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Computer System Organization

INTRODUCTION

A computer's capability to process, store, and retrieve data and information has made it intrinsic to all kinds of environment—home, office or business. Widespread use of the computer has made it imperative for us to have knowledge about it, its advantages and disadvantages, and its internal structure.

So, technically, a computer is defined as an electronic device that takes input from the user in the form of data and instructions, processes this data and produces result (output) as information.

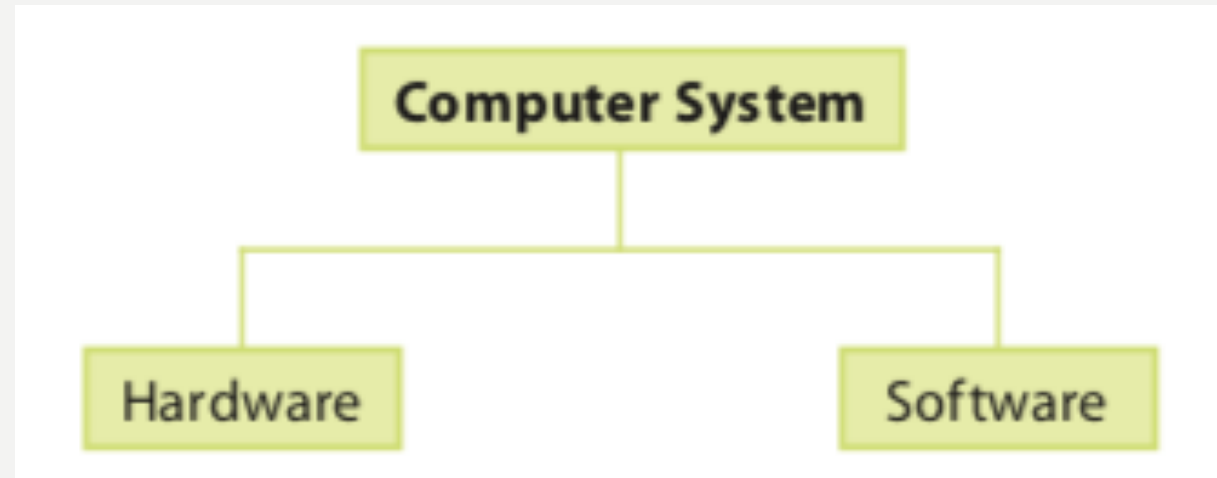


DATA AND INFORMATION

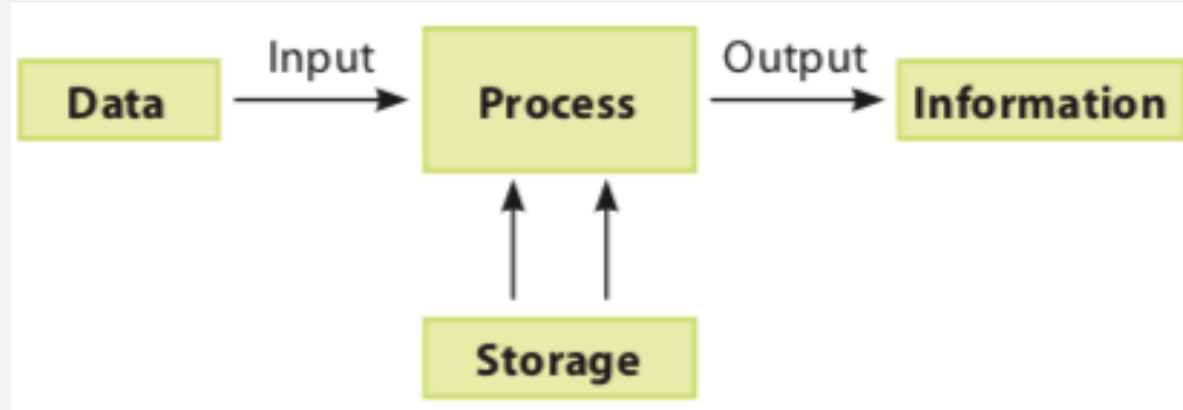
- **Data is defined as the raw facts or figures such as 106, “Shaurya”, “Class II”**
- **Does not convey any meaning in its original form**
- **It can be processed and organized to transform into useful information**
- **Information is the collection of data which is organized to generate some meaningful result. Ex: Shaurya of class II has an enrollment number 106.**
- **Thus computer takes input in the form of data and generates output in the form of information.**
- **This process of converting data into information is also known as IPO Cycle.**

BASIC COMPONENTS OF A COMPUTER SYSTEM

- **Computer is a combination of hardware and software**
- **Hardware is the physical components of the computer and software is the set of instructions.**
- **A computer functions with the help of both hardware and software.**

