FOUNDATIONS OF COMPUTING: FROM HARDWARE ESSENTIALS TO WEB DESIGN

Course Code : GXEST203

MODULE 1

Module 1 topics

MODULE	SUB MODULE	TOPIC	No.of Hours	Level	CO
1	1.1	Computer Hardware - CPU	1	L1	CO1
1	1.2	Memory - Memory hierarchy: registers, cache, RAM, virtual memory	2	L1	CO1
1	1.3	Motherboard	1	L1	CO1
1	1.4	Computer Peripherals - I/O devices	1	L1	CO1
1	1.5	Storage devices- HDDs, SSDs, optical drives	1	L1	CO1
1	1.6	I/O communication and device management	1	L1	CO1
1	1.7	Interface cards, Buses	1	L1	CO1
1	1.8	Firmware.	1	L1	CO1

Introduction to Computers

- **Computer:** A device that accepts input, processes data, stores data, and produces output, all according to a series of stored instructions.
- **Software:** A computer program that tells the computer how to perform particular tasks.
- **Hardware:** Includes the electronic and mechanical devices that process the data; refers to the computer as well as peripheral devices.
- **Peripheral devices:** Used to expand the computer's input, output and storage capabilities.
- **Network:** Two or more computers and other devices that are connected, for the purpose of sharing data and programs.

Introduction to Computers

- The term computer is derived from the word **compute.**
- It is an electronic device that takes data and instructions as an input from the user, processes data, and provides useful information known as output.
- This cycle of operation of a computer is known as the Input-Process-Output cycle.
- Electronic device is known as **Hardware.**
- Set of instructions is known as **Software.**

Introduction to Computers

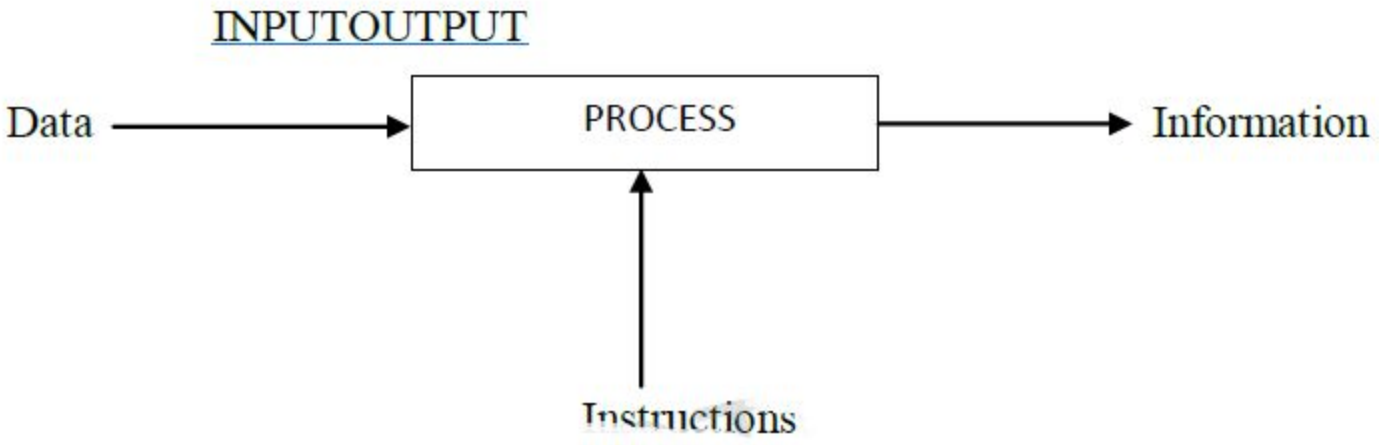


Fig: Input –Process-Output Concept

Computer System Characteristics

Computer is fast and accurate electronic system that is designed to accept and store input data, process them and produce output results using the instructions of a stored program.

1) Speed:Computer executes one instruction at a time. Most instructions are carried out in

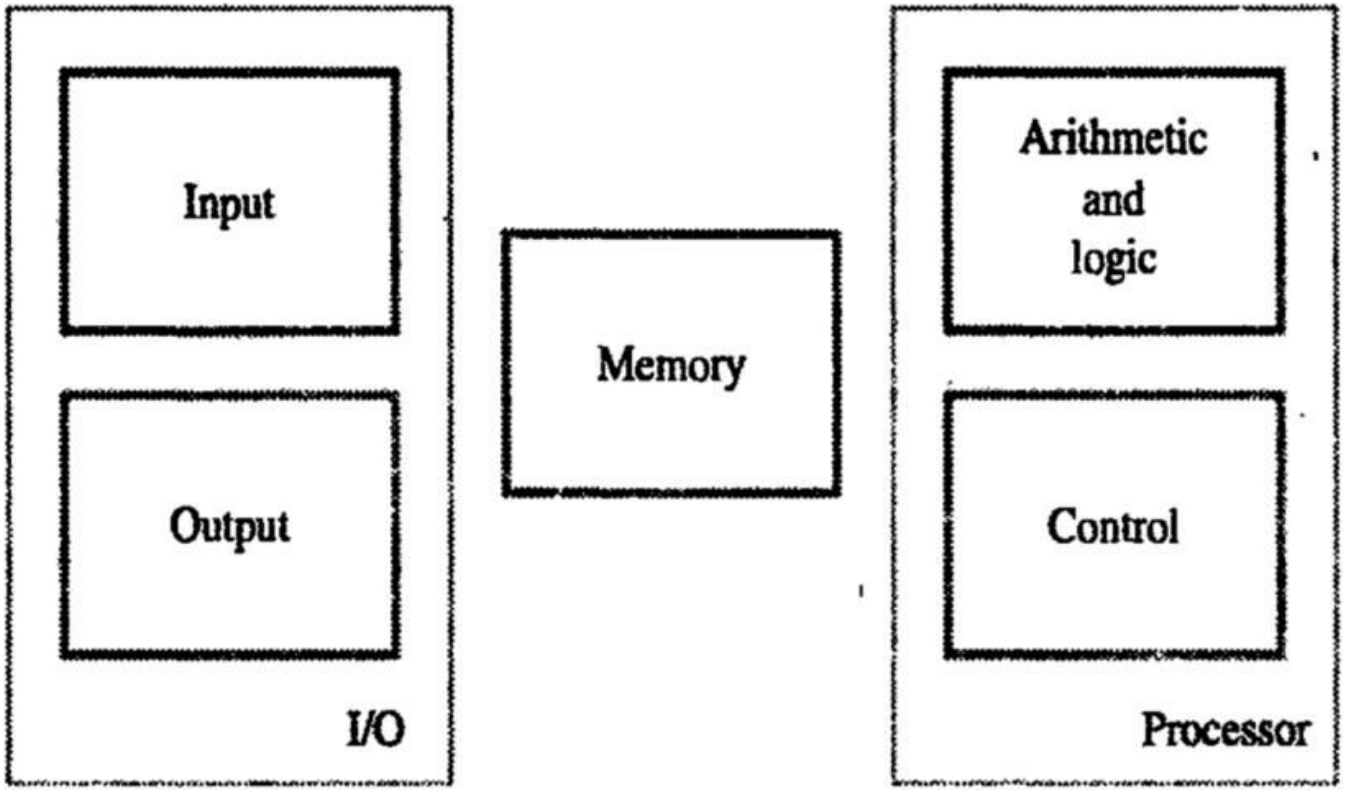
less than a millionth of a second.

