Fundamentals of Information Technology

DECAP145

Edited by
Ajay Kumar Bansal

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CONTENT

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Unit 01: Computer Fundamentals and Data Representation

Objectives

After studying this unit, you will be able to:

- understand the basics of computers
- discuss the computer evolution
- explain all generation of computers
- learn the Number system and its various types.

Introduction

The word "computer" comes from the word "compute", which means, "to calculate". People usually refer to a computer to be a calculating device that can perform arithmetic operations at high speed. Even though the primary objective behind inventing the computer was focused on developing the fast-calculating machine but currently, more than eighty percent work done by computers is both non-mathematical or non-numerical. Therefore, merely defining a computer as a calculating device is to ignore over eighty percent of its functions.

More accurately, we can define a computer as a device that operates upon data. Data can be anything like biodata, hence computer is used for shortlisting candidates for recruiting; marks obtained by students in when used for preparing results; details (name, age, sex, etc.) of passengers when used for or railway reservations: or several different parameters when used for solving scientific problems, etc.

Hence, data comes in various shapes and sizes depending upon the type of computer application. A computer can and retrieves data as and when desired. The fact that computers process data is so fundamental that have started calling it a *data processor.*

A data processor gathers data from various incoming sources, merging (the process of mixing or putting together) them all, sorting (the process of arranging in some of the sequences— ascending or descending) them in the desired order, and finally printing them in the desired format. The activity of processing data using a computer is called *data processing.* Data processing consists of three sub-activities: capturing input data, manipulating the data, and managing output results. As used in data

processing, information is data arranged in an order and form that is useful to people receiving it. Hence, *data is a* raw material used as input to data processing and *information is* processed data obtained as an output of data processing.

People usually consider a computer to be a calculating device that can perform arithmetic operations at high speed. It is also known as a data processor because it not only computes in the usual sense but also performs other functions with the data.

1.1 Characteristics of Computers

The increasing popularity of computers has proved that it is a very powerful and useful tool. The power and use of this popular tool are mainly due to its following characteristics:

1. **Automatic.** Computers are similar to automatic machines that can work by themselves without human intervention. However, computers being machines cannot start themselves and cannot go out and find their own problems and solutions. Computers need to be instructed using coded instructions specifying exactly how they will do a particular job.

2. **Speed.** A computer is a very fast device that can yield output and perform in a few seconds. In other words, a computer can do in a few minutes what would take a man his entire lifetime. The computer speed is measured in terms of seconds or even milliseconds (10–3) but in terms of microseconds (106), nanoseconds (10–9), and even picoseconds (10–12). A powerful computer is capable of performing several billion (l09) simple arithmetic operations per second.

3. **Accuracy.** In addition to being very fast, computers are very accurate. The accuracy of a computer is consistently high and the degree of its accuracy depends upon its design. A computer performs even calculations with the same accuracy. However, errors can occur in a computer. These errors are mainly due to human rather than technological weaknesses.

4. **Diligence.** Unlike human beings, a computer is free from monotony, tiredness, and lack of concentration. It can continuously work for hours without creating any error and without grumbling. Hence, computers score over human beings in doing the routine type of jobs that require great accuracy. If ten million calculations must be performed, a computer will perform the last one with exactly the same accuracy and speed as the first one.

5. **Versatility.** Versatility is one of the most wonderful things about a computer. One moment it is preparing results of an examination, next moment it is busy preparing electricity bills, and in between, it may be helping an office secretary to trace an important letter in seconds. All in all, a computer performs almost any task, provided the task can be reduced to a finite series of logical steps.

6. **Power of Remembering.** As a human being acquires new knowledge, his/her brain subconsciously selects what it feels to be important and worth retaining in memory. The brain relegates unimportant details to the mind or just forgets them. This is not the case with computers. A computer can store and recall any amount of information because of its secondary storage (a type of detachable memory) capability. It can retain a piece of information as long as a user desires and the user can recall the information whenever required. Even after several years, a user can recall the same information that he/she had stored in the computer several years ago.

7. **No IQ.** A computer possesses no intelligence of its own. It needs to be programmed and told about what to do and in what sequence. Hence, only a user determines—at tasks a computer will perform. A computer cannot take its own decision in this regard.

8. **No Feelings.** Computers are devoid of emotions. They have no feelings and no instincts because they are Machines. Although men have succeeded in building a computer memory, no computer processes the equivalent of a human heart and soul. Based on our feelings, taste, knowledge, and experience we often make certain judgments in our day-to-day life whereas, computers cannot make judgments on their own. They make judgments based on the instructions given to them in the form of programs that are written by us (human beings).

1.2 Evolution of Computers

Necessity is the mother of invention. The saying holds true for computers too. Computers were invented because of man's search for fast and accurate calculating devices. Basic Pascal invented the first mechanical adding machine in 1642. Later, in the year 1671, Baron Gottfried Wilhelm von Leibniz of Germany invented the first calculator for multiplication. Keyboard machines originated States around 1880 and we use them even today. Around the same period, Herman Hollerith came up with the concept of punched cards that were extensively used as an input medium in computers even by the late 1970s. Machines and calculators made their appearance in Europe and America towards the end of the century.

Charles Babbage, a nineteenth-century Professor at Cambridge University, is considered the father of modern digital computers. He had employed a group of clerks for preparing mathematical and statistical tables. Babbage had to spend several hours checking these tables because even utmost care and precautions could not eliminate human errors. Soon he became dissatisfied and exasperated with this type of monotonous job. As a result, he started thinking about building a machine that could compute tables guaranteed to be error-free.

In this process, Babbage designed a "Difference Engine" in the year 1822 that could produce reliable tables. In 1842, Babbage came out with his new idea of a completely automatic Analytical Engine for performing basic arithmetic functions for any mathematical problem at an average speed of 60 additions per minute. Unfortunately, he was unable to produce a working model of this machine because the precision engineering required to manufacture the machine was not available during that period. However, his efforts established several principles that are fundamental to the design of any digital computer. Some of the well-known early computers are as follows:

1. **The Mark I Computer (1937-44):** Also known as Automatic Sequence Controlled Calculator, this was the first fully automatic calculating machine designed by Howard A. Aiken of Harvard University in collaboration with IBM (International Business Machines) Corporation. It was an electromechanical device (used both electronic and mechanical components) based on the techniques already developed for punched card machines.

   Although this machine proved to be extremely reliable, it was very complex in design and huge in size. It used over 3000 electrically actuated switches to control its operations and was approximately feet long and 8 feet high. It could perform five basic arithmetic operations: addition, subtraction, multiplication, division, and table reference on numbers as big as 23 decimal digits. It took approximately 0.3 seconds to add two numbers and 4.5 seconds for the multiplication of two numbers.

2. **The Atanasoff-Berry Computer (1939-42):** Dr. John Atanasoff developed an electronic machine to solve certain mathematical equations. The machine was called the Atanasoff- Berry Computer, or ABC, after its inventor's name and his assistant, Clifford Berry. It used 45 vacuum tubes for internal logic and capacitors for storage.

3. **The ENIAC (1943-46).** The Electronic Numerical Integrator And Calculator (ENIAC) was the first all-electronic computer. It was constructed at the Moore School of Engineering of the University of Pennsylvania, U.S.A. by a design team led by Professors J. Presper Eckert and John Mauchly. The team developed ENIAC because of military needs. It was used for many years to solve ballistic-related problems. It took up wall space in a 20 x 40 square feet room and used 18,000 vacuum tubes it could add two numbers in 200 microseconds and multiply them in 2000 microseconds.

4. **The EDVAC (1946-52):** A major drawback of ENIAC was that its programs were wired on boards that made it difficult to change the programs. Dr. John Von Neumann later introduced the "stored program" concept that helped in overcoming this problem. The basic idea behind this concept is that a sequence of instructions and data can be stored in the memory of a computer for automatically directing the flow of operations. This feature considerably influenced the development of modern digital computers because of the ease with which different programs can be loaded and executed on the same computer. Due to this feature, we often refer to modern digital computers as stored-program digital computers. The Electronic Discrete Variable Automatic Computer (EDVAC) used the stored' program concept in its design. Von Neumann also has a share of the credit for introducing the idea of storing both instructions and data in binary form (a system that uses only two digits—0 and I to represent all characters), instead of decimal numbers or human-readable words.

5. **The EDSAC (1947-49):** Almost simultaneously with EDVAC of the U.S.A., the Britishers developed the Electronic Delay Storage Automatic Calculator (EDSAC). The machine executed its first program in May 1949. In this machine, addition operations took 1500 microseconds, and multiplication operation: took 4000 microseconds. A group of scientists headed by Professor Maurice Wilkes at the Cambridge University Mathematical Laboratory developed this machine.

6. **The UNIVAC I (1951):** The Universal Automatic Computer (UNIVAC) was the first digital computer that was not "one of a kind". Many UNIVAC machines were produced, the first of which was installed in the Census Bureau in 1951 and was used continuously for 10 years. The first business use of a computer, a UNIVAC I, was by General Electric Corporation in 1954. In 1952, the International Business Machines (IBM) Corporation introduced the IBM-701 commercial computer. In rapid succession, improved models of the UNIVAC I and other 700-series machines were introduced. In 1953, IBM produced the IBM-650 and sold over 1000 of these computers. UNIVAC marked the arrival of commercially available digital computers for business and scientific applications.

Some of the well-known early computers are the MARK 1 (1937-44), the ATANASOFF-BERRY (1939-42), the ENIAC (1943-46), the EDVAC (1946–52), the EDSAC (1947-49), and the UNIVAC I (1951).

1.3 Computer Generations

Generation in computer talk is a step in technology. It provides a framework for the growth of the computer industry. Originally, the term "generation" was used to distinguish between varying hardware technologies but it has now been extended to include both hardware and software that together make up a computer system. The custom of referring to the computer era in terms of generations came into wide use only after 1964. There are 5 computer generations known till today.

First Generation (1942-1955)

We have already discussed some of the early computers—ENIAC, EDVAC, EDSAC, UNIVAC 1, and IBM 701. These machines and others of their time used thousands of vacuum tubes. A vacuum tube [see Figure 1 (a)] was a fragile glass device, which used filaments as a source of electronics and could control and amplify electronic signals. It was the only high-speed electronic switching device available in those days. These vacuum tube computers could perform computations in milliseconds and were referred to as first-generation computers.

The memory of these computers used electromagnetic relays, and all data and instructions were fed into the system from punched cards. The instructions were written in machine and assembly languages because high-level programming languages were introduced much later. Since machine and assembly languages are very difficult to work with, only a few specialists understood how to program these early computers.

Characteristic features of first-generation computers are as follows:
1. They were the fastest calculating devices of their time.
2. They were too bulky in size, requiring large rooms for installation.
3. They used thousands of vacuum tubes that emitted a large amount of heat and burnt out frequently. Hence, the rooms/areas in which these computers were located had to be properly air-conditioned.
4. Each vacuum tube consumed about half a watt of power. Since a computer typically used more than ten thousand vacuum tubes, the power consumption of these computers was very high.
5. As vacuum tubes used filaments, they had a limited life. Because a computer used thousands of vacuum tubes, these computers were prone to frequent hardware failures.
6. Due to the low mean time between failures, these computers required constant maintenance.
7. In these computers, thousands of individual components were assembled manually into electronic circuits. Hence, the commercial production of these computers was difficult and costly.
8. Since these computers were difficult to program and use, they had limited commercial use.

Task   Give a brief description of first-generation computers.

Second Generation (1955-1964)

John Bardeen, Willian Shockley, and Walter Brattain invented a new electronic switching device called transistor [see Figure 1(b)] at Bell Laboratories in 1947. Transistors soon proved to be a better electronic switching device than vacuum tubes due to their following properties:
1. They were more rugged and easier to handle than tubes since they were made of germanium semiconductor material rather than glass.
2. They were highly reliable as compared to tubes since they had no parts like a filament that could burn out.
3. They could switch much faster (almost ten times faster) than tubes. Hence, switching circuits made of transistors could operate much faster than their counterparts made of tubes.
4. They consumed almost one-tenth of the power consumed by tube and were much smaller than a tube and less expensive to produce as well.
5. They dissipated much less heat as compared to vacuum tubes.

Due to the properties of transistors listed above, these computers were more powerful, more reliable, less expensive, smaller, and cooler to operate than the first-generation computers. They used magnetic cores for main memory and magnetic disk and tape as secondary storage media. Punched

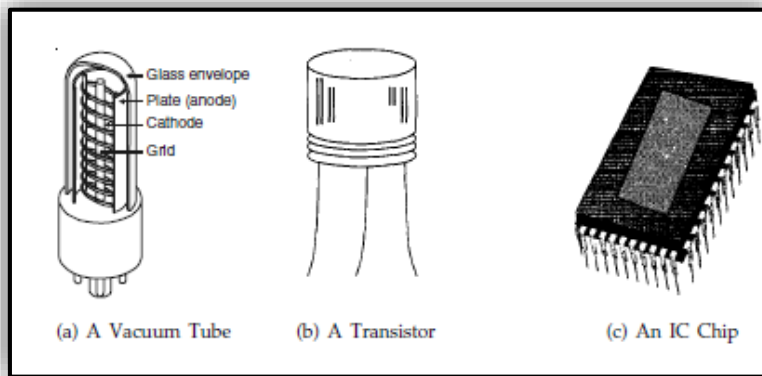cards were still popular and widely used for preparing and feeding programs and data to these computers.

Figure 1: Electronic Devices Used for Manufacturing Computers of Different Generations.

On the software front, high-level programming languages (like FORTRAN, COBOL, ALGOL, and SNOBOL) and batch operating systems emerged during the second-generation. High-level programming languages were easier for people to understand and work with than assembly or machine languages making second-generation computers easier to program and use than first-generation computers. The introduction of batch operating system enabled multiple jobs to be batched together and submitted at a time.

A batch operating system causes an automatic transition from one job to another as soon as the former job completes. This concept helped in reducing human intervention while processing multiple jobs resulting in faster processing, enhanced throughput, and easier operation of second-generation computers.

The first-generation computers were mainly used for scientific computations. However, the second-generation computers were increasingly used in business and industry for commercial data processing applications like payroll, inventory control, marketing, and production planning. The characteristic features of second-generation computers are as follows:

1. They were more than ten times faster requiring smaller space as compared to the first-generation computers.

2. They consumed less power and dissipated less heat than the first-generation computers. The rooms/areas in which the second-generation computers were located still required to be properly air-conditioned.

3. They were more reliable and less prone to hardware failures than the first-generation computers.

4. They had faster and larger primary and secondary storage as compared to first-generation computers.

5. Such systems were easier to program & were commercially more viable with thousands of individual transistors assembled manually into electronic circuits.

Task   Discuss the second-generation computers.

Third Generation (1964-1975)

In 1958, Jack Clair Kilby and Robert Noyce invented the first integrated circuit. *Integrated circuits (ICs)* are circuits consisting of several electronic components like transistors, resistors, and capacitors grown on a single chip of silicon eliminating wired interconnection between components. The IC technology made it possible to integrate a larger number of circuit components into a very small (less than 5 mm square) surface of silicon, known as "chip" [see Figure 1(c)]. Initially, the integrated circuits contained only about ten to twenty components. This technology was named *small-scale integration (*SSI*).* Later with the advancement in technology for manufacturing ICs, it became possible

to integrate up to about components on a single chip. This technology came to be known as *medium-scale integration* (MSI).

Computers built using integrated circuits characterized the third generation. Earlier ones used SSI technology and later used MSI technology. Moreover, the parallel advancements in storage technologies allowed the construction of larger magnetic core-based random access memory as well as larger capacity magnetic disks and tapes. Hence, third-generation computers typically had few megabytes (less than 5 Megabytes) of main memory and magnetic disks capable of storing few tens of megabytes of data per disk drive.

On the software front, standardization of high-level programming languages, timesharing operating systems, unbundling of software from hardware, and creation of an independent software industry happened during the third generation. FORTRAN and COBOL were the most popular high-level programming languages in those days. American National Standards Institute (ANSI) standardized them in 1966 and 1968 respectively, and the standardized versions were called ANSI FORTRAN and ANSI COBOL. Some more high-level programming languages were introduced during the third-generation period. Notable among these were PL/1, PASCAL, and BASIC.

We saw that second-generation computers used batch operating systems. In these systems, users had to prepare their data and programs and then submit them to a computer center for processing. The operator at the computer center collected these user jobs and fed them to a computer in batches at scheduled intervals. The respective users then collected their job output from the computer center. The inevitable delay resulting from this batch processing approach was very frustrating to some users, especially programmers, because often they had to wait for days to locate and correct a few program errors. To rectify this situation, John Kemeny and Thomas Kurtz of Dartmouth College introduced the concept of a timesharing operating system.

Timesharing operating system enables multiple users to directly access and share computing resources simultaneously in a manner that each user feels that no one else is using the computer. This is accomplished by using a large number of independent relatively low-speed, on-line terminals connected to the main computer simultaneously. The introduction of the timesharing concept helped in drastically improving the productivity of programmers and made on-line systems feasible, resulting in new on-line applications like airline reservation systems, interactive query systems, etc.

Until 1965, computer manufacturers sold their hardware along with all associated software without any separate charges for software. From the user's standpoint, the software was free. However, the situation changed in 1969 when IBM and other computer manufacturers began to price their hardware and software products separately. This unbundling of software from hardware allowed users to invest only in the software of their need and value. This led to the creation of many new software houses and the beginning of the independent software industry.

Digital Equipment Corporation (DEC) introduced the first commercially available minicomputer, the PDP-8 (Programmed Data Processor), in 1965. It could easily fit in the corner of a room and did not require the attention of a full-time computer operator. It used a timesharing operating system, and several users could access it simultaneously from different locations in the same building.

The characteristic features of third-generation computers are as follows:

1. They were more powerful than second-generation computers capable of performing about one million instructions per second.

2. They consumed less power and dissipated less heat than second-generation computers. The rooms/areas in which third-generation computers were located still required to be properly air-conditioned.

3. They were smaller, reliable, less prone to hardware failures, & required lower maintenance cost.

4. They had faster and larger primary and secondary storage as compared to second-generation computers.

5. They were general-purpose machines suitable for both scientific and commercial applications.

6. Timesharing operating systems allowed interactive usage and simultaneous use of these systems by multiple users, thereby improving the productivity of programmers down the time and cost of program development by several-fold.

Task — Identify and discuss the various systems belonging to third-generation computer systems.

Fourth Generation (1975-1989)

The average of electronic components packed on a silicon chip doubled each year after 1965. This progress soon led to the era of *large-scale integration* (ISI) when it was possible to integrate over 30,000 electronic components on a single chip, followed by *very large-scale integration (*VLSI*)* when it was possible to integrate about one million electronic components on a single chip. This progress led to a dramatic development— the creation of a microprocessor.

A microprocessor contains all circuits needed to perform arithmetic logic and control: functions, the core activities of all computers, on a single chip. Hence, it became possible to build a complete computer with a Microprocessor, a few additional primary storage chips, and other support circuitry. It started a new social revolution—the *personal computer (*PC*)* revolution. Overnight computers became incredibly compact. They become inexpensive to make, and suddenly it became possible for anyone to own a computer.

During the fourth generation, semiconductor memories replaced magnetic core memories resulting in large random-access memories with very fast access time. On the other hand, hard disks became cheaper, smaller, and larger in capacity. In addition to magnetic tapes, floppy disks became very popular as a portable medium for porting programs and data from one computer system to another. Another significant development during the fourth-generation period was the spread of high-speed computer networking enabling the interconnection of multiple computers to enable them to communicate and share data. Local area networks (LANs) became popular for connecting computers within an organization or within a campus. Similarly, wide area networks (WANs) became popular for connecting computers located at larger distances. This gave rise to networks computers and distributed systems.

On the software front, several new developments emerged to match the new technologies of the fourth generation. For example, several new operating systems were developed for PCs. Notable among these were MS-DOS, MS-windows, and apple's propriety OS. Since PCs were for individuals who were not computer professionals, companies developed graphical user interfaces for making computers more user-friendly (easier to use).

A *graphical user interface ((U1)* provides icons (pictures) and menus (list of choices) that users can select with a mouse. This enables new computer users to learn to use a PC quickly. Several new PC-based applications were also developed to make PCs a powerful tool. Notable among these were powerful word processing packages that allowed easy development of documents, spreadsheet packages that allowed easy manipulation and analysis of data organized in columns and rows, and graphics packages that allowed the easy drawing of pictures and diagrams.

Another very useful concept that became popular during the fourth-generation period was that of multiple windows on a single terminal screen. This feature allowed users to see the current state of several applications simultaneously in separate windows on the same terminal screen. During the fourth-generation period, UNIX operating system and C programming language also became very popular. The characteristic features of fourth-generation computers are as follows:
1. PCs were smaller and cheaper than mainframes or minicomputers of the third generation.
2. Although the fourth-generation mainframes required proper air-conditioning of the rooms/areas in which they were located, no air-conditioning was required for PCs.
3. They were general-purpose affordable machines that consumed less power, were more reliable, and were less prone to hardware failures than third-generation computers requiring negligible maintenance cost.
4. They had faster and larger primary and secondary storage as compared to third-generation computers.
5. Graphical user interface (GUI) enabled new users to quickly learn how to use computers.
6. PC-based applications made PCs a powerful tool for both office and home usage.
7. The network of computers enabled sharing of resources like disks, printers, etc. among multiple computers and their users. They also enabled several new types of applications involving the interaction among computer users at geographically distant locations.

Task — Briefly describe fourth-generation computers.

Fifth Generation (1989-Present)

The trend of further miniaturization of electronic components, a dramatic increase in power of microprocessor-chips, and an increase in capacity of main memory and hard disk continued during the fifth generation. VLSI technology came *ULSI ((Ultra Large-Scale Integration)* technology in the fifth generation resulting in the production of Microprocessor chips having ten million electronic components. The speed of microprocessors and the size of the main memory and hard disk doubled almost every eighteen months. As a result, many features found in the CPUs of large mainframe systems of third- and fourth-generation systems became part of microprocessor architecture in the fifth generation. This ultimately resulted in the availability of very powerful and compact computers becoming available at cheaper rates and the death of traditional large mainframe systems.

Due to this fast pace of advancement in computer technology, more compact and more powerful computers are being introduced almost every year at more or less the same price or even cheaper. Notable among these are portable notebook computers that give the power of a PC to their users even while traveling, powerful desktop PCs and workstations, powerful servers, and very powerful supercomputers.

Storage technology has also advanced providing larger and larger main memory and disk storage capabilities available in newly introduced systems. During the fifth generation, optical disks have also emerged as a popular portable mass storage *D-ROM (Compact Disk - Read Only Memory).*

There was a tremendous outgrowth of computer networks. Communication technologies become faster day-by-day and more and more computers were networked together. This trend resulted in the emergence and popularity of the Internet and associated technologies and applications. The Internet made it possible for computer users sitting across the globe to communicate with each other within minutes by use of electronic mail (known as *e-mail)* facility. A vast ocean of information became readily available to computer users through the World Wide Web (known as WWW*).* Moreover, several new types of exciting applications like e-commerce, virtual libraries, virtual classrooms, distance education, etc., emerged during the period.

Tremendous processing power and the massive storage capacity of fifth-generation computers also made them a very popular tool for a wide range of multimedia applications that deal with information containing text, graphics animation, audio, and video data.

The characteristic features of fifth-generation computers are as follows:
1. Portable PCs (called notebook computers) are much smaller, handy, and more powerful than PCs of the fourth generation allowing users to use computing facilities even while traveling.
2. Although fifth-generation mainframes require proper air-conditioning of the rooms/areas in which they are located, no air-conditioning is normally required for notebook computers, desktop PCs, and workstations.
3. They are general-purpose machines that consume less power than their predecessors, are more reliable, and less prone to hardware failures thus requiring negligible maintenance cost.
4. Many of the large-scale fifth-generation systems have a hot-plug feature that enables a failed component to be replaced with a new one without the need to shut down the system. Hence, the uptime of these systems is very high.
5. They have faster and larger primary and secondary storage as compared to their predecessors.
6. The use of standard high-level programming languages allows programs written for one computer to be easily ported to and executed on another computer.
7. More user-friendly interfaces with multimedia features make the systems easier to learn and use by anyone, including children.
8. Newer and more powerful applications, including multimedia applications, make the systems more useful in every occupation.
9. An explosion in the size of the Internet coupled with Internet-based tools and applications have made these systems influence the life of even common people.

Task   Discuss the various features of fifth-generation computers and different systems belonging to this generation.

Technological progress in this area is continuing at the same rate even now. The fastest-growth period in the history of computing may be still ahead.

1.4 Five Basic Operations of Computer

Certain basic operations are performed by a computer system including (Figure 2):

Inputting: It is the process of entering data and instructions into the computer system. It involves basic operations such as the act of feeding data and conversion into the computer-readable format. Various input devices are used to input data into the computer. Input devices also retrieve information off disks. As the computers work with bits, there should be some mechanism to make data understandable by the CPU (the process is called encoding) and also the information produced by the CPU must be converted to the human-readable form (called decoding). The input unit devices are the ones taking care of the encoding. The devices that can send data directly to the CPU or which do not need to encode it before sending it to the CPU are considered *Direct Entry Input Devices* such as scanners. Devices such as a keyboard that require encoding data so that it is in the form a CPU can understand are *Indirect Entry Input Devices.*

Storing: This involves saving data and instructions to make them readily available for initial or additional processing whenever required.

Processing: It consists of performing arithmetic operations or logical operations on data to convert them into useful information. Majorly, extensive calculations & computations are carried out in this step.

Outputting: The process of producing useful information or results for the user such as a printed report or visual display.

Controlling: The task of directing the manner and sequence in which all of the above 4 operations will be performed is called the operation of the control.
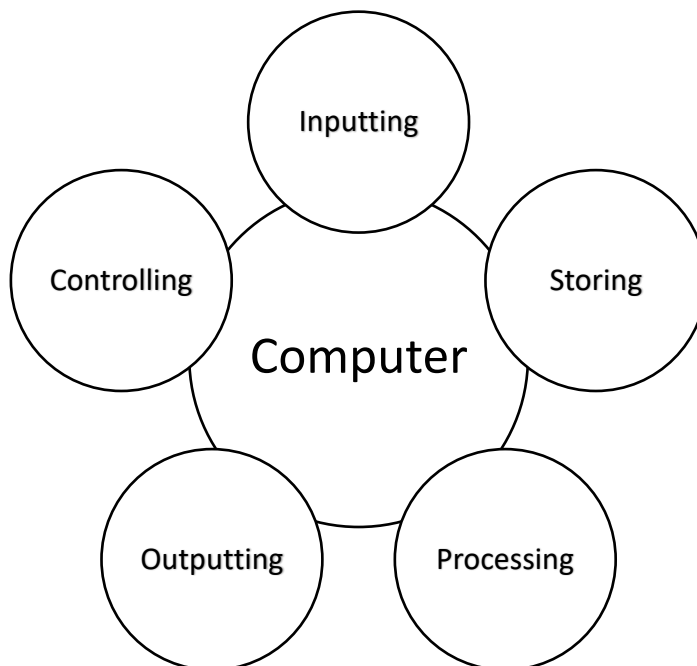

Figure 2: Basic Operations of Computer

1.5 Block Diagram of Computer

The basic components of a computer are:

• Input Unit

• Output Unit

• Memory/Storage Unit

• Arithmetic Logic Unit

• Control Unit

• Central Processing Unit

These   are   shown   in Figure 3.
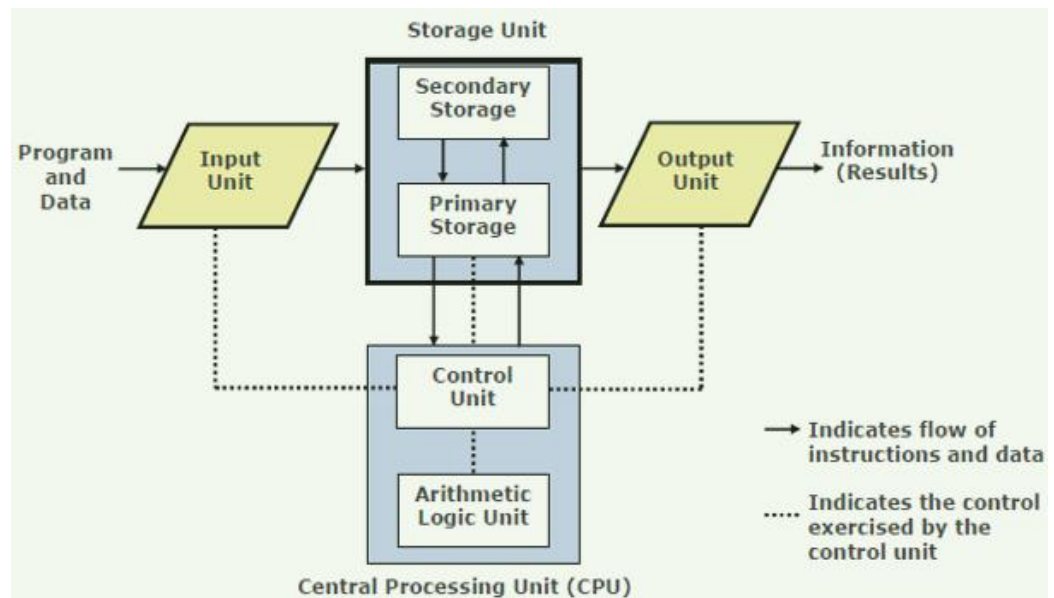

Figure 3: Block Diagram of Computer

A computer can process data, pictures, sound, and graphics. They can solve highly complicated problems quickly and accurately.

Input Unit

Computers need to receive data and instruction to solve any problem. Therefore, we need to input the data and instructions into the computers. The input unit consists of one or more input devices. The keyboard is one of the most commonly used input devices. Other commonly used input devices are the mouse, floppy disk drive, magnetic tape, etc. All the input devices perform the following functions:

• Accept the data and instructions from the outside world.

• Convert it to a form that the computer can understand.

• Supply the converted data to the computer system for further processing.

Output Unit

The output unit of a computer provides the information and results of a computation to the outside world. Printers, Visual Display Unit (VDU) are the commonly used output devices. Other commonly used output devices are floppy disk drive, hard disk drive, and magnetic tape drive.

Storage Unit

The storage unit of the computer holds data and instructions that are entered through the input unit before they are processed. It preserves the intermediate and final results before these are sent to the output devices. It also saves the data for later use. The various storage devices of a computer system are divided into two categories (Figure 4):

Primary Storage: Stores and provides very fast. This memory is generally used to hold the program being currently executed in the computer, the data being received from the input unit, the intermediate and final results of the program. The primary memory is temporary. The data is lost, when the computer is switched off. To store the data permanently, the data has to be transferred to the secondary memory. The cost of primary storage is more compared to secondary storage. Therefore, most computers have limited primary storage capacity.

Secondary Storage: Secondary storage is used as an archive. It stores several programs, documents, databases, etc. The programs that you run on the computer are first transferred to the primary memory before it is run. Whenever the results are saved, again they get stored in the secondary memory. The secondary memory is slower and cheaper than the primary memory. Some of the commonly used secondary memory devices are Hard disk, CD, etc.
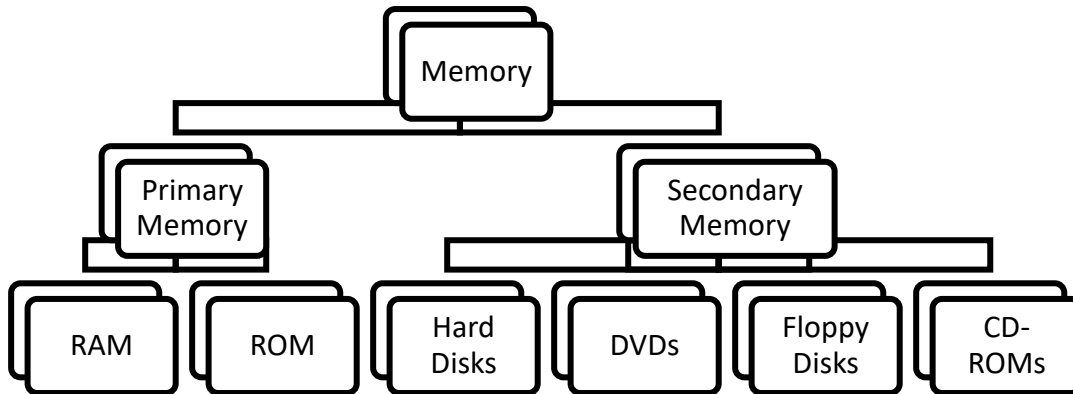
Figure 4: Types of Computer Memory

Arithmetic Logical Unit

All calculations are performed in the Arithmetic Logic Unit (ALU) of the computer. It also does a comparison and takes a decision. The ALU can perform basic operations such as addition, subtraction, multiplication, division, etc, and does logic operations viz, >, <, =, 'etc. Whenever calculations are required, the control unit transfers the data from the storage unit to ALU once the computations are done, the results are transferred to the storage unit by the control unit, and then it is sent to the output unit for displaying results.

Control Unit

It controls all other units in the computer. The control unit instructs the input unit, where to store the data after receiving it from the user. It controls the flow of data and instructions from the storage unit to ALU. It also controls the flow of results from the ALU to the storage unit. The control unit is generally referred to as the central nervous system of the computer that controls and synchronizes the working.
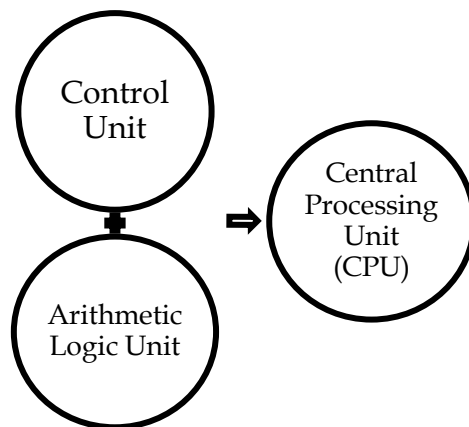

Figure 5: Central Processing Unit (Brain of a Computer System)

Central Processing Unit

The control unit and ALU of the computer are together known as the Central Processing Unit

(CPU). The CPU (Figure 5) is like the brain that performs the following functions:

   • It performs all calculations.

   • It takes all decisions.

   • It controls all units of the computer.

1.6 Applications of Information Technology (IT) in Various Sectors

Computers, due to their enormous speed, accuracy, memory, and other invaluable characteristics, are used in all spheres of applications (Figure 6). There is nothing other than computers which have made rapid progress in all spheres.

Computers in Banking: Today, the banking functions in urban and semiurban areas are fully computerized. As a result of the computerization and networking of a large number of banks, several facilities are being offered to the customers. Using online banking, you can check your past transactions from the date of the account opening with a real-time balance.

Money can be easily be transferred to any account across the globe. Internet banking also allows to use of ATM or Debit Card, Credit Card to shop, buy tickets, pay bills for utility services like electricity, telephone, and mobile recharge. You can even subscribe to free monthly bank account statements and apply online to open fixed deposits. the facility of subscribing to mobile banking enables you to virtually carry along the bank with you. Some banking functions carried out by computers are:

- Automated Teller Machines (ATM)
- Online Banking (NEFT, RTGS)
- Core Banking Systems such as Finacle, BaNCs
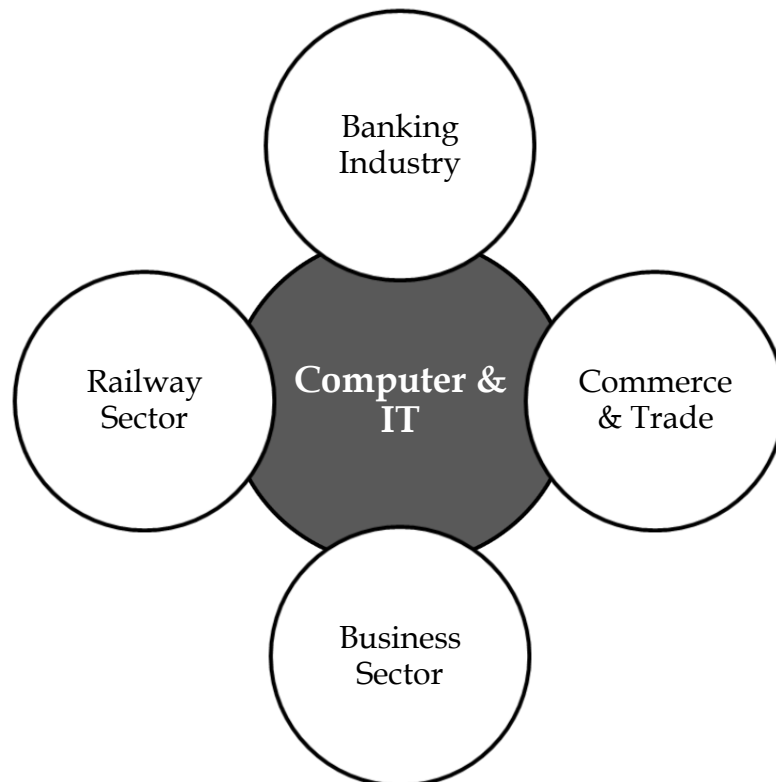
Figure 6: Applications of IT in Various Sectors

Computers in Railway Sector: Railway is the largest organization that is effectively using computers. Computers are being extensively used currently in checking the train records, making online bookings and cancellations, checking train time-tables, live monitoring of the train status, etc.

Computers in Commerce and Trade: The computer is used in all commerce departments like shopping malls and big departmental stores to calculate the sales and purchase of the firm. Computers are very helping in the business to maintain their accounts through the computer Example: Tally Accounting Software, MARG Software. Nowadays every commercial firm uses computers for every transaction. The ease with which databases, spreadsheets, and data can be compiled on a computer has certainly improved the efficiency and management practices of

businesses worldwide. Many offices now use computer programs to handle scheduling, accounting, billing, inventory management, contact management, etc.

Computers in Business: Computer has helped in improving business activities throughout the world. The organization can have access to the latest technology and manpower across the world. Additionally, portable laptop computers, smartphones, wireless internet, air cards, and hub spots are the wave of the future when comes to computer uses in business. Today, the business can be conducted remotely from almost anywhere.

E-commerce has completely changed the scenario of online shopping. Much more online business growth from the application of computer such as Amazon, Flipkart, etc. Global business relations can be now maintained through the Internet. Computers are used in offices for maintaining sales and marketing records, stock control, planning, productions, tax records, and preparing salary sheets, etc.

Computers in Administration: Computers are used for official correspondence, budgeting, accounts, reporting, payroll, attendance, uploading of various schemes, forms, etc. The sector like the census bureau, Income TAX, airline and railway, electricity boards of telephone exchanges are benefiting from computer technology.

Computers in the Healthcare Sector: The application of computers in diagnosing diseases and controlling important medical processes like CITI scan, X-ray, ECG, and Ultrasounds. Computerized equipment helps maintain patients' medical records and perform surgeries. Computers can be used for research and to help doctors in the treatment of diseases. Telehealth, online medicines, telemedicine, telemonitoring are the latest trends in the use of computers in the healthcare sector.

1.7 Data Representation

Digital computers store and process information in binary form as digital logic has only two values "1" and "0" or in other words "True or False" or also said as "ON or OFF". This system is called radix 2. We humans generally deal with radix 10 i.e. decimal. As a matter of convenience there are many other representations like Octal (Radix 8), Hexadecimal (Radix 16), Binary coded decimal (BCD), Decimal, etc.

Every computer's CPU has a width measured in terms of bits such as 8-bit CPU, 16-bit CPU, 32-bit CPU, etc. Similarly, each memory location can store a fixed number of bits and is called memory width. Given the size of the CPU and Memory, it is for the programmer to handle his data representation. Most of the readers may be knowing that 4 bits form a Nibble, 8 bits form a byte. The word length is defined by the Instruction Set Architecture of the CPU. The word length may be equal to the width of the CPU.

The memory simply stores information as a binary pattern of 1's and 0's. It is to be interpreted as what the content of a memory location means. If the CPU is in the Fetch cycle, it interprets the fetched memory content to be instruction and decodes based on Instruction format. In the Execute cycle, the information from memory is considered as data. As a common man using a computer, we think computers handle English or other alphabets, special characters, or numbers. A programmer considers memory content to be the data type of the programming language he uses.

Number Systems

To a computer, everything is a number, i.e., alphabets, pictures, sounds, etc., are numbers. Number System is primarily categorized as Positional & Non-Positional number systems. The positional number system uses only a few symbols called digits. These symbols represent different values depending on the position they occupy in the number. The value of each digit is determined by:

- The digit itself
- The position of the digit in the number
- The base of the number system where **(**base**=** total number of digits in the number system).
- The maximum value of a single digit is always equal to one less than the value of the base.

The non-positional number system uses symbols such as I for 1, II for 2, III for 3, IIII for 4, etc. Each symbol represents the same value regardless of its position in the number. The symbols are simply added to find out the value of a particular number.

The number system is categorized into four types:

- The decimal number system represents values in 10 digits.
- A binary number system consists of only two values, either 0 or 1.
- The octal number system represents values in 8 digits.
- Hexadecimal number system represents values in 16 digits.

Bits and Bytes

Bits− A bit is the smallest possible unit of data that a computer can recognize or use. The computer usually uses bits in groups.

Bytes− Group of eight bits is called a byte. Half a byte is called a nibble.
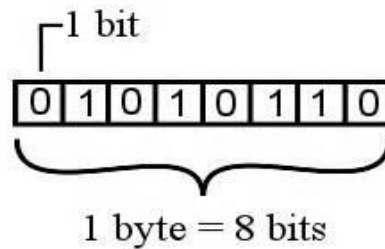
Figure 7: Representation of Bits & Bytes

Figure 7 presents bits & bytes representation in computers and .

 shows the conversion of bits and bytes.

Table 1: Conversion of Bits & Bytes

Byte Value	Bit Value
1 Byte	8 Bits
1024 Bytes	1 Kilobyte
1024 Kilobytes	1 Megabyte
1024 Megabytes	1 Gigabyte
1024 Gigabytes	1 Terabyte
1024 Terabytes	1 Petabyte
1024 Petabytes	1 Exabyte
1024 Exabytes	1 Zettabyte
1024 Zettabytes	1 Yottabyte
1024 Yottabytes	1 Brontobyte
1024 Brontobytes	1 Geopbytes

Decimal Number System

If the Base value of a number system is 10, then it is called the Decimal number system which has the most important role in the development of science and technology for representing real numbers. This is the weighted (or positional) number representation, where the value of each digit is determined by its position (or its weight) in a number. This is also known as the base-10 number

system which has 10 symbols, these are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. The position of every digit has a weight which is a power of 10.

The decimal number system is used in our day-to-day life. The expression of a number using the decimal system is called the decimal expansion, examples of which include 1, 13, 2028, 12.1, and 3.14159. It has 10 symbols or digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9). Hence, its base = 10. The maximum value of a single digit is 9 (one less than the value of the base). In other words, each position of a digit represents a specific power of the base (10).

Each position in the decimal system is 10 times more significant than the previous position, which means the numeric value of a decimal number is determined by multiplying each digit of the number by the value of the position in which the digit appears and then adding the products.

The main advantages of the decimal number system are that it is easily readable, used by humans, and easy to manipulate. However, there are some disadvantages, like wastage of space and time. Since digital system (e.g., Computers) and hardware is based on a binary system (either 0 or 1), so we need to use 4-bit space to store each bit of decimal number, whereas Hexadecimal number is also needed only 4 bit and the hexadecimal number has more digits than the decimal number which is an advantage of the hexadecimal number system.

Convert 2586_{10} into the binary equivalent?

2586_{10} = (2×10^3) + (5×10^2) + (8×10^1) + (6×10^0)
          = 2000 + 500 + 80 + 6

          = 2586

Task   Convert the number 2025_{10} into the binary equivalent.

Binary Number System

Binary Number System is one type of number representation technique. It is most popular and used in digital systems. The binary system is used for representing binary quantities which can be represented by any device that has only two operating states or possible conditions.

The system representing text or computer processor instructions by the use of the binary number system's two-binary digits "0" and "1". The position of every digit has a weight which is a power of 2. Each position in the Binary system is 2 times more significant than the previous position, which means the numeric value of a Binary number is determined by multiplying each digit of the number by the value of the position in which the digit appears and then adding the products. So, it is also a positional (or weighted) number system.

Key characteristics of Binary Number System:

- Only 2 symbols or digits (0 and 1). Hence its base= 2.

- The maximum value of a single digit is 1.

- Each position of a digit represents a specific power of the base (2).

- This number system is used extensively in computers.

The main advantage of using binary is that it is a base that is easily represented by electronic devices. A binary number system offers ease of use in coding, fewer computations, and fewer computational errors. The major disadvantage of the binary number is difficult to read and write for humans because of the large number of binary equivalents of a decimal number.

Convert 10101_2 to its decimal equivalent?

10101_2 = (1×2^4) + (0×2^3) + (1×2^2) + (0×2^1) x (1×2^0)

          = 16 + 0 + 4 + 0 + 1

          = 21_{10}

📋 Task   Convert 1101010_2 to its decimal equivalent?

Octal Number System

Octal Number System is one type of number representation technique, in which their value of base is 8. That means there are only 8 symbols or possible digit values, there are 0, 1, 2, 3, 4, 5, 6, 7. It requires only 3 bits to represent the value of any digit. Octal numbers are indicated by the addition of either an 0o prefix or an 8 suffix.

The position of every digit has a weight which is a power of 8. Each position in the Octal system is 8 times more significant than the previous position, which means the numeric value of an octal number is determined by multiplying each digit of the number by the value of the position in which the digit appears and then adding the products. So, it is also a positional (or weighted) number system.

The octal number system is similar to the Hexadecimal number system. The octal number system provides a convenient way of converting large binary numbers into more compact and smaller groups; however, this octal number system is less popular.

Since the base value of the Octal number system is 8, so their maximum value of a digit is 7 and it cannot be more than 7. In this number system, the successive positions to the left of the octal point having weights of 8^0, 8^1, 8^2, 8^3, and so on. Similarly, the successive positions to the right of the octal point having weights of 8^{-1}, 8^{-2}, 8^{-3} and so on. This is called base power of 8. The decimal value of any octal number can be determined using the sum of the product of each digit with its positional value.

Representation of Octal Number

Each Octal number can be represented using only 3 bits, with each group of bits having a distinct value between 000 (for 0) and 111 (for 7 = 4+2+1). The equivalent binary number of octal numbers are as given below:

Octal Digit Value	Binary Equivalent
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

The main advantage of using octal numbers is that it uses fewer digits than decimal and hexadecimal number system. So, it has fewer computations and fewer computational errors. It uses only 3 bits to represent any digit in binary and easy to convert from octal to binary and vice-versa. It is easier to handle input and output in the octal form. The major disadvantage of the octal number system is that the computer does not understand the octal number system directly, so we need an octal to binary converter.

📝 Note   Representing Numbers in Different Number Systems: To be specific about which number system we are referring to, it is a common practice to indicate the base as a subscript. Thus, we write: $10101_2 = 21_{10}$.

Converting 2057_8 to its binary equivalent.

$2057_8 = (2 \times 8^3) + (0 \times 8^2) + (5 \times 8^1) + (7 \times 8^0)$

$= 1024 + 0 + 40 + 7$

$= 1071_{10}$

Interpret 157_8.

$= (1 \times 8^2) + (5 \times 8^1) + (7 \times 8^0)$

$= 64 + 40 + 7$

$= 111$

Here, rightmost bit 7 is the least significant bit (LSB), and left most bit 1 is the most significant bit (MSB).

Hexadecimal Number System

Hexadecimal Number System is one type of number representation technique, in which their value of base is 16. That means there are only 16 symbols or possible digit values, there are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F. Where A, B, C, D, E, and F are single bit representations of decimal values 10, 11, 12, 13, 14, and 15 respectively.

The position of every digit has a weight which is a power of 16. Each position in the Hexadecimal system is 16 times more significant than the previous position, which means the numeric value of a hexadecimal number is determined by multiplying each digit of the number by the value of the position in which the digit appears and then adding the products. So, it is also a positional (or weighted) number system.

The hexadecimal number system is similar to the Octal number system. Hexadecimal number system provides a convenient way of converting large binary numbers into more compact and smaller groups.

Representation of Hexadecimal Number

Each Hexadecimal number can be represented using only 4 bits, with each group of bits having distinct values between 0000 (for 0) and 1111 (for F = 15 = 8+4+2+1). The equivalent binary number of hexadecimal numbers is given below.

Hex Digit	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000

9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

Since the base value of the hexadecimal number system is 16, so their maximum value of a digit is 15 and it cannot be more than 15. In this number system, the successive positions to the left of the hexadecimal point having weights of 16^0, 16^1, 16^2, 16^3 and so on. Similarly, the successive positions to the right of the hexadecimal point having weights of 16^{-1}, 16^{-2}, 16^{-3} and so on. This is called the base power of 16. The decimal value of any hexadecimal number can be determined using the sum of the product of each digit with its positional value.

The number 512_{16} can be interpreted as:

$=(2 \times 16^2) + (0 \times 16^1) + (0 \times 16^0)$

$=200$

Here, rightmost bit 0 is the least significant bit (LSB) and left most bit 2 is the most significant bit (MSB).

Task   Interpret $1AF_{16}$ into its decimal equivalent.

1.8 Converting from One Number System to Another

Numbers expressed in the decimal number system are much more meaningful to us, than are numbers expressed in any other number system. This is because we have been using decimal numbers in our day-to-day life, right from childhood; however, we can represent any number in one number system in any other number system. Because the input and final output values are to be in decimal, computer professionals are often required to convert a number in other systems to decimal and vice-versa. Many methods can be used to convert numbers from one base to another. A method of converting from another base to decimal and a method of converting from decimal to another base are described below.

Decimal to Binary Conversion

Step 1—Divide the base 10 number by the radix (2) of the binary system and extract the remainder (this becomes the binary number's LSD).

Step 2—Continue the division by dividing the quotient of step 1 by the radix (2).

Step 3—Continue dividing quotients by the radix until the quotient becomes smaller than the divisor; then do one more division. The remainder is our MSD.

Task   Convert: $710 = ?_2$ & $5110 = ?_2$

Decimal to Octal Conversion

The conversion of a decimal number to its base 8 equivalent is done by the repeated division method or Division-Remainder Method. Simply divide the base 10 number by 8 and extract the remainders. The first remainder will be the LSD, and the last remainder will be the MSD.

952_{10}= ?$_8$

Solution:

Hence, 952_{10}= 1670_8

📋 Task　　　Convert: 127_{10}=?$_8$ & 100_{10}=?$_8$

Decimal to Hex conversion

The conversion of a decimal number to base 16 **follows** the repeated division procedures. You have to remember that the remainder is in base 10 and must be converted to hex if it exceeds 9.

📋 Task　　　Convert: 3509_{10}=?$_{16}$ & 31_{10}=?$_{16}$

Binary Number to Equivalent Hexadecimal Number

Step 1: Divide the binary digits into groups of four starting from the right.

Step 2: Combine each group of four binary digits into one hexadecimal digit.

🗨 **Perform: 1111012 = ?16**

Step 1: Divide the binary digits into groups of four starting from the right

<u>0011</u>　　<u>1101</u>

Step 2: Convert each group into a hexadecimal digit.

Hence, 111101_2= $3D_{16}$

Converting a Number of another Base to a Decimal Number

Method 1-

- Step 1: Determine the column (positional) value of each digit.
- Step 2: Multiply the obtained column values by the digits in the corresponding columns.
- Step 3: Calculate the sum of these products.

🗨 **Perform the following Octal to Decimal Conversion:**

4706_8 = ?$_{10}$

=4706_8 = 4 x 8^3 + 7 x 8^2 + 0 x 8^1 + 6 x $8°$ =4x512+7x64+0+6x1

= 2048 + 448 + 0 + 6 (Sum of these products)

=2502_{10}

Summary

- Computer possesses various characteristics including Automatic Machine, Speed, Accuracy, Diligence, Versatility, Power of Remembering.
- Computer generation like First Generation (1942-1955), Second Generation (1955-1964), Third Generation (1964-1975), Fourth Generation (1975-1989), and Fifth Generation (1989-Present).
- Block Diagram of Computer means subpart of computers like input, output, and memory devices.
- CPU is a combination of ALU and AU.
- In an octal number system, there are only eight symbols or digits i.e. 0, 1, 2, 3, 4, 5, 6, 7, 8.
- In the hexadecimal number system, each position represents the power of the base 16.

Keywords

Data processing: The activity of processing data using a computer is called data processing.

Generation: Originally, the term "generation" was used to distinguish between varying hardware technologies, but it has now been extended to include both hardware and software that together make up a computer system.

Integrated circuits: They are usually called ICs or chips. They are complex circuits that have been etched onto tiny chips of semiconductor (silicon). The chip is packaged in a plastic holder with pins spaced on a 0.1" (2.54 mm) grid which will fit the holes on stripboard and breadboards. Very fine wires inside the package link the chip to the pins.

Storage unit: The storage unit of the computer holds data and instructions that are entered through the input unit before they are processed. It preserves the intermediate and final results before these are sent to the output devices.

Binary number system: It is like a decimal number system, except that the base is 2, instead of 10 which uses only two symbols (0 and 1).

n-bit number: An n-bit number is a binary number consisting of 'n' bits.

Decimal number system: In this system, the base is equal to 10 because there are altogether ten symbols or digits (0, 1, 2, 3, 4, 5, 6, 7, 8, and 9).

Explain the various computer generations while listing the main features of each.

Self-Assessment Questions

1. Which of the following is not a Primary Storage device?

(a) RAM   (b) Graphics Card

(c) ROM   (d) USB

2. Which of the following values is the correct value of this hexadecimal code ABCDEF?

    (a) 11259375

    (b) 11259379

    (c) 11259312

    (d) 11257593

3. A computer is accurate, but if the result of a computation is false, what is the main reason for it?

    (a) Power failure

    (b) The computer circuits

    (c) Incorrect data entry

    (d) Distraction

4. Which of the following numbers is a binary number?

    (a) 1 and 0

    (b) 0 and 0.1

    (c) 2 and 0

    (d) 0 and 2

5. Which of the following belongs to Fifth generation computers?

    (a) Laptop

    (b) NoteBook

    (c) UltraBook

    (d) All of the above

6. The decimal equivalent of the binary number 10111 is:

    (a) 21

    (b) 39

    (c) 42

    (d) 23

7. The processed form of data is called:

    (a) Information

    (b) Words

    (c) Fields

    (d) Nibble

8. Select the name of generation in which introduced Microprocessor:

    (a) Second Generation

    (b) Third Generation

    (c) Fourth Generation

    (d) None of the above

9. _____ generation of computer started with using vacuum tubes as the basic components.

    (a) 1st

    (b) 2nd

    (c) 3rd

    (d) 4th

10. The section of the CPU that is responsible for performing the mathematical calculations is:

    (a) Memory

    (b) Registers

    (c) Control Unit

    (d) Arithmetic Logic Unit

11. The second-generation computers used _____ for circuitry.

    (a) Vacuum Tubes

    (b) Transistors

    (c) Integrated Circuits

    (d) None of these

12. The full form for FORTRAN is:

    (a) FOR TRANslation

    (b) FORmula TRANslator

    (c) FORWARD TRANsfer

    (d) FORward TRANsference

13. Which of the following is not a type of number system?

    (a) Positional

    (b) Octal

    (c) Fractional

    (d) Non-positional

14. The 2's complement of 5 is _____.

    (a) 0101

    (b) 1011

    (c) 1010

    (d) 0011

15. The hexadecimal digits are 1 to 0 and A to _____.

    (a) H

    (b) E

    (c) I

    (d) F

Answers to Self-Assessment Questions

1.	d	2.	c	3.	c	4.	a	5.	d
6.	d	7.	a	8.	c	9.	a	10.	d
11.	b	12.	b	13.	c	14.	b	15.	d

Review Questions

6. Find out the decimal equivalent of the binary number 10111?

7. Discuss the block structure of a computer system and the operation of a computer?

8. What are the features of the various computer generations? Elaborate.

9. How the computers in the second-generation differed from the computers in the third generation?

10. Carry out the following conversions:

    (a) $125_8 = ?_{10}$ (b) $(25)_{10} = ?_2$ (c) $ABC_{16} = ?_8$

Further Readings

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2. Fundamental Computer Skills, Feng-Qi Lai, David R. Hofmeister.

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2. Computer Fundamentals Tutorial – Tutorialspoint

3. Learn Computer Fundamentals Tutorial - javatpoint

4. Computer Fundamental - Computer Notes (ecomputernotes.com)

Unit 02: Memory

Objectives

After studying this unit, you will be able to:

• Understand the computer unit- the memory

• Know about the various types of memory

• Explain random-access memory and read-only memory

• Learn about the Input-Output Devices

Introduction

A computer is a programmable machine designed to perform arithmetic and logical operations automatically and sequentially on the input given by the user and gives the desired output after processing. Computer components are divided into two major categories namely hardware and software. Hardware is the machine itself and its connected devices such as monitor, keyboard, mouse, etc. Software is the set of programs that make use of hardware for performing various functions.The computer is an electronic device that performs five major operations or functions irrespective of its size and makes. These are:

- it accepts data or instructions as input,
- it stores data and instruction
- it processes data as per the instructions,
- it controls all operations inside a computer, and
- it gives results in the form of output.

Components of Computer Architecture (Figure 1):

a) **Input Devices:** The input unit comprising of input devices is used for entering data and programs into the computer system by the user for processing.

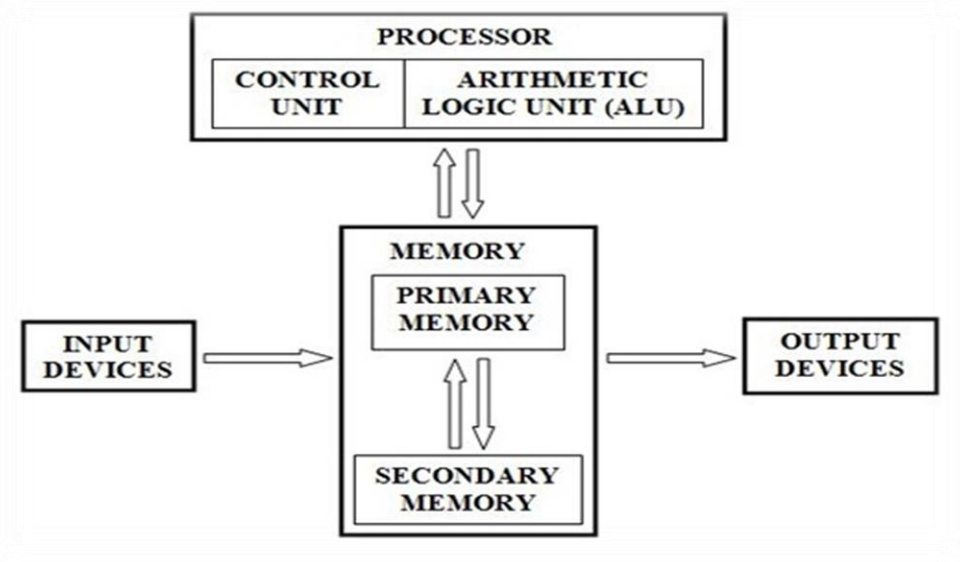b) **Storage Unit:** The storage unit is used for storing dataand instructions before and after processing.

Figure 1: Components of Computer Architecture

c) **Output Devices:** The output unit comprising of output devices is used for storing the result as output produced by the computer after processing.

d) **Processing:** The task of performing operations like arithmetic and logical operations is called processing. The Central Processing Unit (CPU) takes data and instructions from the storage unit and makes all sorts of calculations based on the instructions given and the type of data provided. It is then sent back to the storage unit. CPU includes Arithmetic Logic Unit (ALU) and control unit (CU).

- *Arithmetic Logic Unit* **(ALU):** This component performs all the calculations and comparisons, as per the instructions provided to it. It performs arithmetic functions like addition, subtraction, multiplication, division, and also logical operations like greater than, less than, and equal to, etc.

- *Control Unit*: The task of controlling all the operations like input, processing, and output are carried out by the control unit. It manages and tracks step-by-step processing of all operations inside the computer.

e) **Memory Unit:**It holds or stores data and instructions; intermediate results of the processing; and final results of processing.

2.1 Memory System in a Computer

There are two kinds of computer memory: primary and secondary (Figure 2: Memory Types in a Computer). Primary memory is accessible directly by the processing unit. RAM is an example of primary memory. As soon as the computer is switched off the contents of the primary memory are lost. You can store and retrieve data much faster with primary memory compared to secondary memory. Secondary memory such as floppy disks, magnetic disks, etc., is located outside the computer. Primary memory is more expensive than secondary memory because of this the size of primary memory is less than that of secondary memory.

Computer memory is used to store two things: (i) instructions to execute a program and (ii) data. When the computer is doing any job, the data that have to be processed are stored in the primary memory. This data may come from an input device like a keyboard or from a secondary storage device like a floppy disk.
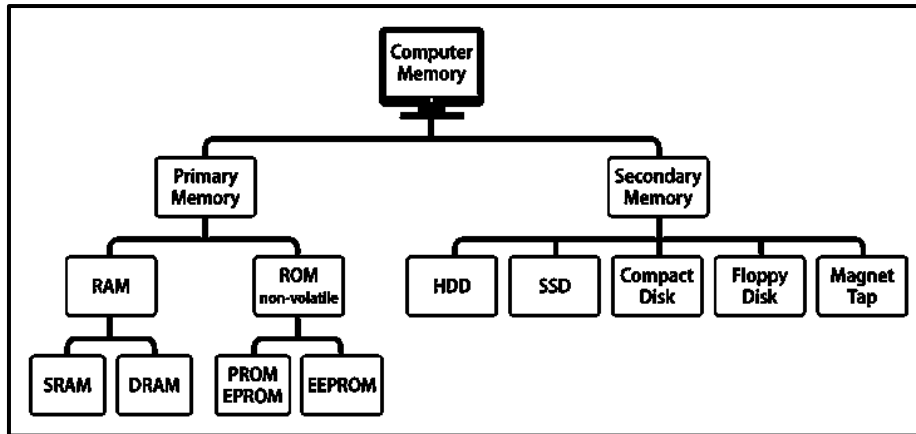
Figure 2: Memory Types in a Computer

Primary Memory

As the program or the set of instructions is kept in primary memory, the computer can follow instantly the set of instructions. In a computer's memory, both programs and data are stored in binary form. The binary system has only two values 0 and 1. These are called bits. As human beings, we all understand the decimal system but the computer can only understand the binary system. It is because a large number of integrated circuits inside the computer can be considered as switches, which can be made ON, or OFF. If a switch is ON it is considered 1 and if it is OFF it is 0. Several switches in different states will give you a message like this: 110101....10.

So, the computer takes input in the form of 0 and 1 and gives output in the form 0 and 1 only. Is it not absurd if the computer gives outputs as 0's & l's only? But you do not have to worry about it. Every number in a binary system can be converted to a decimal system and vice versa; for example, 1010 meaning decimal 10. Therefore, it is the computer that takes information or data in a decimal form from you, converts it into binary form, processes it producing output in binary form, and again converts the output to decimal form.

The internal storage section is made, up of several small storage locations called cells. Each of these cells can store a fixed number of bits called word length. Each cell has a unique number assigned to it called the address of the cell and it is used to identify the cells. The address starts at 0 and goes up to (n--l). You should know that the memory is like a large cabinet containing as many drawers as there are addresses on memory. Each drawer contains a word and the address is written on the outside of the drawer.

Capacity of Primary Memory

You know that each cell of memory contains one character or 1 byte of data. So, the capacity is defined in terms of byte or words. Thus 64 kilobytes (KB) memory is capable of storing 64. x 1024 = 32,768 bytes. (1 kilobyte is 1024 bytes). A memory size ranges from few kilobytes in small systems to several thousand kilobytes in a large mainframe and supercomputer. In your personal computer, you will find memory capacity in the range of 64 MB, 128 MB, 216 MB, and even 1 GB.

The following terms related to the memory of a computer are discussed below:

- *Random Access Memory (RAM):* The primary storage is referred to as random access memory (RAM) because it is possible to randomly select and use any location of the memory to directly store and retrieve data. It takes the same time to any address of the memory as the first address. It is also called read/write memory. The storage of data and instructions inside the primary storage is temporary. It disappears from RAM as soon as the power to the computer is switched off. The memories, which lose their content on the failure of power supply are known as volatile memories. Thus, RAM is called volatile memory.

- *Read-Only Memory (ROM):*Read-only memory (ROM) is a type of non-volatile memory used in computers and other electronic devices (Figure 3). The memory from which we can only read but cannot write on it. In other words, the data held in ROM cannot be electronically

modified after the manufacture of the memory device. The information is stored permanently in such memories during manufacture. A ROM stores such instructions that are required to start a computer. This operation is referred to as **bootstrap**. ROM chips are not only used in the computer but also in other electronic items like the washing machine and microwave oven.
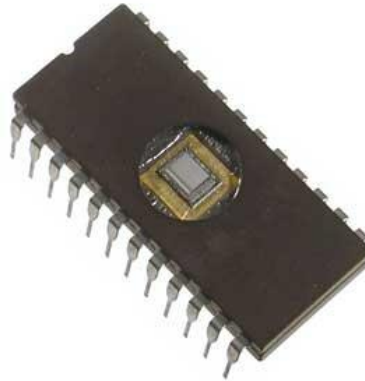

Figure 3: Read-Only Memory

Read-only memory is useful for storing software that is rarely changed during the life of the system, also known as firmware. Software applications (like video games) for programmable devices can be distributed as plug-in cartridges containing ROM.

There are two types of read-only memory (ROM) - manufacturer-programmed and user-programmed. A *manufacturer–programmed ROM* is one in which data is burnt in by the manufacturer of the electronic equipment in which it is used. For example, a personal computer manufacturer may store the system boot program permanently in a ROM chip located on the motherboard of each PC manufactured by it. Similarly, a printer manufacture rmay store the printer controller software in a ROM chip located on the circuit board of each manufactured by it. Manufacturer-programmed ROMs are used mainly in those cases where the demand for such programmed ROMs is large. Note that manufacturer-programmed ROM chips are supplied by the manufacturers of electronic equipment and a user can't modify the programs or data stored in a 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. That is, it is possible for a user to "customize" a system by converting his/her programs to micro-programs and storing them in a user-programmed ROM chip. Such a ROM is commonly known as *Programmable Read-Only Memory (EPROM)* because a user can program it. Once the user programs are stored in a PROM chip, they can be executed usually in a fraction of the time previously required.

- *Basic Input-Output System (BIOS)***:** It is a type of ROM that aids in establishing basic communication initially when a computer is turned on.

- *MROM (Masked ROM)***:** The very first ROMs were hard-wired devices consisting of a pre-programmed set of data or instructions and known as MROMs, which were inexpensive.

- *Programmable ROM***:** PROM is read-only memory that can be modified only once by a user. The user buys a blank PROM and enters the desired contents using a PROM program. Inside the PROM chip, there are small fuses that are burnt open during programming. It can be programmed only once and is not erasable.

PROMs are programmed to record information using a special device known as PROM-programmer. However, once the chip has been programmed, the PROM becomes a ROM.

That is, the information recorded in it can only be read (it cannot be changed). PROM is also non-volatile storage, i.e., the stored information remains intact even if power is switched off or interrupted.

- *Erasable PROM (EPROM):* EPROM can be erased by exposing it to ultra-violet light for a duration of up to 40 minutes. Usually, an EPROM eraser achieves this function. During programming, an electrical charge is trapped in an insulated gate region. The charge is retained for more than 10 years because the charge has no leakage path. For erasing this charge, ultra-violet light is passed through a quartz crystal window (lid). This exposure to ultra-violet light dissipates the charge.

  EPROM chips are of two types—one in which the stored information is erased by exposing the chip for some time of ultraviolet light and the other one in which the stored information is erased by using high voltage electric pulses is known as Ultra-violet EPROM (UVEPROM) and the latter is known as Electrically EPROM (EEPROM). It is easier to alter information stored in an EEPROM chip as compared to a UVEPROM chip. EPROM is also known as *flash memory* because of the ease with which programs stored in it can be altered. Flash memory is used in many new I/O and storage devices; Universal Serial Bus (USB) pen drives and MP3 music players.

- *Electrically Erasable and Programmable Read-Only Memory (EEPROM):* EEPROM is programmed and erased electrically. It can be erased and reprogrammed about ten thousand times. Both erasing and programming take about 4 to 10millisecond/ms. In EEPROM, any location can be selectively erased and programmed one byte at a time, rather than erasing the entire chip. Hence, the process of reprogramming is flexible but slow.

- *Cache Memory:* Cache memory is commonly used for minimizing the memory- processor speed mismatchbecause the rate of data fetching by a computer's CPU from its main memory is about 100times faster than that from high-speed secondary storage like a disk. However, even with the use of main memory, memory-processor speed mismatch becomes a bottleneck in the speed with which the CPU can process instructions because there is a 1 to 10-speed mismatch between the processor and memory. That is, the rate at which data can be fetched from memory is about 10 times slower than the rate at which the CPU can process data. The overall performance of a processor can be improved greatly by minimizing the memory processor speed mismatch.

  Cache memory acts as a high-speed buffer between CPU and main memory and is used to temporarily store very active data and instructions during processing. Caches are extremely fast, with small memory between CPU and main memory having the access time closer to the processing speed of the CPU. Caches are used to store very active data and instructions during processing temporarily. Since, the cache memory is faster than main memory, processing speed is improved by making the data and instructions needed for current processing available in the cache. Cache memory acts as a high-speed buffer between CPU and main memory and is used to temporarily store very active data and instructions during processing.

- *Virtual Memory:* Virtual memory appears to exist as main storage although most of it is supported by data held in secondary storage, transfer between the two being made automatically as required.

- *Registers:* Registers are a type of computer memory used to quickly accept, store, and transfer data and instructions that are being used immediately by the CPU. The registers used by the CPU are often termed processor registers.

┌───┐
│ 📋 *Task*: What is the difference between cache memory and RAM?   │
└───┘

Secondary Memory: Secondary memory is physically placed or located inside a separate storage device which is then connected to the computer for access. HDD and SSD are the most commonly used secondary memory devices in a computer normally. They are not as expensive as the RAM and ROM and are reasonably priced. Their read and write speed are also comparatively lower. Since it is a separate device altogether, it can preserve the data that is saved inside it without the need for power. The data exchanged and stored is first sent to the RAM and then to the CPU for further processing. They have the possibility of permanently storing the data and at the same time, you can easily use them anywhere and carry them along with you.

2.2 Units of Memory

CPU contains necessary circuitry for data processing controlling other components of the computer. However, one thing it does not have built into it is the place to store programs and data needed during data processing. CPU contains several registers for storing data and instructions but they can store only a few bytes at a time. They are just sufficient to hold only one or two instructions with corresponding data. If the instructions and data of a program being executed by a CPU were to reside in secondary storage like a disk, and fetched and loaded one by one into CPU registers as the program execution proceeded, this would lead to the CPU being idle most of the time. This is because there is a large speed mismatch between the rate at which the CPU can process data and the rate at which data can be transferred from disk to CPU registers. For example, a CPU can process data at a rate of about 5nanosecond/byte and a disk reader can read data at a speed of about 5microseconds/byte. Hence, within the time in which a disk can supply one byte of data,a CPU can process 1000 bytes. This would lead to a very slow overall performance evenif a computer used a very fast CPU.

To overcome this problem, there is a need to have a reasonably large storage space that can hold the instructions and data of the program(s) on which CPU is currently working time to fetch and load data from this storage space into CPU registers must also be very small as compared to that space from disk storage to reduce the speed mismatch problem with CPU speed. Every computer has such a storage space known as primary storage, main memory, or simply memory. It is a temporary storage area built into the computer hardware. Instructions and data of a program reside mainly in this area when the CPU is executing the program. Physically, this 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. This built-in memory allows the CPU to store and retrieve data very quickly. The rate of fetching data from this memory is of the order of 50nanoseconds/byte. Hence, the rate of data fetching from main memory is about 100 times faster than that from high-speed secondary storage like a disk.

The memory unit is the amount of data that can be stored in the storage unit. This storage capacity is expressed in terms of Bytes. There are different units of memory as listed in Table 1.

Table 1: Memory Units

Name	Symbol	Binary Measurement	Decimal Measurement	Number of Bytes	Equal to
kilobyte	KB	2^{10}	10^3	1,024	1,024 bytes
megabyte	MB	2^{20}	10^6	1,048,576	1,024 KB
gigabyte	GB	2^{30}	10^9	1,073,741,824	1,024 MB

terabyte	TB	2^40	10^12	1,099,511,627,776	1,024 GB
petabyte	PB	2^50	10^15	1,125,899,906,842,624	1,024 TB
exabyte	EB	2^60	10^18	1,152,921,504,606,846,976	1,024 PB
zettabyte	ZB	2^70	10^21	1,180,591,620,717,411,303, 424	1,024 EB
yottabyte	YB	2^80	10^24	1,208,925,819,614,629,174, 706,176	1,024 ZB

2.3 Classification of Primary and Secondary Memory

Computers work with the help of computer memory as they safely keep the data while they have not been processed yet. Many different types of computer memory can be used in different technologies .Computer memory is a generic term for all of the different types of data storage technology that a computer may use, including RAM, ROM, and flash memory. Some types of computer memory are designed to be very fast, meaning that the CPU can access data stored there very quickly. Other types are designed to be very low cost so that large amounts of data can be stored there economically. A computer system is built using a combination of these types of computer memory, and the exact configuration can be optimized to produce the maximum data processing speed or the minimum cost, or some compromise between the two.

Memory is required in computers to store data and instructions. Computer memory is of two basic types – Primary memory and Secondary memory as depicted in Figure 2.We have already discussed the primary and secondary memory above. Let us explore the further subsequent types of primary and secondary memory each.

Task   How many bytes in 2 GB describe with example?

Primary Memory Types

Prominently, there are two key types of primary memory:

- RAM, or Random-Access Memory
- ROM, or Read-Only Memory

- **Random Access Memory**

Random-access memory (RAM / r æ m /) is a form of computer memory that can be read and changed in any order, typically used to store working data and machine code. The data that is stored in the RAM can be accessed randomly. RAM device allows data items to be read or written in almost the same amount of time irrespective of the physical location of data inside the memory. There is no particular order needed. It is the most expensive type of memory. It is very fast and quick but requires power to run and to exchange data and share data that is stored in its memory. Whichever data is needed to be processed imminently is moved to the RAM where the modification and accessing of the data is done quickly so that there is no waiting period for the CPU to start functioning. It improves the speed of the processing of the CPU and the different multiple commands given to it by the users. Whichever data becomes out of use is then move to the secondary memory and the space in the RAM is freed for further processes.

RAM capacity can be enhanced by adding more memory chips on the mother board. The additional RAM chips, which plug into special sockets on the motherboard, are known as *single-in-line memory modules (SIMMs).*There are two major types of RAM:

a. Dynamic RAM

Dynamic RAM is the commonly used RAM in computers. Unlike earlier times when the computers used to use single data rate (SDR) RAM, now they use dual data rate (DDR) RAM which has faster processing ability. DDR2, DDR3, DDR4 are the available versions of the DRAM each efficient according to their number. The compatibility of the DRAM with the operating system needs to be checked before any installation. The other characteristic features of DRAM are:

• DRAM has memory cells with a paired transistor and capacitor.

• Data is stored in capacitors.

• Capacitors that store data in DRAM gradually discharge energy, no energy means the data has been lost. So, a periodic refresh of power is required to function.

• DRAM is called dynamic as constant change or action i.e. refreshing is needed to keep the data intact.

• It is used to implement main memory.

• Low costs of manufacturing and greater memory capacities.

• Slow access speed and high-power consumption.

b. *Static RAM*

Static RAM is faster than Dynamic RAM and therefore it is more expensive. It has a total of six transistors in each of its cells. Therefore, it is commonly used as a data cache within the CPU and in high-end servers. It helps in the speed improvements of the computer and possesses the following additional characteristics:

• Uses multiple transistors, typically four to six, for each memory cell but doesn't have a capacitor in each cell. It is used primarily for the cache.

• Data is stored in transistors and requires a constant power flow.

• Because of the continuous power, SRAM doesn't need to be refreshed to remember the data being stored.

• Static as no change or action i.e. refreshing is not needed to keep the data intact. It is used in cache memories.

• Low power consumption and faster access speeds.

SRAM has certain disadvantages associated with it including:

o Fewer memory capacities

o High costs of manufacturing

Table 2 lists the comparison between SRAM and DRAM.

Table 2: Comparison SRAM vs DRAM

S.No.	SRAM	DRAM
1.	Transistors are used to store information in SRAM.	Capacitors are used to store data in DRAM.
2.	Capacitors are not used hence no refreshing is required.	To store information for a longer time, the contents of the capacitor need to be refreshed periodically.
3.	SRAM is faster and expensive	DRAM provides slow access speeds.
4.	SRAMs are low-density devices and used in cache memories	DRAMs are high-density devices and used in main memories.

1. Read-Only Memory

Data can be only read and not written to it. It is a fast type of memory. It is a non-volatile type of memory. In case of no power, the data is stored in it and then accessed by the computer when power is turned on. It usually contains the Bootstrap code which is required for the computer to interact with the hardware systems and understand its operations and functions according to the commands given to it. In simpler devices used commonly, there is ROM in which the firmware data is stored to get them to function according to their need.ROM is of different types as listed in Table 3.

Table 3:Different Types of ROMs

Type of ROM	Usage
Manufacturer-programmed ROM	Data is burnt by the manufacturer of the electronic equipment in which it is used.
User-programmed ROM / Programmable ROM(PROM)	The user can load and store "read-only" programs and data in It.
Erasable PROM (EPROM)	The user can erase information and the chip can be reprogrammed to store new information.
Ultra Violet EPROM (UVEPROM)	Type of EPROM in which stored information is erased by exposing the chip for some time to the ultra-violet light.
Electrically EPROM or Flash Memory	Type of EPROM in which stored information is erased by using high voltage electric pulses.

Secondary Memory Types

Secondary memory comprises the storage devices that are built into the computer or connected to the computer. They are also known as External Memory or Auxiliary Storage. The computer usually uses its input/output channels to access secondary storage and transfers the desired data using an intermediate area in primary storage. Secondary memory is non-volatile, that is, it retains data when power is switched off and possesses large capacities to the tune of terabytes.

Depending on whether the second memory device is part of the CPU or not, there are two types of secondary memory (Figure 4):

• **Fixed Secondary Memory:** It is an internal media device that is used by a computer system to store data and is usually referred to as Fixed Disks drives or Hard Drives.Literally, the fixed secondary memory is not fixed and can be removed from the system for repairing work, maintenance purposes, and upgrade, etc.

• **Removable Secondary** Memory: The storage device that can be removed/ejected from a computer system while the system is running is called removable secondary memory. It makes it easier for a user to transfer data from one computer system to another and initiates faster data transfer rates. The major examples include HDDs, CD/DVD, Pendrives, SSDs, Memory card, Blue-ray Disk.
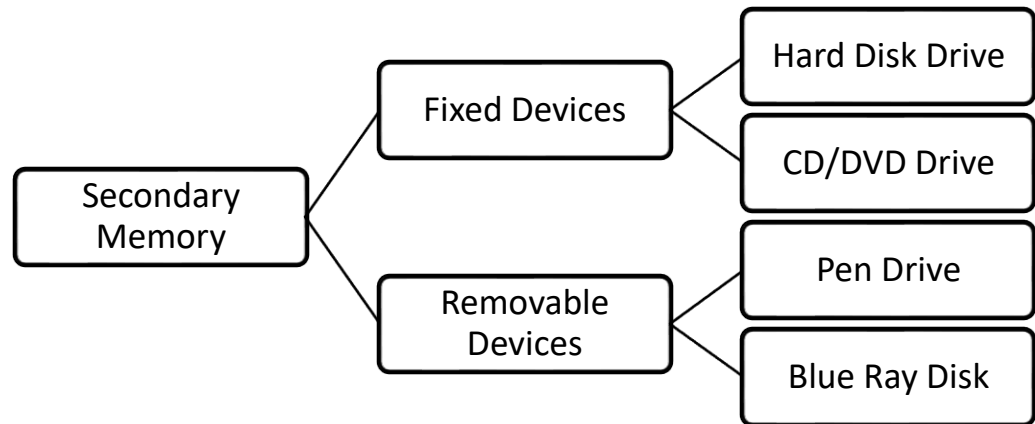
Figure 4: Types of Secondary Memory

Secondary memory comprises many different storage media which can be directly attached to a computer system. These include:

- **Hard Disk Drives:** Hard disk drives are among the most common types of computer memory that can store data and information for a long-term basis. Hard drives work much like records. They are spinning platters that have arms with heads to touch the different parts of it. When the head is at a certain location, data and information is either being written or deleted from that area of the hard drive.

  The speed of HDD refers to the speed at which content can be read and written on a hard disk with the set rotation speed varying from 4500 to 7200 rpm (revolutions per minute). The disk access time in HDD is measured in milliseconds. HDDs are of 2 types: Internal and external HDD. Table 4 lists the comparison between both HDD types.

Table 4: Comparison of Internal and External HDD

Features	Internal HDD	External HDD
Portability	No	Yes
Price	Less expensive	More expensive
Speed	Fast	Slow
Size	Big	Small

- **Solid State Drives (SSDs):** SSDs are non-volatile storage devices capable of holding large amounts of data and use NAND flash memories (millions of transistors wired in a series on a circuit board). They provide immediate access to the data as no moving parts are used thus making them much faster and significantly more expensive than the traditional HDDs. The capacity of SSDs is usually measured in Gigabytes. These can be installed inside a computer or purchased in a portable (external) format and are small in physical size, very light, ideal for portable devices.

- **Optical (CD or DVD) Drives:** Optical drives hold content in the digital format and are read using a laser assembly is considered optical media. They use a laser to scan the surface of a spinning disc made from metal and plastic. The disc's surface is divided into tracks, with each track containing many flat areas and hollows. The flat areas are known as lands and the hollows as pits.When the laser shines on the disc's surface, lands reflect the light, whereas pits scatter the laser

beam. A sensor looks for the reflected light. The reflected light (lands) represents a binary '1', and no reflection (pits) represents a binary '0'.The most common types of optical media are:

> *Compact Disc (CD)*: Compact discs are used to store photos, audio, and computer software and are available in three types which are read-only, recordable, and rewriteable. The different types of CDs are as follows:

Compact DISC Read-Only Memory (CD-ROM):

– The data stored on CD-ROM can only be read. It cannot be deleted or changed.
– Store up to 700MB of data.
– Mostly used to store photos and audios. It is often used to distribute new application software and games.

CD-Recordable (CD-R)

– The user can write data on CD-R only once but can read it many times.
– The data written on CD-R cannot be erased.
– CD-R drives are known as CD burners.
– The process of recording data on CD-R is called burning. CD-R is known as WORM (Write Once Read Many).

Compact Disc Rewriteable (CD-RW)

– Also known as an erasable optical disc.
– The most common type of erasable and rewritable optical disc is the magneto-optical disc.

> **Digital Versatile Disc (DVD):** These are also called Digital Video Discs having storage capability of up to 17 GB of data, much greater than the CD. DVDs are available in three types which are read-only, recordable, and rewritable. Digital Video Disc Read-Only Memory (DVD-ROM)is a high-capacity optical disc that the users can only read but not write or erase. Digital Video Disc Recordable (DVD-R) is similar to a CD-R disc. The written data cannot be erased.Digital Video Disc Rewritable (DVD-RW) enables the users to write data on CD-RW many times by erasing the existing contents.

> **Blu-ray (BD):**Blu-Ray disc is a new and more expensive DVD format that provides higher capacity and better quality than standards DVDs especially for high-definition video. It can store up to 100 GB of data.

• **Tape drives:** Tape drives are types of computer memory that work like tapes or audio cassettes. They have ribbons and spools, where the data and information you would like to store are saved with the ribbon's polarity. These tape drives are mostly used by medium to large organizations as they offer long-term and stable storage.

• **USB Flash Drive:** USB flash drives are small, portable flash memory cards that plug into a computer's USB port and function as a portable hard drive. They are available in sizes such as 256MB, 512MB, 1GB, 5GB, 16GB, and 32 GB are an easy way to transfer and store information.

• **Memory Card:** An electronic flash memory Storage Disk (SD) commonly used in consumer electronic devices such as digital cameras, MP3 players, mobile phones, and other small portable devices. These can be read by connecting the device containing the card to your computer, or by using a USB card reader.

2.4 Memory Instruction Set

Every central processing unit is having a unique instruction set that is distinct to it and identifies a particular processor family. Every CPU has a built-in ability to execute a particular set of machine

instructions. So, a computer operates on this different set of instructions over there. Basically, every ALU (the main part that is executing all the computations and calculations) also operates on a certain set of instructions and every CPU has some built-in instruction set that is a particular set of machine instructions that is called as is instruction set.

Most of the CPUs have around 200 or more instructions, such as addition subtraction comparison, division, multiplication, in their instruction set. So, when we want to divide a particular CPU, basically different manufacturers, what they do they have different CPUs that are designed by them. Suppose a particular CPU belongs to one family and another CPU belongs to another family, a third CPU belongs to another family, and so on. If we want to identify each family which is in turn identified based on the instruction set of the CPU. Thereby, the manufacturers group up to their CPUs into different families that are having similar instruction sets.

