

Lecture 1: Hardware

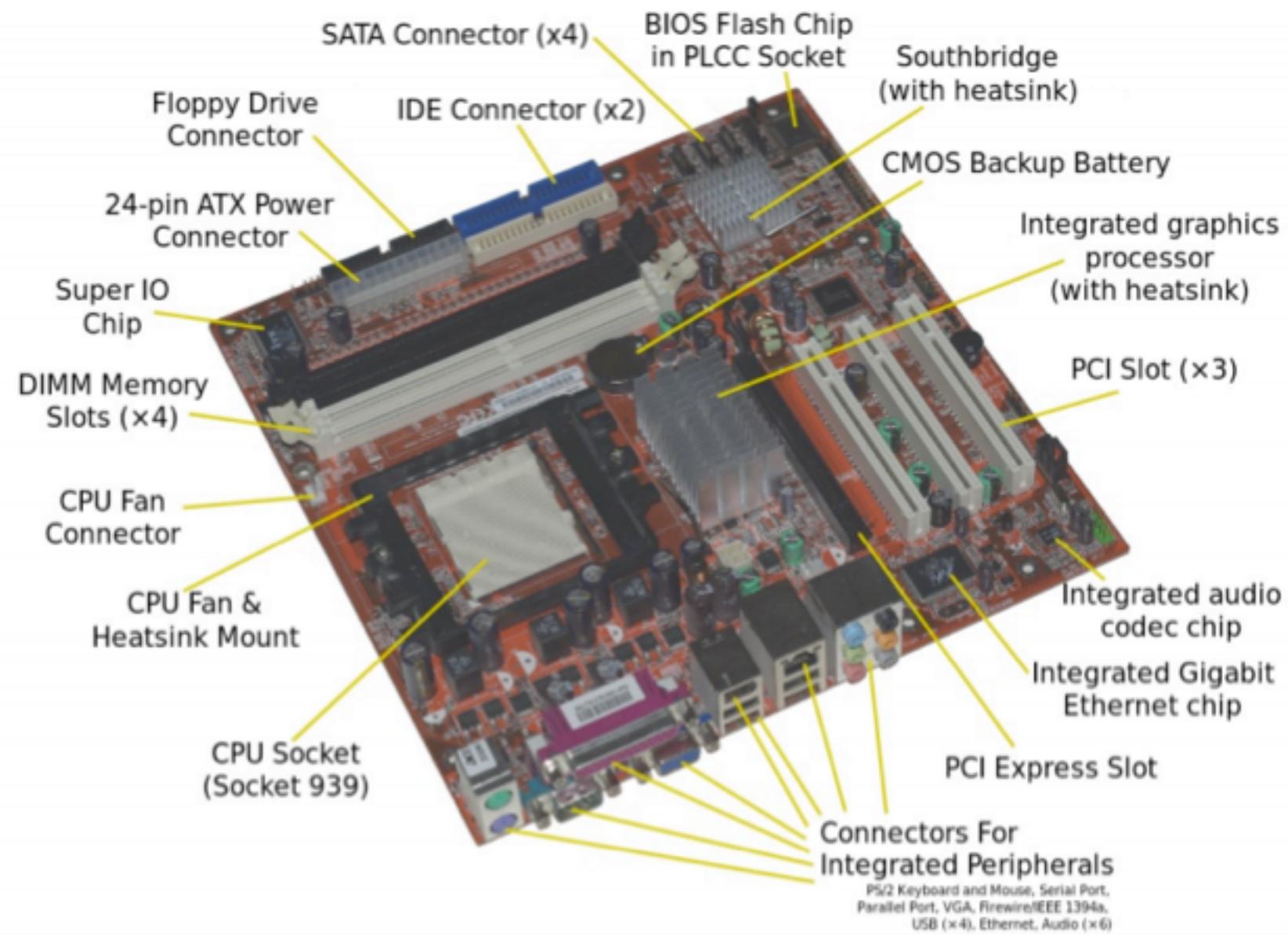
AP Computer Science Principles

Hardware

The **hardware** of a computer consists of its physical components.

Many of the hardware components are connected to the **motherboard**, which is a logic board that manages the communications between various parts.

The Motherboard



Turn on power

When you press the power button, a signal is sent to the power supply which plugs directly into an electrical outlet and manages the electric voltage that is sent to the components of your machine.

The power supply connects to the motherboard via the 24-pin ATX power connector on the top left of the board.

BIOS

Once your computer has power, a piece of software called the **BIOS**, or basic input output system, starts up. BIOS contains the instructions that the computer needs to follow in order to start up.

Without the BIOS's instructions, your computer would have power but wouldn't know what to do with it! On a Mac, this software is called **EFI**, or extensible firmware interface, but it plays the same role.

