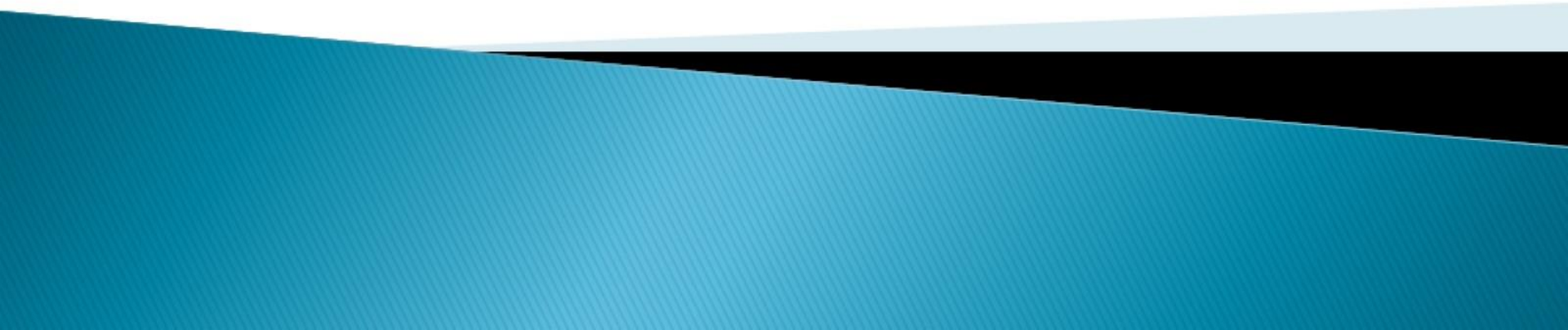
Computer Organization



Memory

The term memory refers to anything that stores information either permanently or temporarily. The memory of a computer can hold program instructions, data values, and the intermediate results of calculations. All the information in memory is encoded in fixed size cells called **bytes**.

A byte can hold a small amount of information, such as a single character or a numeric value between 0 and 255.

The CPU will perform its operations on groups of one, two, four, or eight bytes, depending on the interpretation being placed on the data, and the operations required.

Each byte can be accessed by an address. The address is a unique combination of bits that is transmitted to the memory via address lines in external bus.

