agMOOCs
What is inside a smartphone
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In this lecture we'll have a brief introduction to the smartphone hardware.
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Smartphones are used today for mostly communication and also for processing video, audio and many other high-end applications.
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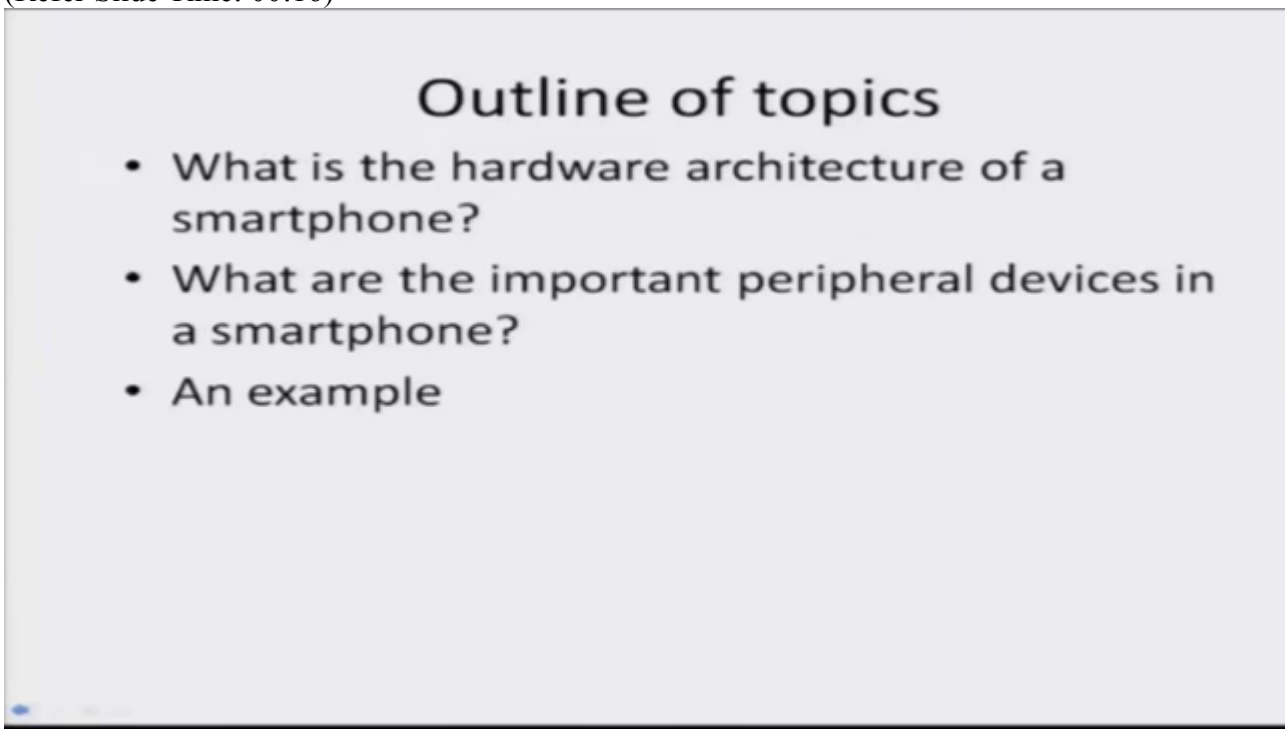

So this is the outline of the topics that we'll be discussing. The number one is the hardware architecture of the smartphone. Second, we look at some of the important peripheral devices

connected to the smartphone. And we'll take a quick look at a simple example of a smartphone.

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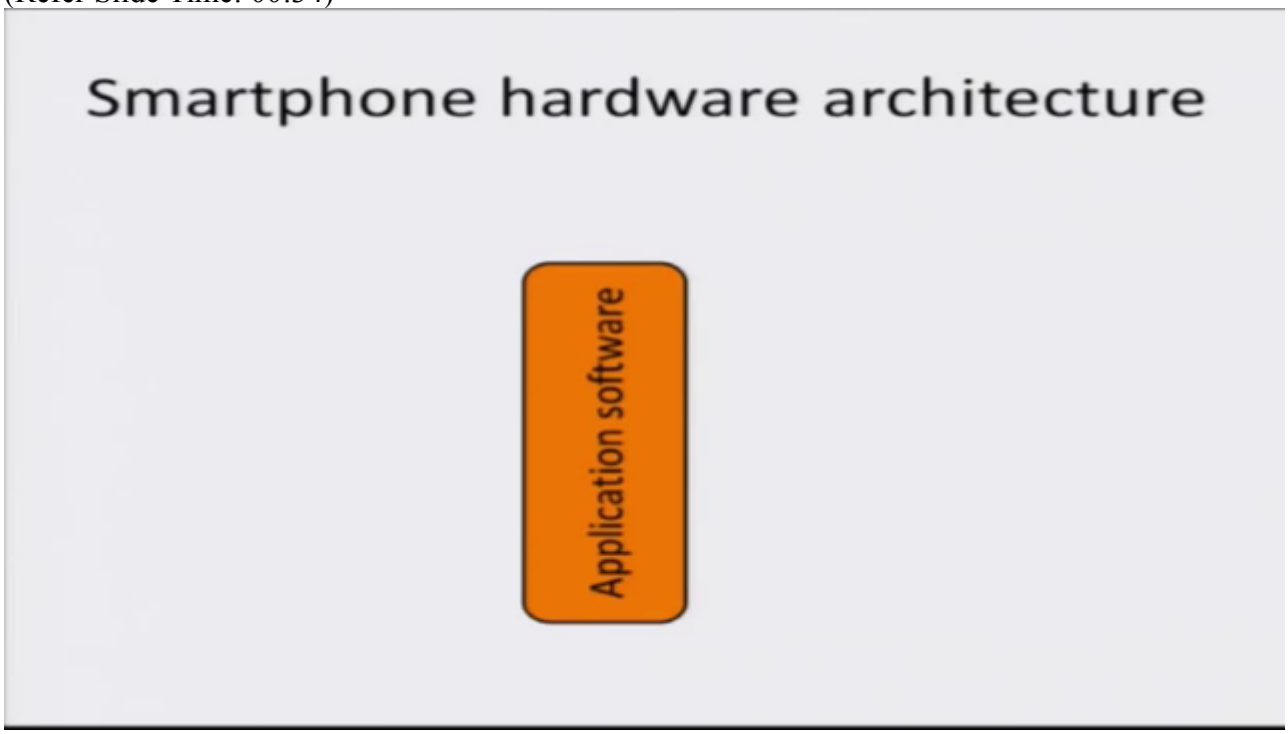

We'll start the hardware architecture description with the application software because this is what actually executes on the smartphone.