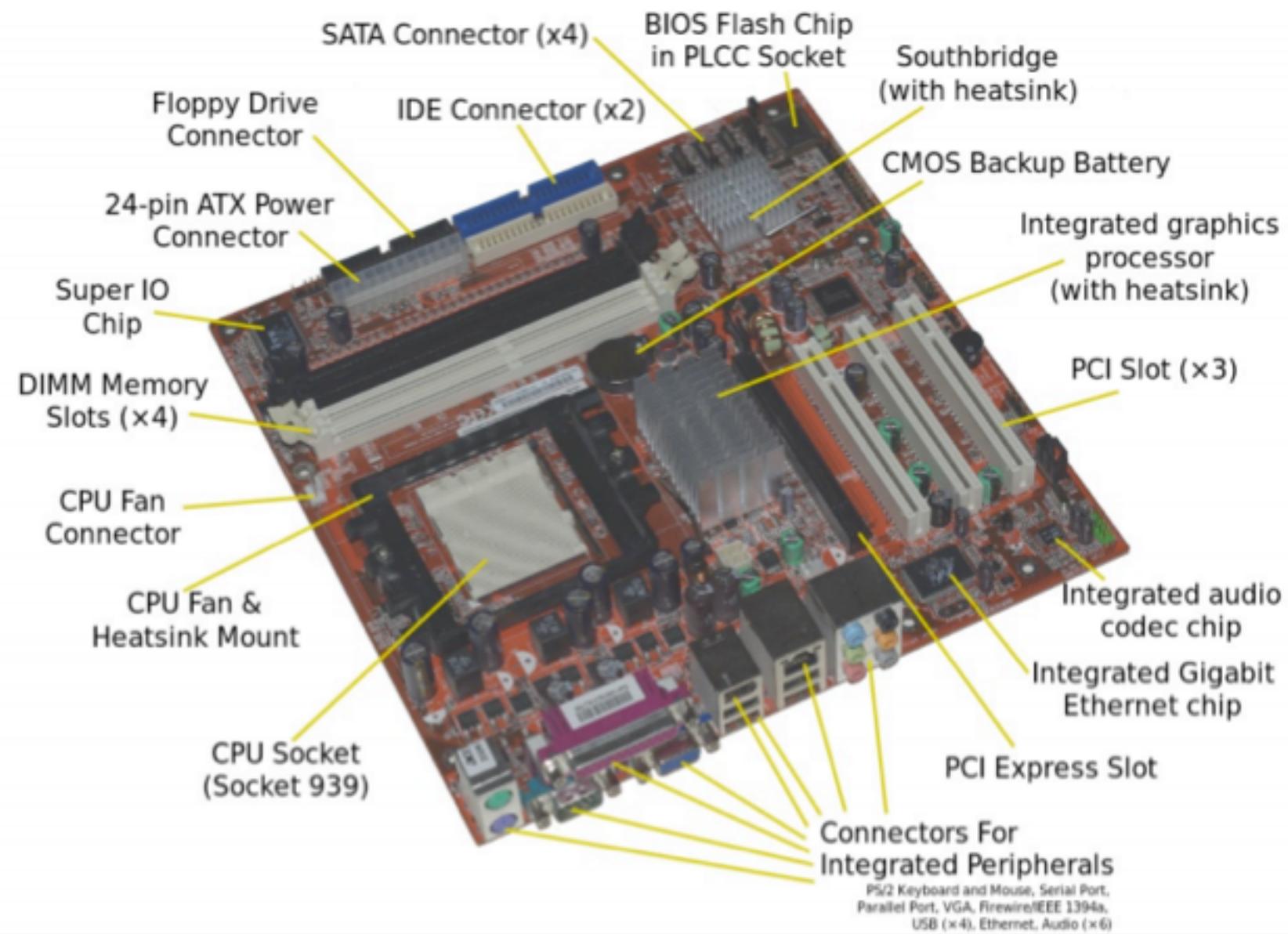
CMOS

First, your BIOS (or EFI) reads a few system settings from the **CMOS**, or complementary metal-oxide semiconductor.

The CMOS stores a small bit of information, such as the current date and time, that is needed by the BIOS in order to begin the startup process.

So that data on the CMOS isn't lost if the computer loses power, it has its own lithium battery, not unlike the one that might be found in a watch.

The Motherboard



PCI Slots

Next, the BIOS ensures that the computer's video card is operational, so that it can output information to the computer's display. The graphics card may connect to the motherboard using a **PCI slot**.

The motherboard above has three PCI slots located near the bottom-right of the board, which serve the purpose of allowing additional hardware to connect to the motherboard.

A Graphics Card



PCI express

In addition to graphics cards, sound cards, video cards, and additional ports, for example, can be added to the motherboard via PCI slots.

The adjacent **PCI express**, or PCIe, slots are used for the same purpose, but compared to PCI, PCIe is a newer and faster standard.

Power on self tests

The BIOS performs a series of power on self tests, or a **POST** for short, to make sure all of your computer's hardware is functioning correctly.

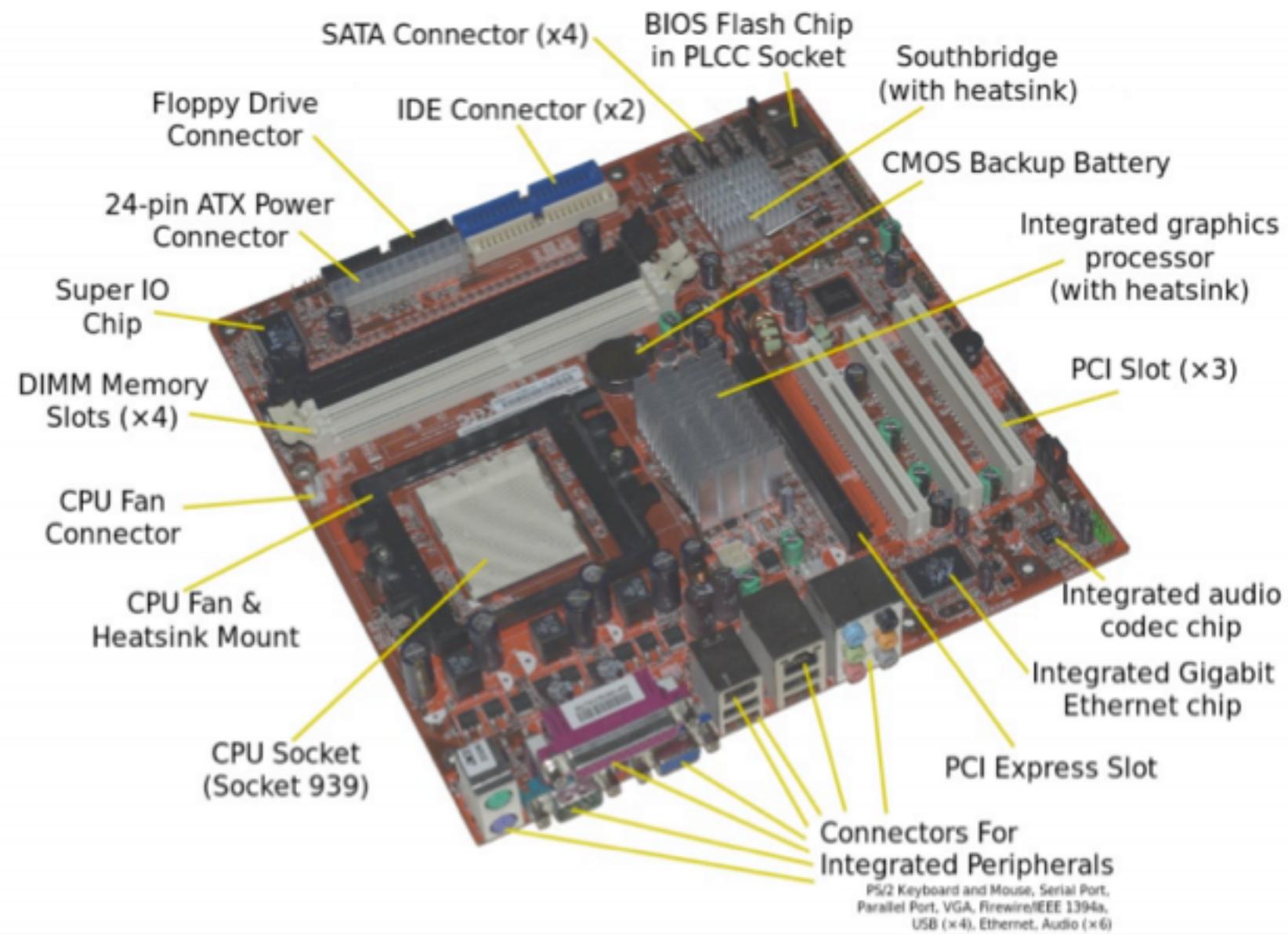
The POST first makes sure that the system's **RAM**, or **random-access memory**, is totally readable and writeable. RAM is your computer's short-term memory, which is used by programs to temporarily store data.

RAM

This data stored in RAM will typically become inaccessible once those programs finish running and once the computer loses power.

RAM is attached to the motherboard via the memory slots at the top-left of the motherboard. These slots look similar to the PCI slots we saw earlier, but they're a bit longer and thinner.