2) Accuracy: Since the circuits in a computer have electronic parts, which far do not have

wear and tear, the instructions are carried out without any mistakes.

3) Vast Storage Media: In a computerized system a very large amount of data can be stored.

Central Processing Unit(CPU)



Central Processing Unit(CPU)

The computer system is divided into five separate units for its operation.

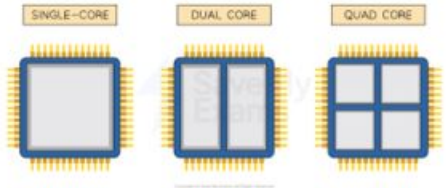
1. Input Unit.
2. ALU.
3. Control Unit.
4. Memory Unit.
5. Output Unit.

Central Processing Unit(CPU)

- CPU [Central Processing Unit]. It is the brain of the computer. It is the part that does most of the work in a computer system.
- All types of data processing operations from simple arithmetic to complex tasks and all the important functions of a computer are performed by the CPU.
- A CPU can be installed into a CPU socket. These sockets are generally located on the motherboard.
- **Types of CPU**
- We have three different types of CPU:
- **Single Core CPU:** The oldest type of computer CPU is a single-core CPU. This means that the single-core CPU can only process one operation at a single time. single-core CPU CPU is not suitable for multitasking.

Central Processing Unit(CPU)…..

- **Dual-Core CPU:** Dual-Core CPUs contain a single Integrated Circuit with two cores.
- Each core has its cache and controller.
- These controllers and cache work as a single unit. dual-core CPUs can work faster than single-core processors.
- **Quad-Core CPU:** Quad-Core CPUs contain two dual-core processors present within a single integrated circuit (IC) or chip.
- A quad-core processor contains a chip with four independent cores.
- Quad Core CPU increases the overall speed of programs



Central Processing Unit(CPU)…..

The CPU itself is often viewed as a composition of three primary subunits:

1. The **arithmetic/logic unit (ALU)** where arithmetic and Boolean logical calculations are performed.

2. The **control unit (CU)**, which controls the processing of instructions and the movement of internal CPU data from one part of the CPU to another.

3. The **interface unit,** which moves program instructions and data between the CPU and other hardware components.

The interface unit interconnects the CPU with memory and also with the various I/O (input/output) modules. It can also be used to connect multiple CPUs together.

In many computer systems, a bus interconnects the CPU, memory, and all of the I/O components.

Central Processing Unit(CPU)…..

- A **bus** is simply a bundle of wires that carry signals and power between different components**.**
- In other systems, the I/O modules are connected to the CPU through one or more separate processors known as **channels.**

Input and Output Unit

- **Input Unit:** Receives data from external devices and converts it into a format that the CPU can understand.
- Some typical input devices are a keyboard, a mouse, scanner, etc.
- **Output Unit:** Displays processed data from the CPU in a human-readable format..
- Output unit sends processed results to the outside world.
- Examples: Display screens, Printers, plotters, microfilms, synthesizers, high-tech blackboards, film recorders, etc.

Memory Unit (MU)

- The memory unit of the computer is used to store data, instructions for processing data, intermediate results for processing and the final processed information.
- The computer memory are of two types: Primary Memory and Secondary Memory.

Arithmetic Logical Unit (ALU)

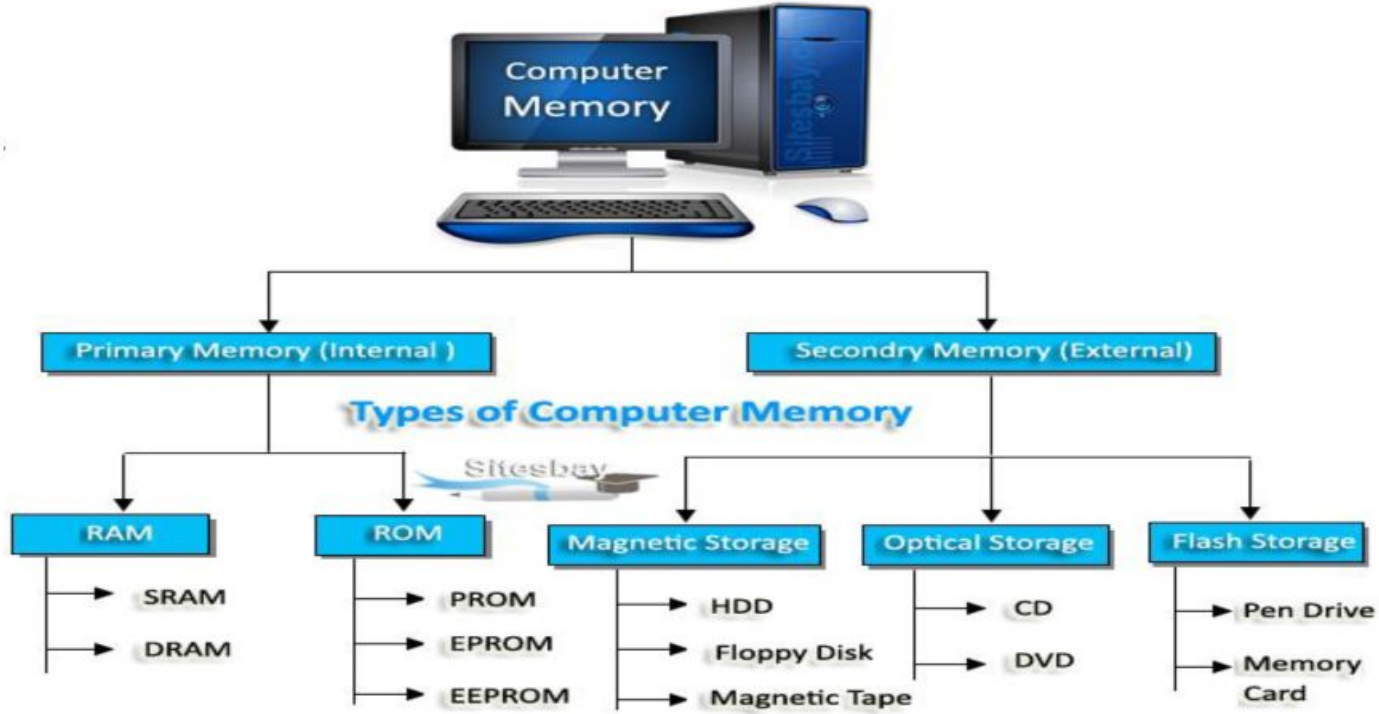
- Arithmetic Logical Unit performs the actual processing of data and instruction.
- The major operations performed by the ALU are arithmetic (addition, subtraction, multiplication, division), and logical (AND, OR, NOT , Comparisons) operations.