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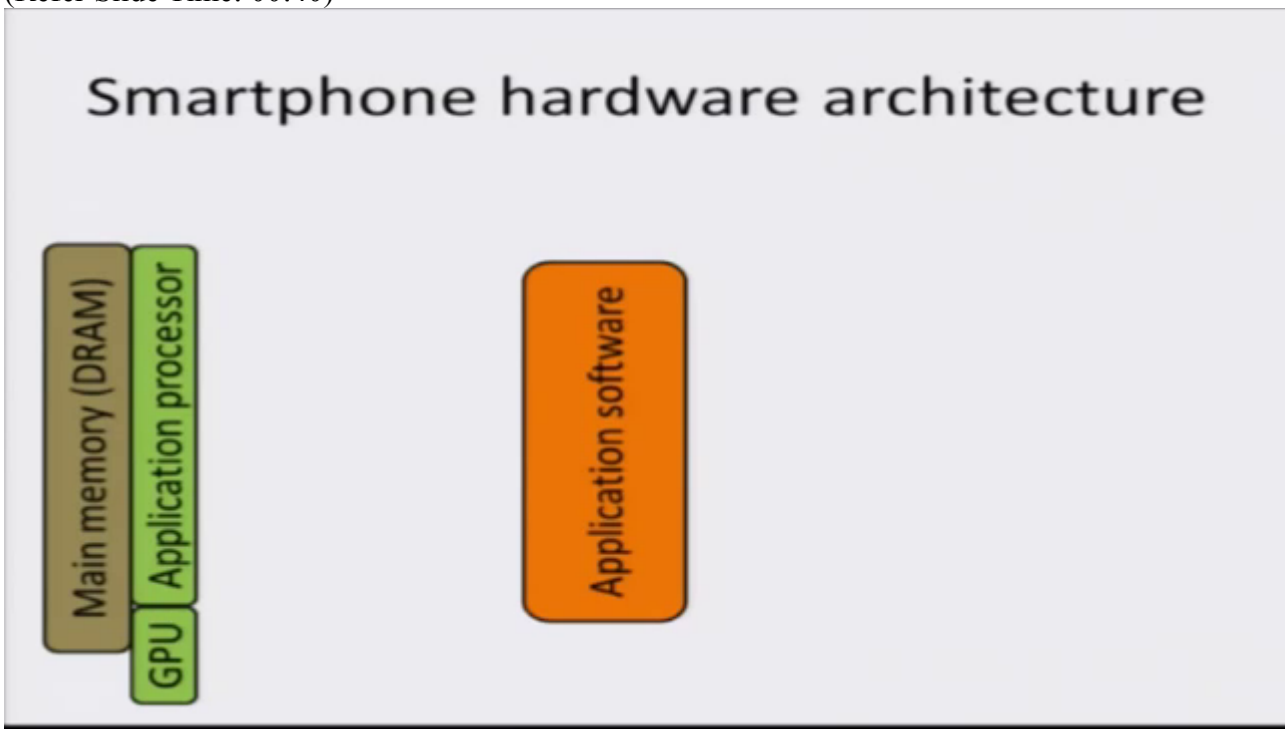

The software gets executed with the help of an application processor often taking help from a graphics processor for rendering scenes and whenever the application processor of the graphics processor needs data it will access the main memory which is dynamic random-access memory.

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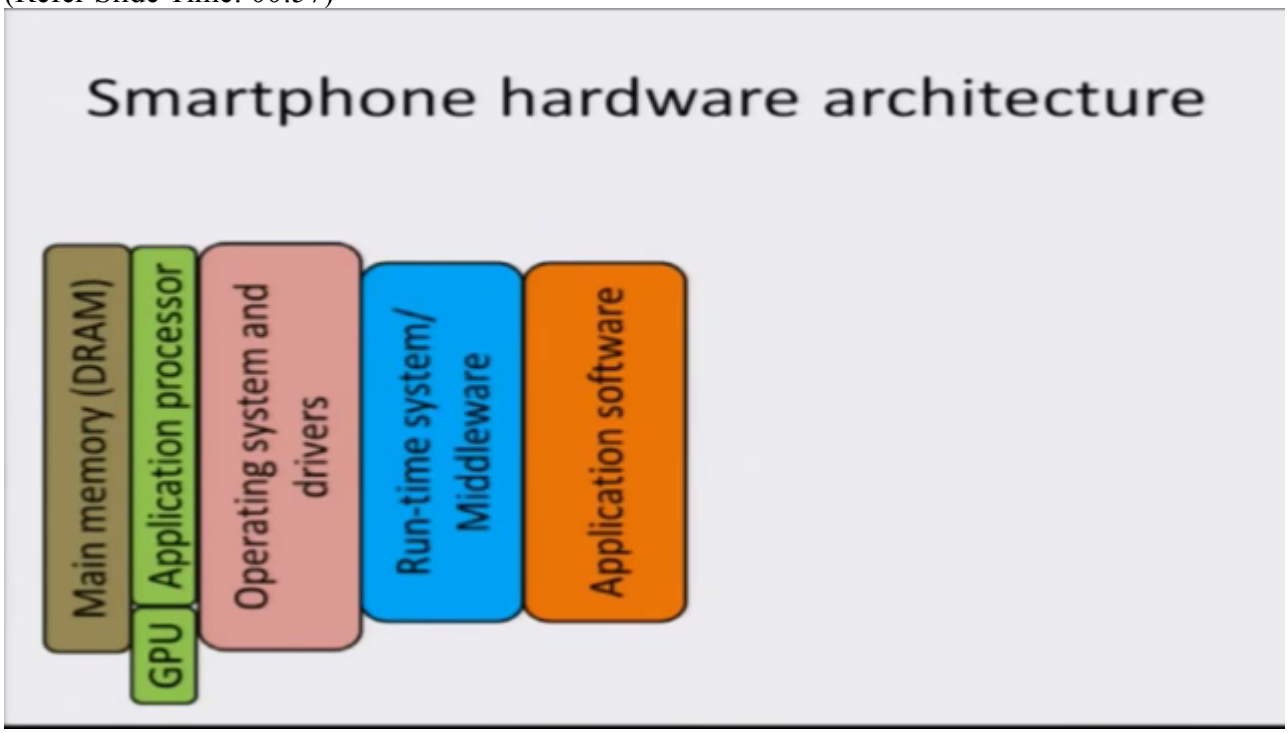

Between the application software and the application processor sit two elements one is the operating system and the drivers that are necessary for handling various types of I/O calls. We'll look at the I/O devices very soon and a runtime system or the middle layer which the application software takes help off to execute various types of application programs.