New CPU whose instruction set includes instruction set of its predecessor CPU is said to be backward compatible with its predecessor. When any new CPU is generated that is having some instruction set, if its instruction set is quite similar or includes the instruction set of its predecessor, then, in that case, we say that the new CPU is backward compatible with its predecessor. So, it is the backward compatibility of a particular CPU.

2.5 Memory Registers

Registers are a type of computer memory used to quickly accept, store, and transfer data and instructions that are being used immediately by the CPU. Registers are the special memory units that hold information temporarily as the instructions are interpreted and executed by the CPU. The registers are part of the CPU (not the main memory). The registers have variable word size which signifies the length of a register equaling the number of bits it can store. Different types of registers are used in computer systems. Table 5 lists the various registers.

Table 5: Most Common Registers Used in a Basic Computer

S. No.	Register	Function
1.	Memory Address (MAR)	Holds the address of the active memory location.
2.	Memory Buffer (MBR)	Holds contents of the accessed (read/written) memory word.
3.	Program Control (PC)	Holds the address of the next instruction to be executed.
4.	Accumulator (A)	Holds data to be operated upon, intermediate results, and final results.
5.	Instruction (I)	Holds an instruction while it is being executed.
6.	Input/ Output (I/O)	Used to communicate with the I/O devices.

2.6 Input-Output Devices

A computer is a very versatile machine that can easily process different types of data. To work with these data, we require different types of devices. These devices can help us enter data into the computer. These devices are called input and output devices (I/O devices). The devices that are used to display the information of the results are known as output devices. While the devices whose main function is to give instructions and data to the computer are called input devices. The I/O devices are indispensable components that are required for users to communicate with the computer (Figure 5). All in all, the I/O devices act as an intermediary between the user and the machine aiding in the process of communication. These are also known as peripherals since they surround the CPU and memory of a computer system.
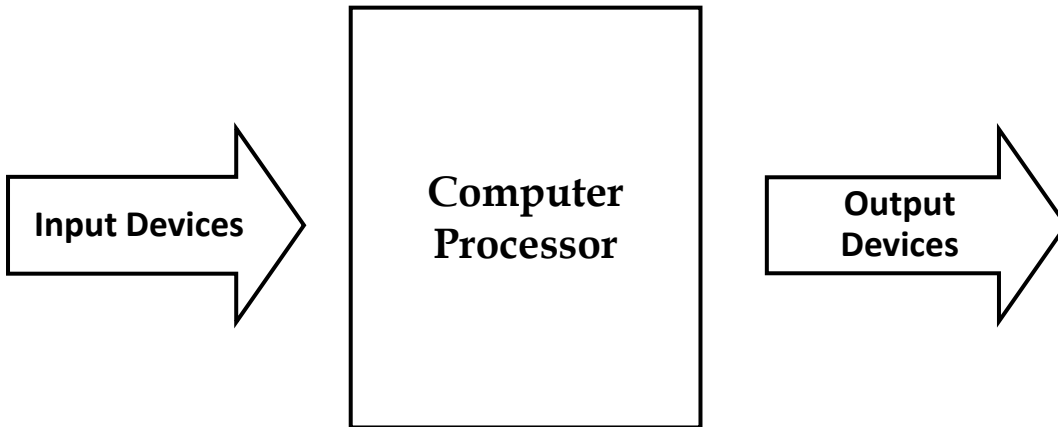
Figure 5: Computers and I/O Devices

Input Devices

Electromechanical devices can be used to enter data and instructions to the computer.Input devices capture and send data and information to a computer.The main function of the input device is to enter the data into the computer. Such devices allowthe users to communicate and feed instructions and data to the computers for processing, displaying, storing, and/or transmission. Input devices perform encoding (Converting the human-readable input into the computer-readable format). The various examples of input data are a mouse, keyboard, light pen, etc.

Mouse: The mouse is found on every computer. It is an integral part of it. It is a pointing device (Figure 6). The main principle it works on is the point and click. The mouse uses the trackball to give the motion to the pointer displayed on the screen. Usually, for windows-based programs, a mouse is used. Nowadays, wireless mouseis becoming more popular among people.

Figure 6: Mouse

Keyboard: The keyboard is used to enter all the data into the computer. It directs the computer through instructions. Normally keyboard has 104 buttons called the keys. You can do various tasks through the keyboard. You can program, type, etc. through a keyboard only.The popular keyboard used today is the 101-keys*QWERTY keyboard (*Figure 7*).*
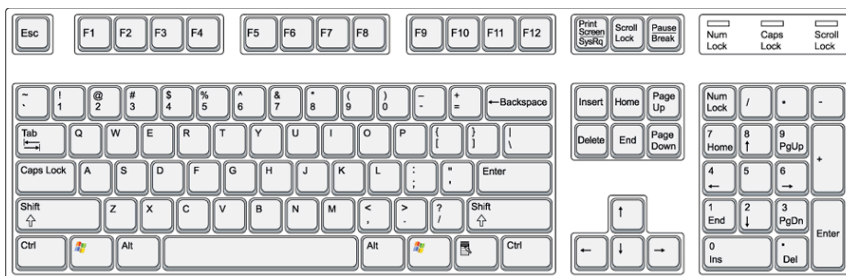

Figure 7: Key Layout on a QWERTY Keyboard

Joystick: Most commonly there are electrical, two-axis joysticks that were invented by C. B. Mirick and name coined by a French pilot Robert Esnault-Pelterie.A joystick is a pointing device that consists of a stick that pivots on a base and reports its angle or direction to the device it is controlling.

Optical Input Devices: Optical input devices use light as a source of input. They eliminate the need for manual entry of data, thus accuracy increases. The most typical types of optical input devices include:

- *Scanners*: A light-sensitive device to copy or capture images, photos, and artwork that exist on paper.

- *Barcode Readers*: An optical scanner that can read bar codes.

Audio Input Devices: The audio-based input devices record the analog sound and convert it into digital form for further processing. There are various types of such devices includingvoice recognition devices, microphones, musical instruments, etc.

Video-Input Devices: The video input devices are usedto enter full-motion video recording into a computer like Cameras.

Output Devices

Thecomputer hardware equipment which givesout the result of the entered input, once it is processed is called an output device. The output devices perform decoding (that is, convert data from machine language to a human-understandable language or convert electronically generated information into human-readable form). These devices are used to communicate the results of data processing carried out by an information processing system. Output devices such as printers, projectors receive the data from a computer usually for display or projection either in softcopy or hard copy format. The different types of output devices include:

Monitor: The monitor is an important component of a computer that is used to display the processed information. It is known as a visual display unit (VDU). Monitors are the computer hardware that displays the video and graphics information generated by the computer as illustrated in Figure 8.

Figure 8: Monitors

The pictures that are displayed on the screen are shown by using a large number of tiny dots known as pixels. These pixels that are shown on the monitor are referred to as the resolution of the screen. There are mostly two types of monitors:

- LCD or liquid crystal display monitor
- CRT or Cathode Ray tube monitor

In modern times, the monitors are typically TFT-LCD or LED display, while older monitors used a CRT display. The LCD monitors are lighter in weight can compare to CRT monitors and they are very popular nowadays. The output that is displayed on the screen is known as the soft copy output as it cannot be retained for a longer time.

Printers: The printer is a very important component of a computer that gives you a printed result of what is displayed on the monitor (Figure 9). The output received from the printer is called hard copy because you can retain it even after you turn off the computer or are no longer working on it. In other words, the printers are the peripherals that are used to print human-readable representations of graphics or text on paper. The world's first computer printer was invented by Charles Babbage.When

you look at the printing techniques, there are mainly two types of printers- *Iimpact printers and Non-impact printers.*

Figure 9: A Printer

The impact printer contacts the paper and usually forms the print image by pressing an inked ribbon against the paper using a hammer or pins. The different examples for impact printers are Dot-Matrix, Daisy Wheel. The non-impact printers do not use a striking device to produce characters on the paper; and because these printers do not hammer against the paper that is why they are much quieter. Inkjet and Laser printers are an example of non-impact printers.

Plotters:A plotter is a printer that interprets commands from a computer to make line drawings on paper with one or more automated pens (Figure 10). Unlike a regular printer, the plotter can draw continuous point-to-point lines directly from vector graphics files or commands. The engineering design applications like the architectural plan of a building, design of mechanical components of an aircraft or a car, etc., often require high-quality, perfectly-proportioned graphic output on large sheets. Plotters are an ideal output device for architects, engineers, city planners, and others who need to routinely generate high-precision, hard-copy, the graphic output of widely varying sizes.

Figure 10: A Plotter

The two commonly used types of plotters are drum plotters and flatbed plotters. In a drum plotter, the paper on which the design is to be made is placed over a drum that can rotate in both clockwise and anti-clockwise directions to produce vertical motion. The mechanism also consists of one or more penholders mounted perpendicular to the drum's surface. The pen(s) clamped in the holder(s) can move left to or right to left to produce horizontal motion. A graph-plotting program controls the movements of the drum and pen(s) that is, under computer control, the drum and pen(s) move simultaneously to draw designs and graphs; sheet placed on the drum. The plotter can also annotate the designs and graphs so drawn by using the pen to draw characters of various sizes. Since each penis program selectable, pens having ink of different colours can be mounted in different holders to produce multi-coloured designs.A flatbed plotter is a computerized plotter that works by using an arm that moves a pen over paper rather than having paper move under the arm as with a drum plotter. The paper is placed on the bed, a flat surface, of the flatbed plotter.

Audio Output Devices: Any devices that attach to a computer to play sound, such as music or speech(speakers, headphones, and sound cards, etc.) are called audio output devices.

• *Speakers:* A device through which we can listen to a sound as an outcome of what we command a computer to do is called a speaker and also are a hardware device which can be attached separately. With the advancement in technology, speakers are now available which are wireless and can be connected using Bluetooth or other applications.

• *Projector*: An optical device that presents an image or moves images onto a projection screen is called a projector. Most commonly these projectors are used in auditoriums and movie theatres for the display of the videos or lighting.

• *Headphones*: A headphone performs the same function as a speaker; the only difference is the frequency of sound. While using the speakers, the sound can be heard over a larger area, and using headphones, the sound is only audible to the person using them. Headphones are also known as earphones or headsets.

2.7 Latest Input-Output Devices in Market

Input Devices:

1. Keyboard
2. Pointing Devices
   (a) Mouse
        i. Mechanical mouse
        ii. Optical mouse
   (b) Track Ball
   (c) Joystick
   (d) Touch Screen
   (e) Light Pen
   (f) Touch Pad
3. Digital Camera
4. Scanner
5. Microphone
6. Graphic Digitizer
7. Optical Scanners
8. Optical Character Recognition (OCR)
9. Optical Mark Recognition (OMR)
10. Magnetic-Ink Character Recognition (MICR)

⚠ *Caution:* In the current market there are many local devices are available so never take local devices.

Lab Exercise: Find out the latest trends in the market related to various I/O devices?

**Output Devices*:*

1. Monitor
2. Compact Disk
3. Printers
4. Speaker
5. Disk Drives

6. Floppy Disk

7. Headphone

8. Projector

Summary

- CPU contains necessary circuitry for data processing.

- The computer's motherboard is designed in a manner that its memory capacity can been handed easily by adding more memory chips.

- Micro programs are the special programs for building an electronic circuit to perform operations.

- Manufacturer programmed; ROM is one in which data is burned in the manufacture of electronic unit/equipment in which it is used.

- Secondary storage is a hard disk that saves more data on the computer.

- Input devices provide the input from the user side in the computer while the output devices display the results of the computer.

- Non-impact printers are larger but are very quiet in operation. Being of non-impact type, they cannot be used to produce multiple copies of a document in a single printing.

Keywords

Single line memory modules: The additional RAM clip that plugs into special sockets on the motherboard.

PROM: Programmable ROM is one in which data is burnt in by the manufacturer of the electronic equipment in which it is used.

Cache memory: It is used to temporarily store very active data and instructions during processing.

Terminal: A monitor is associated usually with a keyboard and together they form a Video Display Terminal (VDT). A VDT (often referred to as just terminal) is the most popular input/output (I/O) device used with today's computers.

Flush memory: Storage technology Recall that flash is a non-volatile, Electrically Erasable Programmable Read-Only Memory (EEPROM) chip.

Plotter: Plotters are an ideal output device for architects, engineers, city planners, and others who need to routinely generate high-precision, hard-copy, the graphic output of widely varying sizes.

LCD: LCD stands for Liquid Crystal Display, referring to the technology behind these popular flat-panel monitors.

*Lab Exercise***:**

1. Define various input-output devices.

2. Define all Secondary storage devices.

Self-Assessment Questions

1. Which of the following is NOT an input device?

(a) Barcode Reader   (b)Scanner

(c) Touchpad   (d) Speaker

2. The additional RAM chips which plug into special sockets on the motherboard areknown as

(a) SIMMs   (b) SIMs

(c) PROM   (d) All of these

3. CRT stands for ……………….

(a) Crystal ray tube   (b) Cathode ray tube

(c) Crystal rode tube   (d) Cathode rode tube

4. Which of the following memories must be refreshed many times per second?

(a) EPROM   (b) ROM

(c) Static RAM   (d) Dynamic RAM

5. The main memory of the computer is-

(a) Internal   (b)External

(c)Auxiliary   (d) Both (a) and (b)

6. In which storage device, recording is done by burning tiny pits on a circular disk?

(a) Punched cards(b) Floppy disk

(c) Magnetic tape   (d) Optical disk

7. Which of the following can be an output by a computer?

(a) Graphics   (b) Text

(c) Voice   (d) All of these

8. Daisy wheel printer is a type of

(a) Matrix printer   (b) Impact printer

(c) Laser printer   (d) Manual printer

9. The memory which is programmed at the time it is manufactured is

(a) ROM (b) RAM

(c) PROM   (d) EPROM

10. Continuous line drawings are produced using

(a) chain printers (b) daisy wheel printers

(c) plotters   (d) thermal devices

11. The two types of primary memory are

(a) cache and buffer   (b) ROM and RAM

(c) random and sequential (d) central and peripherals

12. Memory is

(a) A device that performs a sequence of operations specified by the instructions in memory

(b) The device where information is stored

(c) a sequence of instructions

(d) typically characterised by interactive processing and time-sharing of the CPU's time to allow quick response to each user.

13. The QWERTY keyboard

(a) is the most popular keyboard   (b) is the fastest keyboard

(c) is a keyboard rarely used   (d) uses Dvorak layout

14. The linkage between the CPU and users is provided by

(a) storage   (b) software

(c)peripheral devices   (d) control unit

15. _____ acts as a high-speed buffer between CPU and main memory and is used to temporarily store very active data and instructions during processing.

(a) Buffered memory   (b) Storage memory

(c)Cache memory   (d) Matrix memory

Answers for Self-Assessment Questions

1. d	2. A	3. b	4. d	5. a
6. d	7. D	8. b	9. a	10. c
11. b	12. B	13. a	14. c	15. c

Review Questions

1. Define Primary memory? Explain the difference between RAM and ROM?
2. What is secondary storage? How does it differ from primary storage?
3. Define memory and its types.
4. Discuss the difference between SRAM and DRAM?
5. Explain the different I/O devices used in a computer system? Why I/O devices are necessary for a computer system?
6. Why I/O devices are very slow as compared to the speed of primary storage and CPU?

Further Readings

Books

1. *Fundamental Computer Skills*, Feng-Qi Lai, David R. Hofmeister.
2. *A Study of Computer Fundamental*, Shu-Jung Yi.

*Online Link***:**

1. CompFunds.pdf (cam.ac.uk)

Unit 03: Processing Data

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Objectives

Introduction

3.1   Functional units of a computer

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Summary

Keywords

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Objectives

After studying this unit, you will be able to:

- Explain conversion of the data into information
- Discuss data representation in the computer
- Explain data processing cycle and data processing system
- Learn about the machine cycle
- Explain different types of memory and computer registers
- Explain computer bus
- Discuss cache memory in detail

Introduction

The computer accepts data as an input, stores it processes it as the user requires, and produces information or processed data as an output in the desired format. The use of Information Technology (IT) is well recognized. IT has become a must for the survival of the business houses with the growing information technology trends. The computer is one of the major components of an IT network and gaining increasing popularity. Today, computer technology has permeated every sphere of existence of modern man. From railway reservations to medical diagnosis; from TV programs to satellite launching; from matchmaking to criminal catching—everywhere we witness the elegance, sophistication, and efficiency possible only with the help of computers. The basic computer operations are:

  • it accepts data or instruction by way of input,

  • it stores data,

  • it can process data as required by the user,

  • it gives results in the form of output, and

• it controls all operations inside a computer

3.1 **Functional units of a computer**

There are multiple functional units of a computer system that perform various functions such as the Arithmetic Logic Unit (ALU), Central Processing Unit (CPU), Control Unit (Figure 1).
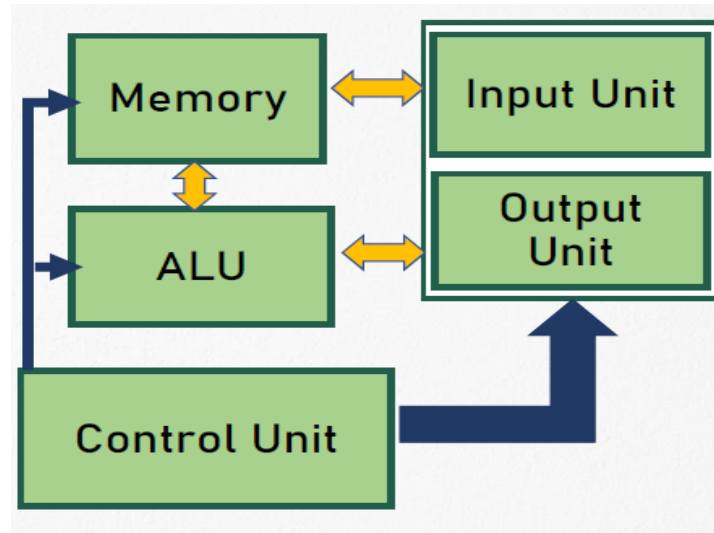

Figure 1: Components of a Computer System

Arithmetic Logic Unit (ALU): After you enter data through the input device it is stored in the primary storage unit. The actual processing of the data and instruction are performed by Arithmetic Logical Unit. The major operations performed by the ALU are addition, subtraction, multiplication, division, logic, and comparison. Data is transferred to ALU from the storage unit when required. After processing, the output is returned to the storage unit for further processing or getting stored.

Control Unit: The next component of a computer is the Control Unit, which acts like the **supervisor** seeing that things are done properly. The control unit determines the sequence in which computer programs and instructions are executed. Things like processing of programs stored in the main memory, interpretation of the instructions, and issuing of signals for other units of the computer to execute them.
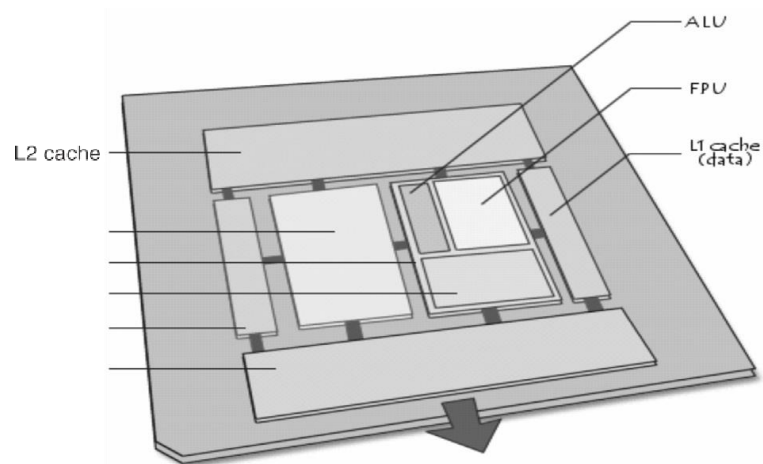

Figure 2: Central Processing Unit

Central Processing Unit (CPU): The ALU and the CU of a computer system are jointly known as the Central Processing Unit (Figure 2). You may call the CPU the brain of any computer system. It is just like the brain that takes all major decisions, makes all sorts of calculations, and directs different parts of the computer functions by activating and controlling the operations.

📋   Draw a diagram which explains all functional units and their working in a computer system.

3.2 **Transforming Data Into Information**

The process of converting or producing results from raw data that is converting them into some meaningful information is called the process of transforming data into information basically, the information we say data that has been transformed into some meaningful information or meaningful way and it can be used for some specific purpose that is called as information. For example: Suppose, you have some raw data, you have a numeric number, say, 25. You don't know whether this number 25 is corresponding to some age of a person or it refers to some rupees some currency. So, you are not aware of the exact value or exact inference for this number 25. It can be anything. We have this 25 as raw data, but when we say that, it is rupees 25 or we say age is equal to 25 there we get to know some information that this 25 number is referring to this particular instance or this particular variable.

Finally, the output that is produced by a computer after processing that data is kept somewhere into the computer system, and then it is converted back into the human-readable format. The computer understands its language. So, whenever data is fed into it, it will understand its format, that is, the machine language. Subsequently, when a computer wants to represent that output to the user that has been processed, the information needs to be delivered out as a form of output to the user. It needs to be converted out into a human-readable form that we can understand easily now.

Initially, the data is useless like we had a value of 25. Formally, we don't know what it is. So, it is a useless item for us unless we get to know about the other attributes related to that number 25. The process of manipulation, the process of organization, the process of analysis, and evaluation and in a manner that would be easily be understood is called conversion or transference from data to information. Now, see, you have a set of letters, you have a set of numbers, they can be meaningful to a particular person, but for the other person, they cannot be carrying any particular meaning for them. For example, you go to a departmental store, you buy different kinds of products over there. Now, what happens, suppose we have kept about 10 items in a cart, we know the number of items in the cart, name, address, and all other attributes like the price of each item, what can be the tax it has been levied upon. The bill gets generated for the same, which refers to a business transaction. Okay. This business transaction is one particular piece of information. When we bring these all things together and formulate it into a particular bill document, that bill is indicating one business transaction. The business transaction is a kind of information that we have an extract from that all data items. Thus, initially, the data is useless but when you clubbed it, manipulate it, organize it, analyze it, evaluate it, then we can convert that data into some meaningful information.

3.3 **How Computer Represent Data**

The data representation considers how a computer uses numbers to represent data inside the computer. Three types of data are considered at this stage:

(a) Numbers including positive, negative, and fractions

(b) Text

(c) Graphics

The following are the different types of data representations followed by a computer system:

Decimal Representation

The binary number system is most natural for computers because of the two stable states of its components. But, unfortunately, this is not a very natural system for us as we work with a decimal number system. Then, how does the computer do the arithmetic? One of the solutions, which are followed in most computers, is to convert all input values to binary. Then, the computer performs arithmetic operations and finally converts the results back to the decimal number so that we can interpret them easily. Is there any alternative to this scheme? Yes, there exists an alternative way of performing the computation in decimal form but it requires that the decimal numbers should be coded suitably before performing these computations. Normally, the decimal digits are coded in 6-8 bits as alphanumeric characters but for arithmetic calculations, the decimal digits are treated as 4-bit binary code. As we know 2 binary bits can represent $2^2 = 4$ different combination, 3 bits can represent $2^3 = 8$ combination and 4 bits can represent $2^4 = 16$ combination. To represent decimal digits into the binary form we require 10 combinations only, but we need to have a 4-digit code. One of the common

representations is to use the first ten binary combinations to represent the ten decimal digits. These are popularly known as *Binary Coded Decimals (BCD).*

The following representation shows the binary coded decimal numbers (Table 1). Let us represent 43.125 in BCD. It is 0100 0011.0001 0010 0101

Example: To represent 43.125 in BCD.

4 is represented as 0100

3 is represented as 0011

1 is represented as 0001

2 is represented as 0010

5 is represented as 0101

Therefore, 43.125 is represented as: 0100 0011.0001 0010 0101

Table 1: Decimal with its corresponding BCD value

Decimal	Binary Coded Decimal
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	0001 0000
11	0001 0001
12	0001 0010
13	0001 0011
……	…………..
20	0010 0000
……	…………..
30	0011 0000

Alphanumeric Representation

What about alphabets and special characters like +, - etc.? How do we represent these on the computer? A set containing alphabets (in both cases), the decimal digits (1 0 in number), and special characters (roughly 10-15 in numbers) consist of at least 70-80 elements. One such Code generated for this set and is popularly used is *ASCII (American National Standard Code for Information Interchange)*. This code uses 7 bits to represent 128 characters. Now an extended ASCII is used having 8-bit character representation code on Microcomputers. Similarly, binary codes can be formulated for any set of discrete elements, for example, colors, the spectrum, the musical notes, chessboard positions, etc. Besides, these binary codes are also used to formulate instructions, which are an advanced form of data representation.

> The binary numeral system, or base-2 number system, represents numeric values using two symbols, 0 and 1. More specifically, the usual base-2 system is a positional notation with a radix of 2.

Binary Representation

The binary numeral system is the base-2 number system that primarily represents numeric values using two symbols, 0 and 1. The binary codes are also used to formulate instructions, which are an advanced form of data representation. A binary number is made up of elements called *bits* where each bit can be in one of the two possible states. Generally, we represent them with the numerals 1 and 0. We also talk about them being true and false. Electrically, the two states might be represented by high and low voltages or some form of switch turned on or off.

We build binary numbers the same way we build numbers in our traditional base 10 system. However, instead of a one's column, a 10's column, a 100's column (and so on) we have a one's column, a two's column, a four's column, an eight's column, and so on, as illustrated below.

We can make the binary numbers into the following two groups− *Unsigned numbers* and *Signed numbers*.

Unsigned Numbers

Unsigned numbers contain only the magnitude of the number. They don't have any sign. That means all unsigned binary numbers are positive. As in the decimal number system, the placing of a positive sign in front of the number is optional for representing positive numbers. Therefore, all positive numbers including zero can be treated as unsigned numbers if the positive sign is not assigned in front of the number.

Signed Numbers

Signed numbers contain both the sign and magnitude of the number. Generally, the sign is placed in front of the number. So, we have to consider the positive sign for positive numbers and the negative sign for negative numbers. Therefore, all numbers can be treated as signed numbers if the corresponding sign is assigned in front of the number.

If the sign bit is zero, which indicates the binary number is positive. Similarly, if the sign bit is one, which indicates the binary number is negative.

Representation of Un-Signed Binary Numbers

The bits present in the unsigned binary number hold the **magnitude** of a number. That means, if the unsigned binary number contains **'N'** bits, then all **N** bits represent the magnitude of the number since it doesn't have any sign bit.

Example: Consider the decimal number 108. The binary equivalent of this number is 1101100. This is the representation of an unsigned binary number.

$108108_{10} = 1101100110110 0_{2}$

It is having 7 bits. These 7 bits represent the magnitude of the number 108.

Representation of Signed Binary Numbers

The Most Significant Bit (MSB) of signed binary numbers is used to indicate the sign of the numbers. Hence, it is also called the sign bit. The positive sign is represented by placing '0' in the sign bit. Similarly, the negative sign is represented by placing '1' in the sign bit.

If the signed binary number contains 'N' bits, then N−1 bits only represent the magnitude of the number since one-bit MSB is reserved for representing the sign of the number. There are three types of representations for signed binary numbers:

- Sign-Magnitude form
- 1's complement form
- 2's complement form

The representation of a positive number in all these 3 forms is the same. But, only the representation of negative numbers will differ in each form.

Example: Consider the positive decimal number +108. The binary equivalent of the magnitude of this number is 1101100. These 7 bits represent the magnitude of the number 108. Since it is a positive number, consider the sign bit is zero, which is placed on the leftmost side of magnitude.

$$+108_{10} = 01101100_2$$

Therefore, the signed binary representation of positive decimal number +108 is **01101100**. So, the same representation is valid in sign-magnitude form, 1's complement form, and 2's complement form for positive decimal number +108.

Now, let us consider an example of a negative decimal number -108.

We know the 1's complement of $(108)_{10}$ is $(10010011)_2$

2's complement of 108108_{10} *= 1's complement of* 108108_{10} *+ 1.*

= 10010011 + 1

= 10010100

Therefore, the 2's complement of 108108_{10} is 1001010010010100_2.

Converting 25 to Base-2 (11001)

Computational Data Representation (CDR)

Computational Data Representations is used to represent data for scientific calculations. In this case, the information is stored in flip-flops (storage cells in a computer), which are two-state devices, in binary form. The CDR in binary form conversion requires:

- Representation of sign; and representation of Magnitude;
- If the number is fractional then a binary or decimal point, and exponent.
- The sign can be either positive or negative, therefore, one bit can be used to represent the sign.
- Left Most Bit (LSB) is used by default.
- Several *n* bits can be represented as n + l bit number where n + lth bit is the sign bit while the rest *n* bits represent its magnitude.
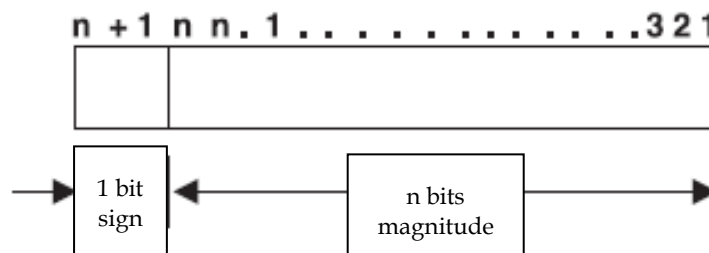
Complement

Complements are used in digital computers to simplify the subtraction operation and for logical manipulations. There are two types of complements for a number of base, r, these are called r's

complement and (r - 1)'s complement. For example, for decimal numbers the base is 10, therefore, complements will be 10's complement and (10 - 1) = 9's complements.

Find the 9's complement and 10's complement for the decimal number 256.

Solution:

Firstly, find the 9's complement:

9 9 9

-2 -5 -6

7 4 3

Then, compute the 10's complement: adding 1 in the 9's complement. Therefore, 10's complement of 256 = 743+ 1= 74.4
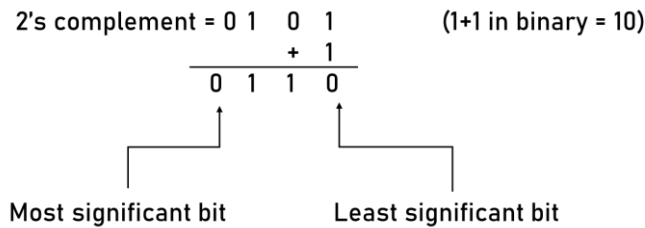
For the binary numbers, we consider 2's and 1's complements.

Example 1: Find 1's and 2's complement of 1010.

Solution:

First, find the 1's complement: 0101

Then, find the 2's complement, that is. perform 1's complement and then add 1 to LSB.

Example 2: Find 2's complement of binary number 10101110 (You can refer to Table 2).

Solution:

For: 10101110 -----1's Complement is: 01010001

Then add 1 to the LSB of this result, i.e., 01010001+1=01010010 which is the answer.

Table 2: Binary Number and its 1's and 2's Complement

Binary number	1's complement	2's complement
000	111	000
001	110	111
010	101	110
011	100	101
100	011	100
101	010	011
110	001	010
111	000	001

Fixed Point Representation

The fixed-point numbers it 1 binary uses a sign bit. A positive number has a sign bit 0, while the negative number has a sign bit 1. In the fixed-point numbers, we assume that the position of the binary point is at the end. It implies that all the represented numbers should be integers.

A negative number can be represented in one of the following ways:

• Signed magnitude representation.

• Signed 1's complement representation.

• Signed 2's complement representation.

First of all, we need to understand the different ways of representing. So, you need to use the sign-magnitude representation that is with the sign. Then, we have the signed one's complement of that particular number. Then, we have the signed two's complement representation for that particular number.

Here, we have the signed magnitude representation for the number plus six. In the case of plus six, we have the most significant bit that is representing the sign. So, in case of a positive number as the signed bit of the most significant value will be zero, the sign will be zero. But in case of a negative number, that signed a bit will represent one over here. You can see a sign bit for this for minus six over here. So, no change in the magnitude only the sign bit will change.

Similarly, if we go with the signed one's complement. We get 110 over here. We had to convert into the seven-bit representation for the fixed point where one bit is for the sign that is in case it is plus six as the bit is zero. Then, we embed zeros to get the 7-bit notations. Next, we have a negative sign. We will complement all the bits, including the sign bit of the positive number to obtain its complement negative number.

In case of obtaining the signed two's complement, you will simply add one to the particular least significant bit for obtaining the two's complement of the positive number including the sign bit. Then, we will complement and add one to the carry notations.

Signed magnitude representation

+6   –6

0   000110   1   000110

↑   ↑

Sign bit   Sign bit (No change in the magnitude
                              only sign bit changes)

Signed 1's complement   0   000110   1   111001
                          ↑

Sign bit (complement all the bits
          including sign bit of the
          positive number to obtain its
          complement   negative
          number)

Signed 2's complement   0   000110   1   111010
                          ↑

Sign bit (2's complement of the
          positive number including
          sign bit)

Arithmetic Addition: The complexity of arithmetic addition is dependent on the representation, which has been followed. Let us discuss this with the help of the following example.

Add 25 and - 30 in binary using 7-bit register in signed magnitude representation.

Solution:

signed magnitude representation.

signed 1's complement

signed 2's complement.

Solution: 25 or +25 is 0 01 1001

- 30 in signed magnitude representation is:

+30 is 0 01 1 1 l0, therefore - 30 is 1 01 11 I0

To do the arithmetic addition with one negative number we have to check the magnitude of the numbers. The number having a smaller magnitude is then subtracted from the bigger number and the sign of a bigger number is selected. The implementation of such a scheme in digital hardware will require a long sequence of control decisions as well as circuits that will add, compare and subtract numbers. Is there a better alternative than this scheme? Let us first try the signed 2's complement.

–30 in signed 2's complement notation will be:

+30 is 0011110

–30 is 1100010 (2' complement of 30 including the sign bit)

+25 is 0011001

–25 is 1100111

Decimal Fixed-Point Representation

A decimal digit is represented as a combination of four bits; thus, a 4-digit decimal number will require 16 bits for decimal digit representation and an additional 1 bit for the sign. One decimal digit to 4 bits, the sign sometimes is also assigned a 4-bit code. But, a disadvantage with this scheme wastes a considerable amount of storage space yet it does not require conversion of a decimal number to binary. However, it is used at places where the amount of computer arithmetic is less than the amount of input-output of data e.g. calculators or business data processing. The arithmetic in decimal can also be performed as in binary except that instead of signed one's complement, signed nine's complement is used, and instead of signed 2's complement signed 10's complement is used.

Floating Point Representation

Floating-point number representation consists of two parts. The first part of the number is a signed fixed-point number. which is termed as mantissa. and the second part specifies the decimal or binary point position and is termed as an Exponent. The mantissa can be an integer or a fraction. Please note that the position of decimal or binary point is assumed and it is not a physical point, therefore, wherever we are representing a point it is only the assumed position.

3.4 **Method of Processing Data**

Data processing consists of those activities which are necessary to transform data into information. Man has in course of time devised certain tools to help him in processing data. These include manual tools such as pencil and paper, mechanical tools such as filing cabinets, electromechanical tools such as adding machines and typewriters, and electronic tools such as calculators and computers.

Mostly data processing is associated with computers where the **processing** is the **thinking** that the computer does - the calculations, comparisons, and decisions. People also process data. What you see and hear and touch and feel is input. Then you connect this new input with what you already know, look for how it all fits together, and come up with a reaction, your output. "That stove is hot. I'll move my hand now!". All in all, the human senses also follow a particular data processing cycle.

Data Processing System

The activity of the data processing system can be viewed as a "system". The computer system has certain components that formulate an important part of the data processing system as illustrated in and its corresponding flow.

- **Control unit (CU):** The control unit determines the sequence in which computer programs and instructions are executed.
- **Arithmetic Logic Unit (ALU):** ALU **e**xecutes the computer's commands. A command (either a basic arithmetic operation: + - * / or one of logical comparisons: >< =not=). Although, ALU can only do one thing at a time but can work very fast.
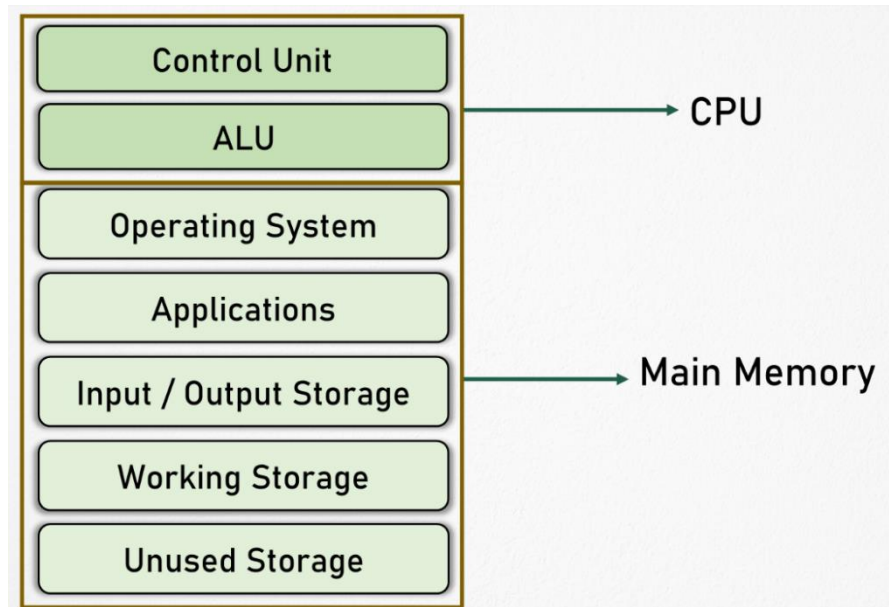
Figure 3: Processing Components Involved in Data Processing

- **Main Memory:** The main memory **s**tores the data and commands that the CPU executes and the results are mostly currently being used. When the computer is turned off, all data in the main memory vanishes. The data storage method of this type is called volatile as the data "evaporates". However, in the case of main memory, the CPU can fetch one piece of data in one machine cycle.
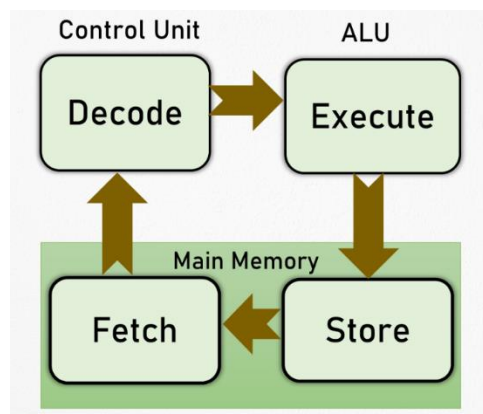

Figure 4: Data Processing System

Data Processing Cycle

The data processing activities can be grouped in four functional categories, viz., data input, data processing, data output, and storage, constituting what is known as a *data processing cycle (*Figure 5: Basic Data Processing CycleFigure 5*).*

(i) Input: Refers to the activities required to record data and to make it available for processing. The input can also include the steps necessary to check, verify and validate data contents.

(ii) Processing: Actual data manipulation techniques such as classifying, sorting, calculating, summarizing, comparing, etc. that convert data into information.

Figure 5: Basic Data Processing Cycle

(iii) Output: It is a communication function that transmits the information, generated after processing of data, to persons who need the information. Sometimes output also includes decoding activity which converts the electronically generated information into human-readable form.

(iv) Storage: It involves the filing of data and information for future use. The above-mentioned four basic functions are performed in a logical sequence data processing system. Figure 6 depicts a detailed and flow diagram for the data processing cycle.
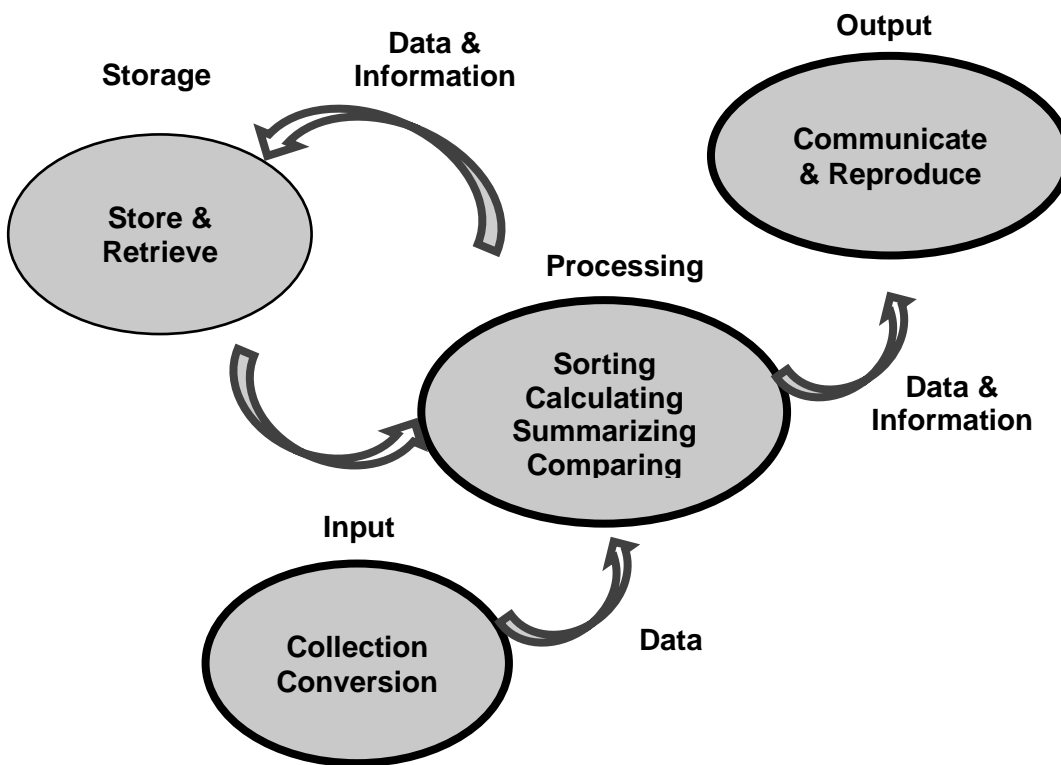

Figure 6: Detailed Data Processing Cycle

3.5 **Machine Cycles**

A machine cycle also called a processor cycle or an instruction cycle is a basic operation performed by a CPU. A machine cycle consists of a sequence of three steps that are performed continuously and at a rate of millions per second while a computer is in operation. They are, the fetch, decode, and execute. There also is a fourth step, store, in which input and output from the other three phases is stored in memory for later use; however, no actual processing is performed during this step. In the fetch step, the control unit requests that the main memory provide it with the instruction that is stored at the address (i.e., location in memory) indicated by the control unit's program counter. The control unit is a part of the CPU that also decodes the instruction in the *instruction register*. A *register* is a very

small amount of very fast memory that is built into the CPU to speed up its operations by providing quick access to commonly used values; instruction registers are registers that hold the instruction being executed by the CPU.

In the decode step, CU decodes the instruction in the instruction register (The instruction register holds the instruction being executed by the CPU). Decoding the instructions in the instruction register involves breaking the operand field into its components based on the instruction's opcode. In the execute step, the actual execution of instructions is carried out.

Opcode (an abbreviation of *operation code*) is the portion of a *machine language* instruction that specifies what operation is to be performed by the CPU. Machine language, also called *machine code*, refers to instructions coded in patterns of bits (i.e., zeros and ones) that are directly readable and executable by a CPU.

A program counter also called the *instruction pointer* in some computers, is a register that indicates where the computer is in its instruction sequence. It holds either the address of the instruction currently being executed or the address of the next instruction to be executed, depending on the details of the particular computer. The program counter is automatically incremented for each machine cycle so that instructions are normally retrieved sequentially from memory.

The control unit places these instructions into its instruction register and then increments the program counter so that it contains the address of the next instruction stored in memory. It then executes the instruction by activating the appropriate circuitry to perform the requested task. As soon as the instruction has been executed, it restarts the machine cycle, beginning with the fetch step.

During one machine cycle, the processor executes at least two steps, fetch (data) and execute (command). The more complex a command is (more data to fetch), the more cycles it will take to execute. Reading data from the zero page typically needs one cycle less as reading from an absolute address. Depending on the command, one or two more cycles will eventually be needed to modify the values and write them to the given address.

3.6 Memory

There are two kinds of computer memory: primary and secondary. Primary memory is an integral part of the computer system and is accessible directly by the processing unit. RAM is an example of primary memory. As soon as the computer is switched off the contents of the primary memory is lost. The primary memory is much faster in speed than the secondary memory. Secondary memory such as floppy disks, magnetic disks, etc., is located external to the computer. Primary memory is more expensive than secondary memory. Because of this, the size of primary memory is less than that of secondary memory. Computer memory is used to store two things: (i) instructions to execute a program and (ii) data.

When the computer is doing any job, the data that have to be processed are stored in the primary memory. This data may come from an input device like a keyboard or from a secondary storage device like a floppy disk. As the program or the set of instructions is kept in primary memory, the computer can follow instantly the set of instructions.

Memory Capacity: The memory capacity pertains to the number of bytes that can be stored in primary storage. Its units are:

• Kilobytes (KB): 1024 (2^{10}) bytes

• Megabytes (MB): 1,048,576 (2^{20}) bytes

• Gigabytes (GB): 1,073,741824 (2^{30}) bytes

Primary Memory: It is temporary storage built into the computer hardware that stores instructions and data of a program mainly when the program is being executed by the CPU. It is also known as main memory, primary storage, or simply memory. Physically, it consists of some chips either on the motherboard or on a small circuit board attached to the motherboard of a computer. It has random access property and is volatile.

The following terms related to the memory of a computer are discussed below:

Random Access Memory (RAM): The primary storage is referred to as random access memory (RAM) because it is possible to randomly select and use any location of the memory directly for storing and retrieving data. It takes the same time to reach any address of the memory whether it is

in the beginning or the last. It is also called read/write memory. The storage of data and instructions inside the primary storage is temporary. It disappears from RAM as soon as the power to the computer is switched off. The memory, which loses its contents on the failure of power supply, are known as volatile memories.

Read-Only Memory (ROM): There is another memory in a computer, which is called Read-Only Memory (ROM). Again, it is the ICs inside the PC that forms the ROM. The storage of the program in the ROM is permanent. The ROM stores some standard processing programs supplied by the manufacturer to operate the personal computer. The ROM can only be read by the CPU but it cannot be changed. The basic input/output program, which is required to start and initialize equipment attached to the PC, is stored in the ROM. The memories, which do not lose their contents on the failure of power supply, are known as non-volatile memories. ROM is a non-volatile memory.

Secondary Memory: This memory is built into a computer or connected to the computer and is also known as External Memory or Auxiliary Storage. The computer usually uses its input/output channels to access secondary storage and transfers the desired data using an intermediate area in primary storage. Secondary memory has large capacities to the tune of terabytes. Examples of secondary memory are magnetic disks, optical disks, floppy disks (Figure 7).
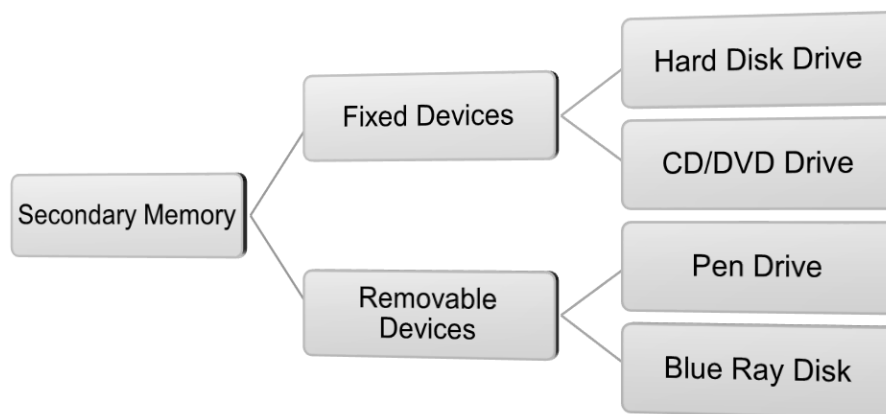

Figure 7: Types of Secondary Memory

Compare primary memory and secondary memory

Compare different types of Primary memory

3.7 **Registers**

Registers are a small amount of very fast memory that is built into the CPU to speed up its operations by providing quick access to commonly used values. A processor register (or general-purpose register) is a small amount of storage available on the CPU whose contents can be accessed more quickly than storage available elsewhere. Modern computers adopt the so-called load-store architecture where the data is loaded from some larger memory be it cache or RAM into registers, manipulated or tested in some way (using machine instructions for arithmetic/logic/comparison), and then stored back into memory, possibly at some different location.

Registers are based on the locality of reference that involves holding frequently used values that are often accessed repeatedly in registers. This helps to improve the program execution and performance.

Categories of Registers

Registers are normally measured by the number of bits they can hold, for example, an "8-bit register" or a "32-bit register". There can be several kinds of registers, classified accordingly to their content or instructions that operate on them.

1. User-accessible registers

   o Classified as data registers and address registers.

2. Data registers

o Hold numeric values such as integer and floating-point values.

3. Address registers

o Hold addresses and are used by instructions that indirectly access memory.

4. Stack Register (Stack Pointer)

o Used by some instructions to maintain a stack.

5. Conditional registers

o Holds the truth values often used to determine whether some instruction should or should not be executed.

6. General-purpose registers (GPRs)

o Can store both data and addresses and can be accessed quickly.

7. Floating-point registers (FPRs)

o Store the floating-point numbers in many architectures.

8. Constant registers

o Hold read-only values such as zero, one, or pi.

9. Vector registers

o Hold data for vector processing done by SIMD instructions (Single Instruction, Multiple Data).

10. Special purpose registers (SPRs)

o Special hardware elements that hold program state.

o Usually include the program counter, stack pointer, and status register.

11. Instruction registers

o Store the instruction currently being executed.

3.8 **The Bus**

An electrical pathway through which the processor communicates with the internal and external devices attached to the computer. It transfers the data between the computer subsystems and sends instructions and commands to and from the processor to different devices. The computer bus connects all internal computer components to the main memory and CPU and is also known as the data bus, address bus, or the local bus. The size of the bus is important as it determines that how much data can be transferred at a time. It has the clock speed, measured in the MHz. The computer bus is classified into different types based on the type of signals it carries and the operations it performs.

- Data Bus: Carries data between the different components of the computer.
- Address Bus: Selects the route that has to be followed by the data bus to transfer the data.
- Control Bus: Decides whether the data should be written or read from the data bus.
- Expansion Bus: Connects the computer's peripheral devices with the processor.

3.9 **Cache Memory**

Cache memory is random access memory (RAM) that a computer microprocessor can access more quickly than it can access regular RAM. As the microprocessor processes data, it looks first in the cache memory and if it finds the data there (from a previous reading of data), it does not have to do the more time-consuming reading of data from larger memory. Cache memory is sometimes described in levels of closeness and accessibility to the microprocessor. An L1 cache is on the same chip as the microprocessor. (For example, the PowerPC 601 processor has a 32-kilobyte level-1 cache built into its chip.) L2 is usually a separate static RAM (SRAM) chip. The main RAM is usually a dynamic RAM (DRAM) chip.

In addition to cache memory, one can think of RAM itself as a cache of memory for hard-disk storage since all of RAM's contents come from the hard disk initially when you turn your computer on and

load the OS (you are loading it into RAM) and later as you start new applications and access new data. RAM can also contain a special area called a disk cache that contains the data most recently read in from the hard disk.

Operation

Hardware implements cache as a block of memory for the temporary storage of data likely to be used again. CPUs and hard drives frequently use a cache, as do web browsers and web servers. A cache is made up of a pool of entries. Each entry has a datum (a nugget of data)—a copy of the same datum in some backing store. Each entry also has a tag, which specifies the identity of the datum in the backing store of which the entry is a copy.

When the cache client (a CPU, web browser, operating system) needs to access a datum presumed to exist in the backing store, it first checks the cache. If an entry can be found with a tag matching that of the desired datum, the datum in the entry is used instead. This situation is known as a *cache hit*. So, for example, a web browser program might check its local cache on disk to see if it has a local copy of the contents of a web page at a particular URL. In this example, the URL is the tag, and the contents of the web page are the datum. The percentage of accesses that result in cache hits is known as the *hit rate* or *hit ratio* of the cache.

The alternative situation, when the cache is consulted and found not to contain a datum with the desired tag, has become known as a **cache miss**. The previously uncached datum fetched from the backing store during miss handling is usually copied into the cache, ready for the next access. During a cache miss, the CPU usually ejects some other entry to make room for the previously uncached datum. The heuristic used to select the entry to eject is known as the replacement policy. One popular replacement policy, "least recently used" (LRU), replaces the least recently used entry. More efficient caches compute use frequency against the size of the stored contents, as well as the latencies and throughputs for both the cache and the backing store. While this works well for larger amounts of data, long latencies, and slow throughputs, such as experienced with a hard drive and the Internet, it is not efficient for use with a CPU cache. When a system writes a datum to the cache, it must at some point write that datum to the backing store as well. The timing of this write is controlled by what is known as the *write policy*.

In a *write-through* cache, every write to the cache causes a synchronous write to the backing store. Alternatively, in a **write-back** (or **write-behind**) cache, writes are not immediately mirrored to the store. Instead, the cache tracks which of its locations have been written over and marks these locations as **dirty**. The data in these locations are written back to the backing store when those data are evicted from the cache, an effect referred to as a **lazy write**. For this reason, a read miss in a write-back cache (which requires a block to be replaced by another) will often require two memory accesses to service: one to retrieve the needed datum, and one to write replaced data from the cache to the store.

Other policies may also trigger data write-back. The client may make many changes to a datum in the cache, and then explicitly notify the cache to write back the datum. *No-write allocation* (a.k.a. write-no-allocate) is a cache policy that caches only processor reads, that is, on a write-miss:

- Datum is written directly to memory,
- Datum at the missed-write location is not added to the cache.

This avoids the need for write-back or write-through when the old value of the datum was absent from the cache before the write. Entities other than the cache may change the data in the backing store, in which case the copy in the cache may become out-of-date or **stale**. Alternatively, when the client updates the data in the cache, copies of those data in other caches will become stale. Communication protocols between the cache managers which keep the data consistent are known as coherency protocols. There are different types of cache memory.

CPU Cache

Small memories on or close to the CPU can operate faster than the much larger main memory. Most CPUs since the 1980s have used one or more caches, and modern high-end embedded, desktop and server *microprocessors* may have as many as half a dozen, each specialized for a specific function. Examples of caches with a specific function are the D-cache and I-cache (data cache and instruction cache).

Disk Cache

While CPU caches are generally managed entirely by hardware, a variety of software manages other caches. The page cache in main memory, which is an example of disk cache, is managed by the OS kernel. While the hard drive's hardware disk buffer is sometimes misleadingly referred to as "disk cache", its main functions are write sequencing and read prefetching. Repeated cache hits are relatively rare, due to the small size of the buffer in comparison to the drive's capacity. However, high-end disk controllers often have their onboard cache of hard disk data blocks. Finally, the fast local hard disk can also cache information held on even slower data storage devices, such as remote servers (web cache) or local tape drives or optical jukeboxes. Such a scheme is the main concept of hierarchical storage management.

Web Cache

Web browsers and web proxy servers employ **web caches** to store previous responses from web servers, such as web pages. Web caches reduce the amount of information that needs to be transmitted across the network, as information previously stored in the cache can often be re-used. This reduces the bandwidth and processing requirements of the web server and helps to improve responsiveness for users of the web. Web browsers employ a built-in web cache, but some internet service providers or organizations also use a caching proxy server, which is a web cache that is shared among all users of that network.

Another form of cache is P2P caching, where the files most sought for by peer-to-peer applications are stored in an ISP cache to accelerate P2P transfers. Similarly, decentralized equivalents exist, which allow communities to perform the same task for P2P traffic, e.g. Corelli.

Other Caches

The BIND DNS daemon caches a mapping of domain names to IP addresses, as does a resolver library. Write-through operation is common when operating over unreliable networks (like an Ethernet LAN), because of the enormous complexity of the coherency protocol required between multiple write-back caches when communication is unreliable. For instance, web page caches and client-side network file system caches (like those in NFS or SMB) are typically read-only or write-through specifically to keep the network protocol simple and reliable.

Search engines also frequently make web pages they have indexed available from their cache. For example, Google provides a "Cached" link next to each search result. This can prove useful when web pages from a web server are temporarily or permanently inaccessible.

Another type of caching is storing computed results that will likely be needed again, or memorization, cache, a program that caches the output of the compilation to speed up the second time compilation, exemplifies this type. Database caching can substantially improve the throughput of database applications, for example in the processing of indexes, data dictionaries, and frequently used subsets of data.

Buffer vs Cache

The terms "buffer" and "cache" are not mutually exclusive and the functions are frequently combined; however, there is a difference in intent. A buffer is a temporary memory location, that is traditionally used because CPU instructions cannot directly address data stored in peripheral devices. Thus, addressable memory is used as the intermediate stage. Additionally, such a buffer may be feasible when a large block of data is assembled or disassembled (as required by a storage device), or when data may be delivered in a different order than that in which it is produced. Also, a whole buffer of data is usually transferred sequentially (for example to hard disk), so buffering itself sometimes increases transfer performance or reduces the variation or jitter of the transfer's latency as opposed to caching where the intent is to reduce the latency. These benefits are present even if the buffered data are written to the buffer once and read from the buffer once.

A cache also increases transfer performance. A part of the increase similarly comes from the possibility that multiple small transfers will combine into one large block. But the main performance gain occurs because there is a good chance that the same datum will be read from cache multiple times, or that written data will soon be read. A cache's sole purpose is to reduce access to the underlying slower storage. The cache is also usually an abstraction layer that is designed to be invisible from the perspective of neighboring layers.

Summary

• The five basic operations that a computer performs. These are input, storage, processing, output, and control.

• A computer accepts data as input, stores it, processes it as the user requires, and provides the output in the desired format.

• Data processing consists of those activities which are necessary to transform data into information.

• OP code (operation code) is the portion of a machine language instruction that specifies what is to be performed by the CPU.

• Computer memory is divided into two types: primary and secondary memory.

• A processor register is a small amount of storage available on the CPU that can be accessed more quickly than storage available.

• The binary numeral system represents numeric values using two digits 0 and 1.

Keywords

Arithmetic Logical Unit (ALU): The actual processing of the data and instruction are performed by Arithmetic Logical Unit. The major operations performed by the ALU are addition, subtraction, multiplication, division, logic, and comparison.

ASCII: (American National Standard Code for Information Interchange). This code uses 7 bits to represent 128 characters. Now an extended ASCII is used having 8-bit character representation code on Microcomputers.

Computer Bus: Computer Bus is an electrical pathway through which the processor communicates with the internal and external devices attached to the computer.

Data Processing System: A group of interrelated components that seeks the attainment of a common goal by accepting inputs and producing outputs in an organized process.

Data Transformation: This is the process of producing results from the data for getting useful information. Similarly, the output produced by the computer after processing must also be kept somewhere inside the computer before being given to you in human-readable form.

Decimal Fixed-Point Representation: A decimal digit is represented as a combination of four bits; thus, a four-digit decimal number will require 16 bits for decimal digit representation and an additional 1 bit for the sign.

Fixed Point Representation: The fixed-point numbers bit 1 binary uses a sign bit. A positive number has a sign bit 0, while a negative number has a sign bit 1. In the fixed-point numbers, we assume that the position of the binary point is at the end.

Floating Point Representation: Floating-point number representation consists of two parts. The first part of the number is a signed fixed-point number. which is termed as mantissa. and the second part specifies the decimal or binary point position and is termed as an Exponent.

Self-Assessment Questions

1. Data processing consists of those activities which are necessary to transform data into _____.

(a) Value   (b)Information

(c) Knowledge   (d) Wisdom

2. Floating-point number representation consists of two parts. The first part of the number are a signed fixed-point number which is termed as _____ and the second part specifies the decimal or binary point position and is termed as an _____.

(*a*) mantissa, exponent   (*b*) exponent, mantissa

(c) fixed-value, decimal-value   (d) first-fixed, second-decimal

3. _____ is an integral part of the computer system and is accessible directly by the processing unit.

(*a*) Primary memory   (*b*) Secondary memory

(c) Stable memory   (d) Consistent memory

4. In a computer architecture, a _____ is a small amount of storage available on the CPU whose contents can be accessed more quickly than storage available elsewhere.

(*a*) instruction register   (*b*) processor register

(c) accumulator   (d) program register

5. RAM is an example of _____ memory.

(*a*) secondary   (*b*) cache

(c) primary   (d) consistent

6. Programmable Read-Only Memory (PROM) is a type of primary memory in computer.

(*a*) True   (*b*) False

7. A collection of 8-bit is called _____.

(*a*) double-word   (*b*) nibble

(c) word   (d) byte

8. The difference between raw data and information is

(*a*) Addition of intellect   (*b*) Addition of processing

(c) Addition of intelligence   (d) All of these

9. What is the range of a binary number system?

(*a*) 0 to 8   (*b*) 0 to F

(c) 0 to 16   (d) 0 to 1

10. Auxiliary memory is also called

(*a*) Third memory   (*b*) secondary memory

(c) primary memory   (d) extra memory

11. The ALU of a computer responds to the commands coming from

(*a*) External memory   (*b*) Internal memory

(c) Primary memory   (d) Control selection

12. ROM is composed of

(*a*) Photoelectric cells   (*b*) Micro-processors

(c) Magnetic cores   (d) Floppy disks

13. LRU stands for _____

(a) Low Rate Usage   (b) Least Rate Usage

(c) Least Recently Used   (d) Low Required Usage

14. What is the high-speed memory between the main memory and the CPU called?

(a) Register Memory   (b) Cache Memory

(c) Storage Memory   (d) Virtual Memory

15. If an entry can be found with a tag matching that of the desired datum in the cache, the datum in the entry is used instead. This is called as:

(a) cache miss   (b) cache hit

(c) missed datum   (d) hitting datum

Answers for Self-Assessment Questions

1. (b)	2. (a)	3. (a)	4. (b)
5. (c)	6. (a)	7. (d)	8. (c)
9. (d)	10. (b)	11. (d)	12. (b)
13. (c)	14. (b)	15. (b)	

Review Questions

1. Identify various data processing activities.
2. Explain the following in detail:
 (a) Fixed-Point Representation
 (b) Decimal Fixed-Point Representation
 (c) Floating-Point Representation
3. Define the various steps of data processing cycles.
4. Differentiate between:
 (a) RAM and ROM
 (b) PROM and EPROM
 (c) Primary memory and Secondary memory
5. Explain cache memory. How is it different from primary memory?
6. Define the terms data, data processing, and information.
7. Explain Data Processing System.
8. Explain Registers and categories of registers.
9. What is Computer Bus? What are the different types of computer bus?
10. Differentiate between the following :
 (a) Data and Information
 (b) Data processing and Data processing system

Further Reading

- Introduction to Computers, by Peter Norton, Publisher: McGraw Hill, Sixth Edition.

- https://www.talend.com/resources/what-is-data-processing/#:~:text=Collecting%20data%20is%20the%20first,of%20the%20highest%20possible%20quality.
- https://planningtank.com/computer-applications/data-processing#:~:text=Data%20processing%20is%20the%20conversion%20of%20data%20into%20usable%20and%20desired%20form.&text=Example%20of%20these%20forms%20include,to%20as%20automatic%20data%20processing.

Unit- 04: Operating Systems

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Objectives

After studying this unit, you will be able to:

- Basics of the operating system.
- Purposes of the operating system.
- Types of the operating system.
- Explain the purpose of the operating system.
- Discuss the types of operating systems.
- Explain the user interfaces.

4.1 Operating System

An Operating System (OS) is an important part of almost every computer system. A collection of programs that manage and coordinate the activities taking place within a computer. An OS is specialized software that controls and monitors the execution of all other programs that reside in the computer, including application programs and other system software. It aids in the execution of the user programs and makes solving the user problems easier. An OS acts as an interface between the software and the computer hardware. It is an intermediary between the user of a computer and the computer hardware and application programs (*Figure 1*).

Additionally, the **OS** manages a computer's resources, especially the allocation of those resources among other programs. Typical resources include the Central Processing Unit (CPU), computer memory, file storage, input/output (I/O) devices, and network connections. Management tasks include scheduling resource use to avoid conflicts and interference between programs. Unlike most programs, which complete a task and terminate, an operating system runs indefinitely and terminates only when the computer is turned off.
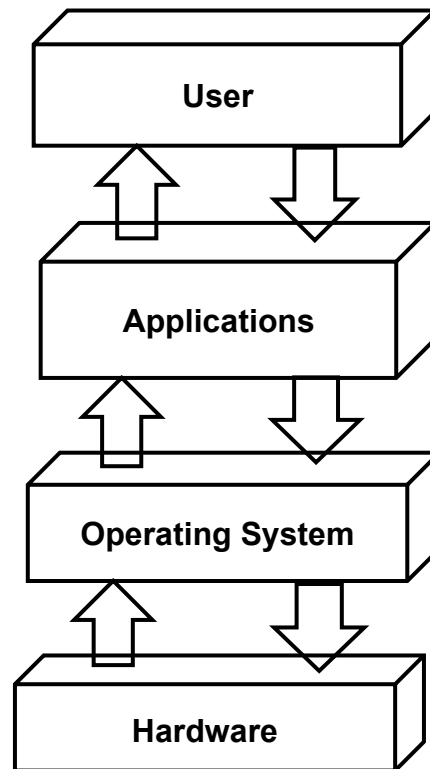
Figure 1: Operating System as an Interface

The first digital computers had no OSs. They ran one program at a time, which had command of all system resources, and a human operator would provide any special resources needed. The first OSs were developed in the mid-1950s. These were small "supervisor programs" that provided basic I/O operations (such as controlling punch card readers and printers) and kept accounts of CPU usage for billing. The supervisor programs also provided multiprogramming capabilities to enable several programs to run at once. This was particularly important so that these early multimillion-dollar machines would not be idle during slow I/O operations.

Modern multiprocessing OSs allow many processes to be active, where each process is a "thread" of computation being used to execute a program. One form of multiprocessing is called time-sharing, which lets many users share computer access by rapidly switching between them. Time-sharing must guard against interference between users' programs, and most systems use virtual memory, in which the memory, or "address space," used by a program may reside in secondary memory (such as on a magnetic hard disk drive) when not in immediate use, to be swapped back to occupy the faster main computer memory on demand. This virtual memory both increases the address space available to a program and helps to prevent programs from interfering with each other, but it requires careful control by the operating system and a set of allocation tables to keep track of memory use. Perhaps the most delicate and critical task for a modern OS is allocation of the CPU; each process is allowed to use the CPU for a limited time, which may be a fraction of a second, and then must give up control and become suspended until its next turn. Switching between processes must use the CPU while protecting all data of the processes.

A computer system can be divided roughly into four components—the hardware, the operating system, the application programs, and the users (Figure 2). The hardware-the CPU, the memory, and the I/O devices provide the basic computing resources. The application programs, such as word processors, spreadsheets, compilers, and web browsers-define how these resources are used to solve the computing problems of the users. The OS controls and coordinates the use of the hardware among the various application programs for the various users. The OS provides the means for the proper use of these resources in the operation of the computer system. An operating system is similar to a government. Like a government, it performs no useful function by itself. It simply provides an environment within which other programs can do useful work.
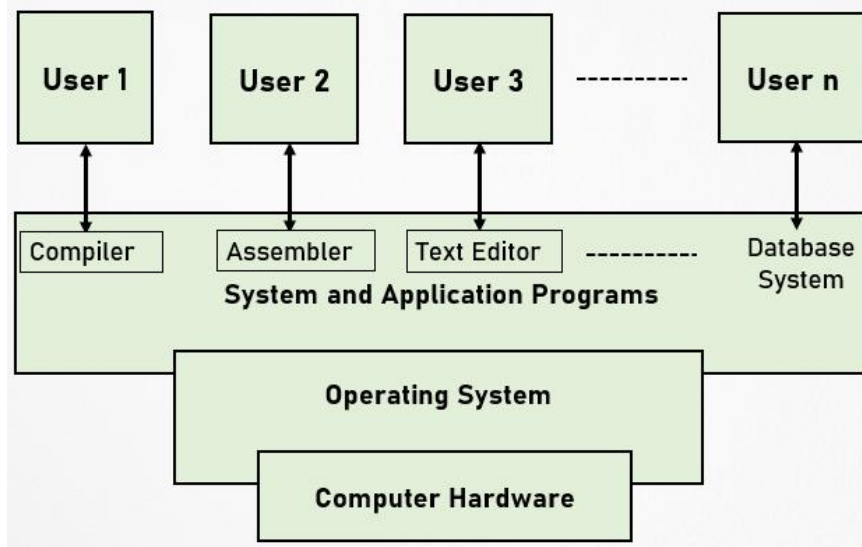
Figure 2: Abstract View of the Components of a Computer System

Objectives of Operating Systems

An OS is an integrated set of specialized programs used to manage the overall resources and operations of the computer. It helps in making the computer system convenient to use (adding *convenience*). The main objective of an OS is to manage all the other resources and operations of the computer system. It helps to make computing much more convenient much easy to use. The problem-solving capabilities can be more easily done with the help of an OS.

Another important aspect when we talk about OS is the capability of abstraction. You must have studied out in different programming languages of the computer that there is a term called abstraction. Abstraction deals out to hide the inner details from the users. So, you just get an illusion of a computer system that is completely dedicated to you but what is going in around into it. You are not concerned with that you just have to input your data, and you get output but how it is working, who is controlling that operation, and what is the logic that is being controlled out how memory is accessed, how processors are managed, how the programs are executed. All these operations are carried out by an OS. It acts as an intermediary between the hardware and its users, making it easier for the users to access and use other resources facilitating the use of the computer hardware efficiently.

The OS provides the users with an interactive interface to use the computer system/ *Interfacing with the Users* (typically via a GUI). It provides an interactive interface that is one to one interface between the user and the computer system. The computer system interfacing with the users is much easier, this is facilitated with the help of a Graphical User Interface (GUI).

Then, it helps out to keep track of who is using which resource, how the resources are being scheduled out. It helps in granting the resource requests. Suppose one user wants access to any particular file on a system. The file is also a resource one user wants to access the printer. Here, the printer is also a resource. If a user wants to perform some calculation, here, the processor is also a resource. The decisions related to how resources are allocated, how grant to those resources is done are done by an OS. It helps in mediating any kind of conflicts also so if one user requests a printer, another user also requests a printer. The printer is required by both the users. An OS ensures efficient and fair sharing of resources, among the users, as well as the user programs.

4.2 Functions of an Operating System

The OS performs a large variety of functions that include:

Booting the Computer: The first most important function of an OS is booting. It helps in loading the essential part of an OS, that is, the Kernel which is the most basic level or core of an OS. The kernel performs all the tasks related to booting, resource allocation, file management, security by an OS. The booting of the computer system also involves reading the opening batch of instructions for a computer system to start. Initially, the kernel is loaded out into the computer system, and to the memory main memory of the computer system. It also helps to determine the hardware connected to a computer.

Configuring Devices: The connecting of different kinds of hardware resources determining which resources are connected to a computer system involves the configuration of devices that are connected to it. Different device drivers are needed out to run the devices. Such device drivers can be reinstalled or can be updated. The connection of the various USB to the computer system is also determined by an OS. The concept of plug-and-play of the devices you connect to the computer system is extensively done and recognized automatically by an OS.

Managing Network Connections: The management of network connections is done by an OS. It helps to manage the wired connections to a computer system as well as detecting the wireless connections at your home, your school or work, or wherever you go. The remote connections are also maintained out through the help of this OS. Usually, the wired and wireless adapters are all controlled out by an OS.

Managing and Monitoring Resources and Jobs: Another objective of an OS is management and monitoring of resources and jobs. This involves the management of different resources. If a user wants to access any particular file, another user wants to access a printer, the third user wants to access, another device in a computer system. All requests to these resources are also provisioned out with the help of an OS. In case a deadlock arises, like, both, there are two users or three users. All of these want to access a printer, so, in that situation to which user a printer is required to be given, and for how much time it is required to be given that is all decided out with the OS. The management of resources, availability of resources making the resources available to any user any program or any devices, this is all done by an OS. The monitoring tracks the usage and duration of usage of the resources. The pending requests for accessing the resources and their priorities are decided by an OS. The additional monitoring activities or tracking activities are also done by an OS.

Job Scheduling: An OS performs the task of scheduling the jobs. Suppose you have a printer with a scheduled job of printing five different files. You give print commands for all those files so that job scheduling, file 1, file 2, file 3, file 4, and file 5 are waiting for printing. All these are managed or scheduled in a particular order as decided by an OS.

Security: An OS prevents unauthorized access to programs and data using passwords and other similar techniques. It offers password protection; monitoring the biometric characteristics and providing biometric access; offering security through firewalls.

Core Functions of an Operating System

Memory Management: Main memory is a large array of words or bytes where each word or byte has its address. The main memory provides fast storage that can be accessed directly by the CPU. For a program to be executed, it must in the main memory. The OS manages the main memory. It keeps tracks of primary memory, that is, what art of it are in use by whom, what part are not in use. The OS decides which process will get memory when and how much. It allocates the memory when a process requests it to do so as well as deallocates the memory when a process no longer needs it or has been terminated.

Processor Management: In a multiprogramming environment, the OS decides which process gets the processor when and for how much time. This function is called process scheduling. An OS acts as processor management. It does the following activities for processor management −

- Keeps track of the processor and status of the process.
- The program responsible for tracking the processor and its status is known as the traffic controller.
- Allocates the processor (CPU) to a process.
- De-allocates processor when a process is no longer required.

Device Management: An OS manages the device communication via their respective drivers. The following activities for device management are carried out by OS:

- Keeps tracks of all devices.
- The program responsible for this task is known as the I/O controller.
- Decides which process gets the device when and for how much time.
- Allocates the device in an efficient way.

• De-allocates devices.

File Management: The files in a computer system are viewed out in a hierarchical format. There is a hierarchy that is established, the files can be organized out into directories and subdirectories can be there, which helps in easy navigation and usage so all the records. An OS manages the files and helps to keep track of the information that is stored in a file. The location of a file, who are the users of it; when the file was generated out; when it was edited out; and what is the status of a file are all managed and tracked by an OS with the help of maintaining a file system.
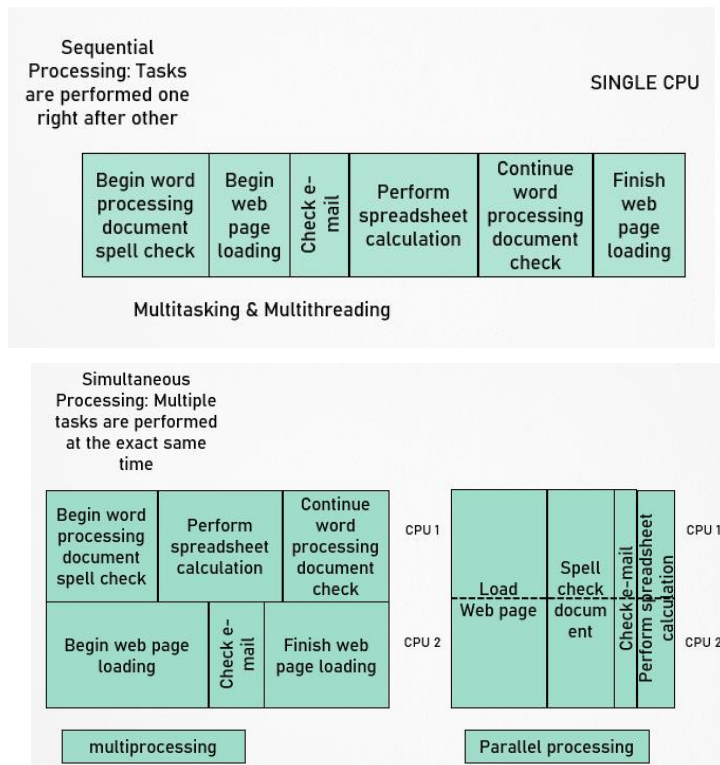
Figure 3: Sequential vs Multiprocessing

Additional OS Responsibilities

• **Job Accounting**– Keeps track of time and resources used by various jobs and/or users.

• **Control Over System Performance**– Records delays between the request for a service and from the system.

• **Interaction with the Operators**– Interaction may take place via the console of the computer in the form of instructions. The OS acknowledges the same, does the corresponding action and informs the operation by a display screen.

• **Error-detecting Aids**– Production of dumps, traces, error messages, and other debugging and error-detecting methods.

• **Coordination Between Other Software and Users** – Coordination and assignment of compilers, interpreters, assemblers, and other software to the various users of the computer systems.

• **Multitasking and Multithreading:** The ability of an OS to have more than one program (task) open at one time is called Multitasking. OS enables a CPU on rotating between tasks doing the switching. The ability to rotate between multiple threads so that processing is completed faster and more efficiently. An OS monitors that the sequence of instructions within a program is independent of other threads.

• **Multiprocessing and Parallel Processing:** Multiple processors (or multiple cores) are used in one computer system to perform work more efficiently. Multiprocessing is handled by an OS. Figure 3 depicts the sequential and multiprocessing concept.

4.3 Operating System Kernel

The Kernel is the central component of most computer OSs that acts as a bridge between the applications and the actual data processing done at the hardware level. It is also called the nucleus or core and was conceived as containing only the essential support features of the OS (Figure 4). The kernel is responsible for managing the system's resources (such as communication between the hardware and the software components) and can provide the lowest-level abstraction layer for the resources (especially processors and I/O devices). It decides which memory each process can use, and determining what to do when not enough memory is available. It makes the facilities available to application processes through inter-process communication mechanisms and system calls.

The kernel is the most significant OS component that decides at any time which of the many running programs should be allocated to the processor or processors. It allocates requests from applications to perform I/O to an appropriate device. In a monolithic kernel, all OS services run along with the main kernel thread, thus also residing in the same memory area. In the microkernel approach, the kernel itself only provides basic functionality that allows the execution of servers, separate programs that assume former kernel functions, such as device drivers, GUI servers, etc.
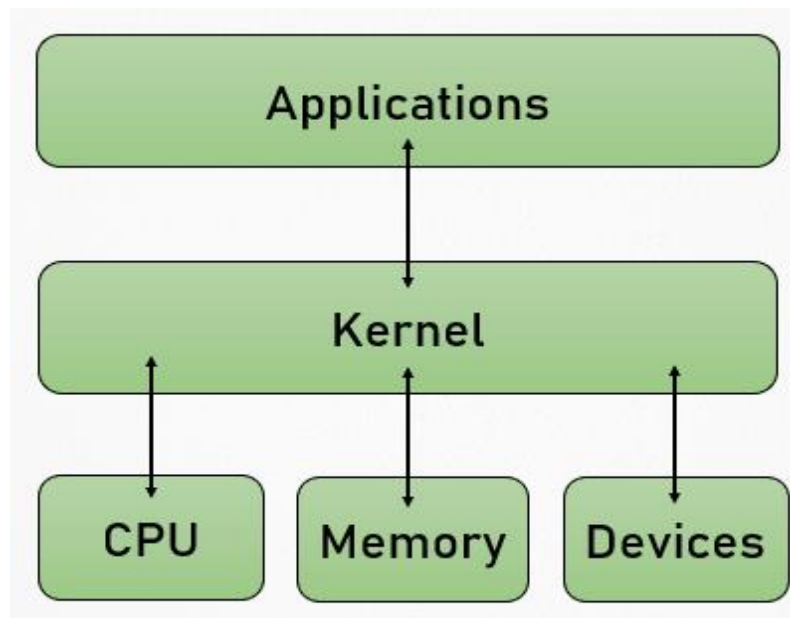

Figure 4: Kernel Interface with Applications and Computer Components

System Call Model in Operating System

A system call is a mechanism used by an application to request service from the OS based on the monolithic kernel or to system services on the OSs based on the microkernel structure. System Calls are requests by programs for services to be provided by the OS.

System call represents the interface of a program to the kernel of the OS with the following characteristics:

• The system call API (Application Program Interface) is given in C.

• The system call is a wrapper routine typically consisting of a short piece of assembly language code.

• The system call generates a hardware trap and passes the user's arguments and an index into the kernel's system call table for the service requested.

• The kernel processes the request by looking up the index passed to see the service to perform and carries out the request.

• Upon completion, the kernel returns a value that represents either successful completion of the requestor an error. If an error occurs, the kernel sets a global variable, err no, indicating the reason for the error.

• The process is delivered the return value and continues its execution.

4.4 Types of Operating Systems

Within the broad family of operating systems, there are different types, categorized based on the types of computers they control and the sort of applications they support (Figure 5).

Batch Processing

This type of operating system does not interact with the computer directly. There is an operator which takes similar jobs having the same requirement and groups them into batches (Figure 6). It is the responsibility of the operator to sort jobs with similar needs. Some computer processes are very lengthy and time-consuming. To speed the same process, a job with a similar type of needs is batched together and run as a group. The user of a batch operating system never directly interacts with the computer. In this type of OS, every user prepares his or her job on an offline device like a punch card and submits it to the computer operator. Examples of the batch OS are the Payroll system, Bank statements, etc.
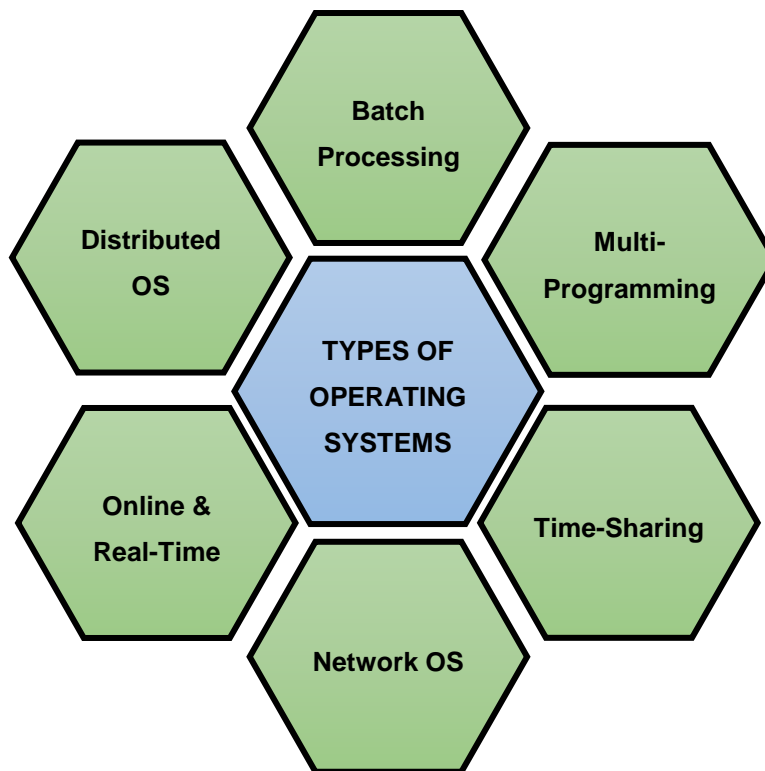
Figure 5: Different Types of Operating Systems

Advantages of Batch Operating System:

- It is very difficult to guess or know the time required for any job to complete. Processors of the batch systems know how long the job would be when it is in queue
- Multiple users can share the batch systems
- The idle time for the batch system is very less
- It is easy to manage large work repeatedly in batch systems

Disadvantages of Batch Operating System:

- The computer operators should be well known with batch systems
- Batch systems are hard to debug
- It is sometimes costly
- The other jobs will have to wait for an unknown time if any job fails
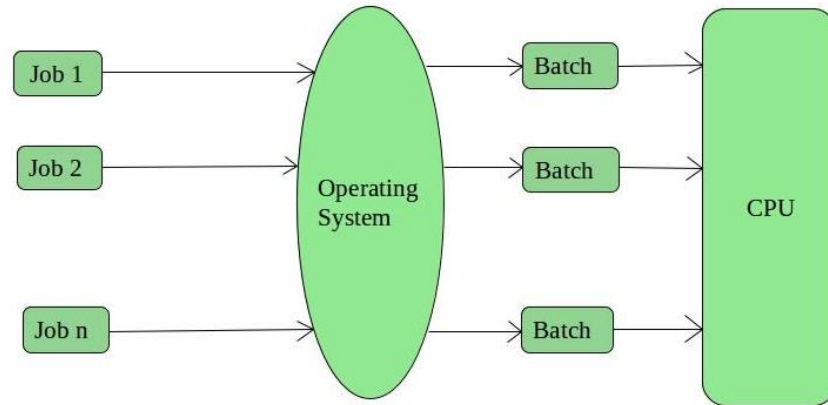
Figure 6: Batch Operating System Environment

Multi-Programming Operating System

In the multi-programming system, one or multiple programs can be loaded into its main memory for execution. Only one program or process is capable to get CPU for the execution of the instructions while other programs wait for getting their turn. Primarily, the objective of multiprogramming is to manage entire resources of the system that includes system components such as command **processor**, file system, I/O control system, and transient area. A multiprogramming system helps to overcome the issue of under-utilization of CPU & primary memory

Time-Sharing Operating System

Each task is given some time to execute so that all the tasks work smoothly. Each user gets the time of CPU as they use a single system. These systems are also known as multitasking systems. The task can be from a single user or different users also. The time that each task gets to execute is called quantum. After this time interval is over OS switches over to the next task.

