BE 101-05 : Introduction to Computing and Problem Solving

Chapter 1 - Basics of computer system

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1 Introduction

Computer is an advanced electronic device that takes raw data as input from the user and processes these data under the control of a set of instructions (called program) and gives the result (output) and saves the output for the future use. It can perform both numerical (arithmetic) and non-numerical (logical) calculations. All types of computers follow a same basic logical structure and perform the following set of five basic operations (referred to as **input-process-output concept**) for converting raw input data into useful output information:

Input – Input refers to the data and instructions fed to a computer system. The input is entered into the computer through an input device like keyboard. The input can be characters, words, sound, images etc.

Process – Processing data means performing some actions on the data by using the instructions or program given by the user of the data in order to convert them into useful information. The action could be an arithmetic or logic calculation, editing, modifying a document etc. During processing, the data, instructions and the output are stored temporarily in the computer's memory.

Output – Output is the useful information or result produced by the computer after data processing. The output may be in the form of text, sound, image, printed document, etc. The computer may display the output on a monitor, send output to the printer for printing or even play the output (if the output is sound).

Storage – The data and instructions need to be saved somewhere so that they are available for processing as and when required. The computer uses its memory for storage purposes.

Control – The computer also controls the workflow by directing the manner and sequence in which all of the above operations are performed.

2 Characteristics of computer

Here we dicuss the characteristics of a computer : its pros and cons.

Advantages

- High Speed : The computer can process huge amount of data very fast, at the rate of millions of instructions per second. Some calculations that would have taken hours and days to complete otherwise, can be completed in a few seconds using the computer.

- Accuracy : Computer provides a high degree of accuracy. For example, the computer can accurately give the result of division of two numbers up to 10 decimal places.

- Diligence : When used for a longer period of time, the computer does not get tired or fatigued. It can perform long and complex calculations with the same speed and accuracy from the start till the end.

- Storage Capability : Large volumes of data and information can be stored in the computer and also retrieved whenever required. It can store any type of data such as images, videos, text, audio and many others.

- Versatility : Computer is versatile in nature. It can perform different types of tasks with the same ease. At one instance, it may be solving a complex scientific problem and the very next moment you may play music or print a document.

- Automation : Automation means ability to perform the given task automatically. Once a program is given to computer i.e., stored in computer memory, the program and instruction can control the program execution without human interaction.

Limitations

- No intelligence : A computer is a dumb machine that has no intelligence to perform any task. Each instruction has to be given to computer. A computer cannot take any decision on its own. Computers have no feelings or emotions too.

- Dependency : Computer can only perform tasks that it has been programmed to do. Computer cannot do any work without instructions from the user. It executes instructions as specified by the user. In this sense, computer is fully dependent on human beings.

3 Parts of a computer system

A computer system typically is composed of four main parts:

1. **Hardware** – consists of the mechanical parts that make up the computer as a machine. The hardware consists of physical devices of the computer. The devices are required for input, output, storage and processing of the data. Keyboard, monitor, hard disk drive, floppy disk drive, printer, processor and motherboard are some of the hardware devices.

2. **Software** – is a set of instructions that tells the computer about the tasks to be performed and how these tasks are to be performed. *Program* is a set of instructions, written in a language understood by the computer, to perform a specific task. A set of programs and documents are collectively called *software*. The hardware of the computer system cannot perform any task on its own. The hardware needs to be instructed about the task to be performed. Software instructs the computer about the task to be performed. The hardware carries out these tasks.

3. **Data** – are isolated values or raw facts, provided as input to the computer, which is processed to generate some meaningful information.

4. **Users** – are people who write computer programs or interact with the computer. They are also known as skinware, liveware, humanware or peopleware. Programmers, data entry operators, system analysts and computer hardware engineers fall into this category.

