Mobile Device Hardware

CSE 3203
Overview of Mobile Systems

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Content Overview

• Major types and makes of mobile devices
• General smartphone structure and major hardware components; focus on
  – CPU/Chipset/SoC
  – Display/Touchscreen
  – Sensors
Type of Devices

• A mobile device is a general term for any type of portable/movable devices with computing power, connectivity and interactivity. Common features include:
  – Portable (or movable)
  – Computing power: general or specific purpose, with storage.
  – Various connection methods (WiFi, cellular)
  – Various interaction methods (touchscreen, remote control, connected I/O)

• The core type of mobile devices is the smartphone
  – Estimated 2.5 billion smartphone users worldwide [Source: https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/]

• Other device types
  – Laptop, netbook, ultrabook
  – Tablet [Source: https://www.zdnet.com/article/tablet-computers-an-overview/]
  – Handheld e-reader, PDA, gaming console, music player (iPod)
  – Wearable: watch, glasses, headsets, pens, etc.
  – Movable attached/integrated: cars, drones, bikes, robot, etc.
  – Human augmenter (implants)
  – Home: TV, home automation, TV box, projector, etc.? 
  – IoT devices?
  – Anything else?

• Globally, 75% of mobile connections will be 'smart' connections by 2021, up from 46% in 2016.
• In the United States, 99% of mobile connections (excluding LPWA) will be 'smart' connections by 2021, up from 80% in 2016. [Source: https://www.cisco.com/c/dam/assets/sol/sp/vni/forecast_highlights_mobile/index.html]
Other Types of Mobile Devices
Smartphone

• Smartphones are phones with additional functionalities supported by high computing power (way beyond a “phone”); they typically run an operating system and more applications, have a larger screen size (resolution), and have touchscreens.

• Should it be called a smartphone? https://blog.untitledkingdom.com/we-need-a-new-name-for-smartphone-c4258efd6e43

• General features
  – High computing power: CPU, GPU
  – Large storage/memory
  – Touch screen
  – Integrated peripherals
    • Speaker, mic, camera, light, projector (Motorola Droid)
  – Integrated connectivity
    • WiFi, Bluetooth, USB, etc.
  – Integrated sensors
    • Motion, environment, position, location
  – Long lasting battery

• Evolution of phones
  – https://www.tigermobiles.com/evolution
General Smartphone Structure

Image from http://cnoemphone.net/industry/mobile-phone-components/mobile-structure-introduction
Major Hardware Components

• Core
  – Motherboard, SoC, CPU, GPU, memory, storage

• I/O
  – Display, touchscreen
  – Connector: SIM, USB, SD card, etc.
  – Physical key/button: switch, volume

• Communication
  – Network/communication transmitter/receiver
  – Radio, WiFi, Bluetooth

• Integrated peripherals
  – Speaker, mic, camera, light

• Sensors, GPS
Motherboard

- Motherboard is the main circuit board that holds together all sorts of functional units together.
  - [http://cnoemphone.net/industry/mobile-phone-components/motherboard](http://cnoemphone.net/industry/mobile-phone-components/motherboard)

[Image of iPhone motherboard]


CPU

- CPU is the central processor of the phone, just like computers.
- Majority of smartphone CPUs are based on the ARM architecture.
- An ARM processor is one of a family of CPUs based on the RISC (reduced instruction set computer) architecture developed by Advanced RISC Machines (ARM).
  - http://whatis.techtarget.com/definition/ARM-processor
- The ARM architecture is different to the Intel architecture that we find in our desktops and laptops. It was designed for power-efficiency and became the de-facto CPU architecture for mobile phones even before smartphones.
  - https://www.androidauthority.com/what-is-in-your-smartphone-gary-explains-749709
- 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 SoCs.
Processor/System-on-a-Chip

- **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, communication, and multimedia processors.

- **Major suppliers**
  - Qualcomm (Snapdragon)
  - Apple
  - MediaTek
  - Samsung
  - Hisilicon
  - Nvidia


Memory and Storages

- **RAM (Random Access Memory)**
  - Used for temporary storage for running applications
  - Very fast
  - Lose contents when power-off

- **ROM (Read-only Memory)**
  - Store the operating system and critical files
  - Fast access
  - Permanent storage
  - Not updatable by users; usually can be *flashed* through special procedures (for system update).