The Motherboard

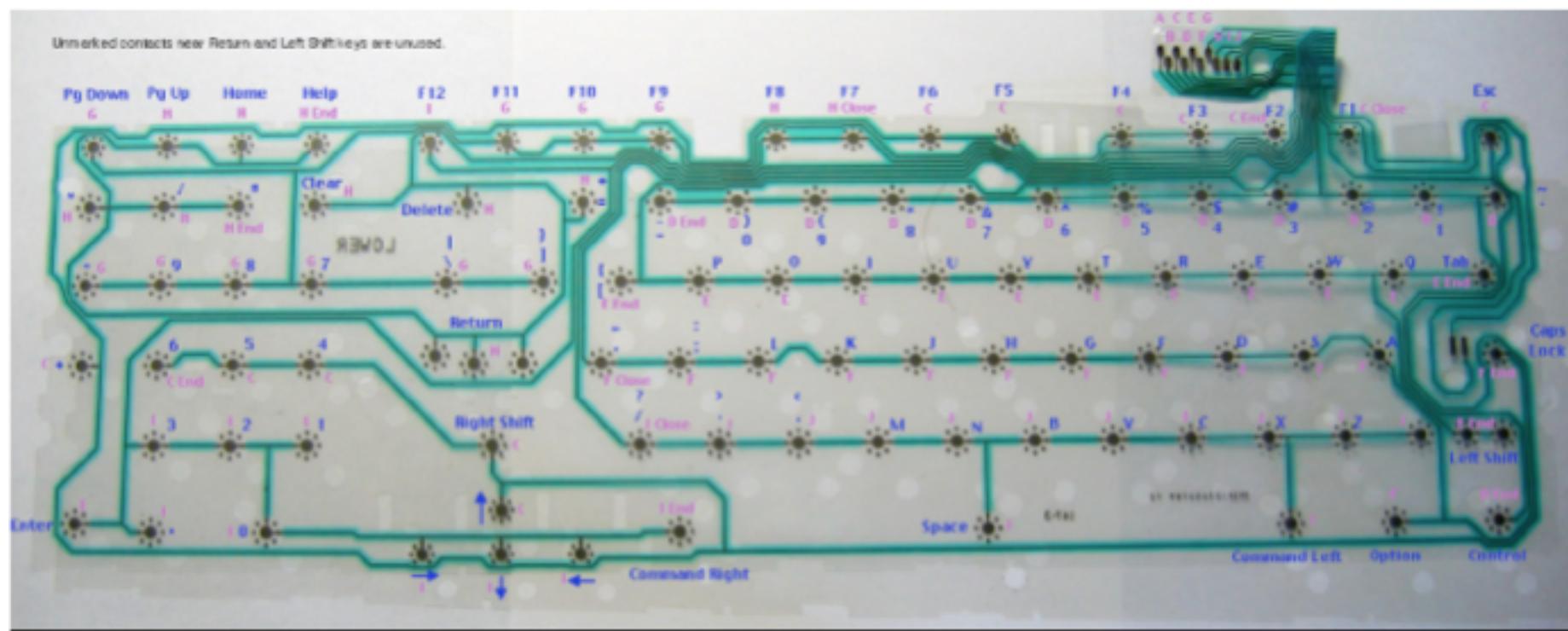


Peripherals

Next, the POST checks for any **peripherals** attached to the computer, which could include the keyboard, mouse, flash drives, or printers. The ports that allow additional hardware to be plugged into your computer can be found in the three columns at the bottom of this motherboard.

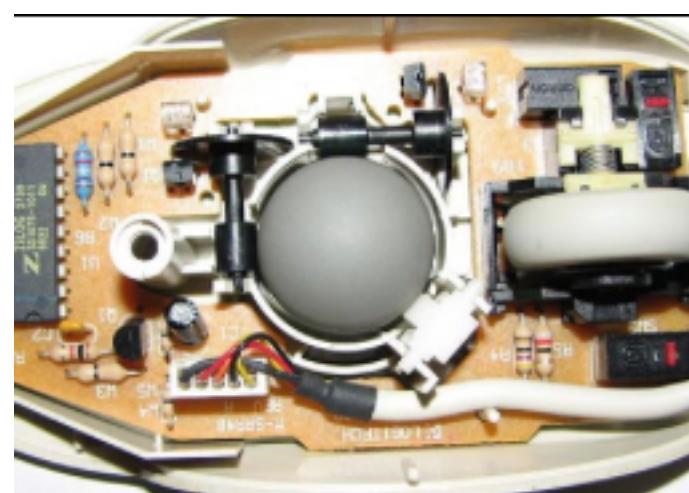
The rightmost column of ports on this picture are used for both audio out (e.g, speakers) and audio in (e.g., a microphone). Here, the additional audio jacks allow the computer to handle both a microphone and an additional digital line in/out.

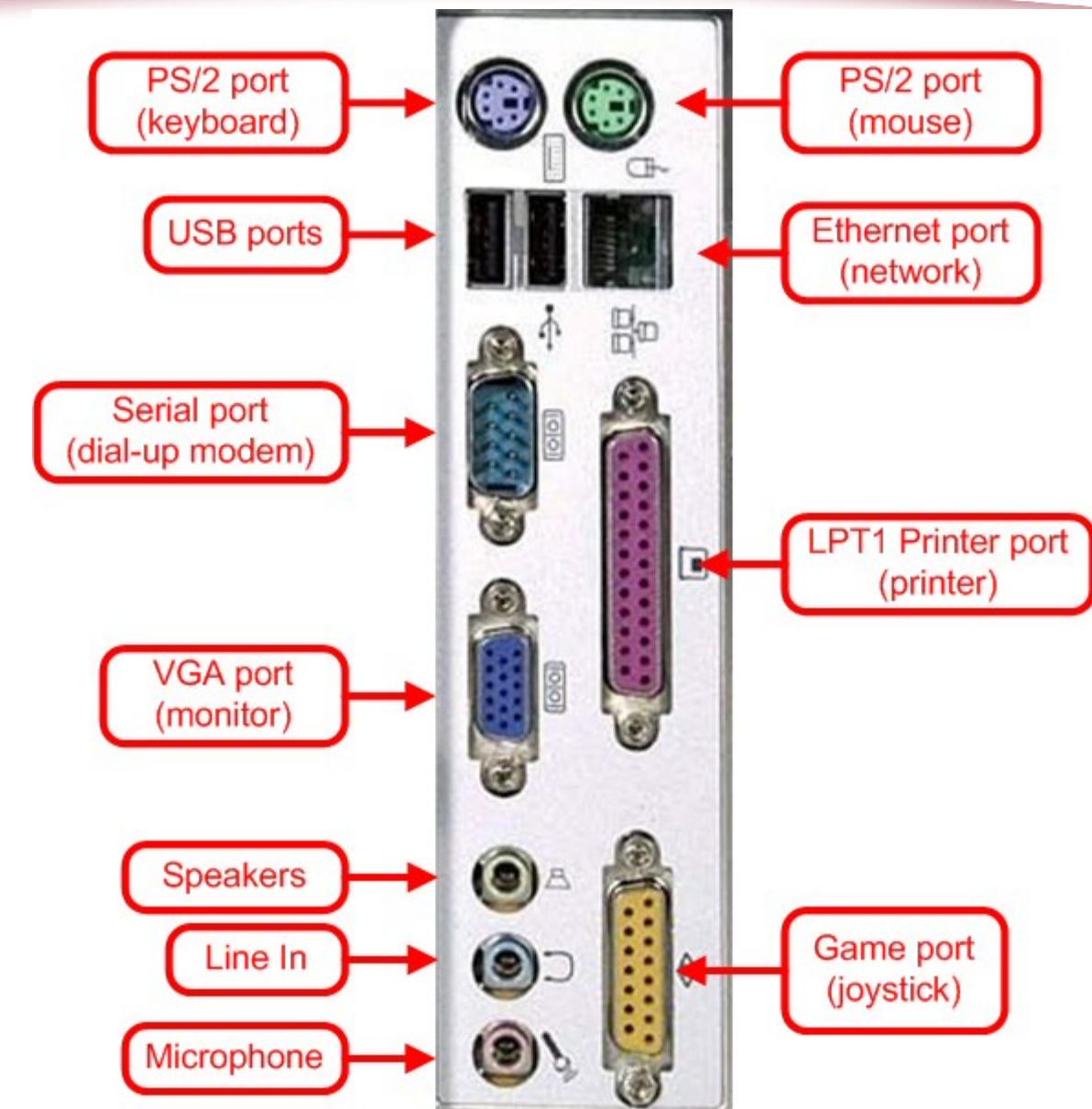
What is this?