Advantages of Time-Sharing OS:

 • Each task gets an equal opportunity

 • Fewer chances of duplication of software

 • CPU idle time can be reduced

Disadvantages of Time-Sharing OS:

 • Reliability problem

 • One must have to take care of the security and integrity of user programs and data

 • Data communication problem

Network Operating System (NOS)

These systems run on a server and provide the capability to manage data, users, groups, security, applications, and other networking functions. These types of OSs allow shared access of files, printers, security, applications, and other networking functions over a small private network. One more important aspect of NOS is that all the users are well aware of the underlying configuration, of all other users within the network, their connections, etc. and that's why these computers are popularly known as **ti**ghtly coupled systems**.**

Advantages of Network Operating System:

 • Highly stable centralized servers that handle the security concerns

 • New technologies and hardware up-gradation are easily integrated into the system

 • Server access is possible remotely from different locations and types of systems

Disadvantages of Network Operating System:

 • Servers are costly

 • User has to depend on a central location for most operations

• Maintenance and updates are required regularly

Real-Time Operating System (RTOS)

Real-time operating systems are used to control machinery, scientific instruments, and industrial systems such as embedded systems (programmable thermostats, household appliance controllers), industrial robots, spacecraft, industrial control (manufacturing, production, power generation, fabrication, and refining), and scientific research equipment. An RTOS typically has the very little user interface capability, and no end-user utilities, since the system will be a "sealed box" when delivered for use. A very important part of an RTOS is managing the resources of the computer so that a particular operation executes in precisely the same amount of time, every time it occurs. In a complex machine, having a part move more quickly just because system resources are available may be just as catastrophic as having it not move at all because the system is busy.

An RTOS facilitates the creation of a real-time system, but does not guarantee the final result will be real-time; this requires correct development of the software. An RTOS does not necessarily have high throughput; rather, an RTOS provides facilities that, if used properly, guarantee deadlines can be met generally (soft real-time) or deterministically (hard real-time). An RTOS will typically use specialized scheduling algorithms to provide the real-time developer with the tools necessary to produce deterministic behavior in the final system. An RTOS is valued more for how quickly and/or predictably it can respond to a particular event than for the given amount of work it can perform over time.

Distributed Operating System

It is a recent advancement in the world of computer technology and is being widely accepted all over the world and, that too, with a great pace. Various autonomous interconnected computers communicate with each other using a shared communication network. Independent systems possess their memory unit and CPU. These are referred to as loosely coupled systems or distributed systems. These system's processors differ in size and function. The major benefit of working with these types of the operating system is that it is always possible that one user can access the files or software which are not present on his system but some other system connected within this network i.e., remote access is enabled within the devices connected in that network.

Advantages of Distributed Operating System:

• Failure of one will not affect the other network communication, as all systems are independent of each other

• Electronic mail increases the data exchange speed

• Since resources are being shared, computation is highly fast and durable

• Load on host computer reduces

• These systems are easily scalable as many systems can be easily added to the network

• Delay in data processing reduces

Disadvantages of Distributed Operating System:

• Failure of the main network will stop the entire communication

• To establish distributed systems the language which is used are not well defined yet

• These types of systems are not readily available as they are very expensive. Not only that the underlying software is highly complex and not understood well yet

> Explore the different types of Operating Systems along with their characteristics.

4.5 Providing a User Interface

The user interface is the space where interaction between humans and machines occurs. The goal of interaction between a human and a machine at the user interface is effective operation and control of the machine, and feedback from the machine which aids the operator in making operational decisions. A user interface is a system by which people (users) interact with a machine. The user

interface includes hardware (physical) and software (logical) components. User interfaces exist for various systems and provide a means of:

• Input, allowing the users to manipulate a system, and/or
• Output, allowing the system to indicate the effects of the users' manipulation.

The following types of the user interface are the most common:

1. **Graphical User Interfaces (GUIs):** Most modern operating systems, like Windows and the Macintosh OS, provide a graphical user interface (GUI). A GUI lets you control the system by using a mouse to click *graphical objects* on the screen. A GUI is based on the desktop metaphor. Graphical objects appear on a background (the desktop), representing resources you can use. *Icons* are pictures that represent computer resources, such as printers, documents, and programs. You double-click an icon to choose (activate) it, for instance, to launch a program. The Windows operating system offers two unique tools, called the taskbar and the Start button. These help you run and manage programs.

2. **Command-Line Interfaces:** A CLI (command line interface) is a user interface to a computer's operating system or an application in which the user responds to a visual prompt by typing in a command on a specified line, receives a response from the system, and then enters another command, and so forth. The MS-DOS Prompt application in a Windows operating system is an example of the provision of a command-line interface. Today, most users prefer the graphical user interface (GUI) offered by Windows, Mac OS, BeOS, and others. Typically, most of today's UNIX-based systems offer both a command-line interface and a graphical user interface.

Case Study

In the 1980s UNIX, VMS and many others had operating systems that were built this way. GNU/Linux and Mac OS X are also built this way. Modern releases of Microsoft Windows such as Windows Vista implement a graphics subsystem that is mostly in user-space; however, the graphics drawing routines of versions between Windows NT 4.0 and Windows Server 2003 exist mostly in kernel space. Windows 9x had very little distinction between the interface and the kernel.

4.6 Running Programs

One of the most important X features is that windows can come either from programs running on another computer or from an operating system other than UNIX. So, if your favorite MS-DOS program doesn't run under UNIX but has an X interface, you can run the program under MSDOS and display its windows with X on your UNIX computer. Researchers can run graphical data analysis programs on supercomputers in other parts of the country and see the results in their offices.

Setting Focus

Of all the windows on your screen, only one window receives the keystrokes you type. This window is usually highlighted in some way. By default, in *the mwm window manager,* for instance, the frame of the window that receives your input is a darker shade of grey. In X jargon, choosing the window you type to is called "setting the *input focus.*" Most window managers can be configured to set the focus in one of the following two ways:

(*a*) Point to the window and click a mouse button (usually the first button). You may need to click on the title bar at the top of the window.

(*b*) Simply move the pointer inside the window. When you use **mwm,** any new windows will get the input focus automatically as they pop up.

The Xterm Window

One of the most important windows is an xterm window. The xterm makes a terminal emulator window with a UNIX login session inside, just like a miniature terminal. You can also start separate X-based window programs (typically called clients) by entering commands in an xterm window.

The Root Menu

If you move the pointer onto the root window (the "desktop" behind the windows) and press the correct mouse button (usually the first or third button, depending on your setup), you should see the root menu. It has commands for controlling windows. The menu's commands may differ depending

on the system. The system administrator (or window manager) can add commands to the root menu. These can be window manager operations or commands to open other windows.

4.7 Sharing Information

UNIX makes it easy for users to share files and directories. It involves controlling exactly who has access takes some explaining. The directory access permissions exist that help to control access to the files in it. It affects the overall ability to use files and subdirectories in the directory.

There is a different kind of file access permissions, any kind of file access from any kind of access permissions that are used for controlling the content of a particular file, who will be able to access it, which user will be able to edit it which user will be able to just view it, that is all included out into this file access permissions. These access permissions support controlling a particular file content. With the access permissions on a particular directory as well where the file is kept under control whether the file can be renamed or removed or whether it can be edited or not.

Certain files can be made private files. In case you want to make a particular file private, only you can edit it. We use ch mod 600 commands as a terminal emulator. To provide access to the user for editing, we can use a command ch mod 600 filenames. To protect a particular file from any kind of accidental editing in cases suppose a user starts editing it and it is not provided out for editing, command ch mod 400 file name is used. In order to edit a particular file and let everyone else on a particular system only read it without editing, then we use ch mod 644 filename. Now, in case you want to provide that particular file to the non-group users to read it, but not edit it then we use the commands, we use ch mod 664 filename. In case you want to specify any particular file to be read and edited by anyone else, then, there we use a CH mod 666 file name. We have different kinds of file and directory, sub-directory permissions that are provided out to an OS using different kinds of commands.

4.8 Managing Hardware

It is possible to supply command-line options when starting the Hardware Management Agent manually. Use the command-line options as follows:

hwagentd *OPTIONS*

The command line options are explained in the following Table 1.

Table 1: Command-Line Options

Options	Function
-h	Displays the usage message and exits
-v	Displays the hardware Management Agent version currently installed on this Sun x 64 Server and exits
-l level	Override the logging level set in the hwagentd.conf file with level

When using the logging levels option, you must supply a decimal number to set the logging level to use. This decimal number is calculated from a bitfield, depending on the logging level you want to specify. For more information on the bit field used to configure different log levels.

Hardware Management Agent Configuration File

Once the Hardware Management Agent and Hardware SNMP Plugins are installed on the Sun x64 server. There is only one configuration file for the Hardware Management Agent, which configures the level of detail used for log messages. It records log messages into the log file. These messages can be used to troubleshoot the running status of the Hardware Management Agent. Once the Hardware Management Agent and Hardware SNMP Plugins are installed on the Oracle server you want to monitor, you can configure the level of detail used for log messages using the hwmgmtd.conf file.

Configuring the Hardware Management Agent Logging Level

To configure the logging level, modify the *hwagentd_log_levels* parameter in the hwagentd. conf file. The *hwagentd_log_levels* parameter is a bit flag set expressed as a decimal integer. In order to configure the Hardware Management Agent Logging Level, the following steps are followed:

a) Depending on the host OS, the Hardware Management Agent is running on, open the hwagentd.conf file. You can use any text editor to modify this file.

b) Find the *hwagentd_log_levels* parameter and enter the decimal number calculated using the instructions above.

c) Save the modified hwagentd.conf file.

d) Choose one of the following options to make the Hardware Management Agent reread the hwagentd.conf file.

On Linux and Solaris OSs, (Solaris OS: refresh) the Hardware Management Agent can be manually restarted, which forces the hwagentd.conf to be reread. Depending on the host OS the Hardware Management Agent is running on, restart the Hardware Management Agent.

On Windows OSs, you can restart the service using the Microsoft Management Console Services snap-in. The Hardware Management Agent rereads the hwagentd.conf file with the modified *hwagentd_log_levels* parameter.

4.9 Enhancing an OS with Utility Software

Utility software is a kind of system software designed to help analyze, configure, optimize and maintain the computer. A single piece of utility software is usually called *a utility (abbr. util) or tool.* Utility software should be contrasted with application software, which allows users to do things like creating text documents, playing games, listening to music, or surfing the web. Rather than providing these kinds of user-oriented or output-oriented functionality, utility software usually focuses on *how* the computer infrastructure (including the computer hardware, operating system, and application software and data storage) operates. Due to this focus, utilities are often rather technical and targeted at people with an advanced level of computer knowledge.

Most utilities are highly specialized and designed to perform only a single task or a small range of tasks. However, some utility suites combine several features in one piece of software. Most major operating systems come with several pre-installed utilities.

Application Software: An application software focuses on how computer infrastructure (including computer hardware, OS, & application software & data storage) operates. It allows the users to do things like creating text documents, playing games, listening to music or surfing the web. It offers user-oriented or output-oriented functionality.

Utility vs Application Software

• Utilities are technical & targeted at people with an advanced level of computer knowledge.

• Most utilities are highly specialized and designed to perform only a single task or a small range of tasks.

• Some utility suites combine several features in one piece of software.

• Most major OSs come with several pre-installed utilities.

Utility Software Categories

Disk storage utilities

• Disk defragmenters can detect computer files whose contents are broken across several locations on the hard disk, and move the fragments to one location to increase efficiency.

• Disk checkers can scan the contents of a hard disk to find files or areas that are corrupted in some way, or were not correctly saved, and eliminate them.

• *Disk cleaners* help to find files that are unnecessary to the computer operation or take up considerable amounts of space. They help the user to decide what to delete if the hard disk is full.

• *Disk space analyzer* offers visualization of disk space usage by getting the size for each folder (including subfolders) & files in a folder or drive. These show the distribution of the used space.

- *Disk partitions* divide an individual drive into multiple logical drives, each with its file system which can be mounted by the OS and treated as an individual drive.

- *Backup utilities* make a copy of all information stored on a disk and restore either the entire disk (e.g. in an event of disk failure) or selected files (e.g. in an event of accidental deletion).
- *Disk compression utilities* can transparently compress/uncompress the contents of a disk, increasing the capacity of the disk.
- *File managers* provide a convenient method of performing routine data management tasks, such as deleting, renaming, cataloging, uncataloging, moving, copying, merging, generating, and modifying data sets.
- *Archive utilities:* The archive utilities *o*utput a stream or a single file when provided with a directory or a set of files. Unlike archive suites, these usually do not include compression or encryption capabilities.
- *System profilers* provide detailed information about the software installed and hardware attached to the computer.
- *System monitors* for monitoring resources and performance in a computer system.
- *Anti-virus utilities* scan for computer viruses.
- *Hex editors* directly modify the text or data of a file.
- *Data compression utilities* output a shorter stream or a smaller file when provided with a stream or file.
- *Cryptographic utilities* encrypt and decrypt streams and files.
- *Launcher applications* provide a convenient access point for application software.
- *Registry cleaners* clean and optimize the Windows registry by removing old registry keys that are no longer in use.
- *Network utilities* analyze the computer's network connectivity, configure network settings, check data transfer or log events.
- *Screensavers* were desired to prevent phosphor burn-in on CRT and plasma computer monitors by blanking the screen or filling it with moving images or patterns when the computer is not in use. Contemporary screensavers are used primarily for entertainment or security.

How we manage hardware in Operating Systems?

What are the different categories of Utilities?

Summary

- The computer system can be divided into four components—hardware, operating system, the application program, and the user.

- An operating system is an interface between your computer and the outside world.

- Multiuser is a term that defines an operating system or application software that allows concurrent access by multiple users of a computer.

- A system call is a mechanism used by an application program to request services from the OS.

- The kernel is a computer program at the core of a computer's operating system that has complete control over everything in the system.

- The kernel is the portion of the operating system code that is always resident in memory and facilitates interactions between hardware and software components.

- Utilities are often rather technical and targeted at people with an advanced level of computer knowledge.

Keywords

Directory Access Permissions: A directory's access permissions help to control access to the files in it. These affect the overall ability to use files and subdirectories in the directory.

File Access Permissions: Access permissions on a file control what can be done to the file's contents.

*Graphical User Interfaces***:** Most of the modern computer systems support graphical user interfaces (GUI), and often include them. In some computer systems, such as the original implementation of Mac OS, the GUI is integrated into the kernel.

*Real-Time Operating System (RTOS)***:** Real-time operating systems are used to control machinery, scientific instruments, and industrial systems.

*System Calls***:** In computing, a system call is a mechanism used by an application program to request service from the operating system based on the monolithic kernel or to system servers on operating systems based on the microkernel structure.

*The Root Menu***:** If you move the pointer onto the root window (the "desktop" behind the windows) and press the correct mouse button (usually the first or third button, depending on your setup), you should see the *root menu*.

*The xterm Window***:** One of the most important windows is an xterm window. xterm makes a terminal emulator window with a UNIX login session inside, just like a miniature terminal.

Utility Software: Kind of system software designed to help analyze, configure, optimize and maintain the computer. A single piece of utility software is usually called a utility or tool.

Draw a flow chart for components of a computer system.

Self-Assessment Questions

1. Which of the following provides the interface to access the services of the operating system?

(*a*) API   (*b*) System call

(*c*) Library   (*d*) Assembly instruction

2. What is Microsoft window?

(*a*) An operating system   (*b*) A graphics program

(*c*) A word processing application   (*d*) A database program

3. What is the use of directory structure in the operating system?

(a) The directory structure is used to solve the problem of the network connection in OS.

(b) It is used to store folders and files hierarchically.

(c) It is used to store the program in file format.

(d) All of the these

4. Which of the following operating system runs on the server?

(*a*) Batch OS   (*b*) Real-time OS

(*c*)Distributed OS   (*d*) Network OS

5. The operating system work between

(*a*) User and computer   (*b*) Network and user

(*c*)One user to another user   (*d*) All of these

6. Which of the following operating systems supports only real-time applications?

(*a*) Batch OS   (*b*) Distributed OS

(*c*)Real-time OS   (*d*) Network OS

7. Which of the following is/are the functions of the operating system?

   i.Sharing hardware among users

  ii.Allowing users to share data among themselves

iii.Recovering from errors

iv.Scheduling resources among users

(*a*) i, ii, and iii only   (*b*) ii, iii, and iv only

(*c*) i, iii, and iv only   (*d*) All i, ii, iii, and iv

8. _____ is a large kernel containing virtually the complete operating system, including scheduling, file system, device drivers, and memory management.

(*a*) Multilithic kernel   (*b*) Monolithic kernel

(*c*) Micro kernel   (*d*) Macro kernel

9. _____ is a kind of system software designed to help analyze, configure, optimize and maintain the computer.

(*a*) Application software   (*b*) Compiler

(*c*) Kernel   (*d*) Utility software

10. Which of the following offer(s) visualization of disk space usage by getting the size for each folder (including subfolders) and files in folder or drive.

(*a*) Disk cleaner   (*b*) Disk space analyser

(*c*) Disk compression   (*d*) Disk fragmentary

11. _____ makes a terminal emulator window with a UNIX login session inside, just like a miniature terminal.

(*a*) xterm   (*b*) DOS

(*c*)Session terminal   (*d*) Disk engine

12. _____ focuses on how computer infrastructure (including computer hardware, OS, & application software & data storage) operates.

(*a*) Kernel   (*b*) Compiler

(*c*) Application software   (*d*) Utility software

13. _____ make a copy of all information stored on a disk, and restore either the entire disk (e.g. in an event of disk failure) or selected files (e.g. in an event of accidental deletion).

(*a*) Archive utilities   (*b*) Backup utilities

(*c*) Disk storage utilities   (*d*) Fragmentation utilities

14. The access permissions on a file control what can be done to the file's contents are:

(a) Disk access permissions   (b) File access permissions

(c) Backup access permissions   (d) Directory access permissions

15. The ability of an OS to have more than one program (task) open at one time is called _____.

(*a*) threading   (*b*) programming

(*c*) multitasking   (*d*) utilization

Answers for Self-Assessment Questions

1. (b)	2. (a)	3. (b)	4. (d)	5. (a)	6. (c)
7. (d)	8. (b)	9. (d)	10. (b)	11. (a)	12. (c)
13. (b)	14. (d)	15. (c)			

Review Questions

1. What is an operating system? Give its types.
2. Define System Calls. Give their types also.
3. What are the different functions of an operating system?
4. What are user interfaces in the operating system?
5. Define GUI and Command-Line?
6. What is the setting of focus?
7. Define the xterm Window and Root Menu?
8. What is sharing of files? Also, give the commands for sharing the files?
9. Give steps of Managing hardware in Operating Systems.
10. What is the difference between Utility Software and Application software?
11. Define Real-Time Operating System (RTOS) and Distributed OS?
12. Describe how to run the program in the Operating system.

Further Readings

Introduction to Computers, by Peter Norton, Publisher: McGraw Hill, Sixth Edition.

http://computer.howstuffworks.com/operating-system.htm

What is an Operating System? Types of OS, Features and Examples (guru99.com)

Unit- 05:Data Communication

CONTENTS

Objectives

Data Communication

Objectives

- Explore the concept of data communications
- Know about the local and global reach of network
- Understand data communication with standard telephone lines
- Analyse data communication with modems
- Discuss data communication using digital data connections
- Describe wireless networks

Data Communication

Data Communications is the transfer of data or information between a source and a receiver. The source transmits the data and the receiver receives it. The actual generation of the information is not part of data communications nor is the resulting action of the information at the receiver. Data Communication is interested in the transfer of data, the method of transfer, and the preservation of the data during the transfer process.

In Local Area Networks, we are interested in "connectivity", connecting computers to share resources. Even though the computers can have different disk operating systems, languages, cabling, and locations, they still can communicate with one another and share resources.

The purpose of Data Communications is to provide the rules and regulations that allow computers with different disk operating systems, languages, cabling, and locations to share resources. The rules and regulations are called protocols and standards in data communications.

### Effectiveness of a Data Communication System

The effectiveness of a data communication system depends on the four fundamental characteristics:

1. **Delivery:** System must deliver data to the correct destination. Data must be received by the intended device or user and only by that device or user.

2. **Accuracy:** System must deliver data accurately. Data that have been altered in transmission and left uncorrected are rustles.

3. **Timelines:** The system must deliver data on time. The data that are delivered late are useless. For example: In the case of video, audio, and voice data, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. The timely delivery of data is called real-time transmission.

4. **Jitter:** "Jitter" describes timing errors within a system. In a communications system, the accumulation of jitter will eventually lead to data errors. The parameter that is of most value to the system user is the frequency of occurrence of these data errors, normally referred to as the Bit Error Rate (BER). Jitter doesn't affect sending emails as much as it would a voice chat. So, it depends on what we're willing to accept as irregularities and fluctuations in data transfers. But poor audio and video quality leads to a poor user experience and can impact an organization's bottom line.

Components of a Data Communication System

As we have discussed the effectiveness parameters for a data communication system. Let us now understand the basic requirements for a working communication system. Initially, the sender/source creates a message to be transmitted where a medium carries the message. The receiver (sink) who receives the message. The data communication system constitutes of the following components:
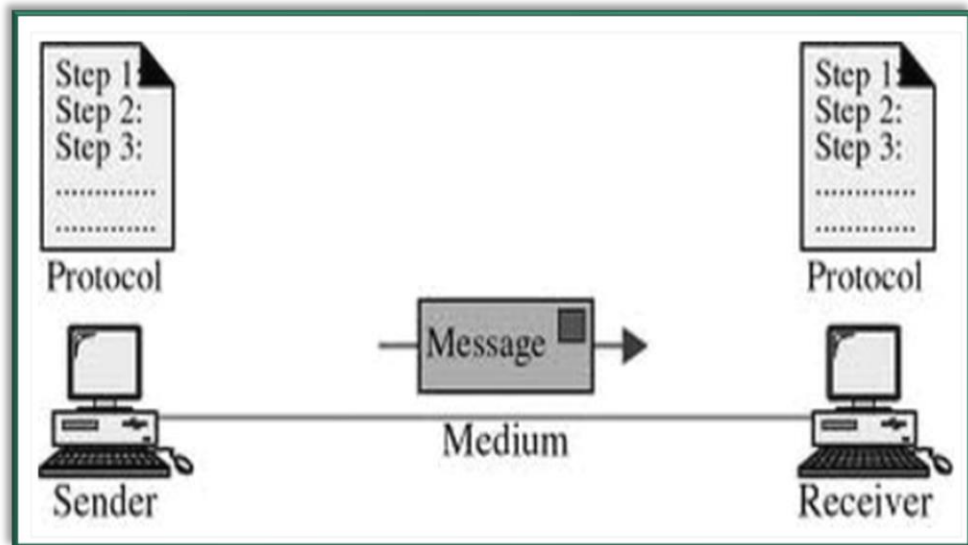
1. Message: A message in its most general meaning is an object of communication. It is a vessel that provides information. It can also be this information. Therefore, its meaning is dependent upon the context in which it is used; the term may apply to both the information and its form.

2. Sender: The sender will have some kind of meaning she wishes to convey to the receiver. It might not be conscious knowledge, it might be a subconscious wish for communication. What is desired to be communicated would be some kind of idea, perception, feeling, or datum.

3. Receiver: These messages are delivered to another party. The other party also enters into the communication process with ideas & feelings that will undoubtedly influence their understanding of your message and their response.

4. Medium: The medium acts as a means to exchange/transmit the message. The sender must choose an appropriate medium for transmitting the message else the message might not be conveyed to the desired recipients. The choice of an appropriate medium of communication is essential for making the message effective and correctly interpreted by the recipient. However, the choice of communication medium varies depending upon the features of communication.

5. Protocols: Protocols implies the formal description of digital message formats and the rules for exchanging those messages in or between computing systems and telecommunications. The

protocols may include signaling, authentication, and error detection and correction syntax, semantics, and synchronization of communication and may be implemented in hardware or software, or both.

6. Feedback: Feedback is the main component of the communication process that permits the sender to analyze the efficacy of the message and confirm the correct interpretation of the message by the decoder. It may be verbal (through words) or non-verbal (in form of smiles, sighs, etc.) and may take written form also in form of memos, reports, etc.

5.1 Local and Global Reach of the Network

Data transmission, digital transmission, or digital communications is the physical transfer of data (a digital bitstream) over a point-to-point or point-to-multi-point communication channel. Examples of such channels are Copper wires, optical fibers, wireless communication channels, and storage media. The data is represented as an electromagnetic signal, such as an electrical voltage, radio waves, microwaves, or infrared signals.

The messages are either represented by a sequence of pulses using a line code (baseband transmission), or by a limited set of continuously varying waveforms (passband transmission), using a digital modulation method. The passband modulation and corresponding demodulation (also known as detection) are carried out by modem equipment. According to the most common definition of digital signal, both baseband and passband signals representing bit-streams are considered as digital transmission, while an alternative definition only considers the baseband signal as digital, and passband transmission of digital data as a form of digital-to-analog conversion.

The data transmitted may be digital messages originating from a data source (a computer or a keyboard). It may also be an analog signal such as a phone call or a video signal, digitized into a bit-stream for example using pulse-code modulation (PCM) or (analog-to-digital conversion and data compression) schemes. However, this source coding and decoding are carried out by code equipment.

Computer networking/ Data communications (Datacom) is the engineering discipline concerned with the communication between computer systems or devices. It is a sub-discipline of telecommunications, computer science, IT, and/or computer engineering that relies heavily upon the theoretical & practical application of these scientific and engineering disciplines. A computer network is any set of computers or devices connected with the ability to exchange data. There are three types of networks: Internet, intranet, and extranet.

5.2 Computer Networks

A computer network, often simply referred to as a network, is a collection of computers and devices interconnected by communications channels that facilitate communications and allows sharing of resources and information among interconnected devices.

Networking Methods

The examples of different networking methods are:

- Local area network (LAN), which is usually a small network constrained to a small geographic area. An example of a LAN would be a computer network within a building.

- Metropolitan area network (MAN), which is used for medium size areas. examples for a city or a state.

- Wide area network (WAN) is usually a larger network that covers a large geographic area.

- Wireless LANs and WANs (WLAN & WWAN) are the wireless equivalents of the LAN and WAN.

One way to categorize computer networks is by their geographic scope, although many real-world networks interconnect Local Area Networks (LAN) via Wide Area Networks (WAN) and wireless wide area networks (WWAN). All the networks are interconnected to allow communication with a variety of different kinds of media, including twisted-pair copper wire cable, coaxial cable, optical fiber, power lines, and various wireless technologies. The devices can be separated by a few meters (e.g. via Bluetooth) or nearly unlimited distances (e.g. via the interconnections of the Internet).

Networking, routers, routing protocols, and networking over the public Internet have their specifications defined in documents called RFCs. Let us explore each in detail:

Figure 1: A LAN Network

Local Area Network (LAN): A small network constrained to a small geographic area (Figure 1: A LAN NetworkFigure 1). It spans a relatively small space and provides services to a small number of people. A set of arbitrarily located users share a set of servers, and possibly also communicate via peer-to-peer technologies. Example of LAN includes a computer network within a building. The users can share printers and some servers from a workgroup, which usually means they are in the same geographic location and are on the same LAN, whereas a network administrator is responsible to keep that network up and running.
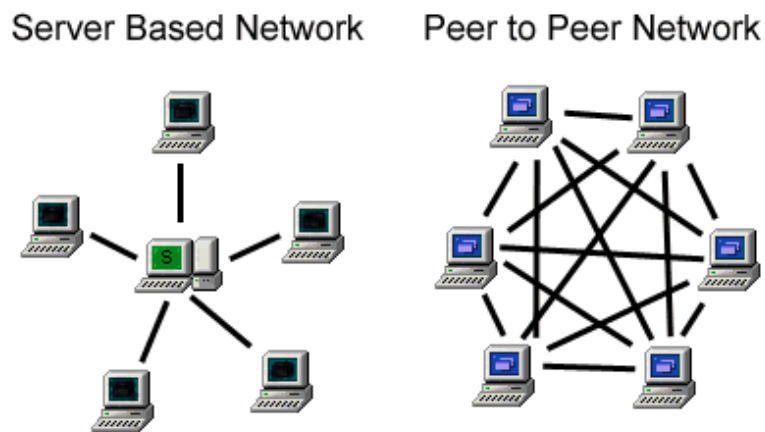
Figure 2: Client-Server & Peer-to-Peer Network

Client-Server and Peer-to-Peer Network: A peer-to-peer or client-server method of networking methods can be used (Figure 2). A peer-to-peer network is where each client shares their resources with other workstations in the network. Examples of peer-to-peer networks are small office networks where resource use is minimal and a home network.

In a client-server network, every client is connected to the server and each other. The client-server networks use servers in different capacities. These can be classified into two types: Single-service servers and print servers. The server performs one task such as a file server, while other servers can not only perform in the capacity of file servers and print servers but also can conduct calculations and use them to provide information to clients (Web/Intranet Server). Computers may be connected

in many different ways, including Ethernet cables, Wireless networks, or other types of wires such as power or phone lines.

Metropolitan Area Network (MAN): It is used for medium size areas. MAN is a computer network that interconnects users with computer resources in a geographic region of the size of a metropolitan area (Figure 3). Examples: Network for a city or a state.
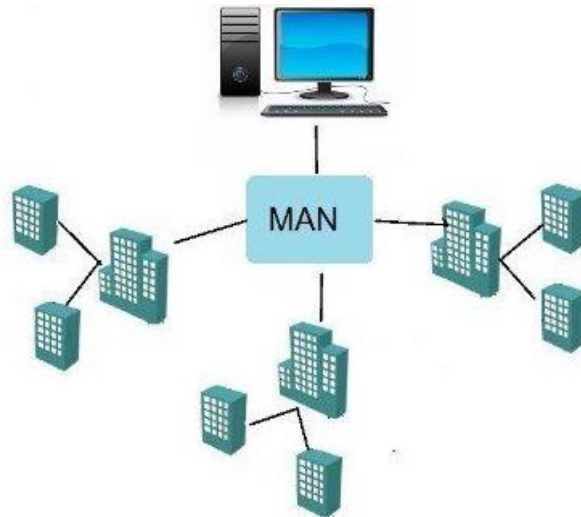

Figure 3: A Metropolitan-Area Network

Wide Area Network (WAN): A WAN is a network where a wide variety of resources are deployed across a large domestic area or internationally (Figure 4). An example of this is a multinational business that uses a WAN to interconnect their offices in different countries. The largest and best example of a WAN is the Internet, which is a network composed of many smaller networks (Figure 5). The Internet is considered the largest network in the world. The PSTN (Public Switched Telephone Network) also is an extremely large network that is converging to use Internet technologies, although not necessarily through the public Internet.
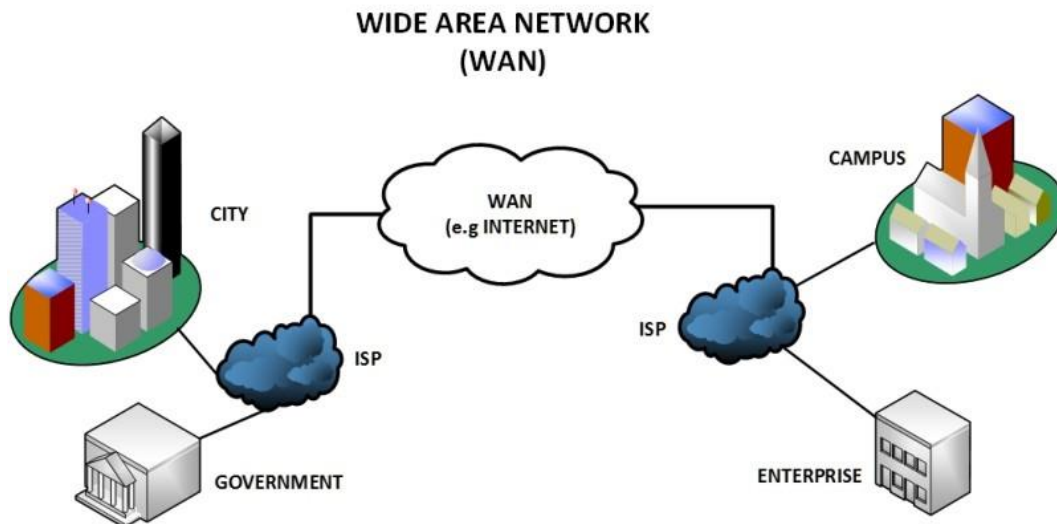

Figure 4: A Wide Area Network

A Wide Area Network involves communication through the use of a wide range of different technologies. These technologies include Point-to-Point WANs such as Point-to-Point Protocol (PPP) and High-Level Data Link Control (HDLC), Frame Relay, ATM (Asynchronous Transfer Mode), and Sonet (Synchronous Optical Network). The difference between the WAN technologies is based on the switching capabilities they perform and the speed at which sending and receiving bits of information (data) occur.
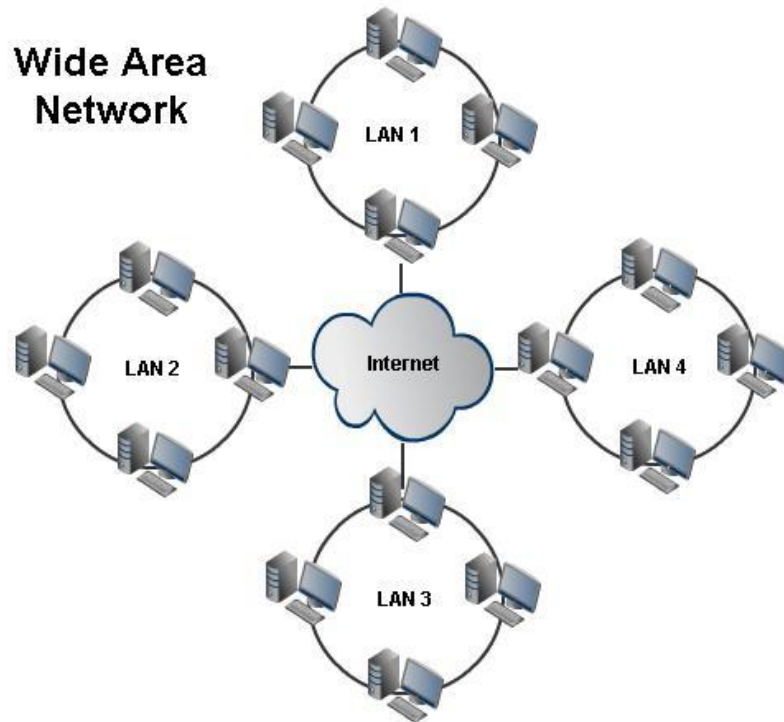
Figure 5: Internet

Wireless Networks (WLAN, WWAN): A wireless network is the same as a LAN or a WAN but there are no wires between hosts and servers (Figure 6). The data is transferred over sets of radio transceivers. These types of networks are beneficial when it is too costly or inconvenient to run the necessary cables. The media access protocols for LANs come from the IEEE. The most common IEEE 802.11 WLANs cover, depending on antennas, ranges from hundreds of meters to a few kilometers. For larger areas, either communications satellites of various types, cellular radio, or wireless local loop (IEEE 802.16) all have advantages and disadvantages. Depending on the type of mobility needed, the relevant standards may come from the IETF or the ITU.

Figure 6: Wireless Network

Network Protocol and its Components

Protocol is a set of rules that governs data communication. It represents an agreement between the communicating devices. Without protocol two devices may be connected but cannot communicate. The key elements of protocol are:

1. Syntax: Refers to the structure or format of the data, meaning the order in which they are presented.

2. Semantics: Refers how a particular pattern to be interpreted and what action is to be taken based on that interpretation.

3. Timing: Refers to when the data should be sent and how fast it should be sent.

The key functions that a protocol performs are:

- Protocol Data Unit: It refers to the breaking of data in manageable units called Protocol Data Unit e.g. Segment, Packet, Frame, etc.

- Format of packet: Format of the packet like which group of bits in the packet constitute data, address, or control bits.

- Sequencing: Refers to breaking long messages into smaller units. Sequencing is the responsibility protocol.

- Routing of packets: Finding the most efficient path between source and destination is the responsibility of protocol.

o Flow control: It is the responsibility of the protocol to prevent the fast sender to overwhelm the slow receiver. It ensures resource sharing and protection against traffic congestion by regulating the flow of data through the shared medium.

o Error control: Protocol is responsible to provide a method for error detection and correction.

o Creating and terminating a connection: Protocol defines the rules to create and terminate a connection between sender and receiver to communicate among each other.

o Security of data: Certain communication software has features to prevent data from unauthorized access.

5.3 Data Communication with Standard Telephone Lines

The public switched telephone network (PSTN) is the worldwide telephone system and usually, this network system uses digital technology. In the past, it was used for voice communication only but now it is playing very important role in data communication in the computer network such as in the Internet. There are different types of telephone lines that are used for data communication in the network. These are discussed below.

1. Dial-Up Lines

It is a temporary connection that uses communication. Modern is used at the s telephone number is dialed from the sender the receiving end answers the call. In the communication between computers or e the cost of data communication is very Internet through this connection.

2. Dedicated Lines

It is a permanent connection that establishes a connection between two permanently. It is better than dial-up lines connection because dedicated lines provide a constant connection. These types of connections may be digital or analog. The data transmission speed, of digital lines, is very fast as compared to analog dedicated lines. The data transmission speed is also measured in bits per second (bps). In dial-up and dedicated lines, it is up to 56 Kbps. The dedicated lines are mostly used for business purposes. The most important digital dedicated lines are described below.

Integrated Services Digital Network (ISDN)

ISDN is a set of standards used for digital transmission over the telephone line. The ISDN uses the multiplexing technique to carry three or more data signals at once through the telephone line. It is because the data transmission speed of the ISDN line is very fast. In the ISDN line, both ends of connections require the ISDN modem and a special telephone set for voice communication. Its data transmission speed is up to 128 Kbps.

Digital Subscriber Line (DSL)

In DSL, both ends of connections require the network cards and DSL modems for data communication. The data transmission speed and other functions are similar to the ISDN line. DSL

transmits data on existing standard copper telephone wiring. Some DSLs provide a dial tone, which allows both voice and data communication.

Asymmetric Digital Subscriber Line (ADSL)

ADSL is another digital connection. It is faster than DSL. ADSL is much easier to install and provides a much faster data transfer rate. Its data transmission speed is from 128 Kbps up to 10 tvlbps. This connection is ideal for internet access.

Cable Television Line (CATV)

CATV line is not a standard telephone line. It is a dedicated line used to access the Internet. Its data transmission speed is 128 Kbps to 3 Mbps. A cable, modem is used with the CATV that provides a high-speed internet connection through the cable television network. A cable modem sends and receives digital data over the cable television network. To access the Internet using the CATV network, the CATV Company installs a splitter inside your house. From the splitter, one part of the cable runs to your television, and the other part connects to the cable modem. A cable modem usually is an external device, in which one end of a cable connects to a CATV wall outlet while the other end plugs into a port (such as on an Ethernet card) in the system unit.

T-Carrier Lines

It is very fast digital line that can carry multiple signals over a single communication line whereas a standard dialup telephone line carries only one signal. 1-carrier lines use multiplexing so that multiple signals share the line. T-carrier lines provide very fast data transfer rates. The T-carrier lines are very expensive and large companies can afford these

lines. The most popular T-carrier lines are:

i. T1 Line: The most popular 1-carrier line is the T1 line (dedicated line). Its data transmission speed is 1.5 Mbps. Many ISPs use T1, lines to connect to the Internet backbone. Another type of TI line is the fractional TI line. It is slower than the TI line but it is less expensive. The home and business users use this line to connect to the Internet and share a connection to the T1 line with other users.

ii. T3 Line: Another most popular and faster 1-carrier line is the T3 line. Its data transmission speed is 44 Mbps. It is more expensive than the T1 line. The main users of the T3 line are telephone companies and ISPs. The internet backbone itself also uses T3 lines.

Businesses often use T1 lines to connect to the Internet.

Asynchronous Transfer Mode (ATM)

It is a very, fast data transmission connection line that can carry data, voice, video, multimedia, etc. Telephone networks, the Internet, and other networks use ATMs. In near future, ATM will become the Internet standard for data transmission instead of T3 lines. Its data transmission speed is from 155 Mbps to 600 Mbps.

5.4 Data Communication with Modems

A modem (modulator-demodulator) is a device (Figure 7) that modulates an analog carrier signal to encode digital information, and also demodulates such a carrier signal to decode the transmitted information. The goal is to produce a signal that can be transmitted easily and decoded to reproduce the original digital data. Modems can be used over any means of transmitting analog signals, from driven diodes to radio.
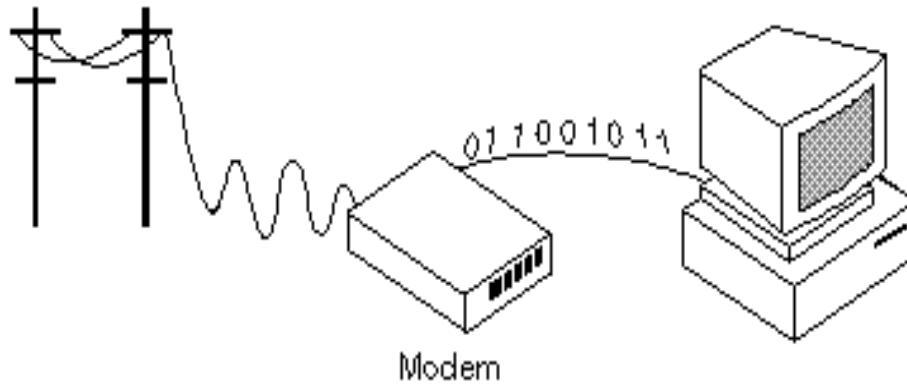
Figure 7: Data Communication with Modem

The most familiar example is a voice band modem that turns the digital data of a personal computer into modulated electrical signals in the voice frequency range of a telephone channel. These signals can be transmitted over telephone lines and demodulated by another modem at the receiver side to recover the digital data.

Modems are generally classified by the amount of data they can send in a given time unit, normally measured in bits per second (bit/s, or bps). They can also be classified by the symbol rate measured in baud, the number of times the modem changes its signal state per second. For example, the ITU V.21 standard used audio frequency-shift keying, aka tones, to carry 300 bit/s using 300 baud, whereas the original ITU V.22 standard allowed 1,200 bit/s with 600 baud using phase-shift keying.

(modem) **(n.)** Short for **mo**dulator-**dem**odulator. A modem is a device or program that enables a computer to transmit data over, for example, telephone or cable lines.

Fortunately, there is one standard interface for connecting external modems to computers called RS-232. Consequently, any external modem can be attached to any computer that has an RS-232 port, which almost all personal computers have. Some modems come as an expansion board that you can insert into a vacant expansion slot. These are sometimes called onboard or internal modems.

While the modem interfaces are standardized, many different protocols for formatting data to be transmitted over telephone lines exist. Some, like CCITT V.34, are official standards, while others have been developed by private companies. Most modems have built-in support for the more common protocols at slow data transmission speeds at least, most modems can communicate with each other. At high transmission speeds, however, the protocols are less standardized. Aside from the transmission protocols that they support, the following characteristics distinguish one modem from another:

Bits Per Second (BPS) : How fast the modem can transmit and receive data? At slow rates, modems are measured in terms of baud rates. The slowest rate is 300 baud (about 25 cps). At higher speeds, modems are measured in terms of bits per second (bps). The fastest modems run at 57,600 bps, although they can achieve even higher data transfer rates by compressing the data. Obviously, the faster the transmission rate, the faster you can send and receive data. Note, however, that you cannot receive data any faster than it is being sent. If, for example, the device sending data to your computer is sending it at 2,400 bps, you must receive it at 2,400 bps. It does not always pay, therefore, to have a very fast modem. Besides, some telephone lines are unable to transmit data reliably at very high rates.

Voice/data: Many modems support a switch to change between voice and data modes. In data mode, the modem acts like a regular modem. In voice mode, the modem acts like a regular telephone. Modems that support a voice/data switch have a built-in loudspeaker and microphone for voice communication.

Auto-answer: An auto-answer modem enables your computer to receive calls in your absence. This is only necessary if you are offering some type of computer service that people can call in to use.

Data compression: Some modems perform data compression, which enables them to send data at faster rates. However, the modem at the receiving end must be able to decompress the data using the same compression technique.

Flash memory: Some modems come with flash memory rather than conventional ROM, which means that the communications protocols can be easily updated if necessary.

Narrow-Band/Phone-Line Dialup Modems

The dialup modems are a standard modem of today that contain two functional parts: an analog section for generating the signals and operating the phone, and a digital section for setup and control. This functionality is often incorporated into a single chip nowadays, but the division remains in theory. In operation, the modem can be in one of two modes, data mode in which data is sent to and from the computer over the phone lines, and command mode in which the modem listens to the data from the computer for commands, and carries them out. A typical session consists of powering up the modem (often inside the computer itself) which automatically assumes command mode, then sending it the command for dialing a number. After the connection is established to the remote modem, the modem automatically goes into data mode, and the user can send and receive data.

When the user is finished, the escape sequence, "+++" followed by a pause of about a second, may be sent to the modem to return it to command mode, then a command (e.g. "ATH") to hang up the phone is sent. Note that on many modem controllers it is possible to issue commands to disable the escape sequence so that it is not possible for data being exchanged to trigger the mode change inadvertently.

The commands themselves are typically from the Hayes command set, although that term is somewhat misleading. The original Hayes commands were useful for 300 bit/s operations only and then extended for their 1,200 bit/s modems. Faster speeds required new commands, leading to a proliferation of command sets in the early 1990s. Things became considerably more standardized in the second half of the 1990s when most modems were built from one of a very small number of chipsets. We call this the Hayes command set even today, although it has three or four times the number of commands as the actual standard.

Radio Modems

Radio modems are used extensively in direct broadcast satellite, WiFi, and mobile phones. Most of the modern telecommunications and data networks make use of them. Radio modems are used where long-distance data links are required & formulate an important part of the PSTN. Radio modems are commonly used for high-speed computer n/w links to outlying areas where fiber is not economical.

Wireless Data Modems

The wireless data modems are used in the WiFi & WiMax standards, operating at microwave frequencies. WiFi is principally used in laptops for Internet connections (wireless access point) & wireless application protocol (WAP). They are commonly used for high-speed computer n/w links to outlying areas where fiber is not economical.

Mobile Modems and Routers

Modems that use a mobile telephone system (GPRS, UMTS, HSPA, EVDO, WiMax, etc.), are known as wireless modems (cellular modems). Wireless modems can be embedded inside a laptop or appliance or external to it. The external wireless modems connect cards, USB modems for mobile broadband, and cellular routers. A connect card is a PC card or ExpressCard (Figure 8) which slides into a PCMCIA/PC card/ExpressCard slot on a computer. The USB wireless modems (Figure 9) use a USB port on the laptop instead of a PC card or ExpressCard slot. The cellular router may have an external data card (AirCard) that slides into it.

Figure 8: T-Mobile Universal Mobile Telecommunications System PC Card Modem

Figure 9: Huawei CDMA2000 Evolution-Data Optimized USB Wireless Modem

Broadband

ADSL modems, a more recent development, are not limited to the telephone's voiceband audio frequencies. Some ADSL modems use coded orthogonal frequency division modulation (DMT, for Discrete MultiTone; also called COFDM, for digital TV in much of the world). The broadband modems use complex waveforms to carry digital data and are more advanced devices than traditional dial-up modems as they are capable of modulating/demodulating hundreds of channels simultaneously.

Home Networking

The modems are also used for high-speed home networking applications, especially those using existing home wiring. One example is the G.hn standard, developed by ITU-T, which provides a high-speed (up to 1 Gbit/s). The LANs with such modems can be using existing home wiring (power lines, phone lines, and coaxial cables).

Deep-space Telecommunications

Many modern modems have their origin in deep space telecommunications systems of the 1960s. The comparison of deep space telecom modems with landline modems lies on following features:

a) digital modulation formats that have high doppler immunity are typically used.

b) waveform complexity tends to be low, typically binary phase-shift keying.

c) error correction varies from mission to mission but is typically much stronger than most landline modems.

Voice Modems

Voice modems are regular modems that are capable of recording or playing audio over the telephone line and are mostly used for telephony applications. They can be used as an FXO card for Private branch exchange systems (compare V.92).

5.5 Data Communication Using Digital Data Connections

A communications system may be digital either by the nature of the information (also known as data) which is passed or like the signals which are transmitted. If either of these is digital then for our purposes it is considered to be a digital communications system. There are four possible combinations of data and signal types:

1. Digital data, analog signal

2. Analog data, digital signal

3. Digital data, digital signal

4. Analog data, analog signal

Digital Data with Analog Signals

This method is used to send computer information over transmission channels that require analog signals, like a fiber-optic network, computer modems, cellular phone networks, and satellite systems. In each of these systems, an electromagnetic carrier wave is used to carry the information over great distances and connect digital information users at remote locations. The digital data is used to modulate one or more of the parameters of the carrier wave. This basic process is given the name "shift-keying" to differentiate it from the purely analog systems like AM and FM.

As with analog modulation, there are three parameters of the carrier wave to vary and therefore three basic types of shift keying:

Amplitude Shift Keying (ASK): The carrier wave amplitude is changed between discrete levels (usually two) in accordance with digital data. Here, the digital data to be transmitted is binary number 1011. Two amplitudes are used to directly represent the data, either 0 or 1. This modulation is called binary amplitude shift keying or BASK.

Frequency Shift Keying (FSK): The carrier frequency is changed between discrete values. If only two frequencies are used then this will be called BFSK, for binary frequency shift keying.

Phase Shift Keying (PSK): The phase of the carrier wave at the beginning of the pulse is changed between discrete values. We have *amplitude phase keying* that uses combinations of amplitude and phase keying. For example, if we use two levels of amplitude and two levels of phase together, there will be a total of four possibilities. This is used to transmit two independent channels of digital data simultaneously. It is also called Quadrature AM or Quaternary PSK. Another type of phase keying is *Minimum Shift Keying (MSK)* that is used to find the minimum signal bandwidth for a particular method (usually FSK).

Analog Data with Digital Signals

A digital signal can be transmitted over a dedicated connection between two or more users. In order to transmit analog data, it must first be converted into a digital form. This process is called sampling, or encoding.

Sampling involves two steps, that is, taking the measurements at regular sampling intervals and then converting the value of the measurement into binary code. Sampling has certain considerations where the amplitude of a signal is measured at regular intervals and the interval is designated as ts and is called sample interval. However, the sample interval must be chosen to be short enough. The sampling rate (inverse of the sample interval) should be greater than twice the highest frequency component of the signal which is being sampled Known as the Nyquist frequency. If sampling is done at a lower rate, then there is the risk of missing some information, known as aliasing.

Encoding is the process where once the samples are obtained, they must be encoded into binary. For a given number of bits, each sample may take on only a finite number of values. If more bits are used for each sample, then a higher degree of resolution is obtained. The higher bit sampling requires more storage for data and requires more bandwidth to transmit.

Digital Data with Digital Signals

Digital data is a collection of zeroes and ones, where the value at any one time is called a bit. There are several different ways in which a binary number be formatted. This is called pulse code modulation or PCM. The most straightforward PCM format is designated as NRZ-L (nonreturn to zero levels). In this format, the level directly represents the binary value: low level = 0, high level = 1.

Analog Data with Analog Signals

When a low-pass analog signal is converted into a bandpass analog signal, it is called analog-to-analog conversion. It is a similar situation when data from one computer is sent to another via some analog carrier, it is first converted into analog signals.

5.6 <u>Wireless Networks</u>

A wireless network refers to any type of computer network that is not connected by cables of any kind. It is a method by which telecommunications networks and enterprise (business), installations avoid the costly process of introducing cables into a building, or as a connection between various equipment locations. Wireless telecommunications networks are generally implemented and administered using a transmission system called radio waves. This implementation takes place at the physical level, (layer), of the network structure.

Types of Wireless Connections

Wireless Local Area Networks (WLANs): WLANs allow the users in a local area, such as a university campus or library, to form a network or gain access to the internet (Figure 10). These are temporary networks that can be formed by a small number of users without the need for an access point.

Wireless Personal Area Networks (WPANs): A personal telecommunications device that communicates in the individual distance (Figure 11). The two current technologies include Infra-Red (IR) and Bluetooth (IEEE 802.15). WPANs allow the connectivity of personal devices within an area of about 30 feet. The IR requires a direct line of sight and the range is less.
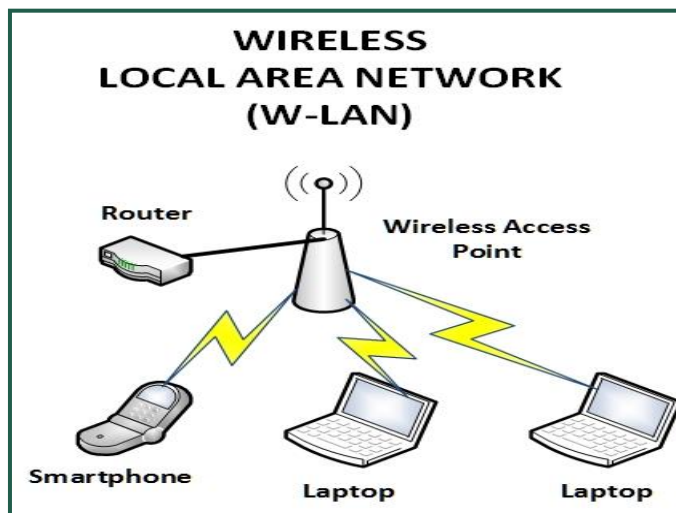

Figure 10: Wireless LANs

Figure 11: WPANs Scenario

Wireless Metropolitan Area Networks (WMANs): The WMANs allow the connection of multiple networks in a metropolitan area such as different buildings in a city as depicted in Figure 12.
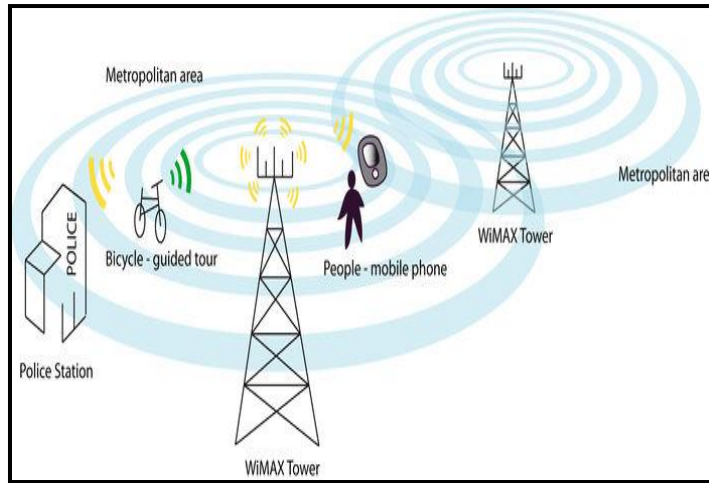
Figure 12: WMANs Scenario

Wireless Wide Area Networks (WWANs): These can be maintained over large areas, such as cities or countries, via multiple satellite systems or antenna sites looked after by an ISP. Currently, Information and Communication Technology (ICT) sector is focusing on 5G (5th generation) systems. WWAN connect two or more areas in geographical context e.g. state, province, country such as Notre Dame in Fremantle and Broome (Figure 13).
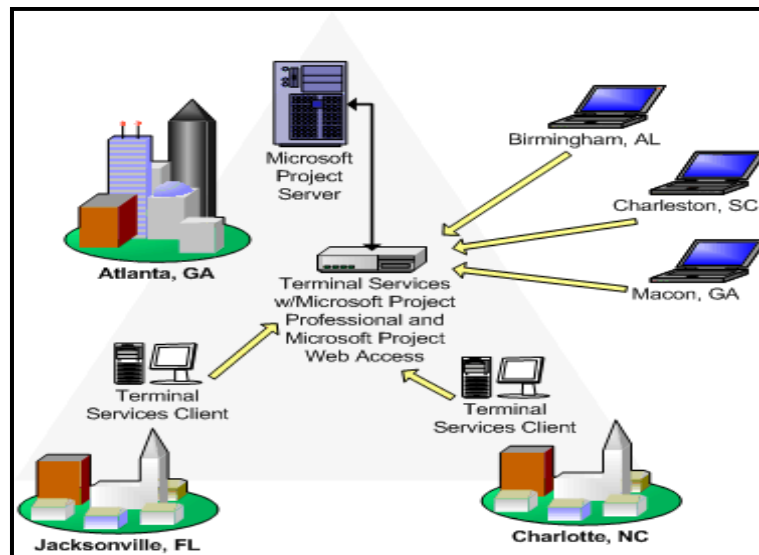

Figure 13: Wireless Wide Area Networks (WWANs)

Difference Between Different Types of Wireless Connections

Type	Coverage	Performance	Standards	Applications
Wireless PAN	Within reach of a person	Moderate	Wireless PAN Within reach of a person Moderate Bluetooth, IEEE 802.15, and IrDa Cable replacement for peripherals	Cable replacement for peripherals
Wireless LAN	Within a building or campus	High	IEEE 802.11, Wi-Fi, and HiperLAN	Mobile extension of wired networks
Wireless MAN	Within a city	High	Proprietary, IEEE 802.16, and WIMAX	Fixed wireless between homes

				and businesses and the Internet
Wireless WAN	Worldwide	Low	CDPD and Cellular 2G, 2.5G, and 3G	Mobile access to the Internet from outdoor areas

5.7 <u>Summary</u>

- Digital communication is the physical transfer of data over a point to point or point to a multipoint communication channel.
- The public switched telephone network (PSTN) is a worldwide telephone system and usually, this network system uses the digital technology.
- A modem is a device that modulates an analog carrier signal to encode, digital information, **Notes** and also demodulates such a carrier signal to decode the transmitted information.
- A wireless network refers to any type of computer network that is not connected by cables of any kind.
- Wireless telecommunication networks are generally implemented and administered using a transmission system called radio waves.

5.8 <u>Keywords</u>

Computer networking: A computer network, often simply referred to as a network, is a collection of computers and devices interconnected by communications channels that facilitate communications among users and allows users to share resources. Networks may be classified according to a wide variety of characteristics.

Data transmission: Data transmission, digital transmission, or digital communications is the physical transfer of data (a digital bitstream) over a point-to-point or point-to-multipoint communication channel.

Dial-Up lines: Dial-up networking is an important connection method for remote and mobile users. A dial-up line is a connection or circuit between two sites through a switched telephone network.
DNS: The Domain Name System (DNS) is a hierarchical naming system built on a distributed database for computers, services, or any resource connected to the Internet or a private network.

DSL: Digital Subscriber Line (DSL) is a family of technologies that provides digital data transmission over the wires of a local telephone network.

GSM: Global System for Mobile Communications, or GSM (originally from Groupe Spécial Mobile), is the world's most popular standard for mobile telephone systems.

ISDN Lines: Integrated Services Digital Network (ISDN) is a set of communications standards for simultaneous digital transmission of voice, video, data, and other network services over the traditional circuits of the public switched telephone network.

LAN: A local area network (LAN) is a computer network that connects computers and devices in a limited geographical area such as a home, school, computer laboratory, or office building.

MAN: A metropolitan area network (MAN) is a computer network that usually spans a city or a large campus.

Modem: A modem (modulator-demodulator) is a device that modulates an analog carrier signal to encode digital information, and also demodulates such a carrier signal to decode the transmitted information.

PSTN: The public switched telephone network (PSTN) is the network of the world's public circuit-switched telephone networks. It consists of telephone lines, fiber optic cables, microwave transmission links, cellular networks, communications satellites, and undersea telephone cables all

inter-connected by switching centers that allow any telephone in the world to communicate with any other.

WAN: A wide area network (WAN) is a computer network that covers a broad area (i.e., any network whose communications links cross metropolitan, regional, or national boundaries).

WISP: Wireless Internet Service Providers (WISPs) are Internet service providers with networks built around wireless networking.

5.9 Self-assessment Questions

1. What is Data Communication?
    (a) The transmission of data from one location to another for direct use or further processing.
    (b) A system made up of hardware, software and communication facilities, computer terminals, and input\output devices linked locally or globally.
    (c) A telegraphy system.
    (d) A channel is used to transmit data at a rate of 1000-8000cps.

2. The three classes of channel that makes up bandwidth are:
    (a) Data, communication, transmission.
    (b) Analogue signals, digital signals, standard telephone lines.
    (c) Narrow-band, voice-band, broad-band channels.
    (d) Automatic dialing, signal transmission, modems.

3. A data communication system consists of
    (a) The transmission of data from one location to another for indirect use.
    (b) A system made up of hardware, software and communication facilities, computer terminals, and input\output devices linked locally or globally.
    (c) A telegraphy system.
    (d) A channel used to transmit data at a rate of 1000-8000cps.

4. Digital communication is the _____ transfer of data over a point to point or point to multipoint communication channel.
    (a) logical
    (b) virtual
    (c) physical
    (d) singular

5. A bandwidth determines the volume of data that can be transmitted in a given time?
    (a) True   (b) False

6. LAN is a computer network that connects computers and devices in a _____.
    (a) limited geographical area
    (b) expanded geographical area
    (c) distributed manner across multiple domains
    (d) metropolitan area

7. A modem is a device that _____ an analog carrier signal to encode digital information, and also _____ a carrier signal to decode the transmitted information.
   (a) carries, observes
   (b) observes, carries
   (c) demodulates, modulates
   (d) modulates, demodulates

8. A _____ is a computer network that usually spans a city or a large campus.
   (a) Local Area Network (LAN)

(b) Metropolitan Area Network (MAN)

(c) Global Area Network (GAN)

(d) City Area Network (CAN)

9. IEEE 802.11, Wi-Fi, and HiperLAN are the standards for _____.

   (a) Wireless PAN

   (b) Wireless MAN

   (c) Wireless WAN

   (d) Wireless LAN

10. WISP stands for:

   (a) Wireless Instantaneous Source Provider

   (b) Wireless Internet Service Providers

   (c) Wideband Internet Service Providers

   (d) Wideband Internet Source Protocol

11. A digital signal can be transmitted over a dedicated connection between two or more users. In order to transmit analog data, it must first be converted into a digital form. This process is called as _____.

   (a) Demodulation

   (b) Modulation

   (c) Sampling

   (d) Transmission

12. The data transmission speed for _____ ranges from 155 Mbps to 600 Mbps.

   (a) Asymmetric Digital Subscriber Line (ADSL)

   (b) Cable Television Line (CATV)

   (c) Asynchronous Transfer Mode (ATM)

   (d) T-Carrier Lines

13. ASK is a result of a combination of shift keying and

   (a) digital modulation

   (b) amplitude modulation

   (c) analog modulation

   (d) none of the above

14. Which of the following is not a digital-to-analog conversion?

   (a) ASK

   (b) PSK

   (c) FSK

   (d) AM

15. Integrated Services Digital Network uses the _____ technique to carry three or more data signals at once through the telephone line.

   (a) demultiplexing

   (b) encoding

   (c) aliasing

   (d) multiplexing

5.10   Review Questions

1. What do you mean by data communication?

2. Explain the general model of data communication. What is the role of the modem in it?

3. Explain the general model of digital transmission of data. Why is analog data sampled?

4. What do you mean by digital modulation? Explain various digital modulation techniques.

5. What are computer networks?

6. How data communication is done using standard telephone lines?

7. What is ATM switch? Under what condition it is used?

8. What do you understand by ISDN?

9. What are the different network methods? Give a brief introduction about each.

10. What do you understand by wireless networks? What is the use of the wireless network?

11. Give the types of wireless networks.

12. What is the difference between broadcast and point-to-point networks?

Answers for Self-Assessment Questions

1. (a)	2. (c)	3. (b)	4. (c)
5. (a)	6. (a)	7. (d)	8. (b)
9. (d)	10. (b)	11. (c)	12. (c)
13. (b)	14. (d)	15. (d)	

Further Reading

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Unit 06: Networks

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Objectives

• Discuss use of network. and explain sharing data any time anywhere.

• Explain common types of network.

• Understand the network structure and its elements.

• Learn about network topologies and the types

• Describe network protocols and their models.

• Know about the characteristics of the network media.

• Analyse and understand the importance of network hardware

6.1 Network

A network is a set of devices (often referred to as nodes) connected by communication links. A node or a device can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes/ devices on the network. Here, a link can be a cable, air, optical fiber, or any medium which can transport a signal carrying information. There are certain criteria's for defining and analyzing the network efficacy such as:

• Performance: The performance of a network depends on network elements and is measured in terms of delay and throughput. The network delay or latency is the time required for data to travel from the sender to the receiver. Network latency is different from network speed or bandwidth or throughput, which is the amount of data that can be transferred per unit time. A network can be both high speed and high latency. The network performance depends upon: Software capability, hardware efficiency, number of users and type of transmission media used.

• Reliability: The network reliability pertains to the capacity of the network to offer the same services even during a failure. Single failures (node or link) are usually considered since they

account for the vast majority of failures. It is often measured in terms of availability and robustness of a network.

• Security: Network security consists of the policies, processes and practices adopted to prevent, detect and monitor unauthorized access, misuse, modification, or denial of a computer network and network-accessible resources. Network security involves the authorization of access to data in a network, which is controlled by the network administrator. It involves protection of data against corruption/loss of data due to errors and malicious users.

• Energy Efficiency: Some amount of energy is consumed per unit of successful communication. Energy is becoming even more important due to climate change and sustainability considerations. The potential increase in data traffic (up to 1,000 times more) and the infrastructure to cope with it in the 5G era could make 5G to, arguably, consume up to 2-3 times as much energy. This potential increase in energy, coming from a high number of base stations, retail stores and office space, maintaining legacy plus 5G networks and the increasing cost of energy supply – call for action. The many solutions to enhance network energy efficiency fall into two major groups: increasing the use of alternative energy sources to reduce dependence on the main power grid; network load optimization to reduce the energy consumption.

• Scalability: A network property that ensures that the overall network performance may not significantly degrade, regardless the size of the network increasing. It specifies the ability to accommodate the change in network size.

• Fairness: The ability of different systems to equally share a common transmission channel. Fairness measures or metrics are used in network engineering to determine whether users or applications are receiving a fair share of system resources.

• Adaptability: Adaptability refers to users that can substantially customize the system through tailoring activities by themselves, i.e. an adaptable system. The ability to accommodate the changes in the network topology is judged by the network's adaptability.

• Channel Utilization: Channel utilization considers the bandwidth utilization for effective communication.It is a term related to the use of the channel disregarding the throughput. It counts not only with the data bits but also with the overhead that makes use of the channel. The transmission overhead consists of preamble sequences, frame headers and acknowledge packets.

• Throughput: Network throughput is the data per second that can be transferred by a network connection at a point in time. It can be said as the amount of data successfully transferred from a sender to a receiver in a given time.It is also common to measure throughput in gigabytes, megabytes and kilobytes. This uses slightly different notation: GBps, MBps and KBps. A byte is 8 times larger than a bit. As such, throughput of 1 GBps is eight times faster than 1 Gbps.

Types of Network Connections

Networks come in many forms: home networks, business networks, and the internet are three common examples. Devices may use any of several methods to connect to these (and other kinds of) networks. Three basic types of network connections exist:

Point-to-point connections allow one device to communicate with one other device. For example, two phones may pair with each other to exchange contact information or pictures.

Broadcast/multicast connections allow a device to send one message out to the network and have copies of that message delivered to multiple recipients.

Multipoint connections allow one device to connect and deliver messages to multiple devices in parallel.

6.2 Sharing Data Any Time Any Where

A computer network, often simply referred to as a network, is a collection of computers and devices interconnected by communications channels that facilitate communications and allows sharing of resources and information among interconnected devices.Networks may be classified according to a wide variety of characteristics. A computer network allows sharing of resources and information among interconnected devices.

1. **Sharing Data Over a Network**

In addition to saving place marks or folders to your local computer, you can also save place data to a web server or network server. For example, Google Earth (a global mapping program) users who have access to the server can then use the data. As with other documents, you can create links or references to KMZ files (stores map locations viewable in Google Earth; Keyhole Mark-up language Zipped) for easy access. The storage of a place mark file on the network or on a web server offers the following advantages:

Accessibility: If your place data is stored on a network or the Web, you can access it from any computer anywhere, provided the location is either publicly available or you have log in access.

Ease in Distribution: The network consists of computers and devices that are geographically distributed. Example: Develop an extensive presentation folder for Google Earth software, then make that presentation available to everyone who has access to your network storage location or web server. It is more convenient than sending the data via email when you want to make it persistently available to a large number of people.

Automatic Updates/Network Link Access: Any new information or changes you make to network-based KMZ information is automatically available to all users who access the KML data via a network link.

Backup: If for some reason the data on your local computer is corrupt or lost, you can open any of the KMZ files that you have saved to a network location, and if so desired, save it as a local file again.

2. **Saving Data to a Server**

To make place marks or folders available to other people via server, save file to appropriate location such as a network server or a web server etc.

a) Saving to Network Server: To save a folder or place mark to a location on network, follow the steps in Saving Places Data & save file in a location on your company network rather to the local file system.

b) Saving to a Web Server: To save a place mark or folder to a web server, first save the file to your local computer as discussed above. Once the file is saved on your local computer as a separate KMZ file, you can use an FTP or similar utility to transfer the file to the web servers.

> Illustration the parallels between web-based content and KMZ content via a network link using Google Earth

3. **Opening Data from a Network Server**

If you are working in an organization where place data is saved to a network that you have access to, you can open that data in the same way you would open a saved KMZ file on your local computer.From the File menu, select Open (CTRL + O in Windows/Linux, + O on the Mac) and then locate the file you want to open.

Navigate to your network places and locate the KMZ or KML data you want to open in Google Earth. Select the file and click the Open button. The folder or placemark appears in the 'Places' panel and the 3D viewer flies to the view set for the folder or placemark (if any). Files opened in this way are NOT automatically saved for the next time you use Google Earth. If you want the placemark or folder to appear the next time you use Google Earth, drag the item to your 'My Places' folder to save it for the next session. This is followed by locating the file.

Once you have located the file on your network places, you can simply drag and drop the KMZ file over the 'Places' panel. The 3D viewer flies to the view set for the folder or placemark (if any).When

you use the drag-and-drop method of opening a placemark or folder, you can drop the item over a specific folder in the 'Places' panel. If the 'My Places' folder is closed and you want to drop it there, just hold the item over the 'My Places' folder until the folder opens up and you can place the item within subfolders or in the list. Items dropped in the 'My Places' folder appear the next time you start Google Earth. Otherwise, you can drop the item in the white space below the 'Places' panel so that it appears in the 'Temporary Places' folder. Items opened this way appear only for the current session of Google Earth unless you save them.

6.3 Uses of a Network

Connecting computers in a local area network lets people increase their efficiency by sharing files, resources, and more. Local area networking has attained much popularity in recent years—so much that it seems networking was just invented. In reality, local area networks (LANs) appeared more than ten years ago, when the arrival of the microcomputer gave multiple users access to the same computer.LAN networks have increased the efficiency of communication.

6.4 Types of Networks

Different types of computer network are classified based on their geographical scope or scale (Figure 1). The different area network types are:

  • PAN – Personal Area Network

  • LAN - Local Area Network

  • MAN - Metropolitan Area Network

  • WLAN - Wireless Local Area Network

  • WAN - Wide Area Network

Distance	Area covered
1 m	Working table
10 m	Room
100 m	Building
1 km	Campus
10 km	City
100 km	Country
1000 km	Continent
10,000 km	Planet

PAN –Personal Area Network

LAN –Local Area Network

MAN –Metropolitan Area Network

WAN –Wide Area Network

Internet

Figure 1: Types of Networks & their Range

Personal Area Network (PAN)

A network concerned with the exchange of information in the vicinity of a person. In a PAN network, the systems are wireless and involve the transmission of data between devices such as smart phones, personal computers, tablet computers, etc (Figure 2). It allows either transmission of data or information between such devices or to server as the network that allows further up link to the Internet.
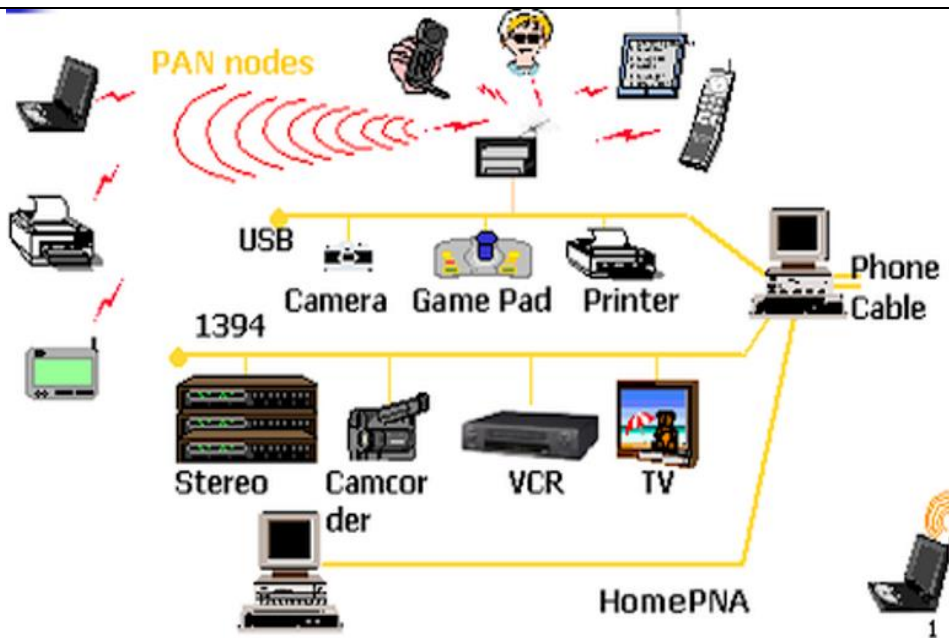
Figure 2: Personal Area Network

Local Area Network (LAN)

A LAN connects network devices over a relatively short distance. It can be a privately owned network that operates in very small geographical area (10 m to a few km). It is widely used to connect personal computers and workstations in offices and factories; to share hardware (like printers, scanners) and software (application software) and to exchange information.
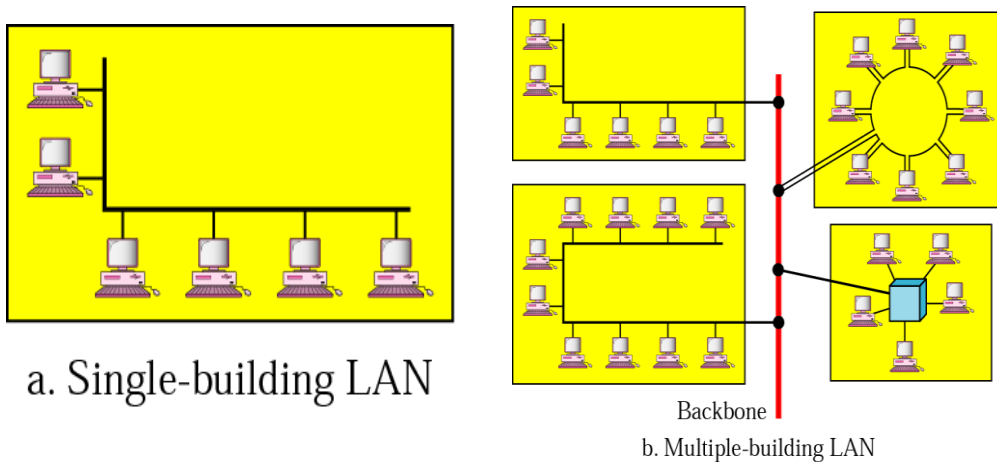
The example of a LAN can be a networked office building, school, or home usually containing a single LAN, though sometimes one building will contain a few small LANs (perhaps one per room), and occasionally a LAN will span a group of nearby buildings .LANs are also owned, controlled, and managed by a single person or organization using certain connectivity technologies, primarily Ethernet and Token Ring. LANs are distinguished from one other by three characteristics:

- *Size of LAN:* It is restricted by number of users licensed to access the operating system or application software

- *Transmission Technology:* LAN consists of single type of cable and all the computers/ communicating devices connected to it.Mostly LANs use a 48-bit physical address

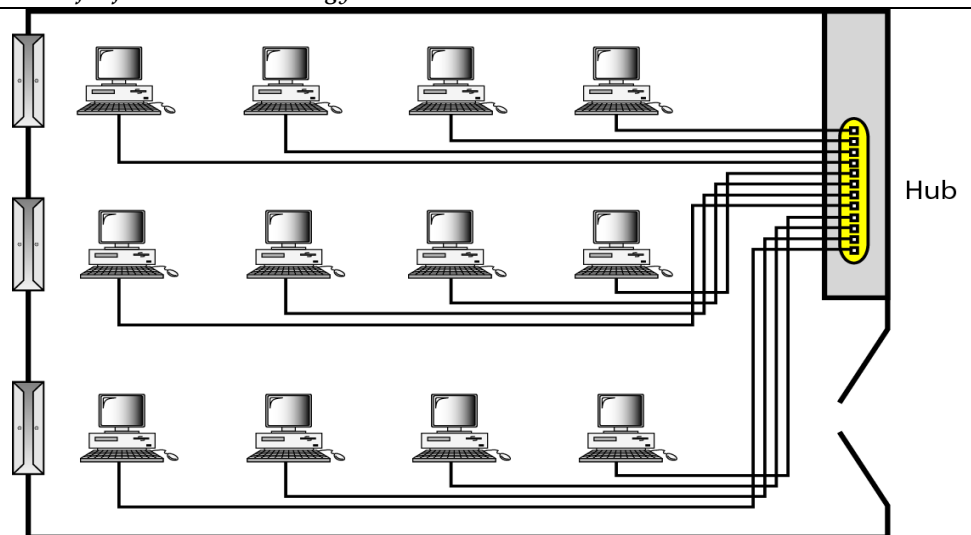- *Topology used:* LANs vary in the type of topology used in arranging the network devices.

Figure 3: An Isolated LAN Connecting 12 Computers to a Hub in a Closet

Wireless Local Area Network (WLAN)

A network that allows devices to connect and communicate wirelessly.Unlike a traditional wired LAN, in which devices communicate over Ethernet cables, devices on a WLAN communicate via Wi-Fi (Figure 4). In a WAN, new devices are typically added and configured using DHCP. WLAN can communicate with other devices on the network the same way they would on a wired network. The primary difference lies in how the data is transmitted.

In a LAN, data is transmitted over physical cables in a series of ethernet packets containing. Ina WLAN, data is transmitted over the air using one of the IEEE 802.11 protocols.Many wireless routers also include Ethernet ports, providing connections for a limited number of wireless devices.
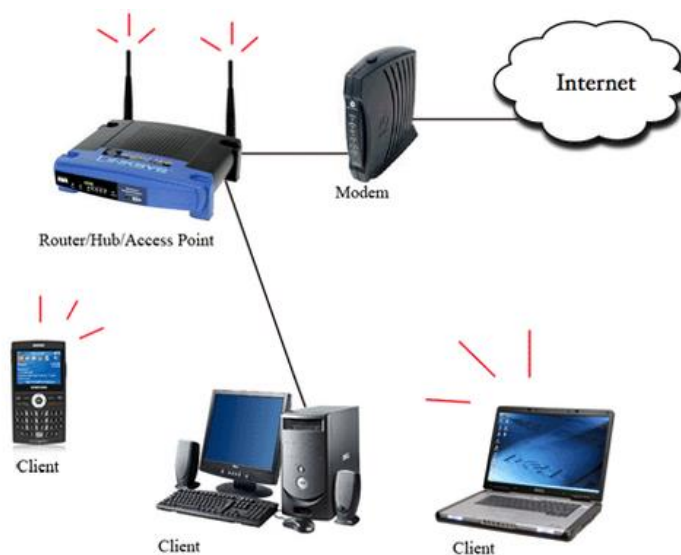

Figure 4: Wireless Local Area Network (WLAN)

Metropolitan Area Network (MAN)

A metropolitan-area network spanning a physical area larger than a LAN but smaller than a WAN, such as a city. It is owned and operated by a single entity such as a government body or large corporation (as illustrated in Figure 5).
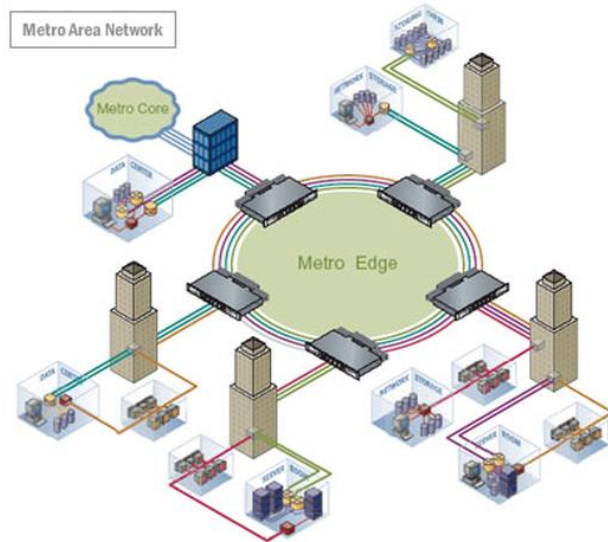
Figure 5: Metropolitan Area Network

Wide Area Network (WAN)

WAN spans more than one geographical location often connecting separated LANs (depicted in Figure 6).It is geographically-dispersed collection of LANs. The WAN spans a large physical distance. Example: The Internet. Basically, a network device called a router connects LANs to a WAN. In IP networking, the router maintains both a LAN address and a WAN address.
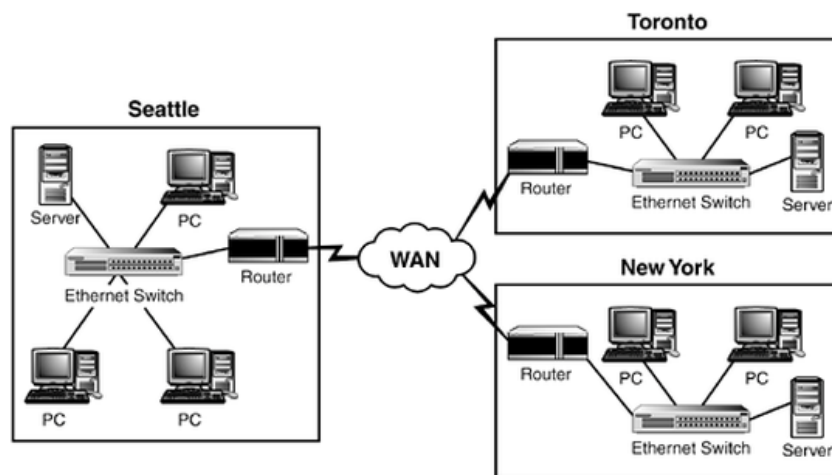

Figure 6: Wide Area Networks

WANs vs LANs

• WANs are slower than LANs and often require additional and costly hardware such as routers, dedicated leased lines, and complicated implementation procedures.

• Most WANs (like the Internet) are not owned by any one organization but rather exist under collective or distributed ownership and management.

• WANs tend to use technology like ATM, Frame Relay and X.25 for connectivity over the longer distances.

Internetworks

An internetwork is the connection of two or more private computer networks via a common routing technology (OSI Layer 3) using routers (depicted in Figure 7). The Internet is an aggregation of many internetworks, hence its name was shortened to Internet. The practice of connecting a computer network with other networks through the use of gateways.The resulting system of interconnected networks is called an internetwork, or simply an internet.