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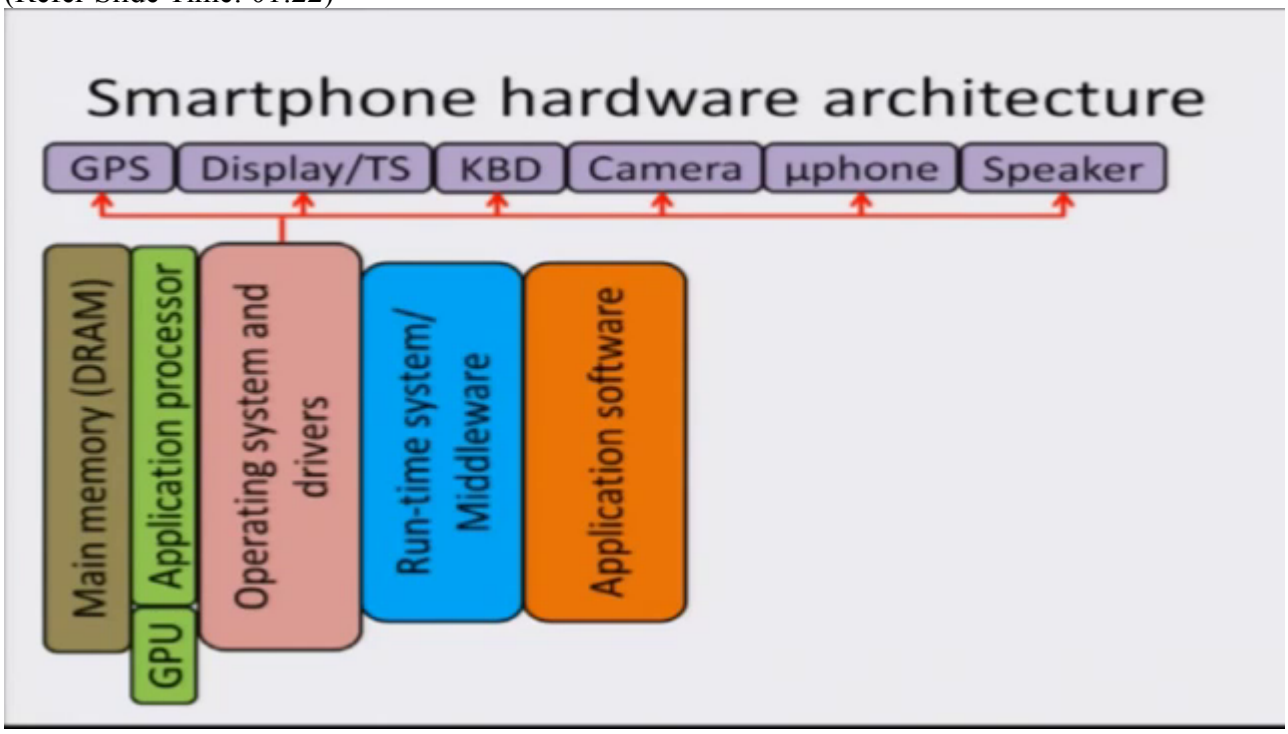

The operating system must have drivers for various types of peripheral or I/O devices for example the Global Positioning System, Display and the Touchscreen, Keyboard, Camera, Microphone, Speaker and so on.

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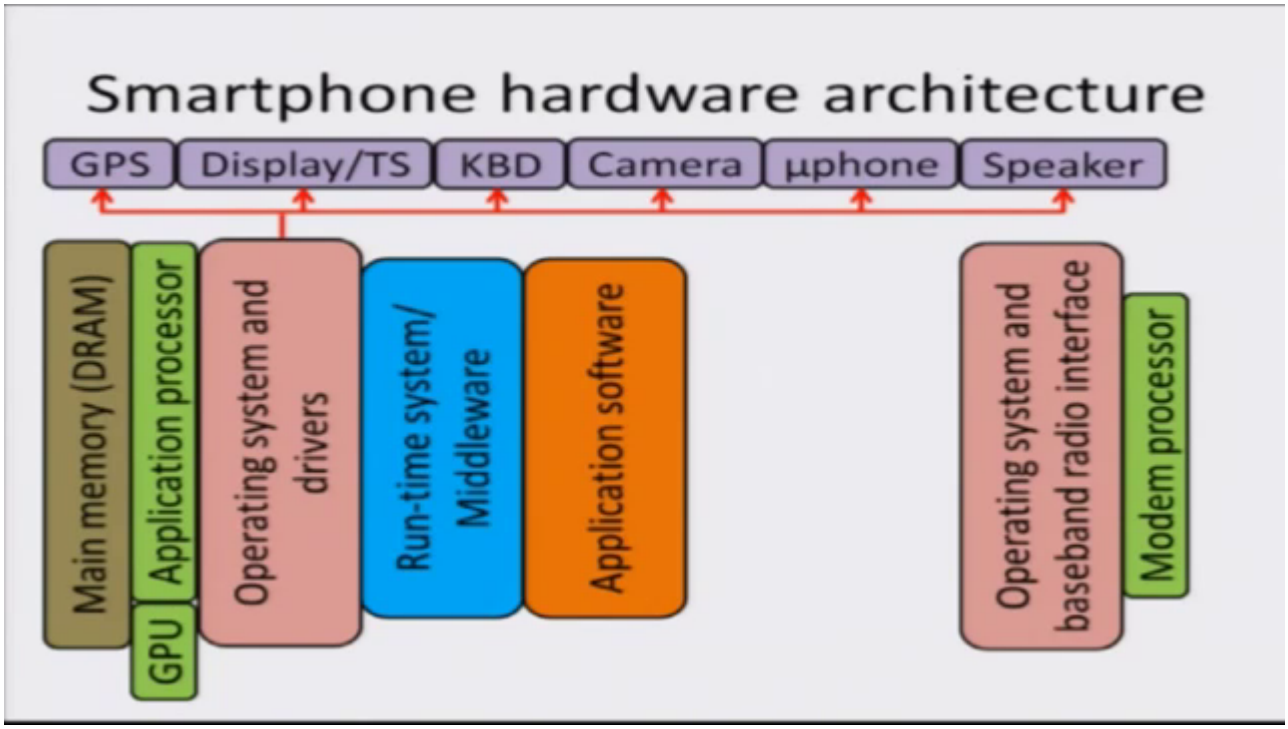

The communication is handled by a modem processor which receives all the signals and passes them on to the operating system and the baseband radio interface.

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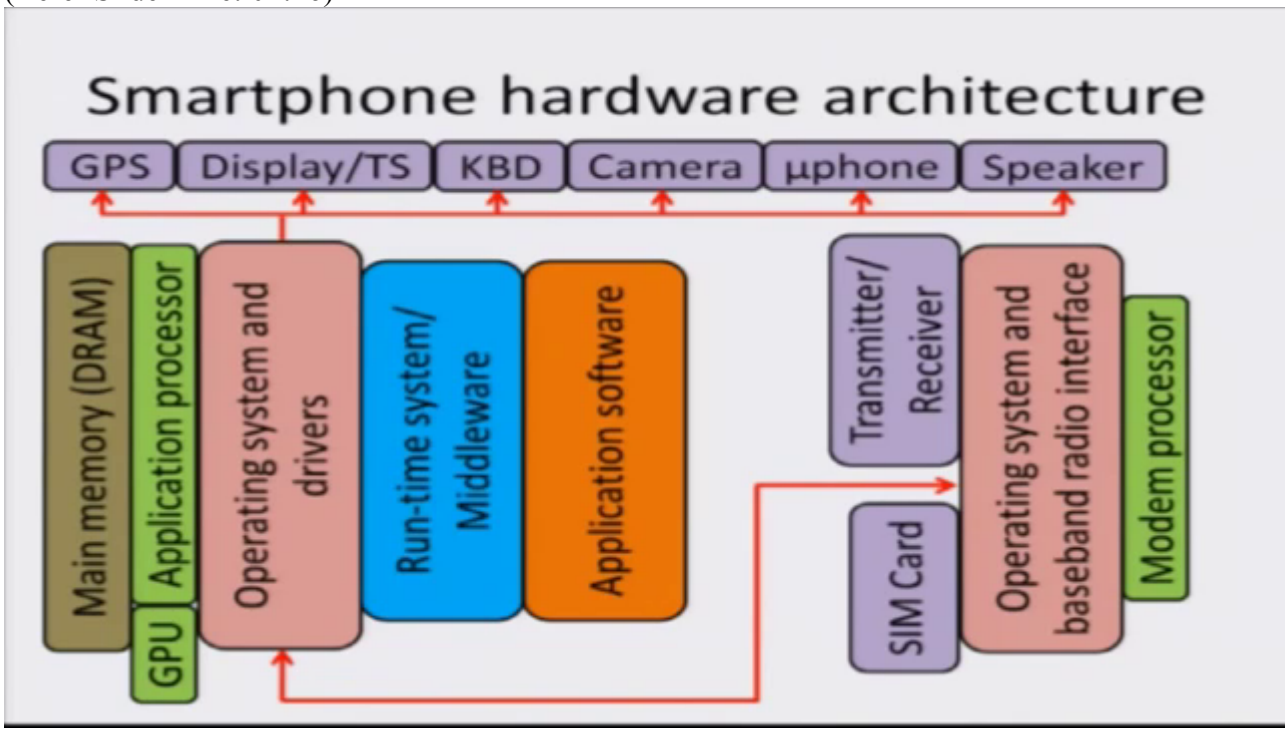

