GCA(S1) 01-01

Computer Fundamentals

SEMESTER - 1

BACHELOR OF COMPUTER APPLICATION

Block 1

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BACHELOR OF COMPUTER APPLICATION

COMPUTER FUNDAMENTALS

DETAILED SYLLABUS

Block-1

UNIT 1: Introduction to Computer **Pages: 7-20**

Computer– a Definition; Characteristics of Computer; Generations of Computers; Structural Evolution of Computers; File Structure of Computers; Flynn's Classification of Computer Architecture; Applications of Computer: Advantages of Computer

UNIT 2: Basic Features of Computer Classification **Pages: 21-33**

Computer Classification based on Operating Principles: Analog Computers, Digital Computers, Hybrid Computers; Computer Classification based on Applications: General Purpose Computers, Special Purpose Computers; Computer Classification based on Size and Capability: Micro Computers, Mini Computers, Mainframe Computers, Super Computers

UNIT 3: Basic Components of Computer **Pages: 34-52**

Main Components of a Computer System; Input Unit; Output Unit; Storage Unit; Central Processing Unit: Control Unit, Arithmetic Logic Unit

UNIT 4: Computer Memory and Storage **Pages: 53-64**

Memory Representations; Memory Hierarchy; CPU Registers; Primary Memory: Random Access Memory, Read Only Memory; Secondary Memory; Cache Memory; Virtual Memory

UNIT 5: Buses **Pages: 65-74**

Bus Structure: Address Bus, Data Bus, Control Bus; Types of Buses: ISA (Industry Standard Architecture) Bus, PCI (Peripheral Component Interconnect) Bus, EISA (Extended Industry Standard Architecture) Bus, VESA (Video Electronics Standards Association) Local Bus, MCA (Micro Channel Architecture) Bus

UNIT 6: Introduction to System Software **Pages: 75-83**

Compiler; Assembler; Linker; Loader; Editor

COURSE INTRODUCTION

This course has been prepared for the beginners as well as advanced learners to provide an introductory knowledge of computer fundamentals. As the name of the course suggests, this course includes different fundamental concepts of computer from different advanced topics which we will come across in later semesters.

This course on **Computer Fundamentals** consists of 11 units and provides an introduction to various fundamental concepts in computer science. It includes topics like basic components of computer system, computer memory and storage and buses. Basics of different operating systems are also discussed in this course along with an introduction to system software. An introductory unit for programming is also included along with the file structure and computer security is also included in this block.

The course is divided into two blocks:

Block 1 introduces us to the basic concepts of computer. Flynm's classification of computer architecture, different generation of computers, classifications of computers on the basis of size and capability are discussed. The basic components of computer system, its memory and storage are also discussed in this block. The block also includes units on different types of buses and an introduction to system software.

Block 2 includes an introduction to the different instruction types used in computer systems. The basics of different operating systems are discussed in this block. Topics on programming basics, file structure and computer security are also discussed in detail in this block.

BLOCK INTRODUCTION

This is the *First Block* of the course “Computer Fundamentals”. After completing this block you will find yourself at a moderate level of expertise in knowledge of computer basics.

This block comprises the following six units:

Unit 1: introduces you to the different generation and applications of computer. The structural evolution and Flynm’s classification of computer architecture are discussed in this unit.

Unit 2: concentrates on the different classifications of computers based on their size, capability and applications.

Unit 3: deals with the main components of computer system. Different types of input and output devices are discussed in details in this unit.

Unit 4: introduces us to the basics of computer memory and storage. Concepts of bits and bytes, memory hierarchy are introduced in this unit. Different types of memory - primary, secondary, cache and virtual memory are also discussed.

Unit 5: deals with buses. Different types of buses- address, data and control buses are discussed in this unit.

Unit 6: introduces us to the basics of system software. Compiler, linker, loader and editor are discussed in this unit.

The structure of Block 1 is as follows:

UNIT 1: Introduction to Computer

UNIT 2: Basic Features of Computer Classification

UNIT 3: Basic Components of Computer

UNIT 4: Computer Memory and Storage

UNIT 5: Buses

UNIT 6: Introduction to System Software

While going through a unit, you will notice some along-side boxes, which have been included to help you know some of the difficult, unseen terms. Again, we have included some relevant concepts in “LET US KNOW” along with the text. And, at the end of each section, you will get “CHECK YOUR PROGRESS” questions. These have been designed to self-check your progress of study. It will be better if you solve the problems put in these boxes immediately after you go through the sections of the units and then match your answers with “ANSWERS TO CHECK YOUR PPROGRESS” given at the end of each unit.

UNIT 1: INTRODUCTION TO COMPUTER

UNIT STRUCTURE

1.1 Learning Objectives

1.2 Introduction

1.3 Computer– a Definition

1.4 Characteristics of Computer

1.5 Generations of Computers

1.6 Structural Evolution of Computers

1.7 File Structure of Computers

1.8 Flynn's Classification of Computer Architecture

1.9 Applications of Computer

1.9.1 Advantages of Computer

1.10 Let Us Sum Up

1.11 Answers to Check Your Progress

1.12 Further Reading

1.13 Model Questions

1.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- define the term ''Computer''
- describe the key characteristics of a computer
- describe the generations of computers
- trace the structural evolution of computers
- describe the applications of computer.

1.2 INTRODUCTION

Computer is the most powerful tool man has ever created. Computers have made a great impact on our everyday life. Today, computer technology has permeated every sphere of existence of modern human beings. With the growing information needs the computer has become one of the vital components for the survival of the business houses. Their presence is felt

at almost every working place from the bus and railway ticket reservation to satellite launching, from retail stores to medical diagnosis and from home use to research and design organization– everywhere, we witness on elegance, sophistication and efficiency that have been made possible only with the help of computers.

In this unit, we shall introduce you to the computer fundamentals including its various components and functionality. We shall discuss the characteristics of computers including its evolution and generations. We will also discuss the categories of computers along with its application in the various fields of the modern world.

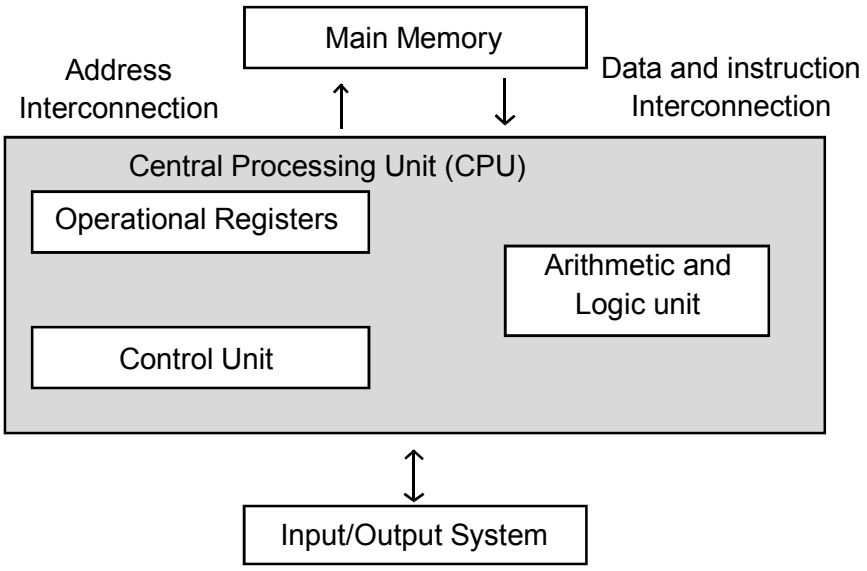
1.3 COMPUTER– A DEFINITION

The term ***computer*** is derived from the word ***compute***, which means ***to calculate.*** In the simplest form a computer can be defined as a ***programmable machine.*** In a more formal way it can be defined as an ***Electronic machine*** capable of performing calculations and other manipulations of various types of data, under the control of a stored set of instructions. A computer accepts data from an input device and processes it into useful information which it displays on its output devices. Actually, a computer is a collection of ***hardware*** and ***software*** components that help you to accomplish many different tasks. The machine itself is the hardware; and the instructions are the program or software.

Most of today's computer designs are based on the concepts developed by ***John Von Neumann*** referred to as the ***"Von Neumann architecture"***. According to this structure a computer must have two units - a processing unit and a single separate storage unit. The term "stored program computer" is generally used to mean a computer of this design. The processing unit is termed as ***Central Processing Unit (CPU)*** which mainly comprises with two other units namely ***Arithmetic and Logic Unit (ALU)*** and ***Control Unit (CU)***. The ALU performs the arithmetic operations on data such as addition, subtraction, multiplication and division, and the logical operations such as >, <, >=, <= etc. The control unit directs the ALU to perform specific arithmetic and logical functions on the data.

The storage unit is used to store instructions and data temporarily. This component is referred to as memory. The memory unit stores all the information in a group of memory cells, also called memory locations, as ***binary digits (bits).*** Each memory location has a unique address and can be addressed independently.

The instruction and data can be put into the computer with the help of the input module. Similarly, it needs another component that will report the results in proper format and form. This component is called output module. The following figure shows the basic structure of a conventional *Von Neumann machine:*



1.4 CHARACTERISTICS OF COMPUTER

Some of the main characteristics of computers that make them an essential part of every emerging technology and a desirable tool in human development can be cited as follows:

- **Speed:** In a few seconds a computer can perform such a huge amount of task that a normal human being may take days or even years to complete. At present, a powerful computer can perform billions of operations in just one second.
- **Accuracy:** The computers are very accurate. The level of accuracy depends on the instructions and the type of machine used.

- **Diligence:** Being a machine, computers do not suffer from tiredness and lack of concentration even if the same job has to be done repeatedly unlike we human beings. It can perform even millions of calculations all with the same accuracy and speed.
- **Reliability:** Computers are reliable, because at the machinery level, they do not require any human intervention between its processing operations. Computers also have built-in diagnostic capabilities, which help in continuous monitoring of the system.
- **Storage Capacity:** Computers can store large amounts of data and can recall the required information almost instantaneously.
- **Versatility:** Computers can perform multiple tasks simultaneously.
- **Resource Sharing:** With the tremendous growth in computer technologies resource sharing is easily possible.
- **Lack of Intelligence:** A computer can only perform what it is programmed to do. It cannot take any decision. This is the main limitation of a computer.

1.5 GENERATION OF COMPUTERS

The history of computer development is often considered with reference to the different generations of computing device. Each generation of computers is characterized by a major technological development that had fundamentally changed the way computers operate, resulting in increasingly smaller, cheaper, and more powerful and more efficient and reliable devices. There are five generations of computers as follows:

- **First Generation (1945 - 55):** Examples of computers of this generation are:

  ENIAC– Electronic Numerical Integrator And Calculator

  EDSAC– Electronic Delay Storage Automatic Calculator

  EDVAC– Electronic Discrete Variable Automatic Computer

  UNIVAC– Universal Automatic Computer IBM 701

  Characteristics of first generation computers:

  - Vacuum tubes were used
  - Basic arithmetic operations took few milliseconds

- Bulky i.e., very large in size
- Consume more power with limited performance
- High cost
- Use assembly language to prepare programs. These were translated into machine level language for execution
- Electrostatic memories were used
- Punched cards and paper tape were invented to feed programs and data and to get results
- Magnetic tape /magnetic drum were used as secondary memory
- Mainly used for scientific computations.

- **Second Generation (1955-65):** Examples of computers of this generation are– IBM 7030, Digital Data Corporation's PDP 1/5/8 Honeywell 400.

  Characteristics of second generation computers:

  - Transistors were used in place of vacuum tubes
  - Smaller in size
  - Less power consumption and better performance
  - Lower cost
  - Magnetic ferrite core memories were used as main memory which is a random access non-volatile memory
  - Magnetic tapes and magnetic disks were used as secondary memory
  - High level languages such as FORTRAN, COBOL etc. were used
  - Separate input-output processors were developed that could operate in parallel with CPU.
  - Punched cards continued during this period also
  - Increasingly used in business, industry and commercial organizations for preparation of payroll, inventory control, marketing, production planning, research, scientific and engineering analysis and design etc.

- **Third Generation (1965-75):** Examples of computers of this generation are– 360 Mainframe from IBM, PDP-8 Mini Computer from Digital Equipment corporation).

Characteristics of third generation computers

- ICs were used
- Small Scale Integration and Medium Scale Integration technology were implemented in CPU, I/O processors etc.
- Smaller and better performance
- Comparatively lesser cost
- Faster processors
- In the beginning magnetic core memories were used. Later they were replaced by semiconductor memories (RAM & ROM)
- Introduced microprogramming
- Operating system software were introduced
- Cache and virtual memories were introduced (Cache memory makes the main memory appear faster than it really is. Virtual memory makes it appear larger)
- Database management, multi-user application, online systems like closed loop process control, airline reservation, interactive query systems, automatic industrial control etc. emerged during this period.

- **Fourth Generation (1975-89):** Examples of computers of this generation are– Intel's 8088, 80286, 80386, 80486, .., Motorola's 68000, 68030, 68040, Apple II, CRAY I/2/X/MP etc)

  Characteristics of fourth generation computers

  - Microprocessors were introduced as CPU-Complete processors and large section of main memory could be implemented in a single chip
  - Tens of thousands of transistors can be placed in a single chip (VLSI design implemented)
  - CRT screen, laser & inkjet printers, scanners etc were developed.
  - Semiconductor memory chips were used as the main memory.
  - Secondary memory was composed of hard disks - Floppy disks and magnetic tapes were used for backup memory
  - Parallelism, pipelining cache memory and virtual memory were applied in a better way

- Local Area Networks (LAN) and Wide Area Networks (WAN) were developed
- Introduced C language and Unix OS
- Introduced Graphical User Interface (GUI).

