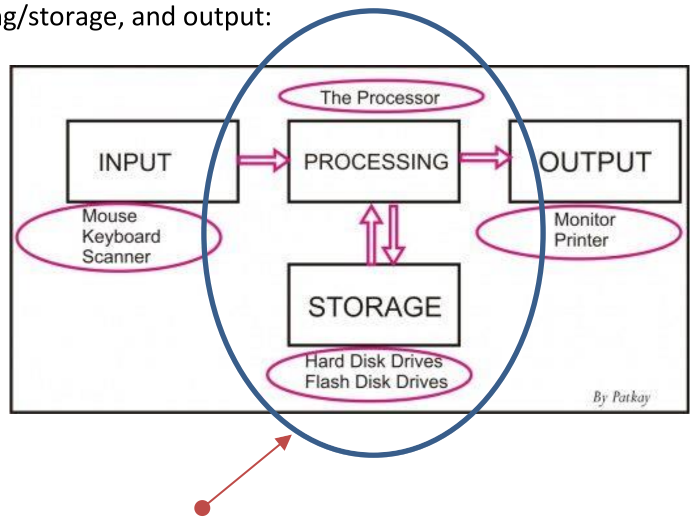
Mr. Bellavia

LESSON 02 - COMPUTER STORAGE & PROCESSING

In this lesson we will explore some of the basic components of a computer and how your computer stores and processes binary information.

Recall: input, processing/storage, and output:

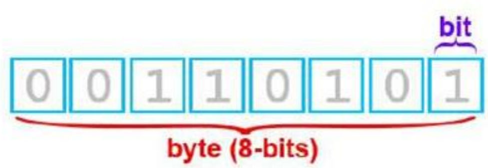


This lesson will focus on the **processing/storage** portion of a computer.

Sections:

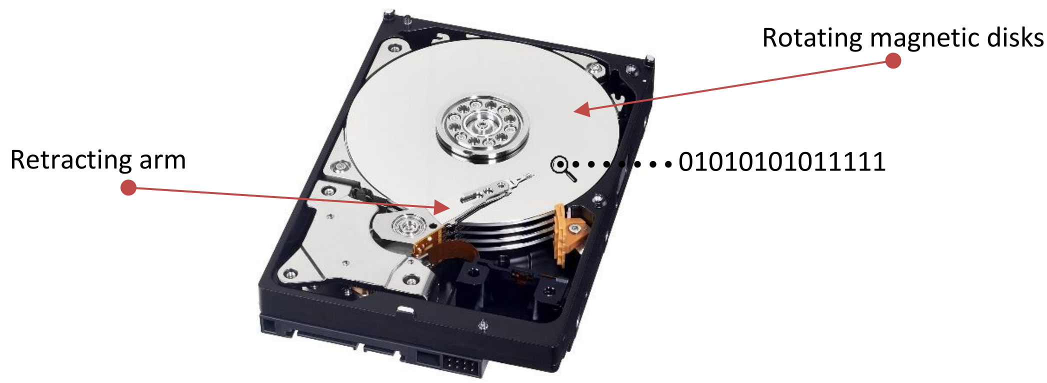
I. HOW A COMPUTER STORES INFORMATION/BINARY CODE (COMPUTER MEMORY):

As you have seen in the last lesson, data is stored on a computer using binary code (patterns of 0s and 1s). These 0s and 1s are called **bits** and they are grouped together in patterns of **8** which is referred to as **1 byte:**



A **byte** is the smallest unit of information on your computer. If you look back at the ASCII table in the previous lesson you will see that every number, letter, and symbol is represented as a single byte.