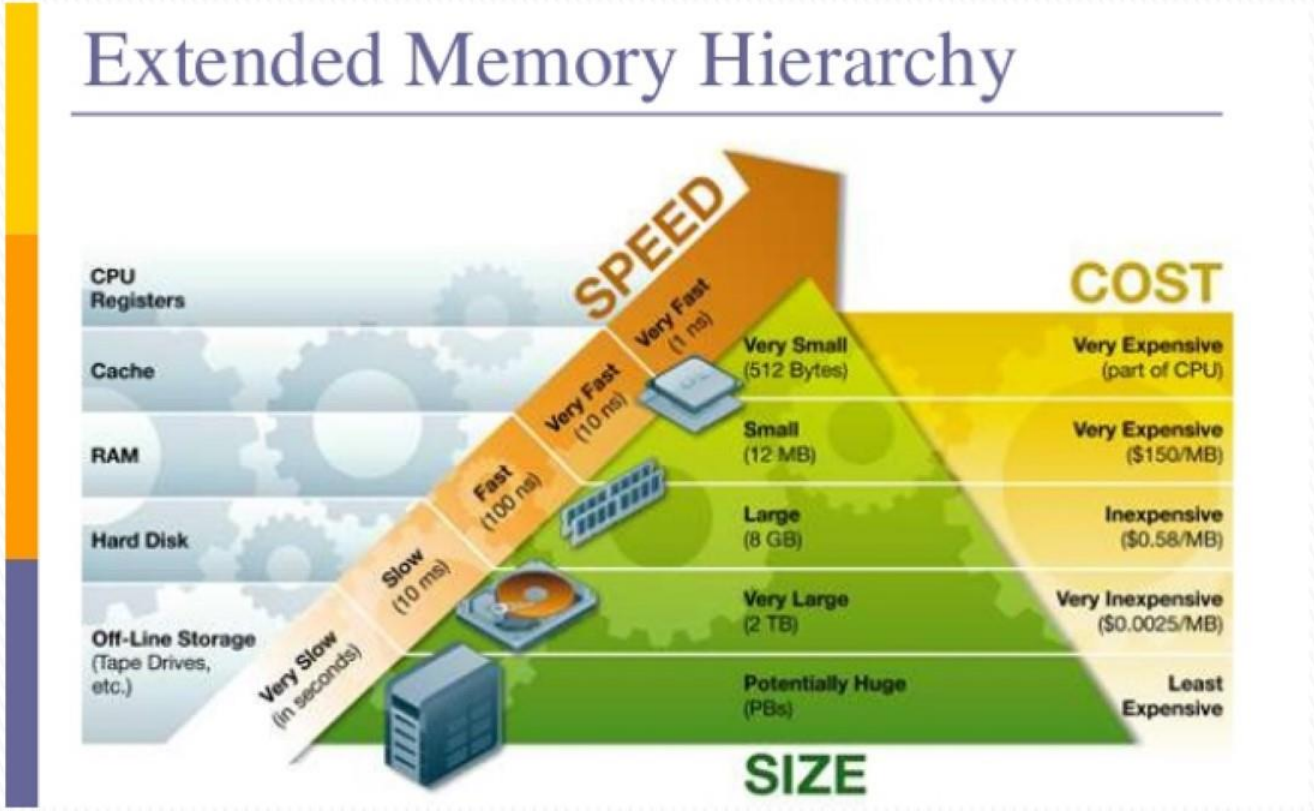
Types of Memory

- **Internal Memory or Primary Memory –**

Comprising of Main Memory, Cache Memory & CPU registers. This is directly accessible by the processor.

- **External Memory or Secondary Memory –**

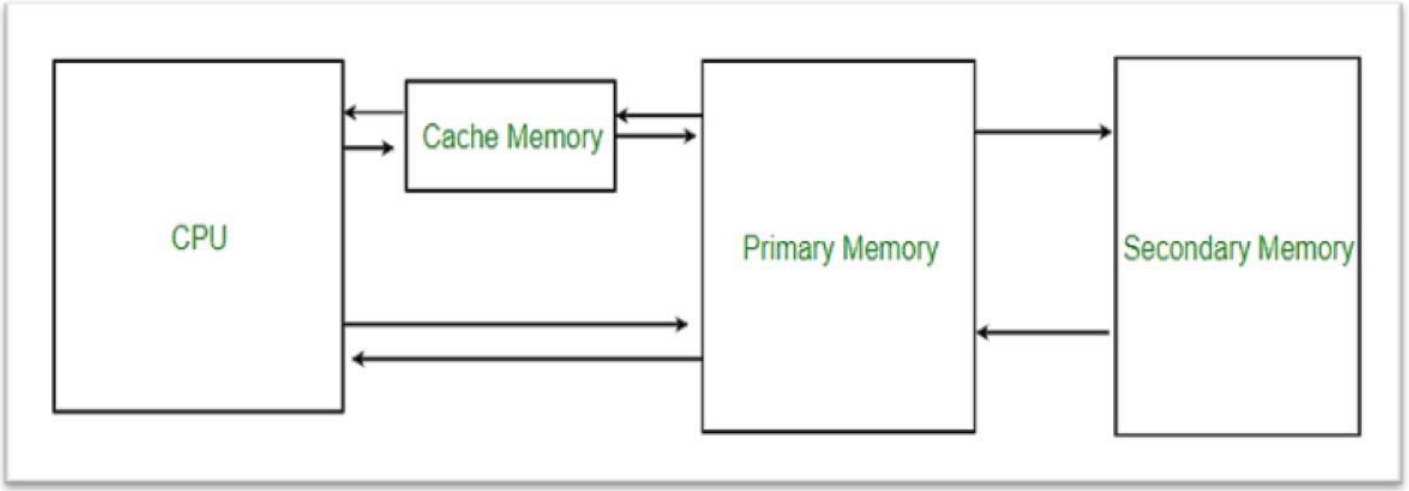
Comprising of Magnetic Disk, Optical Disk, Magnetic Tape i.e. peripheral storage devices which are accessible by the processor via I/O Module.



