UNIT 3 MEMORY SYSTEM

Introduction

- **Input Device (Ears): Receives the question, like a teacher's ears hearing a student.**
- **CPU (Brain): Processes the question, similar to how a teacher's brain analyzes information.**
- **Output Device (Mouth): Provides the answer, akin to a teacher verbalizing the response.**
- **Printer: Prints the answer, analogous to a teacher writing down the solution.**

Every modern computer system consists of three basic sections:
1. Input device (i.e. Keyboard, mouse or scanner etc.)
2. Processor (or CPU):
Control unit (CU)
Arithmetic and Logic Unit (ALU)
Memory unit
3. Output device (Visual Display Unit (Monitor/screen) or printer etc.)

Basics of Computer Hardware

- **Input devices like keyboards, mice, or scanners are used to directly input data and instructions into the computer system.**
- **CPU (Central Processing Unit): Acts like the brain of the computer, processing information.**
- **Memory: Functions similar to human memory, storing data temporarily for quick access.**
- **Control Unit (CU): Similar to the regulatory part of the brain, it oversees and controls all operations of the computer, including input and output devices.**
- **The Arithmetic and Logic Unit (ALU) in a computer does two main things: arithmetic (like math) and logic (like reasoning). It can add, subtract, multiply, and divide numbers. It can also compare numbers to see which is bigger or smaller. This makes it different from a basic calculator, which can only do math.**

Memory

- **Memory Unit: Stores data and instructions in binary form (0s and 1s) for retrieval as needed.**
- **Importance: Critical for holding data and programs currently in use by the computer.**
- **Variety of Devices: Computers use different storage devices for holding data and instructions.**
- **Faster Access: Accessing data from memory is much quicker than accessing it from the hard drive.**
- **Constant Usage: CPU continually interacts with the memory system from startup to shutdown.**
- **Operations: Writing data into memory is called a memory write operation, while retrieving data is called a memory read operation.**
- **Data Movement: Data and instructions are transferred to and from memory in word length chunks.**
- **Memory Devices Categories: Categorized based on access time, storage capacity, and cost-per-bit of storage.**

Computer memory stores data and instructions in binary form for quick access by the CPU, enhancing system efficiency. Memory operations involve writing and reading data, crucial for ongoing computer functionality. Memory devices are categorized by access time, storage capacity, and cost efficiency.

Technology	Nature of Storage Medium	Access Mode	Volatile/Nonvolatile	Access Time (in sec)	Average Cost (Rs/bit)
Semiconductor Memories	Electronic	Random (or Direct)	Volatile	10^-8	10^-2
Magnetic Memories	Magnetic	Sequential/Random	Non-volatile	10^-1	10^-6
Optical Memories	Optical (laser beam)	Random	Non-volatile	1	10^-7

- **Sequential Access Memory:**
  - **Reads data in sequence; retrieved in the same order as stored.**
  - **Suitable for applications like monthly pay slips or bills where data needs to be accessed sequentially.**
  - **Organized linearly, with no unique storage addresses; data is accessed serially.**
  - **Example: Magnetic tape.**
- **Random Access Memory:**
  - **Data available randomly; any location can be selected.**
  - **Each storage position has a unique address and can be accessed individually in approximately equal time.**
  - **Examples: Magnetic disk, CD-ROM.**
- **Comparison of Access Modes:**
  - **Sequential access involves accessing data sequentially, suitable for linearly stored data like on magnetic tapes.**
  - **Random access allows accessing any location in the device in approximately equal time, typical of magnetic disks and CD-ROMs.**

Basic Storage Fundamentals

- **Data in computer systems is represented using electronic or magnetic signals, creating a two-state or binary representation.**
- **Transistor and semiconductor circuits are either in a conducting (ON) or non-conducting (OFF) state, representing 1 and 0 respectively in positive logic.**
- **Magnetic media, like disks or tapes, use magnetized spots with different polarities to represent 1s and 0s.**
- **The smallest unit of data is a bit, with values of either 0 or 1.**
- **Memory chip capacity is typically expressed in bits, with 8 bits forming a byte.**

- **Dual-Ported DRAM allows simultaneous access to two memory locations and is commonly used in video RAM (VRAM).**
- **SIMM (Single Inline Memory Module) and DIMM (Double Inline Memory Module) are small circuit cards containing multiple DRAM memory chips, plugged into the computer's system board.**

ROM (Read Only Memory)

- **Read-Only Memory (ROM) is a non-volatile memory, meaning the information stored in it is retained even when the power supply is turned off.**
- **ROM stores data permanently and cannot be modified or written to by the user.**
- **Unlike RAM, which allows both reading and writing of data, ROM can only be read by the CPU.**
- **ROMs are cheaper compared to RAM when produced in large volumes.**
- **ROM is commonly used to store a special set of instructions needed by the computer during startup (boot-up).**
- **The contents of ROMs are determined by the manufacturers and are permanently stored at the time of manufacture.**
- **From a programming perspective, there are two main types of ROM:**
    - **Masked-programmed ROMs, where the contents are written during IC manufacture.**
    - **User-programmed ROMs, such as PROM, EPROM, and EEPROM, where the contents can be programmed by the user after manufacture.**
- **Mask-programmed ROMs are sometimes referred to simply as ROMs.**
- **An example of a ROM is the Toshiba mask ROM, TCS 534000.**

