



Computer Memory - Lecture notes 3

Introduction to computer systems (Jomo Kenyatta University of Agriculture and Technology)

COMPUTER MEMORY

PRIMARY MEMORY

Memory is used to store the information (programs and data) that the computer is currently using. It is sometimes called main or primary memory. There are 2 types:

A) RAM - RANDOM ACCESS MEMORY.

This means that any location in memory may be accessed in the same amount of time as any other location.

Memory access means one of two things, either the CPU is *reading* from a memory location or the CPU is *writing* to a memory location.

When the CPU reads from a memory location, the contents of the memory location are copied to a CPU register. When the CPU writes to a memory location, the CPU copies the contents of a CPU register to the memory location, overwriting the previous contents of the location. The CPU cannot carry out any other operations on memory locations.

RAM is a form of short term or volatile memory. Information stored in short term storage is lost when the computer is switched off (or when power fails). There is therefore a requirement for permanent or long term storage which is also referred to as secondary storage or auxiliary storage. This role is fulfilled by disk and tape storage.

Summary Random Access Memory (RAM)

- RAM(Random Access Memory) is the internal memory of the CPU for storing data, program and program result. It is read/write memory which stores data until the machine is working. As soon as the machine is switched off, data is erased.

- Access time in RAM is independent of the address that is, each storage location inside the memory is as easy to reach as other locations and takes the same amount of time. Data in the RAM can be accessed randomly but it is very expensive.
- RAM is volatile, i.e. data stored in it is lost when we switch off the computer or if there is a power failure. Hence a backup uninterruptible power system(UPS) is often used with computers.
- RAM is small, both in terms of its physical size and in the amount of data it can hold.

RAM is of two types

- Static RAM (SRAM)
- Dynamic RAM (DRAM)



1) Static RAM (SRAM)

The word **static** indicates that the *memory retains its contents as long as power is being supplied*. However, data is lost when the power gets down due to volatile nature. SRAM need not have to be refreshed on a regular basis in order to maintain the data . SRAM is used as cache memory and has very fast access.

Characteristic of the Static RAM

- It has long life
- There is no need to refresh
- Faster
- Used as cache memory
- Large size
- Expensive
- High power consumption

2)Dynamic RAM (DRAM)

DRAM, unlike SRAM, must be continually **refreshed** (recharged) in order to maintain the data. This is done by placing the memory on a refresh circuit that rewrites the data several hundred times per second. DRAM is used for most system memory because it is cheap and small.

Characteristics of the Dynamic RAM

- It has short data lifetime
- Need to be refreshed continuously
- Slower as compared to SRAM
- Used as RAM
- Lesser in size
- Less expensive
- Less power consumption

B) READ ONLY MEMORY (ROM)

ROM stands for Read Only Memory. The memory from which we can only read but cannot write on it. This type of memory is non-volatile. The information is stored permanently in such memories during manufacture. A ROM, stores such instructions that are required to start a computer. This operation is referred to as bootstrap. ROM chips are not only used in the computer but also in other electronic items like washing machine and microwave oven.

Following are the various types of ROM

1)MROM (Masked ROM)

The very first ROMs were hard-wired devices that contained a pre-programmed set of data or instructions. These kind of ROMs are known as masked ROMs which are inexpensive.

2)PROM (Programmable Read only Memory)

PROM is read-only memory that can be *modified only once by a user*. It can be programmed only once and is not erasable.

3)EPROM(Erasable and Programmable Read Only Memory)

The EPROM can be erased by exposing it to ultra-violet light for a duration of up to 40 minutes.

4)EEPROM(Electrically Erasable and Programmable Read Only Memory)

The EEPROM is programmed and erased electrically. It can be erased and reprogrammed about ten thousand times.

Advantages of ROM

The advantages of ROM are as follows:

- Non-volatile in nature
- These cannot be accidentally changed
- Cheaper than RAMs
- More reliable than RAMs
- These are static and do not require refreshing
- Its contents are always known and can be verified

Parameter	RAM	ROM
Volatility	RAM is volatile in nature as it automatically erased when computer shutdowns	ROM is non-volatile since it is never erased when there is any shutdown or restart of computer.
Accessibility	RAM can be directly accessed by the processor	ROM can't be directly accessed by the processor since it is transferred into RAM where it is executed by the processor.
Storage	RAM is used to store the temporary information for limited time.	ROM is used to store permanent information which can't be deleted.
Hardware structure	RAM is in form of chip while	ROM is generally optical drivers made of magnetic tapes
Cost	Costlier than ROM	Cheaper than RAM
Size	Chip Size is larger than ROM	Chip Size is smaller than RAM
Writing speed	Writing data to a RAM chip is a faster process	Writing data to a ROM chip is a slow process
Storage Limit	A RAM chip can store multiple gigabytes (GB) of data , up to 16 GB or more per chip	A ROM chip typically stores only several megabytes (MB) of data, up to 4 MB or more per chip
Examples	Static and dynamic RAM	PROM, EPROM and EEPROM are types of ROM.