It involves a common method of routing information packets between the networks. Example: Internet, a network of networks based on many underlying hardware technologies, but unified by an internetworking protocol standard, the Internet Protocol Suite, often also referred to as TCP/IP.
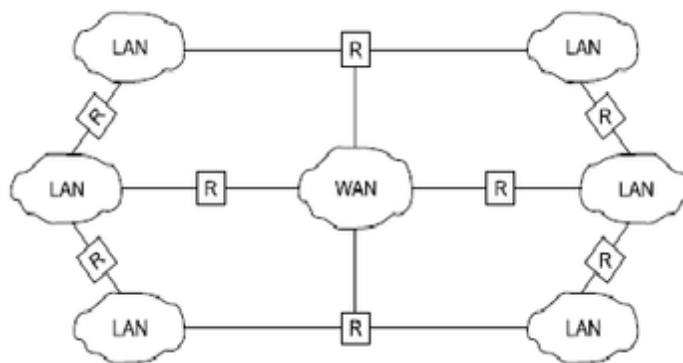

Figure 7: Internetwork

Example of Internetwork: A heterogeneous network made of four WANs and two LANs (Figure 8).
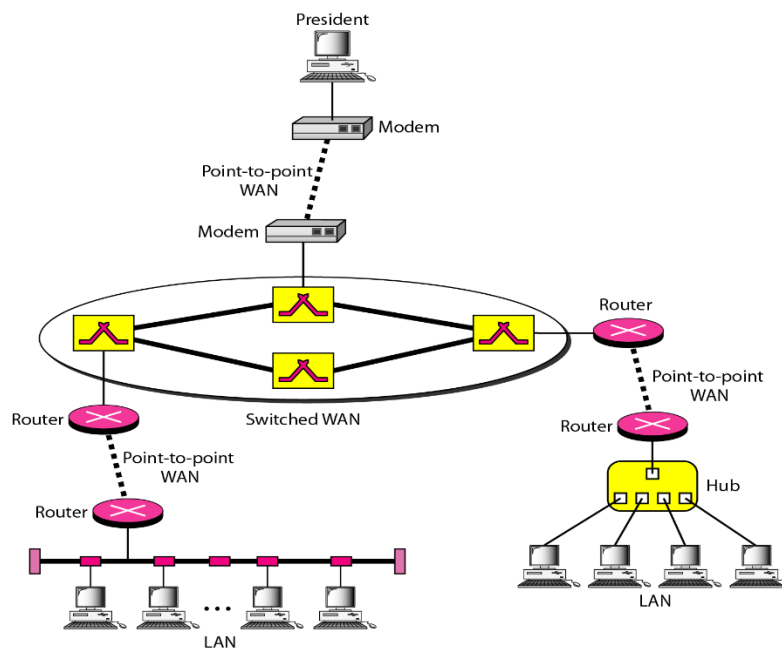

Figure 8: Heterogeneous network consisting of 4 WANs and 2 LANs

6.5 How Networks are Structured

Networks are usually classified using three properties: Topology, Protocol, and Architecture. The network topology specifies the geometric arrangement of the network. Common topologies are a bus, ring, and star. The protocol specifies a common set of rules and signals the computers on the network use to communicate. There are many protocols, each having advantages over others. The network architecture refers to one of the two major types of network architecture. Peer-to-peer or client/server. In a Peer-to-Peer networking configuration, there is no server, and computers simply connect with each other in a workgroup to share files, printers, and Internet Access. This is most commonly found in home configurations, and is only practical for workgroups of a dozen or less computers. In a client/server network, there is usually an NT Domain Controller, which all of the computers log on to. This server can provide various services, including centrally routed Internet Access, mail (including e-mail), file sharing, and printer access, as well as ensuring security across the network. This is most commonly found in corporate configurations, where network security is essential. The subsequent sections discuss each element of the network structure in detail.

6.6 Network Topologies

Network topology is the layout pattern of interconnections of the various elements (links, nodes, etc.) of a computer network. Network topologies may be physical or logical. Physical topology means the physical design of a network including the devices, location and cable installation. Logical topology refers to how data is actually transferred in a network as opposed to its physical design. In general, physical topology relates to a core network whereas logical topology relates to basic network.

Topology can be considered as a virtual shape or structure of a network. This shape does not correspond to the actual physical design of the devices on the computer network. The computers on a home network can be arranged in a circle but it does not necessarily mean that it represents a ring topology.

Any particular network topology is determined only by the graphical mapping of the configuration of physical and/or logical connections between nodes. The study of network topology uses graph theory. Distances between nodes, physical interconnections, transmission rates, and/or signal types may differ in two networks and yet their topologies may be identical.

A local area network (LAN) is one example of a network that exhibits both a physical topology and a logical topology. Any given node in the LAN has one or more links to one or more nodes in the network and the mapping of these links and nodes in a graph results in a geometric shape that may be used to describe the physical topology of the network. Likewise, the mapping of the data flow between the nodes in the network determines the logical topology of the network. The physical and logical topologies may or may not be identical in any particular network.

Network topology refers to the way in which the end points or stations/computer systems, attached to the networks, are interconnected. A topology is essentially a stable geometric arrangement of computers in a network. The topology selection demands consideration of following points:

Application S/W and protocols

Types of data communicating devices

Geographic scope of the network

Cost

Reliability

Types of Topologies

The network topology classification is based on the interconnection between computers—be it physical or logical. The physical topology of a network is determined by the capabilities of the network access devices and media, the level of control or fault tolerance desired, and the cost associated with cabling or telecommunications circuits. Networks can be classified according to their physical span as follows:

- LANs (Local Area Networks)
- Building or campus internetworks
- Wide area internetworks

• **Point-to-Point Topology:** Point-to-point networks contains exactly two hosts such as computer, switches or routers, servers connected back to back using a single piece of cable (Figure 9). In point-to-point topology, the receiving end of one host is connected to sending end of the other and vice-versa. If the hosts are connected point-to-point logically, then may have multiple intermediate devices. The end hosts are unaware of underlying network and see each other as if they are connected directly.
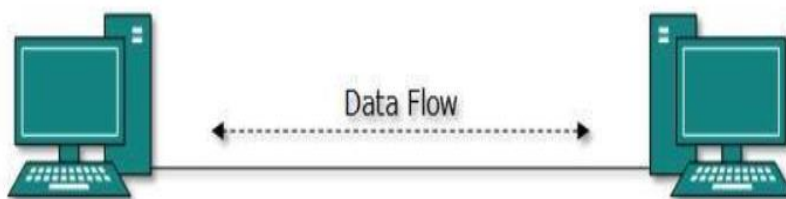
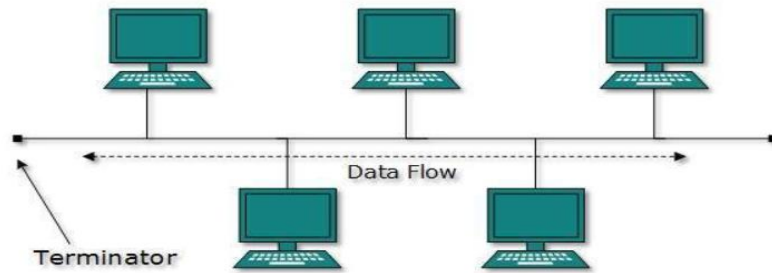

Figure 9: Point-to-Point Topology

Figure 10: Bus Topology

• **Bus Topology**: In LANs, mostly bus topology is used where each machine is connected to a single cable (Figure 10). Each computer or server is connected to the single bus cable through some kind of connector. A terminator is required at each end of the bus cable to prevent the signal from bouncing back and forth on the bus cable. A signal from the source travels in both directions to all machines connected on the bus cable until it finds the MAC address or IP address on the network that is the intended recipient. If the machine address does not match the intended address for the data, the machine ignores the data.

Alternatively, if the data does match the machine address, the data is accepted. Since the bus topology consists of only one wire, it is rather inexpensive to implement when compared to other topologies. However, the low cost of implementing the technology is offset by the high cost of managing the network. Additionally, since only one cable is utilized, it can be the single point of failure. If the network cable breaks, the entire network will be down.

• **Star Topology:** All hosts in star topology are connected to a central device (**Error! Reference source not found.** and **Error! Reference source not found.**). There exists a point-to- point connection between the hosts and the central device. As in the bus topology, hub acts as single point of failure. If hub fails, connectivity of all hosts to all other hosts fails. Every communication between hosts, takes place through only the hub. Star topology is economical as to connect one
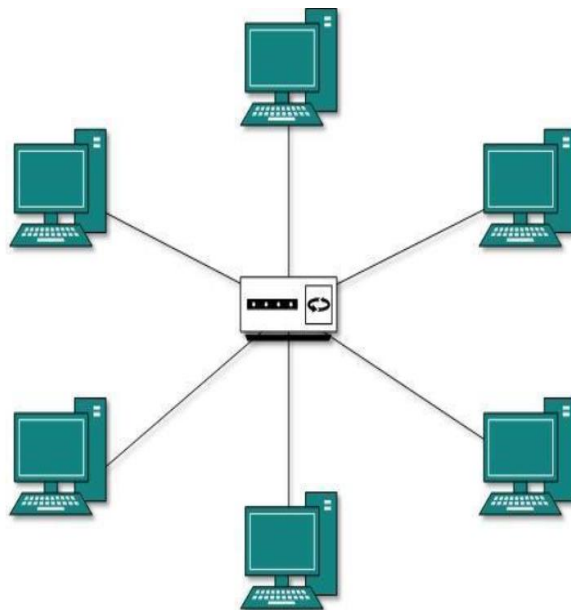
more host, only one cable is required and configuration is simple.
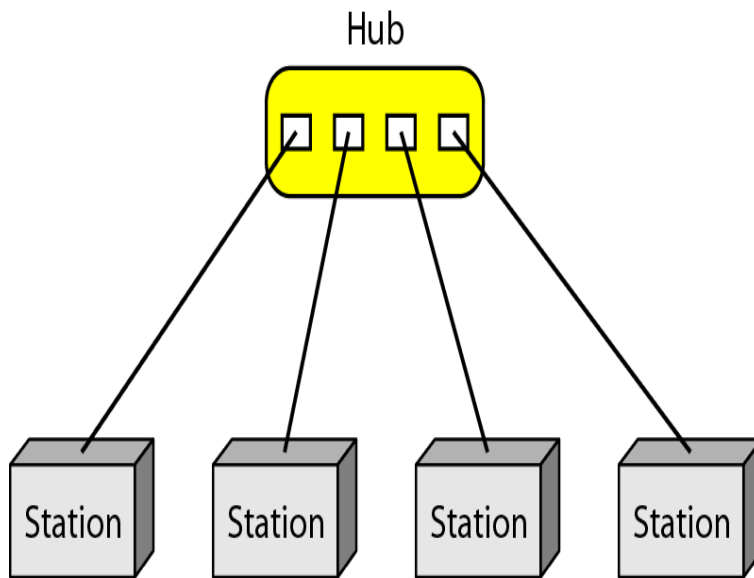
Figure 11: Star Topology

Figure 12: Star Topology Connecting 4 Stations

• **Ring Topology:** In ring topology, each host machine connects to exactly two other machines, creating a circular network structure (Figure 11 and Figure 12).   When one host tries to communicate or send message to a host which is not adjacent to it, the data travels through all intermediate hosts. In order to connect one more host in the existing structure, the administrator may need only one more extra cable. The failure of any host results in failure of the whole ring. Thus, every connection in the ring is a point of failure.
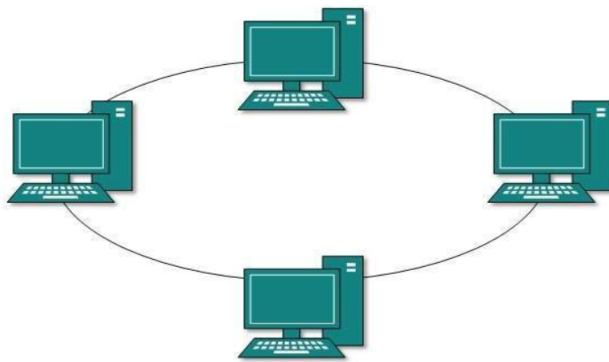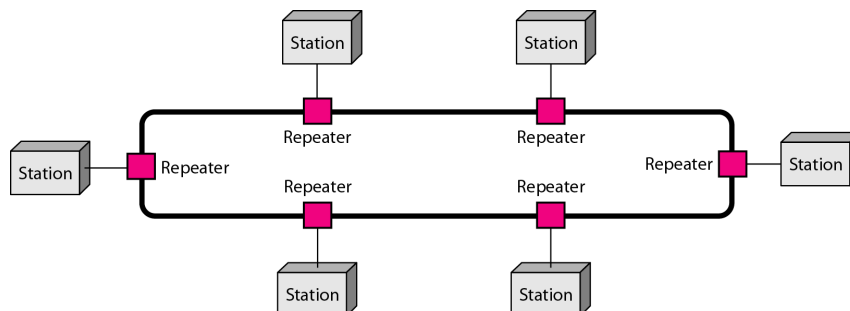

Figure 11: Ring Topology Scenario

Figure 12: Ring Topology Connecting Six Stations

• **Mesh Topology:** In a mesh topology, a host is connected to one or multiple hosts (Figure 13). It has hosts in a point-to-point connection with every other host or may also have hosts which are in point-to-point connection to few hosts only. The hosts work as relay for other hosts which do not have direct point-to-point links. There are two types of mesh topology, namely, full mesh and partial mesh. In a full mesh, all hosts have a point-to-point connection to every other host in the network while in a partial mesh, not all hosts have point-to-point connection to every other host.
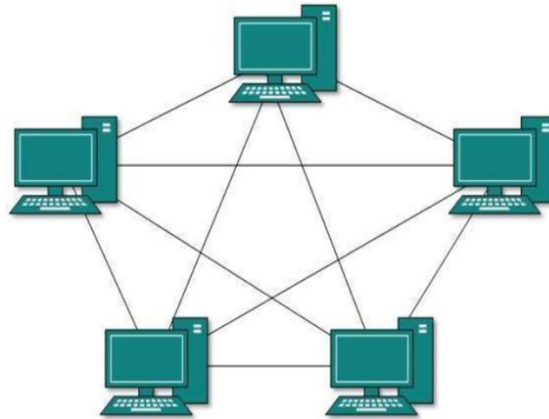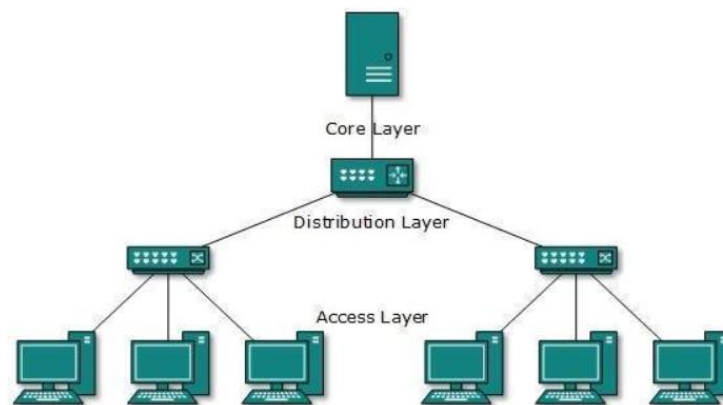

Figure 13: Mesh Topology

Fig 16: Hierarchical (Tree) Topology

• **Tree (Hierarchical) Topology:** The tree topology also known as hierarchical topology and is the most common form of network topology in use presently (**Error! Reference source not found.**). It imitates extended star topology and inherits properties of bus topology. It divides the network in to multiple levels/layers of the network. The lowermost is access-layer where computers are attached. The middle layer is known as distribution layer, which works as mediator between upper layer and lower layer. The highest layer is known as core layer, and is central point of the network, i.e. root of the tree from which all nodes fork. All the neighbouring hosts have point-to-point connection between them.

• **Daisy Chain Topology:** It connects all the hosts in a linear fashion. It is similar to ring topology, all hosts are connected to two hosts only, except the end hosts. This means, if the end hosts in daisy chain are connected then it represents ring topology (Figure 14). Each link in daisy chain topology represents single point of failure. Every link failure splits the network into two segments. Every intermediate host works as relay for its immediate hosts.
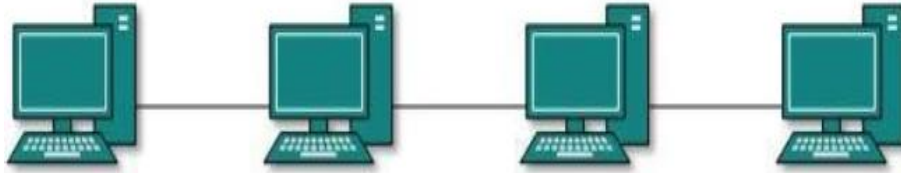
Figure 14: Daisywheel Topology

6.7 Hybrid Topology/ Network

Hybrid networks use a combination of any two or more topologies in such a way that the resulting network does not exhibit one of the standard topologies (e.g., bus, star, ring, etc.). For example, a tree network connected to a tree network is still a tree network, but two-star networks connected together exhibit a hybrid network topology. A hybrid topology is always produced when two different basic network topologies are connected (Figure 15 and Figure 16). Two common examples for hybrid network are: starring network and star bus network.

- A *Star ring network* consists of two or more-star topologies connected using a multi-station access unit (MAU) as a centralized hub.

- A *Star bus network* consists of two or more-star topologies connected using a bus trunk (the bus trunk serves as the network's backbone).

While grid networks have found popularity in high-performance computing applications, certain systems have used genetic algorithms to design custom networks that have the fewest possible hops in between different nodes. Some of the resulting layouts are nearly incomprehensible, although they function quite well. A Snowflake topology is really a "Star of Stars" network, so it exhibits characteristics of a hybrid network topology but is not composed of two different basic network topologies being connected together.
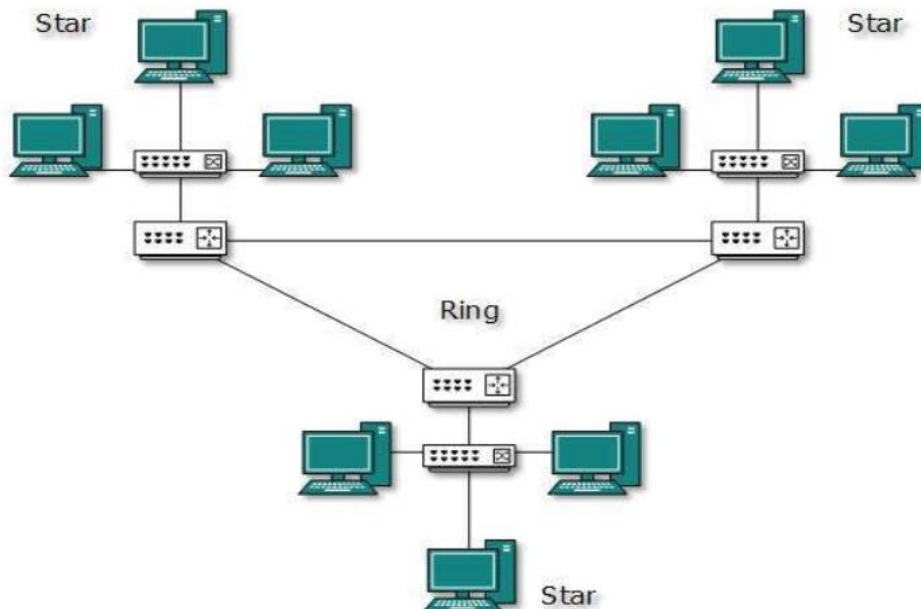

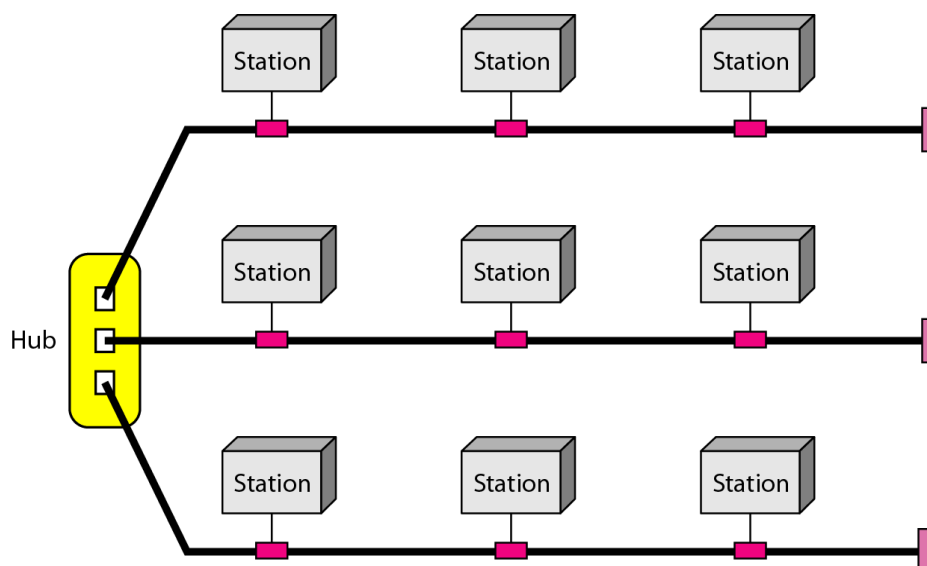*Figure 15: Hybrid Network Consisting of Various Topologies*

Figure 16: Hybrid Topology with a Star Backbone with 3 Bus Networks

6.8 Network Protocols

Network Protocols are a set of rules governing exchange of information in an easy, reliable and secure way. Before we discuss the most common protocols used to transmit and receive data over a network, we need to understand how a network is logically organized or designed.

Network Models

For data communication to take place and two or more users can transmit data from one to other, a systematic approach is required. This approach enables users to communicate and transmit data through efficient and ordered path. It is implemented using models in computer networks and are known as computer network models .Computer network models are responsible for establishing a connection among the sender and receiver and transmitting the data in a smooth manner respectively. There are two computer network models on which the whole data communication process relies:

OSI Model

TCP/IP Model

Layered Architecture

The main aim of the layered architecture is to divide the design into small pieces. Each lower layer adds its services to the higher layer to provide a full set of services to manage communications and run the applications. The layered architecture provides modularity and clear interfaces, i.e., provides interaction between subsystems. It ensures the independence between layers by providing the services from lower to higher layer without defining how the services are implemented. Any modification in a layer will not affect the other layers.

The number of layers, functions, contents of each layer will vary from network to network. The purpose of each layer is to provide the service from lower to a higher layer and hiding the details from the layers of how the services are implemented.

Basic Elements of Layered Architecture

Service: Set of actions that a layer provides to the higher layer.

Protocol: Set of rules that a layer uses to exchange the information with peer entity. These rules mainly concern about both the contents and order of the messages used.

Interface: It is a way through which the message is transferred from one layer to another layer.

Open Systems Interconnection (OSI) Model

Open Systems Interconnection (OSI) model, developed by International Organization for Standardization (ISO), is an open standard for communication in the network across different equipment and applications by different vendors. Though not widely deployed, the OSI seven-layer model is considered the primary network architectural model for inter-computing and inter-networking communications (Figure 17 and Figure 18). In addition to the OSI network architecture model, there exist other network architecture models by many vendors, such as IBM SNA (Systems Network Architecture), Digital Equipment Corporation (DEC; now part of HP) DNA (Digital Network Architecture), Apple computers AppleTalk, and Novells NetWare. Network architecture provides only a conceptual framework for communications between computers. The model itself does not provide specific methods of communication.
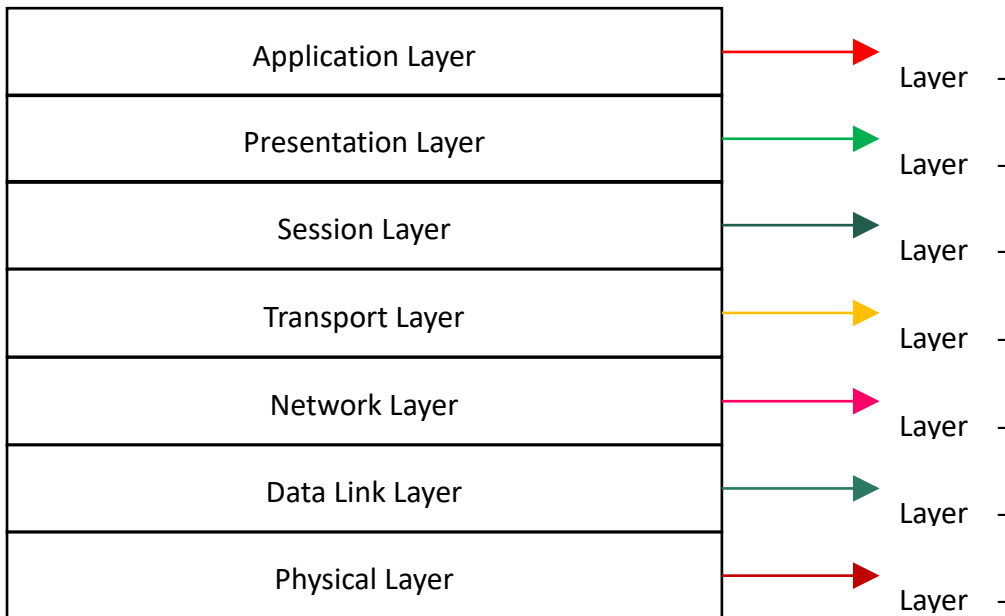
Application Layer	→ Layer -
Presentation Layer	→ Layer -
Session Layer	→ Layer -
Transport Layer	→ Layer -
Network Layer	→ Layer -
Data Link Layer	→ Layer -
Physical Layer	→ Layer -

Figure 17: The OSI Model

OSI model is not a network architecture because it does not specify the exact services and protocols for each layer. It simply tells what each layer should do by defining its input and output data. It is up to network architects to implement the layers according to their needs and resources available .The functions carried out by the seven layers of the OSI mode are:

• **Physical layer**−It is the first layer that physically connects the two systems that need to communicate. It transmits data in bits and manages simplex or duplex transmission by modem. It also manages Network Interface Card's hardware interface to the network, like cabling, cable terminators, topography, voltage levels, etc.

• **Data link layer**− Data Link layer defines the format of data on the network. A network data frame, aka packet, includes checksum, source and destination address, and data. The largest packet that can be sent through a data link layer defines the Maximum Transmission Unit (MTU). The data link layer handles the physical and logical connections to the packet's destination, using a network interface. A host connected to an Ethernet would have an Ethernet interface to handle connections to the outside world, and a loopback interface to send packets to itself.

Data link is the firmware layer of Network Interface Card (NIC). It assembles datagrams into frames and adds start and stop flags to each frame. It also resolves problems caused by damaged, lost or duplicate frames.

Ethernet addresses a host using a unique, 48-bit address called its Ethernet address or Media Access Control (MAC) address. MAC addresses are usually represented as six colon-separated pairs of hex digits, e.g., 8:0:20:11:ac:85. This number is unique and is associated with a particular Ethernet device. Hosts with multiple network interfaces should use the same MAC address on each. The data link layer's protocol-specific header specifies the MAC address of the packet's source and destination. When a packet is sent to all hosts (broadcast), a special MAC address (ff: ff:ff:ff:ff:ff) is used.

- **Network layer**− It is concerned with routing, switching and controlling flow of information between the workstations. It also breaks down transport layer data grams into smaller data grams.

- **Transport layer**− Till the session layer, file is in its own form. Transport layer breaks it down into data frames, provides error checking at network segment level and prevents a fast host from overrunning a slower one. Transport layer isolates the upper layers from network hardware.

- **Session layer**− This layer is responsible for establishing a session between two workstations that want to exchange data .It has a session protocol that defines the format of the data sent over the connections. The NFS uses the Remote Procedure Call (RPC) for its session protocol. RPC may be built on either TCP or UDP.Session layer acts as a dialog controller that creates a dialog between two processes or we can say that it allows the communication between two processes which can be either half-duplex or full-duplex.

    Session layer adds some checkpoints when transmitting the data in a sequence. If some error occurs in the middle of the transmission of data, then the transmission will take place again from the checkpoint. This process is known as Synchronization and recovery.

- **Presentation layer**− This layer is concerned with correct representation of data, i.e. syntax and semantics of information. It controls file level security and is also responsible for converting data to network standards.It converts local representation of data to its canonical form and vice versa. The canonical uses a standard byte ordering and structure packing convention, independent of the host.

    The presentation layer is concerned with the syntax and semantics of the information exchanged between the two systems. It acts as a data translator for a network. It is a part of the operating system that converts the data from one presentation format to another format and is also known as the syntax layer.

- **Application layer**− It is the topmost layer of the network that is responsible for sending application requests by the user to the lower levels. Typical applications include file transfer, E-mail, remote logon, data entry, etc. It pprovides network services to the end-users. Mail, ftp, telnet, DNS, NIS, NFS are examples of network applications. It is not necessary for every network to have all the layers. For example, network layer is not there in broadcast networks. When a system wants to share data with another workstation or send a request over the network, it is received by the application layer. Data then proceeds to lower layers after processing till it reaches the physical layer. At the physical layer, the data is actually transferred and received by the physical layer of the destination workstation. There, the data proceeds to upper layers after processing till it reaches application layer.

    At the application layer, data or request is shared with the workstation. So, each layer has opposite functions for source and destination workstations. For example, data link layer of the source workstation adds start and stop flags to the frames but the same layer of the destination workstation will remove the start and stop flags from the frames.
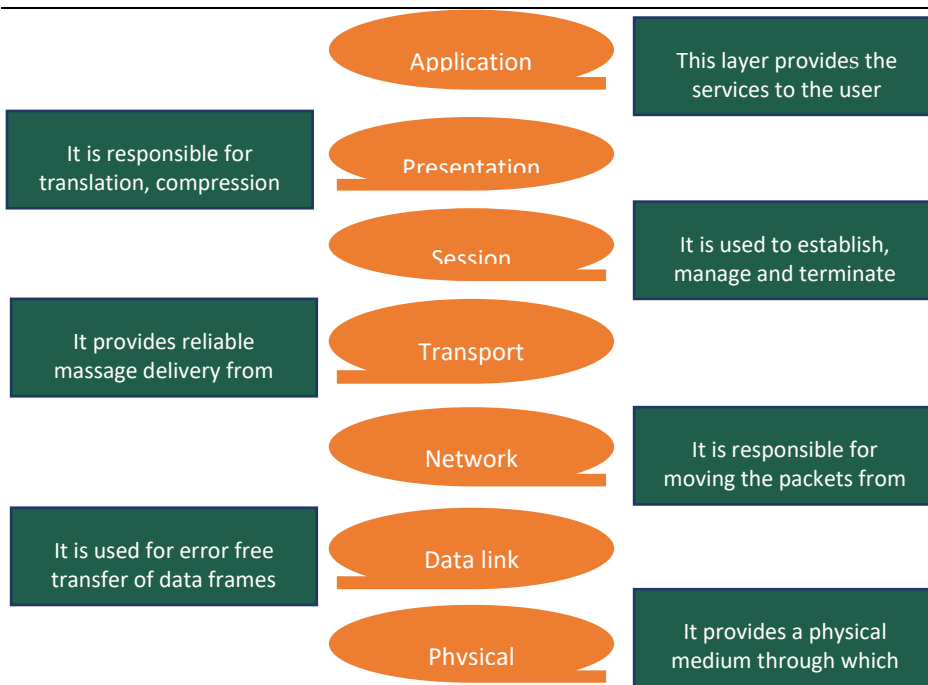
Figure 18: Overview of OSI Model Layer Functionality

TCP/IP Model

TCP/IP stands for *Transmission Control Protocol/Internet Protocol.* TCP/IP is a set of layered protocols used for communication over the Internet. The communication model of this suite is client-server model. A computer that sends a request is the client and a computer to which the request is sent is the server.

TCP/IP is the basic communication language or protocol of the Internet. It can also be used as a communications protocol in a private network (either an intranet or an extranet). When you are set up with direct access to the Internet, your computer is provided with a copy of the TCP/IP program just as every other computer that you may send messages to or get information from also has a copy of TCP/IP.

TCP/Ip is a hierarchical protocol made up of interactive modules, and each of them provides specific functionality. The first four layers provide physical standards, network interface, internetworking, and transport functions that correspond to the first four layers of the OSI model and these four layers are represented in TCP/IP model by a single layer called the application layer.
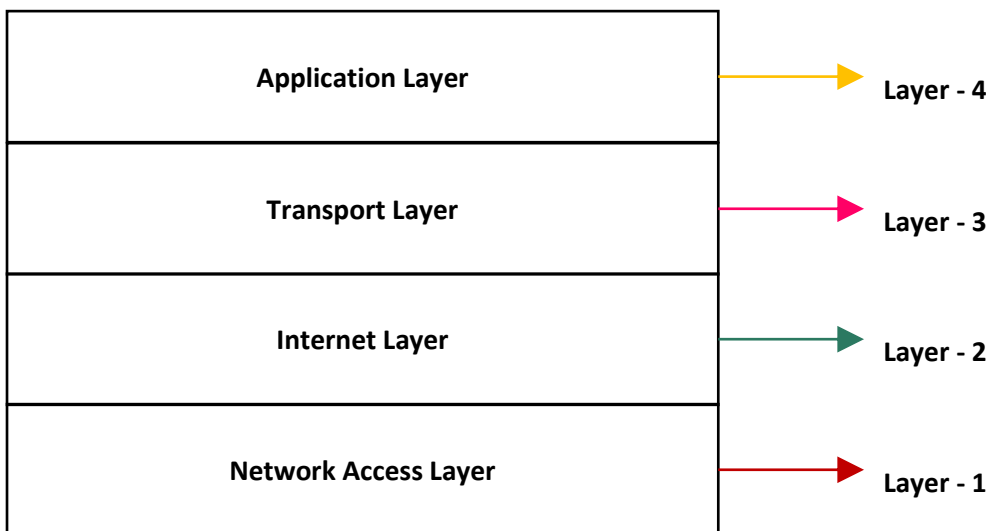
TCP/IP has four layers −

• **Application layer** − Application layer protocols like HTTP and FTP are used.It is responsible for handling high-level protocols, issues of representation and allows the user to interact with the application. When one application layer protocol wants to communicate with another application layer, it will forward the communication.

• **Transport layer** − Data is transmitted in form of data grams using the Transmission Control Protocol (TCP). TCP is responsible for breaking up data at the client side and then reassembling it on the server side.

• **Network layer/ Internet Layer** − Network layer connection is established using Internet Protocol (IP) at the network layer. Every machine connected to the Internet is assigned an address called IP address by the protocol to easily identify source and destination machines. The following protocols are used at this layer :Internet Protocol (IP) is the most significant part of the entire TCP/IP suite; and Address Resolution Protocol (ARP) is used to find the physical address from the IP address.

• **Data link layer** − Actual data transmission in bits occurs at the data link layer using the destination address provided by network layer.

6.9 Network Media

Network media is the actual path over which an electrical signal travels as it moves from one component to another. This chapter describes the common types of network media, including twisted-pair cable, coaxial cable, fibre-optic cable, and wireless.

Network transmission media is a communication channel that carries the information from the sender to the receiver. The data is transmitted through the electromagnetic signals and the main functionality of the network media IS To carry the information in the form of bits through LAN.

The network media specifies the physical path between transmitter and receiver in data communication. In a copper-based network, the bits are in the form of electrical signals while in a fibre-based network, the bits in the form of light pulses.

In the OSI reference model, the transmission media is available in the lowest layer i.e., Physical layer and thus, it is considered as a Layer 1 component. The electrical signals can be sent through the copper wire, fibre optics, atmosphere, water, and vacuum.

The characteristics and quality of data transmission are determined by the characteristics of medium and signal.

Classification of Transmission Media

The network media is of two types (Figure 19):

• **Guided (Wired) media:** Medium characteristics are more important

• **Unguided (Wireless) media:** Signal characteristics are more important.

Different transmission media have different properties such as bandwidth, delay, cost and ease of installation and maintenance. The factors affecting transmission media include:

• Bandwidth: Greater the bandwidth of a medium, the higher the data transmission rate of a signal.

• Interference: Process of disrupting a signal when it travels over a communication medium on the addition of some unwanted signal.

• Transmission impairment: Received signal is not identical to the transmitted one. The quality of the signals will get destroyed. There can be multiple causes of transmission impairment such as attenuation (signal strength decreases with increasing the distance (results in loss of energy)), distortion (change in the shape of the signal) and noise (caused by some unwanted signal added to data transmission over a medium which creates the noise).
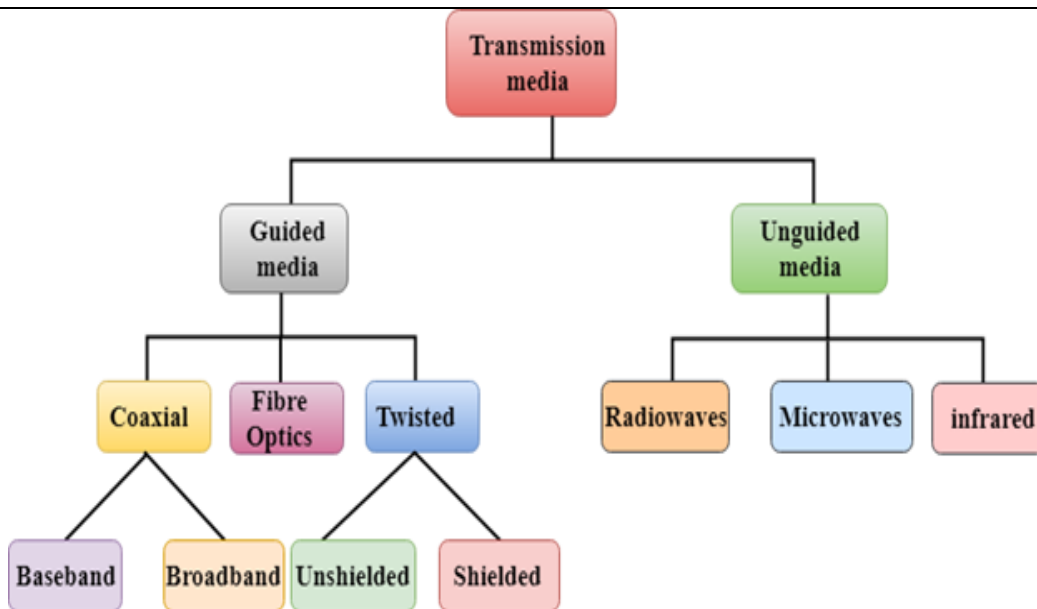
Figure 19: Classification of Network Media

Guided Transmission Media

The physical medium through which the signals are transmitted. It is also known as bounded media.They comprise of the cables or wires through which data is transmitted. They are called guided since they provide a physical conduit from the sender device to the receiver device.The most popular guided media are −

Twisted Pair Cable

Twisted pair is a physical media made up of a pair of cables twisted with each other. The twisted-pair cable is a type of cabling that is used for telephone communications and most modern Ethernet networks. A pair of wires forms a circuit that can transmit data. The pairs are twisted to provide protection against crosstalk, the noise generated by adjacent pairs. When electrical current flows through a wire, it creates a small, circular magnetic field around the wire. When two wires in an electrical circuit are placed close together, their magnetic fields are the exact opposite of each other. Thus, the two magnetic fields cancel each other out. They also cancel out any outside magnetic fields. Twisting the wires can enhance this cancellation effect. Using cancellation together with twisting the wires, cable designers can effectively provide self-shielding for wire pairs within the network media. There are 2 basic types of twisted-pair cable exist: unshielded twisted pair (UTP) and shielded twisted pair (STP).The following sections discuss UTP and STP cable in more detail.

• **Unshielded Twisted Pair Cable (UTP):** UTP cable is a medium that is composed of pairs of wires. UTP cable is used in a variety of networks. Each of the eight individual copper wires in UTP cable is covered by an insulating material. In addition, the wires in each pair are twisted around each other. UTP cable relies solely on the cancellation effect produced by the twisted wire pairs to limit signal degradation caused by electromagnetic interference (EMI) and radio frequency interference (RFI).

To further reduce crosstalk between the pairs in UTP cable, the number of twists in the wire pairs varies. UTP cable must follow precise specifications governing how many twists or braids are permitted per meter (3.28 feet) of cable. UTP cable often is installed using a Registered Jack 45 (RJ-45) connector. The RJ-45 is an eight wire connector used commonly to connect computers onto a local-area network (LAN), especially Ethernets. When used as a networking medium, UTP cable has four pairs of either 22- or 24-gauge copper wire. UTP used as a networking medium has an impedance of 100 ohms; this differentiates it from other types of twisted-pair wiring such as that used for telephone wiring, which has impedance of 600 ohms.

UTP cable offers many advantages: Because UTP has an external diameter of approximately0.43 cm (0.17 inches), its small size can be advantageous during installation. Because it has such a small external diameter, UTP does not fill up wiring ducts as rapidly as other types of cable. This can be an extremely important factor to consider, particularly when installing a network in an older building. UTP cable is easy to install and is less expensive than other types of networking

media. In fact, UTP costs less per meter than any other type of LAN cabling. UTP can be used with most of the major networking architectures, it continues to grow in popularity. Certain disadvantages exist for using UTP.

UTP cable is more prone to electrical noise and interference than other types of networking media, and the distance between signal boosts is shorter for UTP than it is for coaxial and fiber-optic cables.The commonly used types of UTP cabling are as follows:

Category 1: Used for telephone communications. Not suitable for transmitting data.

Category 2: Capable of transmitting data at speeds up to 4 megabits per second (Mbps).

Category 3: Used in 10BASE-T networks. Can transmit data at speeds up to 10 Mbps.

Category 4: Used in Token Ring networks. Can transmit data at speeds up to 16 Mbps.

Category 5: Can transmit data at speeds up to 100 Mbps.

Category 5e—Used in networks running at speeds up to 1000 Mbps (1 gigabit per second [Gbps]).

Category 6—consists of four pairs of 24 American Wire Gauge (AWG) copper wires. Category 6 cables is currently the fastest standard for UTP.

• **Shielded Twisted-Pair Cable:** Shielded twisted-pair (STP) cable combines the techniques of shielding, cancellation, and wire twisting. Each pair of wires is wrapped in a metallic foil. The four pairs of wires then are wrapped in an overall metallic braid or foil, usually 150-ohm cable. As specified for use in Ethernet network installations, STP reduces electrical noise both within the cable (pair-to pair coupling, or crosstalk) and from outside the cable (EMI and RFI). STP usually is installed with STP data connector, which is created especially for the STP cable. However, STP cabling also can use the same RJ connectors that UTP uses.

Although STP prevents interference better than UTP, it is more expensive and difficult to install. In addition, the metallic shielding must be grounded at both ends. If it is improperly grounded, the shield acts like an antenna and picks up unwanted signals. Because of its cost and difficulty with termination, STP is rarely used in Ethernet networks. STP is primarily used in Europe. The following summarizes the features of STP cable:

Speed and throughput-10 to 100 Mbps

Average cost per node-Moderately expensive

Media and connector size-Medium to large

Maximum cable length-100 m (short)

Shielded vs Unshielded Twisted Pair

• The speed of both types of cable is usually satisfactory for local-area distances.
• UTP is less expensive than STP.
• Because most buildings are already wired with UTP, many transmission standards are adapted to use it, to avoid costly rewiring with an alternative cable type.

Coaxial Cables

The coaxial cables are very commonly used transmission media, for example, TV wire is usually a coaxial cable. It contains two conductors parallel to each other and has a higher frequency then twisted pair cable. The inner conductor of the coaxial cable is made up of copper, and the outer conductor is made up of copper mesh. The middle core is made up of non-conductive cover that separates the inner conductor from the outer conductor. The middle core transfers data whereas the copper mesh prevents from the EMI(Electromagnetic interference).
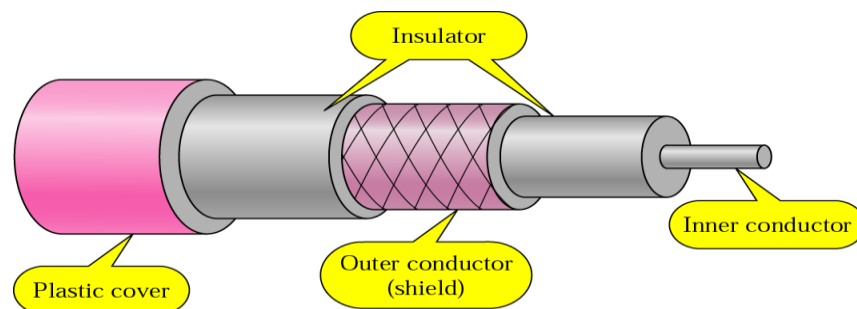

Figure 20: Coaxial Cable

There are two types of coaxial cables:

• Baseband transmission: It is defined as the process of transmitting a single signal at high speed.

• Broadband transmission: It is defined as the process of transmitting multiple signals simultaneously.

Advantages of Coaxial Cables:

  • High speed data transmission.

  • Better shielding as compared to twisted pair cable.

  • Provides higher bandwidth.

Disadvantages of Coaxial Cables:

  • More expensive as compared to twisted pair cable.

  • Any fault in cable causes failure in entire network.

Fiber-optics

Fibre-optic cable uses light signals for communication and holds the optical fibres coated in plastic that are used to send the data by pulses of light. The plastic coating protects the optical fibres from heat, cold, electromagnetic interference from other types of wiring. It provides faster data transmission than copper wires. The basic elements of fibre-optic cable include:
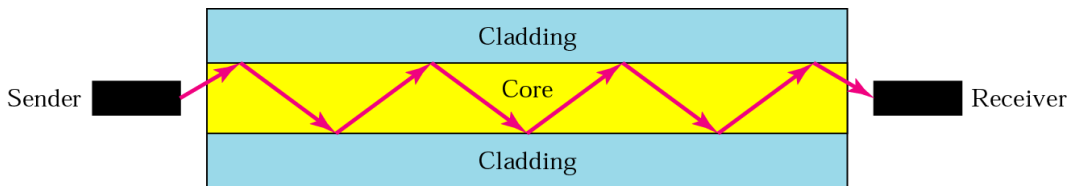

Figure 21: Fibre-optic Cable

Core: A narrow strand of glass or plastic and is a light transmission area of the fibre. The more the area of the core, the more light will be transmitted into the fibre.

Cladding: The concentric layer of glass that provides the lower refractive index at the core interface as to cause the reflection within the core so that the light waves are transmitted through the fibre.

Jacket: The protective coating consisting of plastic that preserves the fibre strength, absorb shock and extra fibre protection.

Propagation Modes in Fibre-optic Cables:

The propagation modes provide different performance with respect to both attenuation and time dispersion. There are two types of propagation mode in fiber-optic cable:

• Single-mode: In a single-mode of propagation, the diameter of the core is fairly small relative to the cladding and the cladding is ten times thicker than the core. The single-mode fiber optic cable provides the better performance at a higher cost.

• Multi-mode: The multi-mode of propagation refers to the variety of angles that will reflect. There are multiple propagation paths that exist and the signal elements spread out in time and hence the data rate. It is further classified as multi-mode steep index and multi-mode graded index. The multi-mode step index refers to the variety of angles that will reflect and the signal elements spread out in time and hence the data rate. The multi-mode graded index varies the refractive index of the core, rays may be focused more efficiently than multimode.

Unguided Transmission Medium

Unguided transmission media are also called wireless media. They transport data in the form of electromagnetic waves that do not require any cables for transmission. These media are bounded by geographical boundaries. This type of communication is commonly referred to as wireless communications. The commonly used unguided transmissions are:

• Radio transmission

• Microwave transmission

• Infrared transmission

• Light transmission

Radio Transmission: The electromagnetic waves that are transmitted in all the directions of free space indicate the radio transmission. Radio waves are omni directional, i.e., the signals are propagated in all the directions. The range in frequencies of radio waves is from 3Khz to 1 khz. The sending and receiving antenna are not aligned, i.e., the wave sent by the sending antenna can be received by any receiving antenna. An example of the radio wave is FM radio.

Applications of Radio waves

    o   Useful for multicasting when there is one sender and many receivers.

    o   An FM radio, television, cordless phones are examples of a radio wave.

Advantages of Radio transmission:

    o   Mainly used for wide area networks and mobile cellular phones.

    o   Radio waves cover a large area, and they can penetrate the walls.

    o   Provides a higher transmission rate.

Microwave Transmission: This involves transmission of information by microwave radio waves. There are 2 types of microwave transmission (Figure 22).
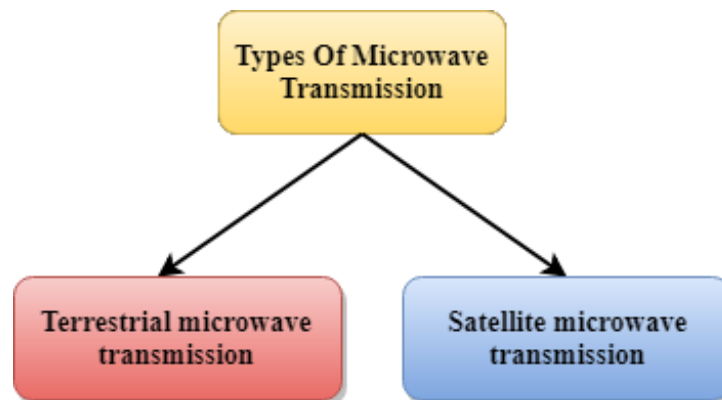
Figure 22: Types of Microwave Transmission

Terrestrial Microwave Transmission: This involves transmission of the focused beam of a radio signal from one ground-based microwave transmission antenna to another.Here the electro-magnetic waves have the frequency in the range from 1GHz to 1000 GHz. These are unidirectional as the sending and receiving antenna is to be aligned, i.e., the waves sent by the sending antenna are narrowly focussed and works on the line of sight transmission, i.e., the antennas mounted on the towers are the direct sight of each other.

Satellite Microwave Communication: A satellite is a physical object that revolves around the earth at a known height. It is more reliable nowadays as it offers more flexibility than cable and fibre optic systems. We can communicate with any point on the globe by using satellite communication.

How Does Satellite work?

The satellite accepts the signal that is transmitted from the earth station, and it amplifies the signal. The amplified signal is retransmitted to another earth station.

Infrared Communication: The infrared is a wireless technology used for communication over short ranges. The frequency of the infrared in the range from 300 GHz to 400 THz. It is used for short-range communication such as data transfer between two cell phones, TV remote operation, data transfer between a computer and cell phone resides in the same closed area.

6.10   Network Hardware

All networks are made up of basic hardware building blocks to interconnect network nodes, such as Network Interface Cards (NICs), Bridges, Hubs, Switches, and Routers. In addition ,some method of connecting these building blocks is required, usually in the form of galvanic cable (most commonly Category 5 cable). Less common are microwave links (as in IEEE 802.12)or optical cable ("optical fiber").

The networking hardware is also called as networking devices. These devices are used for organizing a network, for connecting to a network, for routing the packets, for strengthening the signals, for communicating with others, for surfing the web, and for sharing files on the network etc. There are different types of networking devices as discussed below.

Types of Network Devices

NIC (Network Interface Card):A network card, network adapter, or NIC (network interface card) is a piece of computer hardware designed to allow computers to communicate over a computer network. It provides physical access to a networking medium and often provides a low-level addressing system through the use of MAC addresses. Each network interface card has its unique id. This is written on a chip which is mounted on the card.

Modem: A modem converts the digital signal to the analog signal as a modulator and analog signal to digital signal as a demodulator. It enables the computers to communicate over telephone lines. The speed of modem is measured in bits per second and varies depending upon the type of modem. It is assumed that higher the speed, the faster you can send and receive data over the network. Modems are also used to connect computer to the internet.

Hub: Hub is the most commonly used to connect segments of a LAN and can have many ports in it (Figure 23). A computer which intends to be connected to the network is plugged in to one of these ports. When a data frame arrives at a port, it is broadcast to every other port, without considering whether it is destined for a particular destination or not.
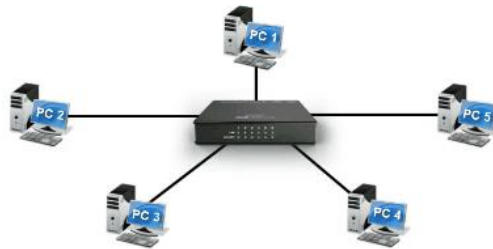
Figure 23: A Hub

The hubs are of different types:

Passive Hub

  • Does not amplify or boost the signal.

  • Does not manipulate or view the traffic that crosses it.

  • Does not require electrical power to work.

Active Hub

  • Amplifies the incoming signal before passing it to the other ports.

  • Requires AC power to do the task.

Intelligent Hub (also called as smart hubs)

  • Function as an active hub and also include diagnostic capabilities.

  • Include microprocessor chip.

  • Very useful in troubleshooting conditions of the network.

Repeater: Repeater is a device that operates at the physical layer and can be used to increase the length of the network by eliminating the effect of attenuation on the signal. It connects two

segments of the same network. It helps to overcome distance limitations of the transmission media and forwards every frame, has no filtering capability. It is actually a regenerator, not an amplifier and can connect segments that have same access methods (CSMA/CD, Token Passing, Polling etc.).

Bridge: A network bridge connects multiple network segments at the data link layer (layer 2) of the OSI model. Bridges broadcast to all ports except the port on which the broadcast was received. However, bridges do not promiscuously copy traffic to all ports, as hubs do, but learn which MAC addresses are reachable through specific ports (Figure 24). Once the bridge associates a port and an address, it will send traffic for that address to that port only.

Figure 24: Bridge and its Routing Table

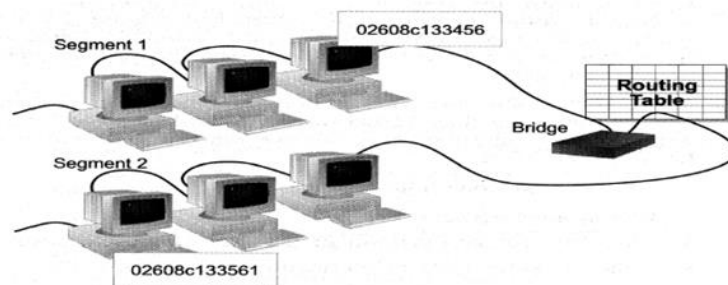Bridges learn the association of ports and addresses by examining the source address of frames that it sees on various ports. Once a frame arrives through a port, its source address is stored and the bridge assumes that MAC address is associated with that port. The first time that a previously unknown destination address is seen, the bridge will forward the frame to all ports other than the one on which the frame arrived.

Switch: A network switch is a device that forwards and filters OSI layer 2 data grams (chunks of data communication) between ports (connected cables) based on the MAC addresses in the packets. A switch is distinct from a hub in that it only forwards the frames to the ports involved in the communication rather than all ports connected. A switch breaks the collision domain but represents itself as a broadcast domain. Switches make forwarding decisions of frames on the basis of MAC addresses. A switch normally has numerous ports, facilitating a star topology for devices, and cascading additional switches. Some switches are capable of routing based on Layer 3 addressing or additional logical levels; these are called multi-layer switches. The term switch is used loosely in marketing to encompass devices including routers and bridges, as well as devices that may distribute traffic on load or by application content (e.g., a Web URL identifier).

The switches use two different methods for switching the packets: In cut-through method, switch examines the header of the packet and decides, where to pass the packet before it receives the whole packet. In store and forward method, switch reads the entire packet in its memory and checks for error before transmitting the packet. However, this method is slower and time consuming but error free.

Router: A router is an internetworking device that forwards packets between networks by processing information found in the datagram or packet (Internet protocol information from Layer 3 of the OSI Model) as illustrated in Figure 25. In many situations, this information is processed in conjunction with the routing table (also known as forwarding table). Routers use routing tables to determine what interface to forward packets (this can include the "null" also known as the "black hole" interface because data can go into it, however, no further processing is done for said data).
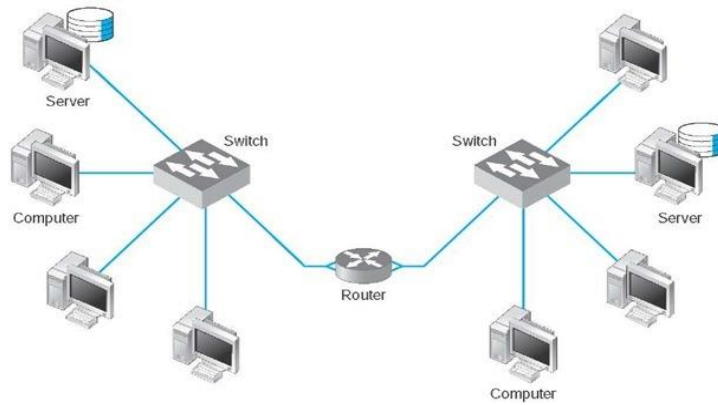
Figure 25: A Router Connecting Different LANs

Gateway: Gateways are a network point that act as entry point to other network and translates one data format to another.A gateway is a network node that forms a passage between two networks operating with different transmission protocols. The most common type of gateways, the network gateway operates at layer 3, i.e. network layer of the OSI (open systems interconnection) model. However, depending upon the functionality, a gateway can operate at any of the seven layers of OSI model. It acts as the entry – exit point for a network since all traffic that flows across the networks should pass through the gateway. Only the internal traffic between the nodes of a LAN does not pass through the gateway.

Summary

- A computer network, often simply referred to as a network, is a collection of computers and devices interconnected by communication channels that facilitate communications among users and allows users to share resources.
- A data can be saved on the network so that other users who access the network can share the data from network.
- The network link feature in Google Earth provides a way for multiple clients to view the same network based or web-based KMZ data and automatically see any changes to the content as those changes are made.
- Connecting computers in a local area network lets people increase their efficiency by sharing files, resources and more.
- Networks are often classified as local area network (LAN) wide area network (WAN),metropolitan area network (MAN), personal area network (PAN), virtual private network (VPN), campus area network (CAN) etc.
- A network architecture is a blue print of the complete computer communication network, which provides a framework and technology foundation of network.
- Network topology is the layout pattern of interconnections of the various elements (links, nodes etc.) of a computer network.
- Protocol specifies a common set of rules and signals of computers on the network use to communicate.
- Network media is the actual path over which an electrical signal travels as it moves from one component to another.
- All networks are made up of basic hardware building blocks to interconnect network nodes such as NICs, bridges, hubs, switches and routers.

Keywords

Campus network: A campus network is a computer network made up of an interconnection of local area networks (LAN's) within a limited geographical area.

Coaxial cable: Coaxial cable is widely used for cable television systems, office buildings, and other work-sites for local area networks.

Ease in Distribution: You can develop an extensive presentation folder for Google Earth software and make that presentation available to everyone who has access to your network storage location or web server. This is more convenient than sending the data via email when you want to make it persistently available to a large number of people.

Global area network (GAN): A global area network (GAN) is a network used for supporting mobile communications across an arbitrary number of wireless LANs, satellite coverage areas, etc.

Home area network (HAN): A home area network (HAN) is a residential LAN which is used for communication between digital devices typically deployed in the home, usually a small number of personal computers and accessories.

Local area network (LAN): A local area network (LAN) is a network that connects computers and devices in a limited geographical area such as home, school, computer laboratory, office building, or closely positioned group of buildings.

Metropolitan area network: A Metropolitan area network is a large computer network that usually spans a city or a large campus.

Personal area network (PAN): A personal area network (PAN) is a computer network used for communication among computer and different information technological devices close to one person.

Wide area network (WAN): A wide area network (WAN) is a computer network that covers a large geographic area such as a city, country, or spans even intercontinental distances, using a communications channel that combines many types of media.

Optical fiber cable: Optical fiber cable consists of one or more filaments of glass fiber wrapped in protective layers that carries a data by means of pulses of light.

Overlay network: An overlay network is a virtual computer network that is built on top of another network. Nodes in the overlay are connected by virtual or logical links, each of which corresponds to a path, perhaps through many physical links, in the underlying network.

Twisted pair wire: Twisted pair wire is the most widely used medium for telecommunication. Twisted-pair cabling consist of copper wires that are twisted into pairs.

Virtual private network (VPN): A virtual private network (VPN) is a computer network in which some of the links between nodes are carried by open connections or virtual circuits in some larger network (e.g., the Internet) instead of by physical wires.

Draw Network Structure.

Self-Assessment

1. Storing a place mark file on the network or on a web server offers the following advantages:
    A. Accessibility
    B. Automatic Updates/Network Link Access
    C. Backup.
    D. All of these

2. To save a place mark or folder to a web server, first save the file to your local computer as described in Saving Places Data.(True/False)

3. In a networked environment, each computer on a network may access and use hardware resources on the network, such as printing a document on a shared network printer.(True/False)

4. The physical or logical arrangement of network is called as_____.

    A. Topology

    B. Routing

    C. Networking

    D. Control

5. Data communication system within a building or campus is _____.

    A. WAN

    B. LAN

    C. MAN

    D. PAN

6. Which transmission media provides the highest transmission speed in a network?

    A. coaxial cable

    B. twisted pair cable

    C. optical fiber

    D. electrical cable

7. Wireless transmission of signals can be done via _____

    A. Radio waves

    B. Microwaves

    C. Infrared

    D. all of the mentioned

8. The functionalities of the presentation layer include _____

    A. Data compression

    B. Data encryption

    C. Data description

    D. All of the mentioned

9. Which network topology requires a central controller or hub?

    A. Ring

    B. Mesh

    C. Star

    D. Bus

10. The combination of two or more topologies is _____

    A. Bus

    B. Hybrid

    C. Star

    D. Daisy Wheel

11. A device that connects networks with different protocols–

    A. Switch

    B. Hub

    C. Gateway

    D. Proxy Server

12. A device that helps prevent congestion and data collisions–

    A. Switch

    B. Hub

    C. Gateway

    D. Proxy Server

13. WAN stands for _____

A.   World area network

B.   Wide area network

C.   Web area network

D.   Web access network

14. Which of the following are transport layer protocols used in networking?

A. TCP and FTP

B. TCP and UDP

C. UDP and HTTP

D. HTTP and FTP

15. The topology involving tokens is _____.

A. Daisywheel

B. Star

C. Hub

D. Rin

Answers for Self Assessment

1.	D	2.	True	3.	False	4.	A	5.	B
6.	C	7.	D	8.	D	9.	C	10.	B
11.	C	12.	A	13.	C	14.	B	15.	D

Review Questions

1.   What is (Wireless/Computer) Networking?

2.   What is Twisted-pair cable? Explain with suitable examples.

3.   What is the difference between shielded and unshielded twisted pair cables?

4.   Differentiate guided and unguided transmission media?

5.   Explain the most common benefits of using a LAN.

6.   What are wireless networks. Explain different types.

7.   How data can be shared anytime and anywhere?

8.   Explain the common types of computer networks.

9.   What are hierarchy and hybrid networks?

10. Explain the transmission media and its types.

11. How will you create a network link?

12. What is the purpose of networking? What different network devices are used for communication?

13. Explain network topology and various types of topologies?

14. What is a network protocol? What are the different protocols for communication?

15. Explain Network architecture and its elements?

16. Discuss various network topologies?

17. Describe in detail the various networking devices and their key characteristics?

18. What are networks? What are the different types of network connections?

Further Reading

Introduction to Computers, by Peter Norton, Publisher: McGraw Hill, Sixth Edition.

Basic Networking Concepts-Beginners Guide (steves-internet-guide.com)

Basics of Computer Networking: What is, Advantages, Components, Uses (guru99.com)

Unit 07: Graphics and Multimedia

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Objectives

After studying this unit, you will be able to:

• Explain information graphics.

• Discuss multimedia and its applications.

• Understand graphics file format.

• Know about the multimedia basics

• learn about graphic software

Introduction

Graphics are visual presentations on some surfaces, such as a wall, canvas, computer screen, paper, or stone to brand, inform, illustrate, or entertain. Examples are photographs, drawings, Line Art, graphs, diagrams, typography, numbers, symbols, geometric designs, maps, engineering drawings, or other images. Graphics often combine text, illustration, and color. Graphic design may consist of the deliberate selection, creation, or arrangement of typography alone, as in a brochure, flyer, poster, website, or book without any other element. Clarity or effective communication may be the objective, association with other cultural elements may be sought, or merely, the creation of a distinctive style.

Graphics refers to a design or visual image displayed on a variety of surfaces, including canvas, paper, walls, signs, or a computer monitor Examples: Photographs, drawings, line art, graphs, diagrams, typography, numbers, symbols, geometric designs, maps, engineering drawings, or other images.

Graphics can be functional or artistic. The latter can be a recorded version, such as a photograph, or an interpretation by a scientist to highlight essential features, or an artist, in which case the distinction with imaginary graphics may become blurred.

7.1 <u>Information Graphics</u>

Information graphics or infographics are graphic visual representations of information, data, or knowledge. These graphics present complex information quickly and clearly, such as in signs, maps, journalism, technical writing, and education. With an information graphic, computer scientists, mathematicians, and statisticians develop and communicate concepts using a single symbol to process information.

Computer scientists, mathematicians, and statisticians develop & communicate concepts using a single symbol to process information through Infographics.A graphics or artistic visual representation of data and information using different elements such as:

- Graphs
- Pictures
- Diagrams
- Narrative
- Checklists etc.

Commonly Used Information Graphics

Visual Devices: Information graphics are visual devices intended to communicate complex information quickly and clearly. The devices include, according to Doug Newsom (2004), charts, diagrams, graphs, tables, maps, and lists.

Diagrams can be used to show how a system works.

Organizational charts show lines of authority.

Systems flowchart shows sequential movement.

Snapshots features are used in mobiles.

Tables are commonly used and may contain lots of numbers.

Modern **interactive maps and bulleted numbers** are also infographic devices.

Among the most common devices are horizontal bar charts, vertical column charts, and round or oval pie charts, which can summarize a lot of statistical information.

Elements of Information Graphics

The basic material of information graphic is the data, information, or knowledge that the graphic presents. In the case of data, the creator may make use of automated tools such as graphing software to represent the data in the form of lines, boxes, arrows, and various symbols and pictograms. The information graphic might also feature a key that defines the visual elements in plain English. A scale and labels are also common. The elements of the info graphic do not have to be an exact or realistic representation of the data but can be a simplified version.

Interpreting Information Graphics

Many information graphics are specialized forms of depiction that represent their content in sophisticated and often abstract ways. To interpret the meaning of these graphics appropriately, the viewer requires a suitable level of graphic knowledge. In many cases, the required graphics knowledge involves comprehension skills that are learned rather than innate. At a fundamental level, the skills of decoding individual graphic signs and symbols must be acquired before sense can be made of information graphic as a whole. However, knowledge of the conventions for distributing and arranging these individual components is also necessary for the building of understanding.

7.2 <u>Understanding Graphics File Formats</u>

The graphic file formats are the standardized means of organizing and storing digital images. There are different types of Graphic formats such as discussed below (Figure 1):
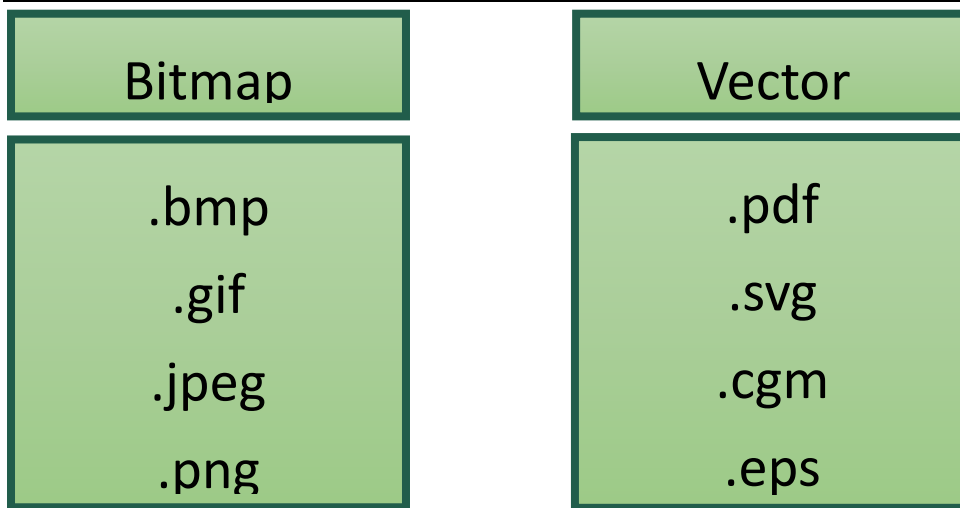
Bitmap	Vector
.bmp	.pdf
.gif	.svg
.jpeg	.cgm
.png	.eps

Figure 1: Different Graphics File Formats

Raster Formats

A raster image file is a rectangular array of regularly sampled values, known as pixels. Each pixel (picture element) has one or more numbers associated with it, specifying a color in which the pixel should be displayed in.

Joint Photographic Experts Group (JPEG/JFIF): JPEG (Joint Photographic Experts Group) is a compression method; JPEG-compressed images are usually stored in the JFIF (JPEG File Interchange Format) file format. JPEG compression is (in most cases) lossy compression. The JPEG/JFIF filename extension is JPG or JPEG. Nearly every digital camera can save images in the JPEG/JFIF format, which supports 8 bits per color (red, green, blue) for a 24-bit total, producing relatively small files. When not too great, the compression does not noticeably detract from the image's quality, but JPEG files suffer generational degradation when repeatedly edited and saved. The JPEG/JFIF format also is used as the image compression algorithm in many PDF files.

JPEG 2000: JPEG 2000 is a compression standard enabling both lossless and lossy storage. The compression methods used are different from the ones in standard JFIF/JPEG; they improve quality and compression ratios, but also require more computational power to process. JPEG 2000 also adds features that are missing in JPEG. It is not nearly as common as JPEG, but it is used currently in professional movie editing and distribution (e.g., some digital cinemas use JPEG 2000 for individual movie frames).

Exchangeable image file format (Exif): Exif format is a file standard similar to the JFIF format with TIFF extensions; it is incorporated in the JPEG-writing software used in most cameras. Its purpose is to record and standardize the exchange of images with image metadata between digital cameras and editing and viewing software. The metadata is recorded for individual images and includes such things as camera settings, time and date, shutter speed, exposure, image size, compression, name of the camera, color information, etc. When images are viewed or edited by image editing software, all of this image information can be displayed.

Tagged Image File Format (TIFF): TIFF format is a flexible format that normally saves 8 bits or 16 bits per color (red, green, blue) for 24-bit and 48-bit totals, respectively, usually using either the TIFF or TIF filename extension. TIFF's flexibility can be both an advantage and disadvantage since a reader that reads every type of TIFF file does not exist. TIFFs can be lossy and lossless; some offer relatively good lossless compression for bi-level (black and white) images. Some digital cameras can save in TIFF format, using the LZW compression algorithm for lossless storage. TIFF image format is not widely supported by web browsers. TIFF remains widely accepted as a photograph file standard in the printing business. TIFF can handle device-specific color spaces, such as the CMYK defined by a particular set of printing press inks. OCR (Optical Character Recognition) software packages commonly generate some (often monochromatic) form of TIFF image for scanned text pages.

Raw Image Formats (RAW): It refers to a family of that are options available on some digital cameras. These formats usually use a lossless or nearly-lossless compression and produce file sizes much smaller than the TIFF formats of full-size processed images from the same cameras. Although

there is a standard raw image format, (ISO 12234-2, TIFF/EP), the raw formats used by most cameras are not standardized or documented, and differ among camera manufacturers. Many graphic programs and image editors may not accept some or all of them, and some older ones have been effectively orphaned already. Adobe's Digital Negative (DNG) specification is an attempt at standardizing a raw image format to be used by cameras, or for archival storage of image data converted from undocumented raw image formats, and is used by several niches and minority camera manufacturers including Pentax, Leica, and Samsung. The raw image formats of more than 230 camera models, including those from manufacturers with the largest market shares such as Canon, Nikon, Sony, and Olympus, can be converted to DNG. DNG was based on ISO 12234-2, TIFF/EP, and ISO's revision of TIFF/EP is reported to be adding Adobe's modifications and developments made for DNG into profile 2 of the new version of the standard.

Portable Network Graphics (PNG): The PNG file format was created as the free, open-source successor to the GIF. The PNG file format supports truecolor (16 million colors) while the GIF supports only 256 colors. The PNG file excels when the image has large, uniformly colored areas. The lossless PNG format is best suited for editing pictures, and the lossy formats, like JPG, are best for the final distribution of photographic images, because in this case, JPG files are usually smaller than PNG files. The Adam7-interlacing allows an early preview, even when only a small percentage of the image data has been transmitted.

PNG provides a patent-free replacement for GIF and can also replace many common uses of TIFF. Indexed-colour, grayscale, and true color images are supported, plus an optional alpha channel. PNG is designed to work well in online viewing applications like web browsers so it is fully streamable with a progressive display option. PNG is robust, providing both full file integrity checking and simple detection of common transmission errors. Also, PNG can store gamma and chromaticity data for improved color matching on heterogeneous platforms. Some programs do not handle PNG gamma correctly, which can cause the images to be saved or displayed darker than they should be. Animated formats derived from PNG are MNG and APNG. The latter is supported by Mozilla Firefox and Opera and is backward compatible with PNG.

Graphics Interchange Format (GIF): The GIF is limited to an 8-bit palette or 256 colors. This makes the GIF format suitable for storing graphics with relatively few colors such as simple diagrams, shapes, logos, and cartoon style images. The GIF format supports animation and is still widely used to provide image animation effects. It also uses a lossless compression that is more effective when large areas have a single color, and ineffective for detailed images or dithered images.

BMP: The BMP file format (Windows bitmap) handles graphics files within the Microsoft Windows OS. Typically, BMP files are uncompressed, hence they are large; the advantage is their simplicity and wide acceptance in Windows programs.

WEBP: WebP is a new image format that uses lossy compression. It was designed by Google to reduce image file size to speed up web page loading: its principal purpose is to supersede JPEG as the primary format for photographs on the web. WebP is based on VP8's intra-frame coding and uses a container based on RIFF.

Others: Other image file formats of raster type include:
  • JPEG XR (New JPEG standard based on Microsoft HD Photo)
  • TGA (TARGA)
  • ILBM (Inter Leaved Bit Map)
  • PCX (Personal Computer eXchange)
  • ECW (Enhanced Compression Wavelet)
  • IMG (ERDAS IMAGINE Image)
  • SID (multire solution seamless image database, MrSID)
  • CD5 (Chasys Draw Image)
  • FITS (Flexible Image Transport System)
  • PGF (Progressive Graphics File)
  • XCF (eXperimental Computing Facility format, native GIMP format)
  • PSD (Adobe PhotoShop Document)
  • PSP (Corel Paint Shop Pro)

Vector Formats

The vector image formats contain a geometric description which can be rendered smoothly at any desired display size. Vector file formats can contain bitmap data as well. 3D graphic file formats are

technically vector formats with pixel data texture mapping on the surface of a vector virtual object, warped to match the angle of the viewing perspective.

At some point, all vector graphics must be rasterized in order to be displayed on digital monitors. However, vector images can be displayed with analog CRT technology such as that used in some electronic test equipment, medical monitors, radar displays, laser shows, and early video games. Plotters are printers that use vector data rather than pixel data to draw graphics.

Computer Graphics Metafile (CGM): Computer Graphics Metafile (CGM) is a file format for 2D vector graphics, raster graphics, and text, and is defined by ISO/IEC 8632. All graphical elements can be specified in a textual source file that can be compiled into a binary file or one of two text representations. CGM provides a means of graphics data interchange for computer representation of 2D graphical information independent from any particular application, system, platform, or device. It has been adopted to some extent in the areas of technical illustration and professional design but has largely been superseded by formats such as SVG and DXF.

Scalable Vector Graphics (SVG): Scalable Vector Graphics (SVG) is an open standard created and developed by the WWW Consortium to address the need (and attempts of several corporations) for a versatile, scriptable, and all-purpose vector format for the web and otherwise. The SVG format does not have a compression scheme of its own, but due to the textual nature of XML, an SVG graphic can be compressed using a program such as gzip.

Others: The other image file formats of vector type include:

- AI (Adobe Illustrator)
- CDR (CorelDRAW)
- EPS (Encapsulated PostScript)
- HVIF (Haiku Vector Icon Format)
- ODG (OpenDocument Graphics)
- PDF (Portable Document Format)
- PGML (Precision Graphics Markup Language)
- SWF (Shockwave Flash) λ VML (Vector Markup Language)
- WMF / EMF (Windows Metafile / Enhanced Metafile)
- XPS (XML Paper Specification)

Bitmap Formats

Bitmap formats are used to store bitmap data. Files of this type are particularly well-suited for the storage of real-world images such as photographs and video images. Bitmap files, sometimes called raster files, essentially contain an exact pixel-by-pixel map of an image. A rendering application can subsequently reconstruct this image on the display surface of an output device. The Microsoft BMP, PCX, TIFF, and TGA are examples of commonly used bitmap formats.

Metafile Formats

Metafiles can contain both bitmap and vector data in a single file. The simplest metafiles resemble vector format files; they provide a language or grammar that may be used to define vector data elements, but they may also store a bitmap representation of an image. Metafiles are frequently used to transport bitmap or vector data between hardware platforms or to move image data between software platforms. WPG, Macintosh PICT, and CGM are examples of commonly used metafile formats.

Scene Formats (Scene Description Files)

Scene format files are designed to store a condensed representation of an image or scene, which is used by a program to reconstruct the actual image. What's the difference between a vector format file and a scene format file? Just that vector files contain descriptions of portions of the image, and scene files contain instructions that the rendering program uses to construct the image. In practice it's sometimes hard to decide whether a particular format is a scene or vector; it's more a matter of degree than anything absolute.

Animation Formats

Animation formats have been around for some time. The basic idea is that of the flip-books you played with as a kid; with those books, you rapidly displayed one image superimposed over another to make it appear as if the objects in the image are moving. Very primitive animation formats store entire images that are displayed in sequence, usually in a loop. Slightly more advanced formats store only a single image but multiple color maps for the image. By loading in a new color map, the colors in the image change, and the objects appear to move. Advanced animation formats store only the differences between two adjacent images (called frames) and update only the pixels that have changed as each frame is displayed. A display rate of 10-15 frames per second is typical for cartoon-like animations. Video animations usually require a display rate of 20 frames per second or better to produce a smoother motion.

TDDD and TTDDD are examples of animation formats.

Multimedia Formats

Multimedia formats are relatively new but are becoming more and more important. They are designed to allow the storage of data of different types in the same file. Multimedia formats usually allow the inclusion of graphics, audio, and video information. Microsoft's RIFF, Apple's QuickTime, MPEG, and Autodesk's FLI are well-known examples, and others are likely to emerge soon.

Hybrid Formats

The hybrid formats are the integration of unstructured text and bitmap data ("hybrid text") and the integration of record-based information and bitmap data ("hybrid database"). They will be capable of efficiently storing graphics data.

Hypertext and Hypermedia Formats

Hypertext is a strategy for allowing nonlinear access to information. In contrast, most books are linear, having a beginning, an end, and a definite pattern of progression through the text. Hypertext, however, enables documents to be constructed with one or more beginnings, with one, none, or multiple ends, and with many hypertext links that allow users to jump to any available place in the document they wish to go.Hypertext languages are not graphics file formats, like the GIF or DXF formats. Instead, they are programming languages, like PostScript or C. As such, they are specifically designed for serial data stream transmission. That is, you can start decoding a stream of hypertext information as you receive the data. You need not wait for the entire hypertext document to be downloaded before viewing it.

The term hypermedia refers to the marriage of hypertext and multimedia. Modern hypertext languages and network protocols support a wide variety of media, including text and fonts, still and animated graphics, audio, video, and 3D data. Hypertext allows the creation of a structure that enables multimedia data to be organized, displayed, and interactively navigated through by a computer user.Hypertext and hypermedia systems, such as the WWW, contain millions of information resources stored in the form of GIF, JPEG, PostScript, MPEG, and AVI files. Many other formats are used as well.

3D Formats

Three-dimensional data files store descriptions of the shape and color of 3D models of imaginary and real-world objects. 3D models are typically constructed of polygons and smooth surfaces, combined with descriptions ofrelated elements, such as color, texture,reflections, and so on, that a rendering application can use to reconstruct the object. Models are placed in scenes with lights and cameras, so objects in 3D files are often called scene elements.

Virtual Reality Modeling Language (VRML) Formats

VRML (pronounced "vermel") may be thought of as a hybrid of 3D graphics and HTML. VRML v1.0 is essentially a subset of the Silicon Graphics Inventor file format and adds to its support for linking to Uniform Resource Locators URLs in the World Wide Web.

VRML encodes 3D data in a format suitable for exchange across the Internet using the Hypertext Transfer Protocol (HTTP). VRML data received from a Web server is displayed on a Web browser that supports VRML language interpretation. We expect that VRML-based 3D graphics will soon be very common on the World Wide Web.

Audio Formats

Audio is typically stored on magnetic tape as analog data. For audio data to be stored on media such as a CD-ROM or hard disk, it must first be encoded using a digital sampling process similar to that used to store digital video data. Once encoded, the audio data can then be written to disk as a raw digital audio data stream, or, more commonly, stored using an audio file format.

Audio file formats are identical in concept to graphics file formats, except that the data they store is rendered for your ears and not for your eyes. Most formats contain a simple header that describes the audio data they contain. Information commonly stored in audio file format headers includes samples per second, number of channels, and number of bits per sample. This information roughly corresponds to the number of samples per pixel, number of color planes, and number of bits per sample information commonly found in graphics file headers.

Font Formats

The font formats contain the descriptions of sets of alphanumeric characters and symbols in a compact, easy-to-access format. They are designed to facilitate random access to the data associated with individual characters. The font files contain the descriptions of sets of alphanumeric characters and symbols in a compact, easy-to-access format. They are generally designed to facilitate random access to the data associated with individual characters. In this sense, they are databases of character or symbol information, and for this reason font files are sometimes used to store graphics data that is not alphanumeric or symbolic. Font files may or may not have a global header, and some files support sub-headers for each character. In any case, it is necessary to know the start of the actual character data, the size of each character's data, and the order in which the characters are stored to retrieve individual characters without having to read and analyze the entire file. Character data in the file may be indexed alphanumerically, by ASCII code, or by some other scheme.

Some font files support arbitrary additions and editing, and thus have an index somewhere in the file to help you find the character data. Some font files support compression and many support encryptions of the character data. The creation of character sets by hand has always been a difficult and time-consuming process, and typically a font designer spent a year or more on a single character set.

Historically there have been three main types of font files: bitmap, stroke, and spline-based outlines, described in the following sections.

- **Bitmap Fonts:** Bitmap fonts consist of a series of character images rendered to small rectangular bitmaps and stored sequentially in a single file. The file may or may not have a header. Most bitmap font files are monochrome, and most store font in uniformly sized rectangles to facilitate speed of access. The characters stored in bitmap format may be quite elaborate, but the size of the file increases, and, consequently, speed and ease of use decline with increasingly complex images. The advantages of bitmap files are speed of access and ease of use--reading and displaying a character from a bitmap file usually involve little more than reading the rectangle containing the data into memory and displaying it on the display surface of the output device.

- **Stroke Fonts:** Stroke fonts are databases of characters stored in vector form. The characters can consist of single strokes or maybe hollow outlines. Stroke character data usually consists of a list of line endpoints meant to be drawn sequentially, reflecting the origin of many stroke fonts in applications supporting pen plotters. Some stroke fonts may be more elaborate, however, and may include instructions for arcs and other curves. Perhaps the best-known and most widely used stroke fonts were the Hershey character sets, which are still available online.

  The advantages of stroke fonts are that they can be scaled and rotated easily and that they are composed of primitives, such as lines and arcs, which are well-supported by most GUI operating environments and rendering applications. The main disadvantage of stroke fonts is that they generally have a mechanical look at variance with what we've come to expect from reading high-quality printed text all our lives.

  Stroke fonts are seldom used today. Most pen plotters support them, however. You also may need to know more about them if you have a specialized industrial application using a vector display or something similar.

- **Spline-based Outline Fonts:** The character descriptions in spline-based fonts are composed of control points allowing the reconstruction of geometric primitives known as splines. There are

several types of splines, but they all enable the drawing of the subtle, eye-pleasing curves we've come to associate with high-quality characters that make up the printed text. The actual outline data is usually accompanied by information used in the reconstruction of the characters.

The advantages of spline-based fonts are that they can be used to create high-quality character representations, in some cases indistinguishable from text made with metal type. Most traditional fonts have been converted to spline-based outlines. In addition, characters can be scaled, rotated, and otherwise manipulated in ways only dreamed about even a generation ago.

Page Description Language (PDL) Formats

Page description languages (PDLs) are actual computer languages used for describing the layout, font information, and graphics of printed and displayed pages. PDLs are used as the interpreted languages used to communicate information to printing devices, such as hardcopy printers, or to display devices, such as graphical user interface (GUI) displays. The greatest difference is that the PDL code is very device-dependent. A typical PostScript file contains detailed information on the output device, font metrics, color palettes, and so on. A PostScript file containing code for a 4-color, A4-sized document can only be printed or displayed on a device that can handle these metrics.

Although PDL files can contain graphical information, we do not consider PDLs to be graphics file formats anymore. PDLs are complete programming languages, requiring the use of sophisticated interpreters to read their data; they are quite different from the much simpler parsers used to read graphics file formats.

7.3 Multimedia

Multimedia is media and content that uses a combination of different content forms. The term can be used as a noun (a medium with multiple content forms) or as an adjective describing a medium as having multiple content forms. The term is used in contrast to media which only use traditional forms of printed or hand-produced material. Multimedia includes a combination of text, audio, still images, animation, video, and interactivity content forms (Figure 2).

Multimedia is usually recorded and played, displayed, or accessed by information content processing devices, such as computerized and electronic devices, but can also be part of a live performance. Multimedia (as an adjective) also describes electronic media devices used to store and experience multimedia content. Multimedia is distinguished from mixed media in fine art; by including audio, for example, it has a broader scope. The term "rich media" is synonymous with interactive multimedia. Hypermedia can be considered one particular multimedia application.
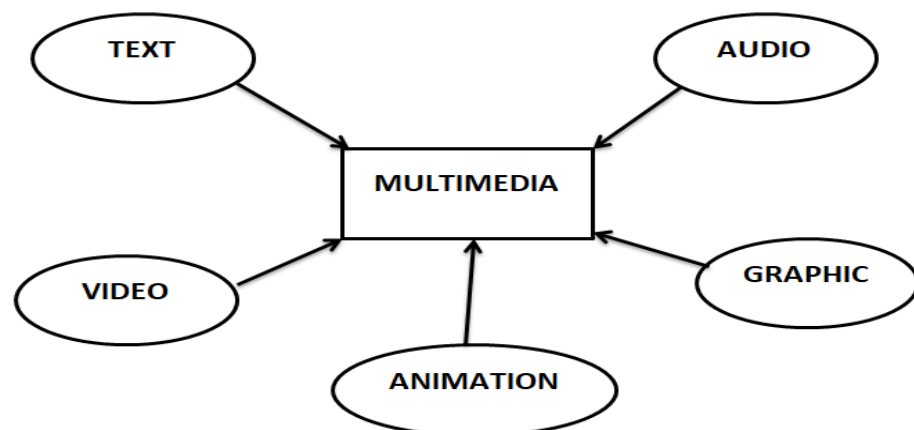
Figure 2: Components of Multimedia

Major Characteristics of Multimedia

Multimedia presentations may be viewed by a person on stage, projected, transmitted, or played locally with a media player. A broadcast may be alive or recorded multimedia presentation. Broadcasts and recordings can be either analog or digital electronic media technology. The digital online multimedia may be downloaded or streamed. Streaming multimedia may be live or on-demand.