- **Fifth Generation (1989 to present):** Examples of computers of this generation are- IBM notebooks, Pantium PCs-Pentium 1/2/3/4/ Dual core/Quad core. SUN work stations, Origin 2000, PARAM 10000, IBM SP/2).

  Characteristics of fifth generation computers:

  - Computers based on artificial intelligence are available
  - Computers use extensive parallel processing, multiple pipelines, multiple processors etc
  - Massive parallel machines and extensively distributed system connected by communication networks fall in this category.
  - Introduced ULSI (Ultra Large Scale Integration) technology - Intel's Pentium 4 microprocessor contains 55 million transistors millions of components on a single IC chip.
  - Superscalar processors, Vector processors, SIMD processors, 32 bit micro controllers and embedded processors, Digital Signal Processors (DSP) etc. have been developed.
  - Memory chips up to 1 GB, hard disk drives up to 180 GB and optical disks up to 27 GB are available.
  - Object oriented language like JAVA suitable for internet programming has been developed.
  - Portable notebook computers introduced
  - Storage technology advanced– large main memory and disk storage available
  - Introduced World Wide Web. (and other existing applications like e-mail, e-Commerce, Virtual libraries/Classrooms, multimedia applications etc.)
  - New operating systems developed– Windows 95/98/XP/…, LINUX, etc.
  - The recent development in the application of internet is the Grid technology which is still in its upcoming stage.

- Quantum mechanism and nenotechnology will radically change the phase of computers.

1.6 STRUCTURAL EVOLUTION OF COMPUTERS

The ABACUS can be considered the ancestor of today's computer. It was built by the people of Asia Minor almost 2000 years ago. It was simply a wooden rack holding parallel wires on which beads were strung. When these beads were moved along the wire according to some rules that the user must memorize, all ordinary arithmetic operations could be performed.

An English mathematics professor, named **Charles Babbage**, in the early 1800s designed a machine to perform differential equations, called **Difference Engine.** It was a steam powered machine as large as a locomotive and had a stored program and could perform calculations and print results automatically.

After Babbage, between 1850 and 1900, many of the new advances in mathematics and physics took place which involved complex calculations and formulas that were very time-consuming for human calculation. Then people started rethinking of the development of a device to help complex calculations.

In the 1890's census of the United States, a machine developed by **Herman Hollerith** was used. Hollerith developed a new punched-card system that could automatically read information on cards without human intervention.

In 1942, John P. Eckert, John W. Mauchley, and their associates at the University of Pennsylvania built a high-speed electronic computer to do the job known as **ENIAC(Electrical Numerical Integrator And Calculator).** It could multiply two numbers at the rate of 300 products per second, by finding the value of each product from a multiplication table stored in its memory. ENIAC was about 1,000 times faster than the previous generation of Computers. ENIAC used vacuum tubes to make the internal parts of the computer and electricity to run. It used punched-card input and output.

In 1945 **John Von Neumann** undertook a theoretical study of computation that demonstrated that a computer could have a very simple

architecture and yet be able to execute any kind of computation effectively by means of proper programmed control without the need for any changes in hardware. Von Neumann came up with incredible ideas which came to be referred to as the **stored-program technique** that became fundamental for future generations of high-speed digital computers and were universally adopted.

With the first wave of modern programmed electronic computers to take the advantage of these improvements there came the first group of modern programmed electronic computers. This group included computers using random access memory (RAM),which is a memory designed to give almost constant access to any particular piece of information. This group of machines included EDVAC, EDSAC(Electronic Delay Storage Automatic Calculator) and UNIVAC, the first commercially available computers. The UNIVAC was developed by John W. Mauchley and John Eckert, Jr. in the 1950s.

In the 1960s efforts to design and develop the fastest possible computers with the greatest capacity reached a turning point with the completion of the **LARC** machine for **Livermore Radiation Laboratories** by the Sperry-Rand Corporation, and the Stretch computer by IBM. During this time the major computer manufacturers began to offer a range of computer capabilities, as well as various computer-related equipment. Input means such as consoles and card feeders; output means such as page printers, cathode-ray-tube displays, and graphing devices; and optional magnetic-tape and magnetic-disk file storage.

In the 1970s entire assemblies, such as adders, shifting registers, and counters, became available on tiny chips of silicon. In 1971 Marcian E. Hoff, Jr., an engineer at the Intel Corporation, invented the microprocessor and another stage in the development of the computer began.

A new revolution in computer hardware was now well under way, involving miniaturization of computer-logic circuitry and of component manufacture by what are called ***large-scale integration*** techniques. In the 1980s ***very large scale integration (VLSI),*** in which hundreds of thousands of transistors are placed on a single chip, became increasingly common.

The trend of reduction in size led to the introduction of Personal Computers (PCs), which are programmable machines small enough and inexpensive enough to be purchased and used by individuals. By the late 1980s some PCs were run by microprocessors, a processor on a single ***integrated circuit (IC)*** chip. The trend continued leading to the development of smaller and smaller microprocessors with a proportionate increase in processing powers.

1.7 FILE STRUCTURE OF COMPUTERS

File Structure is the way we organize our folders on our computer. Keeping all our documents under one folder is a great way to keep ourselves organized and making things easy for backing up our computer.

1.8 FLYNN'S CLASSIFICATION OF COMPUTER ARCHITECTURE

Computer architecture has been classified into four categories according to Flynn's classification based upon the number of concurrent instruction (or control) streams and data streams available in the architecture. These four categories are:

a) Single instruction stream, single data stream (SISD)
b) Single instruction stream, multiple data streams (SIMD)
c) Multiple instruction streams, single data stream (MISD)
d) Multiple instruction streams, multiple data streams (MIMD)

a) Single instruction stream□single data stream (SISD): A sequential computer which exploits no parallelism in either the instruction or data streams. Single control unit (CU) fetches single instruction stream (IS) from memory. The CU then generates appropriate control signals to direct single processing element (PE) to operate on single data stream (DS) i.e., one operation at a time.

Examples of SISD architecture are the traditional uniprocessor machines like older personal computers (PCs of 2010, many PCs had multiple cores) and mainframe computers.

b) Single instruction stream□multiple data streams (SIMD): A computer which exploits multiple data streams against a single

instruction stream to perform operations in a parallel manner. For example, an array processors or graphics processing unit (GPU)

c) **Multiple instruction streams, single data stream (MISD):** Multiple instructions operate on one data stream. This is an uncommon architecture which is generally used for fault tolerance. For example, the Space Shuttle flight control computer.

d) **Multiple instruction streams, multiple data streams (MIMD):** Multiple autonomous processors simultaneously execute different instructions on different data. MIMD architectures include multi-core superscalar processors, and distributed systems, using either one shared memory space or a distributed memory space.

1.9 APPLICATIONS OF COMPUTERS

Now a days, computers are being used almost in every aspects of life. Every company, small or large, government offices, educational institutions are now directly or indirectly dependent on computers mainly for information processing. Computer based railway and airway reservation system is a common example of computer application. Computer system is helping in the efficient management of the banking sector, hospital records, payroll records and so on.

1.9.1 Advantages of Computers

Some of the areas where computers are being used to our advantage can be listed as below:

- **Science:** Scientists are using computers to carry out their research works based on complex computations because of the computer's fast speed and accuracy.
- **Education:** Computers are used now-a-days in schools and colleges, to make education much more interesting. Computer Aided Education (CAE) and Computer Based Training (CBT) packages are making learning much more interactive.
- **Health and Medicine:** Starting from diagnosing illness to monitoring a patient's status during surgery, in pathological

analysis, in CAT scans or MRI scans etc., doctors are using computers. Some special purpose computers are available which can even be operated within the human body.

- **Engineering:** Engineers and architects are using computers in designing machineries, drawing design layouts. Architects can design objects that can be viewed from all the three dimensions by using techniques like virtual reality. In manufacturing industries, using computerized robotic arms hazardous jobs can be performed. The packages like Computer Aided Designing (CAD), Computer Aided Manufacturing (CAM) and so on are used in designing the product, ordering the parts and planning production.
- **Entertainment:** With the use of multimedia facilities, computers are now greatly used in the entertainment industry. Computers are used to control and bring special effects on image and sound.
- **Communication:** Computer network and the Internet have brought drastic changes in communication system. Through E-mail or Electronic mail, it is possible to send messages and reports very fast from one person to another or a group of persons with the aid of computers and telephone lines.
- **Business and Banking:** Computer network and finally the Internet have brought drastic changes in communication system. Through E-mail or Electronic mail, it is possible to send messages and reports very fast from one person to another or a group of persons with the aid of computers and telephone lines.

In order to deposit or withdraw cash from bank, people can use ATM (Automated Teller Machine) services 24 hours of the day. Through the computer networks among different branches of a bank, inter branch transactions can be carried out without delay.



CHECK YOUR PROGRESS

Q.1: State True or False:

i) PARAM is a super computer.

ii) A laptop is a portable computer.

iii) Vacuum tubes were part of the second generation computers.

iv) EDSAC is an example of a second generation computer.

Q.2: Fill in the blanks:

i) Physical components of a computer are called .....

ii) The basic components of first generation computers was .....

iii) PDA stands for .....

iv) ..... is a very small computer that can be held in the palm of the hand.

v) Analytical Engine was developed by .....



1.10 LET US SUM UP

- The computer is an electronic device that is used to perform diverse operations with the help of instructions to process the data in order to produce desired results.
- Speed, accuracy, reliability, versatility, diligence, lack of intelligence are the characteristics of computers.
- There are five generations of computers. In the first generation of computers, **vacuum tubes** were used for circuitry and **magnetic drums** for memory.
- In the second generation of computers, **vacuum tubes** replaced by **transistors.**
- **Integrated circuits** were used in the third generation of computers.
- The fourth generation of computers based on **microprocessors.**
- Fifth generation computers are based on **artificial intelligence.**

1.11 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: i) True, ii) True, iii) False, iv) False

Ans. to Q. No. 2: i) Hardware, ii) Vacuum tubes, iii) Personal Digital Assistant, iv) Palmtop, v) Charles Babbage.



1.12 FURTHER READING

1) Goel, A. (2010): *Computer Fundamentals*; Pearson Education India.
2) Rajaraman, V. & Adabala, N. (2014): *Fundamentals of Computers*; PHI Learning Pvt. Ltd.
3) Sinha, P. K. & Sinha, P. (2010): *Computer Fundamentals* (Vol. 4); BPB publications.



1.13 MODEL QUESTIONS

Q.1: Who invented the concept of stored program? Why is this concept so important?

Q.2: List the key hardware technologies used in building computer of each of the five generations.

Q.3: What are the advantages of transistors over vacuum tubes?

Q.4: What is an IC? How does it help in reducing the size of computers

Q.5: Discuss the important features of various generations of computers. Give some examples of the computers of each generation.

Q.6: Describe in brief Flynn's classification of computer?

Q.7: Describe the evolution of computers.

Q.8: What are the characteristics of a Computer? Do you think computers are superior to human being?

*** ***** ***

UNIT 2: BASIC FEATURES OF COMPUTER CLASSIFICATION

UNIT STRUCTURE

2.1 Learning Objectives

2.2 Introduction

2.3 Computer Classification based on Operating Principles

- 2.3.1 Analog Computers
- 2.3.2 Digital Computers
- 2.3.2 Hybrid Computers

2.4 Computer Classification based on Applications

- 2.4.1 General Purpose Computers
- 2.4.2 Special Purpose Computers

2.5 Computer Classification based on Size and Capability

- 2.5.1 Micro Computers
- 2.5.2 Mini Computers
- 2.5.3 Mainframe Computers
- 2.5.4 Super Computers

2.6 Let Us Sum Up

2.7 Answers to Check Your Progress

2.8 Further Reading

2.9 Model Questions

2.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- describe the different classifications of computers
- learn analog, digital and hybrid computers
- describe general and special purpose computers
- describe minicomputers, microcomputers, mainframe and supercomputers.

2.2 INTRODUCTION

In the previous unit we got an introduction to the computer system. We discussed the evolution and generations of computers.

In this unit we shall learn about the different classifications of computers. We shall discuss how the computers are classified based on operating principle and on the basis of applications. In addition, we shall learn about the classification of computers based on their size and power.

2.3 COMPUTER CLASSIFICATION BASED ON OPERATING PRINCIPLES

Based on the operating principles, computers can be classified into one of the following types:

- Digital Computers
- Analog Computers
- Hybrid Computers

2.3.1 Analog Computers

An analog computer is a form of computer that uses the continuously changeable aspects of physical phenomena such as electrical, mechanical, or hydraulic quantities to model the problem being solved. In contrast, digital computers represent varying quantities symbolically, as their numerical values change.

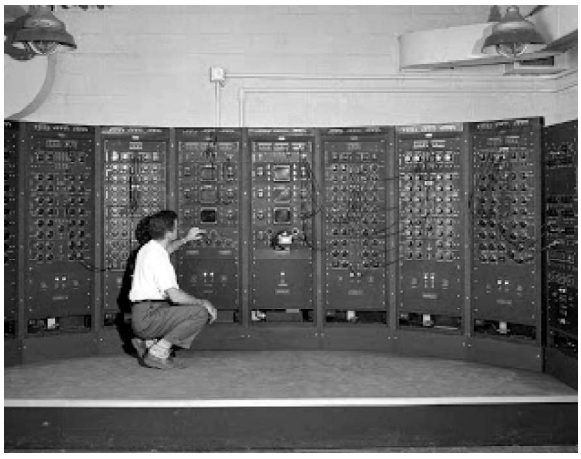


Fig. 2.1: Analog Computers

2.3.2 Digital Computers

Digital computers operate essentially by counting. All quantities are expressed as discrete or numbers. Digital computers are useful for evaluating arithmetic expressions and for manipulations of data (such as preparation of bills, ledgers, solution of simultaneous equations etc.)