Circuit for a keyboard.

Mouse



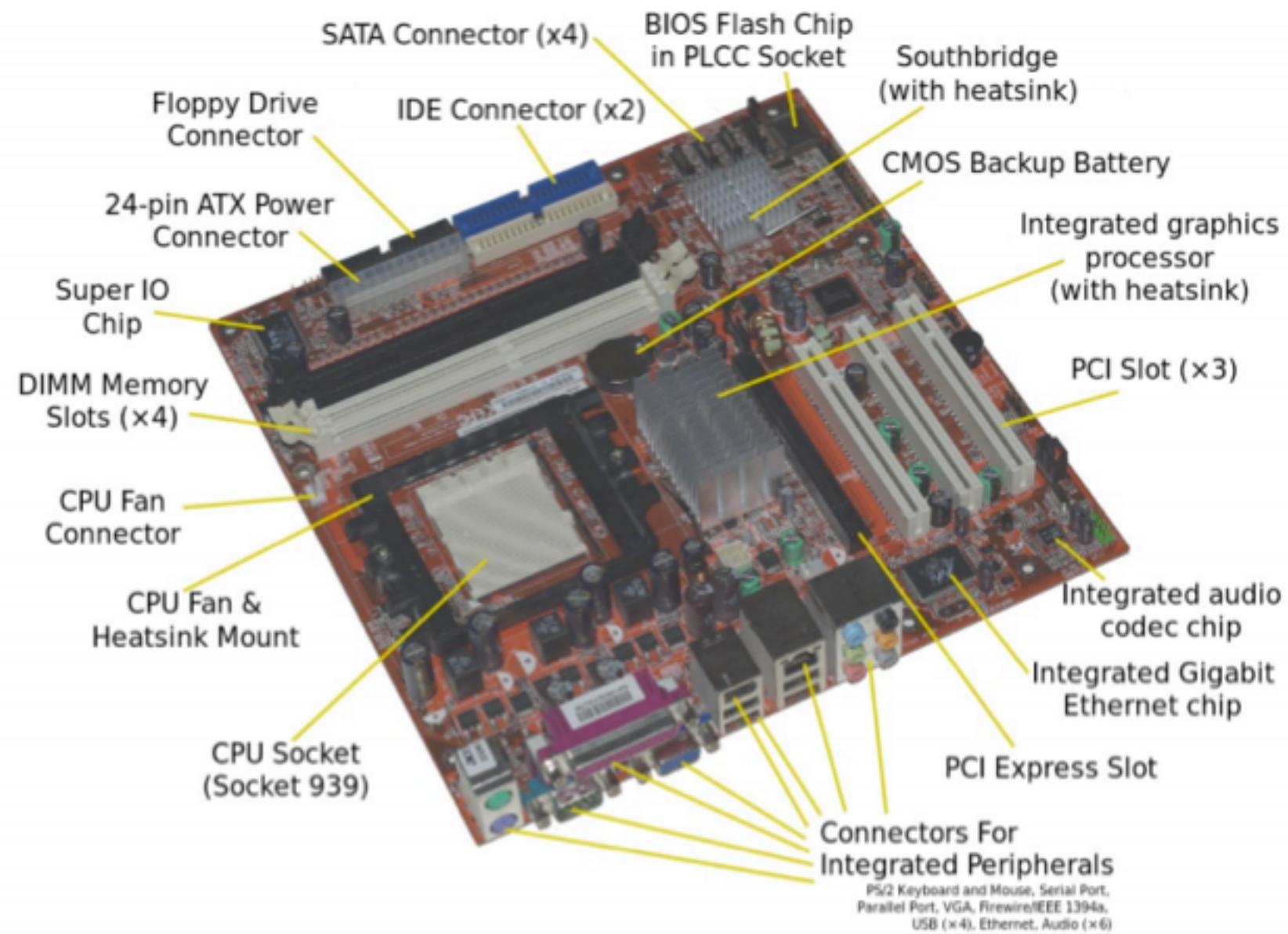


Ethernet

Next to the audio jacks appears to be an **Ethernet(RJ45)** port, which is used to connect your computer to the Internet via a modem or router. More on modem and routers when we discuss networking.

In that same column and the one next to it, we have a good amount of **USB**, or universal serial bus, ports. Today, USB is among the more popular ways of connecting consumer electronics to your computer.

The Motherboard



USB

However, USB cables come in a few different shapes, shown below. Many modern printers use a USB A to B cable, which has a type A connector on one end and a type B connector on the other.

Micro USB to A cables, on the other hand, are commonly used in smartphone chargers. Because cables can have two different types of connectors, many computers simply have slots for USB A, and device-makers supply cables with at least one type A connector.

USB



USB-A



USB-B



USB-MINI4A



USB-MINI4B



USB-MINI5A



USB-MINI5B

USB C



USB-C is a new standard that will soon make other standards obsolete. It is shaping up to replace not just the older USB standards but also the DisplayPort and the Thunderbolt.

USB C



Apple's new MacBooks have the USB-C as its only port for charging as well as for connecting peripherals.

Ports

On the left is a parallel port, serial port, and VGA port. While the larger parallel port and smaller serial port have largely fallen out of use in consumer electronics, **VGA** ports are commonly used to connect an external display to your computer.

You may also have heard of **DVI** and **HDMI** as means of connecting monitors to your computer. While VGA utilizes an analog signal, both DVI and HDMI are digital, which can result in faster data transfer and a higher-quality picture.

Cables



HDMI-HDMI



DVI-DVI



VGA-VGA

Cables

HDMI is popular because they are capable of carrying both audio and video. It is the default cable for TVs, Blu-rays and game consoles.

VGA and DVI, on the other hand, require a separate cable in order to transfer audio between devices. Because VGA uses an analog signal while DVI and HDMI use digital signals, it's generally expensive to convert a VGA to DVI or HDMI.