4 Components of computer hardware

The computer system hardware comprises of three main components:

1. Input/Output (I/O) Unit,

2. Central Processing Unit (CPU), and

3. Memory Unit.

The I/O unit consists of the input unit and the output unit. CPU performs calculations and processing on the input data, to generate the output. The memory unit is used to store the data, the instructions and the output information. Figure 4.1 illustrates the typical interaction among the different components of the computer.
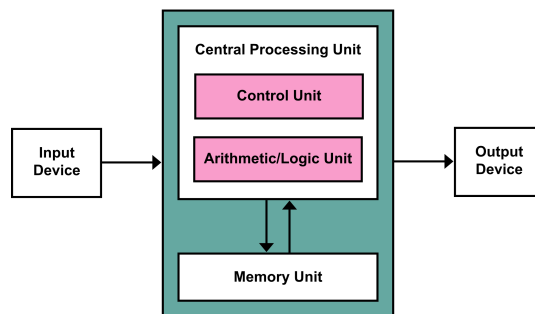

Figure 4.1: Components of a computer

Input/Output Unit – The user interacts with the computer via the I/O unit. The input unit accepts data from the user and the output unit provides the processed data i.e. the information to the user. The input unit converts the data that it accepts from the user, into a form that is understandable by the computer. Similarly, the output unit provides the output in a form that is understandable by the user. The input is provided to the computer using input devices like keyboard, trackball and mouse. Some of the commonly used output devices are monitor and printer.

Central processing unit – CPU is considered as the brain of the computer. CPU performs all types of data processing operations. It controls, coordinates and supervises the operations of the computer. CPU consists of **Arithmetic Logic Unit (ALU)** and **Control Unit (CU)**.

- ALU performs all the arithmetic and logic operations on the input data.
- CU controls the overall operations of the computer i.e. it checks the sequence of execution of instructions and controls and coordinates the overall functioning of the various units of the computer.

CPU also has a set of **registers** for temporary storage of data, instructions, addresses and intermediate results of calculation.

Memory unit – Memory unit stores the data, instructions, intermediate results and output, temporarily, during the processing of data. This memory is also called the main memory or primary memory of the computer. The input data are brought into the main memory before processing. The instructions required for processing of data and any intermediate results are also stored in the main memory. The output is stored in memory before being transferred to the output device.

Another kind of storage unit is the secondary memory of the computer. The secondary memory is used to store data, programs and the output permanently. Magnetic disks, optical disks and magnetic tapes are examples of secondary memory.

5 Von Neumann architecture

If we want to do some processing on data, they must be stored in computer memory. Similarly the instructions that process the data must also be stored in the memory. This concept of storing programs (program is a collection of instructions) in computer memory is what is called **stored program concept**. A computer based on Von Neumann architecture stores data and instructions in the same memory; a computer based on Harvard architecture has separate memories (code memory for programs and data memory for data) for storing program and data. Both are stored-program designs.

The Von Neumann architecture describes a design architecture for an electronic digital computer with parts consisting of a processing unit containing an arithmetic logic unit and a control unit, a memory to store both data and instructions, external memory storage, and input and output mechanisms. The design of a von Neumann architecture machine is simpler than that of a Harvard architecture machine.
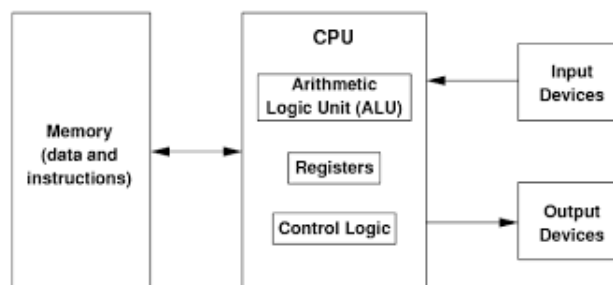

Figure 5.1: Von Neumann architecture

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6   Classification of computers

The computers are broadly classified into four categories based on their size and type:

1. **Microcomputers** : Microcomputers are small, low-cost and single-user digital computers. They consist of CPU, input unit, output unit, storage unit and the software. Although microcomputers are stand-alone machines, they can be connected together to create a network of computers that can serve more than one user. IBM PC based on Pentium microprocessor and Apple Macintosh are some examples of microcomputers. They are further classified into:

   (a) **Desktop Computer or Personal Computer (PC)** – a stand-alone machine that can be placed on top of the desk.

   (b) **Notebook Computers or Laptop** – resemble a notebook. They are portable and have all the features of a desktop computer.

   (c) **Netbook** – smaller notebooks optimized for low weight and low cost, and are designed for accessing web-based applications. Netbooks deliver the performance needed to enjoy popular activities like streaming videos or music, emailing, Web surfing or instant messaging. The word *netbook* is just a blend of the words Inter*net* and note*book*.