Multimedia games and simulations may be used in a physical environment with special effects, with multiple users in an online network, or locally with an offline computer, game system, or simulator. The various formats of technological or digital multimedia may be intended to enhance the users' experience, for example, to make it easier and faster to convey information or in entertainment or art, to transcend everyday experience.

Enhanced levels of interactivity are made possible by combining multiple forms of media content. Online multimedia is increasingly becoming object-oriented and data-driven, enabling applications with collaborative end-user innovation and personalization on multiple forms of content over time. Examples of these range from multiple forms of content on Web sites like photo galleries with both images (pictures) and title (text) user-updated, to simulations whose coefficients, events, illustrations, animations, or videos are modifiable, allowing the multimedia "experience" to be altered without reprogramming. In addition to seeing and hearing, haptic technology enables virtual objects to be felt. The emerging technology involving the illusions of taste and smell may also enhance the multimedia experience.

Types of Multimedia

The term "multimedia" is ambiguous. The static content (such as a paper book) may be considered multimedia if it contains both pictures and text or maybe considered interactive if the user interacts by turning pages at will. The books may also be considered non-linear if the pages are accessed non-sequentially.The term "video", if not used exclusively to describe motion photography, is ambiguous in multimedia terminology. Video is often used to describe the file format, delivery format, or presentation format instead of "footage" which is used to distinguish motion photography from "animation" of rendered motion imagery.

The multiple forms of information content are often not considered modern forms of presentation such as audio or video. Likewise, single forms of information content with single methods of information processing (e.g. non-interactive audio) are often called multimedia, perhaps to distinguish static media from active media. In the Fine arts, for example, ModulArt brings two key elements of musical composition and film into the world of painting: variation of a theme and movement of and within a picture, making ModulArt an interactive multimedia form of art. The performing arts may also be considered multimedia considering that performers and props are multiple forms of both content and media.

Applications of Multimedia

Multimedia finds its application in various areas including, but not limited to, advertisements, art, education, entertainment, engineering, medicine, mathematics, business, scientific research, and spatial-temporal applications. Several examples are as follows:

Multimedia in Business

The multimedia technology along with communication technology has opened the door for information of global wok groups. Today, the team members may be working anywhere and can work for various companies (Figure 3). Consequently, the workplaces have become global.

Figure 3: A Presentation Using PowerPoint. Corporate Presentations May Combine all Forms of Media Content

Multimedia in Creative Industries

Creative industries use multimedia for a variety of purposes ranging from fine arts to entertainment, to commercial art, to journalism, to media and software services provided for any of the industries listed below. An individual multimedia designer may cover the spectrum throughout their career. Request for their skills ranges from technical, to analytical, to creative.

Multimedia in Commercial Sector

Much of the electronic old and new media used by commercial artists is multimedia. Exciting presentations are used to grab and keep attention in advertising. Business business and interoffice communications are often developed by creative services firms for advanced multimedia presentations beyond simple slide shows to sell ideas or liven-up training. Commercial multimedia developers may be hired to design for governmental services and non-profit services applications as well.

Multimedia in Entertainment and Fine Arts

In addition, multimedia is heavily used in the entertainment industry, especially to develop special effects in movies and animations (Figure 4). Multimedia games are a popular pastime and are software programs available either as CD-ROMs or online. Some video games also use multimedia features. Multimedia applications that allow users to actively participate instead of just sitting by as passive recipients of the information are called Interactive Multimedia. In the Arts, there are multimedia artists, whose minds can blend techniques using different media that in some way incorporates interaction with the viewer. Although multimedia display material may be volatile, the survivability of the content is as strong as any traditional media. Digital recording material may be just as durable and infinitely reproducible with perfect copies every time.

Figure 4: A Laser show in a Live Multimedia Performance

Multimedia in Education

In Education, multimedia is used to produce computer-based training courses (popularly called CBTs) and reference books like encyclopedias and almanacs. A CBT lets the user go through a series of presentations, text about a particular topic, and associated illustrations in various information formats. Edutainment is an informal term used to describe combining education with entertainment, especially multimedia entertainment. The learning theory in the past decade has expanded dramatically because of the introduction of multimedia. Several lines of research have evolved (e.g. Cognitive load, Multimedia learning, and the list go on). The possibilities for learning and instruction are nearly endless.

The idea of media convergence is also becoming a major factor in education, particularly higher education. It is defined as separate technologies such as voice (and telephony features), data (and productivity applications), and video that now share resources and interact with each other, synergistically creating new efficiencies, media convergence is rapidly changing the curriculum in universities all over the world. Likewise, it is changing the availability, or lack thereof, of jobs requiring this savvy technological skill.

Multimedia in Banking

Banks can use multimedia in many ways extensively. People go to the bank to open saving/current accounts, deposit funds, withdraw money, know various financial schemes of the bank, obtain loans, etc. Every bank has a lot of information that it wants to impart to in customers. Banks can display information about various schemes on a PC monitor placed in the rest area for customers. Today, online and internet banking have become very popular.

Multimedia in Hospitals

Multimedia systems are used in hospitals for real-time monitoring of conditions of patients in critical illness or accident. The conditions are displayed continuously on a computer screen and can alert the doctor/nurse on duty if any changes are observed on the screen. Multimedia makes it possible to consult a surgeon or an expert who can watch an ongoing surgery line on his PC monitor and give online advice at any crucial juncture. Telehealth and Tele-monitoring are examples of multimedia in hospitals.

Multimedia in Journalism

Newspaper companies all over are also trying to embrace the new phenomenon by implementing its practices in their work. While some have been slow to come around, other major newspapers like The New York Times, USA Today, and The Washington Post are setting the precedent for the positioning of the newspaper industry in a globalized world. The news reporting is not limited to traditional media outlets now. Some freelance journalists can make use of different new media to produce multimedia pieces for their news stories. It engages global audiences and tells stories with technology, which develops new communication techniques for both media producers and consumers. Common Language Project is an example of this type of multimedia journalism production.

Multimedia in Engineering

Software engineers may use multimedia in Computer Simulations for anything from entertainment to training such as military or industrial training. Multimedia for software interfaces is often done as a collaboration between creative professionals and software engineers.

Multimedia in Industry

In the industrial sector, multimedia is used as a way to help present information to shareholders, superiors, and co-workers. Multimedia is also helpful for providing employee training, advertising, and selling products all over the world via virtually unlimited web-based technology.

Multimedia in Mathematical and Scientific Research

In mathematical and scientific research, multimedia is mainly used for modeling and simulation. For example, a scientist can look at a molecular model of a particular substance and manipulate it to arrive at a new substance. Representative research can be found in journals such as the Journal of Multimedia.

Multimedia in Medicine

In Medicine, doctors can get trained by looking at a virtual surgery or they can simulate how the human body is affected by diseases spread by viruses and bacteria and then develop techniques to prevent it.

Advantages of Multimedia

- User friendly interface
- Easy and quick to operate
- Meaningful and easy to use
- Interactivity
- Provides high-quality video,image, audio

Disadvantages of Multimedia

- Time-consuming
- Very expensive
- Complex to create
- Memory storage requirement is very high
- Not always easy to configure

7.4 Multimedia Basics

A combination of text, graphics, sound, animation, and video that is delivered interactively to the user by electronic or digitally manipulated means. This term is often used in reference to creativity using the PC. In simple words, Multimedia means multi (many) and media (communication/transfer medium). Hence it means many mediums working together or independently. It can be considered to be a combination of several mediums (Figure 5):

- Text
- Graphics
- Animation
- Video and Sound

They all are used to present information to the user via the computer. The main feature of any multimedia application is its human interactivity. This means that it is user-friendly and caters to the commands the user dictates. For instance, users can be interactive with a particular program by clicking on various icons and links, the program subsequently reveals detailed information on that particular subject.

Static content (such as a paper book) may be considered multimedia if it contains both pictures and text or maybe considered interactive if the user interacts by turning pages at will. Books may also be considered non-linear if the pages are accessed non-sequentially.

A Multimedia system can be defined as below: A communications network, computer platforms, or a software tool is a multimedia system if it supports the interaction with at least one of the types of mediums. The components of a multimedia package are:
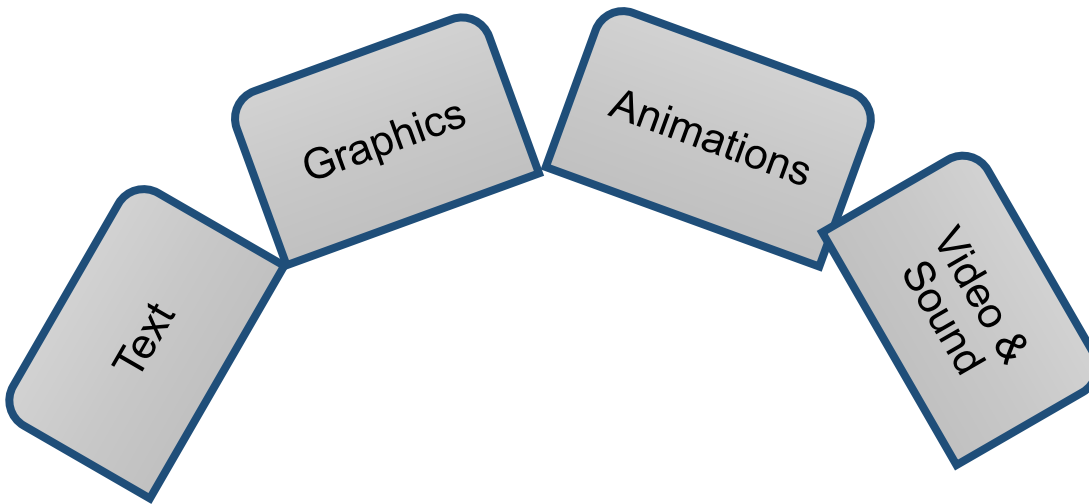

Figure 5: Basics Mediums of Multimedia

Text

Text is the graphic representation of speech. Unlike speech, however, the text is silent, easily stored, and easily manipulated. Text in multimedia presentations makes it possible to convey large amounts of information using very little storage space. Computers customarily represent text using the ASCII (American Standard Code for Information Interchange) system. The ASCII system assigns a number for each of the characters found on a typical typewriter. Each character is representing as a binary number that can be understood by the computer. On the internet, ASCII can be transmitted from one computer to another over telephone lines. Non-text files (like graphics) can also be encoded as ASCII files for transmission. Once received, the ASCII file can be translated by decoding software back into its original format.

Advantages of Text: Text in multimedia presentations makes it possible to convey large amounts of information using very little storage space.

Drawbacks with Text

- Not user-friendly as compared to the other medium.

- Suffers lackluster performance when judged by its counterparts.

- Harder to read from a screen (tires eyes more than reading it in its print version).

- Availability of TEXT to SPEECH software has helped to overcome Text drawbacks.

Fonts

The graphic representation of speech can take many forms. These forms are referred to as fonts or typefaces. Fonts can be characterized by their proportionality and their serif characteristics. The non-proportional fonts, also known as mono spaced fonts, assign the same amount of horizontal space to each character. Mono spaced fonts are ideal for creating tables of information where columns of characters must be aligned. Text created with non-proportional fonts often looks as though they were produced on a typewriter. Two commonly-used non-proportional fonts are Courier and Monaco on the Macintosh and Courier New and FixedSys on Windows.

Proportional fonts vary the spacing between characters according to the width required by each letter. For example, an "l" requires less horizontal space than a "d." Words created with proportional fonts look more like they were typeset by a professional typographer. Two commonly-used proportional fonts are Times and Helvetica on the Macintosh and Times New Roman and Arial on Windows. This article is written using proportional fonts.

Serif fonts are designed with small ticks at the bottom of each character. These ticks aid the reader in following the text. Serif fonts are generally used for text in the body of an article because they are easier to read than Sans Serif fonts. The body text in this article is written using a serif font. Two

commonly-used serif fonts are Times and Courier on the Macintosh and Times New Roman and Courier New on Windows. The body text in this article uses a proportional serif font.

Sans Serif fonts are designed without small ticks at the bottom of each character. Sans Serif fonts are generally used for headers within an article because they create an attractive contrast with the Serif fonts used in the body text. The section headers in this article are written using a sans serif font. Two commonly-used sans serif fonts are Helvetica and Monaco on the Macintosh and Arial and FixedSys on Windows. The headings in this article use a sans proportional serif font.

Font Samples: Times New Roman and Georgia are proportional serif fonts. Verdana and Arial are proportional sans serif fonts. Courier New and Courier are non-proportional serif fonts. Monaco and Fixed System are non-proportional sans serif fonts.

Font Standards: There are two font standards as Postscript fonts and printer fonts (Figure 6).Postscript fonts are designed to produce exceptionally good-looking types when printed on a high-resolution printer. To use a Postscript font, a set of files must be installed on the host computer. These files include a printer font that is downloaded to the printer when a page containing the font is printed and a set of screen fonts which represent the font on screen at various point sizes. If the user chooses to view the font at a size not provided by the font file, the computer interpolates and produces an unattractive font on the screen. The printed output, however, will always appear attractive.

Postscript is a complete page description language that encompasses all elements of a printed page including high-resolution graphics. Postscript was created by Adobe in the mid-1980s and, combined with the introduction of the Macintosh and the Apple LaserWriter printer, created an industry called desktop publishing.

The second standard is called TrueType. TrueType fonts use a variant of postscript technology. To use a TrueType font only one file must be installed on the host computer. This file is used by the printer and by the screen to produce attractive text at any point size. TrueType technology, however, is limited to text. For high-resolution graphics, Postscript is the standard to use. TrueType was created in the early 1990s by Microsoft in cooperation with Apple Computer and others.

Both Macintosh and Windows laptops and desktop computers commonly use TrueType fonts. Postscript technology, however, is much more commonly available on the Macintosh platform because of its dominance in the desktop publishing and multimedia production industries.

Styles and Sizes: The styles such as Bold, Underlined, and Italics can be applied to most fonts. The size of the font also can be altered through software commands.

File Formats: The text created on a computer is stored as a file on a hard disk or floppy disk. The ASCII file format (plain text), is universally understood by all computer systems. There exists a Rich Text Format (RTF) which is a complex file standard developed by Microsoft and allows the exchange of word processing files that include formatting such as text alignment, font styles, and font sizes. Hypertext Markup Language (HTML) file format is a quickly-emerging replacement for RTF and is being used for creating Web pages. HTML files are really just ASCII text files. The content of HTML files contains a standard set of markings to indicate text styles, alignments, hypertext links, graphics, and other formatting essentials
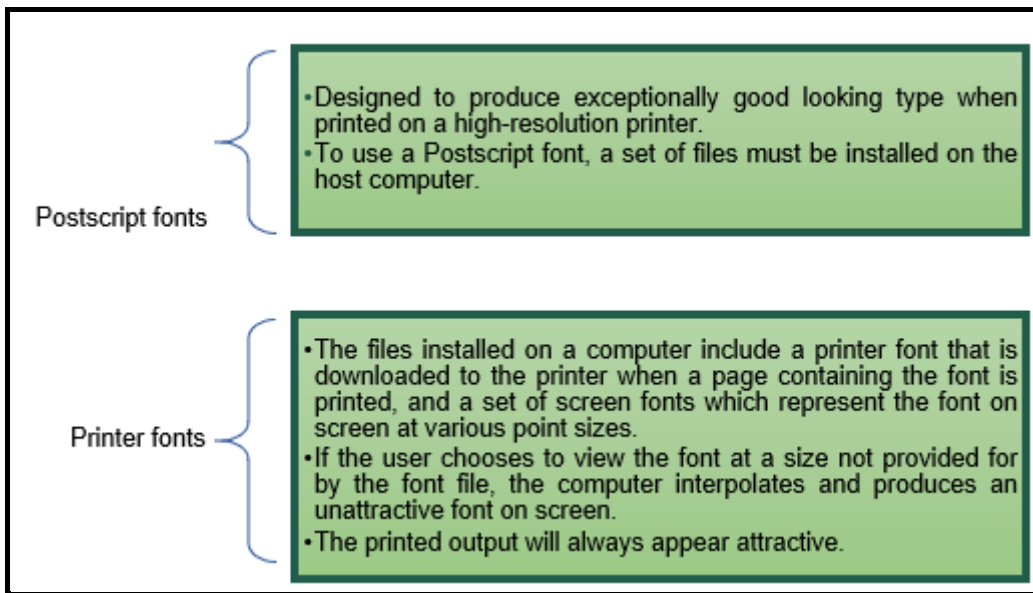
Figure 6: Types of Font Standards

Video and Sound

Sound is used to set the rhythm or a mood in a package. Speech gives an effect of a language (pronunciation) for instance. Sound files in various Sound File Formats like the MP3 can be easily transmitted through the NET. Voice over IP VOIP is an upcoming field with a great future. Sound can be recorded into a mic or from any other medium like tape or cassette player onto the PC. Some of the factors affecting the size of sound files are:

How Sound travels?

- When a tree falls, a person speaks, or a violin string vibrates, the surrounding air is disturbed causing changes in air pressure that are called sound waves.

- When sound waves arrive at our ears they cause small bones in our ears to vibrate.

- These vibrations then cause nerve impulses to be sent to the brain where they are interpreted as sound.

- The voltage changes can be directed to a tape recorder which alters the magnetic particles on the tape to correspond to the voltage changes.

- A "picture" of the sound then exists on the tape.

- When you press play on the tape recorder, the "picture" is read back as a series of voltage changes which are then sent to a speaker.

- The voltage changes cause an electromagnet within the speaker to push and pull on a diaphragm.

Sound File Formats

- When sound is digitally recorded to a hard disk, a file format is assigned by the recording software.

- Sound files are either RAM-based or Disk-based. To playback a RAM-based file, a computer must have enough random-access memory (RAM) to hold the entire file. For example, a computer with 8 megabytes of RAM might not be able to play a large RAM-based sound file but a computer with 16 megabytes of RAM might have no problem with it. The RAM-based formats are appropriate for use with short sound samples.Example: On the Macintosh, System 7 sound and SND resource.System 7 sounds generate the various beeps and alert sounds used on the Macintosh. SND resources are often used as sound resources in HyperCard stacks. System 7 and SND file formats are commonly used with 22 kHz, 8-bit sound samples.

Musical Instrument Digital Interface (MIDI)

The Musical Instrument Digital Interface (MIDI) is a hardware and software standard that, among other things, allows users to record a complete description of a lengthy musical performance using only a small amount of disk space. Standard MIDI Files can be played back using the sound synthesis hardware of a Mac or PC. Using a digital audio file format like AIFF, the same symphony uses over 300 megabytes of hard disk storage. One problem with MIDI is that the quality of the actual sound you hear will vary depending on the quality of your computer's sound hardware. For educational applications, however, MIDI-generated sound can be used to demonstrate musical ideas quite effectively. Another problem with MIDI in the past was the lack of a standard sound set. A MIDI file designed to be played with piano and flute sounds might be realized with organ and clarinet on another person's computer. This problem was partially solved by the advent of the General MIDI standard which created a standard set of 128 sounds. Virtually all MIDI files today are distributed in General MIDI format. Still, it was left to the owner of each computer to be sure their sound hardware could play the General MIDI sounds. Apple Computer solved the problem with the latest version of its QuickTime software.

Application of MIDI

For educational applications, MIDI-generated sound can be used to demonstrate musical ideas quite effectively.

7.5 Graphics Software

Graphics software or Image editing software encompasses the processes of altering images, whether they be digital photographs, traditional analog photographs, or illustrations. Traditional analog image editing is known as photo retouching, using tools such as an airbrush to modify photographs or editing illustrations with any traditional art medium. Graphic software programs, which can be broadly grouped into vector graphics editors, raster graphics editors, and 3d modelers, are the primary tools with which a user may manipulate, enhance, and transform images. Many image editing programs are also used to render or create computer art from scratch.

In computer graphics, graphics software or image editing software is a program or collection of programs that enable a person to manipulate visual images on a computer. Computer graphics can be classified into two distinct categories: raster graphics and vector graphics. Before learning about computer software that manipulates or displays these graphics types, you should be familiar with both.

Graphics software acts as an intermediary between an application program & the graphics hardware. The output primitives & interaction devices that a graphics package supports can range from rudimentary to extremely rich. There are two general classifications for graphics software:

1. General Programming Packages: The general programming packagesprovide an extensive set of graphics functions that can be used in a high-level programming language, such as C or FORTRAN. The basic functions include those for generating picture components (straight line, circle, polygon, etc),setting color and intensity values, & applying transformations.

2. Special-purpose Applications Packages: The special-purpose packages have beendesigned for nonprogrammers so that users can generate displays without worrying about how graphics operations work.Example: Artist's painting programs and various business, medical and CAD systems.

Figure 7: Graphics Software Cartesian Coordinates

Coordinate Representation

General Graphics packages are designed to be used with cartesian coordinates(Figure 7).Several different Cartesian reference frames are used to construct & display a scene.

Functions of Graphics Software

Graphics software provides the users with a variety of functions for creating & manipulating pictures and include the following:

- Output primitives: Basic building blocks.

- Attributes: Properties of the output primitives.

- Geometric transformations: Changing size, position & orientation.

- Modelling transformations: Construct scene using object descriptions.

- Viewing transformations: Used to specify the view that is to be presented.

- Input Functions: Used to control & process the data flow from interactive devices such as a mouse, tablet, or joystick.

- Control operations: Contains no. of housekeeping tasks such as clearing a display screen & initializing parameter.

Many graphics programs focus exclusively on either vector or raster graphics, but there are a few that combine them in interesting and sometimes unexpected ways. It is simple to convert from vector graphics to raster graphics, but going the other way is harder. Some software attempts to do this. Most of the graphics programs can import and export one or more graphics file formats.

Software Standards:A standard graphics package such as GKS(Graphical Kernal System) & PHIGS (Programmers Hierarchical Interactive graphics system) implements a specification designated as standard by an official national or international standard bodies by ISO and ANSI(American National Standard Institute).Standards promote portability of application programs & of programmers.

Non-official Standards: are also developed, promoted & licensed by individual companies or by consortia of companies.Example: Adobe's Postscript & MIT's X window system are two industry standards.

GKS: Designed as a 2-D graphics packages, a 3-D GKS extension was subsequently developed.

PHIGS: An extension of GKS having increased capabilities for object modeling, color specification, surface rendering, etc.Extension of PHIGS called PHIGS+ to provide 3-D surface shading capabilities.

GKS primitives: There are basic four primitives.

(a) Polyline: Used to draw lines.

   POLYLINE(n, X, Y)where n = length of an array

   X & Y = array of x,y coordinate

(b) Polymarker: Used to plot points.

   POLYMARKER (n, X, Y) where n = number of data points

(c) Fill Area: Used to draw the line but it always connects the first and last points in the array.

   FILL AREA(n, X, Y)

(d) Text: Used to print the "string" or "text" starting at the given coordinates.

TEXT(x, y, "String")

Summary

- Multimedia is usually recorded and played, displayed, or accessed by information content processing devices.

- Graphics software or image editing software is a program or collection of programs that enable a person to manipulate the visual image on a computer.

- Most graphics programs can import one or more graphics file formats.

- Multimedia means multi-communication.

Keywords

BMP file format: The BMP file format (Windows bitmap) handles graphics files within the Microsoft Windows OS. Typically, BMP files are uncompressed, hence they are large; the advantage is their simplicity and wide acceptance in Windows programs.

CGM(Computer Graphics Metafile): CGM (Computer Graphics Metafile) is a file format for 2D vector graphics, raster graphics, and text, and is defined by ISO/IEC 8632.

Etching: Etching is an intaglio method of printmaking in which the image is incised into the surface of a metal plate using an acid.

JPEG 2000: JPEG 2000 is a compression standard enabling both lossless and lossy storage.

Metafile formats: Metafile formats are portable formats that can include both raster and vector information.

Raster formats: These formats store images as bitmaps (also known as pixmaps).

Raw Image Formats (RAW): RAW refers to a family of raw image formats that are options available on some digital cameras.

SVG (Scalable Vector Graphics): SVG (Scalable Vector Graphics) is an open standard created and developed by the World Wide Web Consortium to address the need (and attempts of several corporations) for a versatile, scriptable, and all-purpose vector format for the web and otherwise.

TIFF (Tagged Image File Format): The TIFF (Tagged Image File Format) format is a flexible format that normally saves 8 bits or 16 bits per color (red, green, blue) for 24-bit and 48-bit totals, respectively, usually using either the TIFF or TIF filename extension.

Vector file formats: Vector file formats can contain bitmap data as well. 3D graphic file formats are technically vector formats with pixel data texture mapping on the surface of a vector virtual object, warped to match the angle of the viewing perspective.

Raster formats: These formats store images as bitmaps (also known as pixmaps).

RAW: RAW refers to a family of raw image formats that are options available on some digital

cameras.

SVG (Scalable Vector Graphics): SVG (Scalable Vector Graphics) is an open standard created and developed by the World Wide Web Consortium to address the need (and attempts of several corporations) for a versatile, scriptable, and all-purpose vector format for the web and otherwise.

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1. Draw Original waveform and a quantized waveform.

2. Demonstration 2 - MIDI and QuickTime.

Self-Assessment Questions

1. Etching is only used in the manufacturing of printed circuit boards and semiconductor devices.

    A.   True

    B.   (b) False

2. Multimedia is usually recorded and played, displayed or accessed by information content processing devices, such as computerized and electronic devices, but can also be part of a live performance.

    (A) True

(B) False

3. What image types Web pages require?

    (A) JPG

    (B) GIF

    (C) PNG

    (D) All of the above

4. Photo images have

    (A) Discontinuous tones

    (B) Continuous tones

    (C) Wavy tones

    (D) None of these

5. Files are very small files for continuous tone photo images.

    (A) JPG

    (B) GIF

    (C) PNG

    (D) All of these

6. In addition to straight image formats, which formats are portable formats.

    (A) Raster formats

    (B) JPEG

    (C) Metafile

    (D) All of these

7. RAW refers to a family of raw image formats that are options available on some digital cameras.

    (A) True

    (B) False

8. WebP is an old image format that uses lossy compression.

    (A) True

    (B) False

9. What is Graphics software?

    (A) It is a program or collection of programs that enable a person to manipulate visual images on the Web.

    (B) It is a program or collection of programs that disable a person to manipulate visual images on a computer.

    (C) It is a program or collection of programs that enable a person to manipulate visual images on a computer.

    (D) All of the above.

10. What is the major drawback of using text?

(A) It is not user-friendly as compared to the other medium.

(B) It is not flexible as compared to the other medium.

(C) It is not supportive as compared to the other medium.

(D) None of the above

11. Metafile formats are _____ formats which can include both raster and vector information.
   A. non-portable
   B. economical
   C. non-economical
   D. portable

12. The full form for JFIF is
   A. JPEG File Interchange Format
   B. JPEG Follow Interaction Format
   C. JPEG File Interaction Format
   D. Joint File Interpretation Format

13. Graphics Interchange Format (GIF) can support
   A. 125 colors
   B. 256 colors
   C. 128 colors
   D. 512 colors

14. Which of the following corresponds to Exchangeable image-fileformat (Exif)
   A. A file standard similar to the JFIF format with TIFF extensions
   B. Incorporated in the JPEG-writing software used in most cameras
   C. Records and standardizes the exchange of images with image metadata between digital cameras and editing and viewing software
   D. All of the above

15. The major factor to be considered in the multimedia file is the ____ of the file.
   A. Bandwidth
   B. Size
   C. Length
   D. Width

Answer for Self Assessment

1.	B	2.	A	3.	D	4.	B	5.	A
6.	C	7.	A	8.	B	9.	C	10.	A
11.	D	12.	A	13.	B	14.	D	15.	B

Review Questions

1. Explain Graphics and Multimedia.
2. What is multimedia? What are the major characteristics of multimedia?
3. Find out the applications of Multimedia.
4. Explain Image File Formats (TIF, JPG, PNG, GIF).
5. Find differences in the photo and graphic images.
6. What is the image file size?
7. Explain the major graphic file formats?
8. Explain the components of a multimedia package.
9. What are Text and Font? What are the different font standards?
10. What is the difference between Postscript and Printer fonts?
11. What is Sound and how is Sound Recorded?
12. What is Musical Instrument Digital Interface (MIDI)?

Further Readings

Introduction to Computers, by Peter Norton, Publisher: McGraw Hill, Sixth Edition.

Multimedia Introduction - Tutorialspoint

Computer Graphics And Multimedia Application - IPEM (ipemgzb.ac.in)

Unit 08: Data Base Management Systems

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8.5   Database Management Systems

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8.8   Databases at Work

8.9   Common Corporate Database Management Systems

Summary

Keywords

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Objectives

After studying this unit, you will be able to:

- Explain Database.
- Discuss DBMS and its components.
- Know about the database models
- Understand working with database.
- Explain database at work.
- Explain various common corporate DBMS.

Introduction

Data are units of information, often numeric, that are collected through observation. In a more technical sense, data are a set of values of qualitative or quantitative variables about one or more persons or objects, while a datum (singular of data) is a single value of a single variable. Data is the raw material from which useful information is derived. It is defined as raw facts or observations. Data is a collection of unorganized facts but can be made organized into useful information (**Error! Reference source not found.**). A set of values of qualitative or quantitative variables about one or more persons or objects. Data is employed in scientific research, businesses management (e.g., sales data, revenue, profits, stock price), finance, governance (e.g., crime rates, unemployment rates, literacy rates), human organizational activity (e.g., censuses of the number of homeless people by non-profit organizations).

Data is basically a collection of raw facts and figures we have a rough material that can be possessed by any computing machine that actually pertains to data. Example, we have few numbers with us,

but which number it is referring to, it is unknown. We have no idea if it is specifying somebody's age, or it is specifying some currency what it is specifying we don't know. It is just a number. Okay, so actually the collection of facts, which can be in different kind of conclusions can be drawn from it that is actually called as data.

Information pertains to a systematic and meaningful form of data. It is the knowledge acquired through study or experience. The information helps human beings in their decision-making. Information can be said to be data that has been processed in such a way as to increase the knowledge of the person who uses the data.

Knowledge is the understanding based on extensive experience dealing with information on a subject. It is a familiarity, awareness, or understanding of someone or something, such as facts (descriptive knowledge), skills (procedural knowledge), or objects (acquaintance knowledge). By most accounts, knowledge can be acquired in many different ways and from many sources, including but not limited to perception, reason, memory, testimony, scientific inquiry, education, and practice. The philosophical study of knowledge is called epistemology.

Figure 1: Conversion of Raw Data into Information

Let us consider an example of Mount Everest. Most of the books they site out what is the height of Mount Everest, that is just a data. The height can be measured precisely with any altimeter and entered into a particular database. This data can be included in any particular book, along with other data on Mount Everest like how many trees are there or other things related to Mount Everest what is a sea level height. All this data can describe the mountain in a manner that would be useful for those who wish to actually make a decision about whether they should decide out the best manner how they can climb it. Thereby an understanding that is based on experience of climbing the mountains, that could actually be used by some other persons on a way that they can reach the Mount Everest. That is actually the knowledge. However, when we consider that the practical way of actually climbing of Mount Everest by a person climbs, based on his knowledge may be considered as his wisdom. In other words, we can say that wisdom refers to the practical application of a person's ability or a person's knowledge, depending upon the kind of circumstances, which are mostly considered as good.

8.1 Data Processing

The process of converting the facts into meaningful information. Data processing refers to the process of performing specific operations on a set of data or a database. As illustrated in Figure 2, Input one input two input three there are so many different kinds of data processing stages that are involved, like pre-processing is there storage is there, then manipulations are there analysis is there and we have so many different kinds of stages involves sorting is also involved over here, and then an output is generated so this output is the meaningful information or we can say organized data.

Example, every year about one lakh students take admission in National Open School (NOS). If you are asked to memorise records of date of birth, subjects offered and postal address of all these students, it will not be possible for you. In order to deal with such problems, we construct a database where in such situations, all information about students can be arranged in a tabular form. Several records can be maintained.

A database is an organized collection of facts and information, such as records on employees, inventory, customers, and potential customers.

Figure 2: Data Processing Scenario

Metadata: Metadata is the data that describes the properties or characteristics of other data, like we say we have a cat. We have some data about the cat, the name, we can specify the height, we can specify that as a metadata. Therefore, all such data describes the properties or characteristics of other data.

8.2 Database

A database is a system intended to organize, store, and retrieve large amounts of data easily. It consists of an organized collection of data for one or more uses, typically in digital form. One way of classifying databases involves the type of their contents, for example: bibliographic, document-text, statistical. digital databases are managed using database management systems, which store database contents, allowing data creation and maintenance, and search and other access.

A database is a collection of information that is organized so that it can easily be accessed, managed, and updated. In one view, databases can be classified according to types of content: bibliographic, full-text, numeric, and images.

In computing, databases are sometimes classified according to their organizational approach. The most prevalent approach is the relational database, a tabular database in which data is defined so that it can be reorganized and accessed in a number of different ways. A distributed database is one that can be dispersed or replicated among different points in a network. An object-oriented programming database is one that is congruent with the data defined in object classes and subclasses.

Computer databases typically contain aggregations of data records or files, such as sales transactions, product catalogs and inventories, and customer profiles. Typically, a database manager provides users the capabilities of controlling read/write access, specifying report generation, and analyzing usage.

8.3 Types of Databases

There are different types of database as discussed below:

Analytical Database: Analysts may do their work directly against a data warehouse or create a separate analytic database for Online Analytical Processing (OLAP). For example, a company might extract sales records for analyzing the effectiveness of advertising and other sales promotions at an aggregate level.

Data Warehouse: Data warehouses archive modern data from operational databases and often from external sources such as market research firms. Often operational data undergoes transformation on its way into the warehouse, getting summarized, anonym zed, reclassified, etc. The warehouse becomes the central source of data for use by managers and other end-users who may not have access to operational data.

Distributed Database: These are databases of local work-groups and departments at regional offices, branch offices, manufacturing plants and other work sites. These databases can include segments of both common operational and common user databases, as well as data generated and used only at a user's own site.

End User Database: These databases consist of data developed by individual end-users. Examples of these are collections of documents in spread sheets, word processing and downloaded files, even managing their personal baseball card collection.

External Log Database: These databases contain data collected for use across multiple organizations, either freely or via subscription. The Internet movie database is one example.

Hypermedia Log Database: World Wide Web can be thought of as a database, spread across millions of independent computing systems. Web browsers "process" this data one page at a time, while Web crawlers and other software provide the equivalent of database indexes to support search.

Operational Log Database: These databases store detailed data about the operations of an organization. They are typically organized by subject matter, process relatively high volumes of updates using transactions. Essentially every major organization on earth uses such databases. Examples include customer databases that record contact, credit, and demographic information about a business' customers, personnel databases that hold information such as salary, benefits, and skills data about employees, Enterprise resource planning that record details about product components, parts inventory, and financial databases that keep track of the organization's money, accounting and financial dealings.

Customer Database: Such databases record contact, credit, and demographic information about a business' customers.

Personnel Database: It can hold information such as salary, benefits, skills data about employees.

Enterprise resource planning: Such database records details about product components, parts inventory.

Financial Database: Such database tracks an organization's money, accounting and financial dealings.

Purpose of Using a Database

A database is typically designed so that it is easy to store and access information. A good *database is crucial* to any company or organization. This is because the **database** stores all the important details about the company such as employee records, transactional records, salary details. Database management systems are essential for businesses because they offer an efficient way of handling large amounts and multiple types of data. The ability to access data efficiently allows companies to make informed decisions quicker.

8.4 Database Administrator (DBA)

A Database Administrator (DBA) in Database Management System (DBMS) is an IT professional who works on creating, maintaining, querying, and tuning the database of the organization. They are also responsible for maintaining data security and integrity.

Database Manager provides users the capabilities of controlling read/write access, specifying report generation, and analyzing usage. They are prevalent in large mainframe systems, but are also present in smaller distributed workstation and mid-range systems such as the AS/400 and on personal computers. A database manager (DB manager) is a computer program, or a set of computer programs, that provide basic database management functionalities including creation and maintenance of databases. Database managers have several capabilities including the ability to back up and restore, attach and detach, create, clone, delete and rename the databases.

Database Three Level Architecture used for describing the structure of specific database systems. In this architecture, the database schemas can be defined at three levels (Figure 3).
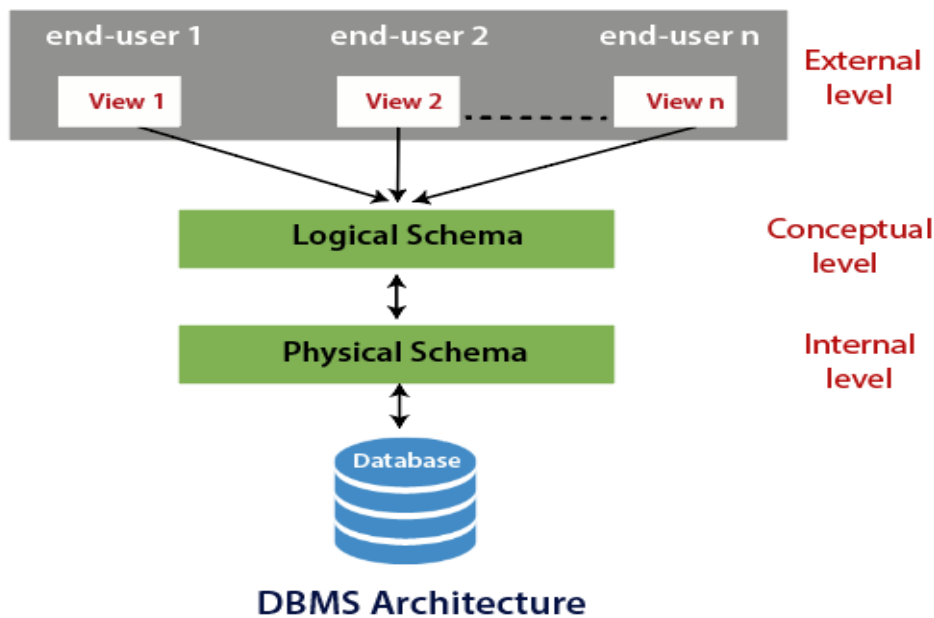
Figure 3: Database- Three Level Architecture

- **Internal/physical level:** Shows how data are stored inside the system. It is the closest level to the physical storage. This level is also known as physical level. This level describes how the data is actually stored in the storage devices. This level is also responsible for allocating space to the data. This is the lowest level of the architecture.

  The physical level keeps the information about the actual representation of the entire database, that is, the actual storage of the data on the disk in the form of records or blocks.

- **Conceptual/logical level:** It is also called **logical level**. The whole design of the database such as relationship among data, schema of data etc. are described in this level. Database constraints and security are also implemented in this level of architecture. This level is maintained by DBA (database administrator).

  This level lies in between the user level and the physical storage view. Only one conceptual view for single database us available. It hides the details of physical storage structures and concentrates on describing entities, data types, relationships, user operations, and constraints.

- **External level:** It is also called **view level**. The reason this level is called "view" is because several users can view their desired data from this level which is internally fetched from database with the help of conceptual and internal level mapping. This is the highest or top level of data abstraction (No knowledge of DBMS Software and Hardware or physical storage). This level is concerned with the user. Each external schema describes the part of the database that a particular user is interested in and hides the rest of the database from user. There can be n number of external views for database where 'n' is the number of users. Example: A accounts department may only be interested in the student fee details. All the database users work on external level of DBMS.
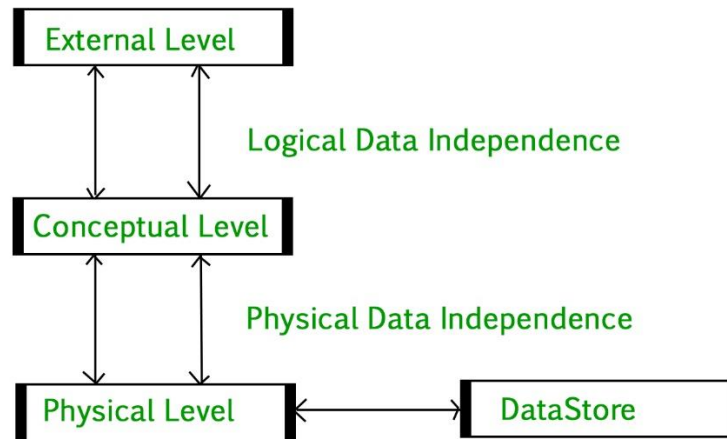
Figure 4: Data Independence

Data Independence

Data Independence is defined as a property of DBMS that helps you to change the database schema at one level of a database system without requiring changing the schema at the next higher level (Figure 4). Data independence helps you to keep data separated from all programs that make use of it. There are two types of data independence:

Physical Data Independence can be defined as the capacity to change the internal schema without having to change the conceptual schema. If we do any changes in the storage size of the database system server, then the conceptual structure of the database will not be affected. It is used to separate conceptual levels from the internal levels. It occurs at the logical interface level.

Logical Data Independence refers characteristic of being able to change the conceptual schema without having to change the external schema. It is used to separate the external level from the conceptual view. If we do any changes in the conceptual view of the data, then the user view of the data would not be affected. It occurs at the user interface level.

Database System Applications

Banking: The banks can use database for storing the customer information, their account details loans that have been sanctioned out, and the different kinds of banking transactions can be also listed out. Thereby, database can be used for storing the customer information, accounts, and loans, and banking transactions.

Airlines: The aviation sector can use database as a basis for reservations and for scheduling different kinds of information.

Universities: A university can maintain the student information and also can maintain the employee database. It can consider out the grade achieved by the students; it can consider out the registrations that are done for a particular course over there.

Credit card Transactions: For purchases on credit cards and generation of monthly statements.

Telecommunication: For keeping records of calls made, generating monthly bills, maintaining balances on prepaid calling cards, and storing information about the communication networks.

Finance: For storing information about holdings, sales, and purchases of financial instruments such as stocks and bonds.

Sales: For customer, product, & purchase information.

Manufacturing: For management of supply chain & for tracking production of items in factories, inventories of items in warehouses/ stores, and orders for items.

Human Resources: For information about employees, salaries, payroll taxes and benefits, and for the generation of paychecks. Mahindra and Mahindra organization are collecting the data from DTO and feeding into database for the purpose of decision making.

8.5 Database Management Systems

The DBMS is a collection of interrelated data and a set of programs to access those data. It can be said to be a software that interacts with end users, applications, and the database itself to capture and analyze the data. It encompasses the core facilities provided to administer the database. The sum total of the database, the DBMS and the associated applications can be referred to as a "database system". The term "database" is often used to loosely refer to any of the DBMS, the database system or an application associated with the database. The data in the databases is viewed as rows and columns in a series of tables, and the vast majority use Structured Query Language (SQL) for writing and querying data.

Purpose of DBMS

- To avoid data redundancy
- To avoid data inconsistency
- Data independence
- Efficient data access
- Data integrity and security
- Data administration
- Concurrent access and crash recovery
- Reduced application development time

Components of DBMS

DBMS consist of five major components (Figure 5):

End Users: All the modern applications, web or mobile, store user data. Applications are programmed in such a way that they collect user data and store the data on DBMS systems running on their server. The users can store, retrieve, update and delete data.

Software: The main component or program that controls everything. It is more like a wrapper around the physical database. It provides an easy-to-use interface to store, access and update data. It capable of understanding the Database Access Language and interpret into actual database commands to execute them on DB.

Hardware: Computer, hard disks, I/O channels for data, Keyboard with which we type commands, computer's RAM, ROM and any other physical component involved before any data is successfully stored into the memory.
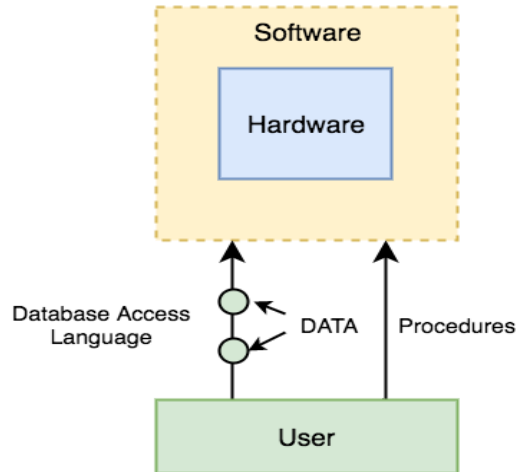
Figure 5: Components of DBMS

Data: Data is the resource, for which DBMS was designed. Primary motive is creation of DBMS was to store and utilize data.

Procedures: Procedures pertain to the general instructions to use a DBMS. It includes instructions to setup and install a DBMS, to login and logout of DBMS software, to manage databases, to take backups, generating reports etc.

Database Access Language: A simple language designed to write commands to access, insert, update and delete data stored in any database. The users can write commands in the Database Access Language and submit it to the DBMS for execution, which is then translated and executed by the DBMS. The users can create new databases, tables, insert data, fetch stored data, update data & delete data.

8.6 Database Models

Data model help to represent data and to make the data understandable. A modeling language is a data modeling language to define the schema of each database hosted in the DBMS, according to the DBMS database model. DBMS are designed to use one of five database structures to provide simplistic access to information stored in databases. The five database structures are:

- Object model
- Hierarchical model
- Network model
- Relational model
- Multidimensional model

Levels of Data Models

Object-based and record-based data models are used to describe data at the conceptual and external levels, the physical data model is used to describe data at the internal level. The object-based data models use concepts such as entities, attributes, and relationships. There are two common types: The *entity-relationship model* has emerged as one of the main techniques for modeling database design and forms the basis for the database design methodology. The *object-oriented data model* extends the definition of an entity to include, not only the attributes that describe the state of the object but also the actions that are associated with the object, that is, its behavior.

Entities are represented by means of rectangles. Rectangles are named with the entity set they represent. As illustrated, we have three entities over here student, teacher and projects (Figure 6).

Figure 6: Entities in ER-Model

Attributes are the properties of entities. These are represented by means of ellipses. Every ellipse represents one attribute and is directly connected to its entity (rectangle) (Figure 7).
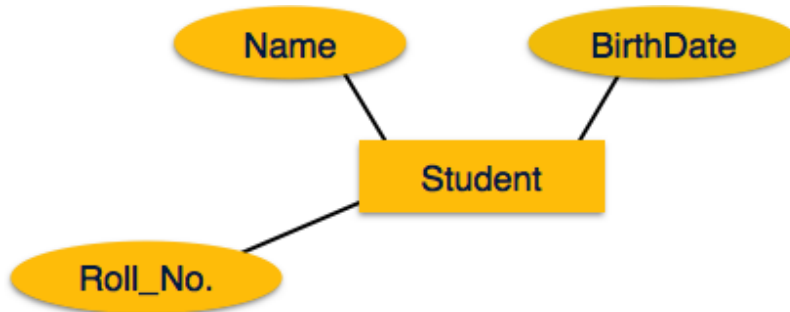

Figure 7: Entities and Attributes in ER-Model

Composite Attributes: If the attributes are composite, they are further divided in a tree like structure. This is a kind of attribute that are composite in nature. They can be further divided out into tree like structure, like a name, name is an attribute. It can consist of two further attributes, that is why we call them as composite attributes. Example, as illustrated in Figure 8, the name can further be segregated into first name and the last name which are composite attributes.
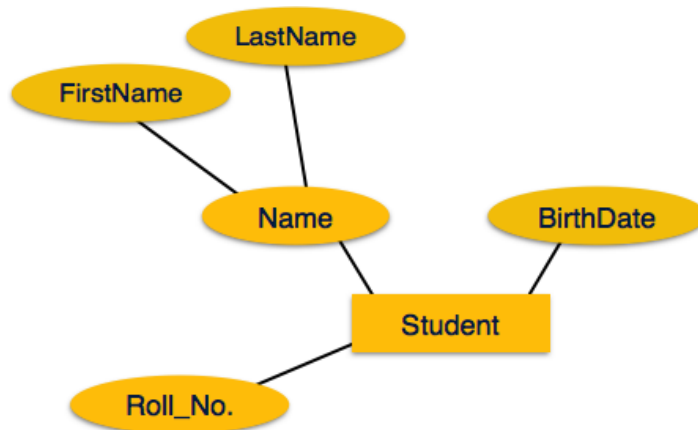

Figure 8: Composite Attributes

Multivalued Attributes: Multivalued attributes are depicted by double ellipse like phone number (Figure 9). It can have multiple values such as a student can have multiple phone numbers. We call it as multivalued attribute as it cannot be a unique to a particular student, a student can have multiple phone numbers as well.
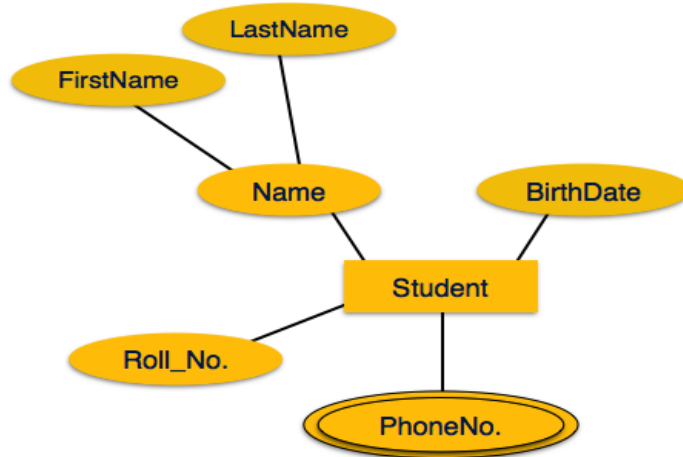
Figure 9: Multivalued Attribute

Derived Attributes: Derived attributes are depicted by dashed ellipse. In Figure 10, age is a derived attribute. Every student is having some age. Age is dependent upon a student. Like birth date is one attribute of a student entity. The age can only be derived from after knowing the birthdate of a particular students so that is why we call it as derived attribute.
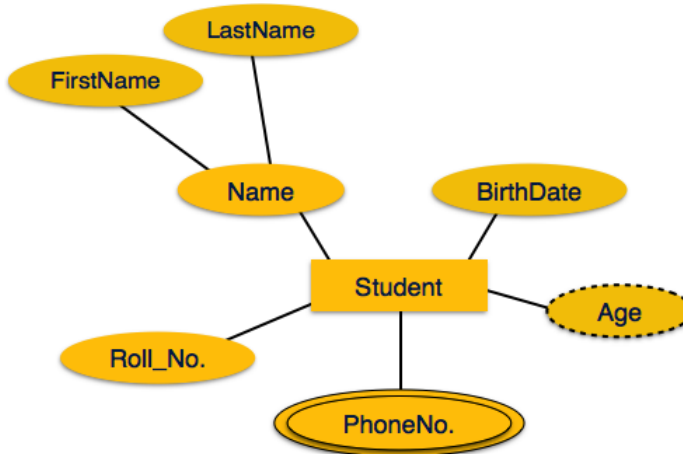

Figure 10: Derived Attribute

Relationships in the ER-model are represented by diamond-shaped box. The name of the relationship is written inside the diamond-box. All the entities (rectangles) participating in a relationship, are connected to it by a line. Figure 11 depicts the sample entity-relationship diagram.
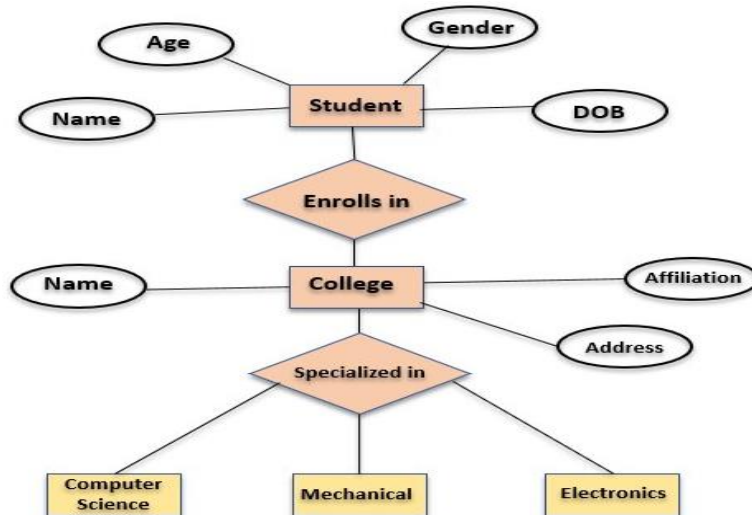

Figure 11: Sample ER-Diagram

Hierarchical database model is the oldest database models. It is like a structure of a tree with the records forming the nodes and fields forming the branches of the tree. The records are forming the nodes, and the fields are forming the branches of a particular tree. As illustrated in Figure 12, we have a root, that is the node (the record). Then, we have the subfields over there that are actually forming the branches of a particular tree that is child with further sub-levels. There are different levels that are involved in a hierarchical database model.
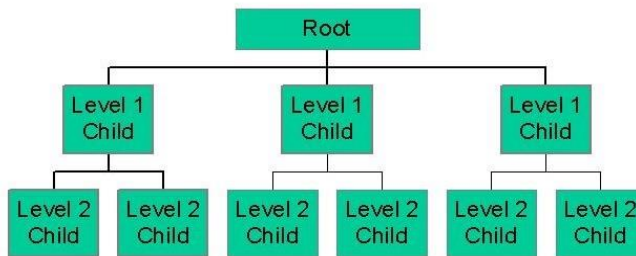
Hierarchical database model

Figure 12: Hierarchical Database Model

Network Model replaces the hierarchical tree with a graph thus allowing more general connections among the nodes (Figure 13). The main difference of the network model from the hierarchical model, is its ability to handle many to many (N:N) relations.

Figure 13: Network Database Model

Relational Model is the most commonly used today. It is used by mainframe, midrange and microcomputer systems. It uses two-dimensional rows and columns to store data (Figure 14). The tables of records can be connected by common key values. While working for IBM, E.F. Codd designed this structure in 1970. The model is not easy for the end user to run queries with because it may require a complex combination of many tables.

Advantages of Relational Model

- Simple: Relational model is simpler as compared to the network and hierarchical model.
- Scalable: It can be easily scaled as we can add as many rows and columns we want.
- Structural Independence: We can make changes in database structure without changing the way to access the data

Figure 14: Depiction of Relational Database Model

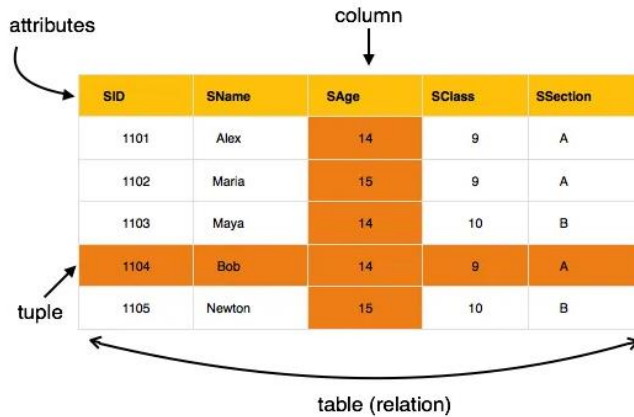**Multidimensional Model** is similar to the relational model. The dimensions of the cube-like model have data relating to elements in each cell. This structure gives a spread sheet-like view of data. This structure is easy to maintain because records are stored as fundamental attributes— in the same way they are viewed— and the structure is easy to understand. Its high performance has made it the most popular database structure when it comes to enabling OLAP.

8.7 Working with Database

A database is an organized collection of data, generally stored and accessed electronically from a computer system. Where databases are more complex, they are often developed using formal design and modelling techniques.

Structured Query Language (SQL)

Structured Query Language (SQL) is the database language. It helps to perform certain operations on the existing database and also can be used to create a database. It uses certain commands like Create, Drop, Insert etc. to carry out the required tasks. There are different data types in SQL such as:

- char(n): Fixed length character string, with user-specified length *n*.
- varchar(n): Variable length character strings, with user-specified maximum length *n*.
- Int: Integer (a finite subset of the integers or numbers that is machine-dependent).

Types of SQL Commands

Data Definition Language (DDL): These are used to change the structure of a database and database objects. These can be used to add, remove, or modify tables with in a database (Table 1). There are various DDL commands such as CREATE, ALTER, DROP, TRUNCATE, RENAME etc.

CREATE: Used to create table in the relational database. This can be done by specifying the names and datatypes of various columns. The syntax:

CREATE TABLE *table_name*

 (
   column1 datatype,
   column2 datatype,
   column3 datatype, ...
);

ALTER: Alter command is used for altering the table in many forms like: add a column; rename existing column; drop a column; modify the size of the column or change data type of the column. Example: If a user wants to add a column in a table, following syntax is used:

ALTER TABLE *table_name*
ADD *column_name datatype*;

Data Manipulation Language (DML): SQL commands that deal with the manipulation of data present in the database belong to DML or Data Manipulation Language. These include most of the SQL statements. They are:

o INSERT- Used to insert data into a table.

o UPDATE– Used to update existing data within a table.

o DELETE- Used to delete records from a database table.

INSERT: The INSERT statement is a SQL query used to insert data into the row of a table. The syntax for it is:

INSERT INTO TABLE_NAME (col1, col2, col3, ..., col N)

VALUES (value1, value2, value3, ... valueN);

Or

INSERT INTO TABLE_NAME

VALUES (value1, value2, value3, ... valueN);

UPDATE: This command is used to update or modify the value of a column in the table. The syntax is:

UPDATE table_name SET [column_name1= value1,...column_nameN = valueN]

[WHERE CONDITION]

DELETE: It is used to remove one or more row from a table. The syntax is:

DELETE FROM table_name [WHERE condition];

Table 1: Comparison of DDL with DML

S. No.	DDL	DML
1.	Stands for Data Definition Language	Stands for Data Manipulation Language
2.	Used to create database schema and can be used to define some constraints as well.	Used to add, retrieve or update the data.
3.	Basically defines the column (Attributes) of the table.	Used to add or update the row of the table. These rows are called as tuple.
4.	Doesn't have any further classification.	Further classified into Procedural and Non-Procedural DML.

Data Control Language (DCL): These commands are used to grant and take back authority from any database user. Some commands that come under DCL are:

o Grant: It is used to give user access privileges to a database. The syntax is:

GRANT SELECT, UPDATE ON MY_TABLE TO SOME_USER, ANOTHER_USER;

o Revoke: It is used to take back permissions from the user. The syntax is:

REVOKE SELECT, UPDATE ON MY_TABLE FROM USER1, USER2;

Data Query Language (DQL): Such commands are used to fetch the data from the database. It uses only one command:

SELECT: This is the same as the projection operation of relational algebra. It is used to select the attribute based on the condition described by WHERE clause. SELECT statement is used to select data from a database. The data returned is stored in a result table, called the result-set. The syntax for SELECT command is:

SELECT expressions

FROM TABLES

WHERE conditions;

For example:

SELECT emp_name

FROM employee

WHERE age > 20;

8.8 Databases at Work

Databases have been a staple of business computing from the very beginning of the digital era. In fact, the relational database was born in 1970. Originally, databases were flat, means, that the information was stored in one long text file, called a tab delimited file. Each entry in the tab delimited file is separated by a special character, such as a vertical bar (|). Each entry contains multiple pieces of information (fields) about a particular object or person grouped together as a record. The text file makes it difficult to search for specific information or to create reports that include only certain fields from each record. One has to search sequentially through the entire file to gather related information, such as age or salary.

Relational databases have grown in popularity to become the standard. Unlike traditional databases, the relational database allows you to easily find specific information. It allows sorting based on any field and generate reports that contain only certain fields from each record. Relational databases use tables to store information. Relational database model takes advantage of this uniformity to build completely new tables out of required information from existing tables. Each table contains a column or columns that other tables can key on to gather information from that table. A typical large database, like the one a big Web site, such as Amazon would have, will contain hundreds or thousands of tables, all used together to quickly find the exact information needed at any given time.

The major uses and characteristics of relational database are:

- One can quickly compare salaries and ages because of the arrangement of data in columns.
- Uses the relationship of similar data to increase the speed and versatility of the database.
- The "relational" part of the name comes into play because of mathematical relations.
- A typical relational database has anywhere from 10 to more than 1,000 tables.
- Relational databases are created using a special computer language, structured query language (SQL), that is the standard for database interoperability.
- SQL is the foundation for all of the popular database applications available today, from Access to Oracle.

Database Transaction comprises of a unit of work performed within a DBMS (or similar system) against a database, and treated in a coherent and reliable way independent of other transactions. The transactions in a database environment have two main purposes:

1. To provide reliable units of work that allow correct recovery from failures and keep a database consistent even in cases of system failure, when execution stops (completely or partially) and many operations upon a database remain uncompleted, with unclear status.

2. To provide isolation between programs accessing a database concurrently.

The database transactions are governed under few considerations such as:

A database transaction must be atomic, consistent, isolated and durable. Such properties of database transactions are cited by the database practitioners using the acronym ACID. Further, the system must isolate each transaction from other transactions, results must conform to existing constraints in the database, and transactions that complete successfully must get written to durable storage.

8.9 Common Corporate Database Management Systems

Different types of software applications have been used in the past and may be still in use on older, legacy systems at various organizations around the world. However, these examples provide an overview of the most popular and most-widely used by IT departments. Some typical examples of DBMS include: Oracle, IBM DB2, Microsoft Access, Microsoft SQL Server, PostgreSQL, MySQL, and FileMaker.

ORACLE

Oracle Database (commonly referred to as Oracle RDBMS or simply as Oracle) is an object-relational database management system (ORDBMS) produced and marketed by Oracle Corporation. Larry Ellison and his friends and former co-workers Bob Miner and Ed Oates started the consultancy Software Development Laboratories (SDL) in 1977. SDL developed the original version of the Oracle software. The name Oracle comes from the code-name of a CIA-funded project Ellison had worked on while previously employed by Ampex.

IBM DB2

IBM DB2 Enterprise Server Edition is a relational model database server developed by IBM. It primarily runs on UNIX (namely AIX), Linux, IBM i (formerly OS/400), z/OS and Windows servers. DB2 also powers the different IBM InfoSphere Warehouse editions. Alongside DB2 is another RDBMS: Informix, which was acquired by IBM in 2001.

Microsoft Access

Microsoft Office Access, previously known as Microsoft Access, is a relational database management system from Microsoft that combines the relational Microsoft Jet Database Engine with a graphical user interface and software-development tools. It is a member of the Microsoft Office suite of applications, included in the Professional and higher editions or sold separately.

Access stores data in its own format based on the Access Jet Database Engine. It can also import or link directly to data stored in other applications and databases.

Software developers and data architects can use Microsoft Access to develop application software, and "power users" can use it to build simple applications. Like other Office applications, Access is supported by Visual Basic for Applications, an object-oriented programming language that can reference a variety of objects including DAO (Data Access Objects), ActiveX Data Objects, and many other ActiveX components. Visual objects used in forms and reports expose their methods and properties in the VBA programming environment, and VBA code modules may declare and call Windows operating-system functions.

Microsoft SQL Server

Microsoft SQL Server is a relational model database server produced by Microsoft. Its primary query languages are T-SQL and ANSI SQL. Since parting ways, several revisions have been done independently. SQL Server 7.0 was a rewrite from the legacy Sybase code. It was succeeded by SQL Server 2000, which was the first edition to be launched in a variant for the IA-64 architecture.

PostgreSQL

PostgreSQL, often simply Postgres, is an object-relational database management system (ORDBMS). It is released under an MIT-style license and is thus free and open source software. The name refers to the project's origins as a "post-Ingres" database, the original authors having also developed the Ingres database. (The name Ingres was an abbreviation for INteractive Graphics REtrieval System.). However, the PostgreSQL Core Team announced in 2007 that the product would continue to use the name PostgreSQL. The name refers to the project's origins as a "post-Ingres" database, the original authors having also developed the Ingres database.

MySQL

MySQL is a relational database management system (RDBMS) that runs as a server providing multi-user access to a number of databases. It is named after developer Michael Widenius' daughter, 'My'. The SQL phrase stands for Structured Query Language. The MySQL development project has made its source code available under the terms of the GNU General Public License, as well as under a variety of proprietary agreements. MySQL was owned and sponsored by a single for-profit firm, the Swedish company MySQL AB, now owned by Oracle Corporation.

For commercial use, several paid editions are available, and offer additional functionality. Some free software project examples: Joomla, WordPress, Mob, phpBB, Drupal and other software built on the LAMP software stack. MySQL is also used in many high-profile, large-scale World Wide Web products, including Wikipedia, Google (though not for searches) and Face book.

FileMaker

FileMaker Pro is a cross-platform relational database application from FileMaker Inc., formerly Claris, a subsidiary of Apple Inc. It integrates a database engine with a GUI-based interface, allowing users to modify the database by dragging new elements into layouts, screens, or forms. The current versions are: FileMaker Pro 11, FileMaker Pro 11 Advanced, FileMaker Pro 11 Server, FileMaker Pro 11 Server Advanced and FileMaker Go.

FileMaker evolved from a DOS application, but was then developed primarily for the Apple Macintosh. Since 1992 it has been available for Microsoft Windows as well as Mac OS, and can be used in a heterogeneous environment. It is available in desktop, server, iOS and web-delivery configurations.

Summary

- Database is a system intended to organize, store and retrieve large amounts of data easily.
- DBMS is a tool that is employed in the broad practice of managing databases.
- Distributed database management system (ODBMS) is collection of data which logically belong to the same system but are spread out over the sites of the computer network.
- A modelling language is a data modelling language to define the scheme of each database hosted in DBMS.
- The end-user databases consist of data developed by individual end-users.
- Data structures optimized to deal with very large amount of data stored on a permanent data storage device.
- The operational databases store detailed data about the operations of an organization.

Keywords

Analytical database: Analysts may do their work directly against a data warehouse or create a separate analytic database for Online Analytical Processing (OLAP).

Data definition subsystem: It helps the user create and maintain the data dictionary and define the structure of the files in a database.

Data structure: Data structures optimized to deal with very large amounts of data stored on a permanent data storage device.

Data warehouse: Data warehouses archive modern data from operational databases and often from external sources such as market research firms.

Database: A database is a system intended to organize, store, and retrieve large amounts of data easily. It consists of an organized collection of data for one or more uses, typically in digital form.

Distributed database: These are databases of local work-groups and departments at regional offices, branch offices, manufacturing plants and other work sites.

Hypermedia databases: WWW can be thought of as a database, albeit one spread across millions of independent computing systems.

Microsoft access: It is a relational database management system from Microsoft that combines the relational Microsoft Jet Database ls.

Modeling language: A modeling language is a data modeling language to define the schema of each database hosted in the DBMS, according to the DBMS database model.

Object database models: In recent years, the object-oriented paradigm has been applied in areas such as engineering and spatial databases, telecommunications and in various scientific domains.

Post-relational database models: The products offering a more general data model than the relational model are sometimes classified as post-relational.

Self-Assessment Questions

1. DBMS helps achieve

    (a) Data independence

    (b) Centralized control of data

    (c) Neither A nor B

    (d) Both A and B

2. Relational model stores data in the form of_____.

    (a) Maps

    (b) Pages

    (c) Tables

    (d) files

3. ………………… is a full form of SQL.

    (a) Standard query language

    (b) Sequential query language

    (c) Structured query language

    (d) Server-side query language

4. Integrity rules that define the procedure to protect the data pertain to _____

    (a) Integrity

    (b) Integration

    (c) Standardization

    (d) Schema

5. A relational database developer refers to a record as

    (a) a criteria

    (b) a relation

    (c) an attribute

    (d) a tuple

6. Multidimensional model is useful in

    (a) CRM systems

    (b) Online Analytical Processing (OLAP)

    (c) ERP systems

    (d) Banking systems

7. Which of the following is not a valid SQL type?

    (a) FLOAT

    (b) NUMERIC

    (c) CHARACTER

    (d) DECIMAL

8. _____ database structure is the most commonly used today.

    (a) Relational structure

    (b) Network structure

    (c) Object structure

    (d) Hierarchical structure

9. _____ was used in early mainframe DBMS records.

    (a) Relational structure

    (b) Network structure

    (c) Object structure

    (d) Hierarchical structure

10. The multidimensional structure is similar to the relational model.

(a) True   (b) False

11. DBMS is a computer hardware program.

    (a) True   (b) False

12. The network structure consists of more

    (a) Complex relationships   (b) Single relationship

    (c) All of these   (d) Double relationship

13. The relational database was born in

    (a) 1978   (b) 1975

    (c) 1970   (d) 1960

14. Which of the following is not a DDL command?

    (a) TRUNCATE
    (b) ALTER
    (c) CREATE
    (d) UPDATE

15. Which command is used to change the definition of a table in SQL?

    (a) ALTER
    (b) CREATE
    (c) UPDATE
    (d) SELECT

Review Questions

1.   What is Database? What are the different types of database?
2.   What are analytical and operational database? What are other types of database?
3.   Define the Data Definition Subsystem.
4.   What is Microsoft Access? Discuss the most commonly used corporate databases.
5.   Write the full form of DBMS. Elaborate the working of DBMS and its components?
6.   Discuss in detail the Entity-Relationship model?
7.   Describe working with Database.
8.   What is Object database models? How it differs from other database models?
9.   Discuss the data independence and its types?
10. What are the various database models? Compare.
11. Describe the common corporate DBMS?
12. What are the different SQL statements? Write the syntax for DDL and DML commands?

Answers to Self-Assessment Questions

1. (d)	2. (c)	3. (c)	4. (a)	5. (d)	6. (b)
7. (d)	8. (a)	9. (d)	10. (a)	11. (b)	12. (a)
13. (c)	14. (d)	15. (a)			

Further Readings

Introduction to Database Management Systems by Atul Kahate, Pearson Publishers

Fundamentals of Database Systems Seventh Edition (iran-lms.com)

Dr. Tarandeep Kaur, Lovely Professional University

Unit 09: Software Programming and Development

Objectives

- Understand the software programming and development
- Discuss Hardware/Software Interaction.
- Know about planning of a computer program
- Understand Basic of Programming.

9.1 Software Programming and Development

Software programming refers to the act of writing computer code that enables the computer software to function. It involves using a computer language to develop programs. The task of software programming is carried out by the software programmers. The software programmers design programs to carry out specific functions.

Software programming is not the same as software development. *Software development* is the actual design of a program while programming is the carrying out of the instructions of development. The people who program software are called as computer programmers. The computer programmers are also concerned with programming the computers by writing the computer programs.

Whatisa ComputerProgram?

A *computer program* is a collection of instructions that can be executed by a computer to perform a specific task. The computer programs may be categorized along functional lines, such as application software and system software.

Computer programming is the process of designing and building an executable computer program to accomplish a specific computing result or to perform a specific task. The programming involves tasks such as: analysis, generating algorithms, profiling algorithms' accuracy and resource consumption, and the implementation of algorithms in a chosen programming language (commonly referred to as coding). The source code of a program is written in one or more languages that are intelligible to programmers, rather than machine code, which is directly executed by the central processing unit.

There are several duties that are performed by the computer programmers such as writing new programs in different languages; updating and expanding existing programs; testing programs for mistakes and fixing faulty code. It also involves using code libraries, or collections of independent code lines, to simplify the code writing process.

Additionally, the purpose of programming is to find a sequence of instructions that will automate the performance of a task (which can be as complex as an operating system) on a computer, often

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for solving a given problem. Proficient programming thus often requires expertise in several different subjects, including knowledge of the application domain, specialized algorithms, and formal logic. The tasks accompanying and related to programming include: testing, debugging, source code maintenance, implementation of build systems, and management of derived artifacts, such as the machine code of computer programs. These might be considered part of the programming process, but often the term software development is used for this larger process with the term programming, implementation, or coding reserved for the actual writing of code. Software engineering combines engineering techniques with software development practices. Reverse engineering is a related process used by designers, analysts and programmers to understand and re-create/re-implement.

Quality Requirements in Programming

Quality requirementsare specifications of thequalityof products, services, processes or environments. Quality is anyelement, tangible or intangible, that gives things value beyond their functionality and features. Whatever the approach to development may be, the final program must satisfy some fundamental properties. The following areillustrative examples of quality requirements in programming (Figure 1):

Performance/ Efficiency

Performance of a program pertains to the amount of system resources a program consumes (processor time, memory space, slow devices such as disks, network bandwidth and to some extent even user interaction): the less, the better. It also includes correct disposal of some resources, such as cleaning up temporary files and lack of memory leaks.

Reliability

Reliability of a program pertains to "How often the results of a program are correct?". It depends on the conceptual correctness of algorithms, and minimization of programming mistakes, such as mistakes in resource management (buffer overflows and race conditions) and logic errors (such as division by zero or off-by-one errors).

Robustness

Robustness of a program focuses on "How well a program anticipates problems not due to programmer error?". It includes situations such as incorrect, inappropriate or corrupt data, unavailability of needed resources such as memory, operating system services and network connections, and user error.

Readability of Source Code

Readability of a source code discusses the ease with which a human reader can comprehend purpose, control flow & operation of source code. It is important for programmers as they spend majority of their time reading, understanding & modifying existing source code, rather writing new source code. Any unreadable code often leads to bugs, inefficiencies & duplicated code. There are several factors that contribute to readability and facilitate efficient compilation and execution of code such as:

o Different indentation styles (whitespace)

o Comments

o Naming conventions for objects (such as variables, classes, procedures, etc.).

Few simple readability transformations can help making the code shorter and drastically reducing time to understand it. It greatly affects the aspects of quality.

Additional Quality Aspects

Figure 1: Additional Aspects of Quality

Portability

The quality aspect, portability, specifies the range of computer hardware and Operating System (OS) platforms on which the source code of a program can be compiled/interpreted and run. It depends on the programming facilities provided by the different platforms (hardware and OS resources, and availability of platform specific compilers for the language of the source code).

Maintainability

Maintainability aspect of quality signifies the ease with which a program can be modified by its present or future developers. It ensures making improvements or customizations, fixing bugs and security holes, or adaptation it to new environments easily. It significantly affects the fate of a program over the long term.

Usability

Usability signifies the ease with which a person can use the program for its intended purpose. It involves a wide range of textual, graphical and sometimes hardware elements that improve the clarity, intuitiveness, cohesiveness and completeness of a program's user interface.

Algorithmic Complexity

The academic field and engineering practice of computer programming are both largely concerned with discovering and implementing the most efficient algorithms for a given class of problem. Mostly, the algorithms are classified into orders using so-called Big O notation, O(n).

Big O notation expresses resource use, such as execution time or memory consumption, in terms of the size of an input. The expert programmers use a variety of well-established algorithms and their respective complexities and use this knowledge to choose algorithms that are best suited to the circumstances.

Methodologies

The first step in software development projects is requirements analysis, followed by testing to determine value modelling, implementation, and failure elimination (debugging). There are many approaches for software development and programming. One approach popular for requirements analysis is Use Case analysis. Certain popularmodelling techniques are used such as: Object-Oriented Analysis and Design (OOAD) and Model-Driven Architecture (MDA). Certain modelling techniques are used for database design, such as, Entity-Relationship Modelling (ER Modeling). Other techniques that are used are imperative languages (object-oriented or procedural), functional languages, and logic languages.

Measuring Language Usage

The kind of applications for which a language will be used also formulates a quality aspect. Some languages are very popular for particular kinds of applications.COBOL is still strong in the corporate data center, FORTRAN in engineering applications, scripting languages in web development, and C in embedded applications. Many applications use a mix of several languages. The methods of measuring programming language popularity include: counting the number of job

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advertisements that mention the language, the number of books teaching the language that are sold (this overestimates the importance of newer languages), and estimates of the number of existing lines of code written in the language.

Debugging

Debugging is an important task in software development process.An incorrect program can have significant consequences for its users. Some languages are more prone to some kinds of faults.Some language specifications does not require compilers to perform as much checking as other languages. Debugging can involve usage of static analysis tools to detect some possible problems. However, it is often done with IDEs like Eclipse, Kdevelop, NetBeans, Code Blocks, and Visual Studio. The standalone debuggers like, gdb, are also used and provide less of a visual environment, usually using a command line.

Programming Languages

Different programming languages support different styles of programming (called programming paradigms). The choice of language used is subject to many considerations, such as company policy, suitability to task, availability of third-party packages, or individual preference. Ideally, the programming language best suited for the task at hand will be selected. The trade-offs from this ideal involve finding enough programmers who know the language to build a team, the availability of compilers for that language, and the efficiency with which programs written in a given language execute. Languages form an approximate spectrum from "low-level" to "high-level"; "low-level" languages are typically more machine-oriented and faster to execute, whereas "high-level" languages are more abstract and easier to use but execute less quickly. It is usually easier to code in "high-level" languages than in "low-level" ones (also listed in Table 1).

Table 1: Comparison of Low-level and High-level Languages

Low-Level Languages	High-Level Languages
More machine-oriented.	More abstract and easier to use.
Faster to execute.	Execute less quickly.
Little complex to code.	Easier to code.

In every programming languages, a few basic instructions appear that include:

o Input: Get data from the keyboard, a file, or some other device.

o Output: Display data on the screen or send data to a file or other device.

o Arithmetic: Perform basic arithmetical operations like addition and multiplication.

o Conditional execution: Check for certain conditions and execute the appropriate sequence of statements.

o Repetition: Perform some action repeatedly, usually with some variation.

Paradigms

Computer programs can be categorized by the programming language paradigm used to produce them. There are two of the main paradigms: imperative and declarative. The programs written using an imperative language specify an algorithm using declarations, expressions, and statements where a declaration couples a variable name to a datatype. For example: An expression yields a value. For example: 2 + 2 yields 4. Finally, a statement might assign an expression to a variable or use the value of a variable to alter the program's control flow.

Contrarily, the programs (written using a declarative language) specify properties that have to be met by the output. Such programs do not specify details expressed in terms of control flow of the executing machine but of the mathematical relations between the declared objects and their properties. The two broad categories of declarative languages are functional languages and logical languages. The functional languages (like Haskell) do not allow side effects, which makes it easier

to reason about programs like mathematical functions. Logical languages (like Prolog) define problem to be solved, the goal and leave detailed solution to Prolog system itself. Initially, the goal is defined by providing a list of subgoals. Then each subgoal is defined by further providing a list of its subgoals. If a path of subgoals fails to find a solution, then that subgoal is backtracked & another path is systematically attempted.The form in which a program is created may be textual or visual. In a visual language program, elements are graphically manipulated rather than textually specified.

Compiling or Interpreting

A computer program in the form of a human-readable, computer programming language is called source code. Source code may be converted into an executable image by a compiler or executed immediately with the aid of an interpreter. The compilers are used to translate source code from a programming language into either object code or machine code. The object code needs further processing to become machine code, and machine code is the CPU's native code, ready for execution.

Java computer programs are compiled ahead of time and stored as a machine independent code called bytecode. The bytecode is executed on request by an interpreter called Virtual Machine (VM).Some systems use just-in-time compilation (JIT) whereby sections of the source are compiled 'on the fly' and stored for subsequent executions.

The interpreted programs allow a user to type commands in an interactive session.When a language is used to give commands to a software application (such as a shell) it is called a scripting language. The interpreted computer programs -in a batch or interactive session—are either decoded and then immediately executed or are decoded into some efficient intermediate representation for future execution. The examples of immediately executed computer programs are- BASIC, Perl, and Python. It is worth noting that software development gets faster using an interpreter because testing is immediate when the compiling step is omitted.

Self-Modifying Programs

A computer program can modify itself.The modified computer program is subsequently executed as part of the same program. Some of the possible programs written in machine code, assembly language, Lisp, C, COBOL, PL/1, Prolog and JavaScript (the eval feature) among others.

Execution and Storage

Computer programs are stored in non-volatile memory until requested either directly or indirectly to be executed by the computer user. Upon such a request, the program is loaded into RAM, by a computer program called an Operating System, where it can be accessed directly by CPU. The CPU then executes the program, instruction by instruction, until termination. Finally, a program in execution is called a process.

Functional Categories

System software and application software are main functional categories in programming.

System Software: System software is software designed to provide a platform for other software. It includes OS which couples computer hardware with application software. It also includes utility programs to manage and tune computer. Examples of system software include operating systems like macOS, Linux, Android and Microsoft Windows, computational science software, game engines, industrial automation, and Software-as-a-Service (SaaS) application.

Application Software: If a computer program is not system software then it is an application software. An application software includes middleware that couples system software with the user interface. It also includes utility programs that help users solve application problems, like the need for sorting.

There existdevelopment environments that gather the system software (compilers and system's batch processing scripting languages) and application software (such as IDEs) for the specific purpose of helping programmers to create new programs.

9.2 Planning a Computer Program

The planning of program is very important task in programming to be done by the programmer. In order to write a correct program, a programmer must write each and every instruction in the

correct sequence. The logic (instruction sequence) of a program can be very complex.Hence, the programs must be planned before they are written to ensure program instructions. It is important to check the appropriateness for the problem and correct sequence for the same.

Algorithm

An algorithm refers to the logic of a program and a step-by-step description of how to arrive at the solution of a given problem.In order to qualify as an algorithm, a sequence of instructions must have following characteristics:

Each and every instruction should be precise and unambiguous.

Each instruction should be such that it can be performed in a finite time.

One or more instructions should not be repeated infinitely. This ensures that the algorithm will ultimately terminate.

After performing the instructions, that is after the algorithm terminates, the desired results must be obtained.

Let us explore few sample examples to understand about algorithm.

Sample Algorithm 1: There are 50 students in a class who appeared in their final examination. Their mark sheets have been given. The division column of the mark sheet contains the division (FIRST, SECOND, THIRD or FAIL) obtained by the student.Write an algorithm to calculate and print the total number of students who passed in FIRST division.

Solution: Follow the steps below in order to calculate and print the total number of students who passed in FIRST division.

- Step 1: Initialize Total_First_Division and Total_Marksheets_Checked to zero.
- Step 2: Take the mark sheet of the next student.
- Step 3: Check the division column of the mark sheet to see if it is FIRST, if no, go to Step 5.
- Step 4: Add 1 to Total_First_Division.
- Step 5: Add 1 to Total_Marksheets_Checked.
- Step 6: Is Total_Marksheets_Checked = 50, if no, go to Step 2.
- Step 7: Print Total_First_Division.
- Step 8: Stop

Sample Algorithm 2: There are 100 employees in an organization. The organization wants to distribute annual bonus to the employees based on their performance. The performance of the employees is recorded in their annual appraisal forms.Every employee's appraisal form contains his/her basic salary and the grade for his/her performance during the year. The grade is of three categories– 'A' for outstanding performance, 'B' for good performance, and 'C' for average performance.It has been decided that the bonus of an employee will be:100% of basic salary for outstanding performance; 70% of the basic salary for good performance and 40% of the basic salary for average performance, and zero for all other cases.

Solution: Follow the steps below in order to find the bonus for the employee as per his performance.

- Step 1: Initialize Total_Bonus and Total_Employees_Checked to zero.
- Step 2: Initialize Bonus and Basic_Salary to zero.
- Step 3: Take the appraisal form of the next employee.
- Step 4: Read the employee's Basic_Salary and Grade.
- Step 5: If Grade= A, then Bonus = Basic_Salary. Go to Step 8.
- Step 6: If Grade= B, then Bonus = Basic_Salary x 0.7. Go to Step 8.
- Step 7: If Grade= C, then Bonus = Basic_Salary x 0.4.
- Step 8: Add Bonus to Total_Bonus.

- Step 9: Add 1 to Total_Employees_Checked.

- Step 10: If Total_Employees_Checked< 100, then go to Step 2.

- Step 11: Print Total_Bonus.

- Step 12: Stop.

Representation of Algorithms

Algorithms can be represented as programs, flowcharts, pseudocodes. An algorithm represented in the form of a programming language becomes a program.Thus, any program is an algorithm, although the reverse is not true. Let us explore each one of the algorithmic representation ways in detail:

Flowcharts: Flowcharts are the pictorial representation of an algorithm. It uses symbols (boxes of different shapes) that have standardized meanings to denote different types of instructions (Figure 2). The actual instructions are written within the boxes where the boxes areconnected by solid lines having arrow marks to indicate the exact sequence in which the instructions are to be executed. The process of drawing a flowchart for an algorithm is called flowcharting.

The flowchart usesvarious kinds of symbols representing different kinds of shapes (Figure 2). The different kinds of boxes have certain standardized meanings to represent or depict various types of instructions that they are representing. The boxes are connected out through solid lines that reflect the flow of data and indicate the exact sequence in which the instructions will be executed. The terminal box indicates the start and final operation; the input-output box is used to read an input, output. Then, there is a processing box that reflects the processing activity and a decision box to check out for any different kinds of conditions. The flow lines have arrows and they indicate the control of sequence of instructions how they will be executing. Then,there are connectors to connect different kind of functions of a particular algorithm or a particular flowchart.