Fig. 2.2: Digital Computer

2.3.3 Hybrid Computers

Hybrid computers are computers that exhibit both the features of analog computers and digital computers. The digital component normally serves as the controller and provides logical operations, while the analog component normally serves as a solver of differential equations.

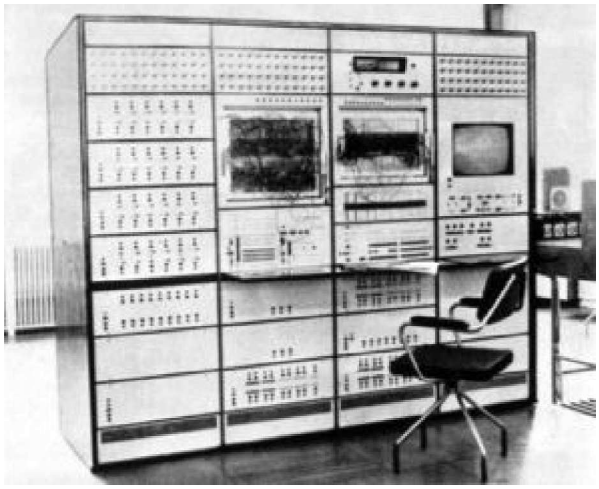


Fig. 2.3: Hybrid Computers

2.4 COMPUTER CLASSIFICATION BASED ON APPLICATIONS

Modern computers depending upon their applications are classified as: -

- General Purpose Computers
- Special Purpose Computers

2.4.1 General Purpose Computers

General purpose computers are designed to meet the needs of many different applications. In these computers, the instructions needed to perform a particular task are wired permanently into the internal memory. When one job is over, instructions for another job can be loaded into the internal memory for processing. Thus, a general purpose machine can be used to prepare pay-bills, manage inventories, print sales report and so on.



Fig. 2.4: General Purpose Computer

2.4.2 Special Purpose Computers

Special purpose computers are designed only to meet the requirements of a particular task or application. The instructions needed to perform a particular task are permanently stored into the internal memory, so that it can perform the given task on a single command. It therefore doesnot possess unnecessary options and is less expensive.



Fig. 2.5: Special Purpose Computer



CHECK YOUR PROGRESS

Q.1: What are the different categories of computers based on applications?

Q.2: What are the different categories of computers based on operating principles?

Q.3: What are hybrid computers?

Q.4: What is the need of special purpose registers?

2.5 COMPUTER CLASSIFICATION BASED ON SIZE AND CAPABILITY

Computers can be classified according to their size and power into four categories. They are:

- Micro Computers
- Mini Computers
- Mainframe Computers
- Supercomputers

Let us look at each of these categories in detail now.

2.5.1 Micro Computers

A microcomputer uses a microprocessor as its Central Processing Unit. Microcomputers are tiny computers that can vary in size from a single chip to the size of a desktop model. They are designed to be used by only one person at a time. Microcomputers are small to medium data storage capacities 500MB-2GB or more. The common examples of microcomputers are chips used in washing machines, TVs, Cars and Notebook/Personal computers. They are: IBM PC, PS/2 and Apple Macintosh.

Micro computers are used in the field of desktop publishing, accounting, statistical analysis, graphic designing, investment analysis, project management, teaching, entertainment etc. The different models of microcomputers are given below:

a) **Personal computers:** The name PC was given by IBM for its microcomputers. PCs are used for word processing, spreadsheet calculations, database management etc.

b) **Notebook or Laptop :** Very small in terms of size. The notebook or laptop can be folded and carried around. The monitor is made up of LCD and the keyboard and system units are contained in a single box. These machines contain all the facilities of a personal computer (HDD, CDD, aound card, network card, modem etc) and a special connection to connect to the desktop PC which can be used to transfer data.

c) **Palm Top:** A smaller model of the microcomputer. A palm top is similar to a calculator– pocket size. It has a processor and memory and a special connection to connect to the desktop PC which can be used to transfer data.

d) **Wrist PC:** The smallest type of microcomputer. The wrist PC can be worn on our wrist like a watch. It has a processor and memory and a wireless modem.

The following figures show the various types of micro computers:



a) Personal Computer



b) Notebook Computer



c) Laptop Computer



d) Palmtop Computer



e) PDA (Personal Digital Assistant)

Fig. 2.6: Micro Computer

2.5.2 Mini Computers

Mini computer uses a microprocessor and performs better than micro computers. Mini computers are large in size and costlier than micro computers. These computers are designed to support more than one user at a time. They posses large storage capacities and operate at higher speed. They are used to support faster peripheral devices like high speed printers and can also be used to communicate with main frames.

Some of the applications of mini computers are given below. These computers are:

- used when the volume of processing is large for e.g., Data processing for a medium sized organization
- used to control and monitor production processes

- to analyze results of experiments in laboratories
- used as servers in LANs (Local Area Networks)

Examples of mini computers are: Digital Equipments PDP 11/45 and VAX 11 etc. The following figure shows a mini computer:



Fig. 2.7: Mini computer

2.5.3 Maintrame Computers

Mainframe computers are able to process large amounts of data at very high speed. They support multi-user facility. The number of processors varies from one to six. The cost ranges from 3500 to many million dollars. They are kept in air conditioned room to keep them cool. Mainframe computers support many I/O and auxiliary storage devices and also support network of terminals. Some of the applications of mainframe computers are as follows. They are:

- used to process large amount of data at very high speed such as in the case of Banks/ Insurance Companies/ Hospitals/ Railways etc. which need online processing of large number of transactions and requires massive data storage and processing capabilities
- used as controlling nodes in WANs (Wide Area Networks)
- used to manage large centralized databases

Examples of main frame computers are: IBM 370, IBM 3081, IBM 3000 series, Univac 1180, DEC IBM 3000 series, CDC Cyber-2000V etc.



Fig. 2.8: Mainframe computer

2.5.4 Super Computers

Super computer is a broad term for one of the fastest computers currently available. The main characteristics of a super computer are:

- The most powerful computer system– needs a large room
- Minimum world length is 64 bits
- CPU speed: 100 MIPS (Million instructions per second)
- Equivalent to 4000 computers
- High cost: 4-5 millions dollars
- Able to handle large amount of data
- High power consumption
- High precision

Some of the applications of supercomputers are:

- In Petroleum industry– to analyze volumes of seismic data which are gathered during oil seeking explorations to identify areas where there is possibility of getting petroleum products inside the earth
- In Aerospace industry– to simulate airflow around an aircraft at different speeds and altitude. This helps in producing an effective aerodynamic design for superior performance

- In Automobile industry– to do crash simulation of the design of an automobile before it is released for manufacturing - for better automobile design
- In structural mechanics– to solve complex structural engineering problems to ensure safety, reliability and cost effectiveness. Eg. Designer of a large bridge has to ensure that the bridge must be proper in various atmospheric conditions and pressures from wind, velocity etc and under load conditions.
- Meteorological centers use super computers for weather forecasting
- In Biomedical research - atomic nuclear and plasma analysis - to study the structure of viruses such as that causing AIDS
- For weapons research and development, sending rockets to space etc.

Examples of supercomputers are: Cray-1(1976), Cray-2(1985), Cray T3D(1993), NEC's SX-S/44(1991), Fujitsu VP 2600/10(1991), Hitachi 820/80(1987), C-DAC's PARAM Series of supercomputers etc. A PARAM 10000 series super computer of IIT Guwahati is shown in the above below.



Fig. 2.9: PARAM 1000 Series Super Computer



CHECK YOUR PROGRESS

Q.5: What are the different categories of computers based on size and power?

Q.6: Mention two applications of supercomputers.

Q.7: How are mini computers different from micro computers?

Q.8: Give two properties of mainframes.



2.6 LET US SUM UP

- An analog computer is a form of computer that uses the continuously changeable aspects of physical phenomena such as electrical, mechanical, or hydraulic quantities to model the problem being solved.
- Digital computers operate essentially by counting. All quantities are expressed as discrete or numbers.
- Hybrid Computers are computers that exhibit features of analog computers and digital computers. The digital component normally serves as the controller and provides logical operations, while the analog component normally serves as a solver of differential equations.
- General purpose computers are designed to meet the needs of many different applications. In these computers, the instructions needed to perform a particular task are wired permanently into the internal memory.
- Special purpose computer is designed only to meet the requirements of a particular task or application.
- A microcomputer uses a microprocessor as its Central Processing Unit. Microcomputers are tiny computers that can vary in size from a single chip to the size of a desktop model.
- A mini computer uses a microprocessor performs better than micro computers. They are large in size and costlier than micro computers. These computers are designed to support more than one user at a time.
- A mainframe computer is able to process large amount of data at very high speed. They support multi-user facility. The number of processors varies from one to six.



2.7 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: The different categories of computers on applications are:

1) General Purpose Computers
2) Special Purpose Computers

Ans. to Q. No. 2: The different categories of computers on operating principles are:

1) Analog Computers
2) Digital Computers
3) Hybrid Computers

Ans. to Q. No. 3: Hybrid Computers are computers that exhibit features of analog computers and digital computers. The digital component normally serves as the controller and provides logical operations, while the analog component normally serves as a solver of differential equations.

Ans. to Q. No. 4: Special purpose computer is designed only to meet the requirements of a particular task or application. The instructions needed to perform a particular task are permanently stored into the internal memory, so that it can perform the given task on a single command.

Ans. to Q. No. 5: The different categories of computers based on size and power are:

1) Mini Computers
2) Micro Computers
3) Mainframe Computers
4) Super computers

Ans. to Q. No. 6: Two applications of supercomputer are in:

1) In Aerospace industry– to simulate airflow around an aircraft at different speeds and altitude. This helps in producing an effective aerodynamic design for superior performance.
2) In Automobile industry– to do crash simulation of the design of an automobile before it is released for manufacturing– for better automobile design.

Ans. to Q. No. 7: A minicomputer uses a microprocessor performs better than micro computers. They are large in size and costlier than micro computers. These computers are designed to support more than one user at a time. They posses large storage capacities and operates at higher speed.

Ans. to Q. No. 8: Two properties of mainframes are:

1) They process large amount of data at very high speed.
2) They support multi-user facility. The number of processors varies from one to six.



2.8 FURTHER READING

1) Goel, A. (2010): *Computer Fundamentals*; Pearson Education India.
2) Rajaraman, V. & Adabala, N. (2014): *Fundamentals of Computers*; PHI Learning Pvt. Ltd.
3) Sinha, P. K. & Sinha, P. (2010): *Computer Fundamentals* (Vol. 4); BPB publications.



2.9 MODEL QUESTIONS

Q.1: Give the importance of special purpose computers.

Q.2: Why do we need supercomputers? How are they different from mainframes?

Q.3: How are analog computers different from digital computers? Are hybrid computers better than analog and digital computers? Give reasons explaining your answer.

Q.4: Give the basic properties that differentiate between mini, micro, mainframes and supercomputers.

Q.5: Why do we need general purpose computers? Give its two applications.

Q.6: Give two examples where analog and digital computers are used.

*** ***** ***

UNIT 3: BASIC COMPONENTS OF COMPUTER

UNIT STRUCTURE

3.1 Learning Objectives

3.2 Introduction

3.3 Main Components of a Computer System

3.4 Input Unit

3.5 Output Unit

3.6 Storage Unit

3.7 Central Processing Unit

- 3.7.1 Control Unit
- 3.7.2 Arithmetic Logic Unit

3.8 Let Us Sum Up

3.9 Answers To Check Your Progress

3.10 Further Reading

3.11 Model Questions

3.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- draw block diagram of a computer
- describe input and output unit of a computer
- explain different components of the storage unit
- explain the role of CPU, ALU and CU of a computer.

3.2 INTRODUCTION

The previous two units were introductory units on computers. They includes the evolution and generations of computers. It also discusses the characteristics of computers along with their classification and applications.

In this unit, we will discuss basic computer organization, which includes the description of different components of a computer system. Any computer consists of some basic components that define its overall structure and organization. Internal architecture of computers differs from one system

model to another. However, the basic organization remains the same for all computer systems.

3.3 MAIN COMPONENTS OF COMPUTER SYSTEM

The major building blocks (or functional units) of a computer system are input unit, output unit, processing unit and the memory. These units correspond to the basic operations performed by all computer system. The block diagram of a basic computer organization is shown in the following Figure 3.1.

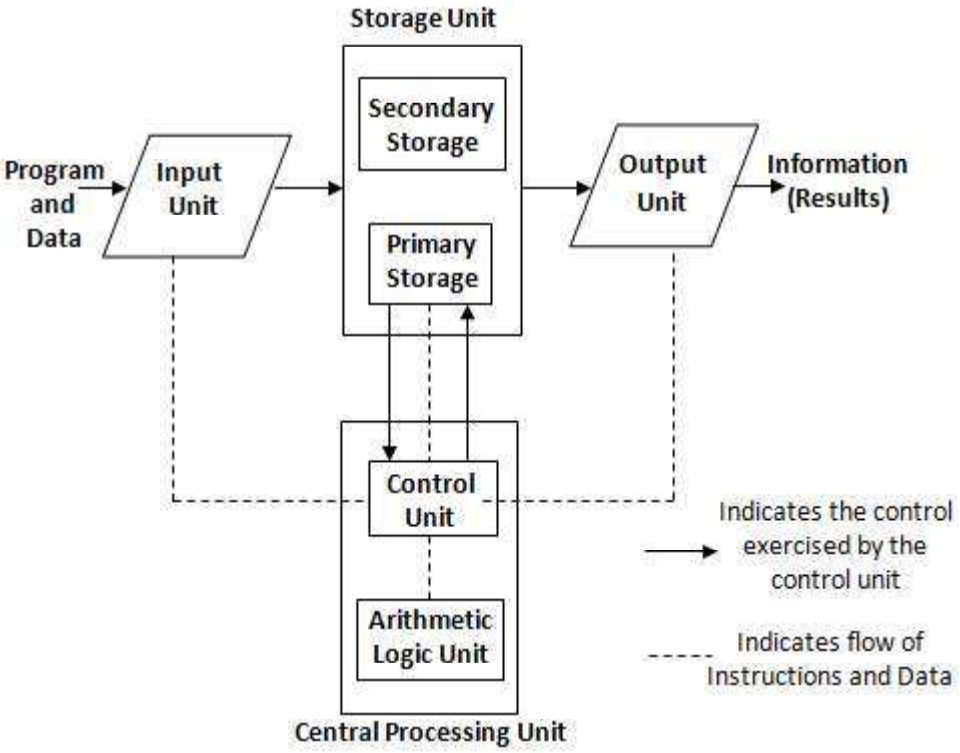


Fig. 3.1 : Basic Organization of a Aomputer System

The five basic operations for converting raw input data into useful information are inputting, storing, processing, outputting and controlling.