The radio interface communicates with the transmitter and receiver and also the SIM card. The two different operating systems residing on the application processor and the modern processor usually communicate with each other for handling data communication between these two modules. For example when the modern processor receives some data it will interrupt the application processor through its operating system and the application processor will now handle the data, copy to its memory, decode it and take appropriate actions.

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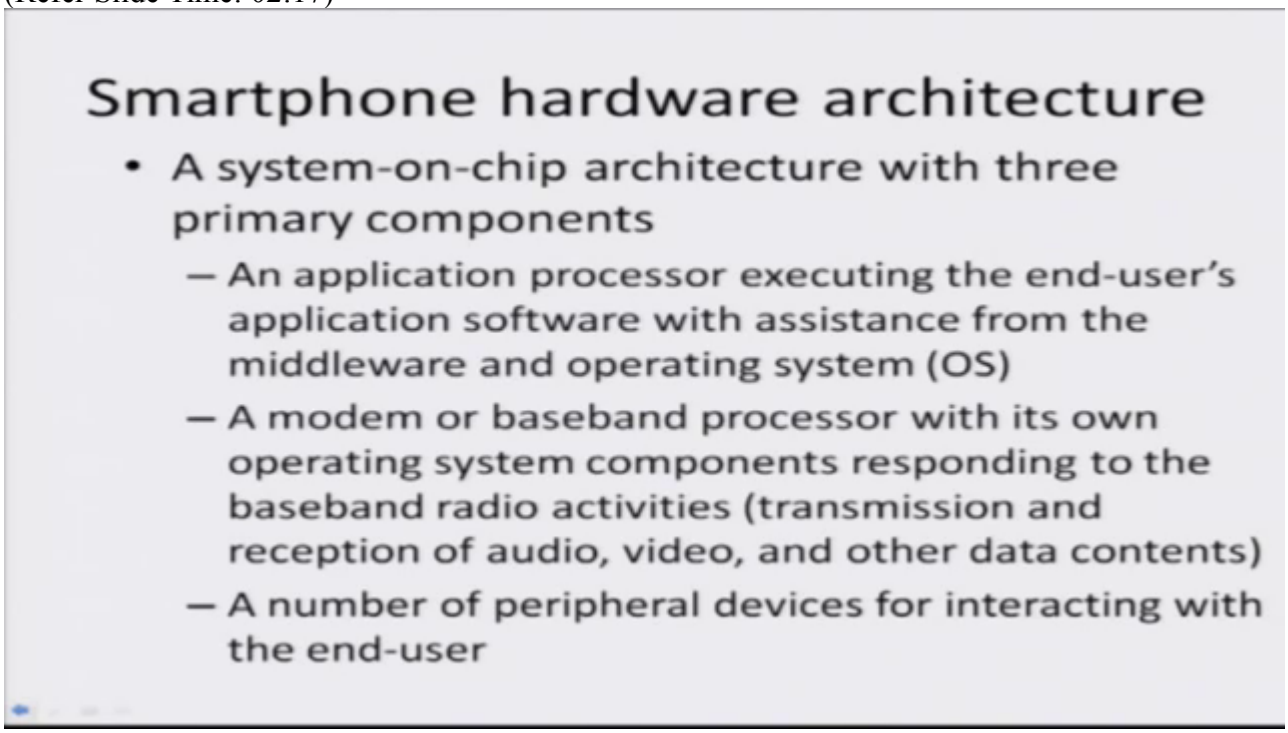

So in summary the smartphone is really a system-on-chip architecture with three primary components; they are first an application processor executing the end-users application software with assistance from the middleware and operating system. Second component is a modem or baseband processor with its own operating system components responding to the baseband radio activities such as transmission and reception of audio video and other data contents. And the third component consists of a number of peripheral devices for interacting with the end-user. So now we'll take a look at the peripheral devices that are usually found in a smart phone.

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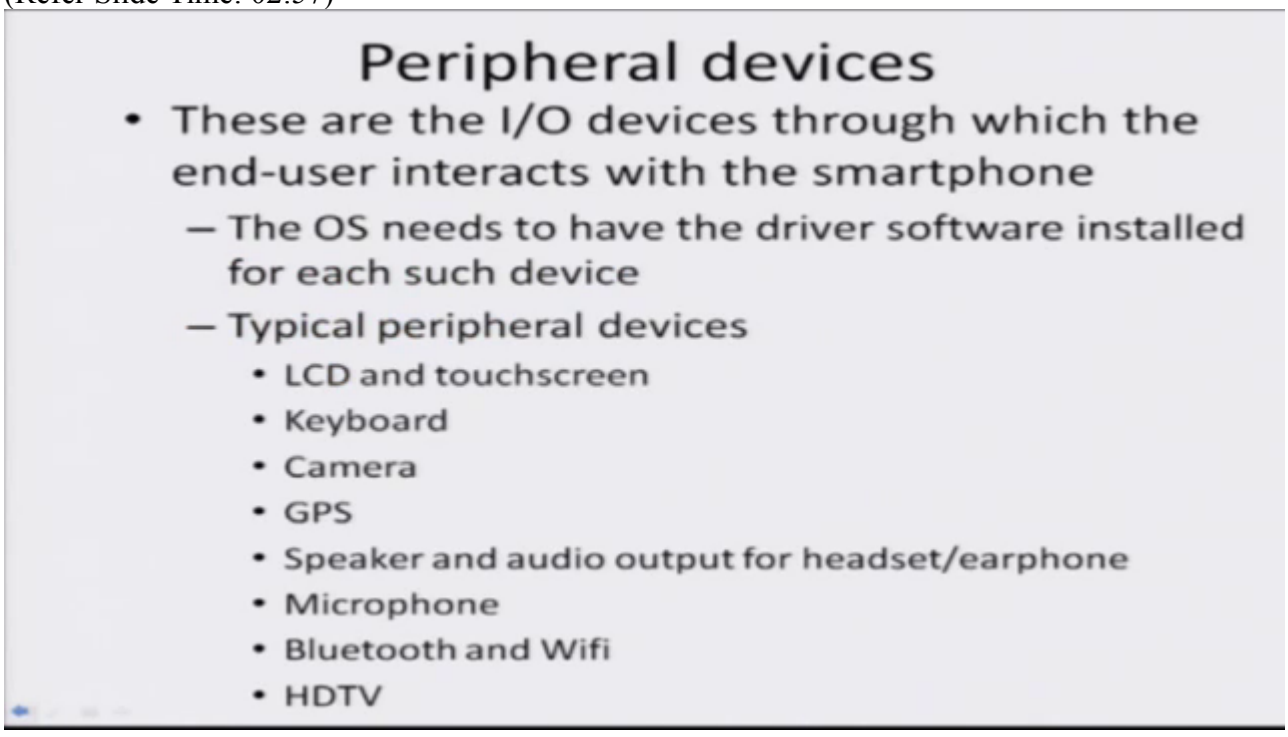

