion, environment, position, location
- Accelerometer – Measures the acceleration force – Detects device movements (acceleration)
- Gyroscope – Measures a device's rate of rotation around each of the three physical axes
- Proximity sensor – Detect the distance from objects
- Light sensor – Detects the light illumination intensity
- Others – Sound, finger print, pressure, humidity, magnetic, compass, temperature, heart beat, and more

# Smartphone Memory

Mobile-phone uses memory to store programs and data. Commonly, memory can be broadly classified into two categories:

- **Read Only Memory (ROM):** Non-Volatile
- **Read Write Memory:** Volatile.



- Read chapter <<Smartphone Hardware and System Design>> in the book
- Question: What are different kinds of Smartphone memories?

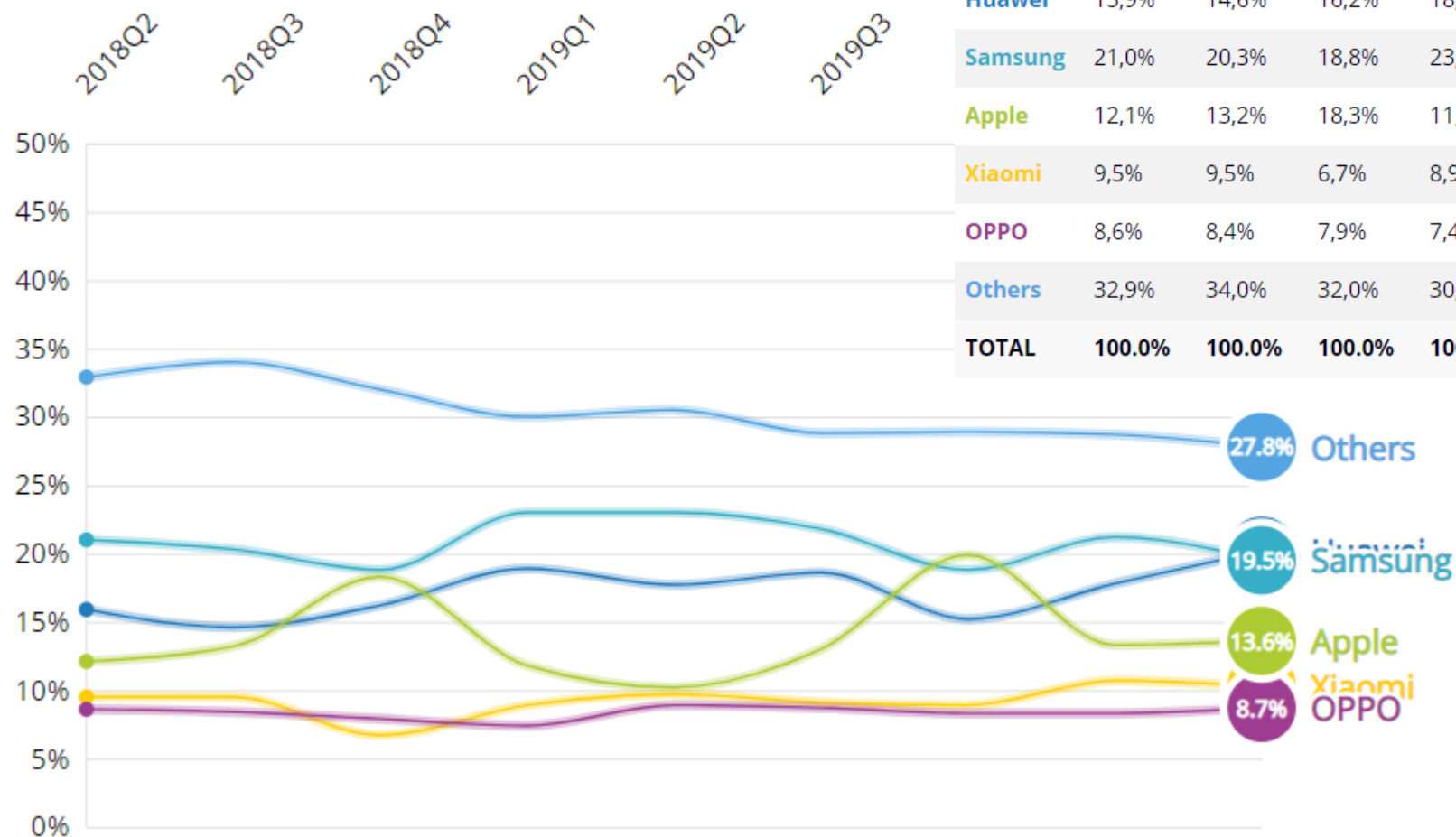
# Mobile Phones Software Development Kits

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- iOS and Android SDKs are major because of the reach of the platforms worldwide
- Quicker Integration: SDK speeds up the development and integration process
- For example, some free SDKs for Augmented Reality development
  - ARToolKit
  - ARKit
  - Flutter
  - EasyAR
  - Xzimg
  - NyARToolkit
  - Kudan
  - MAXST

# Market Share

Worldwide Top 5 Smartphone Company Unit Mark



Quarter	2018Q2	2018Q3	2018Q4	2019Q1	2019Q2	2019Q3	2019Q4	2020Q1	2020Q2
Huawei	15,9%	14,6%	16,2%	18,9%	17,7%	18,6%	15,2%	17,8%	20,2%
Samsung	21,0%	20,3%	18,8%	23,0%	23,0%	21,8%	18,8%	21,2%	19,5%
Apple	12,1%	13,2%	18,3%	11,8%	10,2%	13,0%	19,9%	13,3%	13,6%
Xiaomi	9,5%	9,5%	6,7%	8,9%	9,7%	9,1%	8,9%	10,7%	10,3%
OPPO	8,6%	8,4%	7,9%	7,4%	8,9%	8,7%	8,3%	8,3%	8,7%
Others	32,9%	34,0%	32,0%	30,0%	30,5%	28,8%	28,9%	28,7%	27,8%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

# Reading Material

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Mobile\_Terminal\_Receiver\_Design\_LTE\_and\_LTE-Advanc...\_----\_(Chapter\_5\_Smartphone\_Hardware\_and System\_Design).pdf

SDK: <https://www-morganclaypool-com.offcampus.lib.washington.edu/doi/pdf/10.2200/S00885ED2V01Y201811SPR016>