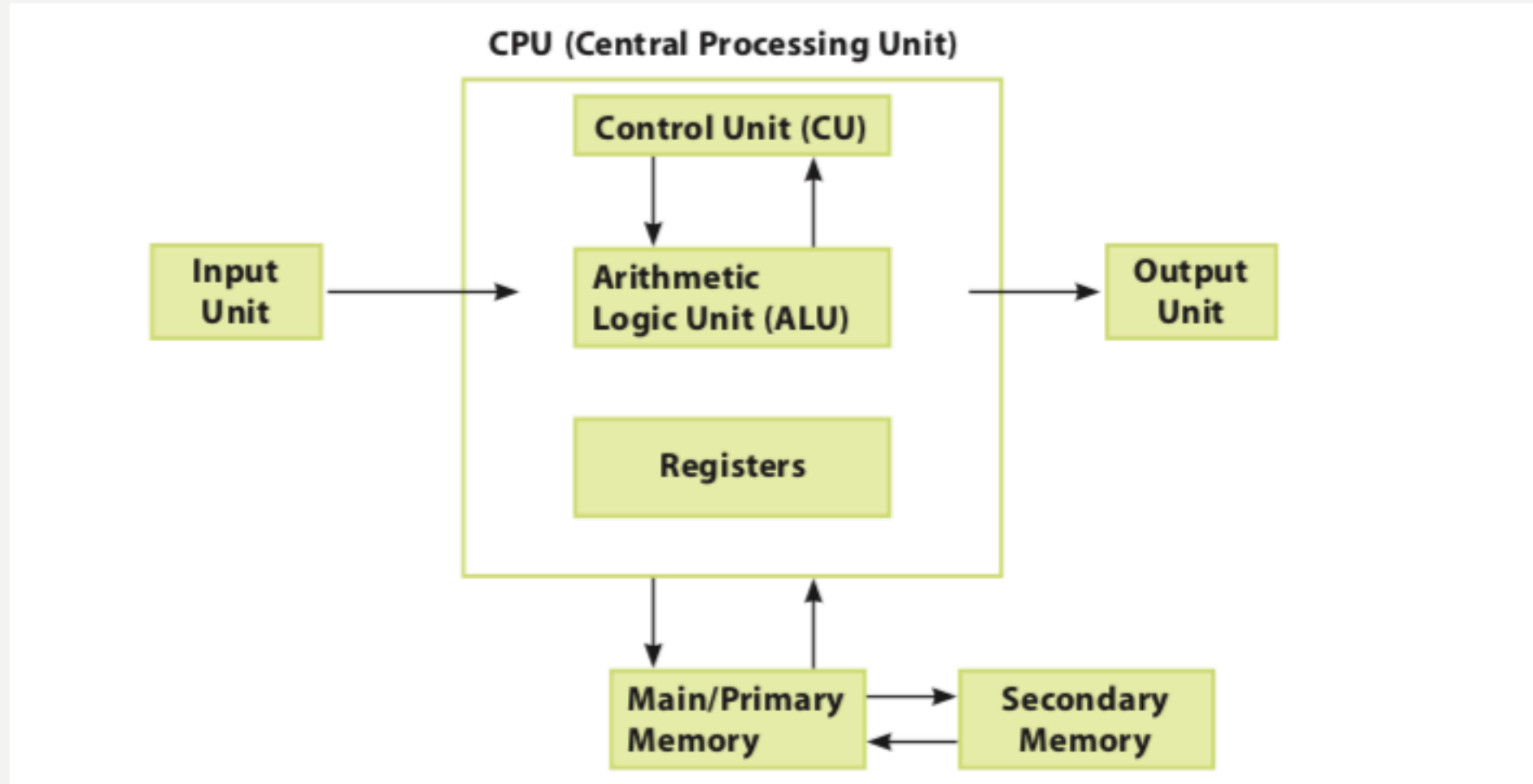


IPO CYCLE



During an Input -> Process -> Output (IPO Cycle), the input unit take the input, the Central Processing Unit (CPU) processes the input and the output unit produces the output or result. The storage unit holds the data and instructions during processing or

VON NEUMANN ARCHITECTURE



VON NEUMANN ARCHITECTURE

- ❖ It shows the basic structure or the functional components of a computer system

A computer receives data and instructions through “Input Devices” which get processed by the CPU and the result is shown through “Output Devices”. The “Main/Primary Memory” and “Secondary/Auxiliary Memory” are used to store data inside the computer.

The main memory holds the input and intermediate output during the processing. Let us discuss each unit/component in detail.

INPUT UNIT

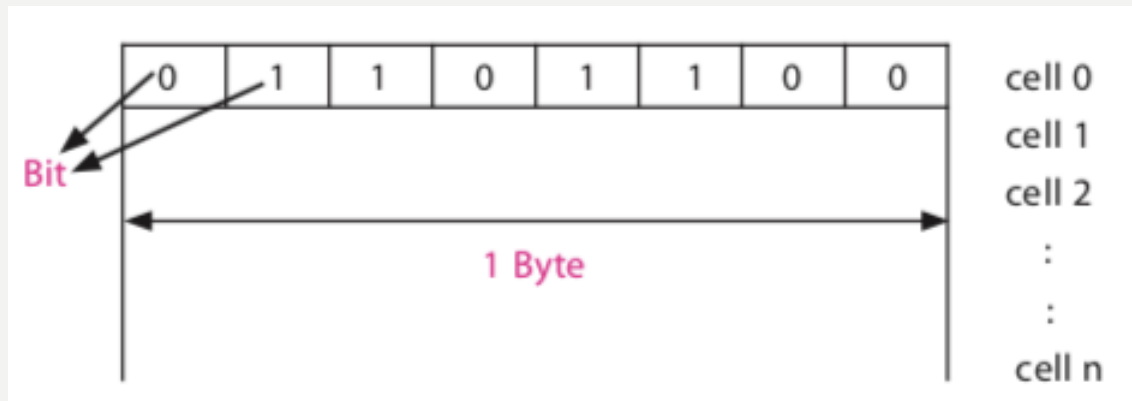
- **An input unit accepts the input and converts it into binary form so that it can be understood by the computer. The computer input constitutes data and instructions.**
- **It comprises input devices that are attached to the computer.**
- **Keyboard, Mouse, Light Pen, Optical Mark Reader (OMR), Smart Card Reader, Bar Code Reader, QR Code Reader, Biometric Sensor, Touch Screen, Microphone, Web Camera are all examples of input devices.**

CENTRAL PROCESSING UNIT (CPU)

- It is the control center or brain of a computer.
- It guides, directs, controls and governs all the processing inside a computer system.
- It has two components: **ALU** and **CU**
- **ALU** or **Arithmetic Logic Unit** carries out all the arithmetic calculations and logical comparisons.
- **CU** or **Control Unit** controls the flow of data from input unit to memory and from memory to output unit. It sends control signals to **ALU** and memory for carrying out the required operations.
- **Registers** are high speed temporary memory found in the **CPU** and used for storing data and instructions immediately required performing an operation.

MEMORY UNIT

- It is used for the storage of data as well as programs (instructions).
- Primary or Main Memory is directly accessible to the CPU during the processing of data.
- The output obtained after processing is stored in the secondary storage or hard disk. Also known as auxiliary memory.
- The main memory of the computer temporarily keeps data to facilitate the working.
- Once the task is finished the memory is cleared and space is made available for the next task to be executed.
- The main memory or RAM (Random Access Memory) is composed of cells that can be further broken into smaller components called bits. (bit -> Binary digit (either 0 or 1))



UNITS OF MEMORY

- A bit is a smallest or elementary unit of measurement of memory
- 8 bits = 1 byte, 4 bits = 1 nibble
- used to store data and instructions

S. No.	Unit	Description
1.	Binary Digit	1 Bit
2.	Byte	1 Byte = 8 Bits
3.	Kilo Byte (KB)	1 KB = 1024 Bytes
4.	Mega Byte (MB)	1 MB = 1024 KB
5.	Giga Byte (GB)	1 GB = 1024 MB
6.	Tera Byte (TB)	1 TB = 1024 GB
7.	Peta Byte (PB)	1 PB = 1024 TB
8.	Exa Byte (EB)	1 EB = 1024 PB
9.	Zetta Byte (ZB)	1 ZB = 1024 EB
10.	Yotta Byte (YB)	1 YB = 1024 ZB
11.	Bronto Byte (Brontobyte)	1 Bronto Byte = 1024 YB
12.	Geop Byte (Geopbyte)	1 Geop Byte = 1024 Brontobytes

- **Main memory is divided into RAM, ROM and Cache**
- **RAM is a volatile memory used to hold active data and instructions.**
- **Loses its contents when power is switched off or interrupted.**
- **DRAM and SRAM are two types of RAM**
- **ROM or Read Only Memory has data written to it at the time of the manufacture and cannot be changed thereafter.**
- **It holds certain essential instructions such as booting, loading OS etc.**
- **Cache is much faster than RAM. CPU first checks the availability of data in cache before requesting RAM as cache stores recently used data.**
- **It is placed in between RAM and CPU and thus makes data available to CPU very quickly.**
- **Hard Disk, USB Drives or Pen Drives, Memory Cards, CD, DVD, Blu-Ray Disc are examples of Secondary storage devices.**

