Unit-1

Computer Systems and Organization

Basic Computer Organization

Introduction to Computer System

A computer is an **electronic device** that takes instructions and data from a user as **input**, **processes** them, and **produces** some meaningful **output** as a result. Computers are a **combination of hardware and software**. Computer systems work on the **IPO (Input-Process-Output)** Model. They process information stored as **binary digits (0s and 1s)** and perform complex tasks with incredible speed and accuracy.

- **Hardware are physical components** which can be **seen and touched (tangible)**. Examples of hardware include CPU, mouse, keyboard, monitor, motherboard, cables, CPU case, power supply unit, RAM, graphics card, sound card etc.
- Various hardware components are **interconnected together using a pathway called 'Bus'**, that facilitates the **transfer of data**.
- **Software is a set of instructions**, its documentation and data, which are **stored digitally** on the computer. Examples are Microsoft Windows, Linux, Paint, Word, PowerPoint, Photoshop, VLC Media Player, VS Code, Python. The software is intangible, i.e cannot be touched.
- A computer system receives instructions from the user (usually a human) using Input Devices.
- The Operating System (OS) is a crucial piece of software that allows users to interact with the computer hardware and other software easily.
- Computers process data through a series of instructions stored in their memory. The CPU fetches these instructions, decodes them, and then executes them.
- Computers can talk to other computers through networking. The Internet is one such network.