Special Purpose Memories

Apart from ROM and RAM there are several types of special purpose memories found inside the CPU or in the input and output devices. These memories are vital because they increase the overall performance of data and instructions moving in and out of the CPU. Cache and Registers are special purpose memories.

Cache Memory

The speed of CPU is extremely high compared to the access time of

main memory. Therefore the performance of CPU decreases due to the slow speed of main memory. To decrease the mismatch in operating speed, a small memory chip is attached between CPU and Main memory whose access time is very close to the processing speed of CPU. It is called CACHE memory. It acts as a buffer between the CPU and Main memory

CACHE memories are accessed much faster than conventional RAM. It is used to store programs or data currently being executed or temporary data frequently used by the CPU. So cache memory “makes main memory to be faster and larger than it really is”.

It is also very expensive to have bigger size of cache memory and its size is normally kept small.

Advantages

- Cache memory is faster than main memory.
- It consumes less access time as compared to main memory.
- It stores the program that can be executed within a short period of time.
- It stores data for temporary use.

Disadvantages

- Cache memory has limited capacity.
- It is very expensive

Registers

The CPU processes data and instructions with high speed; there is also

movement of data between various units of computer. It is necessary to transfer the processed data with high speed. So the computer uses a number of special memory units called registers. They are not part of the main memory but they store data or information temporarily and pass it on as directed by the control unit.

Registers hold one piece of data at a time and are inside the CPU.

Examples of registers are:

An accumulator: This temporarily holds the results of the last processing step of the ALU.

Instruction register: This temporarily holds an instruction just before it is interpreted into a form that CPU can understand it.

An address register: This temporarily holds next piece of data waiting to be processed.

Storage register: This temporarily holds a piece of data that is on its way to and from the CPU and the main memory.

Memory capacities

Memory and storage capacity is measured in special units called bytes. A byte is equivalent to a single character. Characters can be a number from 0 to 9, letters A to Z or a special symbol. For example, a number like 2545 has four bytes while the words, *My Home* has seven bytes

Memory quantities can be expressed in;

1. Kilobytes (kB): Approximately one thousand bytes.(1024)
2. Megabytes (MB): Approximately one million bytes.
3. Gigabytes (GB): Approximately one billion bytes.
4. Terabytes: Approximately one trillion bytes.

Primary Memory	Secondary Memory
<ol style="list-style-type: none"> 1. Used for holding data & instructions required immediately by the CPU 2. It is accessed directly by the CPU 3. Provides fast access to information is accurate & reliable 4. It is expensive per bit of memory due to the technology involved 5. It has low/ limited storage capacity 6. It is volatile & therefore it is used to store temporary programs & data 7. The speed of the processor depends on the size & type of primary storage <p>E.g. Read Only Memory (ROM) & Random Access Memory (RAM)</p>	<ol style="list-style-type: none"> 1. Used for storing backup information that is not needed immediately by the CPU. 2. It is not accessed directly by the CPU 3. Provides slow access of information 4. Secondary storage devices are cheap 5. it has high storage capacity 6. It is non- volatile i.e. stores data permanently. <p>E.g. punched cards, magnetic tapes, floppy disks, hard disks, etc</p>

SECONDARY MEMORY/ STORAGE DEVICES/Auxiliary Memory

Auxiliary memory is much larger in size than main memory but is slower. It normally stores system programs, instruction and data files. It is also known as secondary memory.

It can also be used as an overflow/virtual memory in case the main memory capacity has been exceeded.