Control Unit

- The next component of computer is the control unit, which acts like the supervisor seeing whether things are done in proper fashion.
- Control unit controls and coordinates the entire operations of the computer system.
- The control unit determines the sequence in which computer programs and instructions are executed.
- It also acts as a switchboard operator when several users access the computer simultaneously.

Memory

- Computer memory is just like the human brain. It is used to store data/information and instructions.
- It is a data storage unit or a data storage device where data is to be processed and instructions required for processing are stored.
- It can store both the input and output can be stored here.
- The main memory, often known as primary storage, working storage, or **RAM** (for **r**andom **a**ccess **m**emory), holds programs and data for access by the CPU.
- **Primary storage** is made up of a large number of cells, each numbered and individually addressable.
- Each cell holds a single binary number representing part of a data value or part of an instruction.
- The smallest addressable size of the cell in most current computers is 8 bits, known as a **byte** of memory.


Computer Memory
Primary Memory (Internal)
Secondry Memory (External)
Types of Computer Memory
Sitesbay
RAM
ROM
Magnetic Storage
Optical Storage
Flash Storage
SRAM
DRAM
PROM
EPROM
EEPROM
HDD
Floppy Disk
Magnetic Tape
CD
DVD
Pen Drive
Memory Card

Primary Memory

- Primary memory is faster in speed, less in size (normally a few megabytes) and costlier
- It consists of ROM (Read Only Memory), RAM (Random Access Memory).

1) **ROM (Read Only Memory)**
    - In ROM, the information is burnt (pre-recorded) into the ROM chip at manufacturing time.
    - It stores data and instructions, even when the computer is turned off.
    - It is the permanent memory of the computer where the contents cannot be modified by an end user.
    - ROM is called nonvolatile memory because it never loses its contents.

Primary Memory

ROM stores critical programs such as the program that boots the computer.

1) **Programmable Read Only Memory - PROM**

- PROM is a memory on which data can be written only once.A variation of the
- PROM chip is that it is not burnt at the manufacturing time but can be programmed.
- PROM is also a non-volatile memory.

2) **Erasable Programmable Read Only Memory – EPROM**

- In EPROM, the information can be erased and reprogrammed.
- EPROM is nonvolatile memory.
- An EPROM differs from a PROM in that a PROM can be written to only once and cannot be erased.
- But an ultraviolet light is used to erase the contents of the EPROM.

Primary Memory

3) Electrically Erasable Programmable Read Only Memory - EEPROM

- EEPROM is a recently developed type of memory.
- This is equivalent to EPROM, but does not require ultraviolet light to erase its content.
- It can be erased by exposing it to an electrical charge
- Itis also non-volatile in nature.
- EEPROM is not as fast as RAM or other types of ROM
- A flash memory is a special type of EEPROM that can be erased and reprogrammed

2) RAM (Random Access Memory)

- The most common type of memory is called random access memory (RAM). As a result, the term memory is typically used to mean RAM..
- RAM is like an electronic scratch pad inside the computer. RAM holds data and program instructions while the CPU works with them.
- When a program is launched, it is loaded into and run from memory. As the program needs data, it is loaded into memory for fast access.
- As new data is entered into the computer, it is also stored in memory but only temporarily.
- RAM is volatile, meaning that it loses its contents when the computer is shut off or if there is a power failure. Therefore, RAM needs a constant supply of power to hold its data.

2) RAM (Random Access Memory)...

RAM is of two types:

1. **S RAM (Static RAM):** S RAM uses transistors and the circuits of this memory are capable of retaining their state as long as the power is applied.

This memory consists of the number of flip flops with each flip flop storing 1 bit. It has less access time and hence, it is faster.

2. **D RAM (Dynamic RAM)**: D RAM uses capacitors and transistors and stores the data as a charge on the capacitors.

They contain thousands of memory cells. It needs refreshing of charge on capacitor after a few milliseconds. This memory is slower than S RAM.

Differentiate Static RAM and Dynamic RAM

SRAM	DRAM
It stores information as long as the power is supplied.	It stores information as long as the power is supplied or a few milliseconds when the power is switched off.
Transistors are used to store information in SRAM.	Capacitors are used to store data in DRAM.
SRAM is faster compared to DRAM.	DRAM provides slow access speeds.
These are expensive.	These are cheaper.
These are used in cache memories	These are used in main memories
It does not have a refreshing unit.	It has a refreshing unit.
SRAM is used in high-speed cache memory	DRAM is used in lower-speed main memory
SRAM is used in high performance applications	DRAM is used in general purpose applications

Differentiate RAM & ROM

RAM	ROM
RAM is a volatile memory that could store the data as long as the power is supplied.	ROM is a non-volatile memory that the could retain the data even when the power is turned off.
Read and write operations are supported.	Only read operations are supported.
Used to store the data that has to be currently processed by CPU temporarily.	It is typically used to store firmware or microcode, which is used to initialize and control hardware components of the computer.
It is a high-speed memory.	It is much slower than the RAM.
RAM is more costlier than ROM.	ROM is cheaper than RAM.