Suppose,there are two different branches two-way branches of flowchart, and three-way branching decisions (Figure 3 and Figure 4). In first decision, we have to take decision to check if I is equal to 10. If I=10 is true then control shifts to yes condition and otherwise no condition statements will proceed. In another figure, there is a three-way branch decision. A check decision is required to made regarding two variables, A and B. If A>B, then the branching will move to that decision; if A<B, then branching will proceed to other branching statements; and if A=B, then again branching to next statement will be done. Similarly, we have a multi-way branch decision. The branching will move to the loop where the correct value of I will match.
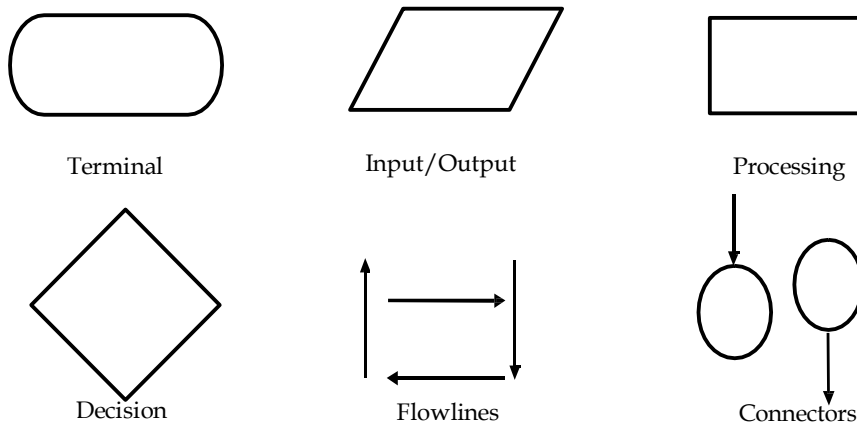

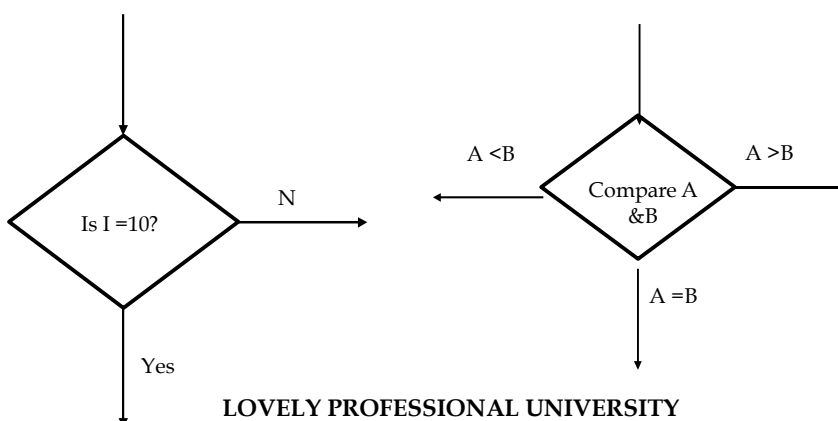*Figure 2: Different Symbols in a Flowchart*

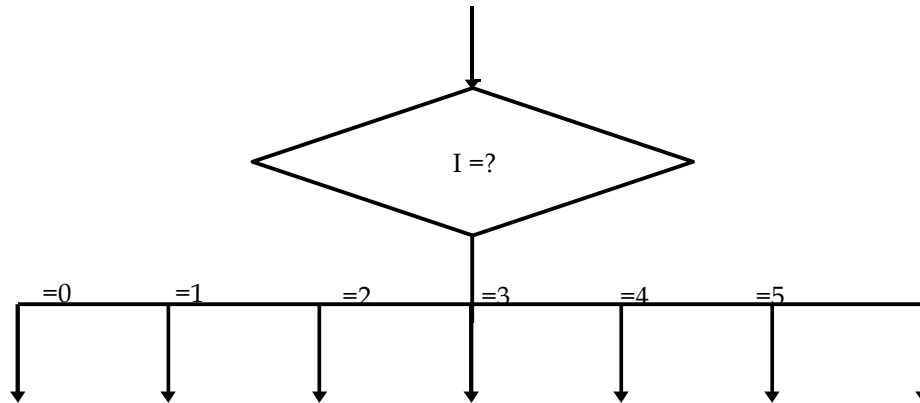*Figure 3 (a) & (b): Two-way and Three-way Branch Decision*

Figure 4: Multiple-way Branch Decision

Let us consider sample flowcharts to understand the working of flowchart. A student appears in an examination, which consists of total 10 subjects, each subject having maximum marks of 100. The roll number of the student, his/her name, and the marks obtained by him/her in various subjects are supplied as input data. Such a collection of related data items, which is treated as a unit is known as a record.Draw a flowchart for the algorithm to calculate the percentage marks obtained by the student in this examination and then to print it along with his/her roll number and name. The following is the flowchart for the same.
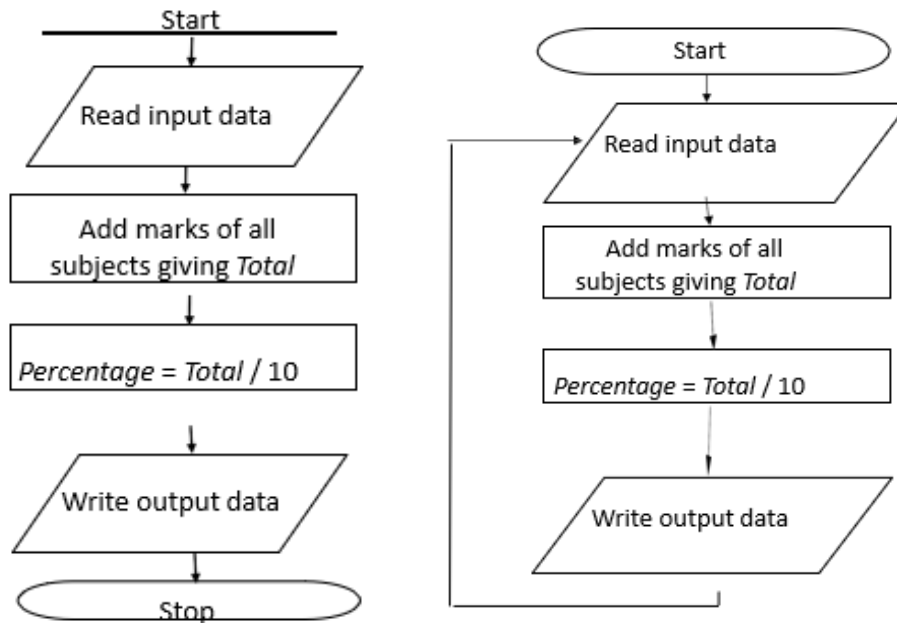

Figure 5: Flowchart 1(a) and 1(b)

In this flowchart (Figure 5-1(a)), a student appears in an examination, which consists of 10 subjects. Each subject is havingmaximum marks of 100.If it's 10 subjects, then total marks are 1000 marks. The roll number of the student and his/her name and the marks that is obtained by him in different kind of subjectsare supplied out as input data. The task is to draw a particular flowchart for this algorithm to calculate the percentage marks that is obtained by this student in this examination and to print his name, along with his roll number.

Firstly, wewill read the input data that is the marks obtained in allsubjects followed by adding all the marks. giving the total value and then calculating the percentage. This is followed by writing

the final output in the input-output box and use the terminate box to indicate the stop condition. In Figure 5- 1(b), there is no termination box and stop condition. This creates an infinite loop and is incomplete.
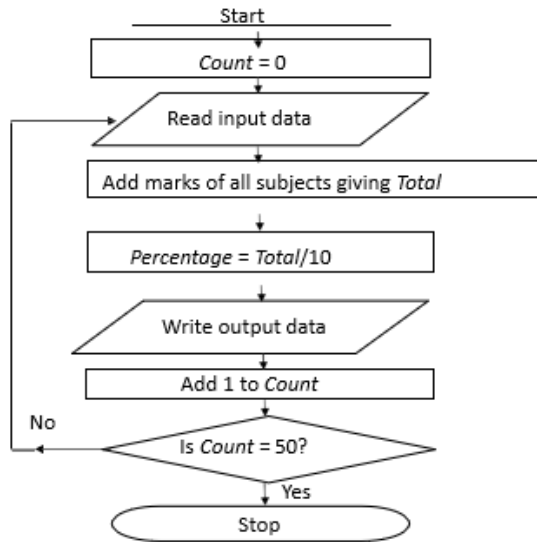

Figure 6: Flowchart 2 Using Counter

Now, suppose there are 50 students in the class who appear in the examination. The problem is to draw a flowchart for this algorithm to calculate and print the percentage marks that are obtained by each student in the class with his/her name and the roll number. Firstly, we will read the marks obtained by all the 50 students in all the subjects. We will calculate the marks of the subjects giving the total value for every student, then calculate the percentage. Finally, the output will be displayed.

In the next scenario, we will use a counter variable that will count how many students to actually initialize. So, there is a counter that we have initialized in the initial stage as zero. We can read the input data of all the students and all the marks they have obtained in 10 subjects; then calculate the percentage and write the output data. Then, we will add one to the count and at the last check whether this count has reached to 50. This process will continue and subsequently move to the next student record until the counter reaches 50.

Levels of Flowchart-Flowchart that outlines the main segments of a program or that shows less details is called as a macro flowchart while a flowchart with more details is a micro flowchart or a detailed flowchart (as illustrated in Figure 7). There are no set standards on the amount of details that should be provided in a flowchart.
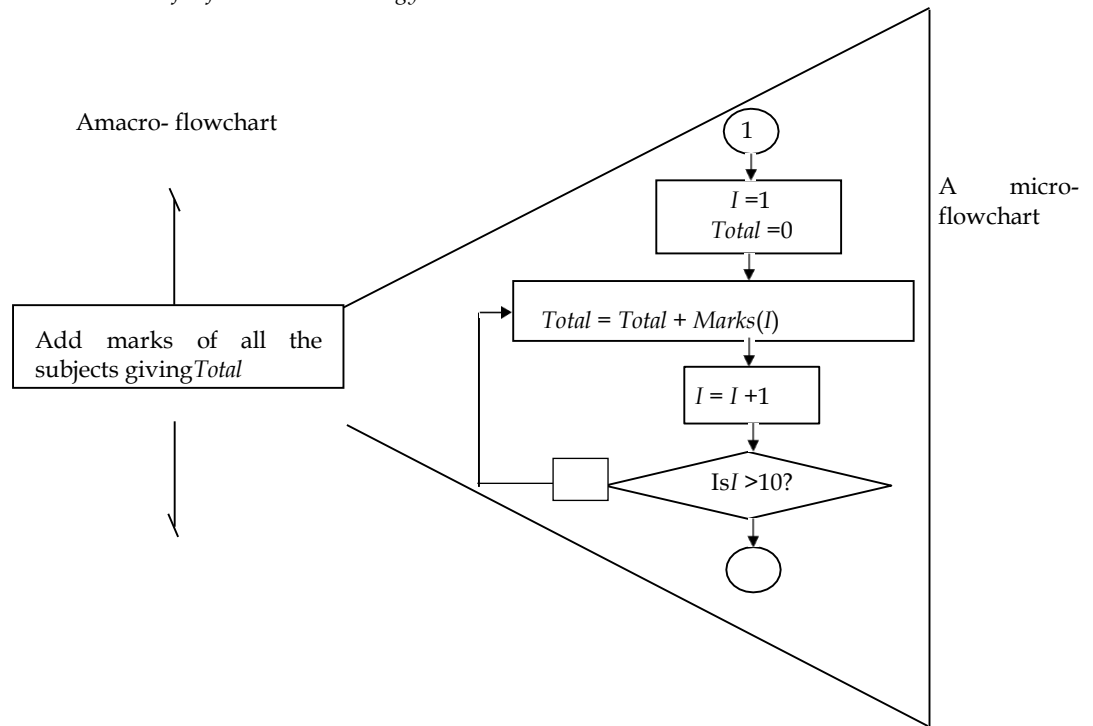
Amacro- flowchart

A   micro-
flowchart

Add marks of all the
subjects giving*Total*

1

$I = 1$
$Total = 0$

$Total = Total + Marks(I)$

$I = I + 1$

Is$I > 10?$

Figure 7: Macro and Micro Flowchart

Flowcharting Rules-There are certain flowcharting rules such as-

- Firstly, chart the main line of logic, then incorporate detail.
- Maintain a consistent level of detail for a given flowchart.
- Do not chart every detail of the program.
- A reader who is interested in greater details can refer to the program itself.
- Words in the flowchart symbols should be common statements and easy to understand.
- Be consistent in using names and variables in a flowchart.
- Go from left to right and top to bottom in constructing flowcharts.
- Keep the flowchart as simple as possible.
- Crossing of flow lines should be avoided as far as practicable.
- If a new flowcharting page is needed, it is recommended that the flowchart be broken at an input or output point.
- Properly labelled connectors should be used to link the portions of the flowchart on different pages.

Advantages of using Flowcharts- There are certain advantages of the flowcharts. Some of them are listed below:

- Better Communication
- Proper program documentation
- Efficient coding
- Systematic debugging
- Systematic testing

Limitations of Flowchart-

- Very time consuming and laborious to draw (especially for large complex programs).
- Redrawing a flowchart for incorporating changes/ modifications is a tedious task.
- No specific standards determining the amount of detail that should be included in a flowchart.

Pseudocode:A program planning tool where program logic is written in an ordinary natural language using a structure that resembles computer instructions."Pseudo" means imitation or false and "Code" refers to the instructions written in a programming language. It is an imitation of actual computer instructions that emphasizes the design of the program. It is also called as Program Design Language (PDL). There are certain advantages of using pseudocodes such as:

- Converting a pseudocode to a programming language is much easier than converting a flowchart to a programming language.

- As compared to a flowchart, it is easier to modify the pseudocode of a program logic when program modifications are necessary.

- Writing of pseudocode involves much less time and effort than drawing an equivalent flowchart as it has only a few rules to follow.

Limitations of Pseudocode

- Graphic representation of program logic is not available.

- No standard rules to follow in using pseudocode.

- Different programmers use their own style of writing pseudocode and hence communication problem occurs due to lack of standardization.

- For a beginner, it is more difficult to follow the logic of or write pseudocode.

Basic Logic (Control) Structures

Any program logic can be expressed by using only following three simple logic structures:

1.Sequence logic

2.Selection logic

3.Iteration (or looping) logic

The programs that are structured by using only these three logic structures are called structured programs. The technique of writing such programs is known as structured programming.

Sequence Logic: It is used for performing instructions one after another in sequence(Figure 8).
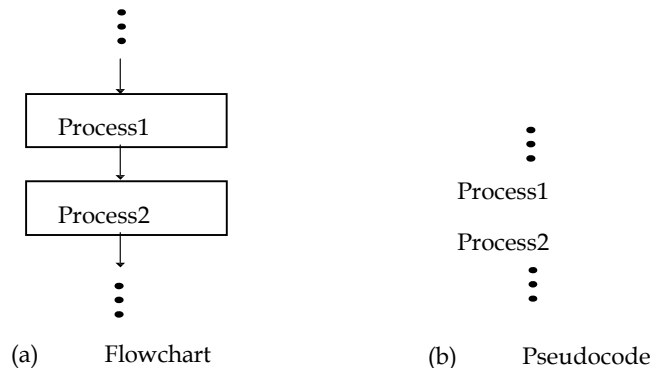
Figure 8: Example for Sequence Logic

Selection Logic: It is also known as decision logic and is used for making decisions. The three popularly used selection logic structures are (Figure 9, Figure 10 and Figure 11):

IF…THEN…ELSE

IF…THEN

CASE

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(a) Flowchart

(b) Pseudocode
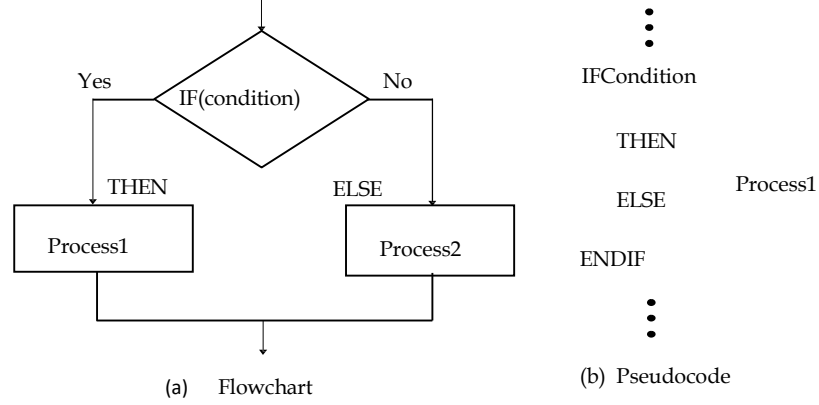
Figure 9: Selection Logic (IF…THEN…ELSE Structure)

(a) Flowchart

(b) Pseudocode
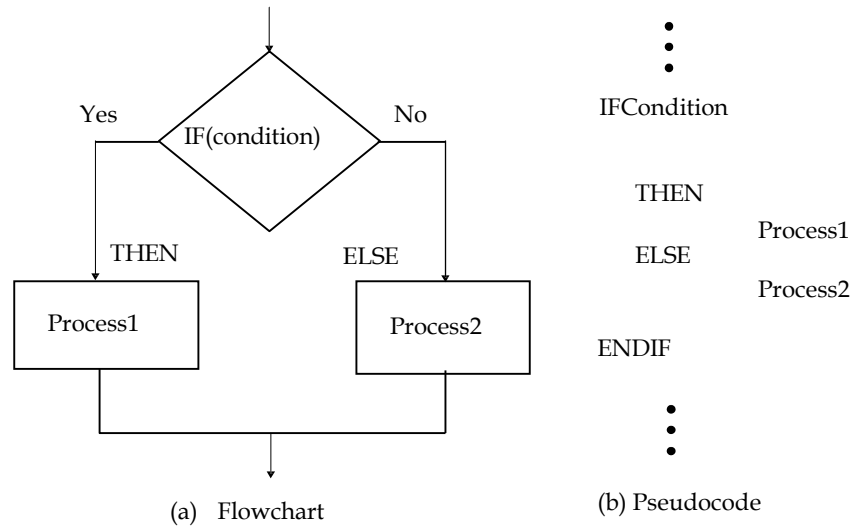
Figure 10: Selection Logic (IF…THEN Structure)

(a) Flowchart

(b)Pseudocode

Figure 11: Selection Logic (CASE Structure)

Iteration (or Looping) Logic: It is used to produce loops in program logic when one or more instructions may be executed several times depending on some conditions. The two most popularly used iteration logic structures are (Figure 12 and Figure 13):
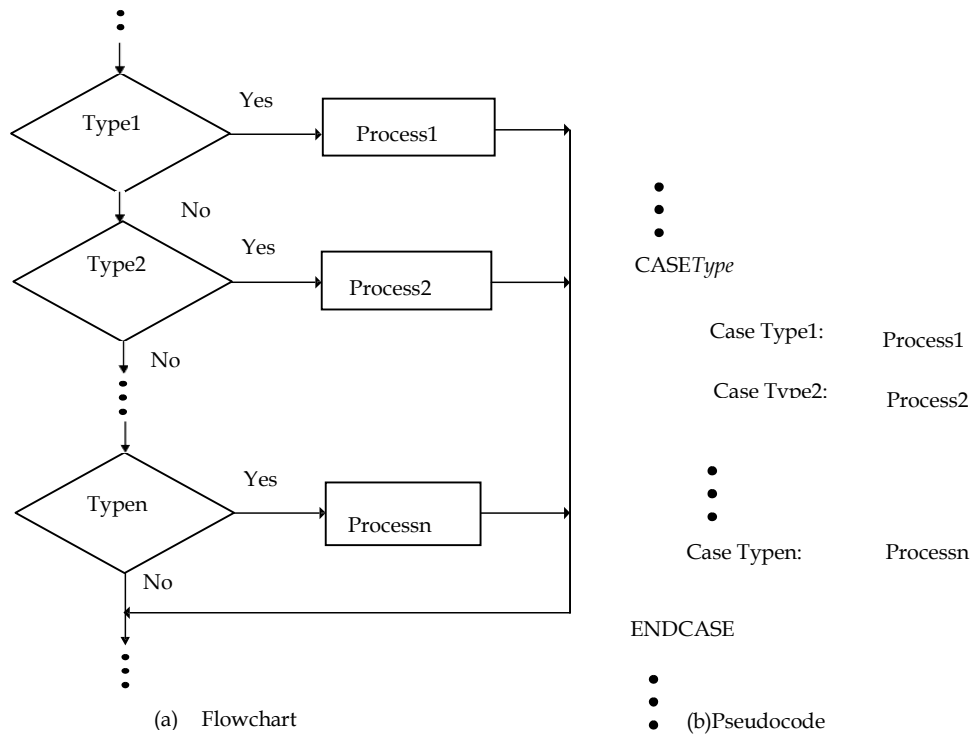
  o DO…WHILE
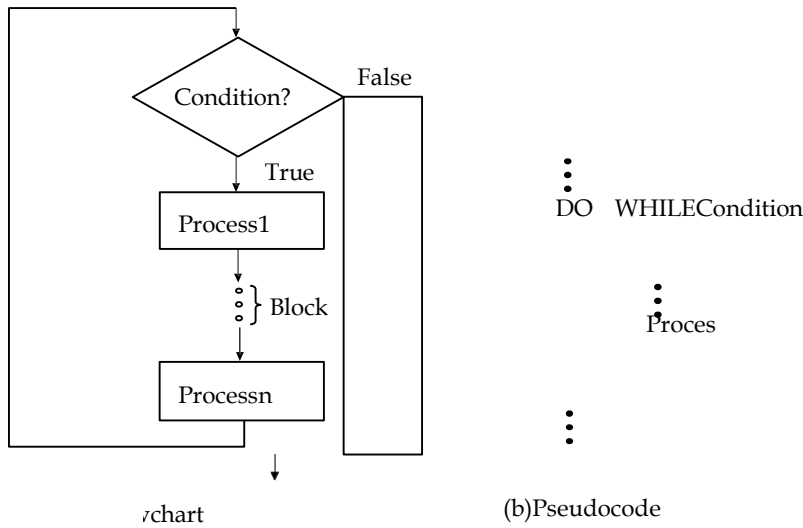
  o REPEAT…UNTIL

Figure 12: Iteration (or Looping) Logic (DO…WHILE Structure)
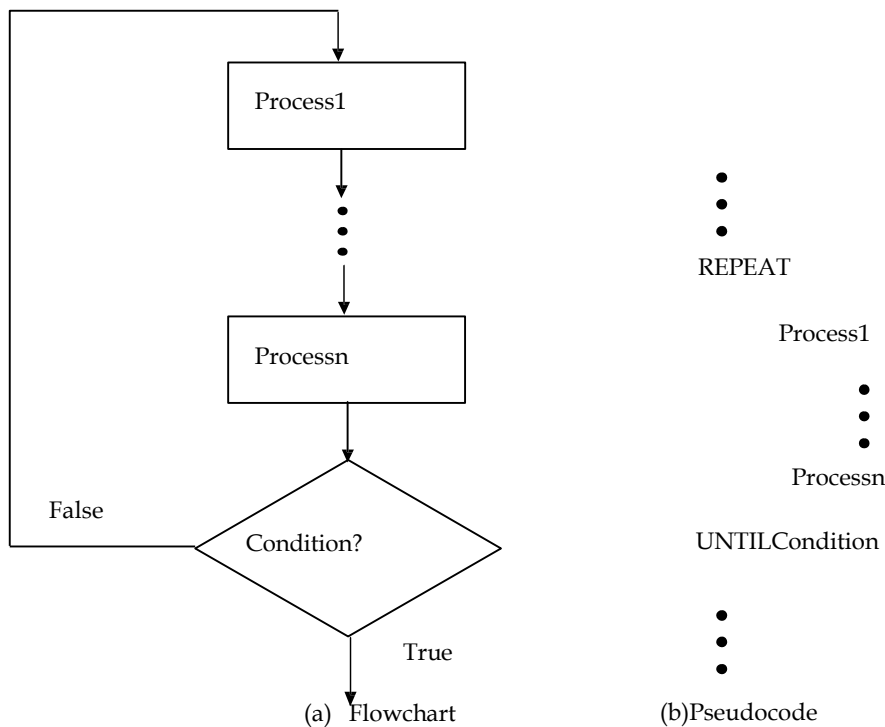
Figure 13: Iteration (or Looping) Logic (Repeat-Until Condition)

9.3 Hardware-Software Interactions

An interfacerefers to a point of interaction between components and is applicable at the level of both hardware and software. It acts as means of communication between the computer and the user through the peripheral devices such a monitor or a keyboard, an interface with the internet via Internet Protocol, and any other point of communication involving a computer. It allows a component whether a piece of hardware such as a graphics card or a piece of software such as an internet browser, to function independently while using interfaces to communicate with other

components via an I/O system.Most modern computer systems are built as a series of layers, or levels. The lowest level is usually considered the physical "hardware" layer and the topmost layer is usually a user application or source code (Figure 14).

Software Interfaces

There are range of different types of interface at different "levels".An Operating System (OS) may interface with pieces of hardware, applications or programs running on the OS may need to interact via streams, and in object-oriented programs, objects within an application may need to interact via methods. There are several software interfaces that are being practically used while certain of them are used in object-oriented languages. The major characteristics for each are:

Software Interfaces in Practice

• S/W provides access to computer resources (memory, CPU, storage etc.) by its underlying computer system.

• Access is allowed only through well-defined entry points, that is, interfaces.

• Types of access that interfaces provide between S/W components can include: constants, data types, types of procedures, exception specifications & method signatures.

• Interface of a software module is deliberately kept separate from the implementation of that module.

• The latter contains the actual code of the procedures and methods described in the interface, as well as other "private" variables, procedures etc.
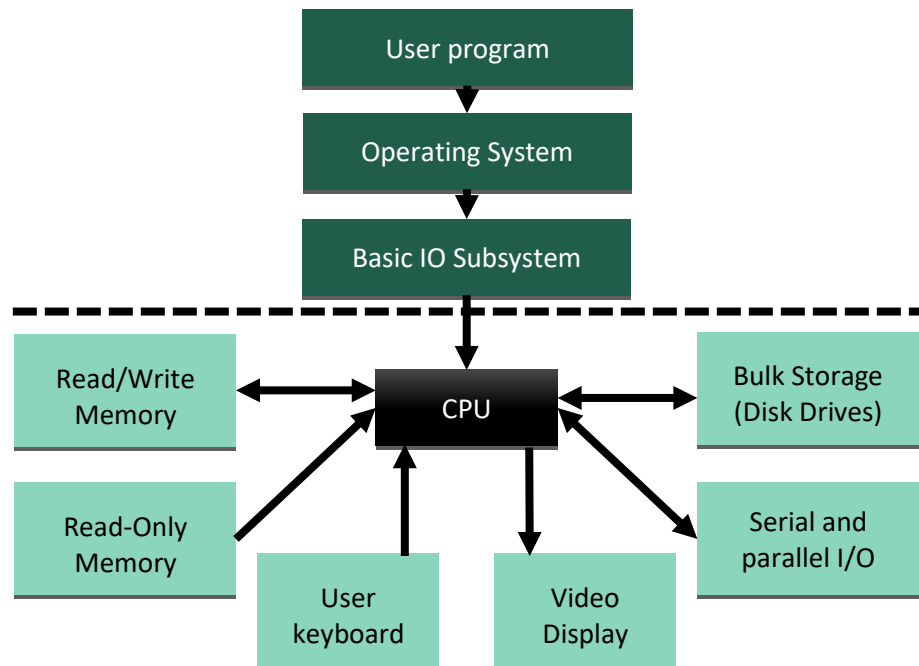
Figure 14: Hardware-Software Interaction Scenario

Software Interfaces in Object Oriented Languages

• In object-oriented languages, the term "interface" is often used to define an abstract type that contains no data but exposes behaviours defined as methods.

• A class having all the methods corresponding to that interface is said to implement that interface.

• A class can implement multiple interfaces, and hence can be of different types at the same time.

• An interface is hence a type definition; anywhere an object can be exchanged (in a function or method call) the type of the object to be exchanged can be defined in terms of an interface instead of a specific class.

• This allows later code to use the same function exchanging different object types.

• A method in an interface cannot be used directly; there must be a class implementing that object to be used for the method invocation.

- Example 1: One can define an interface called "Stack" that has two methods: push () and pop () and later implement it in two different versions such that FastStack and Generic Stack-the first being faster but working with a stack of fixed size, and the second using a data structure that can be resized.This approach helps in defining interfaces with a single method.

- Example 2: Java language defines the interface Readable that has the single read () method and a collection of implementations to be used for different purposes, among others. There are other methods associated with it such as: BufferedReader, FileReader, InputStreamReader, PipedReader, and StringReader.

> In its purest form, an interface (like in Java) must include only methoddefinitions and constant values that make up part of the static interface of atype. Some languages (like C#) also permit the definition to include propertiesowned by the object, which are treated as methods with syntactic sugar

Programming against Software Interfaces: The use of interfaces allows implementation of a programming style called programming against interfaces. The basic idea is to base the logic one develops on the sole interface definition of the objects one uses and not to make the code depend on the internal details. It allows the programmer the ability to later change the behaviour of system by simply swapping object used with another implementing same interface.One can introduce inversion of control which means leaving the context to inject the code with the specific implementations of interface that will be used to perform the work.

Hardware Interfaces

Hardware interfaces exist in computing systems between many of components such as various buses, storage devices, other I/O devices etc. These can be described by mechanical, electrical & logical signals at the interface & the protocol for sequencing them (called signaling). A standard interface, such as SCSI, decouples the design and introduction of computing hardware, such as I/O devices, from design & introduction of other components of a computing system. It allows the users and manufacturers great flexibility in the implementation of computing systems.

9.4 How Programs Solve Problems

The process of solving problems is carried out through a programming process. The development of a program involves steps similar to any problem-solving task. There are five main ingredients in the programming process are:

1. Defining the problem: This phase involves identifying what it is you know (input-given data), and what it is you want to obtain (output-the result). It can be a written agreement specifies the kind of input, processing, and output required.

2. Planning the solution: It is important to plan the possible solution and use different strategies for the same.

3. Coding the program: Coding implies expressing a solution in a programming language. It involves translating the logic from the flowchart or pseudocode-or some other tool-to a programming language. Programming language is a set of rules that provides a way of instructing the computer what operations to perform such as BASIC, COBOL, Pascal, FORTRAN, and C are different programming languages. In order to get a program to work, one has to follow exactly the rules, the syntax-of the language one is using. It is important to ensure the correct use of the language.Then, the coded program must be keyed, probably using a terminal or personal computer, in a form the computer can understand.

4. Testing the program: A well-designed program may not be written correctly the first time. The programmers must tend to be precise, careful, detail-oriented people.After coding the program, one must prepare to test it on the computer. Testing involves these phases:

   (a) Desk-checking: The process in which group of programmer's peers-review a program and offers suggestions. It is similar to proofreading. The careful desk-checking discovers several errors and possibly save time in the long run. It also involves mental tracing, or checking logic of program in attempt to ensure error-free and workable program.

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(b) Translating: The translator is a program that checks syntax of a program to ensure programming language has been used correctly, giving all syntax-error messages, called diagnostics. It translates a program into a form computer can understand and tells if programming language has been used improperly. It helps to discover any syntax errors and produces descriptive error messages. The programs are most commonly translated by a compiler. The compiler translates an entire program at one time. The overall translation process involves original program, called a source module, which is transformed by a compiler into an object module. The prewritten programs from a system library may be added during the link/ load phase, which results in a load module. The load module can then be executed by the computer.

(c) Debugging: It is used extensively in programming and consists of detecting, locating & correcting bugs (mistakes). The bugs are logic errors (like telling computer to repeat an operation but not telling how to stop repeating). It is important to run the program using test data but plan test data carefully to ensure testing every part of program. Debugging is often done with IDE like Eclipse, k develop & visual studio.

5. Documenting the program: It is an ongoing, necessary process which consists of writing a detailed description of programming cycle and specific facts about the program. The program documentation materials include origin & nature of problem, a brief narrative description of program, logic tools (flowcharts and pseudocode, data-record descriptions, program listings, and testing results). Comments in the program itself are also considered an essential part of documentation. In a broader sense, program documentation can be part of the documentation for an entire system. The wise programmer documents the program throughout its design, development, and testing. It is needed to supplement human memory and to help organize program planning as it is critical to communicate with others who have an interest in the program. The written documentation is needed so that those who come after one can make any necessary modifications in the program or track down any errors that one misses.

Summary

- The programmer prepares the instructions of a computer program and runs thoseinstructions on the computer tests the program to see if it is working properly and makescorrections to the program.
- The programmer who uses an assembly language requires a translator to convert theassembly language program into machine language.
- Debugging is often done with IDE like Eclipse, kdvevelop, net bank and visual studio.
- Implementation techniques include imperative languages (object-oriented or procedural)functional languages, and logic languages.
- Computer programs can be categorized by the programming language paradigms used toproduce them. Two of the main paradigms are imperative and declarative.
- Compilers are used to translate source code from a programming language into either objectcode or machine code.
- Computer programs are stored in non-volatile memory until requested either directly orindirectly to be executed by the computer user.

Keywords

Programming language: A programming language is an artificial language designed to express computations that can be performed by a machine, particularly a computer.

Software interfaces: A software interface may refer to a range of different types of interface at different "levels": an operating system may interface with pieces of hardware, applications or programs running on the operating system may need to interact via streams, and in object-oriented programs, objects within an application may need to interact via methods.

Compiler: A compiler is a computer program (or set of programs) that transforms source codewritten in a programming language (the source language) into another computer language (thetarget language, often having a binary form known as object code).

Computer programming: Computer programming is the process of designing, writing, testing,debugging / troubleshooting, and maintaining the source code computer programs.

Debugging: Debugging is a methodical process of finding and reducing the number of bugs,or defects, in a computer program or a piece of electronic hardware, thus making it behave asexpected.

Hardware interfaces: A hardware interface is described by the mechanical, electrical and logicalsignals at the interface and the protocol for sequencing them (sometimes called signaling).

Paradigms: A programming paradigm is a fundamental style of computer programming.(Compare with a methodology, which is a style of solving specific software engineering problems.)

Self-Assessment

1. Robustness is an important quality requirement in programming. Robustness pertains to:

    (a) How feasible the program solution is?

    (b) How often the results of a program are correct?

    (c) How well a program anticipates problems not due to programmer error?

    (d) Ease with which a person can use the program for its intended purpose

2. _____ expresses resource use, such as execution time or memory consumption, in terms of the size of an input.

    (a) Big O notation

    (b) Resource notation

    (c) Memory notation

    (d) Computer notation

3. Which of the following formulates an important aspect of quality in programming?

    (a) Usability

    (b) Reliability

    (c) Maintainability

    (d) All of the these

4. COBOL stands for

    (a) Common Business Oriented Language

    (b) Common Basic Oriented Language

    (c) Coral Business Orchestra Language

    (d) Core Business Operational Language

5. Flowchart with more details is called a _____ flowchart.

    (a) micro

    (b) macro

    (c) display

    (d) taxonomic

6. Any program logic can be expressed by using which of the following?

    (a) Sequence logic

    (b) Selection logic

    (c) Iteration (or looping) logic

    (d) All of the above

7. What is a Computer Program?

    (a) Collection of instructions that can be executed by a computer to perform a specific task.

    (b) Interface of hardware and software

    (c) Sequence of policies

    (d) Security protocols

8. Selection logic is also called as _____.

    (a) Statement logic

    (b) Decision logic

    (c) Procedure logic

    (d) While logic

9. The types of access that interfaces provide between software components can include:

    (a) Constants

    (b) Data types

    (c) Types of procedures

    (d) All of the above

10. A computer programmer

    (a) enters data into computer

    (b) writes programs

    (c) changes flow chart into instructions

    (d) provides solutions to complex problems

11. The most widely used commercial programming computer language is
    (a.) BASIC   (b.) COBOL
    (c.) FORTRAN   (d.) PASCAL

12. Which one of the following is not a programming language of a computer?

    (a.) BASIC   (b.) FORTRAN

    (c.) LASER   (d.) PASCAL

13. Product quality is defined as:

    (a) Delivering a product with correct requirements

    (b) Delivering a product using correct development procedures

    (c) Delivering a product which is developed iteratively

    (d) Delivering a product using high quality procedures

14. _____ is program that alters its own instructionswhile it is executing − usually to reduce the instruction path length and improve performanceor simply to reduce otherwise repetitively similar code, thus simplifying maintenance.

    (a) Selfless program

    (b) Executable program

    (c) Self-modifying program

    (d) Self-executable program

15. _____ is a pictorial representation of an algorithm.

    (a) Program

    (b) Flowchart

    (c) Pseudocode

    (d) Procedure

Answers for Self-Assessment

1.	C	2.	A	3.	D	4.	A	5.	A
6.	D	7.	A	8.	B	9.	D	10.	A
11.	B	12.	C	13.	A	14.	C	15.	B

Review Questions

1. What are computer programs?
2. What are quality requirements in programming?
3. What does the terms debugging and Big-O notation mean?
4. What are self-modifying programs and hardware interfaces?
5. Why programming is needed? What are its uses?
6. What is meant by readability of source code? What are issues with unreadable code?
7. What are algorithms, flowcharts and pseudocodes? Explain with examples.
8. What do you mean by software interfaces?
9. Explain the planning process.
10. What are the different logic structures used in programming?

Further Readings

Computing Fundamentals by Peter Norton

The Programming Process (bham.ac.uk)

Stages_of_program_development_process (Program_development_steps) || CseWorld Online

https://en.wikipedia.org/wiki/Computer_programming

Dr. Tarandeep Kaur, Lovely Professional University

Unit 10: Programming Languages and Programming Process

Objectives

After studying this unit, you will be able to:

- Understand the basics of programming and programming languages
- Explore generations of programming languages and types
- Understand the criteria for a good language design
- Explain the levels of language in computer programming
- Discuss the various language translators or processors
- Learn the web programming and related languages.
- Understand the Software Development Life Cycle (SDLC) of programming.

Introduction

Computer programming (often shortened to programming or coding) is the process of designing, writing, testing, debugging/troubleshooting, and maintaining the source code of computer programs. This source code is written in a programming language. The purpose of programming is to create a program that exhibits a certain desired behavior. The process of writing source code often requires expertise in many different subjects, including knowledge of the application domain, specialized algorithms and formal logic.

Computer programming is the process of transforming a mental plan in familiar terms into one compatible with the computer. Said another way, programming is the craft of transforming requirements into something that a computer can execute.

Why Programming?

You may already have used software, perhaps for word processing or spreadsheets, to solve problems. Perhaps now you are curious to learn how programmers write software. A program is a

set of step-by-step instructions that directs the computer to do the tasks you want it to do and produce the results you want. There are at least three good reasons for learning programming:

- Programming helps you understand computers. The computer is only a tool. If you learn how to write simple programs, you will gain more knowledge about how a computer works.

- Writing a few simple programs increases your confidence level. Many people find great personal satisfaction in creating a set of instructions that solve a problem.

- Learning programming lets you find out quickly whether you like programming and whether you have the analytical turn of mind programmers need. Even if you decide that programming is not for you, understanding the process certainly will increase your appreciation of what programmers and computers can do.

10.1 Programming Language

A set of rules that provides a way of telling a computer what operations to perform is called a *programming language.* There is not, however, just one programming language; there are many. In this chapter you will learn about controlling a computer through the process of programming. You may even discover that you might want to become a programmer. A programming language is a set of rules for communicating an algorithm. It provides a linguistic framework for describing computations. A programming language is a notational system for describing computation in a machine-readable and human-readable form. A programming language is a tool for developing executable models for a class of problem domains.

English is a natural language. It has words, symbols and grammatical rules. A programming language also has words, symbols and rules of grammar. The grammatical rules are called syntax. Each programming language has a different set of syntax rules.

An important point before we proceed: You will not be a programmer when you finish reading this chapter or even when you finish reading the final chapter. Programming proficiency takes practice and training beyond the scope of this book. However, you will become acquainted with how programmers develop solutions to a variety of problems.

Characteristics of Programming Languages

- A programming language must be simple, easy to learn and use, have good readability and human recognizable.

- Abstraction is a must-have Characteristics for a programming language in which ability to define the complex structure and then its degree of usability comes.

- A portable programming language is always preferred.

- Programming language's efficiency must be high so that it can be easily converted into a machine code and executed consumes little space in memory.

- A programming language should be well structured and documented so that it is suitable for application development.

- A programming language should provide single environment known as Integrated Development. The necessary tools for development, debugging, testing, maintenance of a program must be provided by a programming language.

What Programmers Do?

In general, the programmer's job is to convert problem solutions into instructions for the computer. That is, the programmer prepares the instructions of a computer program and runs those instructions on the computer, tests the program to see if it is working properly, and makes corrections to the program. The programmer also writes a report on the program. These activities are all done for the purpose of helping a user fill a need, such as paying employees, billing customers, or admitting students to college.

The programming activities just described could be done, perhaps, as solo activities, but a programmer typically interacts with a variety of people. For example, if a program is part of a system of several programs, the programmer coordinates with other programmers to make sure that the programs fit together well. If you were a programmer, you might also have coordination meetings with users, managers, systems analysts, and with peers who evaluate your work-just as you evaluate theirs.

10.2   Evolution of Programming Languages

Programming languages have evolved over time as better ways have been developed to design them. The first programming languages were developed in the 1950s.Since then thousands of languages have been developed.Different programming languages are designed for different types of programs.

First Generation Languages: First generation (programming) language (1GL) is a grouping of programming languages that are machine level languages used to program first-generation computers. Originally, no translator was used to compile or assemble the first-generation language.

It consisted of machine language that had following characteristics:Operation code– such as addition or subtraction; Operands– that identify the data to be processed. The first-generation languages were machine dependent as it is the only language the computer can understand.0s or 1s where 1s and 0s correspond to the on and off states of electrical switches. It was efficient to code but very difficult to write.

Second Generation Languages: In second generation computers, lines within a program correspond directly to processor commands, essentially acting as a mnemonic device overlaying a first-generation programming language. The code can be read and written by a programmer. To run on a computer, it must be converted into a machine-readable form, a process called assembly. The language is specific to a particular processor family and environment.In assembly language, the symbolic operation codes replaced binary operation codes. It consisted of mnemonics. Theassembly language programs needed to be "assembled" for execution by the computer. Each assembly language instruction is translated into one machine language instruction.

Third Generation Languages: Third-generation programming language (3GL) is a high-level computer programming language that tends to be more machine-independent and programmer-friendly than the machine code of the first-generation and assembly languages of the second-generation, while having a less specific focus to the fourth and fifth generations. Such languages were closer to English but included simple mathematical notation.Programs written in source code which must be translated into machine language programs called object code. The ttranslation of source code to object code was accomplished by a machine language system program called a compiler. An alternative to compilation is interpretation which is accomplished by system program called an interpreter. The common third generation languages: FORTRAN, COBOL, C and C++, Visual Basic etc.

Fourth   Generation   Languages: Fourth-generation programming language (4GL)   is   any computer programming language that   belongs   to   a   class of languages envisioned   as   an advancement   upon   third-generation programming languages (3GL). It consisted of high-level language (4GL) that requires fewer instructions to accomplish a task than a third-generation language and were user-friendly. These languages were quite interactive languages used with databases as querying languages, for report generation, form designing and application generation.

Fifth Generation Languages: Fifth-generation programming language (5GL) is any programming language based on problem-solving using constraints given to the program, rather than using an algorithm written by a programmer. Most constraint-based and logic programming languages and some other declarative languages are fifth-generation languages.

Beyond Fifth Generation Languages: Though no clear definition at present, natural language programs generally can be interpreted and executed by the computer with no other action by the user than stating their question.

10.3   Types of Programming Languages

There are different types of programming languages of variable categories and functionality. These include:

1. Traditional Programming Languages

Formula Translation (FORTRAN): FORTRAN was developed at IBM in the mid-1950s. It was designed for scientific and mathematical applications by scientists and engineers.

COBOL (Common Business Oriented Language): It was developed in 1959 to be common to many different computers. It was typically used for business applications.

BASIC: It stands forBeginner's All-purpose Symbolic Instruction Code, developed at Dartmouth College in mid 1960s. It was developed as a simple language for students to write programs with which they could interact through terminals.

C: C language was developed by Bell Laboratories in the early 1970s. It provides control and efficiency of assembly language while having third generation language features. It is often used for system programs.UNIX operating system has been written in C.

2. Object-Oriented Programming Languages

Such languages are based on object-oriented programming (OOP) approach. These include:

Simula: It was the first object-oriented language that was developed by Ole Johan Dahl in the 1960s.

Smalltalk: Smalltalk was first purely object-oriented language that was developed by Xerox in mid-1970s. It is still in use on some computers.

C++: This language is almost C language with additional features. It was widely used for developing system and application software.Graphical user interfaces can be developed easily with visual programming tools.

JAVA: Java language is quite similar to C++ and eliminates lots of C++'s problematic features. It allows a web page developer to create programs for applications, called applets that can be used through a browser. The objective of JAVA developers is that it be machine, platform and operating system independent.

3. Special Programming Languages

Scripting Languages-A scripting or script language is a programming language for a special run-time environment that automates the execution of tasks; the tasks could alternatively be executed one-by-one by a human operator. Scripting languages are often interpreted, rather than compiled. Examples: JavaScript and VBScript, PHP and ASP, Perl and Python

Command Languages- These languages offer job control in computing and are domain-specific and interpreted languages. The common examples of a command language are shell or batch programming languages. Such languages can be used directly at the command line, but can also automate tasks that would normally be performed manually at the command line. The command languages often have either very simple grammars or syntaxes very close to natural language, to shallow the learning curve, as with many other domain-specific languages. Example: sh, csh, bash

Text processing Languages-Text processing of a regular expression is a virtual editing machine, having a primitive programming language that has named registers (identifiers), and named positions in the sequence of characters comprising the text. Using these the "text processor" can, for example, mark a region of text, and then move it. Example: LaTex, PostScript.

Hyper Text Markup Language (HTML)- HTML is used on Internet and World Wide Web (WWW). A webpage developer puts brief codes called tags in the page to indicate how the page should be formatted.

Extensible Markup Language (XML)- A language for defining other languages.

Criteria in a Good Language Design

A. Programming languages are used by programmers to write programs. Thus, a good language should make it easy for a programmer to express what needs to be done. Several criteria contribute to making a language easy to use (Figure 1). The criterions include:

Figure 1: Attributes for Good Language Design

- Writability: Quality of a language that enables a programmer to use it to express a computation clearly, correctly, concisely, and quickly.

- Readability: Quality of a language that enables a programmer to understand and comprehend the nature of a computation easily and accurately.

- Orthogonality: Quality of a language that features provided have as few restrictions as possible and be combinable in any meaningful way.

- Reliability: Assures a program will not behave in unexpected or disastrous ways during execution.

- Maintainability: Eases errors can be found and corrected and new features added.

- Generality: Avoids special cases in the availability or use of constructs and by combining closely related constructs into a single more general one.

- Uniformity: Quality of a language that similar features should look similar and behave similar.

- Extensibility: Provides some general mechanism for the user to add new constructs to a language.

- Standardability: Allows programs written to be transported from one computer to another without significant change in language structure.

- Implementability: Provides a translator or interpreter can be written. This can address to complexity of the language definition.
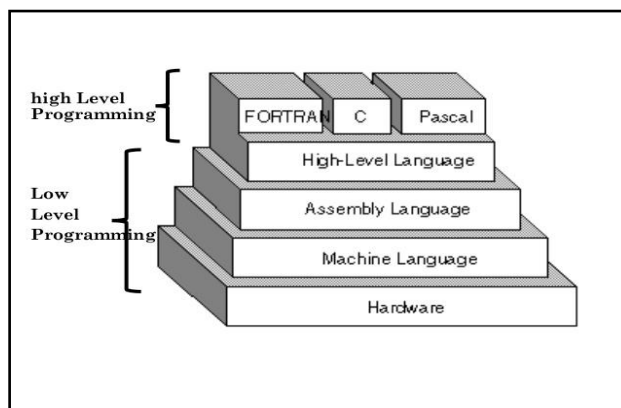
Figure 2: Classification of Programming Languages

10.4   Levels of Language in Computer Programming

Programming languages are said to be "lower" or "higher," depending on how close they are to the language the computer itself uses (0s and 1s = low) or to the language people use (more English-like-high) (Figure 2). We will consider five levels of language. They are numbered 1 through 5 to correspond to levels, or generations. In terms of ease of use and capabilities, each generation is an improvement over its predecessors. The five levels of languages are:

(a) Machine language

(b) Assembly languages

(c) High-level languages

(d) Very high-level languages

(e) Natural languages

Let us look at each of these categories.

Machine Language

Machine language, the numeric codes for the operations that a particular computer can execute directly. The codes are strings of 0s and 1s, or binary digits ("bits"), which are frequently converted both from and to hexadecimal (base 16) for human viewing and modification. Machine language instructions typically use some bits to represent operations, such as addition, and some to represent operands, or perhaps the location of the next instruction. Machine language is difficult to read and write, since it does not resemble conventional mathematical notation or human language, and its codes vary from computer to computer.

Sometimes referred to as machine code or object code, machine language is a collection of binary digits or bits that the computer reads and interprets. Machine language is the only language a computer is capable of understanding. The exact machine language for a program or action can differ by operating system. The computer programs are written in one or more programming languages, like C++, Java, or Visual Basic. A computer cannot directly understand the programming languages used to create computer programs, so the program code must be compiled. Once a program's code is compiled, the computer can understand it because the program's code is turned into machine language.

The major advantage of machine language is that the programs written in machine language can be executed very fast by the computer.Example of Machine language: Below is an example of machine language (Binary) for the text "Hello World"(Figure 3).

01001000 01100101 01101100 01101100 01101111 00100000 01010111 01101111 01110010
01101100 01100100

Figure 3: Machine Language Representation

Assembly Language

Assembly language is a low-level programming language designed for a specific type of processor. It is one level above the machine language and uses short mnemonic codes for instructions and allows the programmer to introduce names for blocks of memory that hold data. One might thus write "add pay, total" instead of "0110101100101000" for an instruction that adds two numbers.

Assembly language is designed to be easily translated into machine language. Although blocks of data may be referred to by name instead of by their machine addresses, assembly language does not provide more sophisticated means of organizing complex information. Like machine language, assembly language requires detailed knowledge of a particular internal computer architecture. It is useful when such details are important, as in programming a computer to interact with input/output devices (printers, scanners, storage devices, and so forth).

Advantages of Assembly Language:

• Memory efficient, as it requires less memory.

• Requires less instruction to get the result.

• Not required to keep track of memory locations.

• Easy to write and remember.

High-Level Languages

The first widespread use of high-level languages in the early 1960s transformed programming into something quite different from what it had been. Programs were written in an English-like manner,

thus making them more convenient to use. As a result, a programmer could accomplish more with less effort, and programs could now direct much more complex tasks.

These so-called third-generation languages spurred the great increase in data processing that characterized the 1960s and 1970s. During that time the number of mainframes in use increased from hundreds to tens of thousands. A translator was used and was needed to translate the symbolic statements of a high-level language into computer-executable machine language; this translator is usually a compiler. There are many compilers for each language and one for each type of computer. Since the machine language generated by one computer's COBOL compiler, for instance, is not the machine language of some other computer, it is necessary to have a COBOL compiler for each type of computer on which COBOL programs are to be run. Some languages are created to serve a specific purpose, such as controlling industrial robots or creating graphics. Many languages, however, are extraordinarily flexible and are considered to be general-purpose. In the past the majority of programming applications were written in BASIC, FORTRAN, or COBOL-all general-purpose languages.

Very High-Level Languages

Languages called as very high-level languages are often known by their generation number, that is, they are called fourth-generation languages or, more simply, 4GLs. We have already discussed such types of languages in the section 10.2 above.

Natural Languages

The word "natural" has become almost as popular in computing circles as it has in the supermarket. Fifth-generation languages are, as you may guess, even more ill-defined than fourth-generation languages. They are most often called natural languages because of their resemblance to the "natural" spoken English language. And, to the manager new to computers for whom these languages are now aimed, natural means human-like. Instead of being forced to key correct commands and data names in correct order, a manager tells the computer what to do by keying in his or her own words.

A manager can say the same thing any number of ways. For example, "Get me tennis racket sales for January" works just as well as "I want January tennis racket revenues." Such a request may contain misspelled words, lack articles and verbs, and even use slang. The natural language translates human instructions-bad grammar, slang, and all-into code the computer understands. If it is not sure what the user has in mind, it politely asks for further explanation.

Natural languages are sometimes referred to as knowledge-based languages, because natural languages are used to interact with a base of knowledge on some subject. The use of a natural language to access a knowledge base is called *a knowledge-based system*.
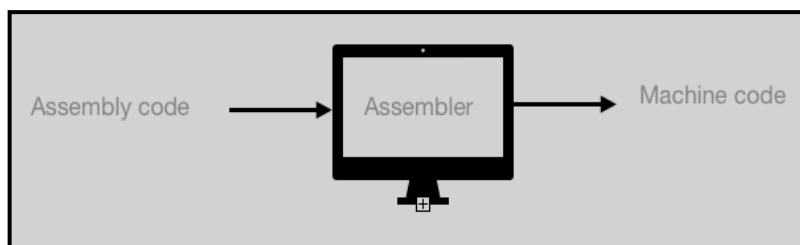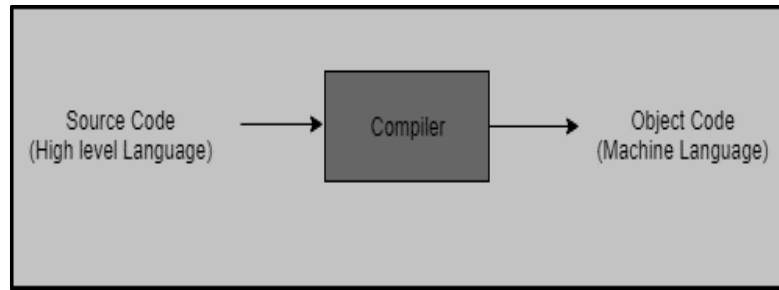

Figure 4: Compilation Process

Figure 5: Assembler Process

Language Processors

Language processors are the special translator system software used to translate the program written in high-level language into machine code. These are of three types:

1. **Complier:**Language processor that reads the complete source program written in high level language as a whole in one go and translates it into an equivalent program in machine language is called as a compiler (Figure 4).

2. **Assembler:** Assembler is a program used for converting instructions written in low-level assembly code into relocatable machine code (Figure 5).

3. **Interpreter:** The translation of single statement of source program into machine code is done by language processor and executes it immediately before moving on to the next line is called an interpreter. Example: Perl, Python and Matlab.

   Table 1lists the comparison between complier and interpreter.

COMPILER	INTERPRETER
Program which coverts the entire source code of a programming language into executable machine code for a CPU.	Takes a source program and runs it line by line, translating each line as it comes to it.
Takes large amount of time to analyze entire source code but overall execution time of program is comparatively faster.	Takes less amount of time to analyze the source code but overall execution time of the program is slower.
Generates error messages only after scanning the whole program, so debugging is comparatively hard as the error can be present anywhere in the program.	Debugging is easier as it continues translating the program until the error is met
Generates intermediate object code.	No intermediate object code is generated.
Examples: C, C++, Java	Examples: Python, Perl

Table 1: Comparison of Compiler and Interpreter

10.5 World Wide Web (Www) Development Language

The World Wide Web, abbreviated as WWW or W3 and commonly known as the Web, is a system of interlinked hypertext documents accessed via the Internet. With a web browser, one can view web pages that may contain text, images, videos, and other multimedia and navigate between them via hyperlinks. Using concepts from earlier hypertext systems, English engineer and computer scientist Sir Tim Berners-Lee, now the Director of the World Wide Web Consortium, wrote a proposal in March 1989 for what would eventually become the World Wide Web.

"The World-Wide Web was developed to be a pool of human knowledge, and human culture, which would allow collaborators in remote sites to share their ideas and all aspects of a common project?"

Web programming languages refers to the writing, markup and coding involved in web development. It involves the practice of writing applications that run on a web server and can be used by many different people. It includes web content, web client and server scripting and network security. Many applications work really well as a web application. The examples of popular web applications include Flickr, Gmail, and Google Maps. Web languages enable to upload and view pictures, send email and lookup directions using these web applications and they are all made possible through web site programming. The common languages are: XML, HTML, JavaScript, Perl 5 and PHP. Such languages are different from just programming (Requires interdisciplinary knowledge on the application area, client and server scripting, and database technology).

Web programming languages are used for client-side coding. Such languages can include static technologies like HTML, XHTML, CSS, JavaScript, and XML.

Benefits of Web Programming

- **Transition:** Allows to turn a simple, static HTML page into a dynamic masterpiece.
- **Interactive:** Allows others to interact with a web site and use the application on any computer with Internet access.
- **Easiness:** Easier than programming applications that will run directly on the computer.
- **Dynamism:** Allows to make or edit anything dynamic on your website, such as a forum, a guestbook, or even a form submission.
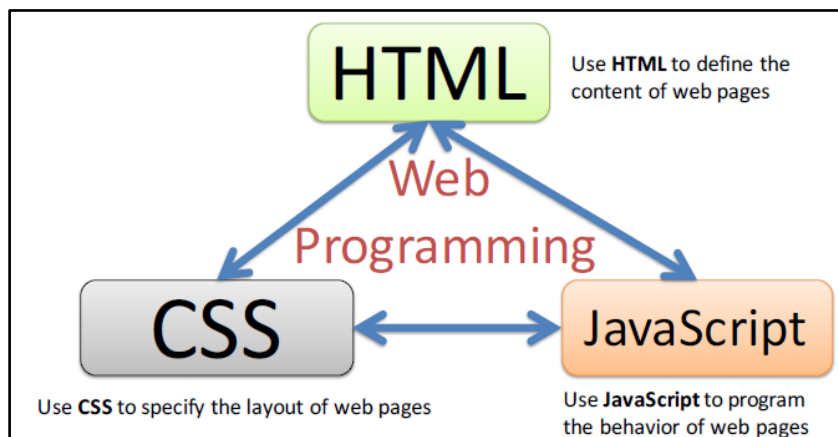
Figure 6: Web Programming Languages

Web Programming: Client-Side

The client-side programming needs programming that is related to assessing the data from the users, and providing information back to them. The clientsneed to ensure that there are enough plug ins to enrich cases. More and more Graphical User Interfaces (GUIs) are involved and they are secured as well so they are including certain security measures. We have a web architecture, Internet Explorer, Chrome, Firefoxare the different kinds of web browsersrunningHTML, CSS, or JavaScript (Figure 6).

Hyper Text Markup Language (HTML)

HTML provides a visual appearance of a particular website. It is also called as a web browser language, all the web browsers, they actually understand HTML, the latest version for this is html5 and it is actually maintained out by World Wide Web Consortium.

Figure 7: Web Processing

You can see the scenario of how it actually works. There is a web platform (Figure 7). The web browser creates a visual web pageon a particular browser that is based on the HTML code. We have the doc type specifying the HTML that is a header, a body having certain tags that are embedded into the code that actually runs on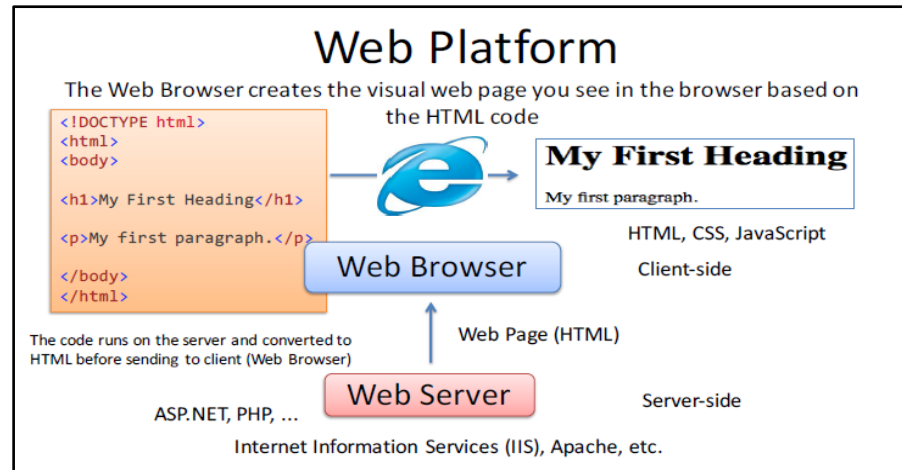 the server and connected to the HTML before sending it back to the client. So that code is written out on the format of web server programming we have ASP dotnet, PHP. The web servers can be Internet Information Services, or Apache.

Another scenario on the client side (Figure 8). My first heading that is a tag used for the first heading,<h1> Then we have the <p> tag that is for the paragraph and we have the closing tags that are used with the different notation so <body> tag is closing <HTML> tag is close.
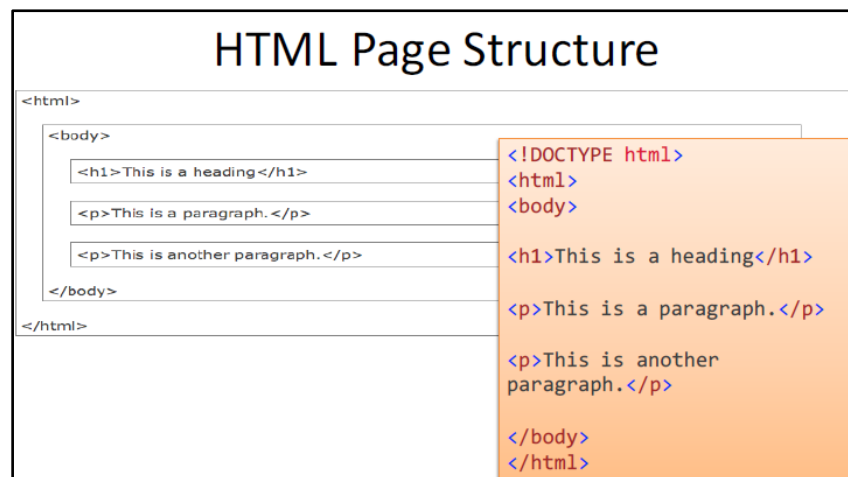
Figure 8: Structure of HTML Page

Cascading Style Sheets (CSS)

CSS define Styles. Styles are defined out how to display a particular HTML element. CSSare used to control the style and layout of multiple web pages, all at once in one particular page design. So why do we actually need CSS? CSS is neededbecause HTML never intended to contain any text for formatting a particular document. HTML was intended to actually define the content of the document, but the styles are added with the help of CSS. Whenever tags like font are used and colour attributes were added to HTML 3.2 specifications, it started producing certain nightmares for the web developers owing to the complexity. So, the development of large websites where fonts and colour information were added to every single page, it became very complex and rigorous process for doing the same. In order to solve the problem World Wide Web Consortium created CSS. All the formatting could be removed from the HTML document, and it could be stored out in a separate CSS sheet. CSS could have could actually be imported out into that particular HTML page.

HTML5 and CSS3

The latest versions are html5 and CSS3. They support most of the client-side functionality that is provided died out by other application frameworks as well.

Javascript

JavaScript is used to improve the user experience and related functionalities on the client-side. It provides excellent client-side platform for designing and implementing different kinds of web applications. All the modern HTML pages are using JavaScript. It is a default scripting language that is used in most of the modern browsers and even in HTML5, it is the most popular programming language across the world as well. It is a language for web, for computers, for servers, for laptops, tablets, Smartphone's, and so many different things.

JavaScript has actually changed HTML elements whichmakes it much more powerful and adventurous. If you are using JavaScript, HTML and CSS, JavaScript is one of the three languages, out of these languages all the web developers must learn it.

Web Programming: Server-Side

Web server can refer to either hardware (the computer) or software (computer application) that helps to deliver web content that can be accessed through the Internet. Most common use of web servers is to host websites, but there are other uses such as gaming, data storage or running enterprise applications.

The server-side code runs on the server and then gives static information back to the web browser (Figure 9).The most popular web programming languages are: PHP, ASP.NET, Ruby on Rails, Perl, ASP classic, Python, and JSP. Server-side needs programming mostly related to data retrieval, security and performance. Some of the tools used include ASP, Lotus Notes, PHP, Java and MySQL.
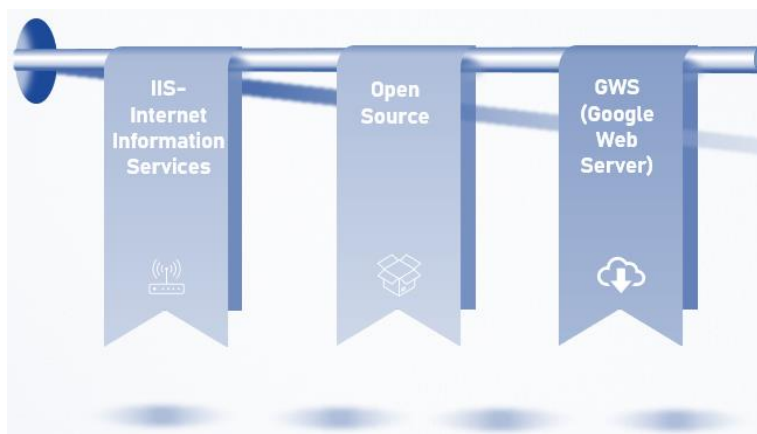
Figure 9: Web Servers

10.6　Software Development Life Cycle (SDLC) of Programming

Software Development Life Cycle (SDLC) is referred to as application development life-cycle that defines a systematic process for building software that ensures the quality and correctness of the software built (Figure 10). SDLC process aims to produce high-quality software that meets customer expectations. The system development should be complete in the pre-defined time frame and cost. It consists of a detailed plan which explains how to plan, build, and maintain specific software. Every phase of the SDLC life Cycle has its own process and deliverables that feed into the next phase.

Importance of SDLC

- Offers a basis for project planning, scheduling, & estimating.

- Provides a framework for a standard set of activities & deliverables
- Facilitates mechanism for project tracking & control.
- Increases visibility of project planning to all involved stakeholders of the development process.
- Increased and enhance development speed.
- Improving the client relations.
- Helps to decrease project risk and project management plan overhead.

Figure 10: SDLC Phases

Phase 1: Requirement Collection and Analysis

This phase gathers the essential requirements from the customer. The information gets collected by the business analyst from their target customer(s) and plans the BRS (Business requirement Specification) for the development of the product. It is conducted by the senior team members with inputs from all the stakeholders and domain experts in the in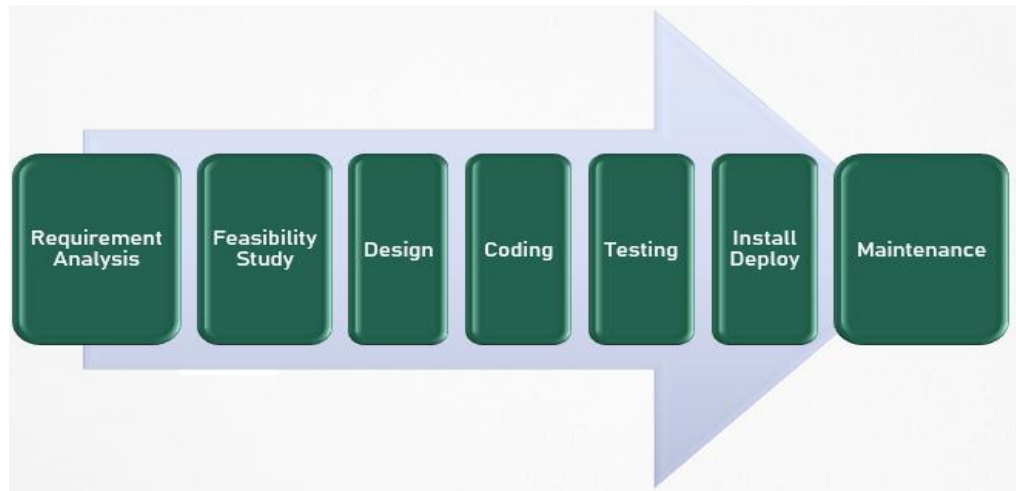dustry.Some popular questions that this meeting picks up are - Who will use the product? What must be the output data by the product?

Phase 2: Feasibility Study

Once the requirement analysis phase is completed the next SDLC step is to define and document software needs. It is a process conducted with the help of 'Software Requirement Specification' document also known as 'SRS' document. It includes everything which should be designed and developed during the project life cycle. There are five types of feasibilities checks:

o Economic: Can we complete the project within the budget or not?

o Legal: Can we handle this project as cyber law and other regulatory framework/compliances.

o Operation feasibility: Can we create operations which is expected by the client?

o Technical: Need to check whether the current computer system can support the software

o Schedule: Decide that the project can be completed within the given schedule or not.

Phase 3: Design

In this third phase, the system and software design documents are prepared as per the requirement specification document. This helps define overall system architecture and design output serves as input for the next phase of the model. The two kinds of design documents developed in this phase:

o High-Level Design (HLD): It lists a brief description and name of each module. It produces an outline about the functionality of every module. It defines the interface relationship and dependencies between modules. The database tables identified along with their key elements. It depicts a complete architecture diagrams along with technology details.

o Low-Level Design(LLD): It displays the functional logic of the modules; database tables, which include type and size; complete detail of the interface. It addresses all types of dependency issues; listing of error messages. It expresses complete input and outputs for every module.

Phase 4: Coding

Once the system design phase is over, the next phase is coding. In this phase, developers start build the entire system by writing code using the chosen programming language. In the coding phase, tasks are divided into units or modules and assigned to the various developers. It is the longest phase of SDLC. In this phase, the developer needs to follow certain predefined coding guidelines. They also need to use programming tools like compiler, interpreters, debugger to generate &implement code.

Phase 5: Testing

Once the software is complete, and it is deployed in the testing environment. The testing team starts testing the functionality of the entire system. This is done to verify that the entire application works according to the customer requirement. During this phase, QA and testing team may find some bugs/defects which they communicate to developers. The development team fixes the bug and send back to QA for a re-test. This process continues until the software is bug-free, stable, and working according to the business needs of that system.

Phase 6: Installation/Deployment

Once the software testing phase is over and no bugs or errors left in the system then the final deployment process starts. Based on the feedback given by the project manager, the final software is released and checked for deployment issues if any.

Phase 7: Maintenance

Once the system is deployed, and customers start using the developed system, following 3 activities occur.

- Bug fixing- bugs are reported because of some scenarios which are not tested at all
- Upgrade- Upgrading the application to the newer versions of the Software
- Enhancement- Adding some new features into the existing software

The main focus of this SDLC phase is to ensure that needs continue to be met and that the system continues to perform as per the specification mentioned in the first phase.

Summary

- The programmer prepares the instructions of a computer program and runs those instructions on the computer tests the program to see if it is working properly and makes corrections to the program.
- Programming languages are said to be "lower" or "higher", depending on how close they are to the language the computer itself uses or the language people use.
- The programmer who uses assembly languages requires a translator to convert the assembly language programming into machine language.
- Languages called very high-level languages are often known by their generation number, that is they are called fourth-generation languages or more simply 4 GLS.
- A standardized query language which can be used with several different commercial data base programs, is structured query language, popularly known as SQL.
- Programming languages can be used to create programs that control the behaviour or a machine, to express algorithms precisely, or as a mode of human communication.
- There are certain set of programming categories such as scripting, programmer's scripting, application development, low-level, pure functional and complete core.

- Machine language is a collection of binary digits or bits thatthe computerreads and interprets and assembly language is a low-level programming language using the human-readable instruction of the CPU.
- WWW is a system of interlinked hypertext documents accessed via the Internet.
- Software development life cycle is a process of creating or altering systems, and the models and methodologies that people use to develop thesystem.
- A software development activity is a structure imposed on the development of a software product.

Keywords

Programming language: A programming language is an artificial language designed to express computations that can be performed by a machine, particularly a computer.

Self-modifying programs: Self-modifying program is program that alters its own instructions while it is executing — usually to reduce the instruction path length and improve performance or simply to reduce otherwise repetitively similar code, thus simplifying maintenance.

Knowledge-based System: Natural languages are sometimes referred to as knowledge-based languages, because natural languages are used to interact with a base of knowledge on some subject. The use of a natural language to access a knowledge base is called a knowledge-based system.

High-level programming language: This is a programming language with strong abstraction from the details of the computer. A high-level language isolates the execution semantics of a computer architecture from the specification of the program.

Machine language: The machine language for a particular computer is tied to the architecture of the CPU.

Software development process: It is also known as a software development lifecycle, is a structure imposed on the development of a software product. Similar terms include software life cycle and software process.

*World Wide Web:*The World Wide Web, abbreviated as WWW or W3 and commonly known as the Web, is a system of interlinked hypertext documents accessed via the Internet.

Self-Assessment Questions

1. A computer programmer
A. enters data into computer
B. writes programs
C. changes flow chart into instructions
D. does total planning and thinking for a computer

2. The most widely used commercial programming computer language is
A. BASIC
B. COBOL
C. FORTRAN
D. PASCAL

3. Which one of the following is not a programming language of a computer?
A. BASIC
B. FORTRAN
C. LASER
D. PASCAL

4. A _____ is an artificial language designed to express computations that can be performed by a machine, particularly a computer.

A. query language

B. script language

C. programming language

D. artificial language

5. The purpose of operating systems and other low-level code we need a language that operates fast and just above the machine level.

A. True

B. False

6. _____ language for a particular computer is tied to the architecture of the CPU.

A. Objective

B. BASIC

C. Binary

D. Machine

7. _____ are just shorthand for machine instructions.

A. BASIC instructions

B. COBOL instructions

C. Binary instructions

D. Assembly instructions

8. A _____ is a programming language with strong abstraction from the details of the computer.

A. middle-level programming language

B. low-level programming language

C. machine-level programming language

D. high-level programming language

9. Abstraction penalty is the barrier that prevents high-level programming techniques from being applied in situations where computational resources are limited.

A. True

B. False

10. Most web pages contain "www" to other related pages and perhaps to downloadable files, source documents, definitions and other web resources.

A. False

B. True

11. Which of the following web programming language is not used for client-side coding?

A. HTML

B. XML

C. PHP

D. XHTML

12. IIS stands for

A. Internal Information Services

B. Input Information Services

C. Internet Information Services

D. Internet Input Scale

13. Third-generation programming language (3GL) are

A. machine-dependant

B. machine-independent

C. machine-friendly

D. complex

14. Special translator system software that is used to translate the program written in high-level language into machine code is _____.

A. code processor

B. language processor

C. code translator

D. software processor

15. _____ is a language processor that reads the complete source program written in high-level language as a whole in one go and translates it into an equivalent program in machine language.

A. Compiler

B. Assembler

C. Interpreter

D. Translator

Answer for Self Assessment

1.	D	2.	B	3.	C	4.	C	5.	A
6.	D	7.	D	8.	D	9.	A	10.	A
11.	C	12.	C	13.	B	14.	B	15.	A

Review Questions

1. What are computer programs?
2. What are quality requirements in programming?
3. Why programming is needed? What are its uses?
4. Give the levels of programming languages.
5. What are the characteristics of very high-level languages and give its uses as well?
6. Give a brief introduction of major programming languages.
7. Differentiate complier and interpreter?
8. What are the various language processors and their features?
9. Give a brief discussion on Machine and Assembly Language?
10. Define System Development Life Cycle (SDLC)?
11. Explain the phases in SDLC?

Further Readings

The Art of Computer Programming by David Knuth.

Fundamentals of Programming Languages by Ellis Horowitz, Computer science press.

The Software Development Lifecycle - A Complete Guide by Richard Murch.

Web Links

computer programming language | Types & Examples | Britannica

Classification of Programming Languages: Low-Level and High-Level - javatpoint

Unit 11: Internet and Applications

Objectives

- Explain brief history and applications of Internet
- Discuss about the Web page its features
- Know about Web servers and Web Browsers
- Learn Internet-related terms such as HTML, website, URLs, XML, DHTML, ISP's etc.
- Know about WWW, email, Internet Telephony, Instant Messaging, Video Conferencing

Introduction

The internet is a globally connected network system facilitating worldwide communication and access to data resources through a vast collection of private, public, business, academic and government networks. It is governed by agencies like the Internet Assigned Numbers Authority (or IANA) that establish universal protocols.The terms internet and World Wide Web (WWW) are often used interchangeably, but they are not exactly the same thing; the internet refers to the global communication system, including hardware and infrastructure, while the web is one of the services communicated over the internet.

The Internet (or internet) is the global system of interconnected computer networks that uses the Internet protocol suite (TCP/IP) to communicate between networks and devices. It is a network of networks that consists of private, public, academic, business, and government networks of local to global scope, linked by a broad array of electronic, wireless, and optical networking technologies. The Internet carries a vast range of information resources and services, such as the inter-linked hypertext documents and applications of the WWW, electronic mail, telephony, and file sharing.
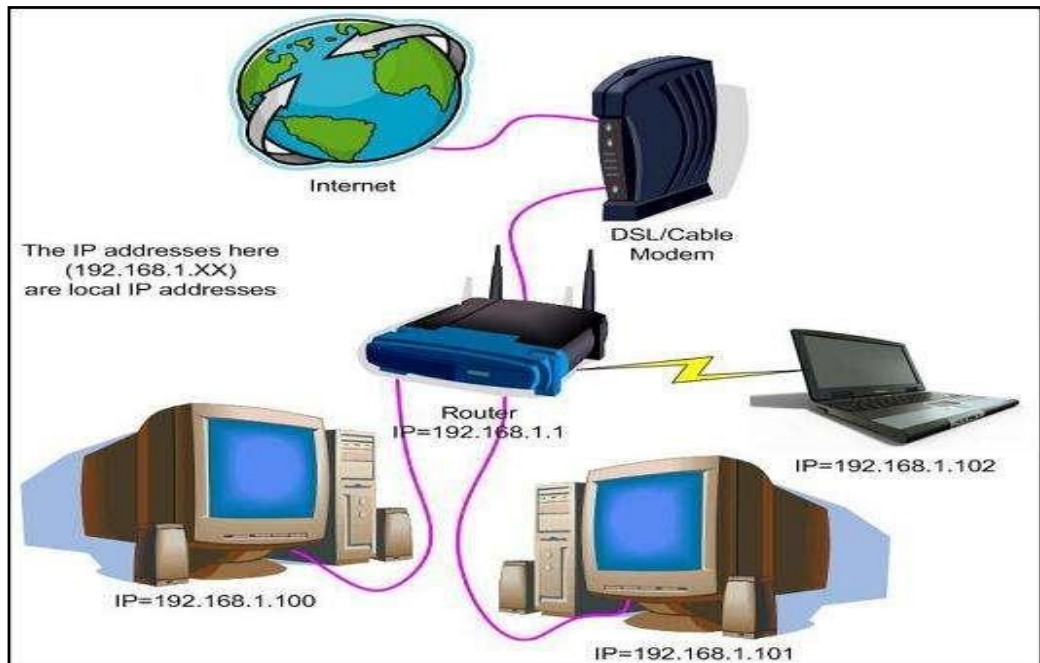
Figure 1: Internet Connectivity

The Internet provides a capability so powerful and general that it can be used for almost any purpose that depends on information, and it is accessible by every individual who connects to one of its constituent networks. It supports human communication via social media, electronic mail (e-mail), "chat rooms," newsgroups, and audio and video transmission and allows people to work collaboratively at many different locations. It supports access to digital information by many applications, including the WWW. The Internet has proved to be a spawning ground for a large and growing number of "e-businesses" (including subsidiaries of traditional "brick-and-mortar" companies) that carry out most of their sales and services over the Internet.Internet makes it possible for millions of users to connect to one another via telephone lines, cable lines and satellites (Figure 1).

Uses of the Internet

- **On-line Communication:** Internet facilitates Instant Messaging (IM), Internet telephony, Email, videoconferencing etc.

  o Instant Messaging (IM): It is one of the fastest-growing forms of Internet communications is instant messaging, or IM. We can suppose IM as a text-based computer conference between two or more people. An IM communications service enables you to create a kind of private chat room with another individual in order to communicate in real-time over the Internet.

  o Internet Telephony and Voice Over Internet Protocol (VoIP): Internet telephony consists of a combination of hardware and software that enables you to use the Internet as the transmission medium for telephone calls. For users who have free, or fixed-price Internet access, Internet telephony software essentially provides free telephone calls anywhere in the world. In its simplest form, PC-to-PC Internet telephony can be as easy as hooking up a microphone to your computer and sending your voice through a cable modem to a person who has Internet telephony software that is compatible with yours.

  o E-Mail:It is short for electronic mail. E-mail isthe transmission of messages over communications networks. The messages can be notes entered from the keyboard or electronic files stored on disk. Most mainframes, minicomputers and computer networks have an e-mail system.

  o Videoconferencing: It isa conference between two or more participants at different sites by using computer networks to transmit audio and video data.

o   SMS andWireless Communications

- **Software Sharing:** The next kind of usage of internet is software sharing. We can share different kinds of software's we can share different kinds of information of the software. Even we can share the movies or any other different applications. We can collaborate on different applications like Google Docs that helps in collaborations that can be easily done.

- **Posting of Information of General Interest:** We extensivelyuse WhatsApp, Twitter these days in order to post our personal views as well as to communicate over or converse out to some other person's point of view. Through Facebook we can different kinds of things. We can post our live locations, share each other our live pictures etc. All this is enabled through Internet.

- **Product Promotion, Feedback about Product, Improving Customer Support Service:** Internet is used for product promotions. For example, we can use internet for promoting a particular products and advertisements. Internet helps in online marketing. People can use Facebook for online advertisements or drag other people's attention towards a particular product or any services. Also, getting feedbacks for services and products can also be done with Internet capabilities. Many different organizations like even the telephony companies, communication companies like Airtel, Vodafonecan actually get a lot of customer feedbacks based on the services that they're providing through online services or online surveys conducted. This helps the customer support services of companies to analyze the feedback provided by the people using their products or services. Consequently, they can improvise their service deliveries.

- **On-line journals and magazines:** Online journals and magazines are accessible these days, we have online newspapers available, we don't need any physical newspaper. Nowadays, we can get latest news and trends information, just logging on to the different kinds of websites like Google we have, or we can also browse through the particular page of a particular newspaper as well.

- **Online Booking and Orders:** The Internet has made it a lot easier for people to book tickets for buses, trains, flights (domestic and international) directly using their devices from anywhere. People can also book a taxi by choosing their current location, and they will be picked up or dropped at a specified location. Now no one needs to wait in long queues for their turn to book tickets at the ticket counter. Besides, people can order a wide variety of products at home using the Internet and devices. It can range from grocery products to ready to eat, fashionable clothes to medicines. Most items can be ordered at home and received directly at the door.

- **Cashless Transactions:** Most countries are promoting cashless transactions and digital payments. This helps people not carry much cash. People can pay their bills through debit or credit cards using POS devices. These devices are connected to the payment gateway on the Internet. Besides, People can also use their smartphone and the Internet for processing transactions on UPI (Unified Payment Interface). It does not even require them to carry their cards. The UPI payment method is continuously evolving and is expected to cover most transactions in the near future.

- **Education:** Most of the devices nowadays are connected through the Internet. The Internet has the availability of broad educational content on any topic with different types. People can study the relevant topic just by spending a couple of minutes over the Internet. Internet Search engines help people quickly find the relevant study material in multiple formats (such as images, videos, documents, etc.). This helps eliminate the need to go to the library to read several books to find the desired information.Besides, the Internet has also enabled students to participate in their classes through video conferencing, where students can connect with their teachers or professionals anywhere in the world.

- **Online Banking and Trading:**The way of banking has changed after the introduction of the Internet. The Internet has made banking online where people can manage their bank accounts while sitting at home or traveling abroad. Nowadays, most of the features of banking are right in

people's hands. With the help of online banking, people can securely transfer the money from one account to another, change their ATM pins, apply for the physical or virtual credit cards, update credit card limits, enable or disable international transactions, track their transactions, and many more. Also, they can even raise an online complaint or contact to bank's support staff.Apart from this, the Internet has made it a lot easier for people to trade in the stock market from anywhere. People can easily buy, sell, or manage stocks online.

- **Research:** The Internet is playing a significant role in the field of research. Before the use of the Internet, it was quite hard to look for information about anything. People had to go through hundreds of books for references to find the desired information. However, the Internet has made it a lot easier, and anyone can find the required information at some clicks only. In research, people can study about the success and failed research and work further for the improvements. Uses of the Internet in research have incredibly beneficial for the researchers.

- **Social Networking:**Social networking sites have connected people around the world. Social networking is an essential part of the Internet. With the help of the Internet, people have got the ability to form social groups where they can share information, thoughts and ideas about anything. The social networking platform is the largest source of content, covering everything from informative content to entertainment. The best thing is that people don't have to pay anything to use these services. This helps businesses develop their community and promote their products.