These are the I/O devices through which the end user interacts with the smart phone and the operating system needs to have the driver software installed to for each such device for it to operate properly. So here is a small list of typical peripheral devices that are found for example, the LCD and the touchscreen, the keyboard, the camera, the GPS, the speaker and audio output for a headset and earphone, the microphone, the bluetooth and the wireless connection and HDTV. Next we'll take a look at an example, but before we go onto an example we need to understand what kind of processors are used in a smartphone.
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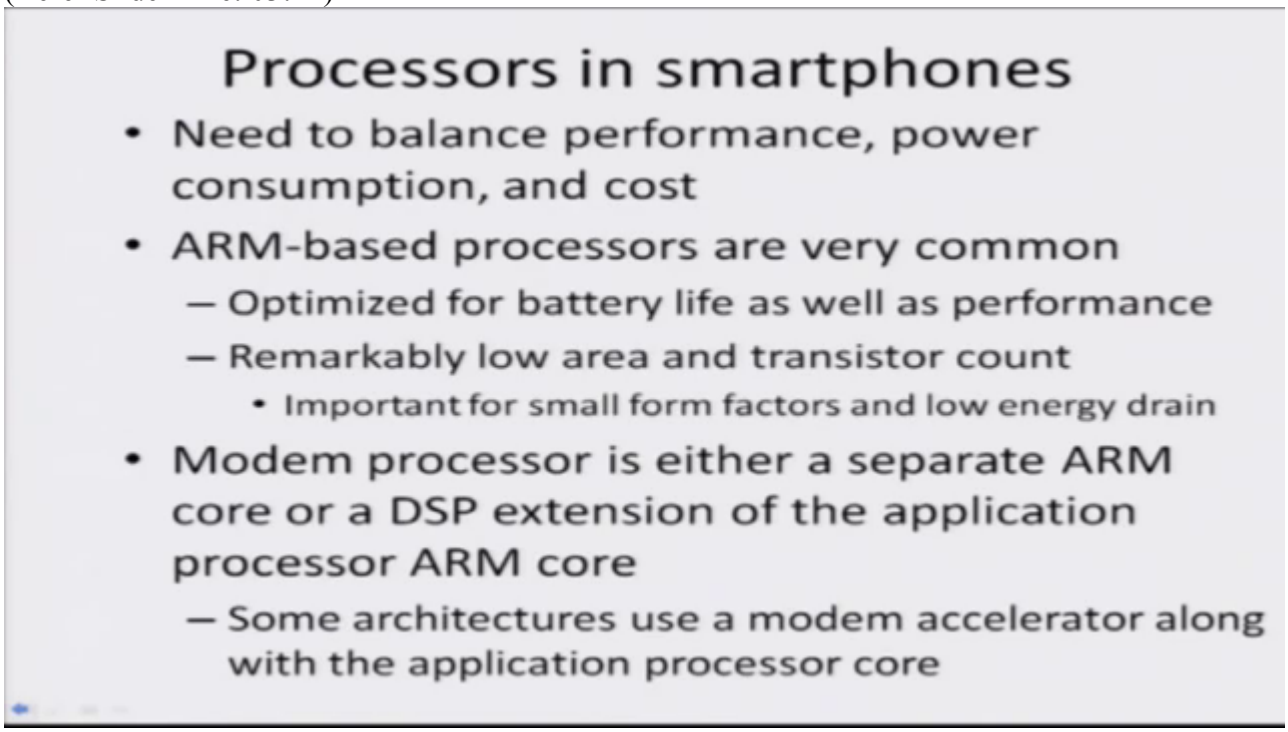

So these processors need to balance performance, power consumption and cost. Arm-based processors have become very common because these are optimized for battery life as well as performance. They also have a remarkably low area and transistor count leading to small form factors and low energy drain which are very important for smartphone applications. The modern processor is either a separate arm core or a digital signal processing extension of the application process and arm core. Some architectures also use a modem accelerator along with the application processor core without having a separate dedicated modern processor.
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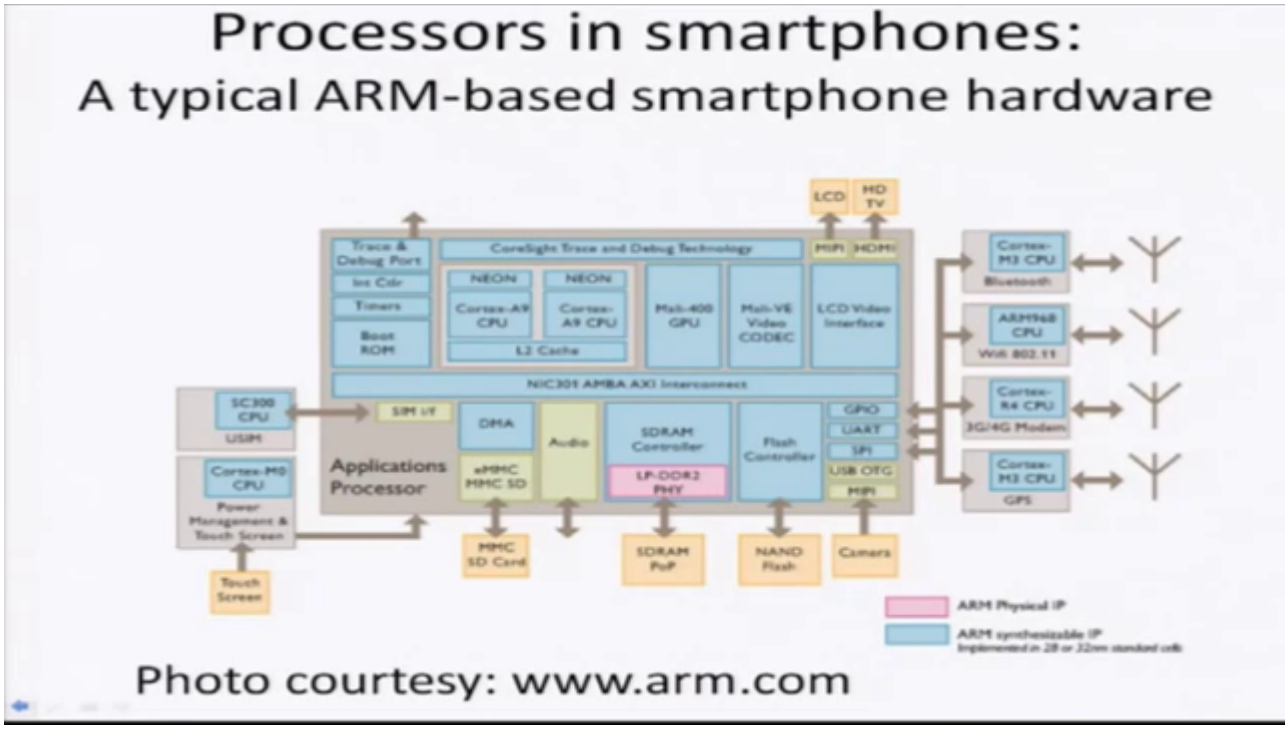

So let's take a look at a typical ARM-based smartphone hardware, it has several components, so let's go through the important ones one by one. This particular example has a dual core ARM Cortex A9 application processor, by dual core I mean there are two processors that can operate simultaneously in parallel handling multiple application requests. It has an Arm Mali graphics processor and a video codec for handling graphics related requests. It has an ARM Cortex R4 3G/4G modem processor for handling the communication part. It has a same interface and control which also has a SC 300 CPU. It has several forms of storage and storage interface. Storage has become very important for smartphones because they operate on complicated applications, so they need big amount of storage.