Bytes of information are referred to as **computer memory.** Your computer is made of physical hardware components that can store and process these bytes of information. **Computer hardware** is anything you can see or touch physically on a computer. One piece of hardware your computer contains is a **hard drive** which acts as computer memory to store all your information, data, and programs even when the computer is turned off. Traditional hard drives contain spinning magnetic disks in which there are billions/trillions of magnetic spots that are turned off/on (representing 0 and 1 respectively) by a retracting arm:



Newer hard drives no longer have spinning magnetic disks but rather contain billions/trillions of microscopic transistors that are switched off/on to represent 0 and 1. These kinds of hard drives are called **Solid State Drives (SSD)** and have no moving parts. They are a little more expensive and typically hold less data, but they are typically much faster than traditional hard drives:

If you ever need to copy information/data from your computer to another computer, or if you wish to backup your data for later use, you can use **external storage devices** like USB keys, CDs, DVDs, etc. However, it has become more common to copy information/data to a **cloud storage** like Google Drive or Microsoft OneDrive. **Cloud Storages** are basically massive servers run by large companies (like Google and Microsoft) that you can access through the Internet. Well go through alternative storage types in the next lesson.

Other types of computer memory Includes **RAM, ROM,** and **CACHES** which we will talk about in the next section.

We have come a long way with the size of available computer memory. Here is a breakdown of how computer memory is measured:

Memory Capacity Conversion Chart

Term (Abbreviation)	Approximate Size
Byte (B)	8 bits
Kilobyte (KB)	1024 bytes / 10^3 bytes
Megabyte (MB)	1024 KB / 10^6 bytes
Gigabyte (GB)	1024 MB / 10^9 bytes
Terabyte (TB)	1024 GB / 10^{12} bytes
Petabyte (PB)	1024 TB / 10^{15} bytes
Exabyte (EB)	1024 PB / 10^{18} bytes
Zettabyte (ZB)	1024 EB / 10^{21} bytes
Yottabyte (YB)	1024 ZB / 10^{24} bytes

Most hard drives are now counted in **Gigabytes** or **Terabytes**. USB Keys are typically measured in Gigabytes, although Terabyte USB keys would not be surprising. Based on the chart above, we an easily calculate how many bytes/bits certain devices can hold. Consider a **256 Gigabyte (GB)** hard drive. Here is a breakdown of how much computer memory that is:

256 * 1024 = 262,144 Megabytes (MB)

Which equates to:

262,144 * 1024 = 268,435,456 Kilobytes (KB)

Which equates to:

268,435,456 * 1024 = 274,877,906,944 (Bytes)

Which equates to:

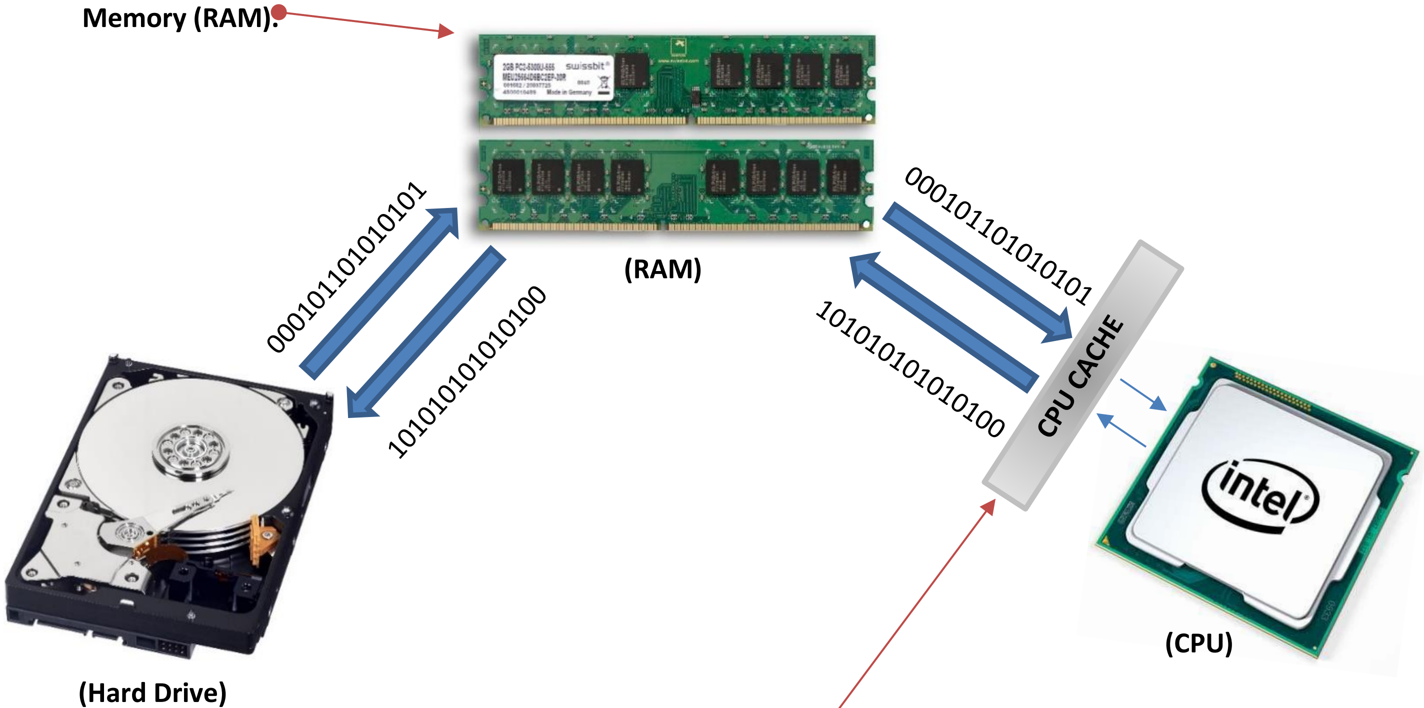
274,877,906,944 * 8 = **2,199,023,255,552 Bits**