Memory Hierarchy

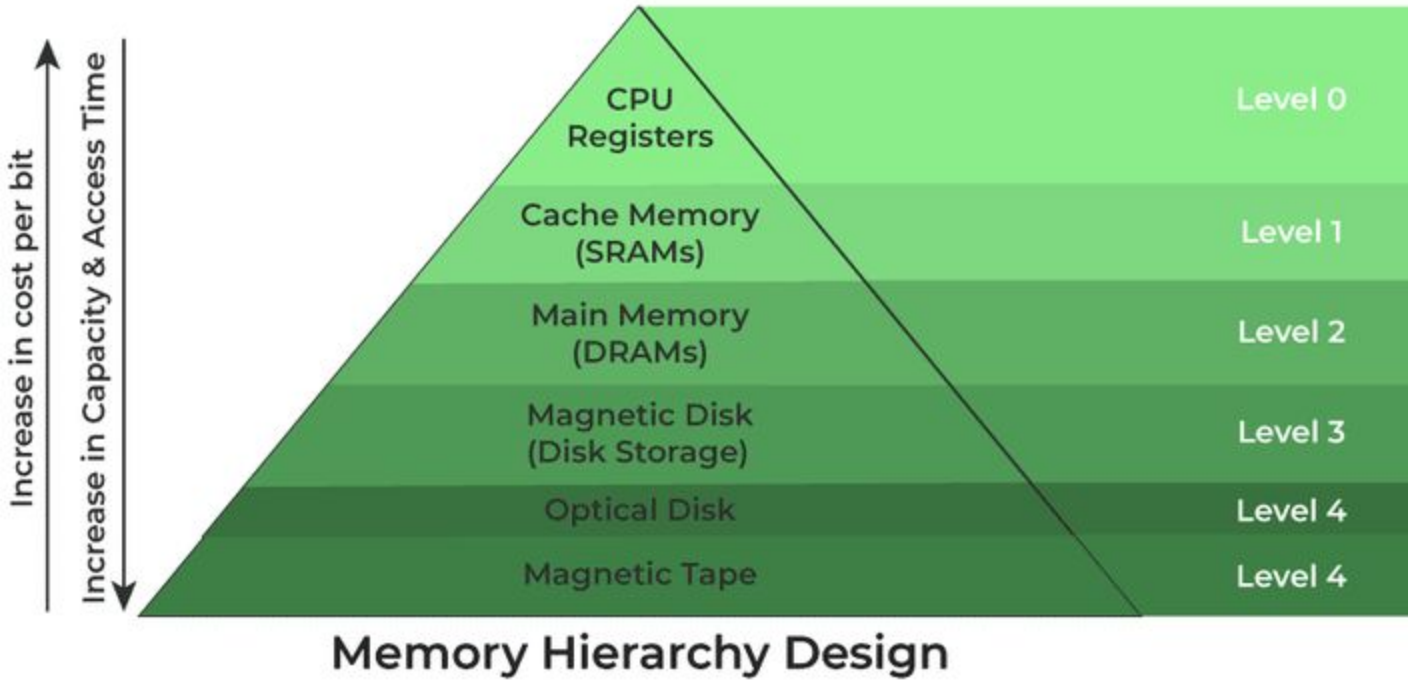
- Computer storage is often conceptualized hierarchically, based upon the speed with which data can be accessed.
- The table in Figure shows this hierarchy, together with some typical access times.
- At the top of the hierarchy are the CPU registers used to hold data for the short term while processing is taking place.
- Access to registers is essentially instantaneous, since the registers are actually a part of the CPU.
- Cache memory, if present, is the fastest memory outside the CPU.
- The CPU will always attempt to access current instructions and data in cache memory before it looks at conventional memory.

Memory Hierarchy...

This Memory Hierarchy Design is divided into 2 main types:

- External Memory or Secondary Memory: Comprising of Magnetic Disk, Optical Disk, and Magnetic Tape i.e. peripheral storage devices which are accessible by the processor via an I/O Module.
- Internal Memory or Primary Memory: Comprising of Main Memory, Cache Memory & CPU registers . This is directly accessible by the processor.

Memory Hierarchy



Memory Hierarchy...

1. Registers

- Registers are small, high-speed memory units located in the CPU.
- They are used to store the most frequently used data and instructions.
- Registers have the fastest access time and the smallest storage capacity, typically ranging from 16 to 64 bits.

2. **Cache Memory**

- Cache Memory is a small, fast memory unit located close to the CPU.
- It stores frequently used data and instructions that have been recently accessed from the main memory.
- Cache memory is designed to minimize the time it takes to access data by providing the CPU with quick access to frequently used data.

Memory Hierarchy

3. Main Memory

Main memory, also known as RAM (Random Access Memory), is the primary memory of a computer system. It has a larger storage capacity than cache memory, but it is slower. Main memory is used to store data and instructions that are currently in use by the CPU.

4. Secondary Storage

- Secondary storage, such as hard disk drives (HDD) and solid-state drives (SSD), is a non-volatile memory unit that has a larger storage capacity than main memory. It is used to store data and instructions that are not currently in use by the CPU. Secondary storage has the slowest access time and is typically the least expensive type of memory in the memory hierarchy.

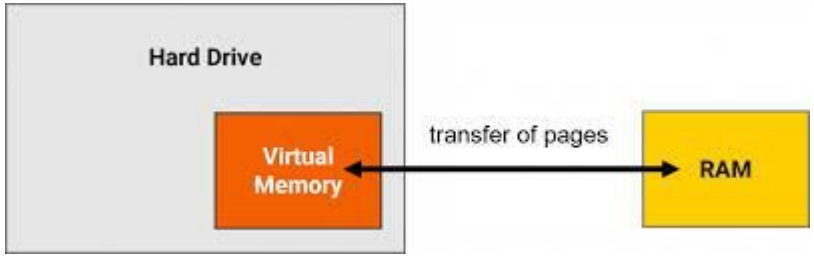
5. Magnetic Disk

- Magnetic Disks are simply circular plates that are fabricated with either a metal or a plastic or a magnetized material. The Magnetic disks work at a high speed inside the computer and these are frequently used.