   (d) **Tablet Computer** – has features of the notebook computer but it can accept input from a stylus or a pen instead of the keyboard or mouse. It is also portable.

   (e) **Handheld Computer or Personal Digital Assistant (PDA)** – a small computer that can be held on the top of the palm. It is small in size and uses a pen or a stylus for input.

   (f) **Smart Phones** – cellular phones that function both as a phone and as a small PC. They may use a stylus or a pen, or may have a small keyboard for input.

2. **Minicomputers** : Minicomputers are digital computers, generally used in multi-user systems. They have high processing speed and high storage capacity than the microcomputers. Minicomputers can support 4 - 200 users simultaneously. The users can access the minicomputer through their PCs or terminal. They are used for real-time applications in industries, research centres etc. PDP 11. IBM (8000 series) are some of the widely used minicomputers.

3. **Mainframe computers** : Mainframe computers are large and powerful systems and are expensive too. They are multi-user, multi-programming and high performance computers. They operate at very high speeds, have huge storage capacity and can handle the workload of thousands of users simultaneously.

   The user accesses the mainframe computer via a terminal that may be a *dumb terminal*, an *intelligent terminal* or a PC. A dumb terminal cannot store data or do processing of its own. It has only input and output devices. An intelligent terminal has input and output devices and can do processing, but cannot store data of its own. The dumb and the intelligent terminals use the processing power and the storage facility of the mainframe computer. Mainframe computers are used in organizations like banks or companies, where many people require frequent access to the same data.

   Some examples of mainframes are CDC 6600 and IBM ES000 series.

4. **Supercomputers** : Supercomputers are one of the fastest computers currently available. The speed of a supercomputer is generally measured in FLOPS (FLoating point Operations Per Second). Some of the faster supercomputers can perform trillions of calculations per second. Supercomputers are built by interconnecting thousands of processors that can work in parallel. Supercomputers are very expensive and are employed for specialized applications that require immense amount of mathematical calculations such as weather forecasting, nuclear research and aircraft design. IBM Road runner, IBM Blue gene and PARAM series (manufactured in India) are some of the popular supercomputers.

7 Applications of computers

Computers have found its applications in almost every face of life. Here we brief some of the applications of computers:

- **Education**

  - Educators use computers to prepare notes and presentations of their lectures.
  - Computers are used to provide distance education using the e-learning software, and to conduct online examinations.
  - Researchers use computers to get easy access to conference and journal publications.

- **Entertainment**

  - Computer users can download and view movies, play games, chat, book tickets for cinema halls.
  - The users can also listen to music, download and share music, create music using computers.

- **Advertising**

  - Advertising professionals can create art and graphics, print and disseminate ads with the goal of selling more products.
  - Advertisements can be displayed on websites, electronic-mails and reviews of a product by different customers can be posted.

- **Medicine**

  - Medical researchers and practitioners use computers to access information about the advances in medical research or to get opinion of doctors globally.
  - Computers are being used in hospitals to keep the record of patients and medicines.
  - ECG, EEG, Ultrasounds and CT, MRI Scans etc., are also done by computerised machines.
  - Computers also provide assistance to the medical surgeons during critical surgeries.

- **Science and Engineering**

  - Scientists and engineers use computers for performing complex scientific calculations, for designing and making drawings (CAD/CAM applications).

- Complex scientific applications like the launch of the rockets, space exploration, etc., are not possible without computers.

- **Government**

  - Computers are used for the filing of income tax return, paying taxes, online payment of water and electricity bills.
  - The police department uses computers to search for criminals using fingerprint matching etc.

- **Home**

  - At home, people use computers to play games, to maintain the home accounts, for communicating with friends and relatives via Internet.
  - Online shopping has been made possible through use of computerised catalogues that provide access to product information and permit direct entry of orders to be filled by the customers.
  - Microcontrollers embedded in house hold utilities like washing machines, TVs, food processors, security devices, etc allow them to be operated remotely.

The list of applications of computers is so long that it is not possible to discuss all of them here. In addition to the applications of the computers discussed above, computers have also proliferated into areas like banking, trading, military operations, meteorological predictions, social networking and so on.