1. Cache Memory :

a special very high-speed memory. It is used to speed up and synchronizing with high-speed CPU. Cache memory is an extremely fast memory type that acts as a buffer between RAM and the CPU. It holds frequently requested data and instructions so that they are immediately available to the CPU when needed.

Cache memory is used to reduce the average time to access data from the Main memory. The cache is a smaller and faster memory which stores copies of the data from frequently used main memory locations. There are various different independent caches in a CPU, which store instructions and data.



Levels of memory

2. Main Memory :

is the working memory of the CPU, with fast access and limited numbers of bytes being transferred.

Main memory is classified according to their **read/write capabilities** as follows ROM and RAM.

❑ Read Only Memory (ROM)

Is a type of memory that cannot be written to. Information is written to ROM chips by the manufacturer, and this information cannot be changed.

In the past, if ROM information needed to be updated, you had to remove the original chip and replace it with an updated ROM chip. Software written to ROM chips is called *firmware*.

One of the major uses for ROM is to store the system **BIOS**, which **contains Power-On Self-Test (POST)** routines and other routines that initiate the loading of the operating system. The BIOS also contains the low-level code that makes communication possible between the central processing unit (CPU) and the hardware devices. Because the system BIOS is stored in ROM, you must remove and replace the ROM chip to update the BIOS software.

ROM can be divided into several types:

- **ROM chips are mask-programmed**: The programs are set during manufacturing.

- **PROM (Programmable Read Only Memory)**: Are chips manufactured with no predefined program. its contents are set by the user using the PROM programmer. Once it's programmed, it can never be changed.

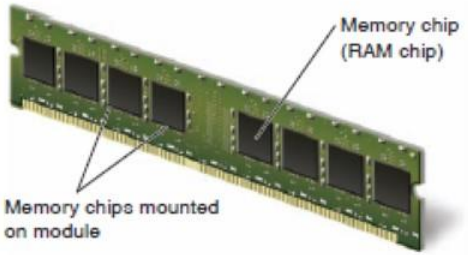
- **EPROM (Erasable Programmable Read Only Memory)**: Is a type of memory that normally cannot be written to because it is a variation of ROM. An EPROM chip is a special ROM chip on which the manufacturer can rewrite information with a special programming device that uses ultraviolet light to erase all the data.

- **EAPROM (Electrically Erasable Programmable ROM or flash ROM)**: A new implementation of ROM is called The manufacturer writes the software instructions into the ROM chip, but you can update these instructions by running special software provided by the manufacturer. The special software is usually provided on a disk or can be downloaded from the manufacturer's Web site. EEPROM has become the typical way to update your system BIOS.

❑ Random Access Memory (RAM)

is responsible for storing the instructions and data that the computer is using at that present moment in time.

It is described as volatile memory as the contents of RAM chips can be lost when the computer is turned off or when new data is being written to RAM while other data is being processed.



(Memory chip)

RAM memory can be divided into two groups, Static Ram and Dynamic Ram :

➢ DRAM (Dynamic RAM)

Is probably the most popular type of memory today When someone says to you ," I have 128MB of RAM!" they are talking about DRAM. Dynamic RAM gets its name from the fact that the information stored in DRAM needs to be constantly refreshed. Refreshing involves reading the bits of data stored in DRAM and then rewriting the same information back.