Virtual Memory

Virtual memory refers to the process of swapping unused contents of RAM to the hard disk to manage a limited amount of physical memory.

- When the computer needs access to other parts of an operating system or a program stored on the disk, it:
  - Swaps out non-essential parts from RAM to the hard disk.
  - Loads or swaps in the required program code or data from the disk into RAM.
- This mechanism enables the system to manage and run larger programs or multitask effectively, even with limited physical RAM.



Virtual Memory…

- Systems with 128 MB or more RAM require less frequent swapping, leading to noticeable performance improvements.
- For instance, Windows runs faster when the CPU doesn't need to frequently swap program instructions between RAM and the hard disk.
- Upgrading RAM is a cost-effective way to enhance system performance and minimize the downsides of virtual memory management.
- The virtual memory is located in the lowest level of the memory hierarchy while still provide the speed of faster memory for most accesses. Processors can access data anywhere using virtual addresses that specify the location in virtual memory.

How Cache Memory Reduces Latency?

- **Faster Access Time**: Cache memory operates much faster than RAM, reducing the time the CPU spends retrieving data.
- **Data Locality**: Leverages temporal and spatial locality by storing recently used data and data near recently accessed addresses.
- **Reduced Data Travel**: Being closer to the CPU, cache minimizes the physical distance data needs to travel, improving access speed.

How do virtual memory and cache memory work together to improve processing efficiency?

- Cache memory stores frequently accessed data close to the CPU, ensuring quick access and reducing latency. On the other hand, virtual memory uses the hard disk to extend RAM, allowing the system to handle larger programs and multitasking when physical memory is insufficient.
- Together, these components enhance efficiency. Virtual memory provides the space required for running larger applications, while cache memory speeds up access to data already in RAM.
- This synergy reduces delays in data retrieval and ensures smooth program execution.

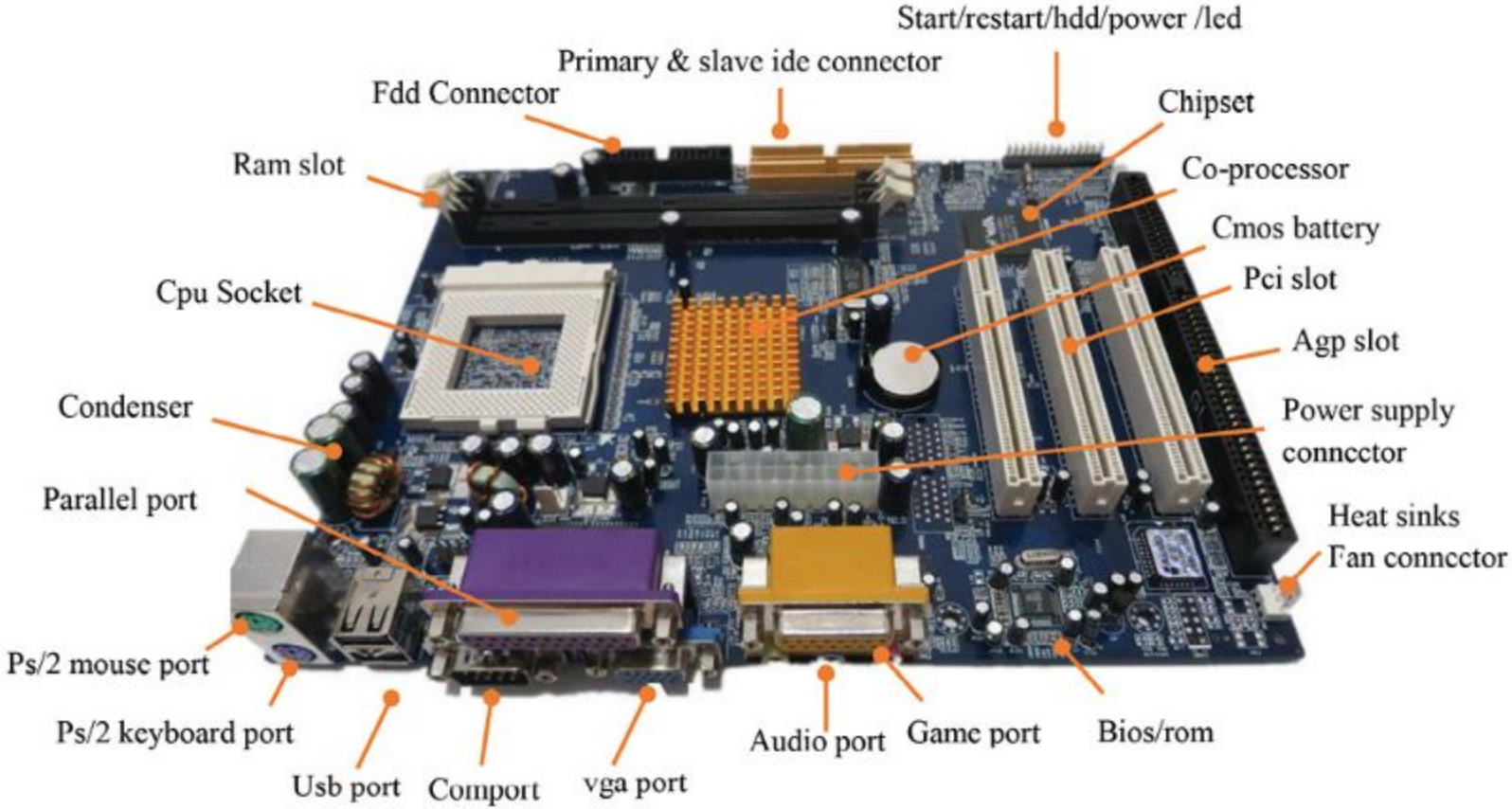
Secondary Memory

- Secondary memory is usually a very large amount of memory (in gigabytes), which is comparatively cheaper and slower than primary memory, but is permanent in nature.

- Thus, anything stored in secondary memory remains available even if the computer is switched off.

Motherboard

- This is the main circuit board to which all of the other internal components connect. The CPU and memory are usually on the motherboard.
- Other systems may be found directly on the motherboard or connected to it through a secondary connection.
- For example, a sound card can be built into the motherboard or connected through an expansion slot.


