CHAPTER 02 | Computer System Organization

Introduction

A system is a collection of elements or components that are organized for a common purpose. Each component has its own function and these components interact each other to accomplish a common goal. Human body can be considered as a system. It has several organs like eye, ear, mouth, brain etc. They have their own functions to perform. When these organs function in an organized manner, the human body can perform all the activities successfully. Similarly a computer can also be considered as a system. It has the components like keyboard, monitor, processor, memory etc. each performing its own functions. These units are arranged in a particular order that enables the computer to perform all its activities. This arrangement of units in a computer is known as organization of computer.

2.1. Components of computer

We know that a computer has two major components - hardware and software. When we think of computer as a system we have to consider two more components, namely firmware and live-ware.

• **Hardware:** The term hardware represents the tangible and visible parts of computer which consists of some electromechanical components. These hardware components are associated with the functional units of a computer which include input unit, output unit, central processing unit and memory unit. Keyboard, monitor, processor etc. are some examples.

• **Software:** Software is a general term used to denote a set of programs that help us to use computer system and other electronic devices efficiently and effectively. Hardware cannot work without the use of software. If hardware is said to form the body of a computer system, software is its soul. GNU Linux, Windows 10, LibreOffice, MS Office etc. are some examples.

• **Firmware:** Instructions written/embedded on a hardware component are known as firmware. The set of BIOS instructions written on Read Only Memory (ROM) chip is an example for firmware. The program controlling the clock of your microwave oven, the traffic signals etc. are some other examples.

• **Live-ware:** Persons or the users, using computers in day to day activity are known as live-ware. They use computers for various purposes. Software engineers, hardware engineers, network administrators, data entry operators etc. belong to live-ware.

2.2 Hardware components

Now let's understand various parts (components) of a computer and be familiarized with the function of each part. A hardware component, also known as system component is basically a tangible and visible part of a computer that enables the computer to perform a particular function. The computer hardware mainly consists of input/output (I/O) devices and the electronic parts within the system unit (Refer Figure 2.1). In this chapter, we will discuss only the internal components of system unit. Various types of I/O devices will be presented in the next chapter.

Figure 2.1: System unit (inside view)

(i) Motherboard and Chipset

Motherboard is alternatively known as the main board, system board, planar board or logic board. It is the main printed circuit board (PCB) inside a computer. It holds many of the crucial electronic components of the system such as the CPU, memory and provides connectors for other peripheral devices. It also provides expansion slots for including memory, sound card, graphics cards, network cards etc. Figure 2.2 shows a motherboard.
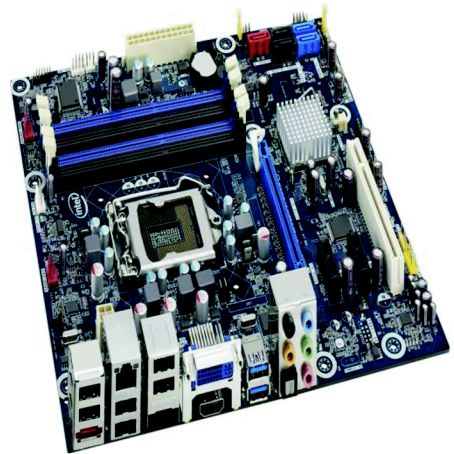
A chipset is a group of Integrated Circuits (ICs) that manages the data flow between the processor, memory and peripherals. It is usually found on the motherboard. Chipsets are usually designed to work with a specific family of microprocessors. As it controls communications between the processor and external devices, chipset plays a vital role in determining system performance.

Figure 2.2: Motherboard and chipset

(ii) Processor

Microprocessor is the most important component in a computer. It is an electronic chip that performs all the arithmetic and logic operations. Let us discuss various microprocessors like Intel and AMD.

- **Intel microprocessor**

Intel microprocessor is developed by Intel Corporation, an American multi-national semiconductor chip manufacture. Intel is one of the world's largest and highest valued semiconductor chip producer. Different types of Intel processors are Celeron, Pentium series, Xenon and latest one is Intel Core i7 processor. Pentium series can process 64 bit data at a time

Figure 2.3(a): Intel processor

and clock rate varies from 60 MHz to 3.8 GHz. Main characteristics of these processors is hyper threading. Hyper threading is a technology used by some Intel microprocessors that allows a single micro-processor to act like two separate processors to the operating system and the application programs that use it.