So in this particular example we have an ml MMC memory card we have the typical SDRAM memory which is in this case low-power DDR2 and also we have a NAND flash card along with is flash controller. And finally there are several peripherals and Arm peripheral, CPUs in this example to go through few of them, it has a touchscreen connected to a Cortex CPU hich which manages the power and the other activities of the touchscreen. It has an audio interface. It has an LCD and HDTV interface connected through HDMI and LCD video interface. It has a camera. It has several communication CPUs, for example, it has a Cortex M3 CPU for Bluetooth handling. It has an Arm 968 CPU for wireless connections and it has a Cortex M3 CPU for the GPS connections.

So this is pretty much a typical ARM based smartphone hardware that are found today. And with this we'll close this lecture. Thank you.

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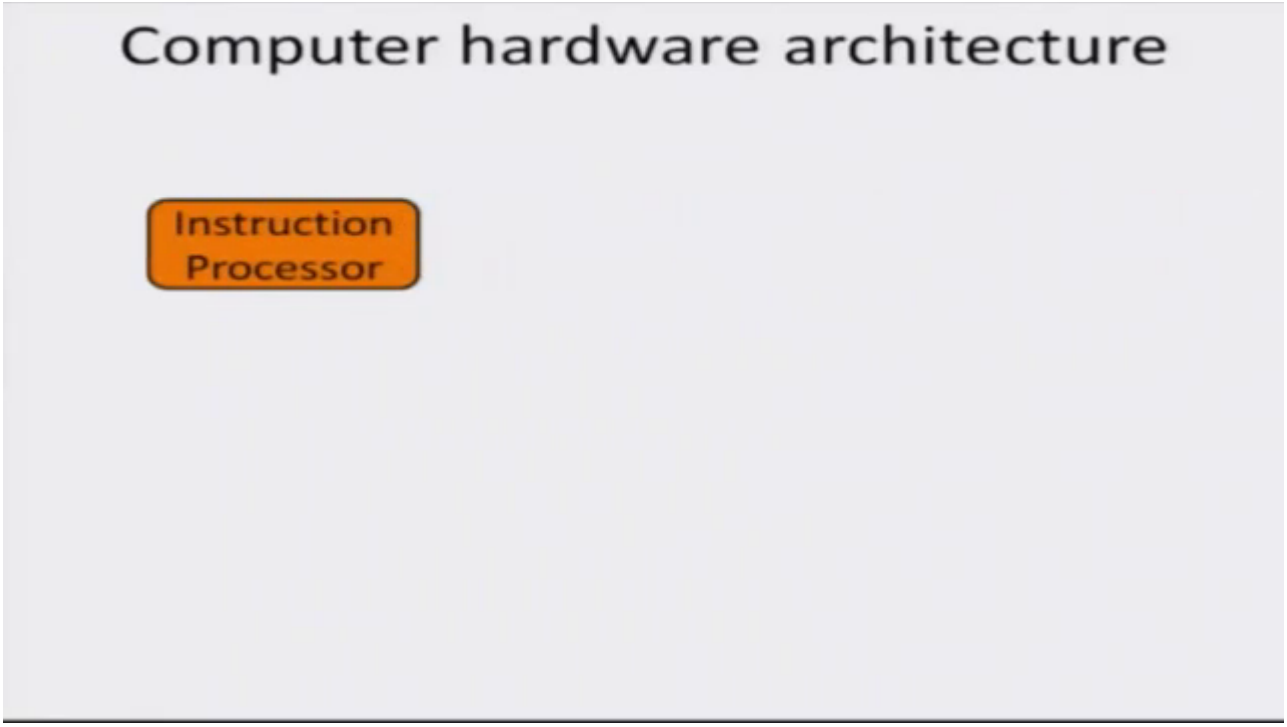

The central processing unit of the motherboard is the main processor which executes instructions. These instructions come from the compiled program and often this is known as an instruction processor. These instructions can be of different types, for example, it could be doing arithmetic operations, it could between logic operations or it could be doing data accesses, you need data to operate on any instruction.

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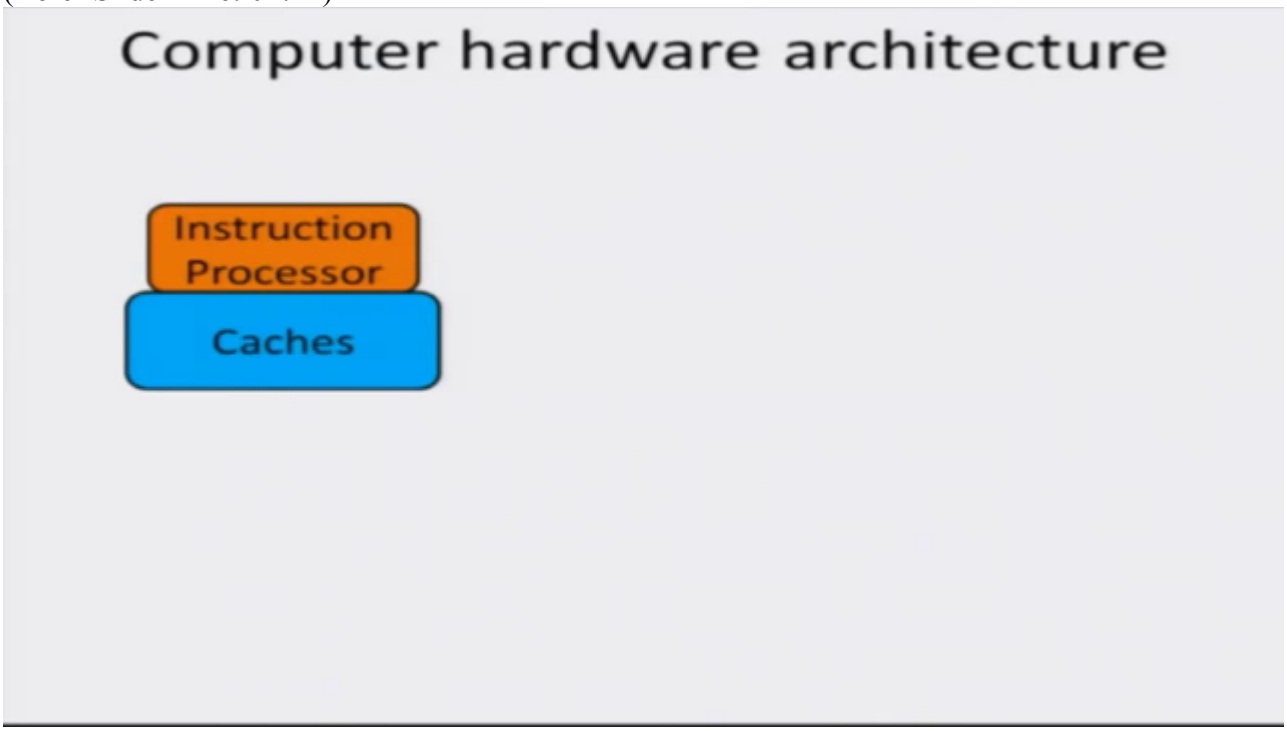

Whenever it requires data it first looks at something called a cache. Cache is a small memory which sits beside the processor and provides the data that have been accessed recently. However it is quite possible that the access data is not found in the Cache.