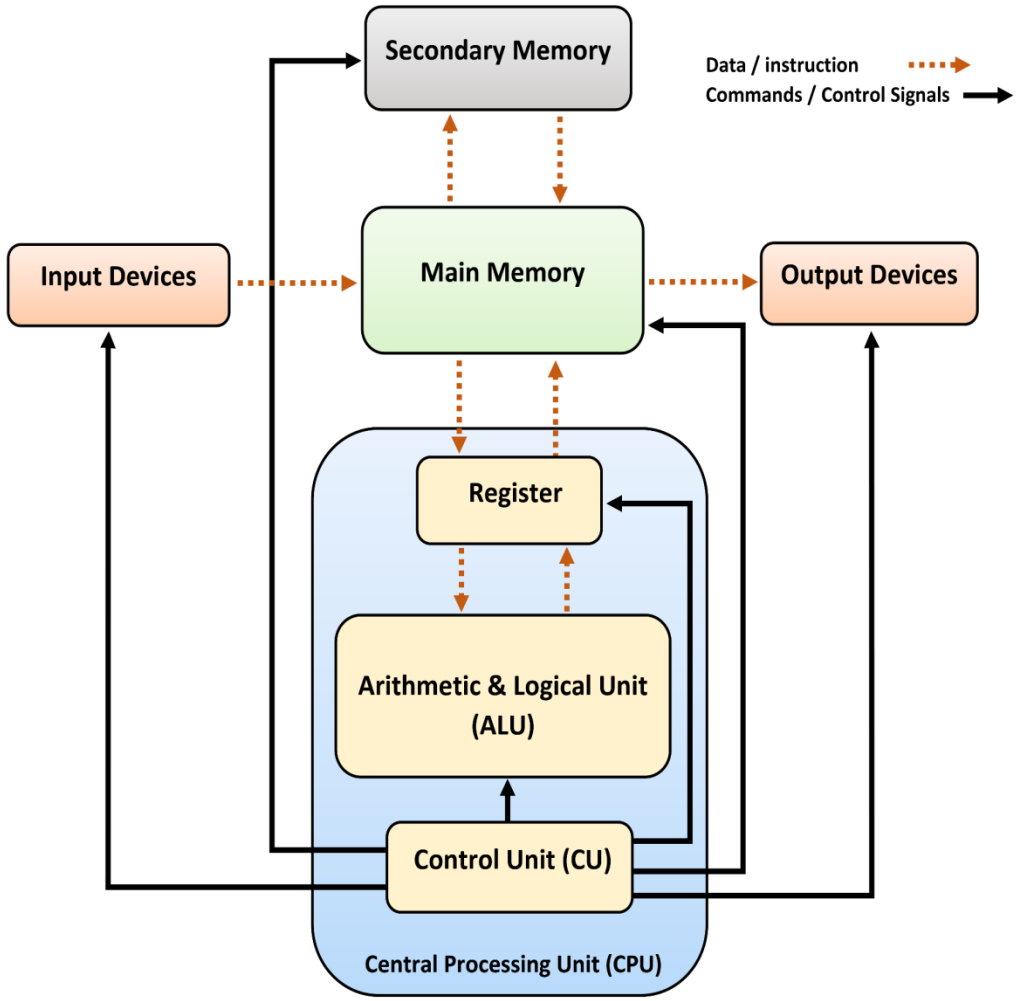
Advantages of Computers

- Multi-tasking - can perform multiple tasks simultaneously
- Speed - computes data rapidly
- Productivity - automates and streamlines work process to increase productivity
- Accuracy - tasks are performed with high accuracy
- Connectivity - access to vast amount of data and global communication networks
- Education- enhances learning through stores resources
- Storage - can store large amounts of data for a long time
- Reliability - can perform its functions adequately in a controlled environment with high precision

Disadvantages of Computers

- High initial costs of purchase, maintenance

- Long use may lead to health issues
- Security Risks - vulnerable to hacking, loss and theft of information
- Environmental Impact due to high carbon emissions
- Software issues - problems may arise due to buggy software



Computer Block Diagram

Input Devices

- The hardware devices that **send input data from the user to the CPU** are known as Input Devices.
- They are responsible for capturing, and transferring data from the outside world into the computer system.
- Some of the popular Input Devices are Keyboard, Mouse, Joystick, Scanner, Microphone, Touchpad, Biometric Sensors, Graphic Tablet, Bar/QR Code Readers, Webcam, Magnetic Ink Character Reader (MICR) and Optical Character Reader (OCR) devices etc.

Output Devices

1. The hardware devices that **are responsible for displaying output from the computer** are known as Output Devices.
2. Some of the popular Output Devices are Display Monitor, Projector, Speaker, Printer, Plotter, Headphones etc

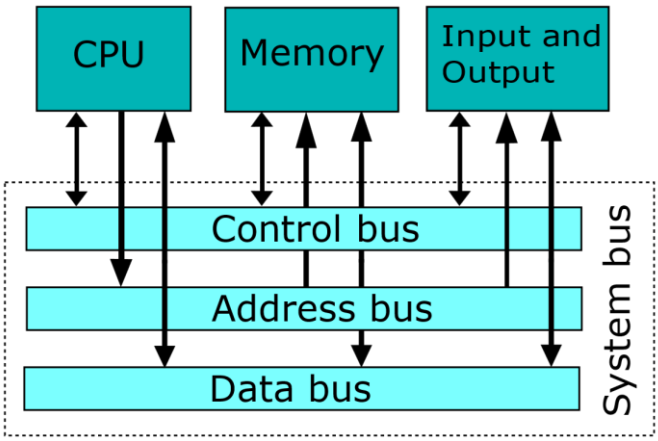
Central Processing Unit

1. The **Central Processing Unit (CPU)** is the **brain** of the computer.
2. It is **responsible for processing** the instructions received, and generating the results.
3. The CPU contains **three major components, namely an Arithmetic and Logic Unit (ALU), a Control Unit (CU) and a set of Registers.**
4. The ALU performs arithmetic operations such as addition, subtraction, division, multiplication, exponentiation etc. It is also responsible for performing logical operations that result in either True or False.
5. The Control Unit (CU) is responsible for proper operation of the system. It controls the different operations of the computer by generating control signals.
6. The set of Registers are local/temporary storage for the CPU.

7. Registers can be accessed in a single CPU instruction and thus are extremely fast storage.
8. Registers are limited in number and thus data has to be transferred from the main/cache memory to the registers for processing of data.

Working of the CPU (Additional Reading)

1. The CPU works on the concept of Information Processing Cycle (also known as Instruction Cycle).
2. Based on a clock signal, the CPU fetches instructions from the main memory.
3. To access the main memory, the CPU transmits signals from the System Bus.
4. The system bus is similar to a road network that connects various peripheral devices to the CPU. It is made up of Control Bus, Address Bus and the Data Bus. The Control Bus transmits controlling signals, the addresses are transmitted through the address bus, and the data is put onto the data bus.
5. The CPU then decodes the instruction into a sequence of operations.
6. It reads the effective address from the memory to fetch the data.
7. Then it performs the operation and stores the result back into the memory.