Because the CPU accesses data in memory, we measure the memory's performance based on the time it takes the CPU to access that data. The measurement used to determine the speed of memory is nanoseconds (ns). One *nanosecond equals a billionth* of a second. The speed of DRAM ranges from 60ns to 80ns. The lower the number of nanoseconds, the better the performance.

- **SRAM**

Static RAM (SRAM) : so-called because the information held in its memory cells doesn't need to be refreshed—requires less overhead to maintain the information stored in memory.

With speeds running at 10ns to 20ns, SRAM is much faster than DRAM. This speed increase comes with a price, however, which is why people add DRAM to their systems more often than they add SRAM. SRAM is typically used for cache memory.

- **VRAM**

Video RAM (VRAM) is dual-ported memory, meaning it can be read from and written to at the same time. DRAM is single-ported (which means that the memory can be written to and read from, but not simultaneously; it has to go one way at a time).

VRAM is most commonly used on video accelerator cards and is used to store the values of the pixels on the screen for refresh purposes. VRAM is the favored memory for video purposes because it outperforms the other memory types by being dual ported.

3. External memory

Is for the long term storage of information. Data from external memory will be transferred to the main memory before the CPU can operate on it. Access to the external memory is much slower, and usually involves groups of several hundred bytes.

External memory which is sometimes called ***backing store or secondary memory***, allows the permanent storage of large quantities of data. The capacity of external memory is high, usually measured in hundreds of megabytes or even in **gigabytes** (thousand million bytes) at present. External memory has the important property that the information stored is not lost when the computer is switched off.

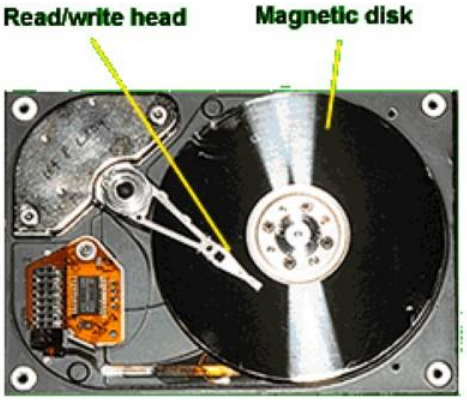
It is important to note that the CPU can only directly access data that is in main memory. To process data that resides in external memory the CPU must first transfer it to main memory. Accessing external memory to find the appropriate data is slow (milliseconds) in relation to CPU speeds but the rate of transfer of data to main memory is reasonably fast once it has been located.

Type of storage device

1. Floppy disks
2. 2. Hard disk:
3. 3. Optical Disks

Storage Devices - Hard Disk

The hard disk is a direct-access storage medium with a rigid magnetic disk. The data is stored as magnetized spots arranged in concentric circles (tracks) on the disk. Each track is divided into sectors. The number of tracks and sectors on a disk is known as its 'format'.



Hard disk showing internal mechanisms

An access arm in the disk drive positions a read/write head over the appropriate track to read and write data from and to the track. This means that before accessing or modifying data the read/write head must be positioned over the correct track.
The storage capacity of a hard disk can be Gigabytes (GB), i.e. thousands of Megabytes (1000Mb), of information.

Storage Devices - Hard Disk

Access Time

- **Access time:** This is an average time taken to complete the transfer of data after the request instruction has been enacted. Today's fast hard drives have access times under 10 milliseconds (ms). Access time is made up of the following four times.

- **Seek Time**: This is the time taken to move an access arm to a certain track on a disk after the computer requests data. Most of the access time is made up of seek time.

- **Head Switching Time**: The time taken for changing from one read/write head to another to read from or write on another part on a disk.

- **Search Time**: It is also called *rotational delay time*. This is a time required for the read/write head to locate particular position on a track.

- **Data Transfer Time**: This is the time for data to be transferred from the disk to primary storage or vice versa.