- **Collaboration:**Due to the Internet, communication has become easier and better. You can easily connect with anyone on the Internet, either texting, calling or video calling. It has created new cooperation opportunities for the people. There are several online chat software and websites that help people create group discussions or meetings. It helps businesses to have a hassle-free discussion. Therefore, people do not always need to travel long distances to attend meetings. This helps people avoid unnecessary travel and save time for productive use. Besides, there are many cloud-based software and websites that offer people to work on the same project simultaneously at the same time. People from different places can easily connect and support their specialties using the Internet.

- **Entertainment:** The Internet is the most effective means of entertainment. There are various options available on the Internet, which people can try, such as watching movies, playing online games, listening to songs, etc. The Internet has also made it easy for people to download entertainment items to their local storage. Using the Internet, people can also share their videos, songs, pictures online with others. Also, nowadays, people can watch live TV or sports on the Internet.

Advantages of Internet

- Allows easy and quick access to information.
- Enables user to access files and information from any computer anywhere in the world.
- People can check financial information, purchase products, and talk to people and much more online.
- Downloading music- quick and easy.
- User can send information quickly from computer to computer.

Disadvantages of Internet

- Promotes violence and bad behavior within society, as it contains violent videos and other disturbing images.
- Can encourage negative activities such as pornography and pedophilia, these things can now be explored more openly due to the internet.

• Stops children from going out, as they wish to stay home and use the internet to talk to friends etc.

World Wide Web (WWW)

WWW is a powerful tool for communicating ideas, facts and opinions throughout the world. It is an open-source information space where documents and other web resources are identified by Uniform Resource Locators (URLs), interlinked by hypertext links, and can be accessed via the internet.The resources of the Web are transferred via the Hypertext Transfer Protocol (HTTP), may be accessed by users by a software application called a web browser, and are published by a software application called a web server. The World Wide Web is not synonymous with the Internet, which pre-dated the Web in some form by over two decades and upon which technologies the Web is built.

WWW is central to the development of the Information age and serves as a primary tool for billions of people to interact over the internet. WWW is a collection of websites or web pages stored in web servers and connected to local computers through the internet. These websites contain text pages, digital images, audios, videos, etc. Users can access the content of these sites from any part of the world over the internet using their devices such as computers, laptops, cell phones, etc. The WWW, along with internet, enables the retrieval and display of text and media to your device.

Difference between World Wide Web and Internet

Some people use the terms 'internet' and 'World Wide Web' interchangeably. They think they are the same thing, but it is not so (Figure 2). Internet is entirely different from WWW. It is a worldwide network of devices like computers, laptops, tablets, etc. It enables users to send emails to other users and chat with them online. For example, when you send an email or chatting with someone online, you are using the internet.

Figure 2: Internet vs WWW

But, when you have opened a website like google.com for information, you are using the World Wide Web; a network of servers over the internet. You request a webpage from your computer using a browser, and the server renders that page to your browser. Your computer is called a client who runs a program (web browser), and asks the other computer (server) for the information it needs.

Hypertext and Hyperlink

Hypertext and hyperlinks are common terminologies that are used with the internet. When we talk about internet,we talk about WWW, we talk about hypertext as well. Hypertext is a document that is containing words that actually connects to other documents rather than remaining being static. Like traditional text, we have hypertext that makes our text a little bit more dynamic. The dynamic organization of information with the help of links and connections that are called as hyperlinks. Hyperlinkis actually a reference to a particular data item that the reader can actually directly connect to it by clicking or by hovering over that particular hyperlink. For example, we have a link:

https://www.google.com/

If you just click on it, it will take you or if you are connected to the internet, you click on it and it will take you to Google's page. Hypertext is basically the same as a regular text, it can be stored,

read,searched or edited with an important exception. Hypertext contains connections with the text or to some other documents or it can be within the same document. Different kinds of connections can be done, it can be involved selecting a particular piece of hypertext. By clicking on hyperlink, it can take you to more and more hypertext on more and more books, or to some images, some sounds or some movies or any other document it can take you with the help of hyperlinks.
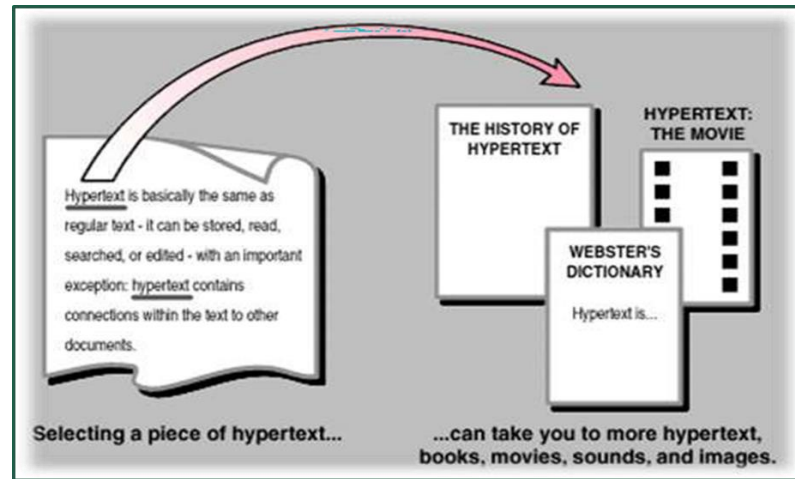
Figure 3: How Hyperlinking Works

As illustrated in Figure 3, we have a hyperlink that has been created from one particular homepage, we have different kinds of connections. From those connections, we can move out to the different kinds of pages or to a particular image file, any document file, any sound file, any music file.

11.1 Webpage

A web page or webpage is a document, commonly written in HTML, that is viewed in an Internet browser (Figure 4). A web page can be accessed by entering a URL address into a browser's address bar. A web page may contain text, graphics, and hyperlinks to other web pages and files. A web page is often used to provide information to viewers, including pictures or videos to help illustrate important topics. A web page may also be used as a method to sell products or services to viewers. When you click a link provided by a search engine, you are accessing a web page. The Internet consists of millions of web pages, with more being added every day.

Figure 4: Webpages

We can have different kinds of web pages such as Facebook page, Twitter page, WhatsApp, Yahoo, Gmail etc. that contain different kinds of layouts. Particularly, there are two main types of pages, a Homepage, and a landing page. The homepage is also written as a start page. It is a main web page of a particular website. It can refer to one or more pages always shown out in a web browser when

the application actually starts out. A landing page is the page where the visitor arrives out at a particular website after he or she clicks out on a particular ad. For example, you have a Google text ad or any display ad, you click on it and you will land to another page that is the landing page.

- Explain video teleconference.
- Explain Website.

11.2 Website

A website is a collection of web pages, which are accessible to a wide range of internet users. A website is a page or collection of pages on the Internet. Even individual people have their own website sometimes, in addition to pages on social media websites like Facebook and Twitter. A website is such a common everyday thing that it would seem odd that the only term describing it is hyphenated or two words, one capitalized. Website is a resource of information that is suitable for the WWW and can be accessed through a web browser. It can usually be in HTML or XHTML format and provides navigation to other web pages via hypertext links. There are different kinds of websites as depicted in Figure 5.

Classification According to Style

Static Website: A static website has web pages stored on the server in the same form as the user views them. It is primarily coded in HTML and it simply presents pre-defined information to the user. It may include information about a company and its products and services via text, photos, Flash animation, audio/video and usually displays the same information to all visitors; thus, the information is static.

Dynamic Website: Dynamic websites does not have web pages stored on the server in the same form as the user will view them. Instead, the web page content changes automatically and/or frequently based on certain criteria. A dynamic website generally collates information on the hope each time a page is requested.
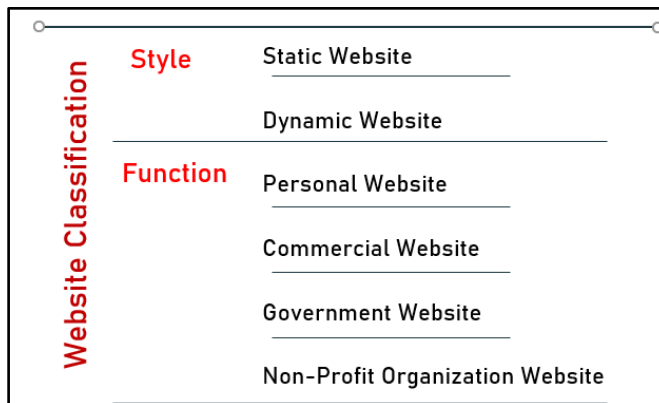
Figure 5: Classification of Websites

Static v/s Dynamic Website
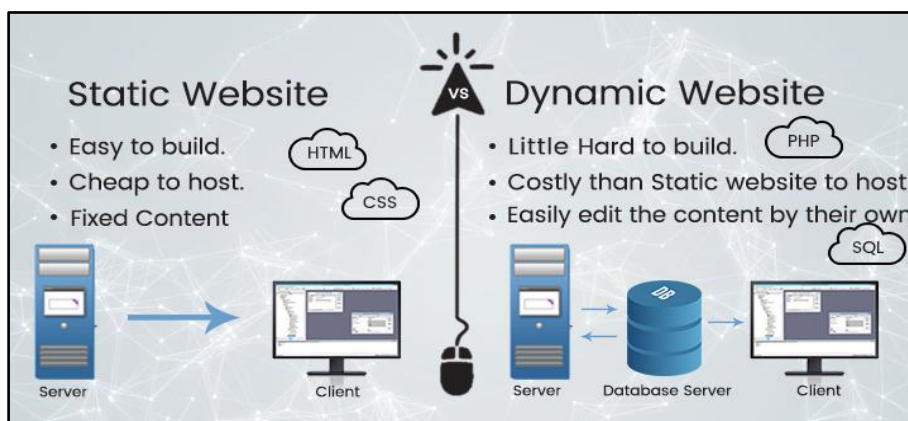
Figure 6: Comparison of Static vs Dynamic Website

Fundamentals of Information Technology

Classification According to Function

Personal Website: A personal website is meant for personal purpose that might include some family photos and personal diaries. It is useful for family members to stay in touch with each other (Figure 8).

Commercial Website: It is meant for commercial or business purpose where company can show off its product for the prospective consumers and create a market for same (Figure 7)

Figure 8: A Personal Website
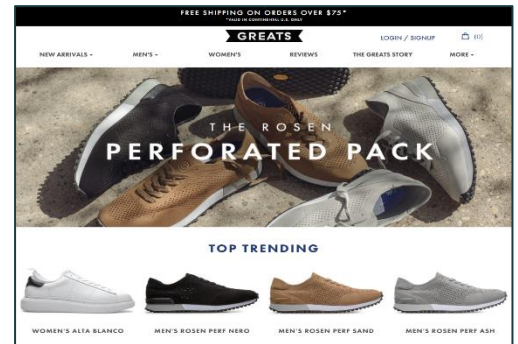
Figure 7: A Commercial Website

Government Website: A government website is meant for digital interactions between a citizen and their government (Figure 9).

Figure 9: A Government Website

Non-Profit Organization Website: Such websites arecreated for the interaction of members with the non-profit organization (Figure 10).
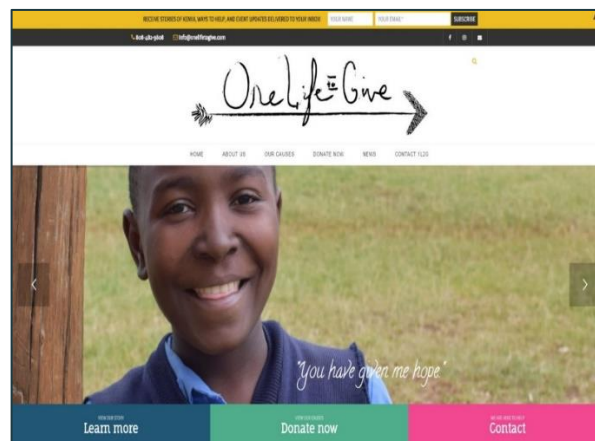
Figure 10: A Non-Profit Organization Website

LOVELY PROFESSIONAL UNIVERSITY

11.3   Search Engine

A web search engine or Internet search engine is a software system that is designed to carry out web search (Internet search), which means to search the WWW in a systematic way for a particular information specified in a web search query (Figure 11). The search results are generally presented in a line of results, often referred to as search engine results pages (SERPs). The information may be a mix of web pages, images, videos, infographics, articles, research papers and other types of files. Some search engines also mine data available in databases or open directories. Unlike web directories, which are maintained only by human editors, search engines also maintain real-time information by running an algorithm on a web crawler. Internet content that is not capable of being searched by a web search engine is generally described as the deep web.

A search engine is software accessed on the Internet that searches a database of information according to the user's query. The engine provides a list of results that best match what the user is trying to find. Today, there are many different search engines available on the Internet, each with its own abilities and features. The first search engine ever developed is considered Archie, which was used to search for FTP files, and the first text-based search engine is considered Veronica. Currently, the most popular and well-known search engine is Google. Other popular search engines include AOL, Ask.com, Baidu, Bing, DuckDuckGo, and Yahoo.

Figure 11: Different Web Search Engines

11.4   Uniform Resource Locators (URLs)

A Uniform Resource Locator (URL), otherwise known as a Universal Resource Locator, is the address of a resource on the Internet and the protocol used to access it.It indicates the location of a web resource like a street address indicates where a person lives physically — because of this, an URL is often referred to as: "web address".A URL contains the following information:

o The protocol used to access the resource.

o The location of the server (whether by IP address or domain name).

o The port number on the server (optional).

o The location of the resource in the directory structure of the server.

o A fragment identifier (optional).

A URL is a type of uniform resource identifier (URI). In common practice, the term URI isn't used, or is used synonymously with URL, even though this is technically incorrect.URL is nothing more than the address of a given unique resource on the web.Each valid URL points to a unique resource. Such resources can be an HTML page, a CSS document, an image etc. Some examples of the URLs that you may have come across:

http://www.google.com

http://www.yahoo.co.uk

http://www.amazon.com

If one types these URLs into their browser, one will go to the exact site he/she wanted without having to use a search engine.One can break a URL down into three sections.

http://www.amazon.co.uk

The www is short for World Wide Web.The www in the URL does not really do anything, it simply grew out of popular use. You will now find many websites which do not have 'www' in their URL Here, amazon.co.uk is called the Domain name and is part of the URL.However, it also tells you which organization owns the site.In this case, a company called Amazon owns the site.Notice that part of the URL contains the word .co that can tell you a lot about the type of website that you will be visiting.In this instance, it means that the website belongs to a company or business.Finally, notice that this URL ends with '.uk'. This means that the website is registered in the United Kingdom. Example: If a website ends with '.fr', it means that it was registered in France.Table 1 lists the other ending of a URL and their significance.

Table 1: Other Endings & their Significance

Ending	What does it Specify???
.gov	Government Site
.com	International Company
.co	Company
.org	Organization (Often a Charity)
.ac	Academic (Often a University)
.sch	School
.ed	Education
.net	Network of Websites

11.5 Internet Service Provider (ISP)

An Internet service provider (ISP) is an organization that provides a myriad of services for accessing, using, or participating in the Internet (Figure 12). ISPs can be organized in various forms, such as commercial, community-owned, non-profit, or otherwise privately owned.Internet services typically provided by ISPs can include Internet access, Internet transit, domain name registration, web hosting, Usenet service, and colocation.An ISP typically serves as the access point or the gateway that provides a user, access to everything available on the Internet.Other than Internet connection, ISPs may also provide related services like Web site hosting and development, e-mail hosting, domain name registration etc.

An ISP is responsible for establishing local, regional, or even national connections to facilitate online data transmissions between users, other ISPs, and internet servers. They are also known as Internet Access Provider (IAP), these companies not only provide an internet connection to their end-users, but are also able to provide other network services, such as email access, domain name registration, web hosting, and data center services.ISPs are able to provide these services by maintaining a large network of technological infrastructures that are maintained by hundreds, or for larger companies even thousands, of technicians. An ISP has a specific Point of Presence (PoP). A PoP refers to a physical access point where ISPs house their network servers, switches, and routers. Companies that provide internet services can have multiple PoPs to support their systems. ISPs cater to a specific geographical location. The range of their services would depend on whether they are a local ISP, regional ISP, or national ISP.

There are 2 main types of ISPs, namely, Regional ISPs and National ISPs.

Regional ISPs: These ISPs provide Internet access to a specific geographic area and usually has a smaller technical support team.

National ISPs: National-level ISPs conduct abusiness that provides Internet access in cities and towns nationwide and have a much larger technical support team.

Responsibilities of an ISP

o Providing and maintaining a connection to the Internet.
o Supporting the hardware and software needed to service that connection.
o To protect their site and network from external threats such as viruses, hacker attacks and other illegal activities.
o Providing 24-hour customer service and technical support.

Figure 12: Different ISPs in India

11.6 Hyper Text Transfer Protocol (HTTP)

Hypertext Transfer Protocol (HTTP) is an application-level protocol for distributed, collaborative, hypermedia information systems. It is a generic, stateless, protocol which can be used for many tasks beyond its use for hypertext, such as name servers and distributed object management systems, through extension of its request methods, error codes and headers. A feature of HTTP is the typing and negotiation of data representation, allowing systems to be built independently of the data being transferred.

HTTP basically involves two main things: One is request and other is the response. Web servers communicate with clients using a Response-Request protocol (Figure 13). Request is something that is done out through the web browser through the client machine. A web browser request is forwarded such that the request can involve a web page, involving a GET request followed by POST response that posts a page back to the server. GET and POST methods are extensively used.
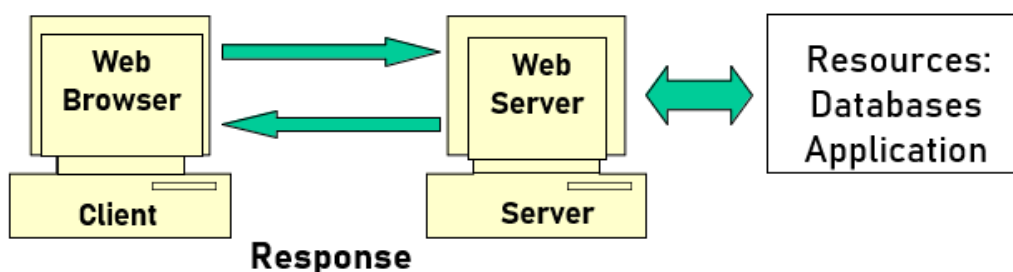
Figure 13: Client-Server Model and HTTP

11.7 Web Server

A web server is software and hardware that uses HTTP (Hypertext Transfer Protocol) and other protocols to respond to client requests made over the World Wide Web. The main job of a web server is to display website content through storing, processing and delivering webpages to users. Besides HTTP, web servers also support SMTP (Simple Mail Transfer Protocol) and FTP (File Transfer Protocol), used for email, file transfer and storage. A web server is aspecialized software

that responds to client (that is, web browser) requests. Every web site requires a web server to process client requests and 'serve up' the pages.

Web server hardware is connected to the internet and allows data to be exchanged with other connected devices, while web server software controls how a user accesses hosted files. The web server process is an example of the client/server model. All computers that host websites must have web server software.Web servers are used in web hosting, or the hosting of data for websites and web-based applications -- or web applications.

A Web server is server software, or hardware dedicated to running said software, that can satisfy World Wide Web client requests. A web server can, in general, contain one or more websites. A web server processes incoming network requests over HTTP and several other related protocols.The primary function of a web server is to store, process and deliver web pages to clients.The communication between client and server takes place using the Hypertext Transfer Protocol (HTTP). Pages delivered are most frequently HTML documents, which may include images, style sheets and scripts in addition to the text content.

A user agent, commonly a web browser or web crawler, initiates communication by making a request for a specific resource using HTTP and the server responds with the content of that resource or an error message if unable to do so. The resource is typically a real file on the server's secondary storage, but this is not necessarily the case and depends on how the web server is implemented.While the primary function is to serve content, a full implementation of HTTP also includes ways of receiving content from clients. This feature is used for submitting web forms, including uploading of files.

Many generic web servers also support server-side scripting using Active Server Pages (ASP), PHP (Hypertext Preprocessor), or other scripting languages. This means that the behaviour of the web server can be scripted in separate files, while the actual server software remains unchanged. Usually, this function is used to generate HTML documents dynamically ("on-the-fly") as opposed to returning static documents. The former is primarily used for retrieving or modifying information from databases. The latter is typically much faster and more easily cached but cannot deliver dynamic content.

Web servers can also frequently be found embedded in devices such as printers, routers, webcams and serving only a local network. The web server may then be used as a part of a system for monitoring or administering the device in question. This usually means that no additional software has to be installed on the client computer since only a web browser is required (which now is included with most operating systems).

How do Web Servers Work?

Web server software is accessed through the domain names of websites and ensures the delivery of the site's content to the requesting user. The software side is also comprised of several components, with at least an HTTP server. The HTTP server is able to understand HTTP and URLs. As hardware, a web server is a computer that stores web server software and other files related to a website, such as HTML documents, images and JavaScript files.

When a web browser, like Google Chrome or Firefox, needs a file that's hosted on a web server, the browser will request the file by HTTP. When the request is received by the web server, the HTTP server will accept the request, find the content and send it back to the browser through HTTP (Figure 14).

Figure 14: Example for Working of Web Server

More specifically, when a browser requests a page from a web server, the process will follow a series of steps. First, a person will specify a URL in a web browser's address bar. The web browser will then obtain the IP address of the domain name -- either translating the URL through DNS (Domain Name System) or by searching in its cache. This will bring the browser to a web server. The browser will then request the specific file from the web server by an HTTP request. The web server will respond, sending the browser the requested page, again, through HTTP. If the requested page does not exist or if something goes wrong, the web server will respond with an error message. The browser will then be able to display the webpage.

Features of Web Servers

- Remote computers or computer programs that deliver web content (like web pages, etc.) to the end user over the internet upon request through a web browser.

- Every web server will have an internet protocol (IP) address and domain name through which it is identified over the internet. Many web servers run on high-speed internet connection.

- Web servers need a continuous power supply and necessary cooling for them to function efficiently.

- Large data storage support: Data storage support is one of the primary features of web server. Every web server supports large storage space for storing data of multiple web sites.

- Bandwidth controlling to regulate network traffic: It is a feature available in web server to minimize excess network traffic. Web Hosts can set bandwidth values to regulate the rate of data transmission over the internet. This feature avoids the down time caused by high web traffic.

- Virtual hosting: Virtual Hosting is a type of web hosting service in which a web server is used to host other software based virtual web-servers web sites, data, applications and other services. Virtualized Web servers do possess this feature to provide virtual hosting.

- Server-side web scripting: This feature of web server enables the user to create dynamic web pages. The popular server-side scripting languages include Perl, Ruby, Python, PHP and ASP etc.

Uses of Web Servers

- **Role of Web Servers in Web Hosting:** The most common use of web servers is to host websites and to deliver the web content from its hosted websites over the internet. While delivering web pages, web servers follow a network protocol known as Hyper Text Transfer Protocol (HTTP).

The web hosting service providers uses web servers to host multiple websites.Other uses such as gaming, data storage or running enterprise applications. It stores and secures website data: In web hosting services, a web server stores all website data and secures it from unauthorized users when it is properly configured.

• **Provides Web Database Access:** Web servers provide access to websites that are hosted. Web hosting service providers own some web servers that are used in variable ways to provide different web hosting services, such as backend database servers.

• **Serve the End User Requests:** Web servers accept requests from different users connected over the internet and serve them accordingly.

Types of Web Servers

Dedicated Server/ Physical Servers: A physical server that is purchased or rented entirely for your own business needs, making it a great solution for large businesses, those that for regulatory reasons require exceptionally high levels of data security, or organisations that have predictable demand necessitating all of their servers running 24*7*365.
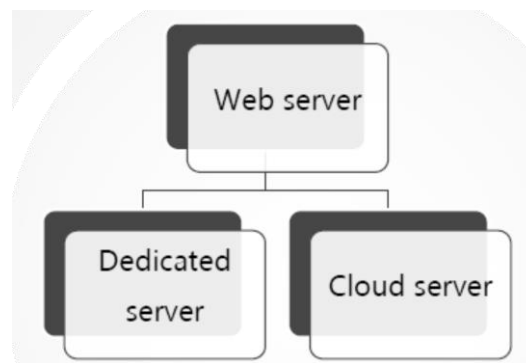
Cloud Server: The virtual server that provides great option for businesses that need to optimise IT performance without the huge costs associated with purchasing and managing a fully dedicated infrastructure. Such servers are popular choice for small and mid-sized businesses.

11.8   Web Browsers

A web browser (commonly referred to as a browser) is a software user agent for accessing information on the World Wide Web. To connect to a website's server and display its pages, a user needs to have a web browser program. This is the program that the user runs to download, format and display a web page on the user's computer.
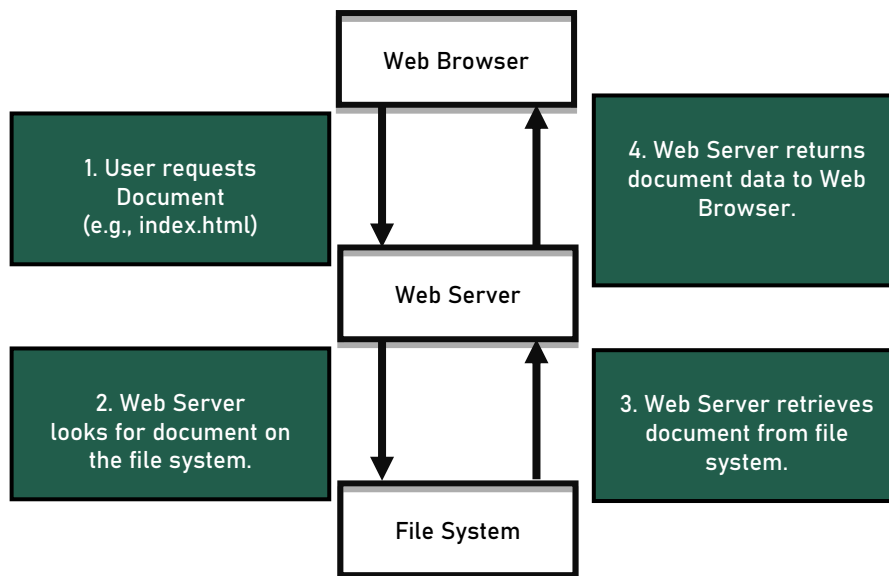
Figure 15: Web Browser and Server Interaction

Web browser acts as an interface between the user and Web server. It is a software application that resides on a computer and is used to locate and display web pages.Web user access information from web servers, through a client program called browser.Web browser helps to locate, retrieve and display content on the WWW, including Web pages, images, video and other files. It is based on client/server model where the browser is the client that runs on a computer that contacts the Web server and requests information (Figure 15).Web server sends the information back to the Web browser which displays the results on the computer or other Internet-enabled device that supports a browser.In addition to allowing users to find, displaying and moving between web pages, a web browser will usually have features like keeping bookmarks, recording history, managing cookies and home pages and may have facilities for recording passwords for logging into web sites.The most popular browsers are Chrome, Firefox, Safari, Internet Explorer, and Edge.

History of Web Browsers

In late 1980s, variety of technologies laid foundation for first Web browser, World Wide Web, by Tim Berners-Lee in 1991.Microsoft responded with its browser Internet Explorer (IE) in 1995 initiating the industry's first browser war.Opera first appeared in 1996; although it has only 2% browser usage share as of April 2010, it has a substantial share of the fast-growing mobile phone Web browser market, being preinstalled on over 40 million phones.In 1998, Netscape launched Mozilla.

Features of Web Browsers

- Major web browsers allow users to open multiple information resources at same time, either in different browser windows or in different tabs of same window.
- Refresh and stop buttons for refreshing and stopping the loading of current documents.
- Home button that gets you to your home page.
- Major browsers also include pop-up blockers to prevent unwanted windows from "popping up" without the user's consent.

Components of a Web Browser
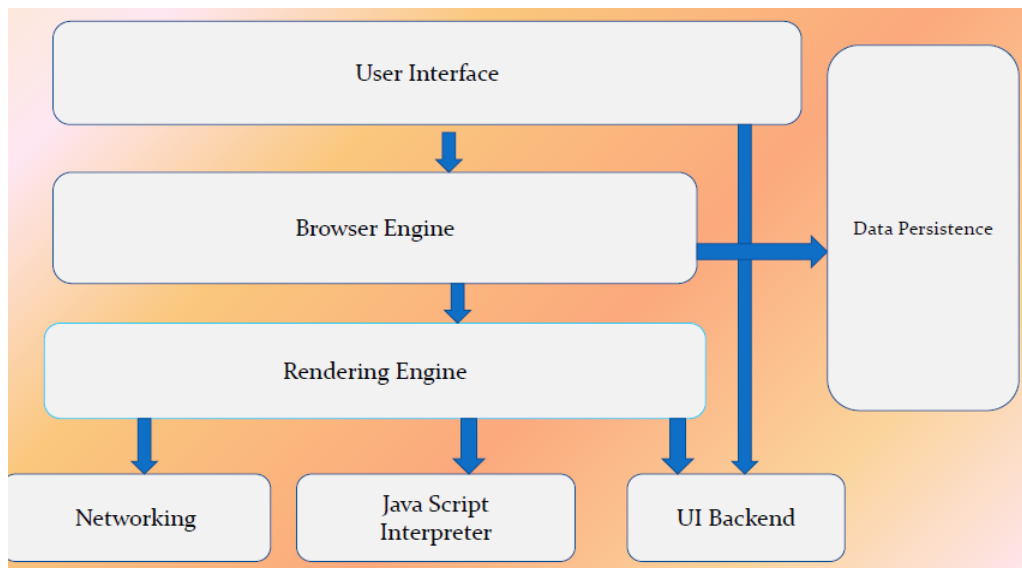
- **User Interface:** It is the space where interaction between users and the browser occurs. It includes the address bar, back/forward button, bookmarking menu etc.
- **Rendering Engine:** Rendering is display of the requested contents on the browser screen.By default, the rendering engine can display HTML and XML documents and images.
- **Browser Engine:** A browser engine is piece of code that communicates the inputs of user interface with the rendering engine. It is responsible for querying and manipulating the rendering engine according to the inputs from various user interfaces.
- **Networking:** The fraction of the code written in the browser, responsible to send various network calls. For example, sending the http requests to the server.
- **Java Script Interpreter:** It is component of the browser written to interpret the java script code presented in a web page.
- **UI Backend:** Draws basic widgets on the browser like combo boxes, windows etc.
- **Data Storage:** Data storage pertains to the small database created on the local drive of the computer where the browser is installed. This database stores various files like cache, cookies, etc.

Working of a Web Browser

The main functionality of a browser is to present the web resource chosen, by requesting it from the server and displaying it on the browser window. The resource is usually an HTML document, but may also be a PDF, image, or other type. The location of the resource is specified by the user using a URI (Uniform resource Identifier).As one writes URL & hits GO button, browser program sends a request to a web server program running on remote computer. The server program gathers request from the browser, tries to hunt for the web page and then formulates a response.If server was able to locate the web page, it sends the HTML file to the web browser. The browser picks up all the information coming in from the server and does its best to display the web page. A typical web page not only has text but also images and these are separate files that need to be transferred from the server to the browser. The browser-server communication goes on till all the files have been transferred to the browser.After that Browser-server connection is disconnected and Web Page is displayed on the browser window.

Different Types of Web Browsers

WorldWide Web- First Web Browser: When it was written, Worldwide Web was the only way to view the Web. It is capable of displaying basic style sheets, downloading and opening any file type

supported by the NeXT system, browsing newsgroups, and spellchecking. At first, images were displayed in separate windows, until NeXTSTEP'sText class supported Image objects. It was later renamed as Nexus.

Mozilla Firefox: Firefox Web Browser is the faster, more secure, and fully customizable way to surf the web.Mozilla is a global community dedicated to building free, open source products like the award-winning Firefox web browser and Thunderbird email software. Mozilla Firefox.

MOSIAC: It was developedat National Center for Supercomputing Applications (NCSA) at University of Illinois Urbana-Champaign beginning in late 1992. The browser software was further innovated by Marc Andreessen, NCSA released it in 1993. It was the first browser to display images inline with text instead of displaying images in a separate window.In 1994, he made his company Netscape and changed mosaic into Netscape Navigator.

Netscape Navigator: Netscape Navigator and Netscape are the names for the proprietary web browser popular in the 1990s. It is flagship product of the Netscape Communications Corporation and the dominant web browser in terms of usage share, although by 2002 its usage had almost disappeared.

Windows Internet Explorer: It was formerly called, Microsoft Internet Explorer. It is a series of graphical web browsers developed by Microsoft and included as part of the Microsoft Windows line of operating systems starting in 1995.

OPERA: Web browser andInternet suite developed by Opera Software that handles common Internet-related tasks such as displaying web sites, sending and receiving e-mail messages, managing contacts, chatting on IRC downloading files via BitTorrent, and reading web feeds. It offered free of charge for personal computers and mobile phones.

SAFARI: Safari is a graphical web browser developed by Apple and included as part of the Mac OS X operating system. It runs on the company's Mac OS X operating system; it became Apple's default browser.

Google Chrome: It is a web browser developed by Google that uses the WebKit layout engine and application framework.First released as a beta version for Microsoft Windows on 2 September 2008, and the public stable release was on 11 December 2008.

Microsoft Edge: This browser has been developedMicrosoft and runs on– windows 10, window 10 mobile, windows server 2016, Xbox one. It has been written in– C++

OtherMobile Browsers: Mobile browsers are called as micro browsers, minibrowsers or wireless internet browsers (WIB). These browsers are designed for use on a mobile device such as a mobile phone or PDA.Opera Mini, offered free of charge, is designed primarily for mobile phones, but also for smartphones and personal digital assistants.

11.9 Web Data Formats

A webpage is best thought as a set of virtual elements (paragraphs, titles, tables, list, images).Hypertext Markup Language (HTML) defines the structure and layout of elements of a Web page with a variety of tags. Each tag may have a set of attributes that modify the appearance and layout of virtual elements contained by the tag.

Hypertext Markup Language (HTML)

HTML is a markup language that depicts a presentation language for the Internet. The commands are tags such as HTML start and end tag, unordered list <ul> etc. These can be represented as:

<center><HTML> … </HTML></center>

<center><UL> … </UL></center>

Many editors automatically generate HTML directly from your document (example, Microsoft Word has a "Save as html" facility).

Importance of HTML:

o   Used to display any type of document on the host computer.

o   A versatile language and can be used on any platform.

o   Used to make the text look attractive.

o   Can link one document with another.

Sample Commands: Every HTML page has an initial HTML start tag. There are other sample commands such as, ul (unordered list) is a tag; LI (list entry); h1 (indicates the largest heading); h2 (second level heading), h3 (third level heading) and so on. There is a B tag (bold); br (used to insert a line break within the extra space that is inserted out mostly in the beginning).

Some other tags such as p tag indicates a paragraph; align tag that can help in aligning the content. There can be different properties or attributes that are associated with the tag, we can simply use align tag attributes such as left, center or right.

<HTML>

<UL>: unordered list

<LI>: list entry

<h1>: largest heading

<h2>: second-level heading, <h3>, <h4> analogous

<B>Title</B>: Bold

This element is used to insert a line break with extra space in the beginning.

A sample code is written below. First of all, it specifies doctype is HTML followed by a HTML starting tag. Then, body tag having h1 heading start tag. The text written within the h1 start and ending tag is written as heading. A paragraph starting tag and paragraph ending tag is specified. The text within these tags is written as paragraph. At the end, there must be closing tags for the body and HTML.

<!DOCTYPE html>

<html>

<body>

<h1> My first Heading </h1>

<p> My first paragraph </p>

</body>

</html>

This needs to be saved and then, the file must be run into the browser to generate the output.

Extensible Markup Language (XML)

It has a self-describing, hierarchal data model that is used in case of web data formats. XML stands for Extensible Markup Language where the x from extensible word m for markup word and language that makes a complete word XML. It is a markup language that is used for documents that are containing structured information. Prominently, we have 4 main specifications for XML:

o XML, the Extensible Markup Language

o XLL, the Extensible Linking Language

o XSL, the Extensible Style Language

o XUA, the XML User Agent

XML is a language that provides a way of communicating different information markup we use because it takes notes or metadata that are describing the data or the language. It is extensible because it is limited, it provides limitless ability to actually define new different languages or different kinds of data sets. It is useful for defining your own language or any protocol you want to define like see, we have a chemical Markup Language over here example for this, it is starting with a molecule tag whose weight is this with the weight tag that is closing, then it's factorize this and figures in case we want to embed any figures in the closing tag for molecule

Chemical Markup Language:

<molecule>

<weight>234.5</weight>

<Spectra>…</Spectra>

<Figures>…</Figures>

</molecule>

XML– Structure

XML is a confluence of Standard Generalized Markup Language (SGML) and HTML.XML looks like HTML. It is a hierarchy of user-defined tags called elements with attributes and data. The data is described by elements, elements are described by attributes.Example: First of all, we have the opening tag for book that is the element with genre as attribute. The attributes provide additional information for element tags.The attribute value here is that it is the science book. The format here is that it is hardcover. Then, we have the closing tag for the book that has a particular XML structure.
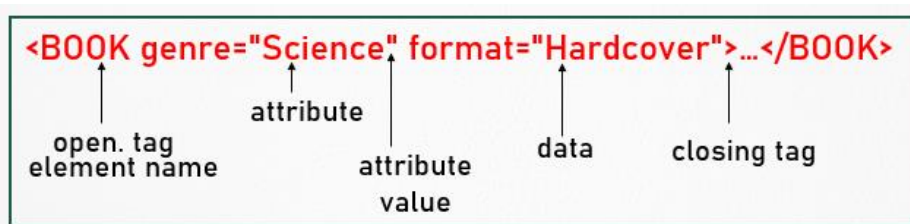
Considerations

- XML is case and space sensitive.
- Element opening and closing tag names must be identical.
- Opening tags: "<" + element name + ">"
- Closing tags: "</" + element name + ">"
- Empty Elements have no data and no closing tag:
- They begin with a "<"and end with a "/>" such as <BOOK/>
- There can be zero or more attributes in every element; each one has the form:

  attribute_name= 'attribute_value'

- There is no space between the name and the "='"
- Attribute values must be surrounded by " or ' characters.
- Multiple attributes are separated by white space.

XML: Data and Commands

o XML data is any information between an opening and closing tag.

o XML data must not contain the '<' or '>' characters

o Comments: <!- comment ->

XML– Nesting and Hierarchy

o XML tags can be nested in a tree hierarchy.

o XML documents can have only one root tag.

o Between an opening and closing tag you can insert:Data, more elements, combination of data and elements.

XML vs HTML :Table 2lists the difference between XML and HTML.

Table 2: XML vs HTML

Extensible Markup Language	Hyper Text Markup Language
XML fundamentally separates contents (data and information) from presentation.	HTML specifies presentation.
XML allows tags and grammars to be used.	HTML explicitly defines a set of legal tags as well as grammar.

Dynamic Hypertext Transfer Markup Language (DHTML)

DHTML is not a language. It is an art of making dynamic and interactive web pages. It is a combination of web development technologies used to create dynamically changing websites. The web pages may include animation, dynamic menus and text effects. The technologies used include a combination of HTML, JavaScript or VBScript CSS and document object model (DOM).

DHTML has been designed to enhance a web user's experience and includes the following features:

    o Dynamic content, which allows the user to dynamically change web page content.

    o Dynamic positioning of web page elements.

    o Dynamic style which allows the user to change the web page's color, font, size or content.

Dynamic HTML is an all-in-one word for web pages that uses:

    o Hypertext Markup Language (HTML),

    o Cascading Style Sheets (CSS), and

    o JavaScript to make the web pages interactive

DHTML describes the abstract concept ofbreaking up a page into elements that can be manipulated; exposing those elements to a scripting language where the script performs the manipulations.

Need of DHTML

- HTML in its traditional form is not powerful enough to create the interactive and multimedia-rich documents.

- Without DHTML, the browser must download another page from the server to change what the user sees on the screen.

- DHTML uses the JavaScript technology for accessing, controlling, and manipulating the HTML elements.

- Example: Javascript (+)

Advantages

- Small file size- DHTML files are small compared to other interactive media such as flash or shockwave. Therefore, they have a shorter download time & take up less bandwidth.

- Supported by both major browser manufactures- both Microsoft and Netscape currently support DHTML in some shape or form.

- DHTML will be a standard: WWW consortium or the W3C is currently implementing standards for DHTML technologies. It has already released preliminary specification for DOM & CSS.
- No plug-ins necessary: DHTML uses most of the features already present in the browsers, so there is no need to download any sort of plug-ins.
- Doesn't require a java virtual machine.

Disadvantages

- Costly editing tools: DHTML provides great functionality but editors available for that in market are pretty expensive. Example: Dreamweaver & fusion.
- Only new browser support DHTML: DHTML is only supported by Netscape 4.0 or higher & internet explorer(IE) 4.0 or higher version.
- Long and complex coding: DHTML coding is long and complex only the expert JavaScript & HTML programmers can write them & edit them with good degree of functionality.
- Browser support problem: DHTML suffer from browser support problems for different browser.
- Unprotected source code.

11.10 Scripting Languages

A programming language that supports scripts, programs written for a special run-time environment is called as scripting language. It can interpret and automate the execution of tasks and can alternatively execute tasks one-by-one by a human operator.

Server-side Scripting: The server-side scripting is used to connect to the databases that reside on the web server. It is used to access the file system residing at the web server. The response from a server-side script is slower as compared to a client-side script because the scripts are processed on the remote computer.

The server-side scripting foes not require the user to download plug-in like Java or Flash (client-side scripting).Scripts are hidden from view. Users only see the HTML output, even when they view the source.

Server-side Scripting Languages:ASP.NET, C, Java via JavaServer Pages, PHP, Python etc.

Client-side Scripting: The program that execute on client-side, by the web browser instead of server side. Upon request, the necessary files are sent to the user's computer by the web server on which they reside. The browser sends to the server an URL request. Web pages are stored on the Web server. The server decides which page, given the URL, to be sent back to the browser where the browser interprets and executes the content of the HTML page, including any scripts.

The client-side scripts allow for more interactivity by immediately responding to user actions. They execute quickly because they don't require a trip to the server and can give developers more control over the look and behavior of their web apps.

Client-side Scripting Languages:JavaScript, ActionScript, Dart etc.

11.11 Services of Internet

Communication: Email is an important communications service available on the Internet.The concept of sending electronic text messages between parties in a way analogous to mailing letters or memos predates the creation of the Internet. Pictures, documents and other files are sent as email attachments. Emails can be cc-ed to multiple email addresses.Example: Yahoomail.com, Hotmail.com, Rediffmail.com

Internet telephony is another common communications service made possible by the creation of the Internet. VoIP stands for Voice-over-Internet Protocol, referring to the protocol that underlies all Internet communication.

Data Transfer: File sharing is an example of transferring large amounts of data across Internet. A computer file can be emailed to customers, colleagues and friends as an attachment. It can be uploaded to a website or FTP server for easy download by others. Example of file sharing are: FTP, TELNET.TELNET(Remote Computing)- Telnet is telecommunication utility software, which uses available telecommunication facility and allows a user access on a remote computer. If one gains access to it, one can use it for intended purpose.TELNET works in a very step by step procedure.

The commands typed on client computer are sent to local ISP, and then from the ISP to remote computer that one has gained access.

Information Access: Many people use the terms Internet and WWW. WWW is a global set of documents, images and other resources, logically interrelated by hyperlinks and referenced with URIs.HTTP is main access protocol of WWW, or one of hundreds of communication protocols used on Internet.Internet is interconnection of large number of heterogeneous computer networks all over the world that can share information back and forth. It involves an interconnected network exchange information by using same standards and protocols.

Internet in Careers: The positive use of the Internet makes our lives, business and career easy and simple.Example: One can learn basic computer skills online and can also use the internet to let more people know about your local business online.Internet provides us useful data, information, and knowledge for personal, social, and economic development and it is up to us to utilize our time on the world wide web in a productive manner. Different job searches (Naukri.com, monster.com, Summerjob.Com, recuritmentindia.com) are supported through Internet.

Internet in Health and Medicine: Traditionally, Internet has been used principally as a tool for a cost-effective communication medium by the healthcare industry. It is set to change healthcare delivery with steady adoption of technology, thereby changing traditional paradigm between doctors and patients as well as manner of healthcare delivery.With more than a billion users, Internet connects researchers and healthcare providers all over the world. It serves as an effective medium of research through academic literature, conducting online interviews and gathering feedback from special focus groups.

Internet in Travel: Currently, we have access to portable internet connectivity. When you are traveling, Internet access allows you to get work done, keep in touch with family and make your next hotel reservation. Depending on where you are, Internet access will vary in availability and reliability. As you plan your trip, research options for getting online to make the transition easier.Example: Indiatravellog.com, rajtravel.com, makemytrip.com

Internet in Entertainment: With an endless supply of entertainment available, it's tough to get bored on the internet. Internet has played a significant role in entertainment. It has changed the way that entertainment is viewed, consumed and also the way in which it's received. Years ago, entertainment was primarily enjoyed in real time and live.WWW has opened up a host of free options, given instant access to a variety of content & allowed more people to create entertainment & art for others to enjoy.People get to experience improved communication with one another through enhanced video chat options and the ability to share memories with one another.Example: Youtube.com, movies.com, espn.com

Internet in Shopping: Internet provides a quick and easy way to purchase a product, some people prefer to use this technology only in a limited way. It acts as a means for gathering more information about a product before buying it in a shop. The latest trends such as machine learning are used for advertisement andmarketing of products. The e-commerce giants such as Myntra.com, Ajio.com, Nykaa.com are perfect examples.

Internet in Education: With the help of Internet, instructional materials can be made available to students online. A large amount of written material, various presentations, assignments can be given to students. Even the instructions too can be conveyed to students via internet.The learner gets the scope of learning desired course anywhere, anytime thereby making learning more flexible, interesting and meaningful.Internet also helps in removing the age restrictions. The learner ranging from young lots to the adults can enhance their learning as per their needs. It is easy to find books and study material. The individualised as well as group methods can be applied online with the help of varied internet tools like e-mail, discussion forum, Chat rooms, WWW etc.

Electronic mail (Email): Email is a method of exchanging messages ("mail") between people using electronic devices.Email entered limited use in 1960s, but users could only send to users of the same computer and some early email systems required author & recipient to both be online simultaneously, similar to instant messaging. Email operates across computer networks. The email servers accept, forward, deliver, and store messages.

Instant Messaging (IM): Instant messaging is a real-time text-based communication sent from one person in a network (public or private) to any one or more people who share that network. The message arrive instantaneously on recipient's communication mode (smartphone, tablet, computer/laptop). IM relies on transmitting a message through wireless phone signals or through Internet systems using a software or program specifically designed for creating an IM network.

Modern IM networks allow for text, graphic, audio, video, & even video conferencing among participants.

Internet Telephony: It is a type of communications technology that allows voice calls and other telephony services like fax, SMS and other voice-messaging applications to be transmitted using Internet as a connection medium.Examples: NFON Cloud Telephone System and Skype for Business.

Video Conferencing: Video conferencing is conducted by a set of telecommunication technologies which allow two or more locations to communicate by simultaneous two-way video and audio transmissions. It is also called as 'visual collaboration' and a type of groupware. It differs from videophone calls in that it's designed to serve a conference or multiple locations rather than individuals.

Summary

- Internet is a network of networks that consists of private, public, academic, business, and government networks of local to global scope, linked by a broad array of electronic, wireless, and optical networking technologies.

- A web page can be accessed by entering a URL address into a browser's address bar. A web page may contain text, graphics, and hyperlinks to other web pages and files.

- A commercial website is meant for business purpose where company can show off its product for the prospective consumers & create a market for same.

- XML is a language that provides a way of communicating different information markup we use because it takes notes or metadata that are describing the data or the language.

- WWW is a powerful tool for communicating ideas, facts and opinions throughout the world. It is an open-source information space where documents and other web resources are identified by Uniform Resource Locators (URLs), interlinked by hypertext links, and can be accessed via the internet.

- Internet telephony consists of a combination of hardware and software that enables you to use the Internet as the transmission medium for telephone calls.

- e-mail is the transmission of messages over communications networks. The messages can be notes entered from the keyboard or electronic files stored on disk. Most mainframes, minicomputers and computer networks have an e-mail system.

- Hypertext Markup Language (HTML) defines the structure and layout of elements of a Web page with a variety of tags. Each tag may have a set of attributes that modify the appearance and layout of virtual elements contained by the tag.

- A Uniform Resource Locator (URL)is the address of a resource on the Internet and the protocol used to access it.It indicates the location of a web resource like a street address indicates where a person lives physically— because of this, an URL is often referred to as: "web address".

- Dynamic Hypertext Markup Language is an art of making dynamic and interactive web pages. It is a combination of web development technologies used to create dynamically changing websites.

Keywords

*Videoconferencing:*Videoconferencing isa conference between two or more participants at different sites by using computer networks to transmit audio and video data.

*Instant Messaging (IM):*Instant messaging is a real-time text-based communication sent from one person in a network (public or private) to any one or more people who share that network.

*Server-side Scripting:*The server-side scripting is used to connect to the databases that reside on the web server.

*Internet:*The Internet (or internet) is the global system of interconnected computer networks that uses the Internet protocol suite (TCP/IP) to communicate between networks and devices.

Hypertext: Hypertext is a document that is containing words that actually connects to other documents rather than remaining being static.

*Web Servers:*Web servers are the remote computers or computer programs that deliver the web content (like web pages, etc.) to the end user over the internet upon request through a web browser.

*Web Page:*A web page or webpage is a document, commonly written in HTML, that is viewed in an Internet browser.

Internet Service Provider: An Internet service provider (ISP) is an organization that provides a myriad of services for accessing, using, or participating in the Internet.

*Scripting Language:*A programming language that supports scripts, programs written for a special run-time environment is called as scripting language.

Self-Assessment

1. Internet consists of very large _____ connecting computers and networks around the world.
    A.   Personal Area Network (PAN)
    B.   Local Area Network (LAN)
    C.   Metropolitan Area Network (MAN)
    D.   Wide Area Network (WAN)

2. _____ is a conference between two or more participants at different sites by using computer networks to transmit audio and video data.
    A.   Photo conferencing
    B.   Videoconferencing
    C.   Computer conferencing
    D.   Participant conferencing

3. _____ is a document containing words that connects to other documents.
    A.   Hypermedia
    B.   Hyperdocument
    C.   Weblink
    D.   HyperText

4. _____ is a database on the WWW that enables to use search terms or key words to find relevant pages or websites.
    A.   Search database
    B.   Web database
    C.   Search engine
    D.   Web engine

5. IM stands for
    A.   Instant messaging
    B.   Internet messaging
    C.   Internet monitoring
    D.   Instant monitoring

6. _____ provides Internet access to a specific geographic area and usually has a smaller technical support team.
    A.   National ISP
    B.   International ISP
    C.   Regional ISP

D. Geographic ISP

7. Web servers communicate with clients using a Response-Request protocol, that is, _____.

    A. HTPS

    B. HTTP

    C. FTP

    D. HTML

8. _____ defines the structure and layout of elements of a Web page with a variety of tags.

    A. WHTML

    B. HTML

    C. CSS

    D. LHTML

9. The element <P> tag signifies _____ in an HTML code.

    A. page

    B. pre-code

    C. pre-set

    D. paragraph

10. XLL stands for _____

    A. Extensible Linking Language

    B. Extensible Loading Language

    C. Extendable Linking Language

    D. Extendable Loading Language

11. _____ are the remote computers or computer programs that delivers web content (like web pages, etc.) to the end user over the internet upon request through system.

    A. Web browsers

    B. Web servers

    C. Proxy servers

    D. Page servers

12. _____ is a type of web hosting service in which a web server is used to host other software based virtual web-servers web sites, data, applications and other services.

    A. Virtual hosting

    B. Page hosting

    C. Cache hosting

    D. Application hosting

13. Which of the following is server-side scripting language?

    A. Perl

    B. Python

    C. PHP

    D. All of the above

14. The other name for mobile browsers is

    A. micro browser

    B. mini browser

    C. wireless internet browser (WIB)

    D. all of the above

15. _____ is a telecommunication utility software, which uses available telecommunication facility and allows a user access on a remote computer.

    A.   Telnet

    B.   REMOTE

    C.   T-UTIL

    D.   TELECOM

Answer for Self Assessment

1.	D	2.	B	3.	D	4.	C	5.	A
6.	C	7.	B	8.	B	9.	D	10.	A
11.	B	12.	A	13.	D	14.	D	15.	A

Review Questions

1. What are the main components of Internet browsers?
2. What are the various applications of Internet?
3. Differentiate static and dynamic websites?
4. What are web browsers? How they work?
5. Discuss the advantages and disadvantages of Internet with suitable examples?
6. What is website? Discuss the website classification.
7. Discuss about the use of Internet Service Providers (ISP) and their types?
8. What is the significance of HTML in Internet Browsers?
9. Compare HTML and XML?
10. What is DHTML? Elaborate.
11. How HTTP works in Internet?
12. What are Uniform Resource Locators (URLs) and they work?

Further Readings

Computer Fundamentals by P.K.Sinha and Preeti Sinha

Internet and Its Uses - Your Home Teacher (whatistheurl.com)

Top 10 Uses of Internet in our daily life | Everyday Science

How does the internet work? - BBC Bitesize

Brief History of the Internet | Internet Society

HTTP (Hypertext Transfer Protocol) Definition (techterms.com)

What's an Internet Browser? A Layman's Guide (thebalanceeveryday.com)

What is a Web Browser? - Definition from Techopedia

What is a Web Server and How Does it Work? (techtarget.com)

HTML Tutorial (w3schools.com)

Dr. Tarandeep Kaur, Lovely Professional University

Unit 12: Understanding the Need of Security Measures and Taking Protective Measures

Objectives

After studying this unit, you will be able to:

- know about the basic security concepts.
- explainthreats to users, threats to hardware and threats to data.
- describe cyber terrorism.
- understand keeping your system safe.
- analyze protecting yourself and understand protect your privacy.
- learn about managing the cookies.
- discuss spyware and other bugs.
- discuss keeping your system secure, backing up data and safe guarding your computer hardware.

Introduction

The term computer security is used frequently, but the content of a computer is vulnerable to few risks unless the computer is connected to other computers on a network. As the use of computer networks, especially the Internet, has become pervasive, the concept of computer security has expanded to denote issues pertaining to the networked use of computers and their resources. Threat is defined as a computer program, a person, or an event that violates the security system. A threat causes loss of data and attacks the data privacy. Security is the protection of assets. The three main aspects are:

- prevention

- detection

- re-action

Security is actually related to protection of assets, assets pertaining to something that we have, like our computer, our laptop, a mobile, all these are assets. The main aspects related to security is prevention of how we can prevent the loss of our particular asset, then detection, if we have lost it, how we can detect it, then the reaction that is pertaining to how we will react to a particular security breach, if it takes place.

12.1   Traditional Security v/s Computer Security

In case of traditional security mechanisms, they were excellent chances that the information can be stolen, but you still have the confidential information, it may get copied or it may get be sold, butthere can be situations with the theft does not get detected. So, criminals may be on the other side of the world that is one important aspect related to the computer security whereas if we talk about computers versus physical security computer security is more concerned with the loss of data and information. If we talk about the physical security of a particular computer system, even our mobile phones or our smartphones or any other laptop devices are physical things. The computer security it means to protect the information. It deals with the prevention, detection and offers any unauthorized actions by the users of a particular computer. The computer security has been extended to include privacy, confidentiality and integrity.

Computer security is the protection afforded to an automated information system in order to attain the applicable objectives of preserving the integrity, availability and confidentiality of information system resources (includes hardware, software, firmware, information/data, and telecommunications). The major focus of security lies on:

o **Application-level Security-** Determines who can access data and what tasks they are allowed to perform.

o **Transport-level Security-** Transport-level mostly determines the security of data as it is transmitted.

Security Triad

The major technical areas of computer security are usually represented by the initials CIA: confidentiality, integrity, and authentication or availability. Confidentiality means that information cannot be access by unauthorized parties. Confidentiality is also known as secrecy or privacy; breaches of confidentiality range from the embarrassing to the disastrous. Integrity means that information is protected against unauthorized changes that are not detectable to authorized users; many incidents of hacking compromise the integrity of databases and other resources. Authentication means that users are who they claim to be. Availability means that resources are accessible by authorized parties; "denial of service" attacks, which are sometimes the topic of national news, are attacks against availability.

The other important concerns of computer security professionals are access control and non-repudiation. Maintaining access control means not only that users can access only those resources and services to which they are entitled, but also that they are not denied resources that they legitimately can expect to access. Non-repudiation implies that a person who sends a message cannot deny that he sent it and, conversely, that a person who has received a message cannot deny that he received it.

Confidentiality: Confidentialityis further subdivided into two main aspects one is a data confidentiality and second is privacy of data, so data confidentiality, it shows that confidential information it is not disclosed to any unauthorized individual. If we talk about privacy, it shows that individual control or influence what information may be collected and what information can be stored. Confidentiality pertains to keeping the information secret or private. It is very important aspect. For example, suppose we have the student grade that is an important information thereby confidentiality is considered as very high. It says that the grades should only be available to the students or their parents. The student enrollment informationhas certain moderate confidentiality rating. If it gets disclosed, there is lesser damaged and then that can be caused.

Integrity: Integrity is further divided into two main parts one is data integrity second is system integrity. Now if I talk about data integrity, it shows that information and the programs, they are changed only in a specified and authorized manner. System integrity means that the system performs its operations in an unimpaired manner. Also, there is no hindrance in performing its actions in case of system integrity. Integrity prevents any unauthorized writing modification or manipulation of information. It means there is an external consistency that is existing in a system, everything is as it is, as it is expected to be like, if I transfer data from one source to a destination then in between that transport-level security is being maintained that means that data does not get manipulated, it does not get modified in between that transition or transport. Data integrity means that data stored on a computer is same as that on the source document. Example: Suppose in healthcare sector, if we talk about a particular hospital it is maintaining the patient's record. Thepatient's allergy information is a very highly integrated data like doctors should be able to trust that the information is correct. Considering a real-world scenario like you go to a hospital, you're working in a hospital, or you have a friend who is a nurse in that hospital. By mistake the nurse has written some data related to a particular patient that she did not mention that this patient is diabetic into the patient's record, but being a diabetic, is considered as the most important aspect in a patient'streatment aspect.

A doctor comes up give certain medicines to the patient, unaware of the thing that the patient is diabetic, so that can cause certain, you know blunder in that case. A missed information or wrong information by the nurse impacts the doctor's treatment. The patient might get certain treatment that would actually exaggerate his diabetic levels. It is a blunder on the aspect of that particular nurse that she did not mention, or maybe one has mentioned but by default that page gets deleted out or that record gets deleted out so in that case the integrity related to a patient's record is extremely important.

What if a particular nurse deliberately falsifies the data, the database should be restored to a trusted basis and falsified information should be traced back to the person who actually did it. Even in online news group registration data, it is of moderate-level, it does not require very much high-level of integrity security.

Availability: Availabilityassures that the systems work promptly, and the service is not denied to any unauthorized users. The information should be accessible, as in when it is required, it should be reasonable, or usable upon appropriate demand by an app or by an authorized user. The availability pertains to prevention of any unauthorized from withholding of information. There are certain attacks that are related to availability like Denial of Service (DoS) attack. In such attacks, the service might get unavailable for the authorized users. Example: If a system provides authentication, it requires higher availability if the customers they can are not able to access their resources. The loss of services could actually result in certain financial loss. The access to a public website of a particular university is an example of moderate availability scenario. If I say a particular online telephone directory lookup is not available or is unavailable for certain reasons. This can cause certain amount of annoyance among the people but this is an example of low-availability scenario.

Other Concepts Related to Security

Authenticity: Authenticity is the property of being genuine and being able to be verified and trusted; confident in the validity of a transmission, or a message, or its originator. It may be obtained by the provision of a password or a scan of your retina.

Accountability: Accountability generates the requirement for actions of an entity to be traced uniquely to that individual to support non-repudiation, deference, fault isolation etc. The system managers are accountable to scrutiny. It can involve audit trails that must be selectively kept protected so that actions affecting security can be traced back to the responsible party. Logs are also used for keeping the account of security and events.

The Need for Security

Administrators normally find that putting together a security policy that restricts both users and attacks is time consuming and costly. Users also become disgruntled at the heavy security policies making their work difficult for no discernable reason, causing bad politics within the company. Planning an audit policy on huge networks takes up both server resources and time, and often administrators take no note of the audited events. A common attitude among users is that if no secret work is being performed, why bother implementing security.

There is a price to pay when a half-hearted security plan is put into action. It can result in unexpected disaster. A password policy that allows users to use blank or weak passwords is a hacker's paradise. No firewall or proxy protection between the organization's private local area network (LAN) and the public Internet makes the company a target for cybercrime.

Organizations need to determine the price they are willing to pay in order to protect data and other assets. This cost must be weighed against the costs of losing information and hardware and disrupting services. The idea is to find the correct balance. If the data needs minimal protection and the loss of that data is not going to cost the company, then the cost of protecting that data will be less. If the data is sensitive and needs maximum protection, then the opposite is normally true.

• Cyber-Crime Rise Issues: No firewall or proxy protection between organization's private LAN & public Internet makes a company a target for cyber-crime.

• Security Loss Costs are High: Organizations will need to determine the price they are willing to pay in order to protect data and other assets. This cost must be weighed against the costs of losing information and hardware and disrupting services.

• Security Policy: Administrators normally find that putting together a security policy that restricts both users and attacks is time consuming and costly.

• Audit Policy: Planning an audit policy on huge networks takes up both server resources and time, and often administrators take no note of the audited events.

• Lack of security can cause unexpected disasters.

• Password policy: Allows users to use blank or weak passwords is a hacker's paradise.

12.2 Computer Security Terminology

Adversary (threat agent)
An entity that attacks, or is a threat to, a system.

Attack
An assault on system security that derives from an intelligent threat; that is, an intelligent act that is a deliberate attempt (especially in the sense of a method or technique) to evade security services and violate the security policy of a system.

Countermeasure
An action, device, procedure, or technique that reduces a threat, a vulnerability, or an attack by eliminating or preventing it, by minimizing the harm it can cause, or by discovering and reporting it so that corrective action can be taken.

Risk
An expectation of loss expressed as the probability that a particular threat will exploit a particular vulnerability with a particular harmful result.

Security Policy
A set of rules and practices that specify or regulate how a system or organization provides security services to protect sensitive and critical system resources.

System Resource (Asset)
Data contained in an information system; or a service provided by a system; or a system capability, such as processing power or communication bandwidth; or an item of system equipment (i.e., a system component--hardware, firmware, software, or documentation); or a facility that houses system operations and equipment.

Threat
A potential for violation of security, which exists when there is a circumstance, capability, action, or event that could breach security and cause harm. That is, a threat is a possible danger that might exploit a vulnerability.

Vulnerability
A flaw or weakness in a system's design, implementation, or operation and management that could be exploited to violate the system's security policy.

12.3 Security Threats

Computer security threats are relentlessly inventive. Masters of disguise and manipulation, these threats constantly evolve to find new ways to annoy, steal and harm. Arm yourself with information and resources to safeguard against complex and growing computer security threats and stay safe online.

Threats to Users: Exploits

Viruses: One of the Most Common Computer Threats

A computer virus is a small program that can replicate itself to infect computers. They were a problem even in the beginning phases of the internet. The first known virus was the Creeper virus, which spread via ARPANET, a progenitor of the internet, in the early 1970s. Today, there are literally thousands of viruses. Not all of them are particularly troublesome, but some of them can cause significant damage. Computer viruses are considered as one of the most well-known computer security threat. This is a program which is written to alter the way a computer operates. And it is obviously without the permission or knowledge of the PC user. A virus replicates and executes itself and damages the files and folders of the computer.

There are several ways to contract these computer threats. They are commonly found in email attachments and downloaded from malicious web sites.

Trojans: The Sneaky Computer Threats

If you use an operating system that was released within the past couple years, then you might occasionally see warning messages about Trojans when you download files. Trojans are small viruses that hide within other programs. They can essentially exist anywhere. Funny pictures, illegal downloads, and pirated software are some of the most common sources.

Worms: The Self-replicating Computer Threats

Worms are similar to viruses in that they are small, malicious programs. The big difference, though, is that worms pose a threat even when computer users don't download any files. These programs use the internet to search for vulnerable computers. Once they locate them, they move in. The computer users probably won't even recognize that anything has happened until he or she begins to experience computer problems.

Spyware: Annoying Threats to your Computer

Spyware is another serious computer security threat. Spyware might seem like viruses, but they don't replicate themselves. This technicality will mean little, though, to those who unintentionally download spyware to their computers. This common threat is usually contracted through peer-topeer file sharing. If you download music, movies, or software illegally, then you have an increased risk of installing spyware. Once installed, these programs start monitoring your online activities. They also have potential to install programs without the consent of the user and capture personal information. To combat spyware threats and stay safe online, it is suggested to consult a spyware removal service provider.

SPAM pertains to the abuse of email systems to send unsolicited email to large numbers of people. It can be a low-cost commercial advertising for questionable products and is a method of marketing also used by many legitimate organizations.

Distributed Denial of Service (DDoS)

In computing, a denial-of-service attack (DoS attack) is a cyber-attack in which the perpetrator seeks to make a machine or network resource unavailable to its intended users by temporarily or indefinitely disrupting services of a host connected to the Internet. Denial of service is typically accomplished by flooding the targeted machine or resource with superfluous requests in an attempt to overload systems and prevent some or all legitimate requests from being fulfilled.

In a distributed denial-of-service attack (DDoS attack), the incoming traffic flooding the victim originates from many different sources. This effectively makes it impossible to stop the attack simply by blocking a single source.A DoS or DDoS attack is analogous to a group of people crowding the entry door of a shop, making it hard for legitimate customers to enter, thus disrupting trade. The criminal perpetrators of DoS attacks often target sites or services hosted on high-profile web servers such as banks or credit card payment gateways. Revenge, blackmailand activism can motivate these attacks.
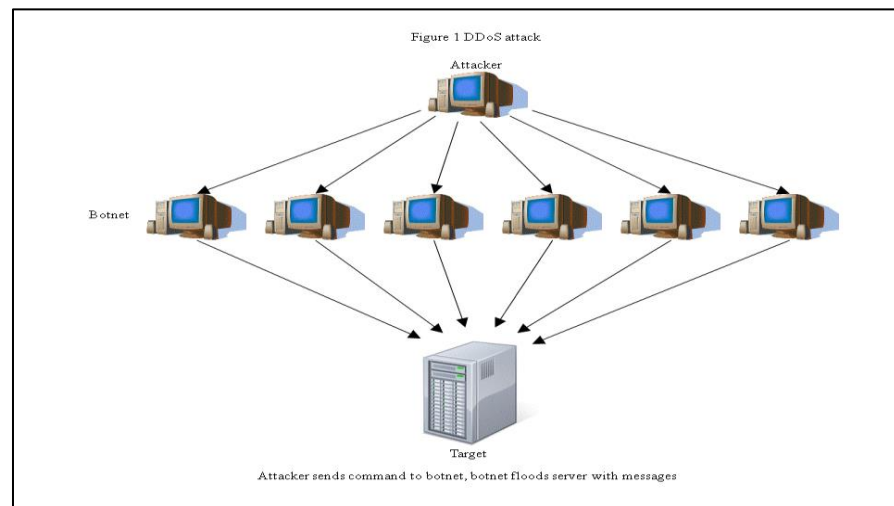
Fundamentals of Information Technology

Figure 1: DDoS Attack Scenario

In a DDoS attack, the malicious hacker takes over computers on the Internet and causes them to flood a target site with demands for data and other small tasks (Figure 1). The computers that are taken over are called *zombies.Botnet* is a very large group of such computers controlled by hackers.

Rootkits (Administrator-level Access)

A rootkit is a collection of computer software, typically malicious, designed to enable access to a computer or an area of its software that is not otherwise allowed (for example, to an unauthorized user) and often masks its existence or the existence of other software**.**It involves a set of programs that enables its user to gain administrator level access to a computer without the end user's consent or knowledge. The process of Rootkit infection is as follows:

- Rootkits are one part of a blended threat, consisting of the dropper, loader, and rootkit.
- Dropper code gets the rootkit installation started and can be activated by clicking on a link to a malicious Web site in an email or opening an infected PDF file.
- Dropper launches loader program & then deletes itself.
- Loader loads the rootkit into memory; at that point, the computer has been compromised.

Symptoms of rootkit infections

- Computer locks up or fails to respond to input from the keyboard or mouse.
- Screen saver changes without any action on the part of the user.
- Taskbar disappears.
- Network activities function extremely slowly.

Solutions: When it is determined that a computer has been infected with a rootkit, there is little to do but:

- reformat the disk;
- reinstall the OS and all applications;
- reconfigure the user's settings.

Phishing

Phishing is a type of social engineering where an attacker sends a fraudulent ("spoofed") message designed to trick a human victim into revealing sensitive information to the attacker or to deploy malicious software on the victim's infrastructure like ransomware.

Phishing attacks are some of the most successful methods for cybercriminals looking to pull off a data breach. Antivirus solutions with identity theft protection can be "taught" to recognize phishing threats in fractions of a second.

*Spear-phishing:*Fraudulent emails to an organization's employees

*Smishing:*Phishing via text messages

*Vishing:*Phishing via voice mail messages

Common Features of Phishing Emails

Too Good to Be True - Lucrative offers and eye-catching or attention-grabbing statements are designed to attract people's attention immediately. For instance, many claims are available that you have won an iPhone, a lottery, or some other lavish prize. Just don't click on any suspicious emails. Remember that if it seems too good to be true, it probably is!

Sense of Urgency - A favorite tactic amongst cybercriminals is to ask you to act fast because the super deals are only for a limited time. Some of them will even tell you that you have only a few minutes to respond. When you come across these kinds of emails, it's best to just ignore them. Sometimes, they will tell you that your account will be suspended unless you update your personal details immediately. Most reliable organizations give ample time before they terminate an account and they never ask patrons to update personal details over the Internet. When in doubt, visit the source directly rather than clicking a link in an email.

Hyperlinks - A link may not be all it appears to be. Hovering over a link shows you the actual URL where you will be directed upon clicking on it. It could be completely different or it could be a popular website with a misspelling, for instance www.bankofarnerica.com - the 'm' is actually an 'r' and an 'n', so look carefully.

Attachments - If you see an attachment in an email you weren't expecting or that doesn't make sense, don't open it! They often contain payloads like ransomware or other viruses. The only file type that is always safe to click on is a .txt file.

Unusual Sender - Whether it looks like it's from someone you don't know or someone you do know, if anything seems out of the ordinary, unexpected, out of character or just suspicious in general don't click on it!

Threats to Hardware

Hardware problems are all too common. We all know that when a PC or disk gets old, it might start acting erratically and damage some data before it totally dies. Unfortunately, hardware errors frequently damage data on even young PCs and disks.

Power Faults

Your PC is busy writing data to the disk and the lights go out! "Arghhhh!" Is everything OK? Maybe so, maybe not; it's vital to know for sure if anything was damaged.

Other power problems of a similar nature would include brownouts, voltage spikes, and frequency shifts. All can cause data problems, particularly if they occur when data is being written to disk (data in memory generally does not get corrupted by power problems; it just gets erased if the problems are serious enough).

Brownout

Lower voltages at electrical outlets. Usually they are caused by an extraordinary drain on the power system. Frequently you will see a brownout during a heat wave when more people than normal have air conditioners on full. Sometimes these power shortages will be "rolling" across the area giving everyone a temporary brownout. Maybe you'll get yours just as that important file is being written to disk.

Voltage Spikes

Temporary voltage increases are fairly common. Large motors or circuit breakers in industry can put them on the electrical line. Sudden losses (e.g., a driver hits a power pole) can causes spikes as the circuits balance. An appliance in your home can cause a spike, particularly with older wiring. Lightning can put large spikes on power lines. And, the list goes on. In addition to current backups and integrity information for your software and data files, including a hardware voltage spike protection device between the wall and your computer hardware (don't forget the printer and monitor) can be very helpful.

Frequency Shifts

While infrequent, if the line frequency varies from the normal 60 Hertz (or 50 Hertz in some countries), the power supply on the computer can be affected and this, in turn, can reflect back into the computer causing data loss.

Incompatibilities

You can have hardware problems on a perfectly healthy PC if you have devices installed that do not properly share interrupts. Sometimes problems are immediately obvious, other times they are subtle and depend upon certain events to happen at just the wrong time, then suddenly strange things happen! (Software can do this too!)

Solution: Make a really good backup before installing anything (hardware or software) so you can revert the system back to a stable state should something crop up.

Finger Faults

These are an all too frequent cause of data corruption. This commonly happens when you are intending to delete or replace one file but actually get another. By using wild cards, you may experience a really "wild" time. "Hmmm I thought I deleted all the .BAK files; but they're still here; something was deleted; what was it? Or was I in the other directory?"

Another finger fault problem arises with touchpads below the space bar on notebook computers. It's very easy to brush the touchpad when you are typing away and suddenly find yourself entering characters in a screen location very different from where you were before you touched the pad.

Solution: Be careful and look up now and again to make certain your cursor is where you want it.

Malicious or Careless Damage

Someone may accidentally or deliberately delete or change a file on your PC when you're not around. If you don't keep your PC locked in a safe, then this is a risk. Who knows what was changed or deleted? Wouldn't it be nice to know if anything changed over the weekend? Most of this type of damage is done unintentionally by someone you probably know. This person didn't mean to cause trouble; they simply didn't know what they were doing when they used your PC.

Solution: Never run the computer as an administrative user and have guest accounts available for others who use the computer. Keep up-to-date backups as well.

Threats to Data

Threat is defined as a computer program, a person, or an event that violates the security system. A threat causes loss of data and attacks the data privacy. Most of the data of an organization stored inside the computer is very important and more valuable than the computer hardware and software. It can be damaged due to many reasons. You must protect your data from illegal access or from damage.

- Some authorized user of data may unintentionally delete or change sensitive data.
- Two solutions to this problem:Firstly, users must be assigned proper rights to minimize such events. Only authorized user with certain rights may be allowed to delete or modify data after following a step-by-step process.Secondly, using periodic backup of data should be taken to recover the deleted data.
- Using password protection should be used to use any resource.
- Using Log file should also be maintained to keep track of all the activities performed on the data.
- Using strong encryption algorithm should be used, such that if anyone gets access to data, can't understand it.
- Using latest antivirus software should be used to scan all data coming into the organization.
- Computers and all backing storage devices should be placed in locked rooms.
- Only authorized users can access these resources.Authorized users must be asked to change their passwords periodically.

12.4   Cyber Terrorism

Cyberterrorism has been defined by the Technolytics Institute as "The premeditated use of disruptive activities, or the threat thereof, against computers and/or networks, with the intention to cause harm or further social, ideological, religious, political or similar objectives. Or to intimidate any person in furtherance of such objectives."

Cyber terrorism is a phrase used to describe the use of Internet based attacks in terrorist activities, including acts of deliberate, large-scale disruption of computer networks, especially of personal computers attached to the Internet, by the means of tools such as computer viruses. Cyber terrorism is a controversial term. Some authors choose a very narrow definition, relating to deployments, by known terrorist organizations, of disruption attacks against information systems for the primary purpose of creating alarm and panic. By this narrow definition, it is difficult to identify any instances of cyber terrorism. Cyber terrorism can also be defined much more generally as any computer crime targeting computer networks without necessarily affecting real world infrastructure, property, or lives. There is much concern from government and media sources about potential damages that could be caused by cyber terrorism, and this has prompted official responses from government agencies.

The National Conference of State Legislatures, an organization of legislators created to help policymakers issues such as economy and homeland security defines cyber terrorism as:"The use of information technology by terrorist groups and individuals to further their agenda. This can include use of information technology to organize and execute attacks against networks, computer systems and telecommunications infrastructures, or for exchanging information or making threats electronically. Examples are hacking into computer systems, introducing viruses to vulnerable networks, web site defacing, Denial-of-service attacks, or terroristic threats made via electronic communication.

Cyber terrorism can also include attacks on Internet business, but when this is done for economic motivations rather than ideological, it is typically regarded as cybercrime. Cyber terrorism is the union of terrorism and the cyberspace. It refers to the use of computer networks to threaten the masses. It involves the utilization of computer infrastructure to terrorize society. According to some, cyber terrorism is the use of Internet by terrorist organizations to spread fear while others refer to it as the disruption of sensitive information stored on the web, thus causing loss of sensitive data. The disruption of information stored on computer networks is also a form of cyber terrorism.

Electronic means cannot cause physical harm. They can spread fear among the common masses but they are very unlikely to result in a massive physical destruction or death. Considering the advanced Internet security measures and the protective technologies in use, there are lesser chances of the Internet leading to terror attacks. Many computer theorists deny the existence of cyber terrorism. They prefer to call it as hacking or information warfare, wherein confidential information of individuals or organizations is put on stake by unethical Internet users. They define cyber terrorism as the group of activities that risk Internet safety of individuals and organizations. However, many consider cyber terrorism as a serious threat to society. It is not right to underestimate the devastating effects of criminal practices like hacking and phishing. Hacking is the activity of breaking into a computer system in order to gain an unauthorized access to it. The unauthorized revelation of passwords, the hacking of IP addresses can prove being severe threats to the well-being of society. There have been instances of terrorist agencies hacking computer systems to gain access to sensitive and critical information. One example is of terrorists in Romania gaining access to the computers controlling the life support systems at the Antarctic research station. A relatively recent example is of the website of the Ukrainian president being attacked by hackers. Another simple example of cyber terrorism could be the hacking of a hospital database system and changing medical prescriptions of the patients. Isn't that scary?

Protection against Cyber Terrorism

In order to take effective measures against cyber terrorism, it is important for the computer professionals to understand its adverse effects and be able to identify the loopholes in Internet security. It is necessary to strengthen Internet security measures so that the society can be assured a safe life on the Internet.

Critical information should be isolated from the outside world. It should be protected by the means of firewalls, antivirus software and complex password systems. Government organizations should be well-equipped to deal with cyber-terrorist activities. Similarly, banks, financial organizations and other critical information units should be well protected from practices such as phishing, hacking and identity theft. The information pertaining to national security is of highest importance for the people of any country. It needs to be effectively protected from unethical Internet users.

It is also important to ensure protection on an individual level. It is essential for all the Internet users to ensure Internet safety. In order to ensure protection from cyber terrorism, one's email accounts should be protected through passwords that are not easily guessable. One should change the network configurations if defects are known and pay heed to network security issues on an urgent basis. One should not visit websites that can seem suspicious in order to keep away from Internet scams. It is important for every Internet user to know about the different types of computer crimes and take due precaution against all the ill-practices that eclipse the advantages of the Internet.

12.5 Keeping Your System Safe

Before diving into the tasks, you need to do to secure your home computer, let's first think about the problem by relating it to something you already know how to do. In this way, you can apply your experience to this new area. So, think of your computer as you would your house, your apartment, or your condo. What do you know about how that living space works, what do you routinely do to keep it secure and what have you installed to improve its security?

For example, you know that if you have a loud conversation, folks outside your space can probably hear you. You also routinely lock the doors and close the windows when you leave, and you don't give the keys to just anyone. Some of you may install a security system to complement your practices. All of these are part of living in your home.

Let's now apply similar thinking to your home computer. Email, instant messaging, and most web traffic go across the Internet in the clear; that is, anyone who can capture that information can read it. These are things you ought to know. You should always select and use strong passwords and exercise due care when reading all email, especially the unsolicited variety. There are certain things and steps you can ought to do. You can add a firewall, an anti-virus program, patches, and file encryption to improve the level of security on your home computer.

Get Free Wireless Network Protection Software

Most home networks are vulnerable to passing "war drivers" who hack into unsuspecting wireless networks. There are plenty of ways you can muck around with your router settings to protect yourself. But what if you don't want to fiddle around with filtering MAC addresses, changing your SSID (network name), and disabling SSID broadcast? You can get a free program that will do most of that for you. Network Magic comes in two versions, a free version and a for-pay version, but if all you want to do is configure your wireless network for maximum security, the free version will work just fine.

Install it, and it examines your router and entire network, and builds a network map of all of your connected devices. It examines your router's security settings and issues a report on what it finds. If, for example, it discovers that you're broadcasting your SSID, it will alert you. A single click of a check box and Network Magic will stop the broadcasting for you. The for-pay version includes other features, such as configuring folder and printer sharing, but if you're only interested in security, you don't really need it.

Use a Free Firewall

It's this simple you need a firewall. It's one of the best ways to protect yourself against Trojans, to keep your PC from becoming a zombie that obeys the commands of a distant hacker, and to stop attackers from worming their way into your PC. If you have Windows XP Service Pack 2, you have a halfway useful firewall built in. (If you haven't installed SP2, immediately upgrade by going to Windows Update.) By default, when you install SP2, the firewall is turned on.

Encrypt Your Data

No matter how good you are at making sure no one else has access to your PC, someone might be able to get in. It could be a hacker, or someone who is on the network you use. If you're at work, it might even be a coworker who sits down at your PC when you're out of the office. Most encryption programs cost money, and many aren't particularly easy to use.

Protect Yourself Against Phishers

Phishing is one of the most insidious and nastiest attacks out there. You get a legitimate-looking e-mail from your bank, eBay, PayPal, or other financial institution warning you that you must click a link to log into your account for some reason -- to update it, confirm your information, or even for protective purposes. There are simple ways to thwart phishing attacks. Never click on a log-in link from an e-mail purporting to be from your financial institution, eBay, or PayPal, no matter how legitimate it looks. Instead, go to the site yourself and log in.

Second, use an anti-phishing toolbar, which will block you from visiting a phishing site or warn you when you're visiting one. There are plenty of good ones out there. The Google Toolbar includes an anti-phishing feature that will block you from visiting a phishing site and pop up a warning about it. After you install the toolbar, click on its "Options" button. Then, under the "Browsing" tab, check the box next to "Safe Browsing." Click the "Safe Browsing Settings" button and configure your level of protection. Click "OK."

Disable File Sharing

One of your biggest security dangers is sitting in plain sight, and you probably don't even know it. If you've set up your PC to share files and folders, it's exceptionally easy for people to look through all your files, grab personal information, and even delete files and folders as well. Odds are, though, that you don't know if you're set up for sharing.

It's easy to find out, and then to turn off sharing. Open Windows Explorer and look at all of your folders. Any folder that has a small hand beneath it means that folder is being shared, and that anyone connected to your network can gain access to it. To turn off sharing, right-click the folder, select Sharing and Security, click the Sharing tab, select "Do not share this folder," and click OK.

By the way, when a folder is shared, all the subfolders beneath it are automatically shared as well. But those subfolders won't show the small hand beneath the folder or indicate that it's shared in the Sharing tab. So be careful to look at all top-level folders to see if they're shared. And you should always check to make sure that your root drives aren't shared, because if they are, others have access to all the folders and files on your system.

Surf the Web Anonymously

When you surf the Web, your life is an open book. Web sites can track your online travels, know what operating system and browser you're running, find out your machine name, peer into your clipboard, uncover the last sites you visited, examine your history list, and delve into your cache. They can also examine your IP address to learn basic information about you, such as your geographic location. But if you'd like, you can browse in perfect anonymity. There's plenty of software you can buy that will do this for you, but you can do it for free by using an anonymous proxy server that sits between you and the Web sites you visit. When you use an anonymous proxy server, your browser doesn't contact Web sites directly—the proxy server acts as a buffer, which means the sites see the IP address of the proxy server, not your PC's IP address. Web sites can't read your cookies, see your history list, or examine your clipboard and cache because your PC is never in direct contact with them. You can surf without a trace.

Say No to Cookies

Online ad networks have the potential to create in-depth profiles of your Web travels and personal interests. They place cookies on your hard disk that track you across multiple sites. You can fight back by placing an opt-out cookie—provided by the ad network—on your hard disk that will tell sites to keep their mitts off your surfing habits. To opt out of the massive Double Click online advertising network, go to its opt-out page and click on the "Ad Cookie Opt-Out" button at the bottom of the screen.

Protect yourself against E-mails

E-mail "Nigerian scams" are among the oldest and well-known on the Internet, in which you're sent an unsolicited e-mail asking for help to transfer millions of dollars out of Nigeria —but somehow, it's your bank account that gets emptied.

Virus Scan

Sometimes, typically via email, viruses are able to cross the wall and end up on your computer anyway. A virus scanner will locate and remove them from your hard disk. A real time virus scanner will notice them as they arrive, even before they hit the disk, but at the cost of slowing down your machine a little. Important: because new viruses are arriving every day, it's important to keep your virus definitions up-to-date. Be sure to enable the scanning software's automaticupdate feature and have it do so everyday.

Kill Spyware

Spyware is similar to virus in that they arrive unexpected and unannounced and proceed to do something undesired. Normally spyware is relatively benign from a safety perspective, but it can violate your privacy by tracking the web sites you visit, or add "features" to your system that you didn't ask for. The worst offenders are spyware that hijack normal functions for themselves. For

example, some like to redirect your web searches to other sites to try and sell you something. T-here are spyware scanners that will locate and remove the offending software.