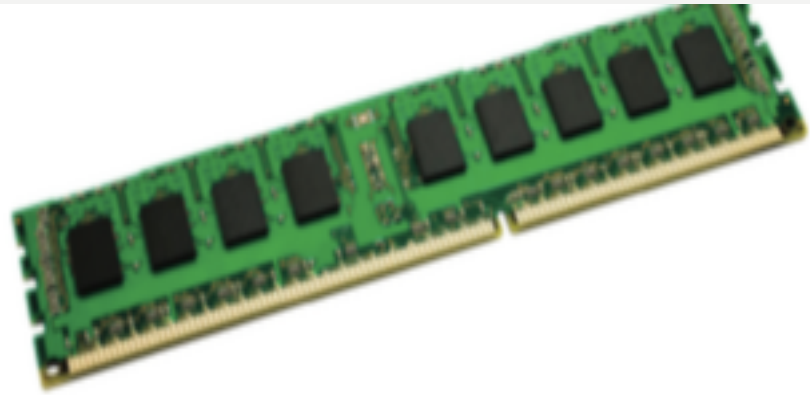
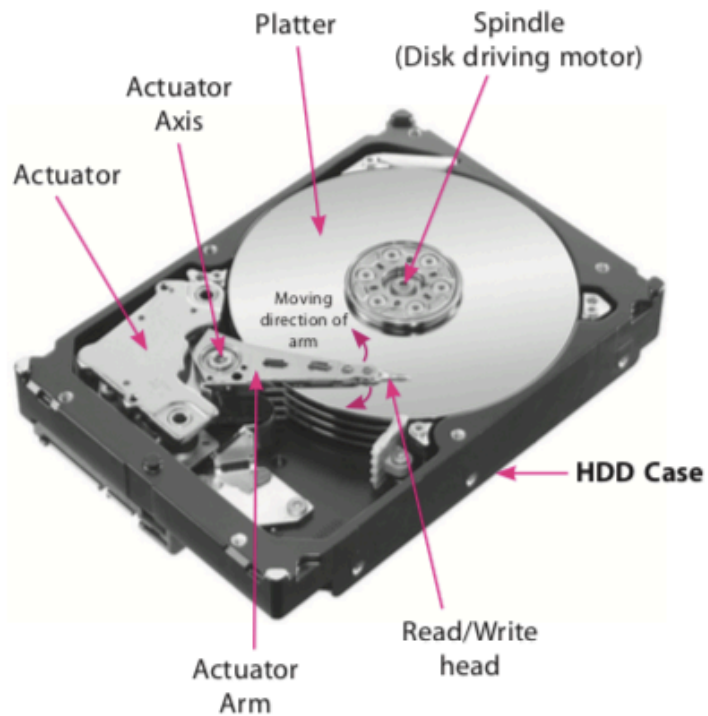


Fig. 1.6: RAM (Random Access Memory)



Fig. 1.7: ROM (Read-Only Memory)



OUTPUT UNIT

- It is formed by the output devices attached to the computer.
- Output devices produce the output generated by the **CPU** in human readable form.
- **VDU** or **Monitor**, **LCD/LED Screens**, **Printer**, **Speakers** and **Plotters** are some of the examples of output devices.

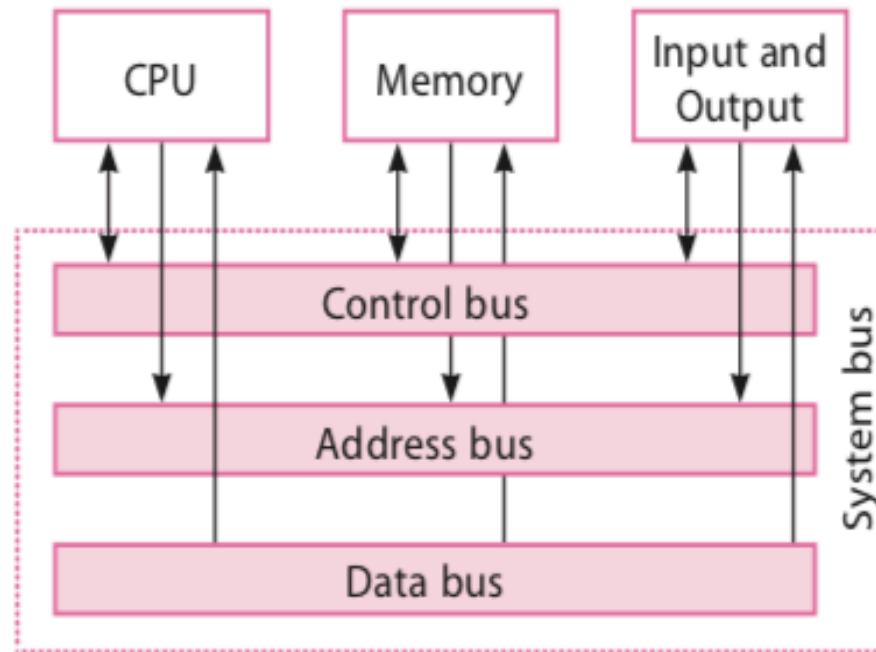
COMMUNICATION BUS

A collection of wires that transfer data between computer components, *i.e.*, carry binary information to or from input/output devices and memory. It usually transmits binary numbers, one bit per wire. The bus system in computer is made up of three types of buses:

1. Address Bus

2. Data Bus

3. Control Bus



1. **Address Bus:** Address bus system is used to specify address of a data/memory location. CPU is connected to main memory by a set of parallel wires which is the Address bus, which carries address to Memory Address Register (MAR). The width of a bus determines the number of memory locations that can be addressed. Address bus consists of 16 wires; thus, it consumes 16 bits, *i.e.*, its width is 16 bits. *For example*, a 64-bit address bus can transfer 2^{64} memory locations/addresses.

2. **Data Bus:** Data bus carries data in binary form. It is an 8-bit bus to transfer data from one place/component to another in a computer system.

The size of data bus from memory to CPU equals the number of bits in an instruction called CPU word length. Also, number of parallel wires is called bus width as it depends on the number of bits.

3. **Control Bus:** Control bus carries instructions to carry out operations such as Read from/Write to memory and its associated Input-Output (I/O) operations.