That is a lot of 0s and 1s!

Note: An easy way to remember memory sizes is that **'terra'** means trillion, **'giga'** means billion, **'mega'** means million, and **'kilo'** means thousand.

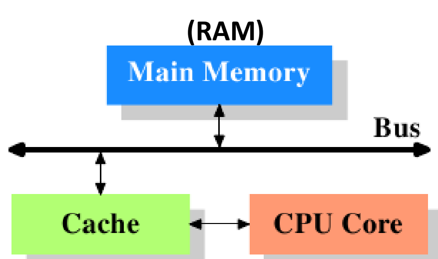
II. HOW A COMPUTER SENDS BINARY CODE TO/FROM THE CPU (RAM, ROM & CACHES):

When a program is written it is stored as binary instructions/data on the computer's hard drive. When the program is started up, it is first copied to a specific type of memory called **Random Access Memory (RAM)**.



The **Central Processing Unit (CPU)** then retrieves the binary instructions from the **RAM** and processes that information (CPUs are described more in the next section). The CPU may send binary instructions/data back to the RAM and the RAM may send binary instructions/data back to the hard drive. **Note:** This is a very simplified view of how binary instructions are interpreted by your computer.

RAM, also known as **'main memory'**, is a **temporary storage area** that is wiped out when your computer shuts off. Programs are first copied into RAM because accessing instructions from RAM is much faster than from a hard drive. Once the program is copied into RAM it does not get directly sent to the CPU, but first to the **CPU's cache.** A **cache** is a smaller, even faster memory, located closer to the processor (CPU) core which holds the next instruction for the CPU to execute. All these instruction signals flow through a **'bus'** which is the circuitry that connects all these components together:

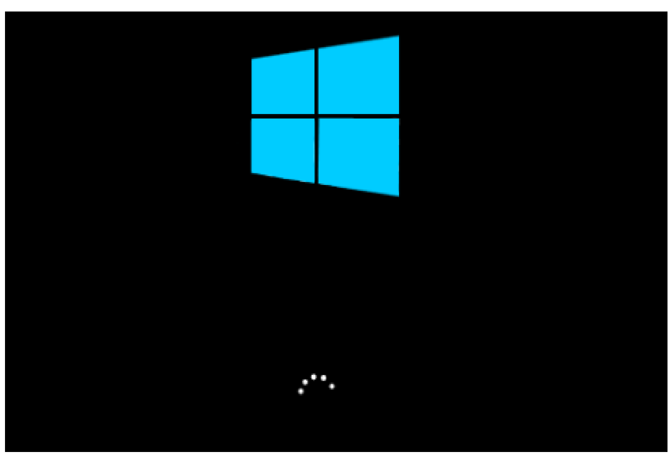


The size of RAM is measured just like hard drives. RAM is usually measured in **Gigabytes (GB),** for example 16GB of RAM can hold approximately 16 billion bytes of information/data/programs.

Another type of memory is **Read Only Memory (ROM)**. This memory typically cannot be deleted or changed. One of its purposes is to hold a specific program that starts up your computer. This ‘start-up’ program that resides on the ROM is called a **BIOS (Basic Input/Output System).** The point of the BIOS is to check and initiate all the hardware inside your computer when your computer is first turned on. When you start a computer, you probably notice a bunch of numbers or perhaps a manufacturer symbol appear right before an operating system (like Windows) starts. That is the BIOS being executed by your computer:

1) Computer powered on (BIOS RUNNING):

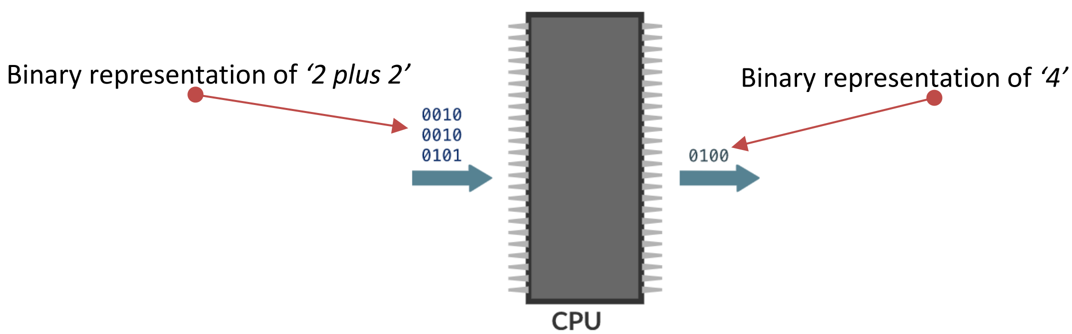
2) Windows starting right after:



III. HOW A COMPUTER PROCESSES INFORMATION (THE CENTRAL PROCESSING UNIT):

We have seen how information can be stored on a computer via computer memory. Now we will briefly discuss how that information is processed via the **Central Processing Unit (CPU).** Every computer/phone/table/etc. has a CPU. The CPU is the electronic circuitry that executes instructions comprising a computer program:

The CPU is considered the **brain** of a computer containing all the circuitry needed to process input, store data, and output results. Instructions of computer programs are constantly sent through a CPU. Think back to the previous lesson where we had a calculator program that added *'2 plus 2'.* Remember that all information in a computer uses binary code, so here is an abstract example of what that may look like when this instruction is sent to the CPU:



Note: This is an abstract view of how a CPU works. To fully understand how CPU processes information with memory is much more complicated, but a general understanding is good enough for this course.

The above diagram demonstrates a **cycle** of processing. A **CPU cycle** is the time required for the execution of one simple processor operation such as an addition (for example *'2 + 2'*). The speed of a CPU is measured in cycles, more specifically as **cycles per second.** 1 cycle per second is referred to as **1 hertz (Hz).** Typically, todays CPU speeds are measured in **Gigahertz (GHz)** which means 1 billion cycles per second. You may also see **Megahertz (MHz)** which means 1 million cycles per second. So, if you have a 2.4GHz CPU then your computer can process approximately 2.4 billion instructions every second! **Note:** The CPU executes only one instruction at a time, but it does so extremely fast to the point where it seems like multiple instructions are being executed simultaneously.