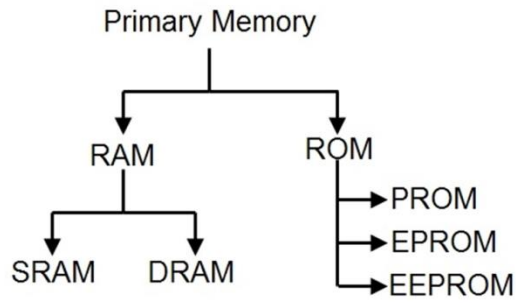
Memory

1. The location where the computer stores data, instructions, and programs is called the Memory.
2. Computer memory is organized into memory cells, each of which stores a fixed amount of data, typically represented in binary as 0s and 1s.
3. The Memory of a computer is divided into Primary, Cache and Secondary Memory.

Primary Memory

1. The primary memory is directly accessible by the CPU.
2. It is a high speed memory which can closely match the operational speed of the CPU.

3. Due to the high speed, the cost of primary memory is high and the storage capacity of primary memory is lower in comparison to the secondary memory.
4. There are two kinds of primary memory, namely RAM and ROM.



Random Access Memory (RAM)

1. RAM, also known as the main memory, is a volatile memory, i.e the contents of the memory are lost as soon as the power to the system is switched off.
2. It is the main memory with which the CPU can interact directly.
3. It stores the instructions and data which are to be processed by the CPU shortly.
4. The data on the memory is stored in a fixed size block address.
5. The addresses on the RAM can be accessed in a random order, hence the name, Random Access.
6. RAM is majorly categorized into SRAM and DRAM.
7. DRAM stands for Dynamic RAM. Its contents have to be refreshed constantly. It is cheaper than SRAM.
8. SRAM stands for Static RAM. It does not require constant refreshing of the contents and hence is generally more expensive than DRAM.

Read Only Memory (ROM)

1. ROM is a non-volatile memory.
2. The purpose of ROM is to store the software instructions required for starting up the computer.
3. The startup process is also called bootstrap or booting the computer.
4. It loads a software called Basic Input Output System (BIOS).
5. It is mainly of three types
    a. PROM - Programmable ROM
    b. EPROM - Erasable Programmable ROM
    c. EEPROM - Electrically Erasable Programmable ROM

Cache Memory

1. Cache memory is an intermediate memory between the CPU and the primary memory.
2. The need for cache memory arises from the difference in operational speed of the CPU and the primary memory.

3. Often, the CPU is faster than the RAM/ main memory, and thus has to wait for the next instruction to be loaded from the memory.
4. To reduce this waiting time, and increase the throughput of the CPU, a cache memory (buffer) is placed between the CPU and primary memory.
5. The cache holds frequently used instructions and data and makes them readily available to the CPU.

Secondary Memory

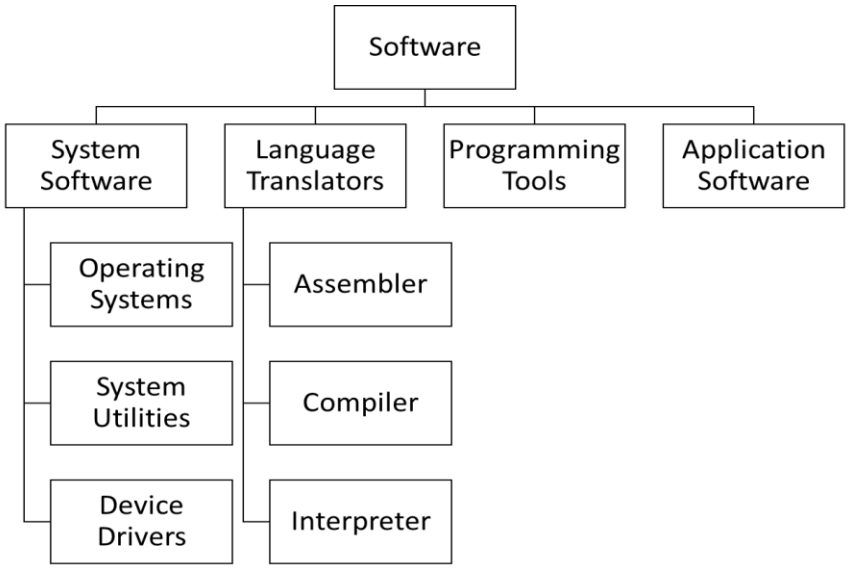
1. Secondary memory is also known as **permanent** memory.
2. It is **non-volatile** in nature, i.e the **data does not get lost even after power is turned off** from the computer.
3. Examples of Secondary memory are Hard Disk Drive, Solid State Drive, USB Flash Drive.
4. The CPU does not interact with the Secondary Memory directly.