- **AMD processor**

AMD or Advanced Micro Devices is a company that has been producing semi conductors, microchips, CPUs, motherboards and other types of computer equipment for the last 40 years. AMD was founded in 1969 in USA. It is the second largest company in this sector after Intel. Different types of AMD processors are Ryzen, Sempron, Athlon, Phenom etc.AMD Atholn processor can process 64 bit data at a time and clock rate varies from 500 MHz to 2.3 GHz.
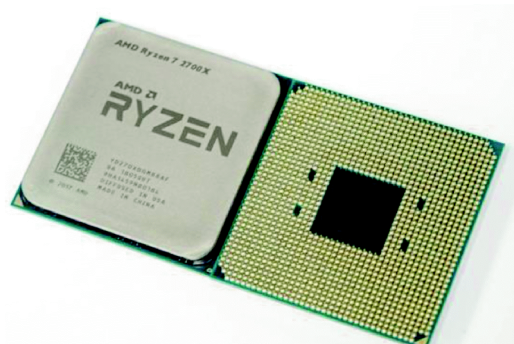

Figure 2.3(b): AMD processor

(iii) Buses

A bus is a set of connections between two or more components/devices. When data is transferred between the functional units of a computer, the bits are transferred simultaneously over a set of parallel lines. These set of lines are called buses. These are the circuits on the motherboard that connects CPU to other components. There are three types of buses in a computer. They are data bus, address bus and control bus. Data bus is the bus through
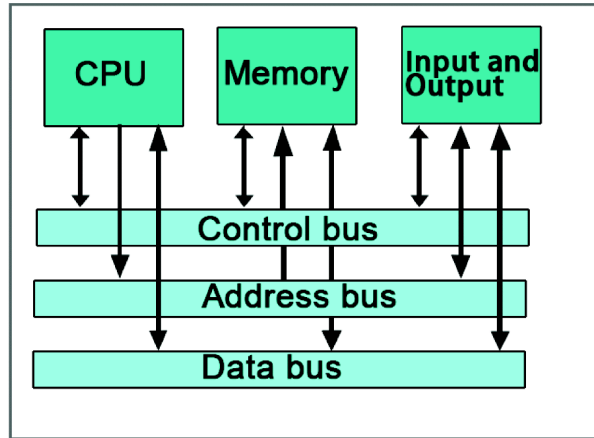
Figure 2.4: Data transfer through buses

which data can be sent or received. Address bus is used to pass address to I/O devices or memory. Control bus is used to send various control signals to and from I/O devices, memory or CPU. Refer Figure 2.4 to see the data transfer among between the components through the buses.

(iv) Expansion slots

Expansion slots or PCI (Peripheral Component Interconnect) slots are used in motherboards to provide additional capability to the computer system. Various expansion slots are sound card slot, video card slot, network interface card slot etc. For playing high end computer games, we have to insert graphic card in an expansion slot area of motherboard called PCI Express graphics slot.
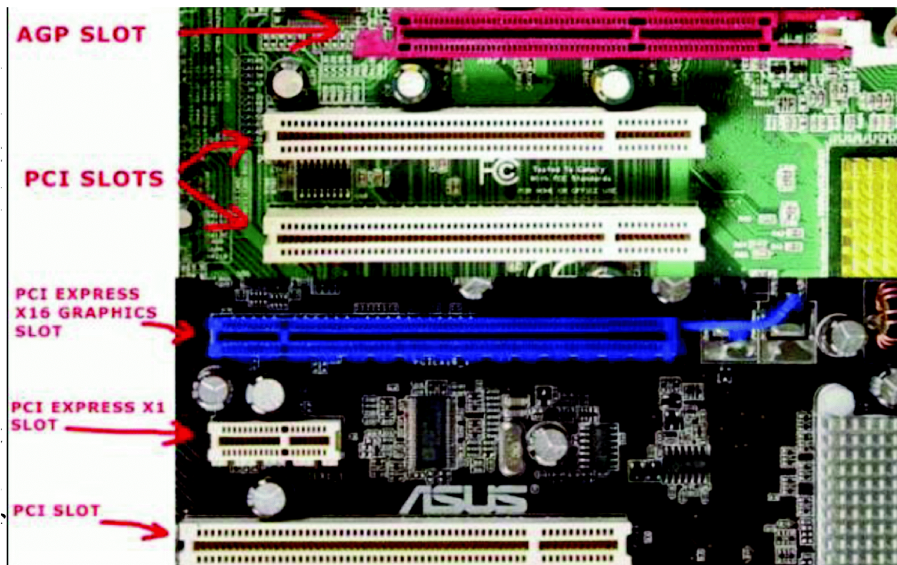