Start/restart/hdd/power /led
Primary & slave ide connector
Fdd Connector
Chipset
Ram slot
Co-processor
Cmos battery
Cpu Socket
Pci slot
Agp slot
Condenser
Power supply
connector
Parallel port
Heat sinks
Fan connector
Ps/2 mouse port
Ps/2 keyboard port
Usb port
Comport
vga port
Audio port
Game port
Bios/rom

Key Components on a Motherboard

- **CPU Socket:** This is where the central processing unit (CPU) is installed.
- **RAM Slots:** These slots hold the Random Access Memory (RAM), which is used for temporary data storage while the computer is running.
- **Expansion Slots:** These slots allow you to add additional components like graphics cards, sound cards, or network cards.
- **Chipset:** This integrated circuit manages communication between the CPU, RAM, and other components.
- **BIOS Chip:** This chip stores the Basic Input/Output System (BIOS), which is essential for the computer to start up.
- **Storage Interfaces:** These interfaces allow you to connect storage devices like hard drives and solid-state drives (SSDs).
- **I/O Ports:** These ports provide connections for external devices like keyboards, mice, monitors, and USB devices.

Key Functions of a Motherboard:

1. **Physical Connection:** The motherboard provides physical slots and sockets for installing essential components like the CPU, RAM, storage drives, and expansion cards. It acts as a platform that holds these components in place.
2. **Data Transfer:** It facilitates the transfer of data between the CPU, RAM, and other components through a network of electrical pathways called traces. These traces enable the seamless flow of information within the system.
3. **Power Distribution:** The motherboard receives power from the power supply unit (PSU) and distributes it to various components, ensuring they receive the correct voltage and current.

4. Communication: It manages communication between the CPU, RAM, and peripherals through the chipset, a specialized integrated circuit. The chipset acts as a bridge, enabling data exchange between different components.

5. Expansion Capabilities: The motherboard provides expansion slots, such as PCIe slots, that allow users to add additional components like graphics cards, sound cards, and network cards, expanding the system's capabilities.

6. I/O Ports: It offers a variety of input/output (I/O) ports, such as USB, HDMI, and audio ports, that enable the connection of external devices like keyboards, mice, monitors, and speakers.

Computer Peripherals

Q) What are the peripherals of a computer?

Peripherals of a computer are those devices that connect to the core computer to give it more power and ability. Printers, speakers, and microphones are examples of computer peripherals.

Q) What are four peripheral devices?

Peripheral devices are those devices that connect to the core computing unit. Four examples of peripheral devices are monitors, mice, keyboards, and printers.

Input/Output Devices

I. Input Devices

➢ Input devices accept data and instructions from the user or from another computer system. The most common input devices are:

1. **Keyboard**:-Which accepts letters, numbers and commands from the user. A standard keyboard includes alphanumeric keys, function keys, modifier keys, cursor movement keys, space bar, escape key, numeric keypad, and some special keys
2. **Mouse:**-The mouse allows the user to select elements on the screen, such as tools and icons. It is also known as a pointing device because it helps to change the position of the pointer or cursor on the screen.The mouse consists of two buttons, a wheel at the top and a ball at the bottom of the mouse.

Input/Output Devices

3. **Scanner**:-A scanner converts documents and images as the digitized images understandable by the computer system.

4. **Joystick**:-It consists of a small, vertical level mounted on a base that is used to steer the screen cursor around

5. **Microphone**:-It is used to input the voice or music as data.

6. **Optical Character Reader(OCR)**:-In OCR the optical character recognition techniques permit the direct reading of any printed character. These readers examine each character as if it were made up of a collection of minute spots ones the whole character has been scanned, the pattern detected is matched against a set of patterns stored in the computer. Whichever pattern it matches, or nearly matches, is considered to be the character read. Patterns which cannot be identified are rejected.OCR readers can read at the rate of up to 2400 characters per second.

Input/Output Devices

II. Output Devices

➢ Output devices return processed data to the user or to another computer system. The most commonly used output devices are:

1. **Monitor:**-A monitor is the most commonly used output device that produces visual displays generated by the computer. The display device is used for visual presentation of textual and graphical information.
2. **Printer:**-Printer is an output device that prints text or images on paper or other media. By printing you create what is known as as hard copy.
3. **Speakers**:-The speaker is a electromechanical transducer that converts an electrical signal into sound. They are attached to computer as output devices, to provide audio output, such as warning sounds and internet audios.We can have built in speakers or attached speakers in a computer to warn end users with error audio messages and alerts.
4. **Plotters:**-It is an output device that is connected to a computer to print large documents, such as engineering or construction drawings.

Storage Devices

- Storage devices are hardware components used to store digital data.
- Storage devices are of two types - Primary and secondary storage devices.

- **Primary storage devices:** It is a type of memory that is actively used or processed by the CPU. It is where the computer stores data and instructions that are currently being used. Eg: RAM, ROM, cache memory, registers etc.

- **Secondary storage devices:** These are used to store data outside of a computer's main memory. This storage is non volatile (it retains data even if the power is turned off). Eg: HDD, SSD, optical drives.

Hard Disk Drives (HDD)

- Hard Disk Drives/ Hard Disks/ Hard Drives use magnetic disks to store data.
- HDDs are where your operating system, applications, and personal files are stored.
- **Structure of HDD**
  - **Platters:** These are circular disks made of non-magnetic material like aluminum or glass. They are coated with a thin layer of magnetic material where data is stored. Multiple platters are stacked on top of each other, increasing storage capacity.
  - **Spindle Motor:** This motor spins the platters at high speeds (usually measured in RPM, revolutions per minute). The faster the spin speed, the quicker the data can be accessed.
  - **Read/Write Heads:** These are tiny electromagnetic devices attached to actuator arms. They move across the surface of the platters to read and write data.
  - **Actuator Arm:** This arm holds the read/write heads and moves them radially across the platter surface. It allows the heads to access different tracks on the platter.
  - **Controller:** This electronic component manages the overall operation of the HDD. It controls the spindle motor, actuator arm, and read/write heads.

Hard Disk Drive (HDD)

Solid State Drives (SSD)

- Solid State storage devices are unique among today's storage devices because they do not use disks or tapes and have no moving parts.
- Solid-state storage is neither magnetic nor optical. Instead, it relies on integrated circuits to hold data.
- It uses flash memory chips to store data electronically.
- While traditional storage (like HDDs) is cheaper and more reliable, SSDs offer a significant advantage: speed.
- SSDs have no moving parts, allowing them to access data much faster than traditional storage. They store data electronically, eliminating the need for mechanical operations to read and write data.