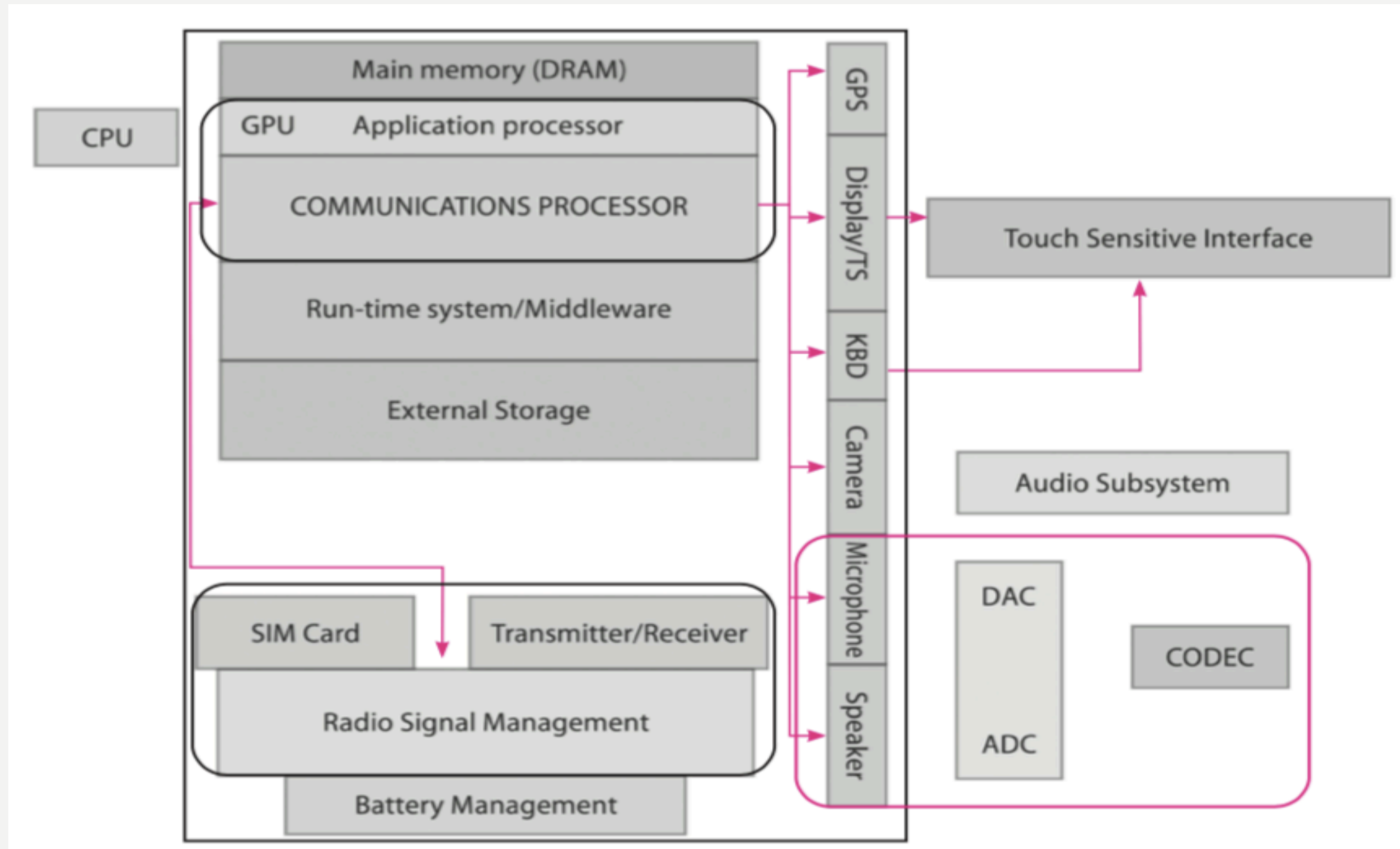
Apart from the above described important bus systems, a separate type of bus called **I/O (Input-Output) bus** connects the input, output and other external devices to the system.

MOBILE SYSTEM ORGANIZATION

In today's modern era, hand-held smartphones have replaced the computer system to a great extent. Although smartphones have greater processing/computing power, it is still much less than a computer system.

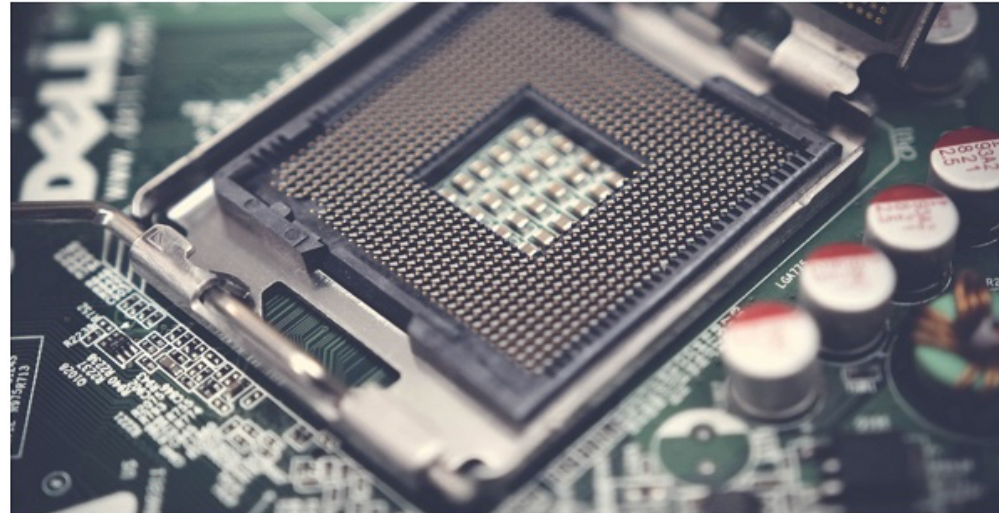
A mobile OS controls the entire functioning of a mobile device through the extensive use of various mobile applications and supports wireless communication. It is capable of handling endless applications, be it sending a text message (SMS), making a call through radio transmission, supporting multimedia formats for sending graphical/audio/video files, offering camera utilities, handling touchscreen responses and much more.

FUNCTIONAL COMPONENTS



MOBILE PROCESSOR

Just like CPU is the brain of a computer system, mobile processor is the brain of a smartphone. It receives and executes every command, performing billions of calculations per second. The effectiveness of the processor directly affects every application you run, whether it's the camera, the music player, or just a simple email program. The ability of the processor to coordinate efficient communication between the wireless data, graphics and memory is essential for effective communication and smooth operation.



A mobile processor further has three units:

➤ APU- Application Processing Unit

- **Works the same way as the CU of Computer. It controls and governs the entire set of tasks and execution. Works in association with the GPU.**

➤ GPU- Graphics Processing Unit

- **Processes graphical and visual data and thus helps in rendering webpages or game play. The better the GPU, the better will be the visualization of complex websites and 3D video games.**

➤ Communications Processing Unit

- **Controls the call making and receiving mechanism on a smartphone**
- **It is composed of digital signal processor that coordinates with Transceiver/Receiver and Audio Subsystem.**

- **Radio Signal Management Unit:** This unit is responsible for connecting **SIM** (Subscriber Identity Module) to the base stations through radio signals like in Cellular networks such as 3G/LTE/4G-based cellular networks.
- **Audio Subsystem:** This sub-unit converts the voice signals (analog type) into digital signals and vice versa. The voice signals receive an input through built-in mic and convert the generated audio output and send it to in-built speaker. The audio system comprises two sub-parts for carrying out the above conversions.
- **DAC (Digital-to-Analog Converter)** converts digital signal into analog audio signal.
- **ADC (Analog-to-Digital Converter)** converts analog audio signal received from the person who is making the call into digital form so that the mobile processor can work on it.