3.4 INPUT UNIT

The input unit of a computer system consists of the input devices like keyboard, mouse, scanner, microphone etc. Any unit that brings data into the computer is called an input unit. Following are some of the names of input devices:

- Keyboard
- Mouse
- Joystick
- Light pen
- Track Ball
- Scanner
- Graphic Tablet
- Microphone
- Magnetic Ink Card Reader (MICR)
- Optical Character Reader (OCR)
- Bar Code Reader
- Optical Mark Reader

- **Keyboard:** The keyboard is the most common and very popular input device. It helps in entering data to the computer. The layout of the keyboard is like that of a traditional typewriter, although there are some additional keys provided for performing some additional functions.

  Keyboards are of two sizes 84 keys or 101/102 keys. But now, 104 keys or 108 keys keyboard is also available for Windows and Internet. The keys in a keyboard are:

Keys	Description
Typing Keys	These keys include the letter keys A to Z and digits keys 0 to 9 which generally give the same layout as that of typewriters.
Numeric Keypad	It is used to enter numeric data or cursor movement. Generally, it consists of a set of 17 keys that are laid out in the same configuration used by most adding machines and calculators.
Function Keys	The twelve function keys are present on the keyboard. These are arranged in a row along the top of the keyboard. Each function key has a unique meaning and is used for some specific purpose.
Control keys	These keys provide cursor and screen control. It includes four directional arrow key. Control keys also include Home, End, Insert, Delete, Page Up, Page Down, Control (Ctrl), Alternate (Alt), Escape (Esc).

Special Purpose Keys	The keyboard also contains some special purpose keys such as Enter, Shift, Caps Lock, Num Lock, Space bar, Tab, and Print Screen.



Fig. 3.2 : A keyboard

- **Mouse:** The mouse is the most popular pointing and cursor-control input device. Generally, it has two buttons called left and right buttons and a scroll bar is present at the middle. The mouse can be used to control the position of the cursor on screen, but it cannot be used to enter text into the computer.



Fig. 3.3: A Mouse

Advantages :

- Easy to use.
- Not very expensive.
- Moves the cursor faster than the arrow keys of the keyboard.

- **Joystick:** The joystick is also a pointing device, which is used to move the cursor position on a monitor screen. It is a stick having a spherical ball at its both lower and upper ends. The lower spherical ball moves in a socket. The joystick can be moved in all four directions.

  The function of a joystick is similar to that of a mouse. It is mainly used in Computer Aided Designing (CAD) and playing computer games.



Fig. 3.4 : A Joystick

- **Light Pen:** The light pen is a pointing device, which is similar to a pen. It is used to select a displayed menu item or draw pictures on the computer screen. It consists of a photocell and an optical system placed in a small tube.

  When the light pen's tip is moved over the computer screen and the pen button is pressed, its photocell sensing element detects the screen location and sends the corresponding signal to the CPU.

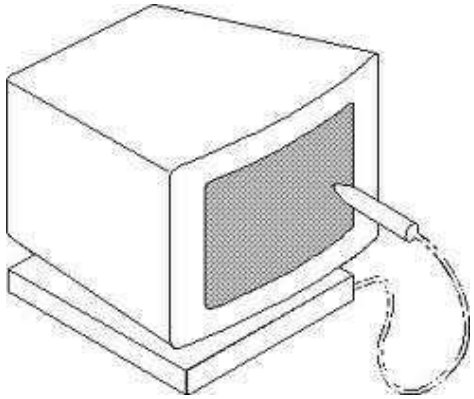


Fig. 3.4: A Joystick

- **Track Ball:** The track ball is an input device that is mostly used in a notebook or a laptop computer, instead of a mouse. This is a ball, which is half inserted and by moving fingers on the ball, the pointer can be moved.

  Since the whole device is not moved, a track ball requires less space than a mouse. A track ball comes in various shapes like a ball, a button and a square.



Fig. 3.6: A Trackball

- **Scanner:** The scanner is an input device, which works more like a photocopy machine. It is used when some information is available on a paper and it is to be transferred to the hard disc of the computer for further manipulation.

A scanner captures images from the source which are then converted into the digital form that can be stored on the disc. These images can be edited before they are printed.



Fig. 3.7: A Scanner

- **Digitizer:** The digitizer is an input device, which converts information from analog to digital form. A digitizer can convert a signal from the television camera into a series of numbers that could be stored in a computer. They can be used by the computer to create a picture of whatever the camera had been pointed at.



Fig. 3.8: A Digitizer

- **Microphone:** The microphone is an input device to add input sound that is then stored in digital form. The microphone is used for various applications like adding sound to a multimedia presentation or for mixing music.



Fig. 3.9: A Microphone

- **Magnetic Ink Card Reader (MICR):** The MICR is generally used in banks because of a large number of cheques to be processed everyday. The bank's code number and cheque number are printed on the cheques with a special type of ink that contains particles of magnetic material that are machine readable.

  This reading process is called Magnetic Ink Character Recognition (MICR). The main advantage of MICR is that it is fast and less error prone.



Fig. 3.9: A Microphone

- **Optical Character Reader (OCR):** The OCR is an input device used to read a printed text. An OCR scans text optically character by character, converts them into a machine readable code and stores the text on the system memory.



Fig. 3.10: An Optical Character Reader

- **Bar Code Readers:** Bar Code Reader is a device used for reading bar coded data (data in form of light and dark lines). Bar coded data is generally used in labelling goods, numbering the books, etc. It may be a hand-held scanner or may be embedded in a stationary scanner.

Bar Code Reader scans a bar code image, converts it into an alphanumeric value, which is then fed to the computer to which bar code reader is connected.



Fig. 3.11: A Bar Code Reader

- **Optical Mark Reader (OMR):** OMR is a special type of optical scanner used to recognize the type of mark made by pen or pencil. It is used where one out of a few alternatives is to be selected and marked. It is specially used for checking the answer sheets of examinations having multiple choice questions.



Fig. 3.12: An Optical Mark Reader

3.5 OUTPUT UNIT

The purpose of the output unit of a computer system is to transfer output data from the computer system to the user. The following are a few of the important output devices, which are used in computer systems:

- Monitor
- Printer
- Graphic Plotter

- **Monitor:** The monitor commonly called as Visual Display Unit (VDU) is the main output device of a computer. It forms images from tiny dots, called pixels, which are arranged in a rectangular form. The

sharpness of the image depends upon the number of the pixels. There are two kinds of viewing screen used for monitors:

- Cathode-Ray Tube (CRT)
- Flat-Panel Display

Cathode-Ray Tube (CRT) Monitor: In the CRT, display is made up of small picture elements called pixels for short. The smaller the pixels, the better the image clarity or resolution. It takes more than one illuminated pixel to form whole character. A finite number of characters can be displayed on a screen at once. The screen can be divided into a series of character boxes– fixed location on the screen where a standard character can be placed. Most screens are capable of displaying 80 characters of data horizontally and 25 lines vertically. The two main disadvantages of CRT are:

- Large in size,
- High power consumption



Fig. 3.13: A CRT Monitor

Flat-Panel Display Monitor : The flat-panel display refers to a class of video devices that have reduced volume, weight and power requirement compared to the CRT. Current uses for flat-panel displays include calculators, video games, monitors, laptop computer, graphics display. The flat-panel displays are divided into two categories: emissive and non-emissive display.

- **Emissive Displays:** Emissive displays are devices that convert electrical energy into light. For example, plasma panel and Light-Emitting Diodes (LED).

- **Non-Emissive Displays:** Non-emissive displays use optical effects to convert sunlight or light from some other source into graphics patterns. For example, Liquid-Crystal Device (LCD).



Fig. 3.14: A Flat-Panel Display Monitor

- **Printers:** The printer is the most important output device, which is used to take printout of our document. There are two types of printers:
  - Impact Printers
  - Non-Impact Printers



Fig. 3.15: A Printer

- **Impact Printers:** The printers that print the characters by striking against the ribbon and onto the paper are called impact printers. Some of the characteristics of impact printers are as follows:
  i) Very low consumable costs
  ii) Impact printers are very noisy
  iii) Useful for bulk printing due to low cost

  Examples of impact printers are:
  - Dot Matrix Printer (DMP)
  - Daisy Wheel
  - **Dot Matrix Printer:** In the market, one of the most popular printers is Dot Matrix Printer because of their ease of printing

features and economical price. Each character printed is in form of pattern of Dot's and head consists of a Matrix of Pins of size (5*7, 7*9, 9*7 or 9*9) which comes out to form a character that is why it is called Dot Matrix Printer.

Advantages:

- Inexpensive.
- Widely used.
- Other language characters can be printed.

Disadvantages:

- Slow Speed.
- Poor Quality.

- **Daisy Wheel:** Head is lying on a wheel and Pins corresponding to characters are like petals of Daisy (flower name) that is why it is called Daisy Wheel Printer. These printers are generally used for word-processing in offices which require a few letters to be sent here and there with very nice quality representation.

  Advantages:

  - More reliable than DMPs.
  - Better quality.
  - The fonts of character can be easily changed.

  Disadvantages:

  - Slower than DMPs.
  - Noisy.
  - More expensive than DMPs.

- **Non-impact Printers:** The printers that print the characters without striking against the ribbon and onto the paper are called Non-impact Printers. Some of the characteristics of non-impact printers are as follows:

  i) Faster than impact printers
  ii) They are not noisy
  iii) High quality
  iv) Support many fonts and different character size

Non-impact printers are of two types:

- Laser Printers
- Inkjet Printers
- **Laser Printers:** Laser printers use laser lights to produce the dots needed to form the characters to be printed on a page.

  Advantages:

  – Very high speed
  – Very high quality output
  – Gives good graphics quality
  – Supports many fonts and different character sizes.

  Disadvantage:

  – Expensive.
  – Cannot be used to produce multiple copies of a document in a single printing.
- **Inkjet Printers:** Inkjet printers are non-impact character printers based on a relatively new technology. They print characters by spraying small drops of ink onto paper. Inkjet printers produce high quality output with presentable features. They make less noise because no hammering is done and these have many styles of printing modes available. Colour printing is also possible. Some models of Inkjet printers can produce multiple copies of printing also.

  Advantages:

  – Expensive.
  – High quality printing.
  – More reliable.

  Disadvantages:

  – Expensive as cost per page is high.
  – Slow as compared to laser printer.

- **Plotter:** A plotter is a special kind of output device that is designed to produce large drawings or images, such as construction plans for buildings or blueprints for mechanical objects. A plotter can be

connected to the port normally used by a printer. Plotters were used in applications such as computer-aided design (CAD), though they have generally been replaced with wide-format conventional printers. An array of different colored pens in a clip rack and a robotic arm is part a plotter. The instructions that a plotter receives from a computer consist of a color, and beginning and ending coordinates for a line. With that information, the plotter picks up the appropriate pen through its arm, positions it at the beginning coordinates drops the pen down to the surface of the paper and draws to the ending coordinates. Plotters draw curves by creating a sequence of very short straight lines. Plotters usually come in two designs:

1) **Flat Bed:** Plotters of small size to be kept on table with restriction of paper size.
2) **Drum:** These plotters are of big size using rolls of paper of unlimited length.



Fig. 3.16: Plotter

3.6 STORAGE UNIT

In practice, almost all computers use a storage hierarchy, which puts fast but expensive and small storage options close to the CPU and slower but larger and cheaper options away from the CPU. Often the fast, volatile technologies are referred to as “memory”, while slower permanent technologies are referred to as “storage”, but these terms can also be used interchangeably.

Computer memory is the storage space in computer where data is to be processed and instructions required for processing are stored. The memory is divided into a large number of small parts. Each part is called cell. Each location or cell has a unique address. For example, if a computer has 64k words, then this memory unit has 64*1024=65536 memory locations.

The address of these locations varies from 0 to 65535. Computer memory can be divided into the following categories:

- Primary or Main Memory
- Secondary Memory
- **Primary Memory:** Primary memory also termed as main memory holds only those data and instructions on which the computer is currently working. It has limited capacity. It is generally made up of semiconductor devices. Primary memory is further divided into two subcategories RAM and ROM.
- **Secondary Memory:** Secondary memory, also termed as external memory/auxiliary memory/secondary storage does not lose the data when the device is powered down. Hence, it is non-volatile.These are used for storing data permanently. It is slower than primary memory. Another difference from primary storage in that it is not directly accessible by the CPU, they are accessed via the input/ output channels. The most common form of secondary memory devices used in computer systems is optical disks (CD/DVD), magnetic disks (hard disk drive) and flash drives.