Secondary memories cannot be accessed directly by a processor. First the data/information of auxiliary memory is transferred to the main memory and then that information can be accessed by the CPU. Characteristics of

Auxiliary Memory are following characteristics–

- **Non-volatile memory** – Data is not lost when power is cut off.
- **Reusable** – The data stays in the secondary storage on permanent basis until it is not overwritten or deleted by the user.
- **Reliable** – Data in secondary storage is safe because of high physical stability of secondary storage device.
- **Convenience** – With the help of a computer software, authorised people can locate and access the data quickly.
- **Capacity** – Secondary storage can store large volumes of data in sets of multiple disks.
- **Cost** – It is much lesser expensive to store data on a tape or disk than primary memory.

Storage holds data, instructions, and information for future use.

Storage has both medium and device:

- (a) **Storage Medium** is the physical material upon which a computer keeps data, instructions, and information.
- (b) **Storage Device drive** is the mechanism that drives the storage medium. E.g. A CD Player would be considered the storage device drive and the actual CD being played is

the medium. In other words, a storage medium is the computer hardware that records and/or retrieves items to and from storage media.

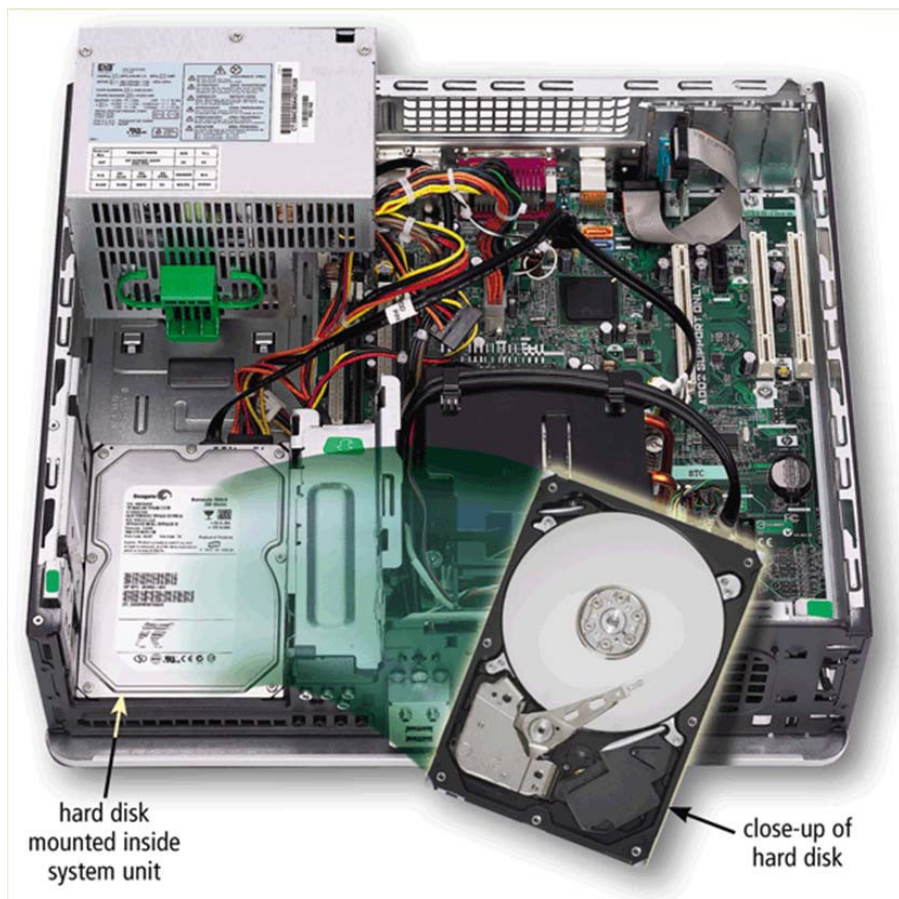
Access Time:

Access time measures:

- (a) The amount of time it takes a storage device to locate an item on a storage medium.
- (b) The time required to deliver an item from memory to the processor.

One of the most popular secondary storage devices is the **Hard Disk**.

A **hard disk** contains one or more inflexible, circular platters that use magnetic particles to store data, instructions, and information. However, today, not all hard disks are magnetic!



Flash Memory Storage (another type of secondary storage):

Flash memory chips are a type of solid state media and contain no moving parts!

Solid State Drives (SSDs) have several advantages over magnetic hard disks:

- (a) Faster access time
- (b) Faster transfer rates
- (c) Generate less heat and consume less power (tablets and some notebooks use it)
- (d) Last longer.
- (e) No noise

Memory Card:

A memory card is a removable flash memory device that you insert and remove from a slot in a computer or mobile device. (e.g. SD, microSD)

USB Flash Drives:

These plug into a USB port on a computer or mobile device.