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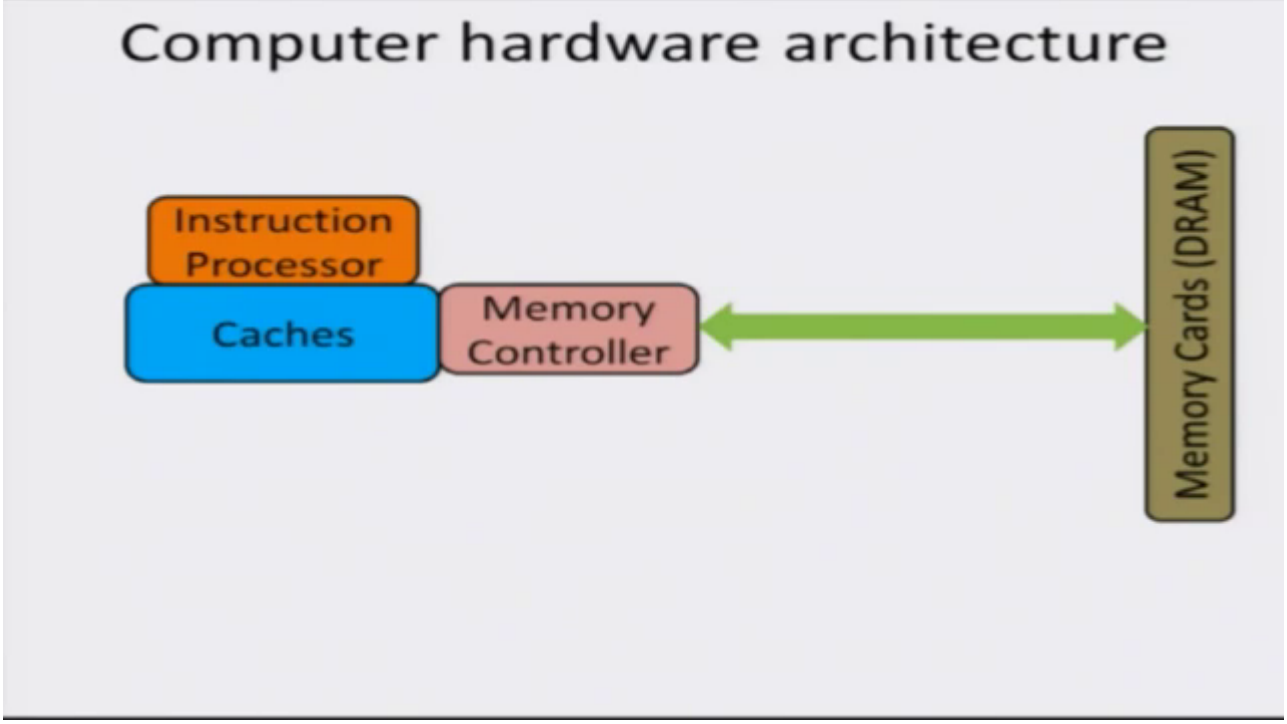

In that case it needs to access the main memory which is known as the Dynamic Random Access Memory or DRAM and these requests normally go through something called a Memory Controller which takes the requests from the Caches and sends the request to the Dynamic Random Access Memory or the Memory Cards and sends the response back to the Caches through the Memory Controller and the Caches will finally deliver the response to the processor which must have been waiting for the data.

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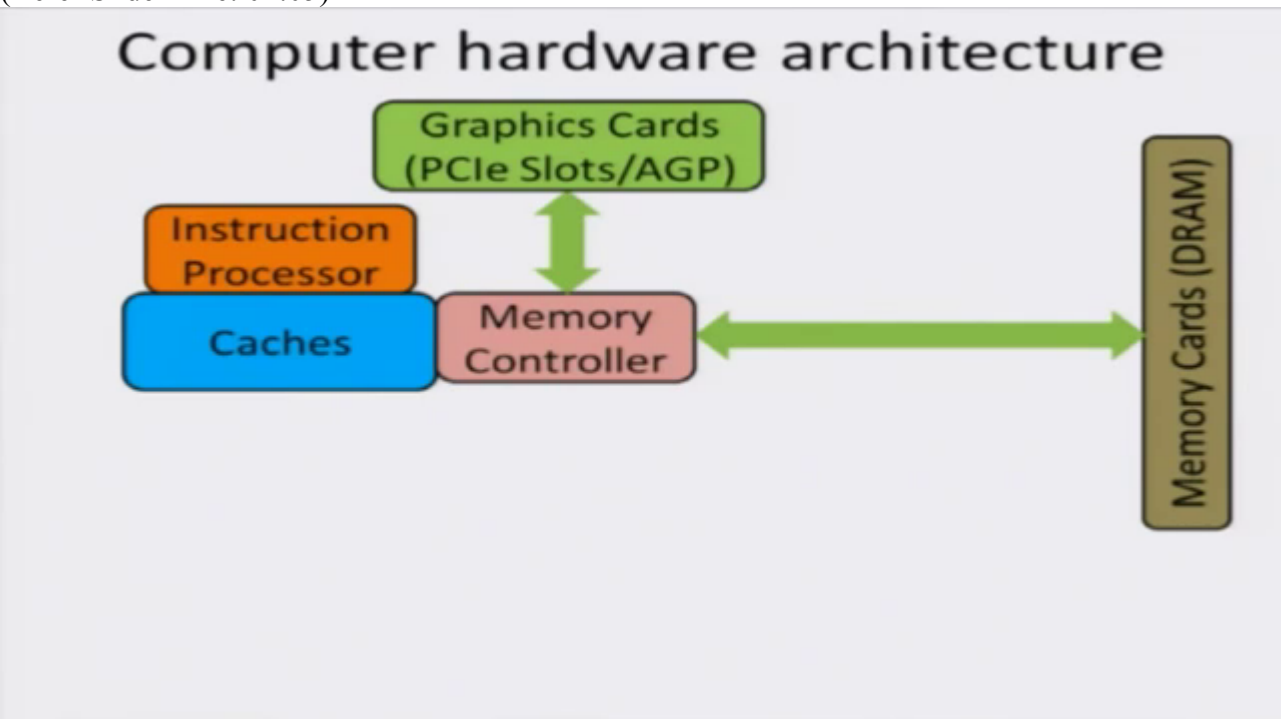

Additionally today in the computers you will find graphics cards for carrying out rendering of scenes and also for doing high-performance computing. These cars are normally connected to the memory controller through a special kind of fast buses that's called a PCI Express bus.