  We will discuss computermemory in details in Unit 4.



CHECK YOUR PROGRESS

Q.1: Fill in the blanks:

a) The purpose of input unit is to input ..... or ..... into the system.

b) ..... is an input device that is mostly used in notebook or laptop computer.

c) A ..... captures images from the source which are then converted into the ..... form that can be stored on the disc.

d) ..... is an input device, which converts analog information into a digital form.

e) ..... is an input device to input sound that is then stored in digital form.

f) ..... is a device used for reading bar coded data.

g) In the CRT, display is made up of small picture elements called .....

h) The printers that print the characters by striking against the ..... and onto the paper, are called ..... printers.

i) ..... Printers are printers, which print one character at a time.

j) ..... printers print characters by spraying small drops of ink onto paper.

3.7 CENTRAL PROCESSING UNIT

Central Processing Unit (CPU) can be regarded as the brain of a computer system. It is used to process much of the information needed by the computer, just like our brain thinks and processes information and gives orders to our other body parts. It is also known as processor. All major calculations and comparisons performed by a computer are carried out inside its CPU. CPU activates and controls the operations of other units of a computer system. In terms of computing power, the CPU is the most important element of a computer system. A computer can have more than one processor. Two typical components of a CPU are:

- **Control Unit (CU)** and
- **Arithmetic Logic Unit (ALU)**

When entire CPU (both CU and ALU) is contained on a single tiny silicon chip, it is called a microprocessor. Every CPU has the ability to execute a set of machine instructions called its instruction set. Each CPU (processor) has a unique instruction set and machine language programs written for a particular computer will not run on another computer with a different CPU.

3.7.1 Control Unit

A **Control Unit (CU)** is the circuitry that directs operations within a computer system. It obtains instructions from a program stored in main memory, interprets the instructions and issues signals

that cause other units of the system to execute them. It has some special purpose registers and a decoder to perform these activities. **Registers** are a special high speed storage area within the CPU. The decoder has necessary circuitry to decode and interpret the meaning of every instructions supported by the CPU. The control unit performs the tasks of fetching, decoding, managing execution and, finally, storing results.

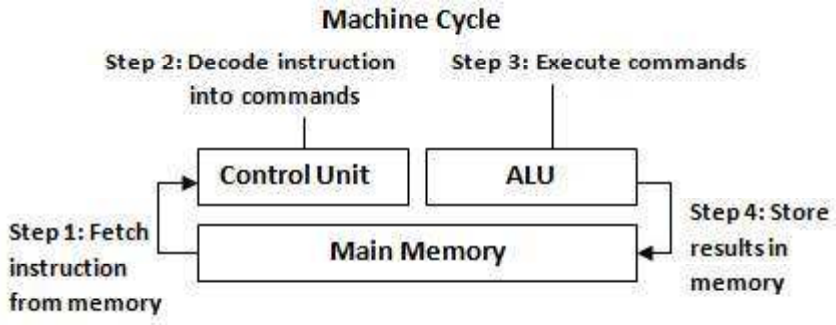


Fig. 3.17: The Control Unit

The control unit does not perform any actual processing of data but it acts as the central nervous system for all other components of the computer. Thus, it manages and coordinates the entire computer system including its input and output units.

3.7.2 Arithmetic Logic Unit

During data processing operation, the actual execution of instructions takes place in ***Arithmetic Logic Unit (ALU)*** of a CPU. When the control unit (CU) encounters an instruction that involves an arithmetic operation (such as addition, subtraction, multiplication, division) or a logic operation (such as less than, equal to, greater than etc.) it passes control to the ALU. The ALU also contain some special purpose registers and necessary circuitry to carry out all arithmetic and logic operations included in the set of instructions.

Registers are used to hold information on a temporary basis and are part of the CPU. They are also used to speed up the execution of instructions by providing quick access to commonly needed values-typically, the values being in the midst of a calculation

at a given point in time. Registers are normally measured by the number of bits they can hold, for example, an “8-bit register”. Most CPUs available today have 32-bit or 64-bit registers. The length of registers of a computer is sometimes called its word size. The bigger the word size, the faster a computer can process a set of data.



CHECK YOUR PROGRESS

Q.2: State whether TRUE or FALSE:

a) The ALU does not have direct input and output access to the processor controller, main memory, and input/ output devices.

b) Inputs and outputs flow along an electronic path that is called a bus.

c) The operation code tells the ALU what operation to perform and the operands are used in the operation.

d) The functions that a control unit performs does not depend on the type of CPU.

e) The control unit implements the instruction set of the CPU.



3.8 LET US SUM UP

- The ***Input Unit*** of the computer system consists of the input devices.
- The purpose of the ***Output Unit*** of a computer system is to output data from the computer system to the user.
- The ***Storage Unit*** of a computer system consists of the various storage devices that are used to store data in a computer system.
- ***Primary Memory*** holds only those data and instructions on which computer is currently working.
- A ***Central Processing Unit (CPU)*** is the hardware within a computer that carries out the instructions of a computer program by performing the basic arithmetical, logical, and input/output operations of the system.

- An ***Arithmetic-Logic Unit (ALU)*** is the part of a computer processor (CPU) that carries out arithmetic and logic operations on the operands in computer instruction words.
- A ***Control Unit*** is the circuitry that directs operations within the computer's processor by directing the input and output of a computer system.



3.9 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: a) data, information, b) Track ball, c) scanner, digital, d) digitizer, e) microphone, f) bar code reader, g) pixels, h) ribbon, impact, i) character, j) inkjet

Ans. to Q. No. 2: a) False, b) True, c) True, d) False, e) True



3.10 FURTHER READING

1) Mano, M. M. (1993): Computer System Architecture; Prentice Hall, 3, 299.
2) Rajaraman, V. & Adabala, N. (2014): *Fundamentals of Computers*; PHI Learning Pvt. Ltd.
3) Sinha, P. K. & Sinha, P. (2010): *Computer Fundamentals* (Vol. 4); BPB publications.



3.11 MODEL QUESTIONS

Q.1: Define the Input unit of a computer. Discuss some input devices of a computer system.

Q.2: Define output unit of a computer system. Discuss any five output devices of a computer system.

Q.3: What is storage unit of a computer system?

Q.4: What is computer memory and how are they classified?

Q.5: What are registers? What does length of a register mean?

Q.6: Discuss the role of ALU of a computer system.

Q.7: What are the two main components of CPU of a computer system? List the main functions of each of these components.

Q.8: Write down the role of Central Processing Unit of a computer system.

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UNIT 4 : COMPUTER PRIMARY MEMORY

UNIT STRUCTURE

4.1 Learning Objectives

4.2 Introduction

4.3 Memory Representations

4.4 Memory Hierarchy

4.5 CPU Registers

4.6 Primary Memory

- 4.6.1 Random Access Memory
- 4.6.2 Read Only Memory

4.7 Secondary Memory

4.8 Cache Memory

4.9 Virtual Memory

4.10 Let Us Sum Up

4.11 Answers to Check Your Progress

4.12 Further Reading

4.13 Model Questions

4.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- define how memory is represented in computers
- learn about memory hierarchy
- describe the role of CPU registers
- state usefulness of cache memory and virtual memory
- learn about primary memory and secondary memory
- describe RAM and ROM.

4.2 INTRODUCTION

In the previous unit we discussed some hardware components that are essential for a computer system. In this unit we will discuss representation of memory in a computer system and memory hierarchy. Here, we will also discuss primary memory elaborately.

A memory system is a hierarchy of storage devices with different capacities, costs, and access times. Memory hierarchies work because well-written programs tend to access the storage at any particular level more frequently than they access the storage at the next lower level. So the storage at the next level can be slower, and thus larger and cheaper per bit. The overall effect is a large pool of memory that costs as much as the cheap storage near the bottom of the hierarchy, but that serves data to programs at the rate of the fast storage near the top of the hierarchy.

4.3 MEMORY REPRESENTATIONS

Binary digit (or bit) is the smallest unit of memory. A bit is the basic unit of representation of data in a computer. A bit can have only two possible states: 1 or 0. As humans, we may find it useful to think of this in terms of "yes or no", "true or false", "on or off", and so on.

Most computers do not work with bit individually, but instead group 8 bits together to form a byte. One byte can store 2^8, i.e., 256 different combinations of bits, and thus can be used to represent 256 different symbols. In a byte, the different combinations of bits fall in the range 00000000 to 11111111. A group of bytes can be further combined to form a word. A word can be a group of 2, 4 or 8 bytes.

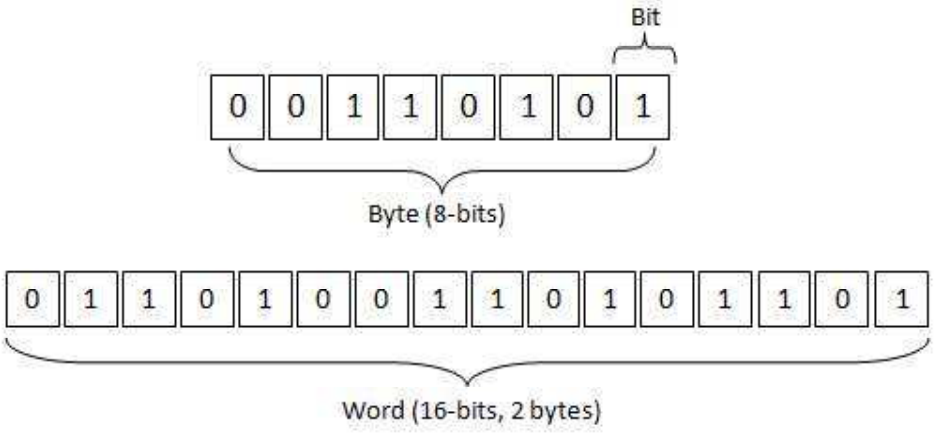


Fig. 4.1: Bit and bytes

One byte = grouping of 8 bits.

For example, 0 1 0 0 0 0 0 1. This one byte can store one letter, e.g., 'A'. The relationship between bit and byte is given below:

1 bit = 0 or 1

1 Byte = 8 bits

1 Kilobyte (KB) = 2^{10} = 1024 Bytes

1 Megabyte (MB) = 2^{20} = 1024 KB

1 Gigabyte (GB) = 2^{30} = 1024 MB = 1024 *1024 KB

1 Terabyte (TB) = 2^{40}= 1024 GB = 1024 * 1024 *1024 KB

1 Petabyte (PB) =2^{50}=1024 TB =1024 * 1024 * 1024 * 1024 KB

The main memory consists of many memory locations, each having a physical address, a code, which the CPU (or other device) can use to access it. For a processor, the range of the memory address is 0 to the maximum size of memory. Figure. 4.2 shows the organization of a 16 MB block of memory for a processor with a 32-bit word length.

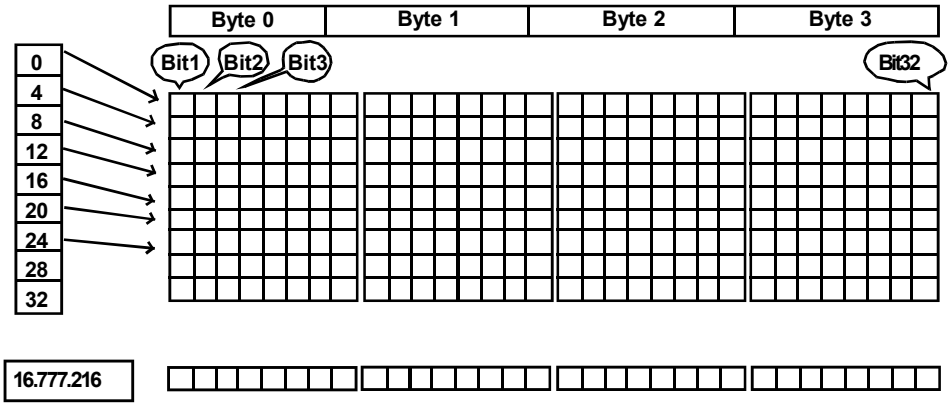


Fig. 4.2: Organization of a 16 MB Block Memory

4.4 MEMORY HIERARCHY

Memory is characterized on the basis of two key factors—storage capacity and access time. Storage capacity is the amount of information (in bits) that a memory can store. Access time is the time required to locate and retrieve stored data from the memory unit in response to a program instruction. The lesser the access time, the faster is the speed of memory. Ideally, the memory with fast access time and large capacity is preferred. However, the cost of fast memory is very high.

The computer uses a hierarchy of memory that is organized in a manner to enable the fastest speed and largest capacity of memory. The hierarchy of the different memory types is shown in Fig.4.3. A memory

hierarchy in computer storage distinguishes each level in the hierarchy by response time.