Cloud Storage:

This is an Internet service that provides storage to computer users. Persons subscribe for a number of reasons e.g

- (a) Access files from any computer
- (b) Store large files instantaneously
- (c) Allow others to access their files
- (d) Store offsite backups

Optical Discs:

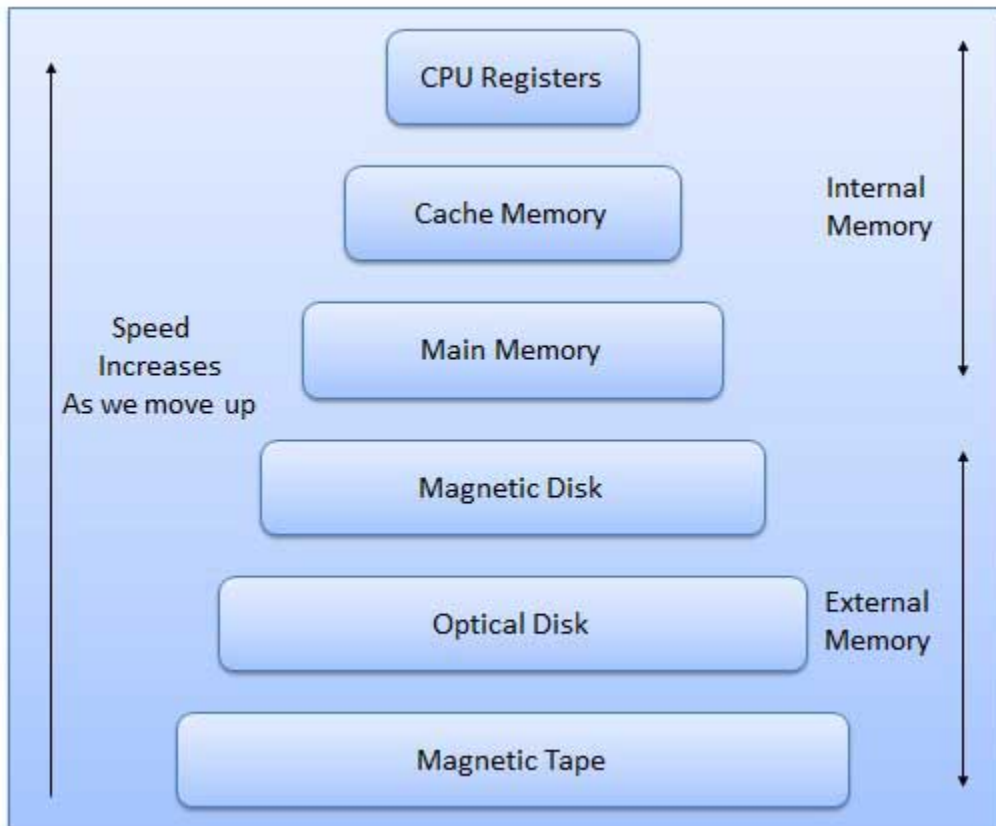
- An optical disc consists of a flat, round, portable disc made of metal, plastic, and lacquer that is written and read by a laser.
- Typically storage software, data, digital photos, movies, and music
- Read only vs. rewritable

Some types of optical discs:

- (a) CD-ROM: can be read from but not written to
- (b) CD-R: is a multisession optical disc on which users can write, but not erase.
- (c) CD-RW is an erasable multisession disc (you must have a CDRW drive). CDs have a capacity of 700 MB
- (d) DVD-ROM: high capacity optical disc on which users can read but not write or erase.
- (e) Blu-ray Disc-ROM (BD-ROM) has a storage capacity of 100GB.
- (f) DVD-RW, DVD+RW and DVD+RAM are high capacity rewritable DVD formats. These are optical devices which have a capacity of up to 17 GBytes of storage. They can hold full motion pictures and many films are now produced on DVD for home viewing.

OTHER TYPES OF STORAGE:

- (a) Tape (Magnetic Tape)
- (b) Magnetic stripe cards and smart cards
- (c) Magnetic Diskettes/floppy disks (1.44 MB)



Memory hierarchy

Characteristics of Memory Hierarchy are following when we go from top to bottom.

- Capacity in terms of storage increases.
- Cost per bit of storage decreases.
- Frequency of access of the memory by the CPU decreases.
- Access time by the CPU increases.