These components are fabricated on a single chip and, hence, the entire integration is described as **System-on-a-Chip (SoC)**. Thus, SoC can be described in the expression as:

SoC = CPU + GPU + Display Processor + Radio signal processor + Video processor

OTHER COMPONENTS

➤ **Camera ISP- Image Signal Processor**

- **Designed to provide an overall good video and image experience**
- **Provides a set of image processing operations like instant image capture, high resolution support and image stabilization.**

➤ **Display Unit**

- **Provides a touch interactive screen that activates touch sensors and responds to the instructions given by the user using the screen.**

➤ **Memory Unit**

- **RAM (Random Access Memory):**The applications which we are working on are first loaded on RAM and then acted upon by processor.
- **ROM(Read Only Memory):**The smartphone OS resides on ROM and gets loaded on RAM when we start running the applications inside the internal memory

POWER MANAGEMENT

A mobile phone battery (cellphone battery, accumulator) is the main source of power supply for this device. Almost all mobile phones are equipped with lithium-ion batteries. A lithium-polymer battery is the latest type of battery being used for smartphones nowadays. The lithium-ion batteries allow for a high charge capacity based on the size and weight of the battery. However, these lithium-ion batteries are slightly expensive and they are not compatible with the old-generation smartphones.

Battery capacity is a measure that indicates how much electricity a battery can give. For smartphones, capacity is measured in milliampere-hours (MAh). A larger capacity of battery provides longer operation time without recharging.



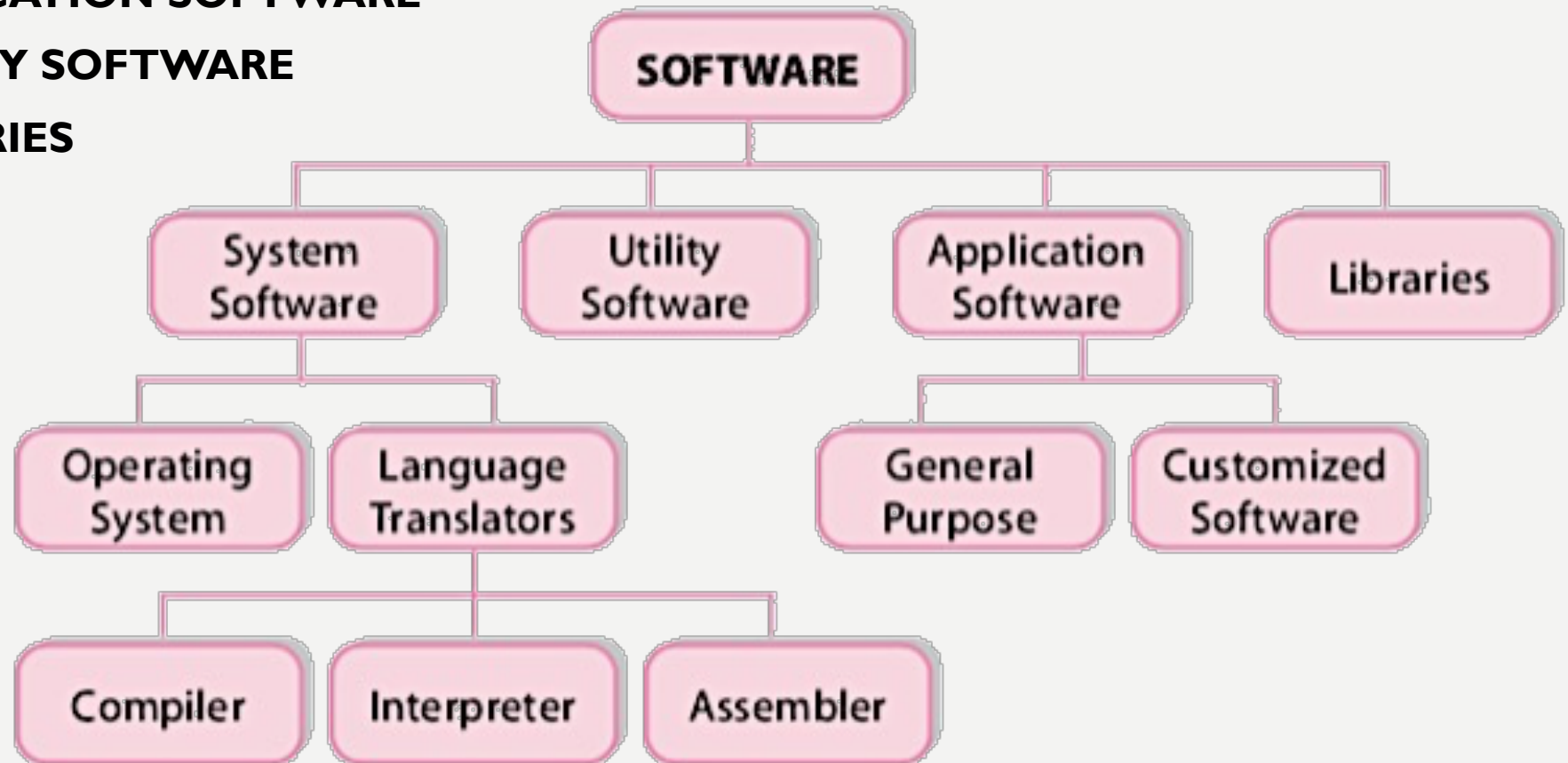
SOFTWARE CONCEPTS

A computer system has two parts—**Hardware** and **Software**. Hardware refers to the physical or tangible (which can be touched) components while software is the code; in other words, a set of instructions necessary to operate/run the computer hardware.

We can also say that software is a set of programs which is designed to perform a well-defined function. A program is a sequence of instructions written to solve a particular problem and to make the hardware run. All the programs used in a computer to perform specific tasks are called software.

TYPES OF SOFTWARE

1. SYSTEM SOFTWARE
2. APPLICATION SOFTWARE
3. UTILITY SOFTWARE
4. LIBRARIES



These programs provide the environment for running application programs and are designed to control the operation of a computer system. System software comprises programs which interact with the hardware at the core or basic level. It directs the computer what to do, when to do and how to do. Thus, system software serves as the interface between hardware and the user.