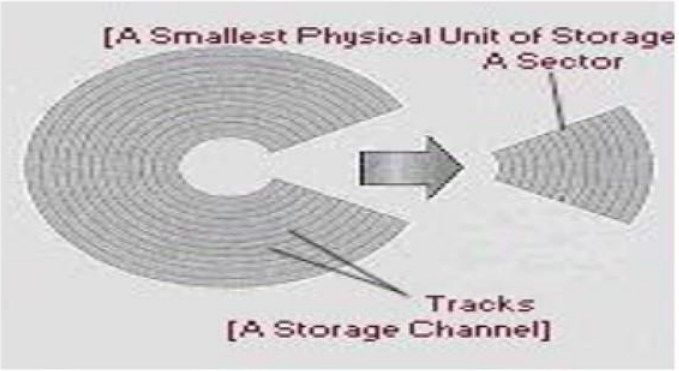
Storage Devices - Floppy disks

Floppy disks are removable, direct access storage media inserted into disk drives. Floppy disks are flat, circular pieces of magnetic material that rotate within a jacket. These are also called *flexible disks*, *floppies*, *Diskettes* or simply *disks*.
Data and instructions are stored as forms of bits and bytes using the *ASCII* data coding schemes. They are stored as electromagnetic charges on a disk surface. The floppy disks are usually 3.5" in size. However, older floppy disks may be in use; these would be 5.25" in size.

Tracks/Sectors

- **Track:** The disk surface is divided into several concentric circles called tracks (The thinner the tracks), the more storage capacity of the disk. Data are recorded as tiny spots on these tracks. These tracks are closed concentric circles, not a single spiral. Each track has the same number of bits although the outer tracks are longer than the inner ones.

- **Sector:** The circular tracks are further divided into edge-shaped sections known as *sectors*. The fields of data within a particular record are organized according to tracks and sectors on a disk.



Storage Devices - Optical Disk

An optical disk is impressed with a series of spiral pits in a flat surface. A master disk is burnt by high-intensity laser beams in bit-patterns from which subsequent copies are formed which can be read optically by laser.

CD-ROM: CD-ROM (*compact disk read only memory*) is an optical disk storage that contains text, graphics and sound. CD-ROM can store around 650 MB of data. CD-ROM disk is almost the same as the music CD, but uses different forms of track for data. A CD-ROM drive can read music CD, but a CD player cannot read CD-ROM. CD-ROM is a *read-only* disk that cannot be written on or erased by the user.

WORM: A WORM (*write once, read many*) disk is an optical disk that written on just once by the user's environment and then cannot be overwritten. A WORM disk is ideal for use as archive because it can be read many times, but the data cannot be erased. The storage capacity of WORM disk ranges from 400 MB to 6.4 GB.

Erasable Optical Disks: This is an optical disk that can be erased and written on repeatedly. An erasable optical disk has a great deal of data capacity. It can store up to 4.6 GB. An erasable optical disk functions like a magnetic disk and has huge capacity, so it will replace the magnetic disk in the future.

how computer memory is measured: bit, byte, KB, MB, GB, TB.

Bits

In all the components of a computer, data and instructions are stored as patters of ones and zeros. These individual ones and zeros are called bits.

In electronic components the one is stored by switching an electronic switch on and a zero by switching it off. On a magnetic material, such as the surface of a hard disk, the one may be stored with a clockwise magnetic field and a zero with a counter-clockwise field.

Bytes

Bits are grouped together into sets of eight. A set of eight bits is called a **byte**.

ASCII or American Standard Code for Information Interchange was a system of representing all the characters of the western alphabet and certain special characters in a single byte. You can think of the byte as the amount of memory required to store a single character. As there are only 256 possible variations within eight bits, this is not sufficient to represent other alphabets. As a result a new system, called **uni-code, has been developed to represent all the** alphabets of the world. This makes use of two bytes. With two bytes, 65536 different characters and symbols can be represented.

Units of memory

kB	kilobyte	2^{10} = 1 024 bytes
Mb	Megabyte	2^{20} = 1 048 576 bytes
Gb	Gigabyte	2^{30} bytes
Tb	Terabyte	2^{40} bytes