Units of Memory

1. The smallest unit of memory is called a binary digit, or a bit.
2. The bit can assume only two values, 0 and 1.
3. A sequence of 4-bits is called a Nibble.
4. A Word is a fixed length sequence of bits which the processor can handle at a time.

Sr. No	Unit	Remarks
1	Bit (b)	Can be 0 or 1
2	Nibble	1 nibble = 4 bits
3	Word	Group of bits on which the CPU can work as a single unit. Can be 8 bits, 16 bits, 32 bits or 64 bits depending on CPU Architecture.
4	Byte (B)	1 B = 8 bits
5	KiloByte(KB)	1 KB = 1024 B
6	MegaByte(MB)	1 MB = 1024 KB
7	GigaByte(GB)	1 GB = 1024 MB
8	TeraByte(TB)	1 TB = 1024 GB
9	PetaByte(PB)	1 PB = 1024 TB

Types of Software



System Software

It is software which controls all the operations of the computer system and interacts with the hardware connected to the computer. The computer cannot operate without system software. System software is majorly categorized into: Operating System, System Utilities and Device Drivers.

Operating System

An operating system is system software that acts as an interface between the user and the computer hardware and manages all the resources of a computer. Examples of operating systems are Microsoft Windows, Ubuntu, Android, Apple iOS etc.

System Utilities

The software that performs maintenance and configuration of the computer system is called System Utility.
Examples include Antivirus software, Disk Defragmentation Tool, System Restore Utility, Disk Partitioning Utility etc.

Device Drivers

The software that directly interacts with a particular hardware or peripheral device is called the device driver. Each hardware has its unique device driver without which the operating system cannot communicate with the device. Examples include RealTek Audio Driver, NVidia Video Driver, MS USB Driver etc.

Language Translators

Languages are majorly divided into two categories: **Low Level Languages and High-Level Languages.**

- Low Level Languages are nearer to Machine Code than to human-like languages. They are difficult to understand by humans but easily understandable by machines.
- On the other hand, humans can easily understand high level languages but computers require language translators to convert high level languages into low level languages which they understand.
- Low level language comprises Binary Language (combination of 0's and 1's) and Assembly Language (uses keywords like ADD, SUB, STR), whereas High Level Language comprises C, C++, Java, Python etc.
- Software that translates one language to another language is called language translators.
- Language Translators can be divided into Compiler, Interpreter and Assembler.

Compiler, Interpreter and Assembler

- A compiler is a language translator that converts high level language into low level language at once. It shows all errors together with line number. Once all errors are corrected and object code is created, compiler is no more required in memory.
- An Interpreter is a language translator that converts high level language into low level language line by line, instead of converting the entire code at once. It stops at the line where error is found and requires rectification of same to move forward. It is always required in memory.
- Assembly language code can be converted to machine code (Binary Code) using translator called Assembler.

Programming Tools

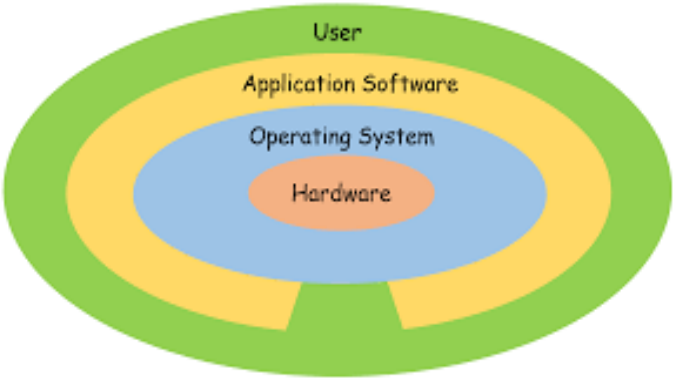
Tools that assist the users/developers in creating, editing, testing and debugging related to the development of software are known as Programming Tools.
They support completion of tasks during the development phase. It includes development tools, code editors and translators.
Examples include : Visual Studio Code, Sublime Text, Eclipse etc.