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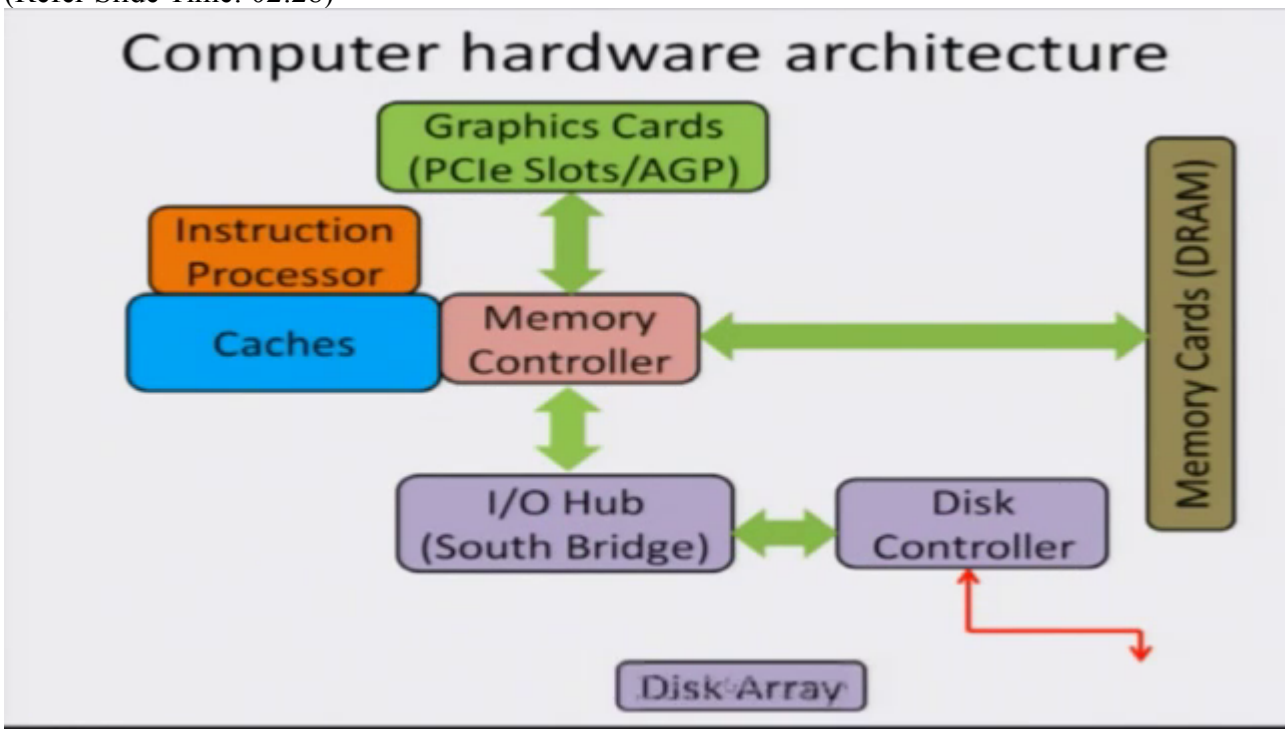

Finally, you need to interact with the environment, which are also known as the I/O devices or the input/output devices, for example, the keyboards, mousse, printers, hard disks, CD-Rom drives, speakers, microphones and so on. so these requests also go through the Memory Controller but they are delivered to something called an I/O Hub or the input/output hub which is also known as the Southbridge of the motherboard. The input/output hub is essentially a I/O controller which takes the requests from the Memory Controller, decodes the request and routes the request to the appropriate I/O device. One of the most important I/O devices connected to the Southbridge is the disk controller which controls accesses to the hard disk. So as you can expect the disk array would be connected to the disk controller.

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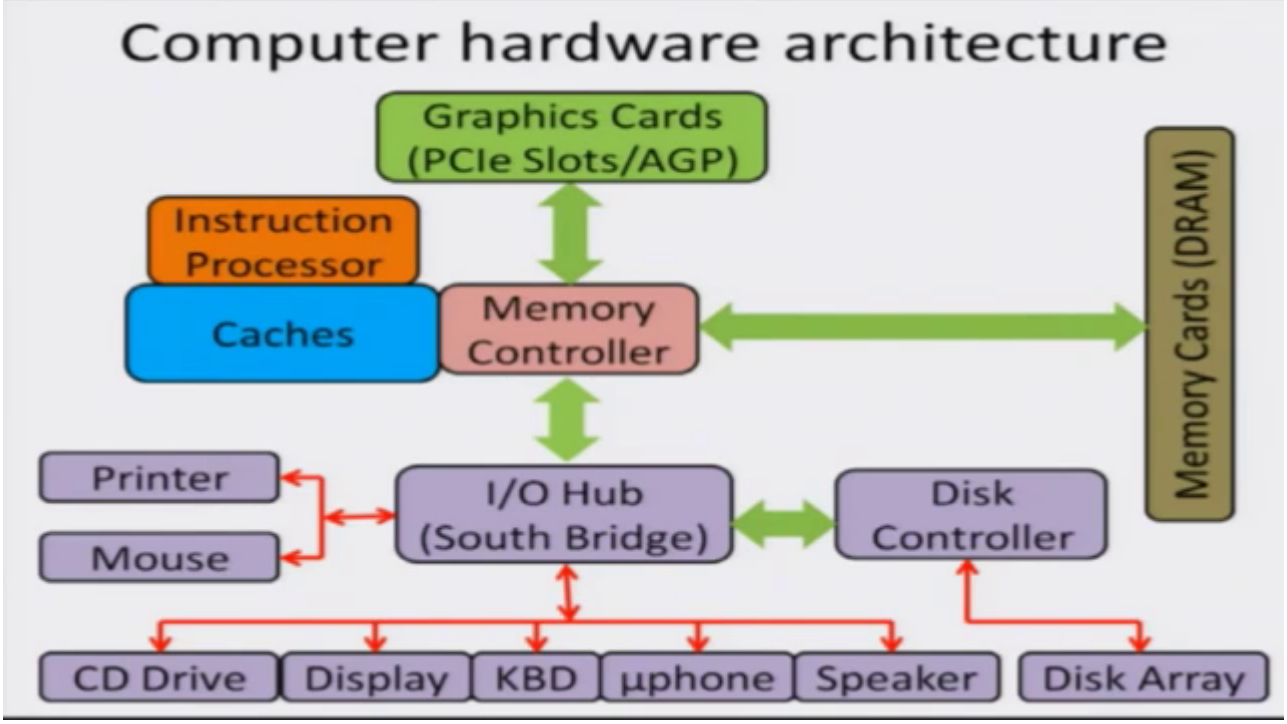

Additionally the south which connects to several other I/O devices, for example, the printer, the mouse the CD-Rom drive, the display or the monitor that you see, keyboard, microphone and the speaker. So this is roughly the overview of the motherboard which plays a key role in how a computer works. Thank you.