The different **functions of system software** are:

1. Reading data and receiving information
2. Translating data and instructions
3. Controlling all the peripheral devices
4. Processing and generating output

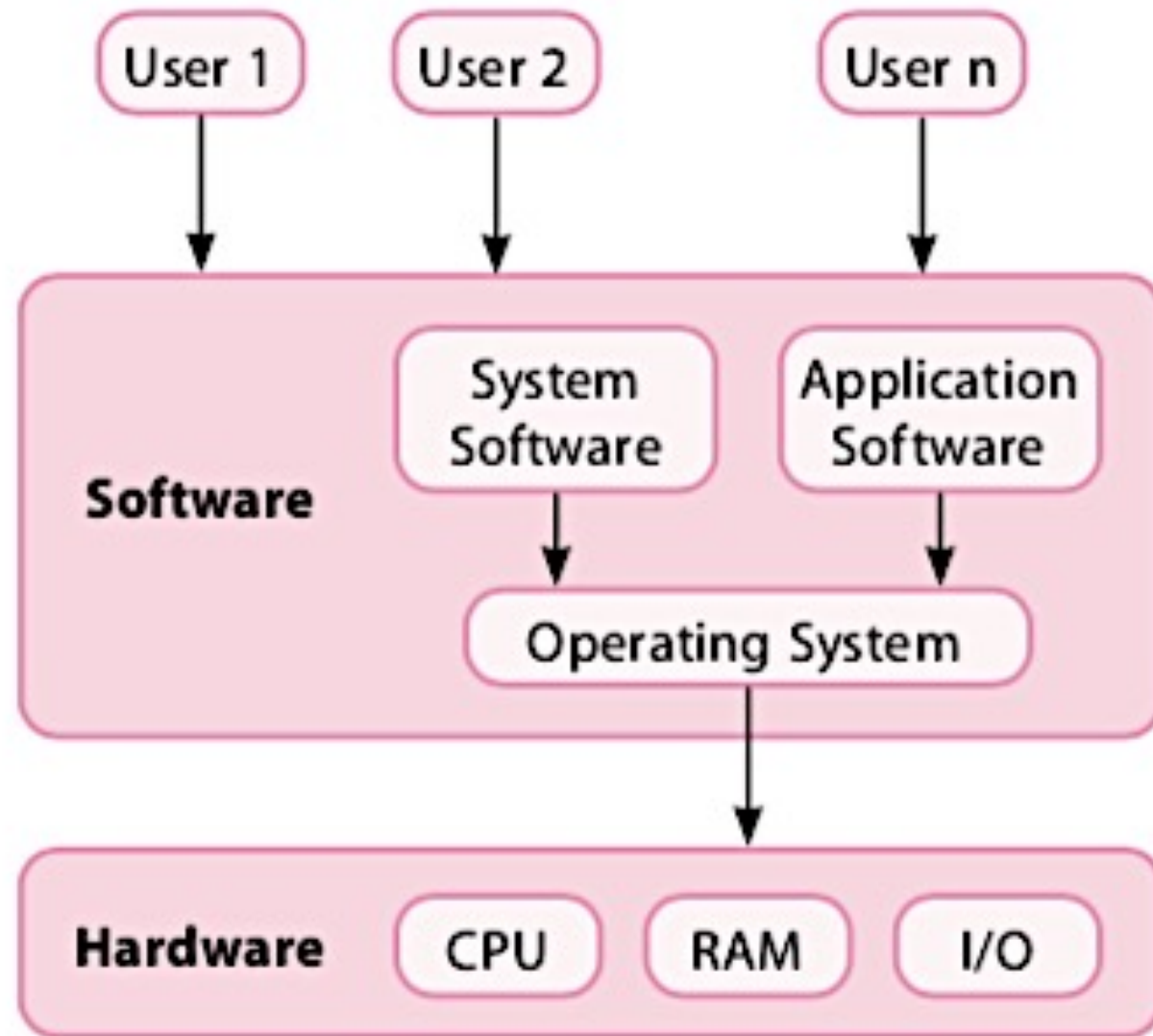
System software can be further categorized into

- Operating System
- Language Translators

SYSTEM SOFTWARE

OPERATING SYSTEM

An operating system is a program that acts as an interface between the user and hardware of the computer as shown in Fig. The OS helps to manage resources of the computer and optimize its performance. An OS is the first program to be executed on a computer after the BIOS. OS performs all basic tasks such as identifying basic input/output devices, accepting input from the input devices, sending results to the output devices, keeping track of files and directories on the disk, and controlling other peripheral devices such as disk drives and printers.



FUNCTIONS OF OPERATING SYSTEM

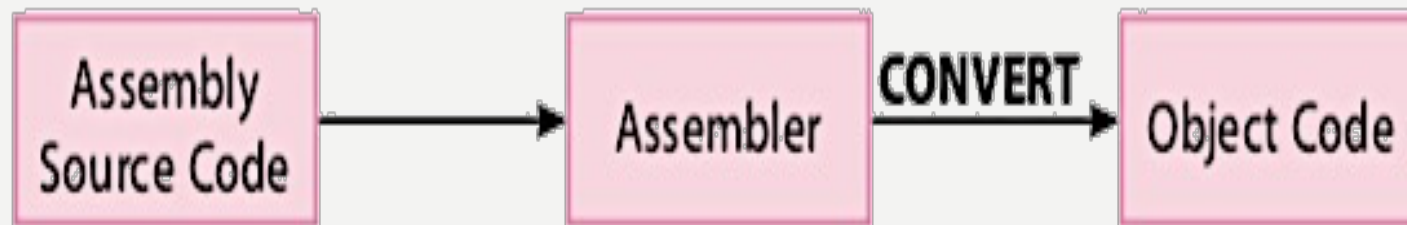
1. **User Interface:** Operating system provides instructions to prepare user interface, *i.e.*, way to interact with the user either through GUI (Graphical User Interface) or command prompts.
2. **Program Execution:** It loads necessary programs into the computer memory which are required for its proper functioning.
3. **Resource Allocation:** Operating system controls and allocates the system resources like CPU time, memory (RAM), etc.
4. **Manipulation of File System:** It manages the method/format in which information is stored on and retrieved from the hard disk.
5. **I/O Operations:** Operating system handles all the input-output (I/O) operations.
6. **Error Detection:** It performs the crucial function of error detection and handling.
7. Operating system controls the various system hardware and software resources and allocates them to the users or programs as per their requirement.

LANGUAGE TRANSLATORS

The special translator system software that is used to translate the program written in high-level language (or assembly language) into machine code is called **language processor** or **translator program**. The language processors can be of any of the following three types—**Assembler, Compiler and Interpreter**.

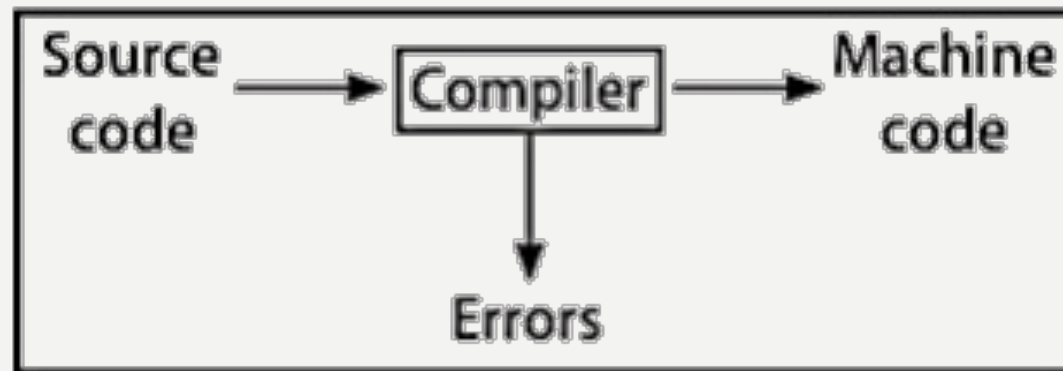
ASSEMBLER

Assembler is used to translate the program written in assembly language into machine code. The input of assembler is a source program that contains assembly language instructions. The output generated by the assembler is the object code or machine code understandable by the computer.