Figure 2.5: Expansion slots

(v) Memory

It facilitates the remembrance power of computer system. It refers to the physical devices used to store programs (sequences of instructions) or data on a temporary or permanent basis for use in a computer or other digital electronic device. Memory can be of two types:

    (a)   Primary memory

    (b)   Secondary memory

Primary memory holds data, intermediate results and results of ongoing jobs temporarily. Secondary memory on the other hand, holds data and information permanently.

Before learning more about memory, let us discuss the different memory measuring units. The smallest unit of memory is bit, which means either 0 or 1. The storage capacity of the memory is expressed in various units of memory. These are as follows:

1 bit	=	0 or 1
1 Nibble	=	4 bits
1 Byte	=	8 bits
1 Kilo Byte (KB)	=	1024 Bytes
1 Mega Byte (MB)	=	1024 KB
1 Giga Byte (GB)	=	1024 MB
1 Tera Byte (TB)	=	1024 GB
1 Peta Byte (PB)	=	1024 TB
1 Exa Byte (EB)	=	1024 PB
1 Zetta Byte (ZB)	=	1024 EB
1 Yotta Byte (YB)	=	1024 ZB

(a) Primary memory

Primary memory is a semiconductor memory that is directly accessed by the CPU. It is capable of sending and receiving data at high speed. Primary memory consists of RAM, ROM and cache memory.

- **RAM:** RAM stands for Random Access Memory. It is also called the main memory of a computer. It requires power to maintain the stored information. It is volatile in nature because as soon as the power is OFF, its contents are also removed. The data is primarily stored on RAM. This is also known as Read-Write memory as both the operations can take place on it. There are two types of RAM such as Static RAM (SRAM) and Dynamic RAM (DRAM).

SRAM retains its contents as long as the power is connected whereas DRAM needs regular refresh cycles to prevent its contents being lost. Static RAM is fast and expensive, while dynamic RAM is less expensive and slower. Therefore static RAM is used to create the CPU's speed-sensitive cache, while dynamic RAM forms the larger system RAM space.
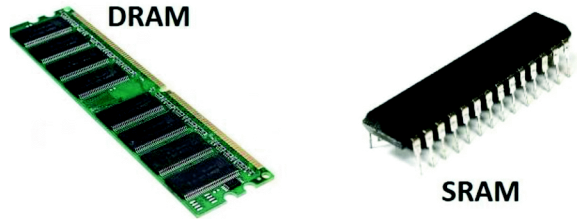

Figure 2.6: DRAM and SRAM - Physical view

- **ROM:** ROM stands for Read Only Memory. As the name indicates only read operation can be performed on ROM. It is permanent in nature. It is a non-volatile memory as it can retain the stored information even when the power is OFF. In ROM, booting instructions for computer are stored in the form of firmware. ROM has different versions such as PROM (Programmable ROM), EPROM (Erasable Programmable ROM), and EEPROM (Electrically Erasable Programmable ROM). PROM is programmable only once, while EPROM is reprogrammable after erasing the existing content with ultraviolet rays. On the other hand, EEPROM is reprogrammable by erasing the selected content using electric charge. Table 2.1 shows a comparison of RAM and ROM.