- **Internal storage**
  - Integrated on the main board or chip to offer critical storage for OS and apps.
  - Updatable by users.

- **Secondary storage**
  - Used for optional expanded storage
  - Through an optional card slot (for example, MicroSD)
  - Not supported by all devices, for example, not in Apple iPhone or iPad
Smartphone Screen/Display

• Major specifications for screens
  – Size
  – Resolution
  – Density
  – Screen-to-body ratio
  – Aspect ratio
  – Screen type
Screen Size

• The screen size of mobile cell phones is given as the diagonal measurement of the phones screen.

- Small screen <4.5”
- The phablet is a class of mobile computing devices designed to combine or straddle the size format of smartphones and tablets
  – Usually > 6”

Size comparison
http://www.phonearena.com/phones/size
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? Or how small is a pixel?)
  – The higher density the better image quality

http://www.ubergizmo.com/what-is/ppi-pixels-per-inch/
PPI Calculation

- PPI is calculated by dividing the number of pixels along either the vertical, horizontal or diagonal axis by the length in inches of the corresponding side.
  - Example: A full HD 5.2 inch screen
  - \( \sqrt{1920^2 + 1080^2} / 5.2 = 424 \text{ PPI} \)

- A set of six generalized densities:
  - ldpi (low) \(~120dpi\)
  - mdpi (medium) \(~160dpi\)
  - hdpi (high) \(~240dpi\)
  - xhdpi (extra-high) \(~320dpi\)
  - xxhdpi (extra-extra-high) \(~480dpi\)
  - xxxhdpi (extra-extra-extra-high) \(~640dpi\)
# Android Device Stats

[https://developer.android.com/about/dashboards/index.html](https://developer.android.com/about/dashboards/index.html)

<table>
<thead>
<tr>
<th></th>
<th>ldpi</th>
<th>mdpi</th>
<th>tvdpi</th>
<th>hdpi</th>
<th>xhdpi</th>
<th>xxhdpi</th>
<th>Total</th>
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<tbody>
<tr>
<td>Small</td>
<td>0.4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1%</td>
<td>0.5%</td>
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<tr>
<td>Normal</td>
<td></td>
<td>0.8%</td>
<td>0.3%</td>
<td>25.4%</td>
<td>41.2%</td>
<td>24.4%</td>
<td>92.1%</td>
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<tr>
<td>Large</td>
<td></td>
<td>2.4%</td>
<td>1.4%</td>
<td>0.3%</td>
<td>0.3%</td>
<td>0.5%</td>
<td>4.9%</td>
</tr>
<tr>
<td>Xlarge</td>
<td></td>
<td>1.6%</td>
<td></td>
<td>0.5%</td>
<td>0.4%</td>
<td></td>
<td>2.5%</td>
</tr>
<tr>
<td>Total</td>
<td>0.4%</td>
<td>4.8%</td>
<td>1.7%</td>
<td>26.2%</td>
<td>41.9%</td>
<td>25.0%</td>
<td></td>
</tr>
</tbody>
</table>

Data collected during a 7-day period ending on August 31, 2018.

Any screen configurations with less than 0.1% distribution are not shown.
Screen-to-Body Ratio

• The display (or screen)-to-body ratio is a measure of how much of the surface of the screen represents when compared to the whole device.
  – Some high ratio phones https://www.digitaltrends.com/mobile/bezel-less-phone-comparison/

iPhone 4 - 50%  
Nexus 5x - 70%  
Samsung S9 - 85%
Aspect Ratio

• Aspect ratio refers to the relationship between the width and height of a screen.

• For a very long time, phones adopted the same aspect ratio as high-definition televisions: 16:9 height of a screen.
  – 1080P HD (1920:1080)

• Newer Samsung features 2:1

• iPhone X 19.5:9
Display Technologies

• Two main types (with subtypes)
  – LCD (Liquid Crystal Display)
  – AMOLED (Active-Matrix Organic Light-Emitting Diode)

• Though there are a variety of technical differences between the two methods, the main difference concerns the way pixels are lit in each application. LCD panels utilize one backlight for the entire screen.