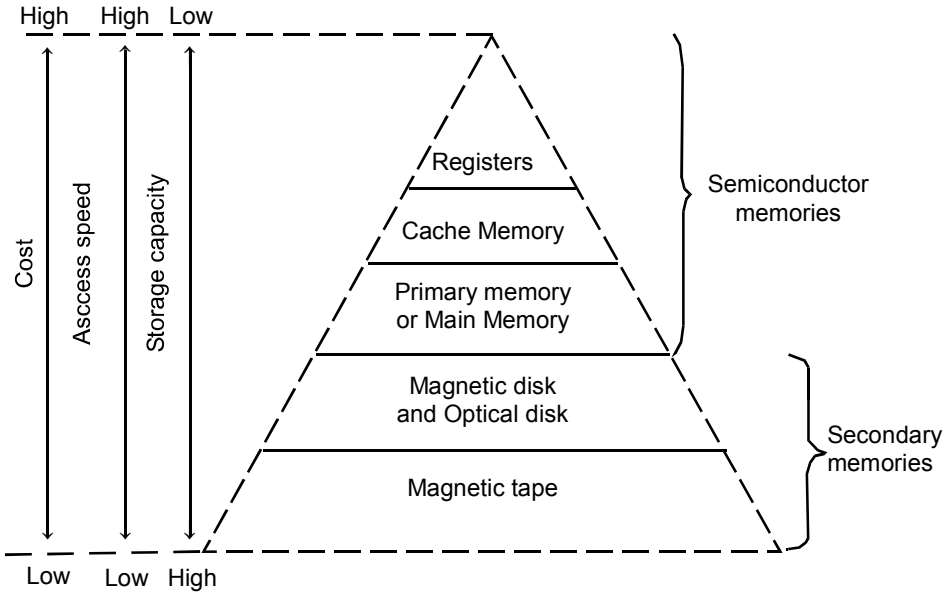


Fig. 4.3: Memory Hierarchy

We can categorize the memory used in a computer as internal and external memory. The internal memory consists of the CPU registers, cache memory and primary memory. The internal memory is used by the CPU to perform the computing tasks.

4.5 CPU REGISTERS

We have heard about CPU registers in Unit 2. A register is a very fast computer memory used to speed up the execution of computer programs by providing quick access to commonly used values inside the CPU. CPU registers are the top of the memory hierarchy, and are the fastest way for the system to manipulate data. In a very simple microprocessor, it consists of a single memory location, usually called an accumulator. Registers are built from fast multi-ported memory cell. The result of ALU operation is stored in registers and could be re-used in a subsequent operation or saved into memory. We have already learnt that registers are usually measured by the number of bits that they can hold. For example, 8-bit register, 32-bit register etc.

Although, the number of registers varies from computer to computer, there are some registers common to all computers. There registers with their role are described below:

a) **Accumulator (A):** It is the most frequently used register. It holds the data to be operated upon, the intermediate results, and the results of processing. It is used during execution of most instructions. Results of arithmetic operations are returned to accumulator register for transfer to main memory through the memory buffer register (MBR). In some computers, there is more than one accumulator.

b) **General Purpose Registers:** General purpose registers are used to store data and intermediate results during program execution. Its contents can be accessed through assembly language programming.

c) **Special Purpose Registers:** Users do not access these registers. These are used by the computer system at the time of program execution. Some types of special purpose registers are given below:

   1) **Memory Address Register (MAR):** It holds the address of the active memory location.

   2) **Memory Buffer Register (MBR):** It holds the contents of the accessed (read/written) memory word. An instruction word placed in this register is transferred to the instruction register. A data word placed in this register is accessible for operation with accumulator register or for transfer to I/O register. A word to be stored in a memory location must be transferred first to MBR from where it is written in memory.

   3) **Instruction Register (IR):** It holds the current instruction being executed. As soon as the instruction is stored in this register, the operation part and the address part of the instruction are separated. The address part of the instruction is sent to MAR while its operation part is sent to control unit. In control unit the operation part is decoded and interpreted. Finally, the CU generates command signals for execution of the task specified in the instruction.

   4) **Program Counter (PC):** It holds the address of the next instruction to be executed. Normally, the instructions of a program are stored

in consecutive memory locations, and are executed in sequence unless a branch instruction is encountered.

5) **Input/output Register (I/O):** It is used to communicate with input/ output devices.



CHECK YOUR PROGRESS

Q.1: Fill in the blanks:

a) A group of 8 bits form a .....

b) Memory is organized as a linear ..... of locations.

c) A memory hierarchy in computer storage distinguishes each level in the hierarchy by .....

d) ..... is the amount of information that a memory can store.

e) ..... is the time interval between the read/write request and the availability of data.

f) A CPU .....is a very fast computer memory used to speed up the execution of computer programs.

g) ..... registers are used to store data and intermediate results during program execution.

4.6 PRIMARY MEMORY

Primary memory (or main memory) is the area of a computer from which the processor can store and retrieve data very quickly. It is active only while the computer is switched on. Every computer should have a primary memory which is a temporary storage area built into the computer hardware. Instructions and data of a program reside mainly in this area when CPU is executing the program. The rate of data fetching from primary memory is about 100 times faster than that from a high speed secondary storage like disk.

Physically, primary memory consists of some integrated circuit (IC) chips either on the motherboard or on a small circuit board attached to the motherboard of a computer system. Primary memory is made up of several

small storage areas called locations or cells. Each of these locations can store a fixed number of bits called word length of the memory. Each word or location has a built-in and unique number assigned to it. This number is called the address of the location and is used to identify the location. For example, if a memory has 1024 locations, then the address ranges from 0 to 1023. We have also heard about 8-bit computers, 16-bit computers, 32-bit computers, 64-bit computers, etc. The numbers refer to the total numbers of bits per memory word. More bits mean more rapid flow of electronic signal and this implies a faster computer. Main memory capacity is defined in terms of number of bytes a computer system can store.

There are two main categories of primary memory. These are:

- **Random Access Memory** (RAM), and
- **Read Only Memory** (ROM)



Fig. 4.4: RAM and ROM

4.6.1 Random Access Memory

Random Access Memory (RAM) is used to store data and instructions during the operation of a computer. The data and instructions that need to be operated upon by the CPU are first brought to RAM from the secondary storage devices like the hard disk. RAM loses its information when the computer is powered off. It is a type of volatile memory. When the power is turned on again, all the files that are required by the CPU are loaded from the hard disk to RAM. Since RAM is volatile memory, any information that needs to be saved for a longer duration of time must not be stored

in RAM. RAM provides random access to the stored bytes, words, or larger data units. This means that it requires the same amount of time to access information from RAM, irrespective of where it is located inside it. The size of RAM is limited due to its high cost. The size of RAM is measured in Megabytes or Gigabytes. The performance of RAM is affected by–

- Access speed (how quickly information can be retrieved). The speed of RAM is expressed in nanoseconds.
- Data transfer unit size (how much information can be retrieved in one request).

RAM typically contains portions of the operating system as well as applications and data in active or frequent use. A part of the operating system is loaded in the primary memory when the computer is turned on, and it stays there until the computer is turned off. RAM is also used for the temporary storage of input data, output data and intermediate results. The input data entered into the computer using the input device is stored in RAM for processing. After processing, the output data is stored in RAM before being sent to the output device. Any intermediate results generated during the processing of program are also stored in RAM.

RAM affects the speed and power of a computer. The more the amount of RAM available in a machine the better is its performance. Now a days computers with 1GB, 2GB, 4 GB or more are available in the market.

4.6.2 Read Only Memory

Read Only Memory (ROM) is a non-volatile memory chip in which data is stored permanently and cannot be altered by usual programs. Once data has been written onto a ROM chip, it cannot be removed/changed and can only be read. This is the reason why it is called read-only memory (ROM). ROM comes programmed by the manufacturer so that they cannot be modified by the users. ROM stores special micro-programs that permanently reside inside it.

A good example of micro-program is "system boot program" which contains a set of start-up instructions to check if the system hardware like memory, I/O devices, etc. is functioning properly. It looks for an operating system and loads its core part in the volatile RAM of the system to produce the initial display-screen prompt. ROM stores the data needed for the start up of the computer.

ROM is categorized in the following two ways:

- **Manufacturer-programmed** and
- **User-programmed**

Manufacturer-programmed ROM chips are supplied by the manufacturers of electronic devices and it is not possible for a user to modify the programs or data stored in ROM chip.

On the other hand, a user-programmed ROM is one in which a user can load and store read-only programs and data. Such a ROM is commonly known as ***Programmable Read-Only Memory (PROM)*** because a user can program it. Once a user's programs are stored in a PROM chip, PROM becomes a ROM. Contents of ROM and PROM cannot be altered. In ***Erasable Programmable Read-Only Memory (EPROM),*** it is possible to erase information stored in an EPROM chip and the chip can be reprogrammed to store new information. A content of EPROM can be erased by exposing it to ultra violet light and reprogramming it.



CHECK YOUR PROGRESS

Q.2: Fill in the blanks:

a) ..... memory transparently stores data so that future requests for that data can be served faster.

b) Hardware implements cache as a block of memory for ..... of data likely to be used again.

c) ..... loses its information when the computer is powered off.

d) The more the amount of RAM available in a machine the better is its .....

e) ..... is defined as the computer memory on which data has been prerecorded.

4.7 SECONDARY MEMORY

Secondary Memory, also known as secondary storage, auxiliary memory or external memory is used primarily to store large volumes of data on permanent basis for a longer period of time in a computer system. Those data can be partially transferred to primary storage whenever required for processing. Secondary storage does not lose any data when the computer is powered down. It is non-volatile and has lower cost per bit stored as compared to primary storage. But it generally has an operating speed far slower than that of primary storage. Secondary storage differs from primary storage since it is not directly accessible by the CPU.

The most common form of auxiliary memory devices used in consumer systems is flash memory, optical discs, and magnetic disks.

4.8 CACHE MEMORY

Fetching of data by the CPU from the main memory is about 100 times faster than that from a secondary storage like disk. Main memory helps in minimizing the mismatched of processor-disk speed to a large extent. Even with the use of main memory, there is a mismatch of speed between the processor and memory. The rate at which the data can be fetched from memory is about 10 times slower than the rate at which CPU can process data.

Cache memory is used to overcome this problem. It minimizes the processor-memory speed mismatch. Cache memory is an extremely fast, small memory between CPU and main memory whose access time is closer to the processing speed of CPU. It is used to temporarily store very active data and instructions during processing. It is made up of static RAM and it acts as high-speed buffer between CPU and main memory.

4.9 VIRTUAL MEMORY

Virtual memory is a memory management technique that is implemented using both hardware and software. It maps memory addresses used by a program, called virtual addresses, into physical addresses in computer memory. Main storage as seen by a process or task appears as a contiguous address space or collection of contiguous segments. The operating system manages virtual address spaces and the assignment of real memory to virtual memory. Address translation hardware in the CPU, often referred to as a memory management unit or MMU, automatically translates virtual addresses to physical addresses. The primary benefits of virtual memory include freeing applications from having to manage a shared memory space, increased security due to memory isolation, and being able to conceptually use more memory than might be physically available, using the technique of paging.



4.10 LET US SUM UP

- ***Primary memory*** is the area of a computer from which the processor can access data quickly.
- ***Computer memory*** stores different kinds of data like input data, output data, intermediate results, etc., and the instructions.
- The ***internal memory*** and ***external memory*** are the two broad categories of memory used in the computer.
- ***Registers*** are built from fast multi-ported memory cell.
- ***RAM i***s used to store data and instructions during the operation of a computer.
- ***RAM*** can be read from and written to with the same speed.
- Once data has been written onto a ***ROM*** chip, it cannot be removed and can only be read.
- ***Cache memory*** is a very fast memory which is used to minimize the processor-memory speed mismatch.



4.11 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: a) byte, b) array, c) response time, d) Capacity, e) Access time, f) register, g) General purpose

Ans. to Q. No. 2: a) Cache, b) temporary storage, c) RAM, d) performance, e) ROM.



4.12 FURTHER READING

1) Rajaraman, V. & Adabala, N. (2014): *Fundamentals of Computers*; PHI Learning Pvt. Ltd.
2) Sinha, P. K. & Sinha, P. (2010): *Computer Fundamentals* (Vol. 4); BPB publications.
3) Thareja, R. (2012): *Computer Fundamentals & Programming in C*; OXFORD University Press.



4.13 MODEL QUESTIONS

Q.1: Write a note on memory representation in computers.

Q.2: Describe the memory hierarchy in computers.

Q.3: What are CPU registers? Describe the different classes of registers.

Q.4: What is cache memory? Describe its usefulness.

Q.5: What is Primary Memory in a computer? Describe its functionality.

Q.6: What is the use of Random Access Memory? What are its types?

Q.7: Differentiate between Static Ram and Dynamic Ram.

Q.8: What is Read Only Memory? What are its different types?

Q.9: What is the advantage of using virtual memory?

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UNIT 5: BUSES

UNIT STRUCTURE

5.1 Learning Objectives

5.2 Introduction

5.3 Bus Structure

- 5.3.1 Address Bus
- 5.3.2 Data Bus
- 5.3.3 Control Bus

5.4 Types of Buses

- 5.4.1 ISA (Industry Standard Architecture) Bus
- 5.4.2 PCI (Peripheral Component Interconnect) Bus
- 5.4.3 EISA (Extended Industry Standard Architecture) Bus
- 5.4.4 VESA (Video Electronics Standards Association) Local Bus
- 5.4.5 MCA (Micro Channel Architecture) Bus

5.5 Let Us Sum Up

5.6 Answers to Check Your Progress

5.7 Further Reading

5.8 Model Questions

5.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- learn the concept of bus and its function
- describe internal bus and external bus system and its architecture
- define the characteristics of various buses
- describe the categories of different buses and their uses.

5.2 INTRODUCTION

A typical computer system is composed of various components such as Central Processing Unit (CPU), Memory Unit and Input/Output (I/O) devices. A bus is a common pathway or a set of wires that interconnect these various subsystems. The buses thus allow the different components to

communicate each others. Actually, a bus in a computer system is a channel or parallel lines over which information flows between units or devices. Buses that transfer several data bits at the same are called parallel buses, for example ISA, PCI, VESA are parallel buses. Serial buses use the same line to transfer the different data bits of the same byte or words for example USB. There are generally three set of parallel lines or buses that are found. These are– (i) Address Bus, (ii) Data Bus and (iii) Control Bus.