RAM	ROM
i. Random Access Memory	i. Read Only Memory
ii. Read and write operations are allowed	ii. Only read operation is performed
iii. It is a volatile (temporary) memory	iii. It is a non-volatile (permanent) memory
iv. Data and programs are stored	iv. BIOS instructions are stored
v. Types are Static and Dynamic RAM	v. Types are PROM, EPROM, EEPROM

Table 2.1: Comparison of RAM and ROM

- **Cache memory:** Cache memory is an intermediate between RAM and processor. It is very fast. Cache memory is also randomly accessible memory that a computer microprocessor can access more quickly than it can access regular RAM. As the microprocessor processes data, it looks first in the cache memory and if it finds the data there (stored by the previous reading), it does not require more time-consuming reading of data from larger memory.

(b) Secondary memory

A memory which stores data and programs for a long period of time is called secondary memory or auxiliary memory. It is also used to copy or move data and programs from one computer to another. Another use of such memory is that it acts as a backup storage device. Secondary storage devices are categorized into magnetic disks, optical disks and flash memories.

- **Magnetic disk:** It is a storage device that uses metal disks coated with magnetic material. Data is recorded magnetically in these devices. A magnetization process is used to write, rewrite and read data. The surface of these disks is divided into tracks and sectors in which the data are stored. Read/write heads are used to access data from these devices.

Figure 2.7: Hard Disk Drive

  Hard Disk Drive (HDD) is the traditional and widely used secondary storage device. The hard disk (Refer Figure 2.7) consists of metal disks coated with magnetic material concealed in dust free containers. Hard disks have very high storage capacity (measured in Terra Bytes), high data transfer rates and faster access time. It is more durable and less error prone.

  Another type of magnetic disk is floppy disks which are now obsolete. Floppy drives are used to read/write data on these disks. These disks have a maximum of 1.44 MB capacity.

Figure 2.8: Floppy and Zip disks

  Similarly Zip disks were introduced with a maximum of 750 MB storage capacity.These require Zip drive to access the content. These are easily portable owing to their small size. Among these, Zip disks are smaller in size.

- **Optical disk:** It is a data storage medium which uses low-powered laser beam to read from and write data into it. The laser beams are transmitted from a laser head mounted on an optical disk drive. The disk consists of an aluminium foil sandwiched between two circular plastic disks. The main types of optical disks are CD, DVD and Blu-ray (Refer Figure 2.9).

CDs are capable of storing upto 700 MB of data. There are two types of CDs: CD-R and CD-RW. In CD-R (CD-Recordable) data can be written once and read many times where in CD-RW (CD-Rewritable) disks can be erased and rewritten at any time.

Figure 2.9: CD, DVD, Blu-ray

DVD (Digital Versatile Disk) is an optical storage medium similar to CD-ROM, but with a higher storage capacity. The capacity of a DVD varies from 4.37 GB to 15.9 GB. There are three major types of DVDs: DVD-ROM, DVD-RW (Rewritable) and DVD-RAM. DVD-ROM and DVD-RW function in the same way as CD-ROM and CD-RW respectively. DVD Random Access Memory disks can be recorded and erased repeatedly. These are compatible only with devices manufactured by companies that support the DVD-RAM format. It is comparable to DVD-Rewritable disk, but have higher lifetime and can be erased more often than a DVD-RW.

Blu-ray is an optical disk format developed to enable recording, rewriting and playback of High Definition (HD) video as well as storing huge amounts of data. CD and DVD technologies use red laser to read and write data while blu-ray format uses a blue-violet laser. Hence it has the name Blu-ray. It is possible to store more data on blu-ray disk even though it is of the same size of a CD/DVD. The format offers more than five times the storage capacity of traditional DVDs and can hold up to 25 GB on a single-layer disk and 50 GB on a dual-layer disk.

- **Flash memories:** Flash drives use EEPROM chips for data storage. These drives are also known as thumb drives, pen drives and sometimes USB drives. Nowadays, it is one of the most popular secondary storage devices. They are basically a small portable storage device that allows us to store, rewrite and delete data easily. The different variants of flash memories are USB flash drives, memory cards and SSD (Solid State Drive).

Figure 2.10: USB flash drives

A USB flash drive is a small external storage device which consists of flash memory, with the size of a human thumb (Refer Figure 2.10). USB flash drives are portable and rewritable. The storage capacity of a USB drive currently varies from 2 GB to 32 GB.

Flash memory card is another type of flash memory. They are flat and have a size of about 1 inch × 0.75 inch with a thickness of about 2 mm.