Macs uses the Mini-Displayport(also called Thunderbolt) for audio and video.

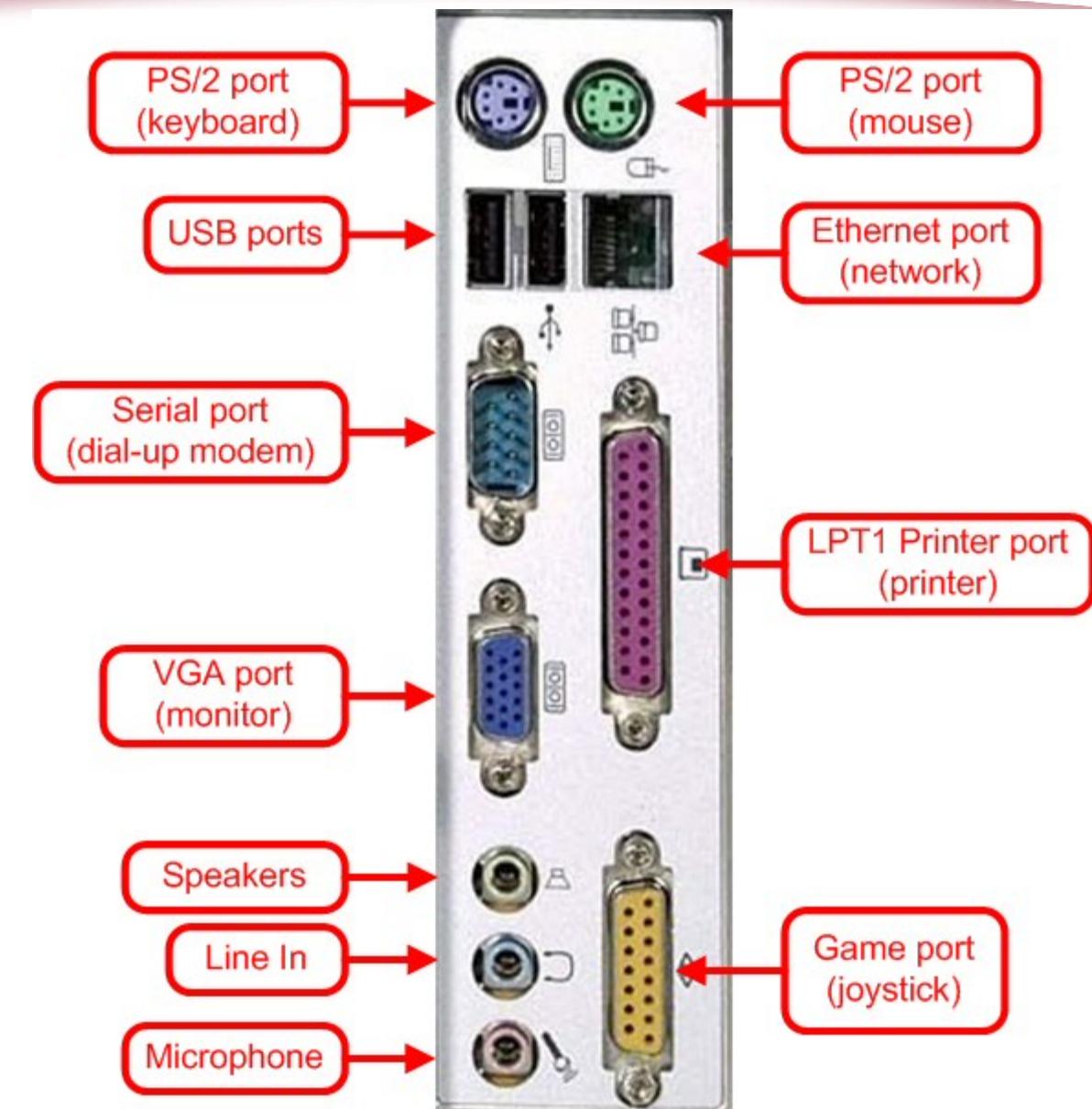
Mini-DisplayPort(Mac)



PS/2

All the way to the left are two **PS/2 ports**, which used to be used to attach your keyboard and mouse to the computer. Though they look identical, the ports used for keyboards and mice are not interchangeable, so you can't plug your keyboard into a mouse port.

USB ports have largely superseded PS/2 ports, and almost any keyboard or mouse you buy today will have a USB connector.



Operating System

Once the POST process has completed and the BIOS has verified that all attached hardware components are working correctly, it can start loading your **operating system**, which is probably a version Windows, OS X, or Linux from the hard drive.

RAM is your computer's short-term memory, while the hard drive functions as its long-term memory. Unlike RAM, data on the hard drive will not be lost when your computer loses power. The amount of space on a hard drive is also much larger than the amount of space in RAM; while RAM is typically 2-4 gigabytes, a hard drive is usually several hundreds of gigabytes in size.

Memory



Desktop RAM memory(above).
Laptop RAM memory(right).