• 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 — and when they’re off, they can deliver true black, with zero light emitted.
Comparison

- **LCD**
  - Cheap to produce
  - Accurate colour reproduction
  - Need backlight
  - Limited viewing angles

- **AMOLED**
  - Actively emits colors
  - Vibrant colors and high contrast
  - Excellent viewing angles
  - Shorter lifespan than LCDs
  - Thinner

Display Specification Examples

• LG Nexus 5X

• iPhone 7

• Samsung Galaxy S7
  – http://www.gsmarena.com/samsung_galaxy_s7-7821.php

• More
  – https://material.io/devices/
Touch Panel

• The touch panel is on top of the screen to capture input

• Mainly captive touch screens
  – Commonly known as “hard screen". As opposed to the resistive touchscreen, the capacitive touchscreen makes use of the electrical properties of the human body.

• Other types
  – [http://cnoemphone.net/industry/mobile-phone-components/touch-panel](http://cnoemphone.net/industry/mobile-phone-components/touch-panel)
Connectivity

- Smartphones come with several different communication and connectivity options including 3G, 4G LTE, Wi-Fi, Bluetooth and NFC. All these protocols need hardware support including modems and other auxiliary chips.

- All the major SoC makers include 4G LTE modem inside their chips.

- The modem usually has its own processor (different from the main CPU)

- The modem can be integrated into an SoC, or a separate unit on the motherboard.
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

- Read more at
# Market Share

## Worldwide Smartphone Market, Top 5 Company Shipments, Market Share, and Year-over-Year Growth, Q2 2018

(Shipments in millions)

<table>
<thead>
<tr>
<th>Vendor</th>
<th>2Q18 Shipments</th>
<th>2Q18 Market Share</th>
<th>2Q17 Shipments</th>
<th>2Q17 Market Share</th>
<th>Year-Over-Year Change</th>
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</thead>
<tbody>
<tr>
<td>1. Samsung</td>
<td>71.5</td>
<td>20.9%</td>
<td>79.8</td>
<td>22.9%</td>
<td>-10.4%</td>
</tr>
<tr>
<td>2. Huawei</td>
<td>54.2</td>
<td>15.8%</td>
<td>38.5</td>
<td>11.0%</td>
<td>40.9%</td>
</tr>
<tr>
<td>3. Apple</td>
<td>41.3</td>
<td>12.1%</td>
<td>41.0</td>
<td>11.8%</td>
<td>0.7%</td>
</tr>
<tr>
<td>4. Xiaomi</td>
<td>31.9</td>
<td>9.3%</td>
<td>21.4</td>
<td>6.2%</td>
<td>48.8%</td>
</tr>
<tr>
<td>5. OPPO</td>
<td>29.4</td>
<td>8.6%</td>
<td>28.0</td>
<td>8.0%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Others</td>
<td>113.7</td>
<td>33.2%</td>
<td>139.5</td>
<td>40.1%</td>
<td>-18.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>342.0</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>348.2</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>-1.8%</strong></td>
</tr>
</tbody>
</table>

Source: IDC Worldwide Quarterly Mobile Phone Tracker, July 31, 2018

[https://www.idc.com/getdoc.jsp?containerId=prUS44188018](https://www.idc.com/getdoc.jsp?containerId=prUS44188018)

More data source:
[http://www.appbrain.com/stats/top-manufacturers](http://www.appbrain.com/stats/top-manufacturers)
Notable Products

• iPhone
  – [https://www.pcmag.com/feature/302519/a-visual-history-of-the-iphone/15](https://www.pcmag.com/feature/302519/a-visual-history-of-the-iphone/15)

• Nexus
  – [https://www.youtube.com/watch?v=7_tAJIjm6xA](https://www.youtube.com/watch?v=7_tAJIjm6xA)
Good Resources

• Learning
  – http://www.phoneppi.com

• Device search/comparison tool
  – https://www.productchart.com

• Screen feature detection website
  – http://mydevice.io

• Device specs database
  – http://www.phonearena.com
  – http://www.gsmarena.com
  – http://www.phonearena.com/phones/size

• Mobile device screen info database
  – http://mydevice.io/devices/
  – http://screensiz.es
  – https://material.io/devices/
  – http://dpi.lv

• https://deviceatlas.com/device-data/properties