Operating System

An operating system is system software that acts as an interface between the user and the computer hardware and manages all the resources of a computer.

Need of Operating System

The main goal of an operating system is to provide a user-friendly environment, to use the available resources in an optimal and efficient manner and to provide services for building and running applications.

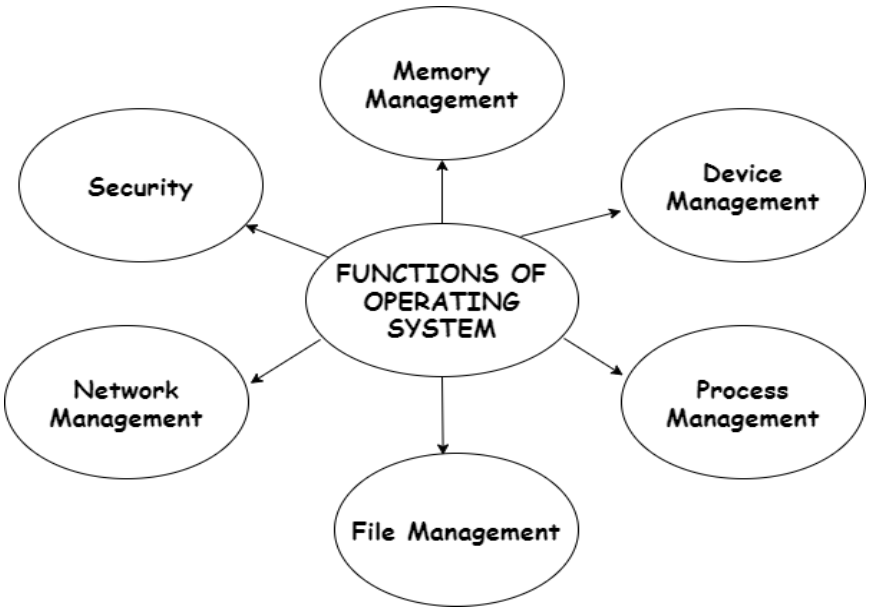


Examples of Operating System

1. **Desktop Operating System**
    a. Microsoft Windows
    b. Apple's macOS
    c. Ubuntu (Linux based open source OS)
    d. Google's ChromeOS

2. **Mobile Operating System**
    a. Google Android
    b. Apple iOS
    c. Symbian
    d. Microsoft Windows RT

Functions of Operating System



Memory Management

The operating system manages the memory resources of a computer system. It keeps a record of used and available memory. It includes:

- Memory Allocation, Reallocation and Deallocation
- Memory Mapping
- Memory Swapping

Device Management

Operating system manages communication among all the devices, keeps track of all the devices, allocates and deallocates devices. It includes:

- Device initialization
- Device Configuration
- Device Scheduling

Process Management

It manages all the programs in execution (processes). It includes:

- Process Creation & Termination
- Process Scheduling
- Context Switching

File Management

The operating system manages all the file management tasks. It keeps track of location, status, storage and operations of a file. It includes:

- File Creation and Deletion
- File Permissions and Security
- File Compression and Encryption
- File Sharing

Network Management

It provides services to organize and maintain the network. It allows computers in a network to communicate with each other. It includes:

- Network Configuration
- Network Connectivity
- Network Resource Management

Security

The operating system protects the system from all the threats, unauthorized access and other vulnerabilities. It includes:

- Authentication
- Authorization
- Data Encryption
- Firewall Management

Other tasks

Some other tasks performed by OS are Job Accounting, Error Detection, Control over System Performance, Resource Allocation, Information and Resource Protection, and Handling I/O Operations.

OS User Interface

Operating system acts as an interface between the user and the hardware. There are types of interfaces to perform different tasks on the basis of requirement.

Command Line Interface

It is the interface where the user interacts with the system through commands. All the operations are carried out on the basis of commands entered by the user.

Graphical Based User Interface

It is the interface that allows users to interact with the system through graphical icons, menu, taskbar etc.

Gesture Based User Interface

It is the interface that uses physical gestures to operate the computer system. It allows users to perform tasks without physically touching the system.

Voice Based User Interface

It is the interface that allows users to interact with a computer through voice commands. Examples of Voice User Interfaces are Google Assistant, Siri and Alexa.

Touch Based User Interface

Touch based user interface requires a physical touch through the input device.