PATRIOT
P210
2.5" SSD 6Gb/s SATA III
2 TB
HIGH PERFORMANCE
022303070501485
www.patriotmemory.com
Made in Taiwan

Fig: SSD

Optical Drives

- Optical drives are devices that use laser light to read and write data to optical discs. These discs include CDs, DVDs, and Blu-ray discs.
- CD-ROM: Compact Disc Read-Only Memory, is a pre-recorded optical disc that stores data in the form of text, graphics, video, and audio.
- DVD-ROM: Digital Versatile Disc-Read Only Memory. It's an optical disc format that can store large amounts of data, such as movies, music, and software.
- While popular in the past, CD-ROMs and DVD-ROMs have been replaced by faster and more flexible storage options like USB drives, external hard drives, and cloud storage.

I/O Communication

- This refers to the process of transferring data between a computer's central processing unit (CPU) and external devices.
- Key techniques for I/O communication
    - Programmed I/O
    - Interrupt-Driven I/O
    - Direct Memory Access (DMA)

Programmed I/O

- CPU directly controls data transfer between itself and I/O devices.
- Uses I/O registers to interface with devices.
- Process:
  - CPU checks device status.
  - If ready, CPU initiates data transfer.
  - Data is transferred between the device and CPU via I/O registers.
  - CPU repeats the process for each data word.

Interrupt Driven I/O

- It is a more efficient method for handling I/O operations compared to programmed I/O.
- When an I/O device (like a keyboard or disk drive) is ready to send or receive data, it generates an interrupt signal.
- This signal is sent to the CPU, interrupting its current execution.
- The CPU pauses its current task and saves its state (program counter, registers, etc.) to a special memory location called the stack.
- The CPU then jumps to a predefined memory location, known as the Interrupt Vector Table (IVT), to fetch the address of the appropriate Interrupt Service Routine (ISR).

- The ISR is a specific piece of code designed to handle the particular type of interrupt.
- The ISR takes control and performs the necessary I/O operations, such as reading data from an input device or writing data to an output device.Data is transferred between the device and the system's memory.

Direct Memory Access (DMA)

- DMA is a technique that lets devices directly access the computer's memory without involving the CPU. This speeds up data transfer, especially for large amounts of data.
- A device, like a hard disk or network card, needs to transfer data, the CPU sets up a special hardware controller called a DMA controller. It tells the controller where to get the data from, where to put it, and how much data to transfer.
- The DMA controller takes over, directly transferring data between the device and memory.
- The CPU can focus on other tasks during this time, improving efficiency.
- Once the transfer is complete, the DMA controller signals the CPU.
- The CPU resumes its original task.
- By offloading data transfers to the DMA controller, the CPU can handle other tasks more efficiently. This is crucial for modern computers that handle large amounts of data.

Device Management

- Device management is a critical function of an operating system (OS) that oversees and controls the hardware devices connected to a computer system.
- It ensures efficient and secure interaction between software applications and physical hardware, optimizing system performance and resource utilization.
- Key Components of Device Management:
  - Device Drivers: Software programs that act as intermediaries between the operating system and hardware devices. They translate high-level software commands into low-level instructions understood by the hardware. Eg: A printer driver for a printer.
  - I/O Controller: Hardware interface that manages communication between the CPU and devices. Eg: Disk controller for HDD and SSD.

Functions of device management

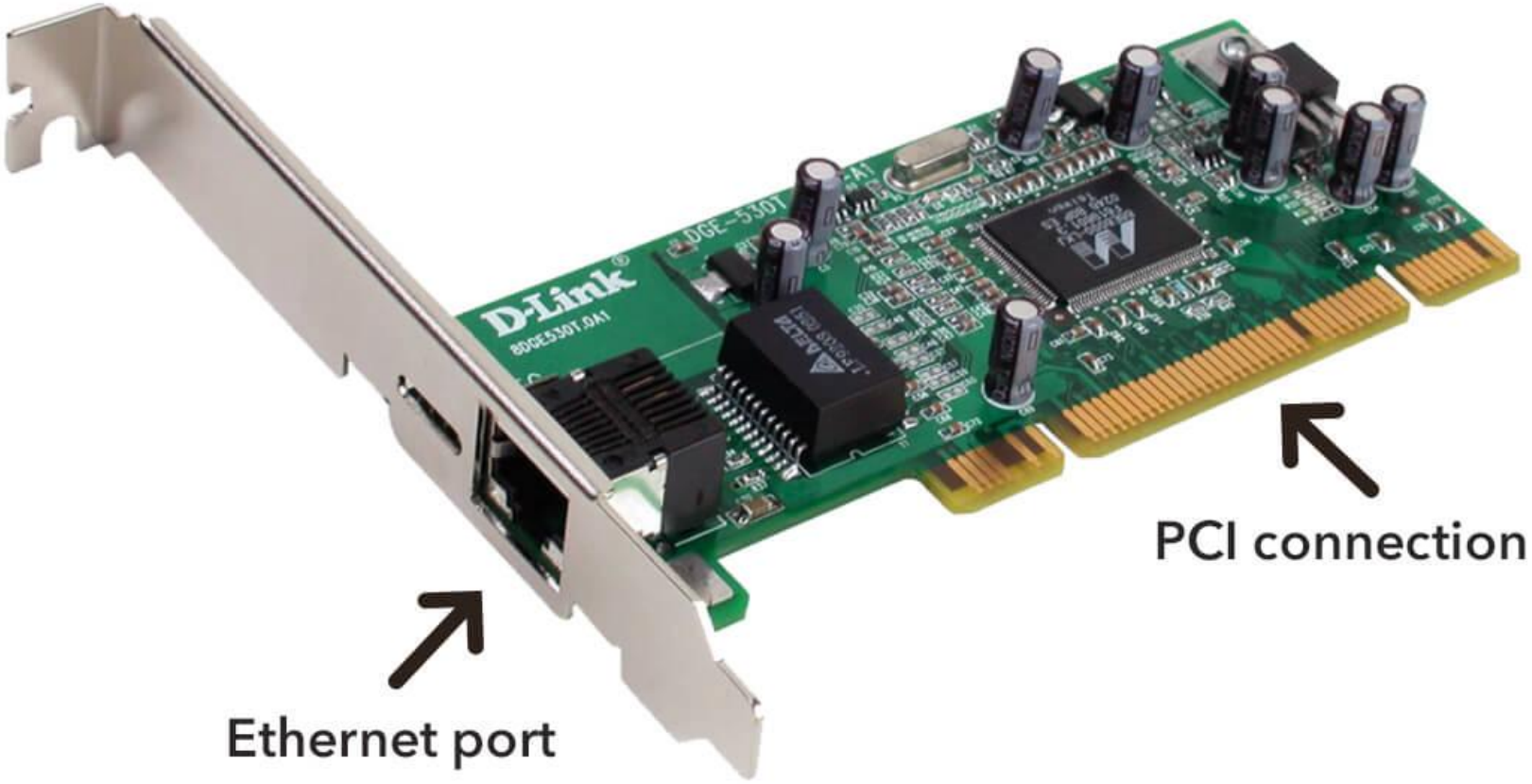
- Device identification: recognizes and keeps track of devices connected to the computer
- Device allocation: Decides which device a program can use and ensures no two program use the same device at the same time.
- Device communication: Helps the OS sends and receives data from devices.
- Device Scheduling: Determines the order in which I/O requests are processed.
- Buffering: Temporarily stores data during transfers to handle speed differences between fast devices (like CPU) and slower ones (like printers).
- Spooling: Queues tasks for devices that can only handle one task at a time. Eg: storing multiple print jobs in a queue while the printer process them one by one.
- Error detection and handling: Monitors devices for errors during operations and take corrective actions.
- Device deallocation: Free up a device after a program finishes using it, so others can use it.