Figure 2.11: Flash memories

Memory cards currently have storage capacities in the range of 1 GB - 32 GB. Flash memory cards also have a smaller version which is used in cell phones, tablets etc. Figure 2.11 shows different types of memory cards.
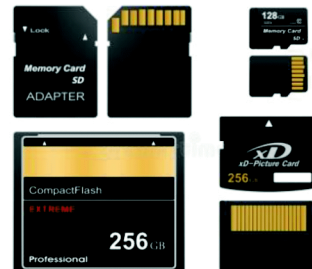
A solid-state drive (SSD) is a new generation of storage device used in computers (Refer Figure 2.12). SSD uses flash-based memory which is much faster than a traditional mechanical hard disk. SSD is flash technology-based storage as it does not require power. Hence, it is also called non volatile flash memory. Upgrading to an SSD is one of the best ways to speed up your computer.
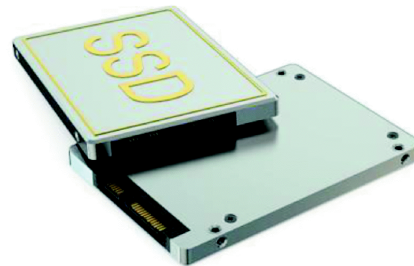

Figure 2.12: SSD

(vi) SMPS

SMPS stands for Switched-Mode Power Supply. It is an electronic power supply that uses a switching regulator to convert electrical power efficiently. It is also known as Switching Mode Power Supply. It is the power supply unit generally used in computers to convert the normal input voltage into the computer acceptable range.

Figure 2.13: SMPS

(vii) Ports

A computer port is an interface or a point of connection between the computer and its peripheral devices. Peripherals include input devices, output devices, external storage and communication devices. These devices communicate with the motherboard, through the ports available on the motherboard like Video Graphics Array (VGA), IBM Personal System/2 (PS/2), Universal Serial Bus (USB), Ethernet, High Definition Multimedia Interface (HDMI), Audio etc. (Refer Figure 2.14). The main function of a computer port is to act as a point of attachment where the cable from the peripheral can be plugged in and allows data-flow between the motherboard and the peripheral devices.
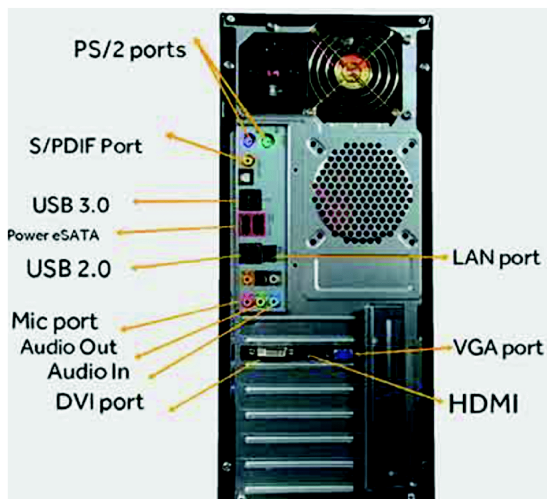

Figure 2.14: Ports at the back of system unit

- **PS/2 port**

    Personal System/2 (PS/2) ports are special ports invented by IBM (International Business Machines) for connecting the keyboard and mouse (refer Figure 2.15). These types of ports are too slow and replaced by faster ports like USB nowadays.
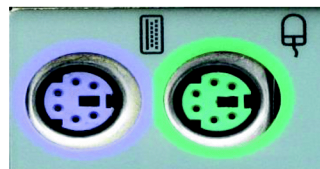

Figure 2.15: PS/2 ports

- **Ethernet port**

    It is alternatively referred to as LAN port, network connection and network port. It allows a computer to connect to a network using a wired connection. The registered jack RJ45 is a standard type of connector used for connecting cables through LAN ports (refer Figure 2.16).

Figure 2.16: LAN port

- **VGA port**

    VGA, stands for Video Graphics Array, is a popular display standard developed by IBM. The VGA port is used to connect a monitor or a projector to a computer. The VGA connector has 15 pins displayed in three rows as indicated in

Figure 2.17: VGA port

Figure 2.17. Regardless of what resolution a monitor is able to support, they are commonly referred to as VGA.