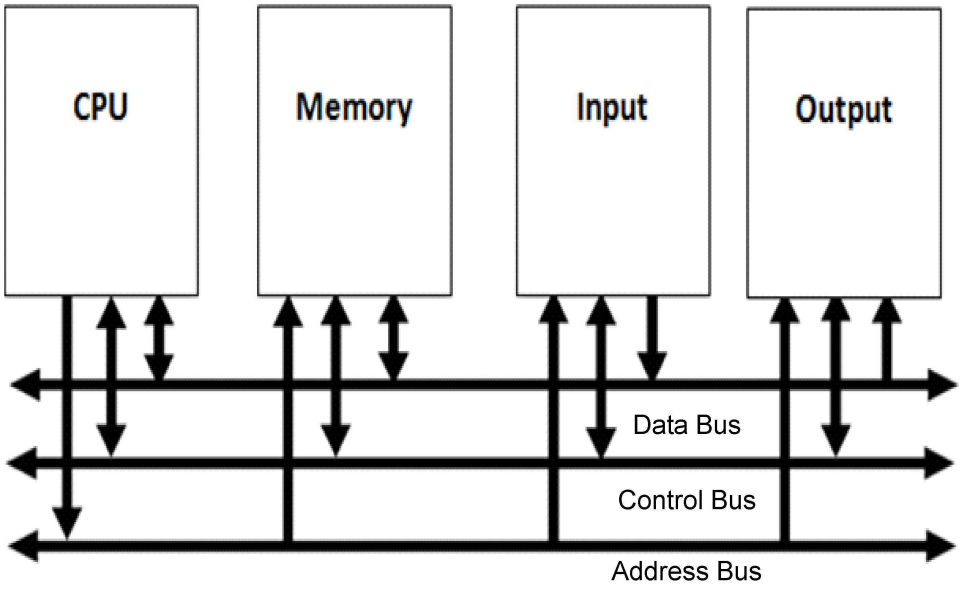


Fig. 5.1: Three Buses Architecture

5.3 BUS STRUCTURE

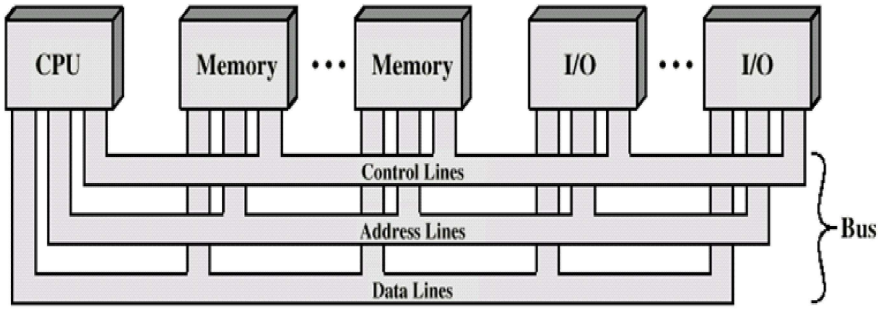


Fig. 5.2: Bus Interconnection Scheme

5.3.1 Address Bus

Through the address bus the processor issues the address of the instruction byte or word to the memory system. As CPU needs

to read an instruction or data from a given location in memory. With the help of address bus CPU identifies the source or destination of data. The bus width determines the maximum memory capacity of the computer system. For example, a 32-bits address bus fetches the instruction or data from an address specified by a 32-bit number. Some other features of address bus are:

- The address bus consists of 16, 20, 24, or 32 parallel signal lines. On these lines the CPU sends out the address of the memory location that is to be written to or read from.
- The number of memory locations that the CPU can address is determined by the number of address lines. If the CPU has N address lines, then it can directly address 2N memory locations. CPU with 16 address lines can address 65,536 memory CPU with 20 address lines can address 1,048,576 locations.
- When the CPU reads data from or writes data to a port, it sends the port address out on the address bus.

5.3.2 Data Bus

The function of a data bus is to send data from one device to another. Data is passed in a serial or a parallel manner. In serial bus communication one bit data is passed per unit time and in parallel, normally multiple of 8 bits passes per unit time. Parallel data bus is faster than the serial bus but it requires an extra handshaking line to synchronize the data transfer. Some important features of data buses are–

- The data bus consists of 8, 16, or 32 parallel signal lines. The data bus lines are bidirectional.
- Many devices in a system will have their outputs connected to the data bus, but only one device at a time will have its outputs enabled.
- Any device connected on the data bus must have three-state outputs so that its outputs can be disabled when it is not being used to put data on the bus.

5.3.3 Control Bus

The control bus issues the signal to control the timing of various actions during interconnection. Also it signals to synchronize the subsystem. Control bus control signals as per CPU design. Some other characteristics of control bus are:

- The control bus consists of 4 to 10 parallel signal lines.
- The CPU sends out signals on the control bus to enable the outputs of addressed memory devices or port devices.
- Typical control bus signals are Memory Read, Memory Write, I/O Read, and I/O Write.
- To read a byte of data from a memory location, the CPU sends out the memory address of the desired byte on the address bus and then sends out a Memory Read signal on the control bus.
- The Memory Read signal enables the addressed memory device to output a data word onto the data bus. The data word from memory travels along the data bus to the CPU.

5.4 TYPES OF BUSES

Today all computers utilize two types of buses, an internal or local bus and an external bus.

An internal bus enables a communication between internal components such as a computer video card and memory (e.g. ISA, EISA, PCI, AGP, etc.)

An external bus is capable of communicating with external components such as a SCSI bus, GPIB, etc.

A computer or devices bus speed or throughput is always measured in bits per second or megabytes per second.

A bus is not only a cable connection but also can be a hardware (bus architecture), protocol, software, and bus controller.

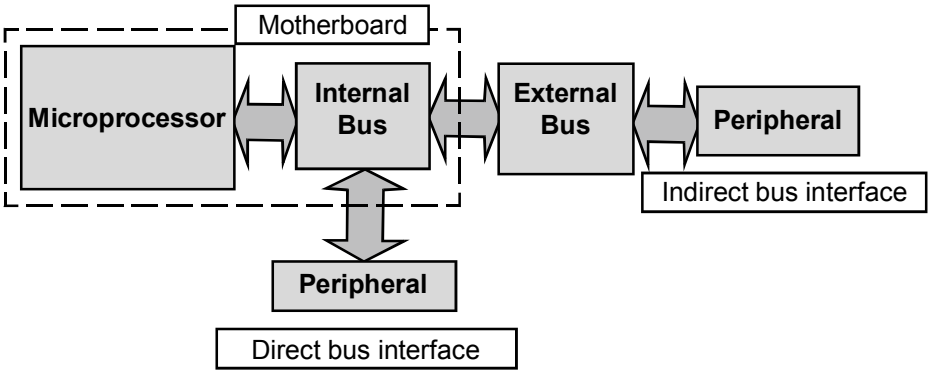


Fig. 5.3: Internal and External Bus

5.4.1 ISA (Industry Standard Architecture) Bus

Introduced by IBM, ISA or Industry Standard Architecture bus was originally an 8-bit bus that was later expanded to a 16-bit bus in 1984. In 1993, Intel and Microsoft introduced a PnP ISA bus that allowed the computer to automatically detect and setup computer ISA peripherals such as a modem or sound card.

Using the PnP technology an end-user would have the capability of connecting a device and not having to configure the device using jumpers or dipswitches.

Many manufacturers are trying to eliminate the usage of the ISA slots however for backwards compatibility you may find 1 or 2 ISA slots with additional PCI slots.

5.4.2 PCI (Peripheral Component Interconnect) Bus

Introduced by Intel in 1992, PCI is short for Peripheral Component Interconnect and is a 32-bit computer bus that is also available as a 64-bit bus today. The PCI bus is the most commonly used and found bus in computers today.

Mini PCI is a new standard developed by leading notebook manufacturer. This technology could allow manufactures to lower their price as the motherboards would be simpler in design.

At least 3 or 4 PCI connectors are generally present on motherboards and can generally be recognized by their standardized white color.

The PCI interface exists in 32 bits with a 124-pin connector, or in 64 bits with a 188-pin connector. There are also two signaling voltage levels for PCI connectors:

i) 3.3V, for laptop computers

ii) 5V, for desktop computers

The signaling voltage does not equal the voltage of the motherboard power supply but rather the voltage threshold for the digital encryption of data.

The original version of the PCI bus is 32-bits wide and has a clock speed of 33 MHz, which allows it to theoretically provide a throughput of 132 Mb/s on 32 bits. On 64-bit architectures, the bus operates on 64 bits and offers a theoretical throughput of 264 Mb/s.

PCI-X is a high performance bus that is designed to meet the increased I/O demands of technologies such as Fiber Channel, Gigabit Ethernet and Ultra3 SCSI.

PCI-X capabilities include:

– Up to 133 MHz bus speed

– 64-Bit bandwidth

– 1GB/sec throughput

PCI-X uses register-to-register protocol and can operate at three different frequencies

i) 66 MHz

ii) 100 MHz

iii) 133 MHz

Connection between ISA and PCI Buses: One of the PCI slots is placed close to one ISA slot and share the (but not at the same time) a back-plate. Some motherboards only offer two ISA slots and as many as five PCI slots.

5.4.3 EISA (Extended Industry Standard Architecture) Bus

Short for Extended Industry Standard Architecture, EISA was announced in September of 1988. EISA is a computer bus designed by 9 competitors to compete with IBM's MCA BUS.

The EISA Bus provide 32-bit slots at an 8.33 MHz cycle rate for the use with 386DX, or higher processors.

EISA Bus never became widely used and is no longer found in computers today. EISA data transfer can reach a peak of 33 megabytes per second

5.4.4 VESA (Video Electronics Standards Association) Local Bus

VESA (Video Electronics Standards Association Local Bus) Local Bus is a standard interface between your computer and its expansion slots that provides faster data flow between the devices controlled by the expansion cards and your computer's microprocessor. A ‘‘Local Bus’’ is a physical path on which data flows at almost the speed of the microprocessor, increasing total system performance. VESA Local Bus is particularly effective in systems with advanced video cards and supports 32-bit data flow at 50 MHz. A VESA Local Bus is implemented by adding a supplemental slot and card that aligns with and augments an ISA expansion card.

VESA is a 33MHz extension of the ISA Bus used for high-speed data transfer applications. It contains 32-bit address and Data Bus and is mainly used for video and disk interfaces. It requires a third connector (VESA connector) to be added behind the standard 16-bit ISA connector.

5.4.5 MCA (Micro Channel Architecture) Bus

Short for Micro Channel Architecture i.e., MCA was introduced by IBM in 1987, The MCA Bus offered several additional features over the ISA such as a 32-bit Bus.

The MCA BUS never became widely used and has since been phased out of the desktop computers.

Table 5.1: Various Buses and its Width, Speed and Bandwidth

BUS	Width (bits)	BUS Speed (MHz)	BUS Bandwidth (Mbytes/sec.)
8-bit ISA	8	8.3	7.9
16-bit ISA	16	8.3	15.9
EISA	32	8.3	31.8
VLB	32	33	127.2
PCI	32	33	127.2
64-bit PCI 2.1	64	66	508.6
AGP	32	66	254.3
AGP (×2 mode)	32	66×2	508.6
AGP (×4 mode)	32	66×4	1,017.3



CHECK YOUR PROGRESS

Q.1: Select the correct option from the following questions:

i) Which is the example of serial bus in computer system–

a) ISA b) PCI

c) VESA d) USB

ii) The control bus consists of parallel signal lines–

a) 4 to 10 b) 8 to 16

c) 6 to 10 d) None of the above

iii) A bus which is 33MHz extension of the ISA bus used of high-speed data transfer applications–

a) VESA b) PCI

c) USB d) ISA

iv) The Bus MCA Stands for–

a) Micro Channel Architecture

b) Master Channel Architecture

c) Macro Channel Architecture

d) Mini Channel Architecture

v) The original version of the PCI bus has–

a) 16-bits wide, clock speed of 33 MHz

b) 32-bits wide, clock speed of 33 MHz

c) 64-bits wide, clock speed of 33 MHz

d) 32-bits wide, clock speed of 64 MHz

vi) The EISA bus supports–

a) 16-bits wide, clock speed of 33 MHz

b) 32-bits wide, clock speed of 33 MHz

c) 64-bits wide, clock speed of 33 MHz

d) 32-bits wide, clock speed of 8.3 MHz



5.5 LET US SUM UP

- A bus is a common pathway or a set of wires that interconnect these various sub systems. The bus thus allows the different components to communicate with each others
- There are generally three set of parallel lines or buses. These are– (i) Address Bus, (ii) Data Bus and (iii) Control Bus.
- Data bus transfer data from and to processor. Function of a data bus is to send data from one device to another.
- Address bus issues the address from processor to address memory and I/O system. Through the address bus, processor issues the address of the instruction byte or word to the memory system.
- Control bus issues the signal to control the timing of various actions during interconnection.
- An internal bus enables communication between internal components such as a computer video card and memory (e.g. ISA, EISA, PCI, AGP, etc.)



5.6 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: i) (d), ii) (a), iii) (a), iv) (c), v) (b), vi) (d)



5.7 FURTHER READING

1) Godse, A. P. & Godse, D. A. (2009): *Computer Organization*; Technical Publications.
2) Hamacher, C., Vranesic, Z. & Zaky, S. (2002): *Computer Organization*; McGraw-Hill.
3) Stallings, W. (2000): *Computer Organization and Architecture: Designing for Performance*; Pearson Education India.



5.8 MODEL QUESTIONS

Q.1: What do you mean by Bus? Explain different categories of buses in Computer architectures,

Q.2: How do internal buses differ from external buses?

Q.3: What is PCI Bus? Explain its significance in computer system.

Q.4: What are the advantages of VESA buses?