Network Interface Card

- An interface card, commonly known as a Network Interface Card (NIC) or Network Adapter, is a hardware component that connects a computer to a computer network.
- It acts as a bridge between the computer's internal components and the external network.
- There are a number of different types of network interfaces, with different network
- interface controllers for each.
- On most systems, the standard connection is to an Ethernet network.
- Nearly every current computer system is supplied with one or more Ethernet network interface cards as a basic part of the system.
- Wireless Ethernet and Bluetooth network interface cards are also commonplace.

- NICs are complex I/O devices that must handle data formatting, addressing, and security protocols to communicate with other devices on a network.
- Unlike many other devices, NICs can independently receive requests and data from the network.
- Each NIC has a unique address known as MAC address (Media Access Control Address) that acts like a physical address for the device on a network to uniquely identify the device.
- It follows specific rules (MAC protocols) to communicate efficiently.

Gigabit Ethernet NIC



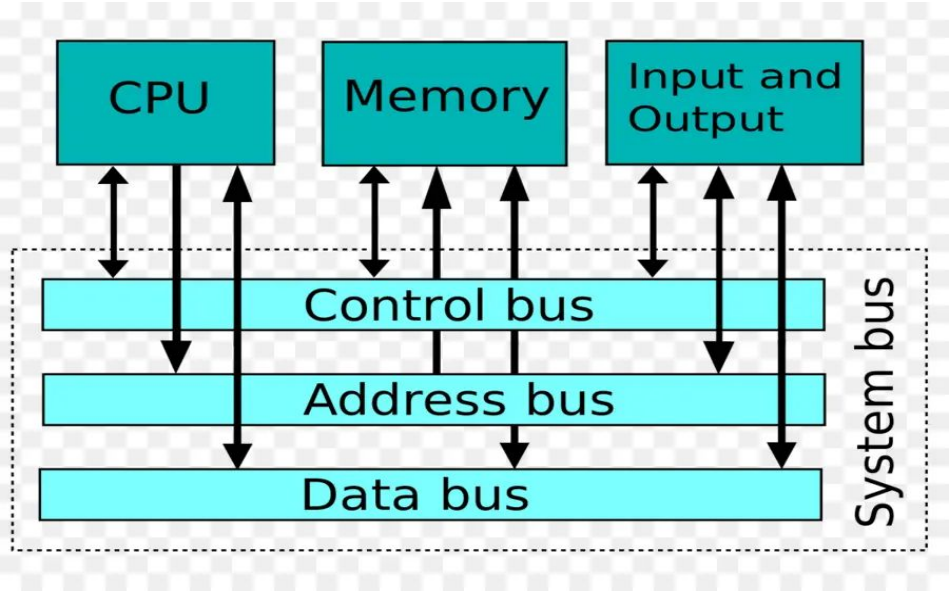
Buses

- A bus is a collection of electrical conduits that carry data, addresses, and control signals between different components of a computer system.

System Bus

- A system bus connects the CPU, memory, and I/O devices.
- It is a combination of three types a buses : data bus, address bus, and control bus.
- Each conductor in the bus is commonly known as a line.
- The bus consists of three sets of lines used to carry address, data, and control signals. I/O device interfaces are connected to these lines.

System Bus


CPU
Memory
Input and Output
Control bus
Address bus
Data bus
System bus

- Data Bus: Data lines carries the actual data to be transferred between components. It is bidirectional.
- Address Bus: Address lines carries the memory address to specify the location of data to be accessed. It is unidirectional as it only sends addresses from the CPU to memory or I/O devices.
- Control Bus: Control lines carries control signals to coordinate data transfer and control the timing of operations. Unidirectional, as it sends control signals from the CPU to other components.

Firmware

- It is a type of software that is embedded directly into hardware components to control their basic functions.
- It acts as a bridge between hardware and higher level software, enabling the hardware to perform its intended operations.
- It stored in non-volatile memory such as ROM.
- Provides fundamental instructions needed for the hardware to function.
- Tailored to the device it operates on. eg: BIOS (Basic Input/Output System)- It initializes hardware during the boot process in PCs.

Functions of firmware:

- Hardware initialization
- Basic I/O operations
- Device specific operations
- Security

Types of Firmware

- **BIOS/UEFI:** Found in computers, it initializes hardware during startup and provides basic input/output services.
- **Embedded Firmware:** Used in various devices like smartphones, routers, and appliances, it controls specific functions and interactions.
- **Device Drivers:** These are software components that enable communication between the operating system and specific hardware devices.

Component	Description	Example
Hardware	Physical components of a computer or electronic device.	CPU, RAM, Hard drive, Monitor, Keyboard
Firmware	Software embedded in hardware, providing low-level control.	BIOS/UEFI, Embedded firmware in smartphones, Device drivers
Software	Set of instructions for a computer to perform tasks.	Operating systems, Applications, Programming languages