COMPILER

The language processor that translates the complete source program as a whole in one go into machine code is called compiler. Some of the examples are C and C++ compilers.

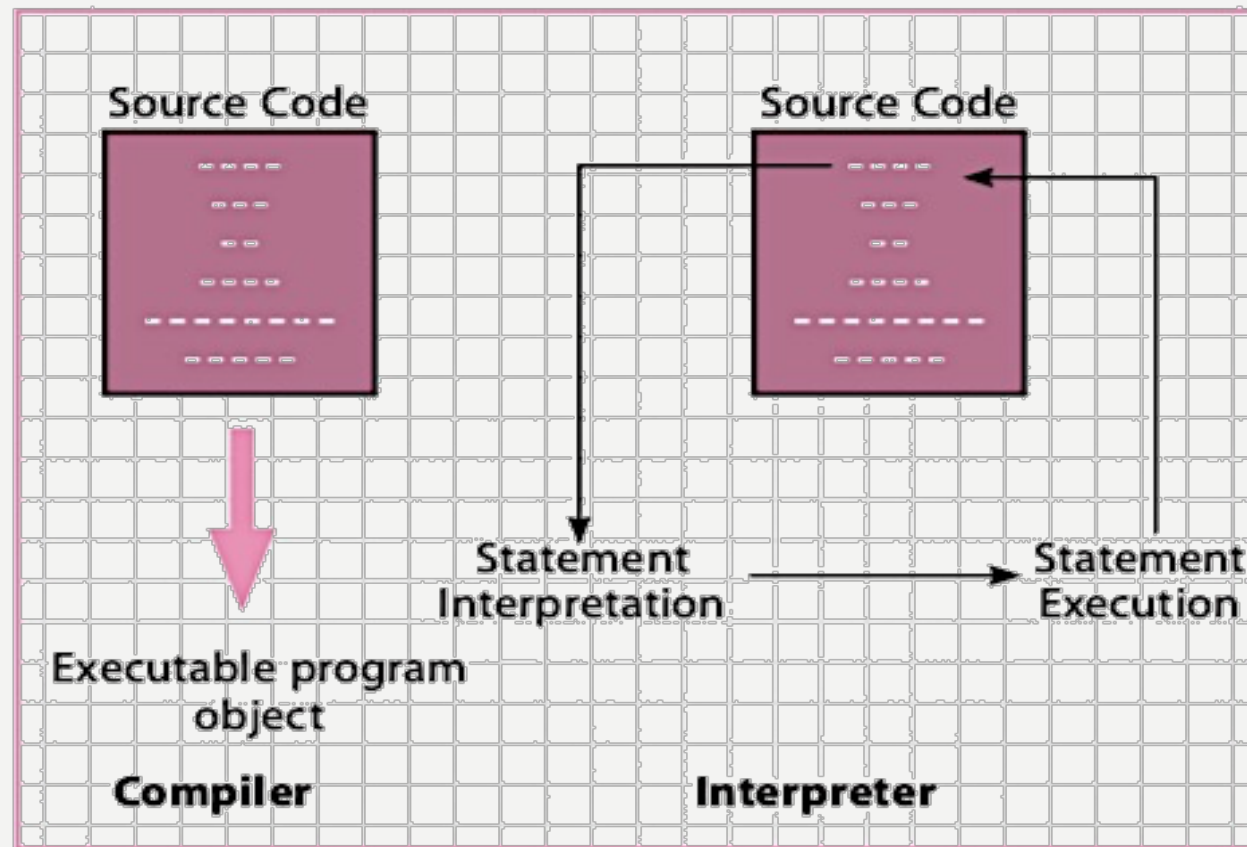


The program translated into machine code is called the object program. The source code is translated into object code successfully if it is free from errors. If there are any errors in the source code, the compiler specifies the errors at the end of the compilation with line numbers. The errors must be removed before the compiler can successfully recompile the source code again.

INTERPRETER

The language processor that translates a single statement of source program into machine code and executes it immediately before moving on to the next line is called an Interpreter. If there is an error in the statement, the interpreter terminates its translating process at that statement and displays an error message.

Only after removal of the error does the interpreter move on to the next line for execution.



UTILITY SOFTWARE

Utility software provides certain tasks that help in proper maintenance of the computer. The job of utility programs is to help the computer system run smoothly. Nowadays, many utility software are part of the operating system itself. Even if there are no utility software on your computer, the computer will work, but with the right kind of utility software loaded, the computer becomes more reliable and even its processing speed increases. Some of the commonly used utility software are antivirus, disk defragmenter, backup, compression, etc.

APPLICATION SOFTWARE

Application software is bought by the user to perform specific applications or tasks, *for example*, making a document or making a presentation or handling inventory or managing the employee database.

Application software are classified into two types—General Purpose Application Software and Customized Application Software.

General Purpose Application Software

Some of the application software are made for the common users for day-to-day applications and uses. These are also referred to as Office Tools. The users may use them in the manner they want.

For example, Word processing software, spreadsheet software, Database Management System (DBMS), Integrated Development Environment (IDE), etc.

Specific Purpose Application/Customized Software

Customized Software is one which is tailor-made as per the user's requirement. Such type of software is customer-specific. It is made keeping in mind the individual needs of the user and so is also referred to as Domain Specific Tool. Such software cannot be installed and used by any other user/customer since the requirements may differ. *For example, Banking System, Payroll Management System, Financial Accounting, Inventory Management Software, Billing System, etc.*