PROM (Programmable ROM)

- **A variation of ROM is Programmable Read-Only Memory (PROM), which is a memory chip where data can be written only once.**
- **ROM chips are provided by computer manufacturers, and users cannot modify the programs stored within them. However, with PROM, users can customize a system by storing their own programs.**
- **Once a program is written onto a PROM chip, the recorded information cannot be changed, effectively turning the PROM into a ROM where only reading of stored information is possible.**
- **PROM is also a non-volatile memory, meaning the stored information remains even if power is switched off.**
- **The fundamental distinction between PROM and ROM lies in their manufacturing process: PROM is produced as blank memory, while ROM is programmed during manufacturing.**
- **To write data onto a PROM chip, a special device called a PROM programmer or PROM burner is required. The process of programming a PROM is sometimes referred to as "burning the PROM."**

Memory and its Features

- **Disk addressing requires specifying the drive number, cylinder number, surface number, and sector number.**
- **Example disk address format for a disk controller with 8 drives, each disk pack having 250 cylinders, 12 surfaces, and 256 sectors.**

Drive Number	Cylinder Number	Surface Number	Sector Number
3 bits	13 bits	4 bits	8 bits

Access time on a magnetic disk

- **Seek Time (Ts):**
  - **Time required to move the read/write head to a specific track.**
  - **Varies based on the initial position of the arm assembly.**
  - **Maximum when moving from outermost to innermost track, zero if already on the desired track.**
  - **Average seek time specified for most systems, typically ranging from milliseconds to fractions of a second.**
  - **Associated only with movable-head systems; for fixed-head systems, it's always 0.**
- **Latency Time (tL) or Search Time:**
  - **Time required to bring the needed data (specified sector) under the read/write head.**
  - **Variable and depends on the distance of the desired data from the initial head position on the specified track and the rotational speed of the disk.**
  - **Average latency time specified for most systems, typically of the order of 10 to 15 milliseconds.**
- **Total Access Time:**
  - **Sum of seek time and latency time.**
  - **Average access time for most disk systems is usually between 10 to 100 milliseconds.**
  - **Access time = Seek time + Latency time**
  - **These metrics are crucial in determining the performance of disk**
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- **Pen Drives:**
  - **Convenient and flexible data storage medium, storing up to 256 GB of data.**
  - **Comparable in function to floppy disks or CD-ROMs but with significantly higher data storage capacity.**
  - **Smaller, faster, durable, and more reliable than floppy disks or CD-ROMs.**
  - **Portable USB flash memory device integrated with a USB interface.**
  - **Used for quick data transfer between systems.**
  - **Can be recognized by modern operating systems without requiring additional drivers.**
  - **Some computers can boot up from pen drives.**
- **Magnetic Tapes:**
  - **Sequential access type secondary storage device used for backups in servers, workstations, and large computers.**
  - **Cheaper and provides unlimited storage capacity (20 GB to 150 GB) as they are removable from the drive.**

These optical disk technologies offer high storage capacities and various levels of read/write capabilities, catering to different data storage needs and preferences.

Different types of Secondary Memories and its Features

Medium	Capacity	Advantages	Disadvantages	Primary Uses	Storage Mechanism
Hard Disk	Variable	- Very robust	- Slower computer performance when disk is full	- To store data and files	Magnetic
				- To store software	
Pen Drive	1 GB - 256 GB	- Portable	- Smaller, faster, and reliable	- To store data and files	Optical
		- Large storage capacity	- Most USB flash drives do not include write-protect mechanism	- For transferring data and files between computers	
CD-ROM/	650-700 MB	- Portable & medium storage capacity	- Some older computers cannot read CD-RW media	- To store files and software	Optical
CD-R/CD-RW		- Inexpensive	- CD-R discs are 'write once', no new data can be added	- To store archive material from hard disks	
		- Some types (CD-RW) can be reused		- To store scanned files such as exam papers	
		- Can be used in certain models of DVD players		- To store applications from the Internet	

- **Cache Memory: High-speed semiconductor memory placed between CPU and main memory to enhance speed.**
- **Main Memory: Falls next in hierarchy after cache memory, faster access compared to secondary storage.**
- **Secondary Storage: Includes devices like hard disks/magnetic disks, slower access compared to main memory but larger capacity.**
- **Mass Storage: Bottom of the hierarchy, includes secondary storage devices used for archival storage, cost-effective for mass storage when fast access time isn't critical.**

The hierarchy ensures that memory elements with faster access times are more expensive and have smaller capacities, while those with slower access times are cheaper and have larger capacities.