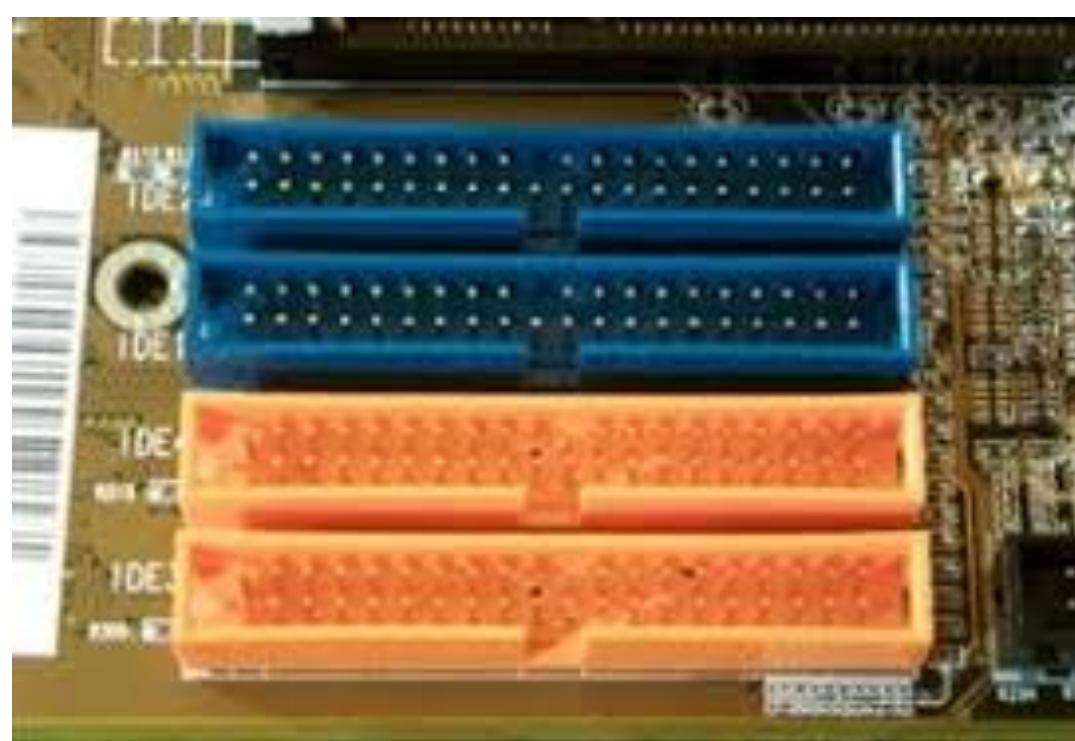


Boot Up

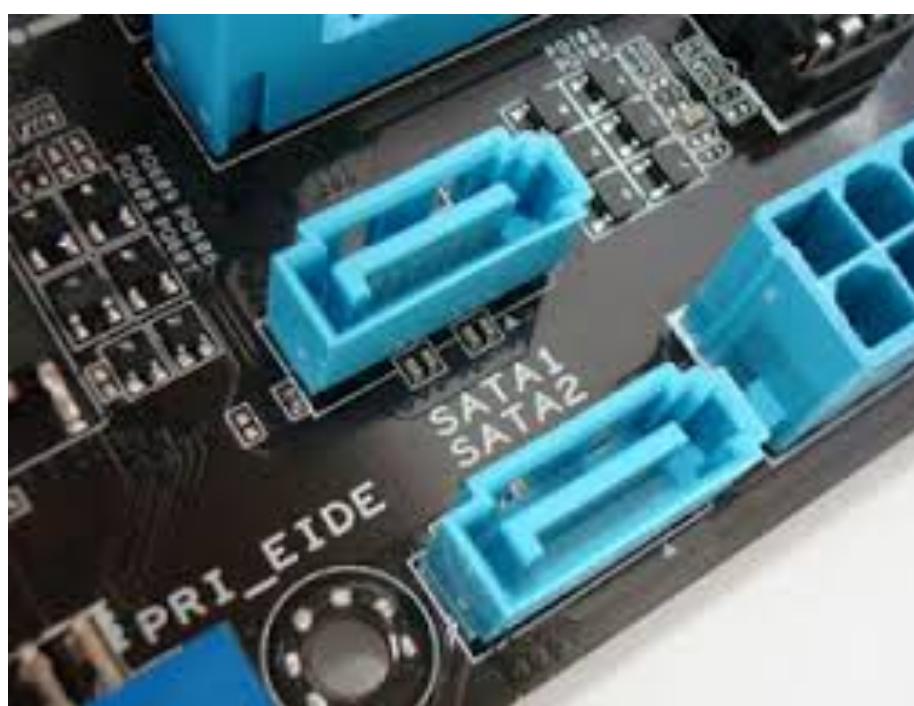
Your computer's hard drive connects to the motherboard via the **SATA(Serial ATA)** connectors and **IDE** (also known as **PATA, Parallel ATA**) connectors, found at the top of this picture. SATA is a newer technology, mostly replacing the older IDE(PATA).

Your computer's hard drive might be a traditional **hard disk drive(HDD)** with moving parts or a cutting-edge **solid-state drive(SSD)**, and its not uncommon for computers to have multiple hard drives, for higher performance or backup purposes.

PATA(IDE) Ports



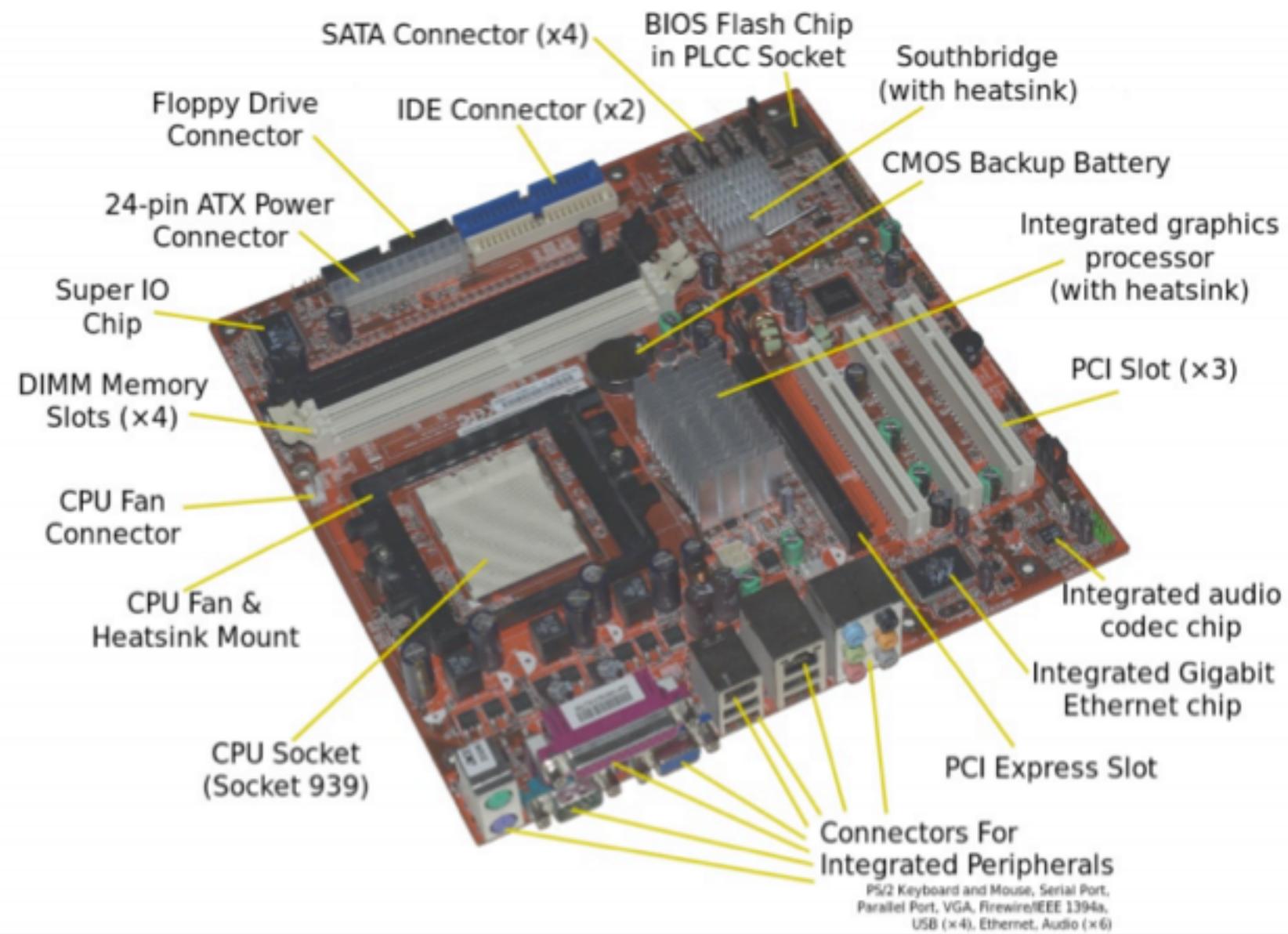
SATA Ports



Hard disk drive(HDD)