- **USB port**

USB (Universal Serial Bus) is a connection that provides high speed data communication between devices. Due to its high bandwidth, data transfer is faster. It is used for shortdistance communication. USB port is used for connecting devices like keyboard, mouse, printer, scanner, flash drive, external hard disk etc. The main advantages of USB ports are:
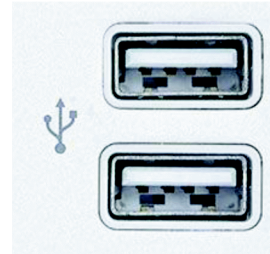

Figure . 2.18: USB port

➢ USB ports are capable of supplying electric power to external devices. This technology led to the development of devices like external hard disk, flash drive, dongle, etc. which draw power from the USB port. It can also be used for power devices like mobile phones, tablets, laptops etc.

➢ USB devices can be connected and disconnected even when the power is on.

- **HDMI port**

HDMI stands for High Definition Multimedia Interface. It works like a digital interface to connect High Definition as well as Ultra High Definition devices like HDTVs, computer monitors, gaming consoles, HD cameras, Blu-Ray players etc. This port is capable of transmitting high-definition video and multi-channel audio over a single cable (refer Figure 2.19).

Figure 2.19: HDMI port

- **Audio port**

Audio ports are used to connect audio devices like speakers, microphone etc. The three small connectors available are given below (Refer Figure 2.20).
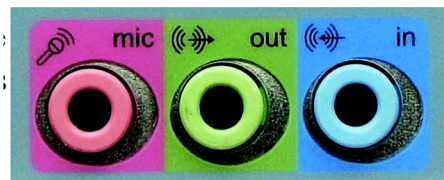
(i) Mic in - Microphone input port.

(ii) Line out - Sound out (to connect your PC's sound output to external speakers)

Figure 2.20 Audio ports

(iii) Line in - Sound input (from any audio device like mobile line out, ipod, etc.)

SUMMARY

A computer system consists of hardware, software, firmware and live-ware as its components. The hardware components consist of the devices and electro-mechanical parts associated with the functional units such as input, output, central processing and memory. The cabinet containing motherboard with chipset, processor, expansion slots, ports etc. and SMPS is known as system unit. Motherboard is the main printed circuit board in which buses act as the communication system that transfers data between components. Processors from Intel and AMD are widely used to perform arithmetic and logical operations. Computer memory is classified into primary and secondary. Primary memory consists of RAM, ROM and cache which are directly accessed by CPU. Secondary memory provides permanent and large amount of data storage. Magnetic disks, optical disks and flash memories are the commonly used secondary storage devices. Different types of ports are provided at the rear side of the system unit to connect various peripheral devices which include I/O devices, portable storage devices and network connector. The power supply to the various components of a computer is taken care of by SMPS where the electric power is plugged in.

E V A L U A T I O N

Objective type questions

1. CPU stands for _____.

2. Write an example for microprocessor.

3. Which of the following is NOT an example for optical storage device?

    (a) CD   (b) SSD

    (c) DVD   (d) Blu-ray

4. The fastest memory in a computer is _____.

5. The smallest unit of memory is called _____.

6. HDMI stands for _____.

7. SSD stands for _____.

8. Name the component of computer that functions as electric power distributer.

9.   Which memory is placed between CPU and RAM?

10. Identify the port used instead PS/2 port nowadays.

    (a) VGA port   (b) HDMI port

    (c) USB port   (d) LAN port.

Very short answer types questions

11. List down the major components of a computer system.

12. What is motherboard?

13. Distinguish between hardware and software.

14. Write short notes on chipset.

15. Which are the two types of RAM?

16. What is meant by live-ware?

Short answer type questions

17. Mention the importance of expansion slots in motherboard?

18. Differentiate between RAM and ROM.

19. Explain the three types of primary memory.

20. Explain the buses in the motherboard.

Descriptive type questions

21. Explain different types of secondary memories.

22. Explain any five ports in the computer.

23. How is memory measured? Write any three memory units and the relationship among them.

Essay type questions

24. Briefly describe the classification of memories.

25. Explain different components in the system unit of a computer.