LIBRARIES

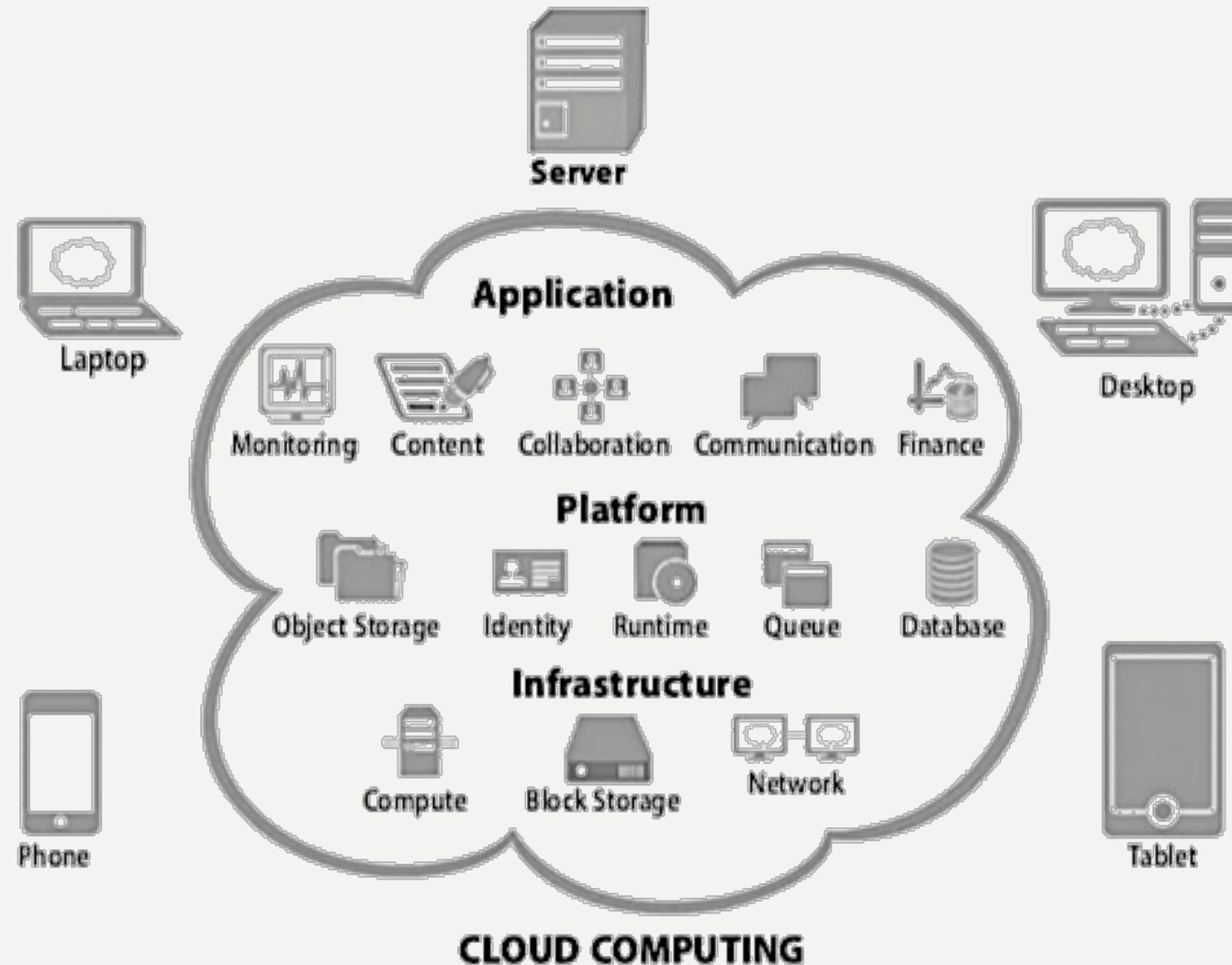
A library is a collection of precompiled routines that a program can use. The routines, sometimes called modules, are stored in object format. Libraries are particularly useful for storing frequently-used routines because you do not need to explicitly link them to every program that uses them. The linker automatically looks in libraries for routines that it does not find elsewhere.

A library consists of several modules which occupy an independent namespace for a particular program language operation or particular task. So, in order to work with a particular function or a specific operation, you must import that particular library into your program. *For example,* while working with Python modules/functions, we may require a particular library to be added to the source code (program).

CLOUD COMPUTING



It is a technology of distributed data processing in which some scalable information resources and capacities are provided as a service to multiple external customers through the internet technology. It allows storing, accessing data and programs using the internet.



There are broadly two types of clouds one can access:

(a) Public Cloud

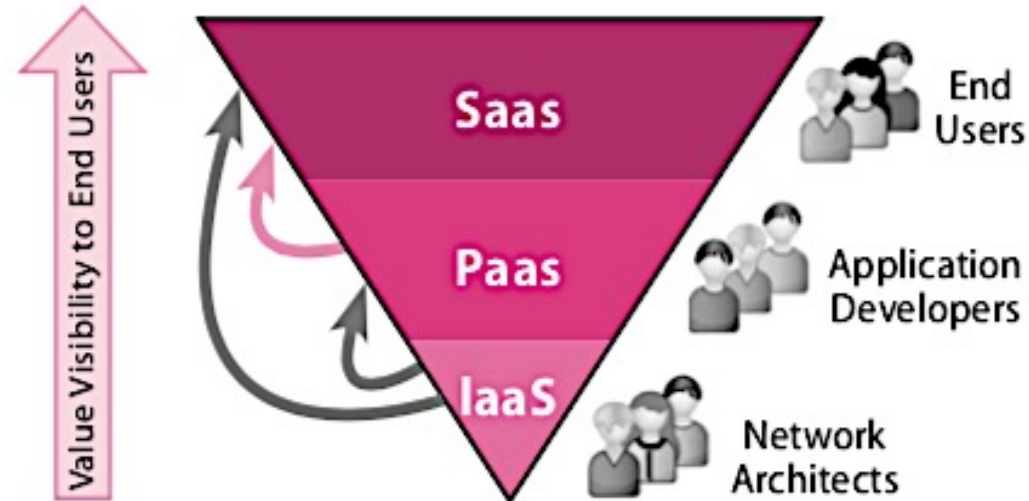
(b) Private Cloud

(a) **Public Cloud:** It is defined as a public or common cloud service provided to multiple users on a network. Public cloud services are provided through a common portal or virtual platform owned and operated by a third-party cloud provider. In a public cloud service, the resources such as memory, hardware devices and network devices are shared by all the clients (or organizations that use the same cloud, called subscribers) who are known as cloud **“tenants”**.

For example, Google drive, Microsoft OneDrive/OneNote, iCloud, Amazon Cloud Drive, etc.

(b) **Private Cloud:** Private cloud is a virtual private interface provided by an individual or owned by one organization. In a private cloud, all the resources such as memory and services are dedicated solely to an organization.

- **IaaS (Infrastructure as a Service)**—A computer infrastructure, typically presented in the form of virtualization. It is a service within the concept of cloud hosting.
- **PaaS (Platform as a Service)**—An integrated platform for the development, deployment, testing and support of web applications. It is presented as a service on the basis of the concept of cloud hosting.
- **SaaS (Software as a Service)**—The business model of software licence which involves development and support of the software vendor. Customers also have the opportunity of paid use of it, usually through the internet.



CTM: Cloud computing refers to having access to all your applications and data from any network device.

ASSIGNMENT

Answer the following:

- 1. Define hardware and software.**
- 2. What is an Operating System?**
- 3. Specify the measuring units of memory.**
- 4. Describe the basic architecture and functioning of a computer system.**
- 5. Explain Assembler, Compiler and Interpreter.**