The Motherboard



Solid State Drive(SSD)



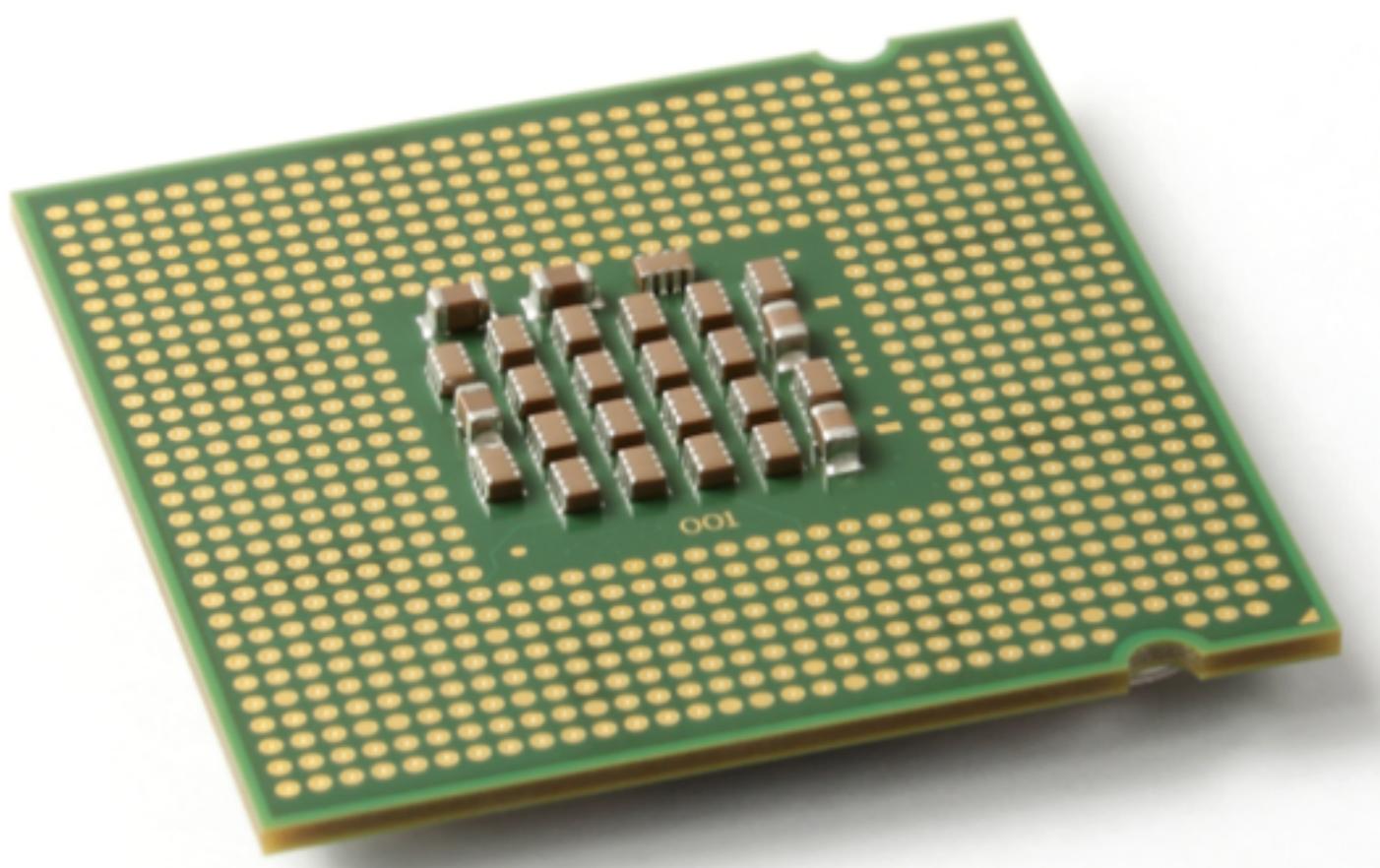
Kernel

The first part of the operating system to be loaded is the **kernel**. The kernel is among the lowest-level pieces of software in the operating system, as its job is to serve as a bridge between your computer's hardware and the other software that might be running on the computer. By the way, when we refer to **software**, we are now referring to intangible computer programs that are capable of running on your computer's hardware.

CPU

The execution of software is handled by the **CPU**, also known as a processor. The CPU is the brains of your machine, as it's responsible for putting the "compute" in "computer" by performing the logic of software programs. Your CPU performs thousands of computations every second, which we measure in **gigahertz**(billion times a second).