Q.5: Write short notes on the followings:

i) ISA Bus ii) USB Bus
iii) EISA Bus iv) PCI-X Bus

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UNIT 6: INTRODUCTION TO SYSTEM SOFTWARE

UNIT STRUCTURE

6.1 Learning Objectives

6.2 Introduction

6.3 Compiler

6.4 Assembler

6.5 Linker

6.6 Loader

6.7 Editor

6.8 Let Us Sum Up

6.9 Answers to Check Your Progress

6.10 Further Reading

6.11 Model Questions

6.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- describe about application software and system software
- learn about low level and high level language
- describe the translation of a high level language program into a machine level language program
- learn how a program gets executed by the computer
- describe the task performed by complier, assembler, linker, loader and editor.

6.2 INTRODUCTION

The computer system performs various tasks with the help of hardware and software. The hardware of a computer system is the part we can see and touch. On the other hand software is the set of computer code or program written to perform a particular task. These software's are broadly of two types– Application Software and System Software. Software's such

as MS Office package, Internet Browser, Oracle DBMS, MySQL etc. those take care of some real world problems are called Application Software. On the other hand, software's such as UNIX OS, Windows OS, Android OS, C Compiler etc., those help users to run the application software in the computer are called System Software.

As we know that the computer performs different tasks as commanded by the user so to provide a command or a set of commands, the user has to write a set of code or a program. The program written by the user should be understandable by the computer system so as to perform the task accordingly. The computer can understand only binary language that is the language comprising of 0s and 1s also called machine language. Thus the user has to write the program in this computer understandable machine language. Since writing programs in machine language is difficult, time consuming and not easily understandable by human users it was required to write the programs in a different language other than machine language. Those other languages are assembly language and high level languages. But the programs written in assembly language and other high level languages are not directly understandable by the computer. To solve this problem, we need assembler, compiler and interpreter. They translate assembly language and high level languages to machine understandable language.

6.3 COMPILER

The compiler is a computer program that translates source code from a high-level programming language to a lower level programming language (e.g., assembly language or machine code).

The codes generated by the compiler are machine specific (the code generated in a particular computer system does not work in other computer system). If the code generated by the compiler can be executed on a computer whose CPU or operating system is different from the one on which the compiler runs, the compiler is known as a cross-compiler.

Often the process of compiling a program includes the task of compiler, assembler and linker. During this process of compiling a program, problems

may arise which are reported to the user by compiler message. There are two types of compiler messages- Compiler Warnings and Compiler Errors. A compiler warning indicates that you have done something bad but not something that will prevent the code from being compiled. On the other hand a compiler error indicates something that must be fixed before the code can be compiled.

The compiler is a component of the language processing system as shown in Figure 6.1. In a language processing system, the source program goes through a preprocessor. For example, when we write a C program, we have a number of macros such as hash define, hash include and so on. These are passed through the preprocessor. The preprocessor expands these macros and takes appropriate action at the compiler level. This modified source code is then fed to the compiler. The compiler generates the machine code. The machine code could be in the form of an assembly code or it could be directly binary code. In the case that the machine code generated by the compiler is an assembly language program, it is fed to an assembler. The assembler converts it into the machine language of target machine.

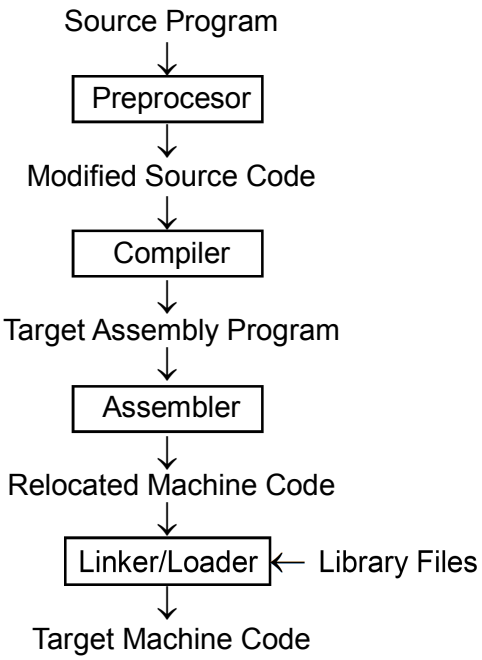


Fig. 6.1: Language Processing System

The linker or loader is needed in order to combine the modules generated by the assembler. Finally, the loader gives out a complete target machine code that can be run on a machine.

Compilation of a program proceeds through a fixed series of phases. Each phase use an (intermediate) form of the program produced by a previous phase. Subsequent phases operate on lower-level code representations.

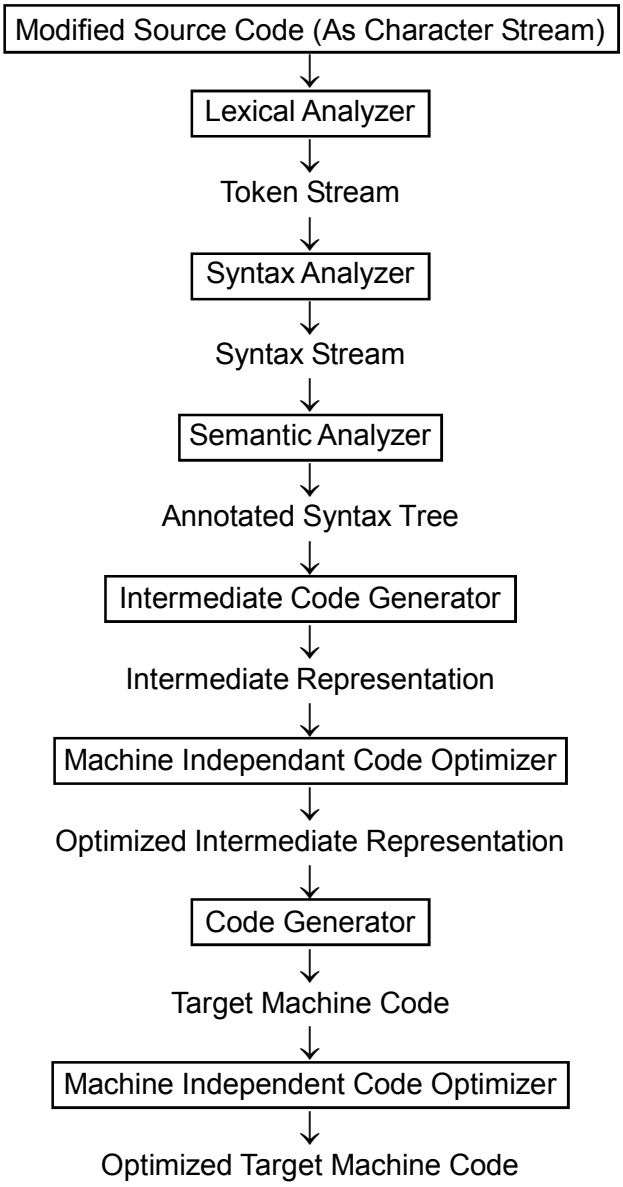


Fig. 6.2: Block Diagram of Phases of Compiler

As shown in Figure 6.2, the compiler has the following phases–

- Lexical analyzer
- Syntax analyzer
- Semantic analyzer
- Intermediate code generator
- Machine independent code optimizer
- Code generator
- Machine dependent code optimizer.

- **Lexical Analyzer** takes the program, which is given in the form of characters. The characters are all read from a file and then the lexical analyzer divides it into a token stream. The token stream is then fed to a syntax analyzer.
- **Syntax Analyzer** checks whether the syntax of the program according to the programming language rules are all satisfied. If they are satisfied, it produces a syntax stream; otherwise, it gives error. The syntax stream is then fed to a semantic analyzer.
- **Semantic Analyzer** checks the mistakes that are not taken care of by the previous phase, and then if everything is right, it produces annotated syntax tree. The annotations are nothing but the semantic information of the program such as what are the symbol names, what are the various constant values and so on. These are all fed to the intermediate code generator.
- **Intermediate Code Generator** produces an intermediate representation.
- **Machine Independent Code Optimizer** makes necessary improvements of the intermediate representation. Then, the optimized intermediate representation is fed to the code generator.
- The **Code Generator** actually is specific to every machine. It converts the optimized intermediate representation into target machine code.
- The **Machine Dependent Code Optimizer** takes the machine code generated by the previous phase. Finally, all possible improvements are made to on the target machine code and we get a very compact optimized target machine code.



CHECK YOUR PROGRESS

Q.1: Can you execute application software without system software?

6.4 ASSEMBLER

The assembler is a computer program that translates assembly language programs into object files. The object files contain a combination of machine language codes, data and information needed to load these instructions properly into the memory.

To assemble a program automatically the assembler needs information in the form of assembler directive that controls the process of assembling the program. The assembler directives are the commands placed in the program by the designer that provides information to the assembler. These directives neither become a part of the final program nor translate into executable code. Therefore, they are also known as pseudo instruction or false instructions.

Each assembler has its own unique pseudo instruction written in assembly language format.

6.5 LINKER

The linker is a computer program or tool that resolves the references and merges the object files produced by separate compilation or assembly and creates an executable file (As shown in Figure 6.3). The linker also searches the program to find library routines or functions used by program. It also determines the memory location that is going to be occupied by the instructions in the program and relocates the instructions accordingly. During this process of linking, if some function or library function that is needed by the program cannot be found then Linker Error is generated.

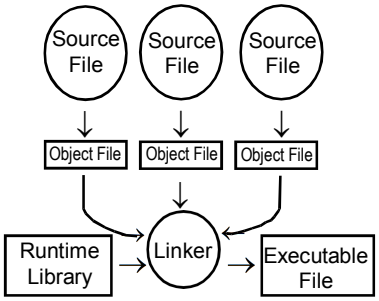


Fig. 6.3: Block Diagram of Linker

6.6 LOADER

The loader is a part of the Operating System that brings an executable file residing on the secondary memory into the main memory to start its execution.

The loader basically reads executable file to determine the size the required memory and creates the address space for the program and copies the instructions and data into the address space. It also copies the arguments passed to the program on the stack and initializes the machine registers including the stack pointer. Finally the loader calls the program's main function to start execution. During the execution of the program, if any error occurs that is termed as run time error. Run time errors are fatal error and logical error. Fatal error occurs when the executable file crashes or when the program tries to access illegal memory, which the program is not allowed to use or that doesn't exist in the computer.

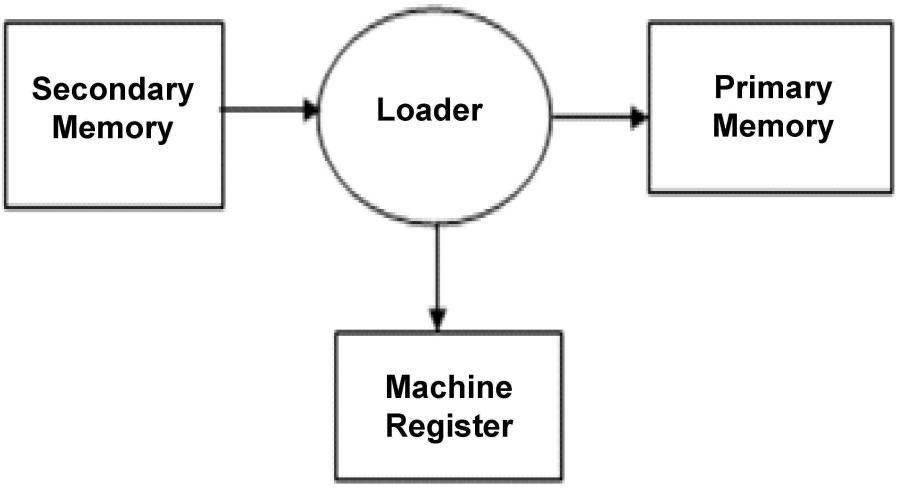


Fig. 6.4: Block Diagram of Loader

6.7 EDITOR

Editor is a computer program that enables the user or programmer to create and modify the source program. An editor may be a standalone application (not a part of the compiler) or it may be a part of an integrated development environment (IDE) or web browser.



CHECK YOUR PROGRESS

Q.2: Why do we need an assembler?

Q.3: Who links the library functions (e.g. printf(), scanf() in C language) to the original program?

Q.4: Who places the machine codes of the program into the main memory?



6.8 LET US SUM UP

- System Software helps to run the application software in the computer system.
- Machine language comprises of 0s and 1s. It is the only language directly understandable by the computer.
- The compiler translates high-level programming language to a lower level programming language.
- The assembler translates assembly language to machine language.
- The linker creates an executable file by merging the object files produced by separate compilation or assembly.
- The loader loads an executable file residing on the secondary memory into the main memory to start its execution.



6.9 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: No, we cannot run application software without the help of system software. Without installing system software in the

computer, the necessary compiler, linker and loader will not be available to support the application software's.

Ans. to Q. No. 2: Assembler is used to translate assembly language to machine level language.

Ans. to Q. No. 3: The Linker links the library functions (e.g. printf(), scanf() in C language) to the original program.

Ans. to Q. No. 4: The Loader places the machine codes of the program into the main memory. The size of the memory required to place the machine codes is estimated by the assembler during the generation of the object code.



6.10 FURTHER READING

1) Dhamdhere, D. M. (1999): *Systems Programming and Operating Systems*; Tata C McGraw-Hill
2) Dhamdhere, D. M. (1986): *Introduction to System Software*; Tata McGraw-Hill Pub.



6.11 MODEL QUESTIONS

Q.1: What is application software and system software?
Q.2: Why do we need system software?
Q.3: What is language processing system?
Q.4: What is Compiler?
Q.5: What are the different phases of a compiler?
Q.6: Briefly describe the task of different phases of a compiler.
Q.7: What is an assembler?
Q.8: What is pseudo code?
Q.9: Describe the task of linker in the process of compilation.
Q.10: Describe the task of loader in the process of compilation.

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