# **Smartphones**

We often talk about the exteriors of our smartphones, the design language, the build materials and the ergonomics. But what about the insides? If we were to take a smartphone apart what would we find? What do all those components do? And how important are they? Let me explain.

**Display**

While the display could be seen as an exterior element of a smartphone, it is also an interior one. As the principle method for interacting with our smartphones, it can be argued that it is the most important component. Displays come in a variety of sizes with a whole gamut of screen resolutions. The common sizes are between 4.5 to 5.7 inches (measured across the diagonal) and the key screen resolutions are 1280 x 720, 1920 x 1080 and 2560 x 1440.

There are two main types of display technology: LCD and LED. The former gives us In-Plane Switching Liquid Crystal Displays or IPS displays, which don’t have the viewing angle problems of cheaper LCD panels; and the latter is the basis for Active Matrix Organic Light-Emitting Diode or AMOLED displays.

LCD displays work by shining a light (called the backlight) through some polarizing filters, a crystal matrix and some color filters. The crystals can be twisted to varying degrees depending on the voltage applied to it, which adjusts the angle of the polarized light. All combined, this allows a LCD display to control the amount of RGB light reaching the surface by culling light from the backlight.

AMOLED displays work differently, here each of the pixels are made up from groups of Light Emitting Diodes, which makes them the source of the light. The advantage of AMOLED over IPS is that OLED type displays can switch off individual pixels and so giving deep blacks and a high contrast ratio. Also, being able to dim and turn off individual pixels saves on power.

**Battery**

The electrical power for all the bits inside your smartphone comes from the battery. A battery can either be user removable, which means you can easily replace it or carry multiple batteries with you; or it can be sealed into the phone, which means it can only be replaced by a technician. The capacity of the battery is a key metric, with most 5.5 inch phones having at least a 3000 mAh unit. When it comes to charging there is a whole spectrum of different charging technologies, however the popular is probably Quick Charge from Qualcomm. Most smartphone batteries today are Lithium-ion (Li-Ion) based, which means you don’t need to worry about things like the battery memory effect.

**System-on-a-Chip**

Your smartphone is a mobile computer and all computers need a Central Processing Unit (CPU) to run software, i.e. Android. However the CPU can’t act alone, it needs the help of several different components for graphics, mobile communications and multimedia. These are all combined onto a single chip which is known as a SoC, a System-on-a-Chip.

**CPU**

The vast majority of smartphones (including Android, iOS and Windows Phones) use a CPU architecture designed by ARM. 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, back in the feature phone era.

There are two types of ARM architecture CPUs: those designed by ARM and those designed by other companies. ARM has a whole range of CPU core designs which it licenses under the Cortex-A branding. This includes cores like the Cortex-A53, the Cortex-A57 and the Cortex-A73. Companies like Qualcomm, Samsung, MediaTek and Huawei take the core designs from ARM and incorporate them into their SoCs. For example, the Huawei Kirin 960 uses four Cortex-A53 cores and four Cortex-A73 cores in an arrangement known as Heterogeneous Multi-Processing (HMP).

ARM also grants a license, known as an architectural license, to other companies to design ARM architecture compatible cores. Qualcomm, Samsung and Apple are all architectural license holders.

**GPU**

The Graphics Processing Unit is a dedicated graphics engine designed primarily for 3D graphics, although it can be used for 2D graphics as well. In a nutshell, the GPU is fed with triangle information along with some program code for the shader cores so it can produce 3D environments on a 2D display.

Qualcomm’s Adreno 530 is found in the 820/821 and the Snapdragon 835 will use the Adreno 540. The 540 is based on the same architecture as the Adreno 530, but features a number of improvements and a 25 percent gain in 3D rendering performance. The Adreno 540 also fully supports the DirectX 12, OpenGL ES 3.2, OpenCL 2.0, and Vulkan graphics APIs, as well as the Google Daydream VR platform.

**MMU**

Although this is technically part of the CPU, it is worth mentioning the Memory Management Unit (MMU) as it plays such an important role and enables [the use of Virtual Memory](https://www.androidauthority.com/what-is-virtual-memory-gary-explains-747960/). For Virtual Memory to work there has to be a mapping between virtual addresses and physical addresses.

This mapping is done in the MMU, with a lot of help from the kernel, in Android’s case that means Linux. The kernel tells the MMU what mappings to use and then when the CPU tries to access a virtual address the MMU automatically maps it to a real physical address.

The advantages of virtual memory are that:

* An app doesn’t care where it is in physical RAM.
* An app only has access to its own address space and can’t interfere with other apps.
* An app doesn’t need to be stored in contiguous blocks of memory and allows the use of paged memory.

Display processor & Video processor

There are a few more dedicated bits of hardware inside the SoC which work in conjunction with the CPU and GPU. First there is the Display Processor which actually takes the pixel information from the memory and talks to the display panel. An example of a Display Processor would be [the Mali-DP650 from ARM](https://www.androidauthority.com/arm-mali-dp650-display-processor-668489/). It offers a wide range of post-processing features such as rotation, scaling and image enhancement, support for resolutions up to 4K. It also supports energy saving technologies such as the ARM Frame Buffer Compression (AFBC) protocol, a lossless image compression protocol and format, which minimizes the amount of data transferred between IP blocks within a SoC. Less data transferred means less power consumed.

While the GPU is specialized at doing 3D processing, there is also a component for doing video decoding and encoding. Whenever you watch a movie from YouTube or Netflix then the compressed video data needs to be decoded as it is being shown on screen. This can be done in software, however it is much more efficient to do it in hardware. Likewise, whenever you use your phone’s camera for video chats then the video data needs to be encoded before sending. Again this can be done in software, but it is better in hardware. ARM supplies video processor technology to its partners and its latest and greatest is the Mali-V61, which includes high quality HEVC encode and VP9 encode/decode, as well as all the standard codecs like H.264, MP4, VP8, VC-1, H.263 and Real.