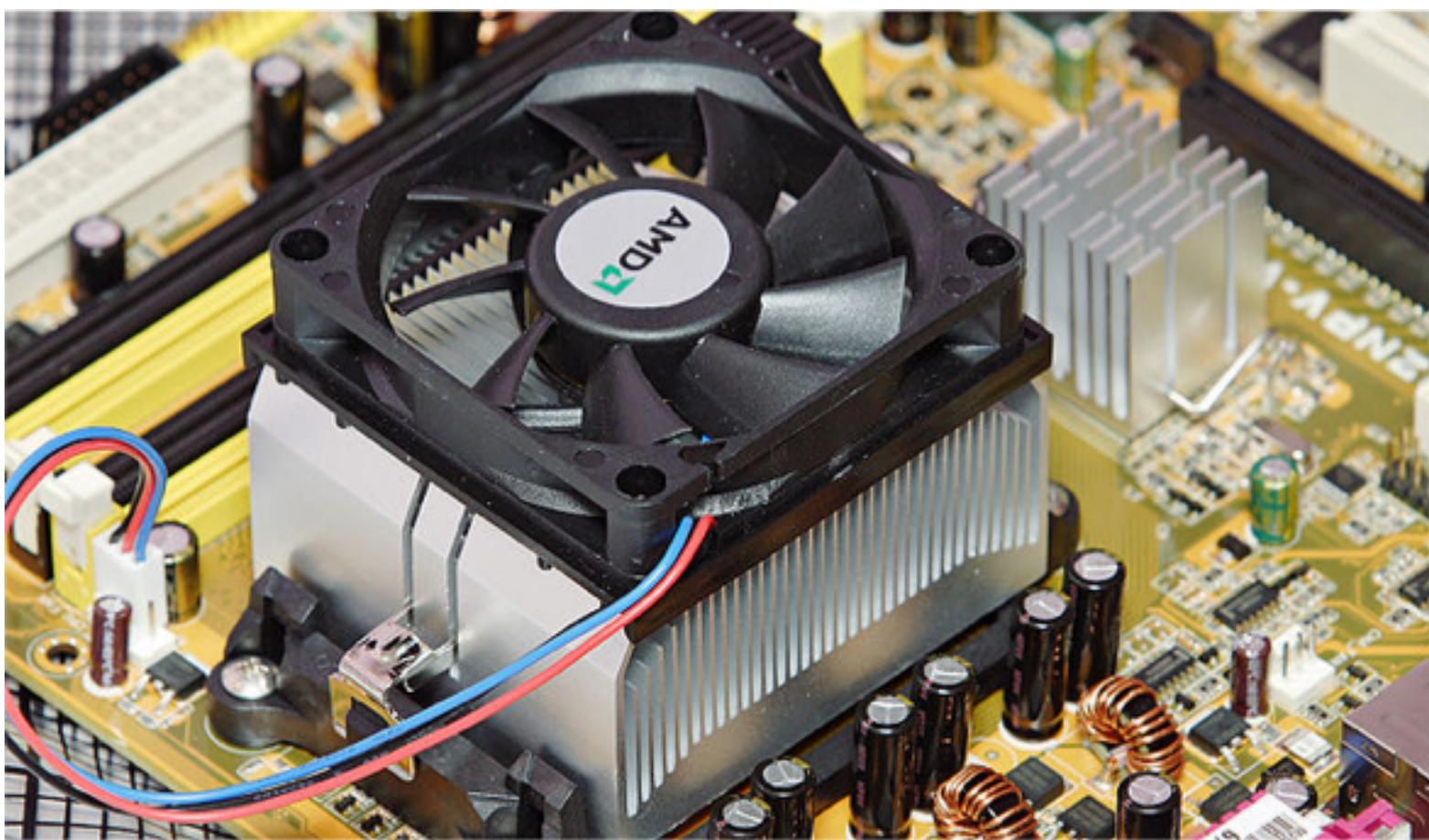
CPU



Heat Sink

The CPU tends to generate large amounts of heat, so it is typically mounted in the motherboard using a **heat sink**, which can cool the CPU using a thermal adhesive, fan, or even a water-based cooling mechanism. Below is a heat sink for an AMD CPU that uses a fan for additional cooling.

Heat Sink



BIOS

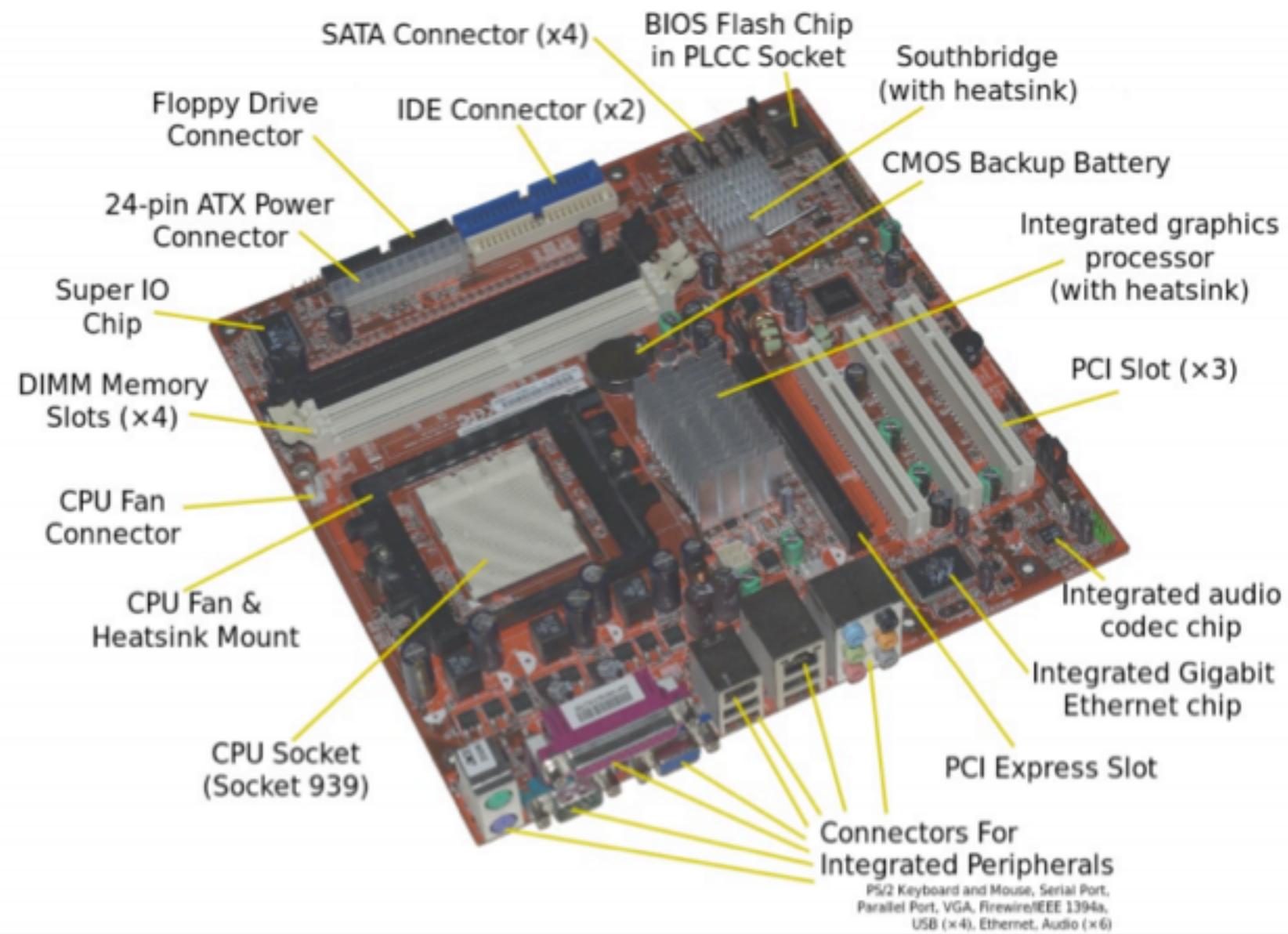
While your computer is booting up, you may see some text displayed by your BIOS that describes how to change BIOS settings. Depending on your BIOS, pressing keys like F2, F9, or F10 will pause the normal boot process and instead bring you to a text-based interface where you can view the hardware that the BIOS determined was present in your computer during POST.

BIOS

Through this interface, you may also be able to view and change CMOS settings, update your BIOS's software, and, as shown below, change the order of the boot sequence.

As we saw, while the BIOS normally looks on the hard drive for the operating system, you can configure your BIOS (as shown below) to instead look first at the DVD drive or flash drive, which can be helpful in diagnosing problems with your hard drive.

The Motherboard



A Newer Motherboard



Ports



USB
2.0

DVI

USB
Type-C

HDMI

USB 3.1

Homework

1) Watch: <https://www.youtube.com/watch?v=ctAVC2JwFwI>

Watch the first half of the video(approx the first 14 minutes), which is the disassembling of a desktop computer.

2) Read and reread these lecture notes.

3) Read (USB 3.0 vs. 2.0 vs Type-C)

<http://www.avadirect.com/blog/usb-3-1-vs-3-0-vs-usb-type-c-thunderbolt-difference/>

4) Analog vs Digital: <https://learn.sparkfun.com/tutorials/analog-vs-digital>

4) Complete Problem Set 1

References

This lecture is a summary of a lecture from an OpenCourseWare course below.

Computer Science E-1 at Harvard Extension School
Understanding Computers and the Internet
by Tommy MacWilliam
<https://www.youtube.com/watch?v=Q2mOfJSG7rc>