Stay Up-To-Date

Software vulnerabilities that the viruses exploit usually already have patches available by the time the virus reaches a computer. The problem? The user simply fails to install the latest patches and updates that would have prevented the infection in the first place.

Secure Your Mobile Connection

If you're traveling and using internet hot spots, free Wifi or internet cafes, you must take extra precautions. Make sure that your web email access is via secure (https) connections, or that your regular mail is over an encrypted connection as well.

Don't let people "shoulder surf" and steal your password by watching you type it in a public place. Make sure your home Wifi has WPA security enabled if anyone can walk within range.

12.6 Protect Yourself & Protect Your Privacy

Identity Thefts and How to Prevent Them?

Identity theft occurs when someone uses another person's personal identifying information, like their name, identifying number, or credit card number, without their permission, to commit fraud or other crimes.

When you're buying online, it can sometimes be hard to tell whether you're dealing with a legitimate merchant or the online equivalent of that guy selling counterfeit watches on 33rd Street. Most shoppers focus on maintaining the privacy of their credit card data, and that's good. But that's not the only privacy concern you should have while shopping online.

The risk: Any time you use your credit card online, your identity is at risk. Organized crime factions from all over the world have streamlined the process of extracting your personal details from all sorts of places, especially shopping sites. These attackers can harvest thousands or even millions of credit cards in one fell swoop. That's a problem for two reasons.

First, and most obviously, there's the problem of having your credit card used to purchase all kinds of goods in places you've never been. Usually your bank protects you from such fraudulent charges. But it's still a hassle to change your account numbers.

But these days, the bad guys aren't satisfied with credit cards alone. In fact, individual card numbers aren't worth that much. But when those numbers are combined with other commonly available bits of personal information—such as addresses and birthdays—attackers can then assemble a virtual dossier of your private information. Identity thieves can parlay that information to secure credit in your name. That credit can be more valuable to them than your credit card and far more difficult and expensive for you to fix: Bank protections focus on credit cards. They are much less help when money is directly extracted from accounts, via debit cards or electronic fund transfers.

In order to prevent identity thefts:

o Do business only with reputable merchants, be sure you are actually on the correct site.

o Apply proverbial sniff-test when selecting an online retailer.

o Check retailer's privacy policy specifying what they will & won't do with your information. Search privacy policy for terms like third-party, e-mail address, or personally identifiable information; to find out what a retailer plans to do with your information.

Spying

Espionage or spying is the act of obtaining secret or confidential information or divulging of the same without the permission of the holder of the information. A person who commits espionage is called an espionage agent or spy. Spies help agencies uncover secret information.

The risk: It may be convenient when your favorite online merchants e-mail offers for products you were thinking about buying. But wait—how did they know that? Unfortunately, if you've been using Google to browse pages for similar products, or perusing the merchant's Website, it's not a secret. You've been telling them what you like to buy and when—they're just listening.

With the advent of tracking technologies and sophisticated analytics, many Web merchants know exactly who you are and what you are most likely to buy. They know because you tell them through your buying and surfing patterns. This is valuable data, and merchants can (and do) sell it to each other.

12.7   Managing Cookies

An internet cookie is a packet of information sent by a server to a browser, which is then sent by the browser each time it accesses the server. Cookies are typically used to authenticate a registered user of a web site, personalizing the site, maintaining an online shopping cart, etc. Originally developed by Netscape, cookies offer convenience to the visitor if care is taken by the website. Usually internet cookies are specific to one domain—meaning a cookie set by one domain cannot be read by other domains. Many websites subscribe to media services that place advertisements for them. One of the controversies surrounding cookies is the use of cookies to build a personal profile of the user's browsing and purchasing habits. One can set the browser to disable cookies, or use Internet filter software to filter out cookies.

Cookies are the small files stored on a user's computer & designed to hold modest amount of data specific to particular client and website, and can be accessed either by web server or client computer. These allowa server to deliver a page tailored to particular user, or page itself can contain some script which is aware of data in cookie and so is able to carry information from one visit to website to next.

Managing Cookies in Internet Explorer

- Open your IE web browser.

- Click the "Tools" icon in the top-right corner, and then click **Internet Options**.

- If you have the Menu Toolbar enabled, you can also click the **Tools menu**, and then click **Internet Options**.

- Click the **Privacy tab**, and then click on of the levels on the slider to select a level of security regarding cookies on Internet Explorer (which will be explained to the right of the slider). The bottom level enables all cookies. The top level disables all cookies. If you want extra options related to managing your cookies in Internet Explorer, click **Advanced**.

- Click the box beside "Override Automatic Cookie Handling" to check it if you want to use custom settings for managing cookies in Internet Explorer. This allows you to set how you want to deal with "First-Party Cookies" (usually the good kind) and "Third-Party Cookies". or each type of cookie, there are 3 options:

    — Accept all cookies of this type

    — Block all cookies of this type

    — Prompt if I get a cookie of a type to decide whether to accept or block.

- Click the check box beside "Always Allow Session Cookies" if you want to always accept first-party cookies that track whether or not you're logged into a website, regardless of how you deal with other first-party cookies.

- When you're done, click **OK**.

- When you've finished making changes, click **Apply** (if you actually changed anything), and then click **OK**.

12.8   Spyware and Other Bugs

Some companies place "spyware" through their software installations, usually without the user's permission. These spyware's pass on information about software, browsing habits and purchasing habits of user to a company's data collection facilities. The spyware programs do not collect information specifically, but report general demographics. They have the capability to take names, credit card and other personal information. The information gathered by such companies are usually sold and combined with other databases to build a profile of individual web users. This profile is mainly used for direct marketing purposes. In order to guard against spyware, you can make use of:

- Software tools

- Modify the hosts file on the system

Explain how bugs can harm our data storage devices?

Other Web Bugs: Graphics on a web page or an email message that is designed to monitor who is reading the web page or email message

12.9   KeepingyourDataSecure

After a series of catastrophic errors by big businesses and the government, data protection issues have been thrown into sharp relief. As criminals become more savvy to how they can use data and the public becomes more alert to the threat's identity theft and careless handling of data pose, it's become increasingly important for businesses to ensure their approach to data protection is as scrupulous as possible.

Data Protection Act

The Data Protection Act came into force in 1998 and provides businesses and public bodies with a series of regulations governing how they handle people's personal information. If you store any personal data on customers or employees, the Data Protection Act applies to you.The information that the Data Protection act covers can be described as any information about living, identified or identifiable individuals. It includes names, addresses, email addresses, dates of birth, bank details and opinions expressed about an individual. It includes eight principles,which require that:

1. Process data fairly and according to the law.

2. Process data for a limited, lawful purpose.

3. Only hold enough information for your purpose — nothing excessive or extraneous.

4. Ensure data held is accurate, relevant and up-to-date.

5. Don't hold the data for any longer than necessary.

6. Process the data in line with individuals' rights (below).

7. Ensure the data is kept physically secure.

8. Don't transfer the data outside the European Economic Area unless it is adequately protected.

You need to be aware of the rights the Data Protection Act grants individuals. These include:

(a) The right of subject access, which allows individuals to see the data you hold on them

(b) The right to prevent direct marketing, which means individuals, can opt out of being targeted with direct marketing, either online or by phone or mail. Once an individual has put their request in writing, you have up to 28 days to stop.

(c) The right to have personal information corrected

(d) The right to prevent automated decisions, which prevents you from making decisions on an individual using an automated process or algorithm. For example, it would be against the law to employ someone based purely on the results of a psychometric test.

Implement an *IT Security Policy* to make clear to your staff exactly how they should be handling data. This should include rules on how to handle customer and business information, limitations on the amount of access your employees have to data, and an acceptable use policy for the internet and eCreate a data backup routine to make sure your business isn't affected if something happens to your servers. This should take place at least once a week, but ideally every day mail.

12.10   Backing UpData

In Information Technology (IT) sector, a backup or the process of backing up refers to making copies of data so that these additional copies may be used to restore the original after a data loss event.Backups have two distinct purposes:

The primary purpose is to recover data as a reaction to data loss, be it by data deletion or corrupted data. Data loss is a very common experience of computer users. 67% of internet users have suffered serious data loss. The secondary purpose of backups is to recover data from a historical period of time within the constraints of a user-defined data retention policy, typically configured within a backup application for how long copies of data are required. Though backups popularly represent a simple form of disaster recovery, and should be part of a disaster recovery plan, by themselves, backups should not alone be considered disaster recovery. Not all backup systems and/or backup applications are able to reconstitute a computer system, or in turn other complex configurations such as a computer cluster, active directory servers, or a database server, by restoring only data from a backup.

Since a backup system contains at least one copy of all data worth saving, the data storage requirements are considerable. Organizing this storage space and managing the backup process is a complicated undertaking. A data repository model can be used to provide structure to the storage. In the modern era of computing there are many different types of data storage devices that are useful for making backups. There are also many different ways in which these devices can be arranged to provide geographic redundancy, data security, and portability.

Before data is sent to its storage location, it is selected, extracted, and manipulated. Many different techniques have been developed to optimize the backup procedure. These include optimizations for dealing with open files and live data sources as well as compression, encryption, and deduplication, among others. Many organizations and individuals try to have confidence that the process is working as expected and work to define measurements and validation techniques. It is also important to recognize the limitations and human factors involved in any backup scheme.

12.11 <u>SafeguardingyourHardware</u>

In small and home-based businesses, the aspect of physical protection is often overlooked. Sufficient measures should also be put in place and maintained for protection against climate and environmental factors such as fire, dust, power, excessive heat and humidity, electrical emanations, and natural calamities. Regulation of power supply is vital.

In a good security policy, special emphasis should be given to protect all equipment handling or containing sensitive information. It should lessen the possibilities for an intruder to access these devices.

In order to have a secure computer network, it is necessary to have a proper mechanism for protecting the computer hardware and other equipment's from external physical threats such as theft, natural calamities (earthquake, floods, or even accidents in the home, etc.).

Physical Access and Data Security: First line of defense locally is to protect network equipment such as servers, switches, and routers is to keep them in a locked, climate controlled, and fire protected environment.If an equipment is not physically accessible to unauthorized personnel, there is less chance of accidental or intentional tampering.

It is important that access to critical system components such as the server is restricted to a small number of individuals (usually the administrator and his backup). The server should be located in a locked room to which access is restricted. Other considerations should include protection of equipment against theft, fire, and electrical hazards.

No one must be able to remove a disk containing sensitive information or to install devices to record confidential information. For this problem to be solved security policy must create to maintain an environment secure enough to contain and keep the information handled by the equipment safe from any damage or loss. See the section entitled "Controlling Access to your PC" for a more in-depth look at dealing with access. There are other specific items left to deal with in protecting computer data besides keeping data from the eyes of unethical immoral people—that of machine failure. Computers crash—Especially when you least want them to, like when you have a big project due or an important email that needs to be responded to immediately—It seems that Murphy's Law is the only law that holds any sway when it comes to your computer's hard drive—Unlike other issues discussed in this book, there are no common sense approaches to keep it from happening, no programmers out there hard at work trying to protect your computer from crashing—There aren't even any hackers or attackers to blame—The fact is that human beings are fallible and so are the things they make and therefore, hard drives are not perfect—Just like you would never expect to drive a car without it breaking down once in a while, so you should expect and learn to deal with crashing hard drives.

There are several very important things you can do to protect your hard drive, the most important being: back up all your data regularly, keep your computer in a cool environment, make an emergency bootable floppy disk, keep a fire extinguisher nearby, and keep programs to a minimum, uninstalling those you don't use, monitor and regulate the power supply and restrict authentication and access to your computer(s). Keeping programs to a minimum: running multiple programs also cause stress on your computer, decreasing your hard drive's life span — Keep beta versions and cracked software off your computer and if you don't use a program anymore, uninstall it.

There are several other security implications that arise from the fact that computers run on electricity. These include radio interference, which can be used for eavesdropping and sabotage, plus radiation, a potential liability threat.

Employee Data- Appropriate Security Measures Disclosure

A large organisation, whose staffs are employed at several locations throughout thecountry, used a central database to record information relating to its employees andtheir work. The complainant questioned the security arrangements in respect of hispersonal data, and the extent of access to such data throughout the organisation.

The organisation's computer system comprised about a hundred personal computersnationwideconnected to a central computer in the Dublin head office. Some sixty laptopcomputers were also provided for use by employees when away from their offices. Theselaptops contained a version of organisation's main database which was downloaded fromthe main computer and updated periodically. Accordingly, data kept by the organisation onits main database was available to staff in the head office, in the local offices, and at off-sitelocations.

The complainant, an employee, made his complaint while the computer system was still beingdeveloped and implemented by the organisation. He made the following points. First, healleged there had been a breach of security because the laptops were without any passwordprotection for a period during the development of the system. Second, the complainant objectedto certain of his personnel data and details of his work activity being generally available tostaff, and argued that such data should only be available to those who needed them to performtheir managerial functions.

Section 2(1) (d) of the Data Protection Act provides that "appropriate security measures shallbe taken against unauthorised access to, or alteration, disclosure or destruction of, the dataand against their accidental loss or destruction." The question of the security of access to thelaptop computers was considered in the light of this provision.

My investigation established that each laptop required use of a password for access to the localversion of the database. Where a laptop was establishing a connection to the main computer,another password was needed, and access to the main database itself required the use of a thirdpassword. In principle this approach appeared to conform well to the requirements of section2(1) (d) above. However, the apparent effectiveness of this approach had been compromised.

In the interests of simplicity of operation the organisation issued a unique centrally-generatedpassword to each member of staff (so that each staff member would only need to remember onepassword) thus reducing the effectiveness of the password system as a whole. Furthermore,in the course of training staff on an upgraded version of the software, the password securitysystem was modified to allow trainees ease of access to the system. This modification gaveopen access to the main database from a number of laptops.

As soon as this fact was discovered, the data controller took steps to rectify the matter. It isnot appropriate for a data controller to allow his standards of security to slip, so that personaldata becomes more widely accessible than is necessary. However, I noted the prompt actiontaken by the data controller to put matters right, and - given that my investigation did notdiscover any evidence of unauthorised access or use of the data during the period when thepasswords were not in operation - I did not uphold this part of the complaint.

The second ground for complaint put forward was the alleged wide availability throughoutthe organisation of details relating to the complainant's work activities including particularsof annual sick leave. This raised two separate but related issues: first, whether this wideavailability constituted "disclosure" for the purposes of the Data Protection Act; and second,whetherthe wide availabilityof data was consistent with the organisation's duty to take"appropriate security

measures ... against unauthorised access to, or alteration, disclosure orof, the data and against their accidental loss or destruction."

On the first question, I noted that the only people with access to the main database were thestaff of the data controller. The definition of "disclosure" given in section 1(1) of the Act,specifically states that disclosure "does not include a disclosure made ... to an employee ...for the purpose of enabling the employee ... to carry out his duties". In my opinion, thesewords require a data controller to make an assessment, in respect of particular employees,as to whether such employees need to have access to particular holdings of personal data,and to provide accordingly. Thus, one would expect a Human Resources Manager to haveaccess to personal data not necessarily available to the manager of a client database, and vice-versa. Data controllers should, in my view, take reasonable steps to prevent personal datafrom being made available to employees who may have no work-related interest in the data.

On the second question, I consider that sensible restriction of the availability of personal datais oneof the "appropriate security measures" that data controllers must consider. The morepeople who have access to personal data, the greater is the risk of unauthorised access ordisclosure. These issues were discussed with the data controller in detail. The organisationexplained that the wide availability of personnel information and staff operational detailswas due in part to business requirements, and in part to the culture and tradition of theorganisation. Following discussions, the data controller made a number of significant changesto the computer system, at some expense, in order to restrict access to the personal data ofemployees. It is my view that, in a case such as this, an appropriate balance must be struckbetween the concerns of the employee as data subject, the real operational requirements ofthe organisation and the costs to the organisation. I took the view that, following the changesreferred to above; the data controller was compliant with the Act.

Questions:

1. Why do the protecting privacy of a data over a communication channel is needed?

2. Explain the process involved in data protection.

Understand the security-related problems that you need to think about and solve them.

Summary

- Cyber terrorism describes the use of Internet-based attacks in terrorist activities, including acts of deliberate, large-scale disruption of computer networks, especially of personal computers attached to the Internet, by the means of tools such as computer viruses.

- Computer security means to protect information; it has been extended to include privacy, confidentiality and integrity.

- Computer viruses are considered as one of the most well-known computer security threat.

- Hardware threats involve threats of physical damage to the router or switch hardware.

- Data can be damaged due to many reasons. You must protect your data from illegal access or from damage.

- Cyber terrorism can be defined in different ways viz. it can be politically motivated hacking operations intended to cause grave harm such as loss of life or severe economic damage.

- Home computers are typically not very secure and are easy to break into, when combined with high-speed Internet connection that are always turned on, intruders can quickly find and then attack home computers.

- A web bug is a graphics on a web or an email message that is designed to monitor who is reading the web page or email message.

- Spyware is similar to virus in that they arrive unexpected and unannounced and proceed to do something undesired.

- Web bugis a graphics on a web page or an email message that is designed to monitor who is reading the web page or email message. A web bug is often invisible as its size is only 1 pixel by 1 pixel.
- A computer virus is a small program that can replicate itself to infect computers. They were a problem even in the beginning phases of the internet.

Keywords

Authentication: The process of verifying that users are who they claim to be when logging onto a system. Generally, the use of user names and passwords accomplishes this. More sophisticated is the use of smart cards and retina scanning. The process of authentication does not grant the user access rights to resources-this is achieved through the authorization process.

Availability: The prevention of unauthorized withholding of information or resources. This does not apply just to personnel withholding information. Information should be as freely available as possible to authorized users.

Brownout: Lower voltages at electrical outlets. Usually they are caused by an extraordinary drain on the power system.

Computer security: Computer security means to protect information. It deals with the prevention and detection of unauthorized actions by users of a computer.

Confidentiality: The prevention of unauthorized disclosure of information. This can be the result of poor security measures or information leaks by personnel. An example of poor security measures would be to allow anonymous access to sensitive information.

Cyber terrorism: It can be defined as any computer crime targeting computer networks without necessarily affecting real world infrastructure, property, or lives.

Data protection: It means making sure that private data belonging to a person or organization is kept hidden from those who are not authorized to use it.

Detection: Take measures that allow you to detect when information has been damaged, altered, or stolen, how it has been damaged, altered, or stolen, and who has caused the damage. Various tools are available to help detect intrusions, damage or alterations, and viruses.

Finger faults: These are an all too frequent cause of data corruption. This commonly happens when you are intending to delete or replace one file but actually get another.

Hacking: It is the activity of breaking into a computer system in order to gain an unauthorized access to it. The unauthorized revelation of passwords, the hacking of IP addresses can prove being severe threats to the well-being of society.

Integrity: The prevention of erroneous modification of information. Authorized users are probably the biggest cause of errors and omissions and the alteration of data. Storing incorrect data within the system can be as bad as losing data. Malicious attackers also can modify, delete, or corrupt information that is vital to the correct operation of business functions.

Prevention: Take measures that prevent your information from being damaged, altered, or stolen. Preventive measures can range from locking the server room door to setting up high-level security policies.

Internet Explorer: In Internet Explorer, you can manage your cookies by clicking on the Tools menu, choosing Internet Options.

Phishing: It is a way that internet scammers trick you into providing your personal and financial details. Phishing opens the door to identity theft, and more.

Threat: Any circumstance or event with the potential to harm an information system through unauthorized access, destruction, disclosure, modification of data, and/or denial of service. Threats arise from human actions and natural events.

Trojans: Trojans are small viruses that hide within other programs. They can essentially exist anywhere.

Worms: Worms are similar to viruses in that they are small, malicious programs. The big difference, though, is that worms pose a threat even when computer users don't download any files.

Self-Assessment

1. What are the major technical areas of computer security are usually represented by the initials CIA?
A. Confidentiality
B. Integrity
C. Authentication
D. All of these

2. A password policy that allows users to use blank or weak passwords is a hacker's paradise.
A. True
B. False

3. Security in the cloud is challenging, due to varied degree of ……………………….
A. Security features and arrangement
B. Security features and management
C. Security wall and management
D. All of the above

4. The consequences of a successful deliberate or inadvertent misuse of a computer system in the aviation industry range from loss of system integrity to loss of confidentiality.
A. True
B. False

5. A computer virus is a small program that can replicate itself to infect computers.
A. True
B. False

6. What does data protection means?
A. Means making sure that private data belonging to a person or organization is kept hidden from those who are authorized to use it.
B. Making sure that private data belonging to a person or organization is kept hidden from those who are not authorized to use it.
C. making sure that organizational data belonging to a person or organization is kept hidden from those who are not authorized to use it.
D. All of the above

7. The acts of deliberate, large-scale disruption of computer networks, especially of personal computers attached to the Internet, by the means of tools such as computer viruses is
A. Cyber Terrorism
B. Hacker
C. Virus act
D. Malicious act

8. Apart from power faults, which of the following causes threat to the hardware
A. Brownouts
B. Voltage spikes
C. Frequency shifts

D. All of the above

9. Cyber terrorism cannot include attacks on Internet business,

A. True

B. False

10. Cookies can harm your computer or your files.

A. True

B. False

11. A web bug is often invisible as its size is only _____.

A. 1 pixel by 3 pixels

B. 1 pixel by 2 pixels

C. 2 pixels by 1 pixel

D. 1 pixel by 1 pixel

12. Spyware is similar to _____.

A. Firewall

B. Virus

C. Both (a) and (b)

D. None of these

13. The Data Protection Act came into force in _____.

A. 1995

B. 1996

C. 1998

D. 1997

14. The Data Protection Act sets out _____ Principles for the safe and legal handling of

data.

A. Five

B. Eight

C. Six

D. Seven

15. Which of the following helps in keeping the system safe?

A. Allowing cookies to access

B. Disabling system updates

C. Deactivating encryptions

D. Using firewalls

Answers for Self Assessment

1.	D	2.	A	3.	B	4.	B	5.	A
6.	B	7.	A	8.	D	9.	B	10.	B
11.	D	12.	B	13.	C	14.	B	15.	D

Review Questions

1. What are security issues related to computer hardware?
2. Elaborate the importance of security in an organization.
3. What are viruses and enumerate and explain briefly about the related risk agents?
4. How important is hardware security and briefly explain the important tricks associated with hardware threats?
5. Elaborate and explain about CIA.
6. What is cyber terrorism and why it is important from national welfare point of view?
7. Define the following terms:
    (a) Root kits
    (b) Spyware
    (c) Phishing
    (d) Trojan
8. What is a cookie?
9. What is spyware and a web bug? How can you guard yourself against Spyware?
10. How to create a system restore point?
11. How to keep your computer running smoothly?
12. How to Organize Your Computer?
13. How to Do a Scan to Clean a Hard Drive?
14. How to Fix a Slow Internet on Windows Vista?
15. How to clean a Computer of viruses?
16. What is a firewall? Why one should need it?

Further Readings

Computer Security: Art and Science 1st Edition by Matthew Bishop, Addison-Wesley Professional, 1st edition.

Introduction to Computer Networks and Cyber security by Chwan-Hwa (John) Wu, J. David Irwin, CRC Press.

What is Computer Security? | Introduction to Computer Security | Edureka

Different Types of Computer Security | Cyber Security Portal (cyberthreatportal.com)

System Security – Geeks for Geeks

Unit 13: Cloud Computing and IoT

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Objectives

- Define cloud computing and its characteristics.
- Learn about cloud service and deployment models.
- Explore virtualization and virtual servers.
- Know about cloud storage.
- Analyze database storage and Database-as-a-Service offered through cloud computing.
- Understand resource management and Service Level Agreements in cloud computing
- Explain the basics of IoT.
-

Introduction

Cloud computing is a construct (infrastructure) that allows to access application that actually resides at a remote location of another internet connected device, most often, this will be a distant datacenter. As per National Institute of Standards and Technology (NIST), "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computer resources (networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

For example: Suppose you want to install MS-Word in your organization's computer. You have bought the CD/DVD of it an install it or can setup a software distribution server to automatically install this application on your machine. Every time Microsoft issued a new version you have to perform same task. But in cloud scenario, you do not need to bother about all these tasks. Instead, the cloud provider will do all this for you.

In a typical cloud scenario (Figure 1), if some other company hosts your application, it is their responsibility to handle the cost of servers, manage the software update. The company will charge the customer as per their utilization, that is, as per the usage you will pay them. This helps to

reduce the overall cost of using that software; cost of installation of heavy serversas well asthe cost of electricity bills.
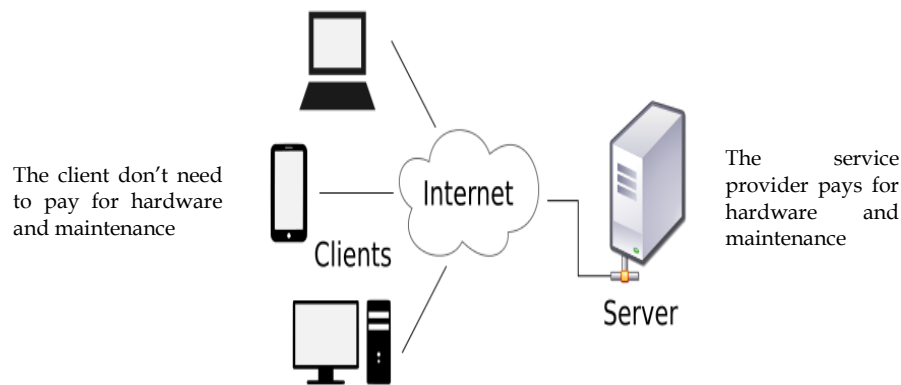

Figure 1: Typical Cloud Scenario

Cloud Properties: Google's Perspective

Google's perspective on cloud computing is based on different characteristics. As per Google,

1. **Cloud computing is User-centric:** Once you as a user are connected to the cloud, whatever is stored there—documents, messages, images, applications, whatever—becomes yours. In addition, not only is the data yours, but you can also share it with others. In effect, any device that accesses your data in the cloud also becomes yours.

2. **Cloud computing is Task-centric:** Instead of focusing on the application and what it can do, the focus is on what you need done and how the application can do it for you., Traditional applications—word processing, spreadsheets, email, and so on—are becoming less important than the documents they create.

3. **Cloud computing is Powerful:** Connecting hundreds or thousands of computers together in a cloud creates a wealth of computing power impossible with a single desktop PC.

4. **Cloud computing is Accessible:** Because data is stored in the cloud, users can instantly retrieve more information from multiple repositories. You're not limited to a single source of data, as you are with a desktop PC.

5. **Cloud computing is Intelligent:** With all the various data stored on the computers in a cloud, data mining and analysis are necessary to access that information in an intelligent manner.

6. **Cloud computing is Programmable:** Many of the tasks necessary with cloud computing must be automated. For example, to protect the integrity of the data, information stored on a single computer in the cloud must be replicated on other computers in the cloud. If that one computer goes offline, the cloud's programming automatically redistributes that computer's data to a new computer in the cloud.

With the growth of the Internet, there was no need to limit group collaboration to a single enterprise's network environment. There can be users from multiple locations within a corporation, and from multiple organizations, desired to collaborate on projects that crossed company and geographic boundaries. The projects had to be housed in the "cloud" of the Internet, and accessed from any Internet-enabled location. The concept of cloud-based documents and services took wing with the development of large server farms, such as those run by Google and other search companies. Cloud computing facilitates internet-based group collaboration. It is an abstraction based on the notion of pooling physical resources and presenting them as a virtual resource.

Cloud computing is a new model for provisioning resources, for staging applications, and for platform-independent user access to services. Clouds can come in many different types, and services and applications that run on cloud may or may not be delivered by a cloud service

provider. The different types and levels of cloud services mean that it is important to define what type of cloud computing system you are working with.

"Cloud" makes reference to the two essential concepts:

- Abstraction: Cloud computing abstracts the details of system implementation from users and developers. Applications run on physical systems that aren't specified, data is stored in locations that are unknown, administration of systems is outsourced to others, and access by users is ubiquitous (Present or found everywhere).
- Virtualization: Cloud computing virtualizes systems by pooling and sharing resources. Systems and storage can be provisioned as needed from a centralized infrastructure, costs are assessed on a metered basis, multi-tenancy is enabled, and resources are scalable with agility.

13.1 Components of Cloud Computing

Cloud computing solution is made up of several elements and these elements make up the three components of a cloud computing solution (Figure 2).

- clients
- the data center, and
- distributed servers

Clients- Clients can be devices that end users interact with to manage their information on cloud. There can be several types of clients such as:

- Mobile Clients: Include PDAs or Smartphone, like a Blackberry, Windows Mobile Smartphone, or an iPhone.
- Thin Clients: Computers that do not have internal hard drives, but rather let the server do all the work, but then display the information.
- Thick (Fat) Clients: It can be a regular computer, using a web browser like Firefox or Internet Explorer to connect to the cloud.
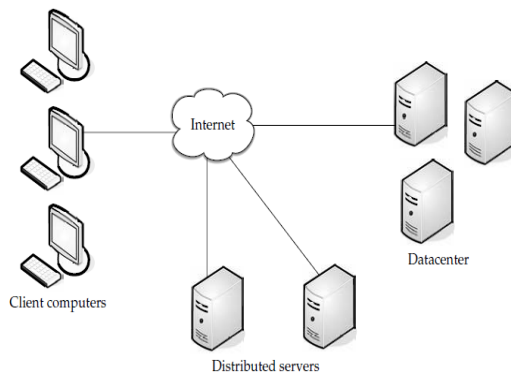

Figure 2: Components of Cloud Computing

A thin client is a computing device that is connected to a network. Unlike a typical PC or "fat client," that has the memory, storage and computing power to run applications and perform computing tasks on its own, a thin client functions as a virtual desktop, using the computing power residing on networked servers. There are several advantages associated with using thin clients:

- Thin clients are becoming an increasingly popular solution, because of their price and effect on the environment.
- Lower hardware costs: Thin clients are cheaper than thick clients because they do not contain as much hardware. They also last longer before they need to be upgraded or become obsolete.
- Lower IT costs: Thin clients are managed at the server and there are fewer points of failure.
- Security: Since the processing takes place on the server and there is no hard drive, there's less chance of malware invading the device. Also, since thin clients don't work without a server, there's less chance of them being physically stolen.

- Data security: Since data is stored on the server, there's less chance for data to be lost if the client computer crashes or is stolen.
- Less power consumption: Thin clients consume less power than thick clients. This means you'll pay less to power them, and you'll also pay less to air-condition the office.
- Ease of repair or replacement: If a thin client dies, it's easy to replace. The box is simply swapped out and the user's desktop returns exactly as it was before the failure.
- Less noise: Without a spinning hard drive, less heat is generated and quieter fans can be used on the thin client.

Data Center: It is collection of servers where the application to which you subscribe is housed. It can be a large room in the basement of your building or a room full of servers on the other side of the world that you access via the Internet. Data centers pertain to a growing trend in the IT world of virtualizing servers. The software can be installed allowing multiple instances of virtual servers to be used. There are extensively half a dozen virtual servers running on one physical server.

Distributed Servers: The distributed servers are located in geographically disparate locations. The distributed servers give the service provider more flexibility in options and security. For instance, Amazon has their cloud solution in servers all over the world. If something were to happen at one site, causing a failure, the service would still be accessed through another site.

Characteristics of Cloud Computing

- **On-demand Self-service**– A user can provision computing capabilities, such as server time and storage, as needed without requiring human interaction.
- **Broader Network Access**– Capabilities are available over a network and typically accessed by the users' mobile phones, tablets, laptops, and workstations.
- **Shared Resource Pooling**– The provider's computing resources are pooled to serve multiple users using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. Examples of resources include storage, processing, memory, and network bandwidth.
- **Rapid Elasticity**– Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward as needed.
- For the user, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.
- **Measured Service**– Cloud systems automatically control and optimize resource use by leveraging a metering capability appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts).
- **"Pay as you grow" model** or for internal IT departments to provide IT chargeback capabilities. The usage of cloud resources is measured and user is charged based on some metrics such as amount of CPU cycles used, amount of storage space used, number of network I/O requests etc. are used to calculate the usage charges for the cloud resources.
- **Performance-**The dynamic allocation of resources as per the application workloads helps to easily scale up or down and maintain performance.
- **Reduced Costs-**Cost benefits for applications as only as much computing and storage resources are required can be provisioned dynamically and upfront investment in purchase of computing assets to cover worst case requirements is avoided.
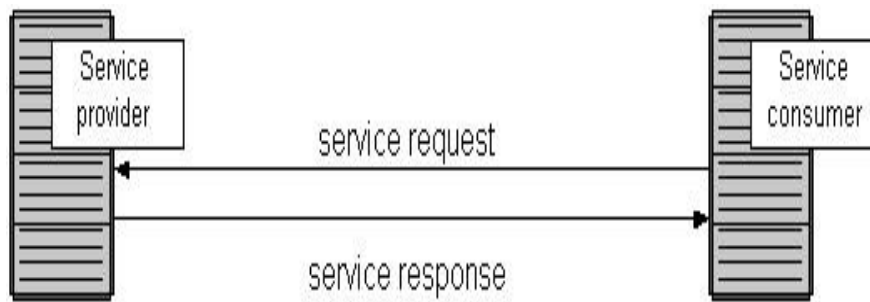
Figure 3: Service-Oriented Architecture

- **Outsourced Management-**Cloud computing allows the users to outsource the IT infrastructure requirements to external cloud providers and save upfront capital investments. This helps in easiness of setting IT infrastructure and pay only for the operational expenses for the cloud resources used.
- **Multitenancy-**Allows multiple users to make use of the same shared resources. Modern applications such as Banking, Financial, Social networking, e-commerce, B2B etc are deployed in cloud environments that support multi-tenanted applications.
- **Service Oriented Architecture:** Service Oriented Architecture (SOA) is essentially a collection of services which communicate with each other (Figure 3). The SOA provides a loosely-integrated suite of services that can be used within multiple business domains.

13.2   Cloud Model Types

Cloud computing is divided into two distinct sets of models: deployment and service models. The cloud deployment models refer to the location and management of the cloud's infrastructure (Figure 4).Cloud computing services come in three types: SaaS (Software as a Service), IaaS (Infrastructure as a Service), and PaaS (Platform as a Service).

Cloud Deployment Models

- **Public Cloud:** The cloud infrastructure and computing resources are made available to general public over a public network. It is owned by an organization selling cloud services, and serves a diverse pool of clients (Figure 5).
- **Private Cloud:** The private cloud gives a single cloud consumer's organization the exclusive access to and usage of the infrastructure and computational resources. It can be managed at various levels. There can be on-site private cloud and outsourced private cloud (A third party, outsourced to a hosting company (outsourced private clouds)).

  The private cloud can be physically located at your organization's on-site datacenter or it can be hosted by a third-party service provider. But in a private cloud, the services and infrastructure are always maintained on a private network and the hardware and software are dedicated solely to your organization.

  In an on-premise private cloud (Figure 6), the data center is owned or leased by the business and then allows this infrastructure to be used to create, manage, and maintain an internal cloud environment.When the organizations choose to outsource cloud services, they also need to choose whether they will manage the cloud or hire a cloud management company's service (Figure 7). Outsourcing to a private managed cloud has various benefits since the business does not run and manage the cloud services on a daily basis.As a result, the business needs less personnel and fewer resources in its IT department. Cloud management companies also ensure that their clients comply with various local and international laws and regulations.
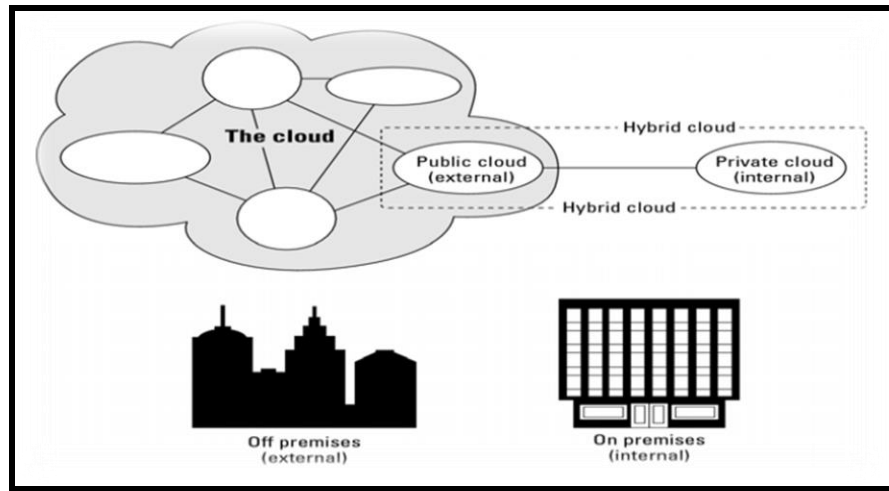
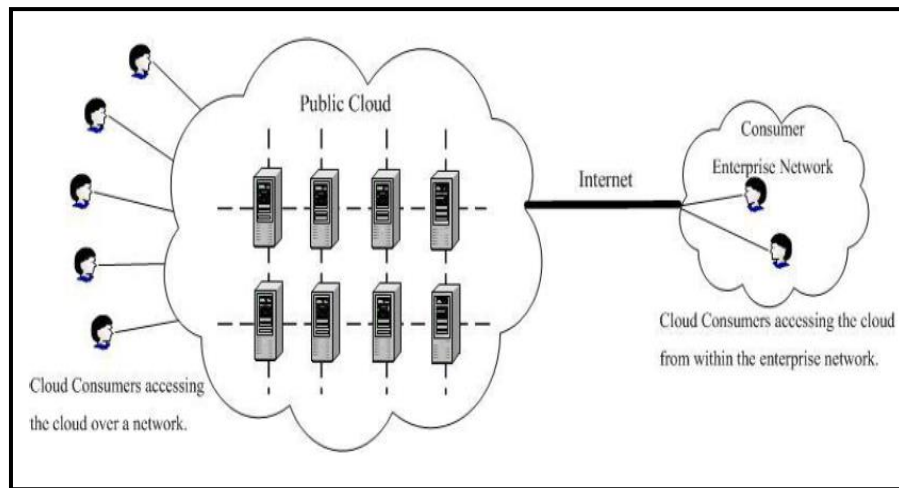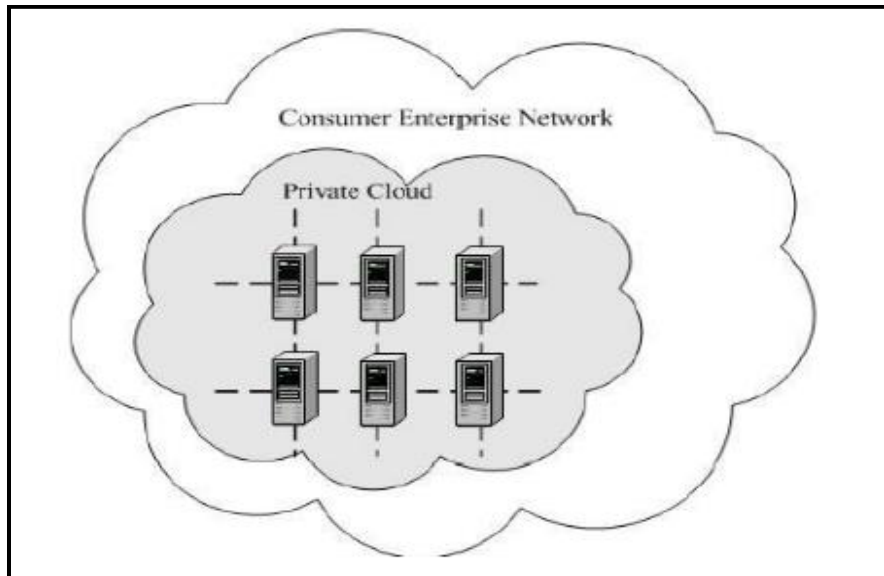*Figure 4: Deployment Locations of Different Cloud Types*

Figure 5: Public Cloud
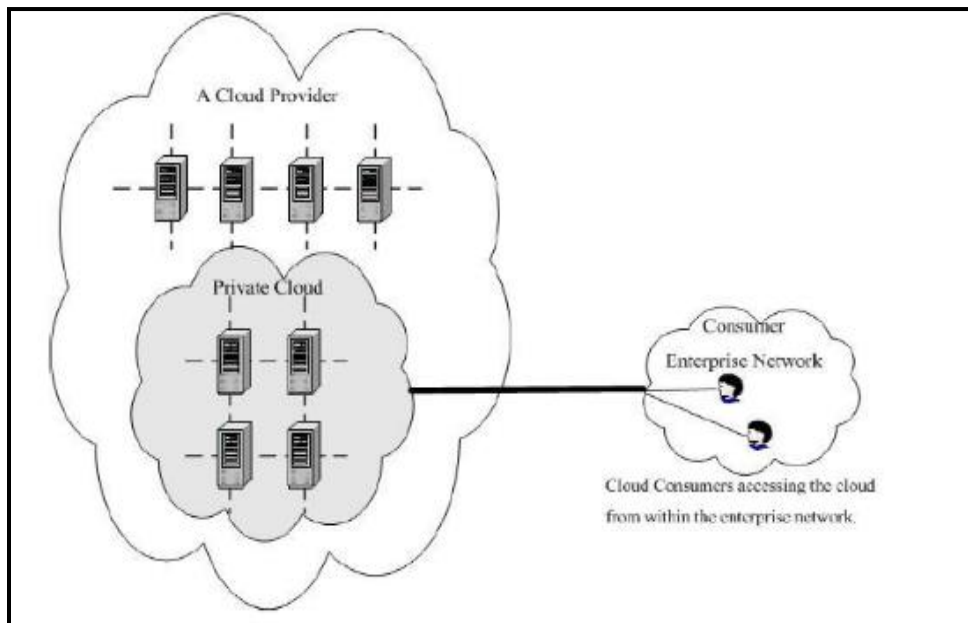

Figure 6: On-site Private Cloud

Figure 7: Outsourced Private Cloud

• **Community Cloud:** The community cloud serves a group of cloud consumers which have shared concerns such as mission objectives, security, privacy and compliance policy. It is similar to private clouds. A community cloud may be managed by:
   o The organizations and may be implemented on customer premise (on-site community cloud)
   o A third party, outsourced to a hosting company (outsourced community cloud)

An on-site community cloud comprises of a number of participant organizations while the cloud consumer can access the local cloud resources, and also resources of other participating organizations through connections between associated organizations (Figure 8). In an outsourced community cloud, the server side is outsourced to a hosting company (Figure 9). It builds its infrastructure off-premise, and serves a set of organizations that request and consume the cloud services.
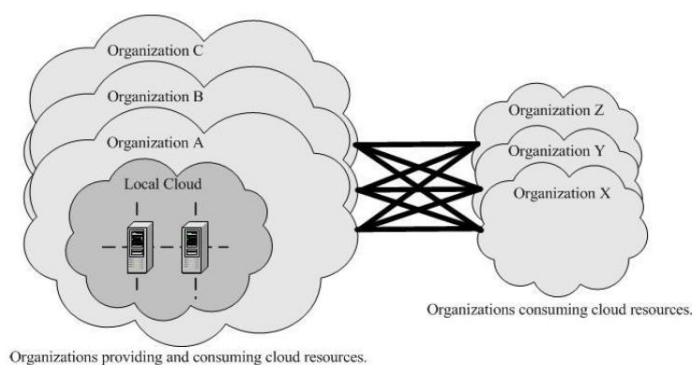

Figure 8: On-site Community Cloud
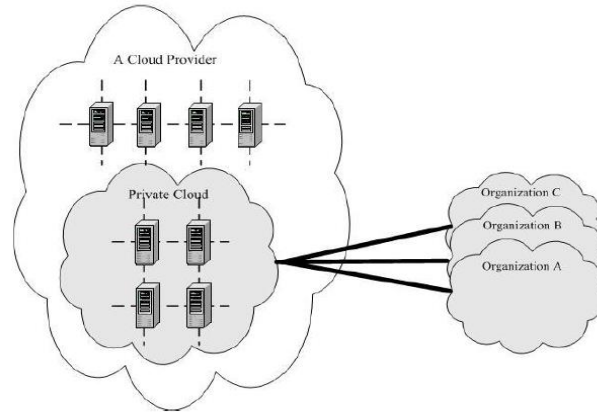
Figure 9: An Outsourced Community Cloud

• **Hybrid Cloud:** Hybrid cloud is composed of two or more clouds that remain as distinct entities but are bound together by standardized or proprietary technology that enables data and application portability (Figure 10).
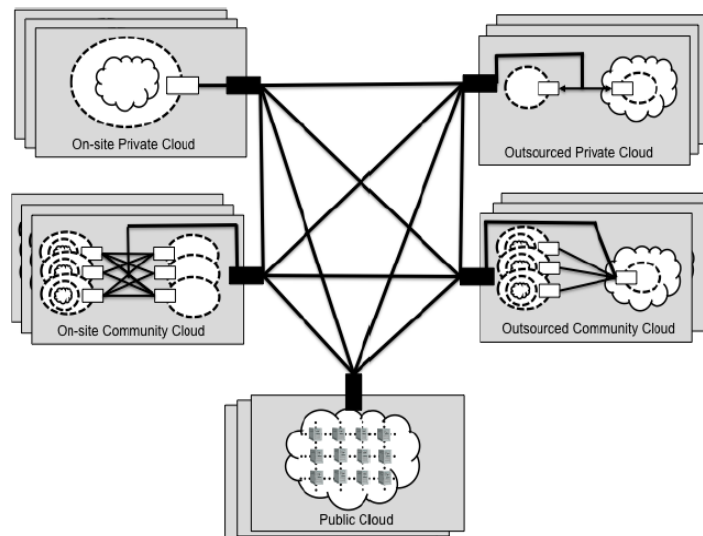
Figure 10: Hybrid Cloud Scenario

Cloud Service Models

The cloud service model consists of the particular types of services that you can access on a cloud computing platform (Figure 11).

• Infrastructure-as-a-Service
• Platform-as-a-Service
• Software -as-a-Service

1. Infrastructure-as-a-Service (IaaS)

• Provides virtual machines, virtual storage, virtual infrastructure, and other hardware assets as resources that clients can provision.
• Service provider manages all infrastructure, while the client is responsible for all other aspects of the deployment.
• Can include the operating system, applications, and user interactions with the system.

Figure 11: Cloud Service Models

2. Platform-as-a-Service (PaaS)

- Provides virtual machines, operating systems, applications, services, development frameworks, transactions, and control structures.
- Client can deploy its applications on the cloud infrastructure or use applications that were programmed using languages and tools that are supported by the PaaS service provider.
- Service provider manages the cloud infrastructure, the operating systems, and the enabling software.
- Client is responsible for installing and managing the application that it is deploying.
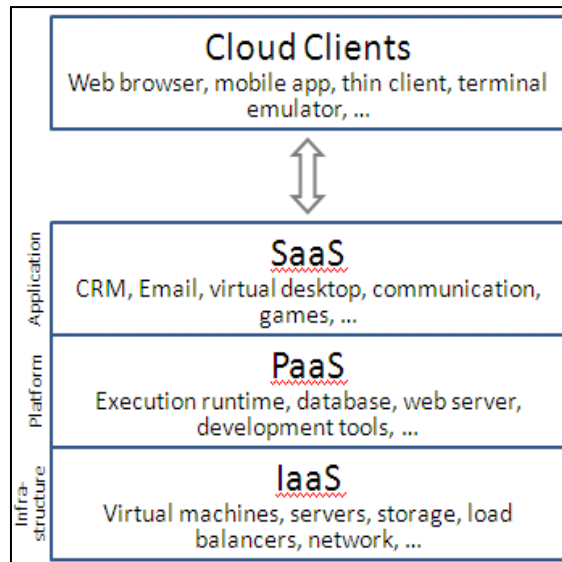- PaaS provide service– Programming IDE in order to develop their service among PaaS.
- Integrate the full functionalities which supported from the underling runtime environment.
- Provide some development tools, such as profiler, debugger and testing environment.
- Programming APIs supported from runtime environment.
- Examples of PaaS Service Providers: Microsoft Windows Azure, Google App Engine, Hadoop etc.

3. Software-as-a-Service (SaaS)

- It facilitates complete operating environment with applications, management, and the user interface.
- To use the provider's applications running on a cloud infrastructure.
- Applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email).
- Consumer does not manage or control the underlying cloud infrastructure including network, servers, OSs, storage, or even individual application capabilities.
- Examples: Google Apps (e.g., Gmail, Google Docs etc.), SalesForce.com, EyeOS etc.
- Enabling Technique– Web Service
  - o Web 2.0 is the trend of using full potential of web.
  - o Viewing the Internet as a computing platform.
  - o Running interactive applications through a web browser.
  - o Leveraging interconnectivity & mobility of devices.
  - o Enhanced effectiveness with greater human participation.

13.3 Virtualization

In computing, virtualization or virtualisation is the act of creating a virtual (rather than actual) version of something, including virtual computer hardware platforms, storage devices, and computer network resources. Virtualization began in the 1960s, as a method of logically dividing the system resources provided by mainframe computers between different applications. Since then, the meaning of the term has broadened. Virtualization technology has transformed hardware into software. It allows to run multiple Operating Systems (OSs) as virtual machines (Figure 12).Each copy of an operating system is installed in to a virtual machine.

Figure 12: Virtualization Scenario

You can see a scenario over here that we have a VMware hypervisor that is also called as a Virtual Machine Manager (VMM). On a physical device, a VMware layer is installed out and on that layer, we have six OSs that are running multiple applications over there, these can be the same kind of OSs or these can be the different kinds of OSs in it.

Virtual Machine (VM):A VM involves anisolated guest OS installation within a normal host OS. From the user perspective, VM is software platform like physical computer that runs OSs and apps. VMs posses hardware virtually.

Why Virtualize?

1. Share same hardware among independent users- Degrees of Hardware parallelism increases.
2. Reduced Hardware footprint through consolidation- Eases management and energy usage.
3. Sandbox/migrate applications- Flexible allocation and utilization.
4. Decouple applications from underlying Hardware- Allows Hardware upgrades without impacting an OS image.

Virtualization enables sharing of resources much easily, it helps in increasing the degree of hardware level parallelism, basically, there is sharing of the same hardware unit among different kinds of independent units, if we say that we have the same physical hardware and on that physical hardware, we have multiple OSs. There can be different users running on different kind of OSs. Therefore, we have a much more processing capability with us. This also helps in increasing the degree of hardware parallelism as well as there is a reduced hardware footprint throughout the VM consolidation. The hardware footprint that is overall hardware consumptionalso reduces out the amount of hardware that is wasted out that can also be reduced out. This consequently helps in easing out the management process and also to reduce the amount of energy that would have been otherwise consumed out by a particular hardware if we would have invested in large number of hardware machines would have been used otherwise. Virtualization helps in sandboxing capabilities or migrating different kinds of applications that in turn enables flexible allocations and utilization of the resources. Additionally, the decoupling of the applications from the underlying hardware is much easier and further aids in allowing more and more hardware upgrades without actually impacting any particular OS image.

Virtualization raises abstraction. Abstraction pertains to hiding of the inner details from a particular user. Virtualization helps in enhancing or increasing the capability of abstraction. It is very similar to how the virtual memory operates. It helps to access the larger address spaces physical memory mapping is actually hidden by an OSwith the help of paging. It can be similar to hardware emulators where codes are allowed on one architecture to run on a different physical device such as virtual devices central processing unit, memory or network interface cards etc.No botheration is actually required out regarding the hardware details of a particular machine. The confinement to the excess of hardware details helps in raising out the abstraction capability through virtualization.

Basically, we have certain requirements for virtualization, first is the efficiency property. Efficiency means that all innocuous instructions are executed by the hardware independently. Then, the resource control property means that it is impossible for the programs to directly affect any kind of system resources. Furthermore, there is an equivalence property that indicates that we have a program which has a virtual machine manager or hypervisor that performs in a particular manner, indistinguishable from another program that is running on it.

Virtualization Architecture

It is important to understand how virtualization actually works. Firstly, in virtualization a virtual layer is installed on the systems. There are two prominent virtualization architectures, bare-metal and hosted hypervisor. In a hosted architecture, a host OS is firstly installed out then a piece of software that is called as a hypervisor or it is called as a VM monitor or Virtual Machine Manager (VMM). The VMM is installed on the top of host OS. The VMM allows the users to run different kinds of guests OSs within their own application window of a particular hypervisor. Different kinds of hypervisors can be Oracle's Virtual Box, Microsoft Virtual PC, VMware Workstation.
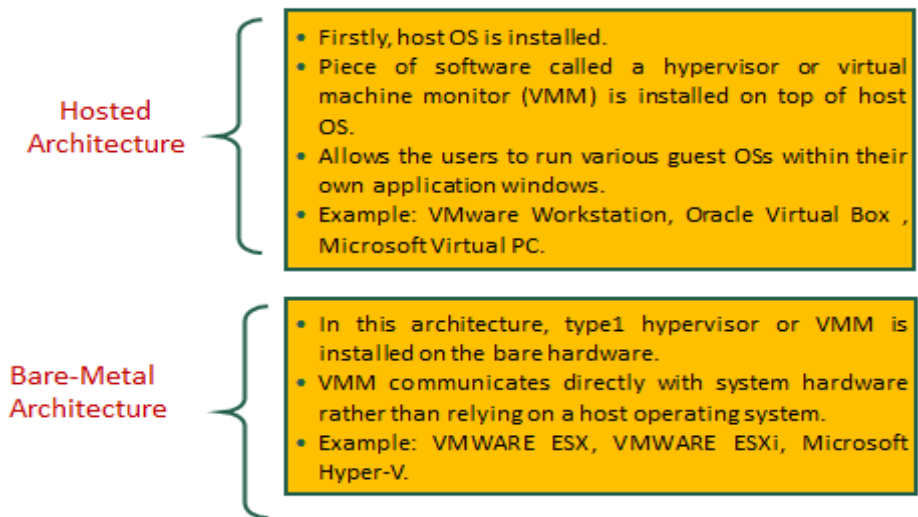
Hosted Architecture
- Firstly, host OS is installed.
- Piece of software called a hypervisor or virtual machine monitor (VMM) is installed on top of host OS.
- Allows the users to run various guest OSs within their own application windows.
- Example: VMware Workstation, Oracle Virtual Box , Microsoft Virtual PC.

Bare-Metal Architecture
- In this architecture, type1 hypervisor or VMM is installed on the bare hardware.
- VMM communicates directly with system hardware rather than relying on a host operating system.
- Example: VMWARE ESX, VMWARE ESXi, Microsoft Hyper-V.

Figure 13: Hosted vs Bare-Metal Virtualization

VMware server is a free application that is supported by Windows as well as by Linux OSs.

In a bare metal architecture, one hypervisor or VMM is actually installed on the bare metal hardware. There is no intermediate OS existing over here. The VMM communicates directly with the system hardware and there is no need for relying on any host OS. VMware ESXi and Microsoft Hyper-V aredifferent hypervisors that are used for bare-metal virtualization.

A. Hosted Virtualization Architecture

Hosted virtualization architecture requires an OS (Windows or Linux) installed on the computer. The virtualization layer is installed as application on the OS.Figure 14 illustrates the hosted virtualization architecture. At the lower layer, we have the shared hardware with a host OS running on this shared hardware. Upon the host OS, a VMM is running that and is creating a virtual layer which is enabling different kinds of OSs to run concurrently. So, you can see a scenario we have a hardware then we add an operating system then a hypervisor is added and different kinds of virtual machines can run on that particular virtual layer and each virtual machine can be running same or different kind of OSs.
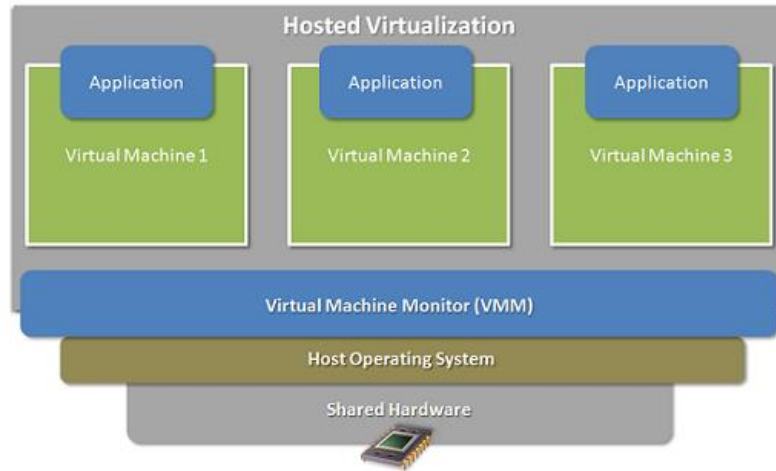
Figure 14: Hosted Virtualization Architecture

Advantages of Hosted Architecture
- Ease of installation and configuration
- Unmodified Host OS & Guest OS
- Run on a wide variety of PCs

Disadvantages of Hosted Architecture
- Performance degradation
- Lack of support for real-time OSs

B. Bare-Metal Virtualization Architecture

In a bare metal architecture, there is an underlying hardware but no underlying OS. There is just a VMM that is installed on that particular hardware and on that there are multiple VMs that are running on a particular hardware unit. As illustrated in the Figure 15, there is shared hardware that is running a VMM on which multiple VMs are running with simultaneous execution of multiple OSs.

Advantages of Bare-Metal Architecture

- Improved I/O performance
- Supports Real-time OS

Disadvantages of Bare-Metal Architecture

- Difficult to install & configure
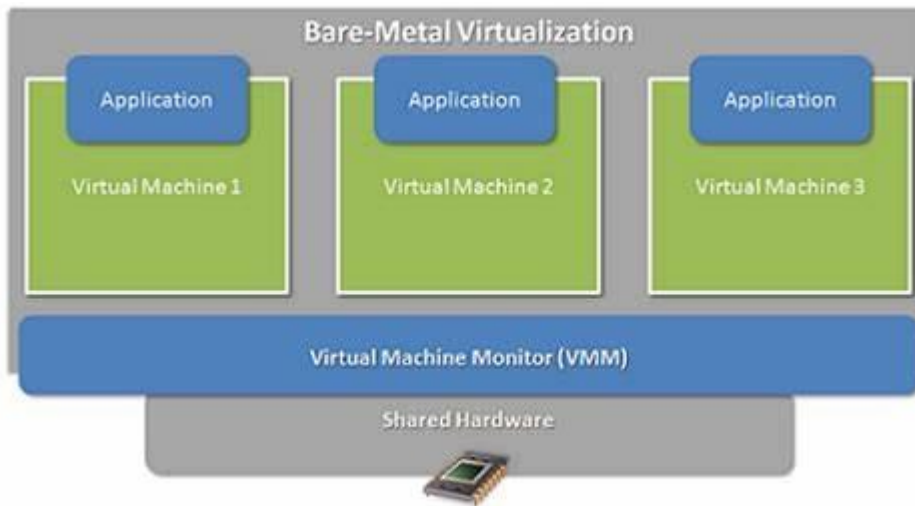- Depends upon hardware platform

Figure 15: Bare-Metal Virtualization Scenario

Virtualization Techniques

There are 4 virtualization techniques namely,

- Full Virtualization (Hardware Assisted Virtualization/ Binary Translation).
- Para Virtualization or OS assisted Virtualization.
- Hybrid Virtualization
- OS level Virtualization

Full Virtualization: The VM simulates hardware to allow an unmodified guest OS to be run in isolation. There are 2 type of full virtualizations in the enterprise market, software-assisted and hardware-assisted full virtualization. In both the cases, the guest OSs source information is not modified.

The software-assisted full virtualization is also called as Binary Translation (BT) and it completely relies on binary translation to trap and virtualize the execution of sensitive, non-virtualizable instructions sets. It emulates the hardware using the software instruction sets. It is often criticized for performance issue due to binary translation. The software that fall under software-assisted (BT) include:

- VMware workstation (32Bit guests)
- Virtual PC
- Virtual Box (32-bit guests)
- VMware Server

The hardware-assisted full virtualization eliminates the binary translation and directly interrupts with hardware using the virtualization technology which has been integrated on X86 processors since 2005 (Intel VT-x and AMD-V). The guest OS's instructions might allow a virtual context execute privileged instructions directly on the processor, even though it is virtualized. There is several enterprise software that support hardware-assisted– Full virtualization which falls under hypervisor type 1 (Bare metal) such as:

- VMware ESXi /ESX
- KVM
- Hyper-V
- Xen

Para Virtualization: The para-virtualization works differently from the full virtualization. It doesn't need to simulate the hardware for the VMs. The hypervisor is installed on a physical server (host) and a guest OS is installed into the environment. The virtual guests are aware that it has been virtualized, unlike the full virtualization (where the guest doesn't know that it has been virtualized) to take advantage of the functions. Also, the guest source codes can be modified with sensitive

information to communicate with the host. The guest OSs require extensions to make API calls to the hypervisor.

Comparatively, in the full virtualization, guests issue hardware calls but in paravirtualization, guests directly communicate with the host (hypervisor) using the drivers. The list of products which supports paravirtualization are:

- Xen
- IBM LPAR
- Oracle VM for SPARC (LDOM)
- Oracle VM for X86 (OVM)

However, due to the architectural difference between windows-based and Linux-based Xen hypervisor, Windows OS can't be para-virtualized. It does for Linux guest by modifying the kernel. VMware ESXi doesn't modify the kernel for both Linux and Windows guests.
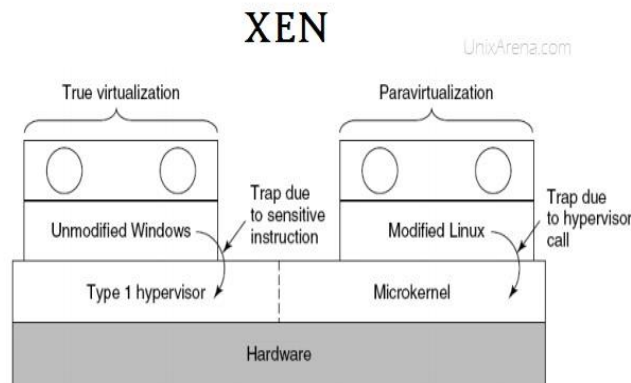

Figure 16: Xen Supports both Full-Virtualization and Para-Virtualization

Hybrid Virtualization (Hardware Virtualized with PV Drivers): In the hardware-assisted full virtualization, the guest OSs are unmodified and many VM traps occur and thus high CPU overheads which limit the scalability. Paravirtualization is a complex method where guest kernel needs to be modified to inject the API. Therefore, due to the issues in full- and para- virtualization, engineers came up with hybrid paravirtualization, that is, a combination of both full and paravirtualization. The VM uses paravirtualization for specific hardware drivers (where there is a bottleneck with full virtualization, especially with I/O & memory intense workloads), and host uses full virtualization for other features. The following products support hybrid virtualization:

- Oracle VM for x86
- Xen
- VMware ESXi

OS Level Virtualization: It is widely used and is also known as "containerization". The host OS kernel allows multiple user spaces aka instance.Unlike other virtualization technologies, there is very little or no overhead since it uses the host OS kernel for execution.Oracle Solaris zone is one of the famous containers in the enterprise market. The list of other containers:

- Linux LCX
- Docker
- AIX WPAR

13.4 Cloud Storage

Cloud storage is a model of computer data storage in which the digital data is stored in logical pools, said to be on "the cloud". The physical storage spans multiple servers (sometimes in multiple locations), and the physical environment is typically owned and managed by a hosting company. These cloud storage providers are responsible for keeping the data available and accessible, and the

physical environment protected and running. People and organizations buy or lease storage capacity from the providers to store user, organization, or application data.

Cloud storage services may be accessed through a co-located cloud computing service, a web service application programming interface (API) or by applications that utilize the API, such as cloud desktop storage, a cloud storage gateway or Web-based content management systems.

Cloud storage is based on highly virtualized infrastructure and is like broader cloud computing in terms of interfaces, near-instant elasticity and scalability, multi-tenancy, and metered resources. Cloud storage services can be utilized from an off-premises service (Amazon S3) or deployed on-premises (ViON Capacity Services).

> *Cloud storage typically refers to a hosted object storage service, but the term has broadened to include other types of data storage that are now available as a service, like block storage. The object storage services like Amazon S3, Oracle Cloud Storage and Microsoft Azure Storage, object storage software like Open stack Swift, object storage systems like EMC Atmos, EMC ECS and Hitachi Content Platform, and distributed storage research projects like Ocean Store and VISION Cloud are all examples of storage that can be hosted and deployed with cloud storage characteristics (*

Figure 17).

Overall, the cloud storage is made up of many distributed resources, but still acts as one, either in a federated or a cooperative storage cloud architecture. It is highly fault tolerant through redundancy and distribution of data; highly durable through the creation of versioned copies and it eventually consistent with regard to the data replicas.

Comparatively, the traditional storage was done using the local physical drives to store the data at the primary location of the client and the user generally used the disk-based hardware to store data as well as for copying, managing, and integrating the data to software.

Cloud Storage Vs Traditional Storage

- Data (or files) are saved on a remote server, which is easily accessible from anywhere with internet access as well as from any device connected to the internet, including computers, tablets and smartphones.
- With traditional alternatives, what you pay for is what you get. If one has invested in a lot of storage to support a new project, then one is still left paying the same amount once it's over – even if one doesn't need the storage anymore.
- Businesses are bound to the traditional office-based 9-5 unlike cloud in which, "teams can access everything from wherever they are".
- Traditional storage solutions involve physical devices in which the monitoring, maintaining and patching the devices is user-dependent and thereby quite overwhelming.
- Cloud storage is more flexible than traditional on-premise alternatives.
- Easy to create a tailored solution that suits a user's specific requirements.
- Freedom to choose a course of action based on a user's current setup and what servers are chosen.

Benefits of Cloud Storage

- All platforms can easily be accessed via a web browser.
- Offer apps for ease of access from a smartphone or tablet.
- Feature a directory structure similar to that of a computer drive; this facilitates navigation and organisation.
- Ease of Access
  - Access to the personal folders is perceived to be more cumbersome (involves 'more clicks').
  - Many people are always logged into Google (and hence Google Drive) in the back ground, both at home and at school
- Online Editing
  - One Drive and Google Drive offer the possibility of editing documents inside a web browser.
  - No additional software is needed.
  - Folders or specific files can be shared with others; this facilitates collaboration.

Online Collaboration
- Documents and folders can be shared with colleagues.
- Editing is possible without downloading the document, eliminating the need to email and save multiple versions of the same documents.

The examples of cloud storage and their characteristics are listed below:

Cloud Storage- Google Drive
- 'Pure' cloud computing service, with all the apps & storage found online.
- Can be used via desktop top computers, tablets like iPad or on smartphones.
- All of Google's services can be considered cloud -based: Gmail, Google Calendar, Google Voice etc.
- Microsoft's OneDrive: Similar to Google Drive.

Figure 17: Different Cloud Storage Examples

Cloud Storage- Dropbox
- Commonly used to store documents and images.
- One can set his/her phone to automatically send all pictures taken with it into their Dropbox account, so that even if one loses their phone, the pictures will still be available to him/her up in space.
- One can use it to access documents at home, and then save changes to it.
- Sugarsyncis another example.

Cloud Storage- Apple iCloud
- Apple's cloud service is primarily used by Apple users for online storage and synchronization of user's mail, contacts, calendar, and more.
- All the data needed is available to a user on whichever device he/she seeks to access it from, iOS, Mac OS, or Windows device.
- If a user makes a change to a document, say, on one of their devices, it will automatically update it so that when next access is made to the account, the amended version will be available on whatever device you use.
- If a user has loads of data up there (perhaps pictures or films have made) then one will need to pay for extra storage.

13.5 Cloud Database

The cloud database is a collection of informational content, either structured or unstructured that resides on a private, public or hybrid cloud computing infrastructure platform.From a structural and design perspective, a cloud database is no different than one that operates on a business's own on-premises servers. However, the critical difference lies in where database resides."Cloud database" can be one of two distinct things: a traditional or NoSQL database installed and running

on a cloud virtual machine, or a cloud provider's fully managed database-as-a-service (DBaaS) offering. It can be said to be running own self-managed database in a cloud environment where an on-premises database is connected to local users through a corporation's internal local area network (LAN), a cloud database resides on servers and storage furnished by a cloud or database as a service (DBaaS) provider and it is accessed solely through the internet. The cloud DBaaS is natural database equivalent of software-as-a-service (SaaS). Cloud database access is based on the pay as you go model.

How Cloud Database Work?

There are two prominent cloud databases: Relational and Non-Relational databases.The relational database is written in Structured Query Language (SQL) and is a set of interrelated tables organized into rows & columns. The relationship between tables and columns (fields) is specified in a schema. Such databases are used in banking transactions or a telephone directory. The popular cloud platforms and cloud providers include MySQL, Oracle, IBM DB2 and Microsoft SQL Server. The non-relational database is sometimes also called as NoSQL as it does not employ a table model. It stores content, regardless of its structure, as a single document and is well-suited for unstructured data, such as social media content, photos and videos.
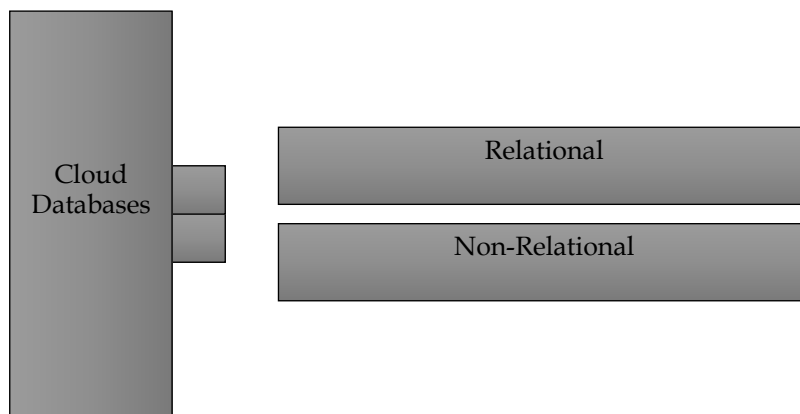

Figure 18: Categorization of Cloud Database

Benefits of Using a Cloud Database

• Ease of Access: Users can access cloud databases from virtually anywhere, using a vendor's API or web interface.

• Scalability: Cloud databases can expand storage capacities on run-time to accommodate changing needs. Organizations only pay for what they use.

• Disaster Recovery: In the event of a natural disaster, equipment failure or power outage, data is kept secure through backups on remote servers.

• Overall cost: The cost of adopting cloud databases can be considerably less than expanding your existing on-site server capability. There are reduced maintenance costs can also cut administrative costs substantially. Cloud's pay-as-you-go costs only increase if one expands or requires additional services.

• Flexible Solutions; Moving database solutions to the cloud can release a business from the demands and costs of managing own services. Cloud databases are massively efficient, as they have no inherent restrictions on their ability to expand.

• Mobile Access: Cloud databases add easiness in business expansion due to the ability of cloud platforms to be accessed and used from a range of remote devices. The applications can be built with geographically dispersed teams at no loss to efficiency or security.

• Disaster Recovery: The applications require reliable connections to the databases that power them. There is built-in redundancy and 24/7 uptime the norm. Cloud offers reliable platform for application development. Moreover, the robust cloud infrastructures are supported.

• Safe and Secure: Moving sensitive data to a cloud platform outside of a business's firewall could be risky. Cloud offers comprehensive security often more robust than that of on-site servers. The adoption of DBaaS infrastructures delivers world-class security.

• Scaling and Managing Database is Easier: Cloud service providers keep on evolving their services, any business can take instant advantage of these improvements, making both scaling and managing a database easier.

Considerations for Moving Database to Cloud

What is current database hosting infrastructure?

• Whether your business runs traditional, relational databases or has embraced NoSQL databases, it's essential to match your hosting environment to the right cloud infrastructure.

• Using DBaaS (Database-as-a-Service).

• Hosting services should be efficient and secure to migrate to and offer a flexible dynamic environment for your applications.

• Hosting environment should have the capacity and features to match these needs.

Are you expanding the capabilities of the applications you are creating?

• As your applications grow in size and complexity, a cloud database can grow along with it.

• Cloud databases have ability to handle rapid expansion and organization of complex data.

• Hosting these databases in the cloud lifts the limits on your application's growth.

Is 24/7 availability essential for your business's applications?

• Cloud databases have built-in back-up and recovery, ensuring database is 'always on.'

• Built-in back-ups help eliminate the risk of data-loss.

• Moving to a cloud database removes the risk of downtime issues.

• Offers steady and reliable connectivity.

Does your business build applications require large datasets to operate efficiently?

• Using a cloud database removes the issues of dealing with large datasets by giving access to data storage that expands to meet user needs.

Example of Cloud Database Service- MongoDB Atlas Cloud Database

• MongoDB Atlas, part of MongoDB's broader Data-as-a-Service (DaaS) development platform.

• Powerful and compelling alternative to managing own NoSQL, or traditional database, or to using a cloud provider-specific managed offering.

• Offers fully managed database services through user's choice of cloud provider, including AWS, Azure, and GCP.

• Fully-managed database services handle the complexities of maintaining a consistently available, high-performance data cluster that developers can access as a single, globally available resource.

13.6   Resource Management in Cloud Computing

Resource management in the cloud computing is the process of allocating computing, storage, networking and indirectly energy resources to a set of applications. It attributes to jointly meet the performance objectives of the infrastructure providers, users of the cloud resources and applications as the major objective of the cloud users tend to focus on application performance. The resource management is a conceptual framework that provides a high-level view of the functional component of cloud resource management systems and all their interactions and is highly critical function that requires complex policies and decisions for multi-objective optimization. It is challenging as the complexity of the system makes it impossible to have accurate global state information.

The management of resources in cloud is highly affected by unpredictable interactions with the environment, e.g., system failures, attacks and is faced with large fluctuating loads which challenge

the claim of cloud elasticity. There is extensive use of resource scheduling that decides how to allocate resources of a system, such as CPU cycles, memory, secondary storage space, I/O and network bandwidth, between users and tasks. Certain policies and mechanisms are used for resource allocation where the policies pertain to the principles guiding decisions whilst the mechanisms are the means to implement policies.

Resource Management Policies

• Admission control: To prevent system from accepting workload in violation of high-level system policies.
• Capacity allocation: Allocate resources for individual activations of a service.
• Load balancing: Distribute workload evenly among servers.
• Energy optimization: Minimization of energy consumption.
• Quality of service (QoS) guarantees: Ability to satisfy timing or other conditions specified by a SLA.

Resource Management Mechanisms

• Control theory: Uses the feedback to guarantee system stability and predict transient behavior.
• Machine learning: Does not need a performance model of the system.
• Utility-based: Require a performance model and a mechanism to correlate user-level performance with cost.
• Market-oriented/economic: Do not require a model of the system, e.g., combinatorial auctions for bundles of resources.

13.7 Service Level Agreements (SLAs) in Cloud Computing

A Service Level Agreement (SLA) is the bond for performance negotiated between the cloud services provider and the client. Earlier, in cloud computing all Service Level Agreements were negotiated between a client and the service consumer. Nowadays, with the initiation of large utility-like cloud computing providers, most Service Level Agreements are standardized until a client becomes a large consumer of cloud services. A properly drafted and well-thought SLA should:

• State business objectives to be achieved in the provision of the services.
• Describe in detail the service deliverables.
• Define performance standards the customer expects in the provision of services by the service provider.
• Provide an on-going reporting mechanism for measuring the expected performance standards.

What should be included in an SLA?

• Provide a remedial mechanism and compensation regime where performance standards are not achieved, whilst incentivizing the service provider to maintain a high level of performance.
• Provide a mechanism for review and change to the service levels over the course of the contract.
• Give the customer the right to terminate the contract where performance standards fall consistently below an acceptable level.

Elements of Good Service Level Agreement (SLA)

• **Description of the Services:** The SLA should include a detailed description of the services. Each individual service should be defined i.e. there should be a description of what the service is, where it is to be provided, to whom it is to be provided and when it is required.

• **Overall objectives:** The SLA should set out the overall objectives for the services to be provided. For example, if the purpose of having an external provider is to improve performance, save costs or provide access to skills and/or technologies which cannot be provided internally, then the SLA should say so. This will help the customer craft the service

levels in order to meet these objectives and should leave the service provider in no doubt as to what is required and why.

• **Critical Failure:** Service credits are useful in getting the service provider to improve its performance, but what happens when service performance falls well below the expected level? If the SLA only included a service credit regime then, unless the service provided was so bad as to constitute a material breach of the contract as a whole, the customer could find itself in the position of having to pay (albeit at a reduced rate) for an unsatisfactory overall performance.

• **Performance Standards:** Then, taking each individual service in turn, the customer should state the expected standards of performance. This will vary depending on the service. Using the "reporting" example referred to above, a possible service level could be 99.5%. However, this has to be considered carefully. Often a customer will want performance standards at the highest level. Whilst understandable, in practice this might prove to be impossible, unnecessary or very expensive to achieve.

• **Compensation/Service Credits:** In order for the SLA to have any "bite", failure to achieve the service levels needs to have a financial consequence for the service provider. This is most often achieved through the inclusion of a service credit regime. In essence, where the service provider fails to achieve the agreed performance standards, the service provider will pay or credit the customer an agreed amount which should act as an incentive for improved performance.

Other Provisions in SLA

Changes to Pricing: Pricing may need to vary depending on a number of factors.SLA can include a pricing review mechanism or provisions dealing with the sharing of cost savings.

Contract Management: In longer term contracts, the parties will need to keep performance of the services under review. The provisions dealing with reporting, meetings, information provision and escalation procedures for disputes. It should be noted that it is vital if contract management procedures are agreed and are actually followed.

Change Control Procedures: The control procedures include the mechanisms for agreeing and recording changes to the agreement or services to be provided. In an agreement of any length or complexity, it is inevitable that changes will be made to the services. However, the properly implemented change control procedure is vital. Also, service credits and the right to terminate are main provisions in an SLA.

Sample Service Level Agreements (SLAs)

1. Windows Azure SLA –

Window Azure has different SLA's for compute and storage. For compute, there is a guarantee that when a client deploys two or more role instances in separate fault and upgrade domains, client's internet facing roles will have external connectivity minimum 99.95% of the time. Moreover, all of the role instances of the client are monitored and there is guarantee of detection 99.9% of the time when a role instance's process is not runs and initiates properly.

2. SQL Azure SLA –

SQL Azure clients will have connectivity between the database and internet gateway of SQL Azure. SQL Azure will handle a "Monthly Availability" of 99.9% within a month. Monthly Availability Proportion for a particular tenant database is the ratio of the time the database was available to customers to the total time in a month. Time is measured in some intervals of minutes in a 30-day monthly cycle. Availability is always remunerated for a complete month. A portion of time is marked as unavailable if the customer's attempts to connect to a database are denied by the SQL Azure gateway.

13.8   Internet of Things (IoT)

The Internet of things (IoT) describes the network of physical objects—a.k.a. "things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.

The Internet of Things (IoT) describes the network of physical objects: "things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These devices range from ordinary household objects to sophisticated industrial tools. With more than 7 billion connected IoT devices today, experts are expecting this number to grow to 10 billion by 2020 and 22 billion by 2025. Oracle has a network of device partners.

In the most general terms, IoT includes any object – or "thing" – that can be connected to an Internet network, from factory equipment and cars to mobile devices and smart watches. But today, the IoT has more specifically come to mean connected things that are equipped with sensors, software, and other technologies that allow them to transmit and receive data – to and from other things. Traditionally, connectivity was achieved mainly via Wi-Fi, whereas today 5G and other types of network platforms are increasingly able to handle large datasets with speed and reliability.

The term "Internet of things" was coined by Kevin Ashton of Procter and Gamble, later MIT's Auto-ID Center, in 1999, though he prefers the phrase "Internet for things". At that point, he viewed radio-frequency identification (RFID) as essential to the Internet of things, which would allow computers to manage all individual things. The main theme of the IoT is to embed short-range mobile transceivers in various gadgets and daily necessities to enable new forms of communication between people and things, and between things themselves.

Why Is Internet of Things (IoT) Important?

Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects—kitchen appliances, cars, thermostats, baby monitors—to the internet via embedded devices, seamless communication is possible between people, processes, and things.

- Dynamic control of industry and daily life- IoT is used in our daily life to automatically make decisions and optimize power consumption. Google Home, Amazon echo, etc. are examples of some of the IoT based home automation devices where IoT and machine learning are used heavily.

- Improves the resource utilization ratio- improving resource efficiency is the lack of suitable capabilities to collect, exchange and share real-time data among various stakeholders. Having such capabilities would provide improved awareness and visibility of resource use and help make better decisions that drive overall productivity.

- Integrating human society and physical systems- Real-time mapping of human environment and physical systems.

- Internet of Things (IoT) is an ecosystem that consists of physical devices that can receive, store, process, and send digital information. Implementing these smart devices requires a variety of skills. In addition to the physical installation, connected devices must be configured and secured properly. That's why the company you choose to implement your IoT solutions must be well versed in cyber-security and the configuration of technology infrastructure.

- IoT is a global inter-connection for devices, objects, and things that contain embedded technologies to sense, communicate, and interact.

Characteristics of IoT

According to the definition of IoT, it is the way to interconnection with the help of the internet devices that can be embedded to implement the functionality in everyday objects by enabling them to send and receive data. Today data is everything and everywhere. Hence, IoT can also be defined

as the analysis of the data generate a meaning action, triggered subsequently after the interchange of data.

Intelligence

IoT comes with the combination of algorithms and computation, software & hardware that makes it smart. Ambient intelligence in IoT enhances its capabilities which facilitate the things to respond in an intelligent way to a particular situation and supports them in carrying out specific tasks. In spite of all the popularity of smart technologies, intelligence in IoT is only concerned as means of interaction between devices, while user and device interaction is achieved by standard input methods and graphical user interface.

Connectivity

Connectivity empowers Internet of Things by bringing together everyday objects. Connectivity of these objects is pivotal because simple object level interactions contribute towards collective intelligence in IoT network. It enables network accessibility and compatibility in the things. With this connectivity, new market opportunities for Internet of things can be created by the networking of smart things and applications.

Dynamic Nature

The primary activity of Internet of Things is to collect data from its environment, this is achieved with the dynamic changes that take place around the devices. The state of these devices change dynamically, example sleeping and waking up, connected and/or disconnected as well as the context of devices including temperature, location and speed. In addition to the state of the device, the number of devices also changes dynamically with a person, place and time.

Enormous Scale

The number of devices that need to be managed and that communicate with each other will be much larger than the devices connected to the current Internet. The management of data generated from these devices and their interpretation for application purposes becomes more critical. Gartner (2015) confirms the enormous scale of IoT in the estimated report where it stated that 5.5 million new things will get connected every day and 6.4 billion connected things will be in use worldwide in 2016, which is up by 30 percent from 2015. The report also forecasts that the number of connected devices will reach 20.8 billion by 2020.

Sensing

IoT wouldn't be possible without sensors which will detect or measure any changes in the environment to generate data that can report on their status or even interact with the environment. Sensing technologies provide the means to create capabilities that reflect a true awareness of the physical world and the people in it. The sensing information is simply the analogue input from the physical world, but it can provide the rich understanding of our complex world.

Heterogeneity

Heterogeneity in Internet of Things as one of the key characteristics. Devices in IoT are based on different hardware platforms and networks and can interact with other devices or service platforms through different networks. IoT architecture should support direct network connectivity between heterogeneous networks. The key design requirements for heterogeneous things and their environments in IoT are scalabilities, modularity, extensibility and interoperability.
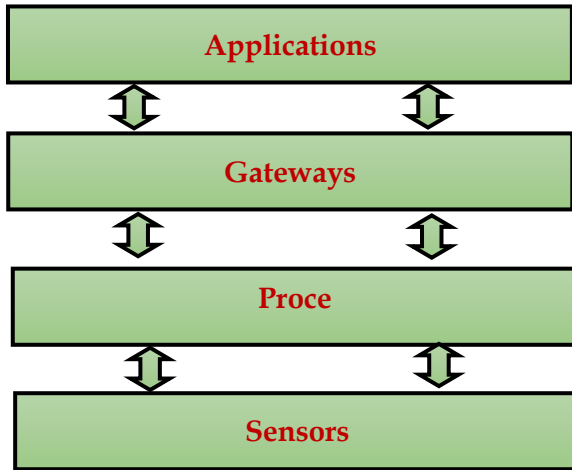
Components of IoT

Four things form basic building blocks or components of the IoT system– sensors, processors, gateways, applications(**Error! Reference source not found.** and Figure 20). Each of these nodes has to have its own characteristics in order to formulate useful IoT system. The smart systems and IoT are driven by a combination of sensors, connectivity and processes.

Sensors/Devices

Sensors are the front-end of the IoT devices and are the so-called "Things" of the IoT system. There main purpose is to collect data from its surroundings (sensors) or give out data to its surrounding (actuators). Each sensor has to be uniquely identifiable devices with a unique IP address so that they can be easily identifiable over a large network. These are active in nature which means that they should be able to collect real-time data. All of this collected data can have various degrees of

complexities ranging from a simple temperature monitoring sensor or a complex full video feed. A device can have multiple sensors that can bundle together to do more than just sense things. For example, our phone is a device that has multiple sensors such as GPS, accelerometer, camera but our phone does not simply sense things. The most rudimentary step will always remain to pick and collect data from the surrounding environment be it a standalone sensor or multiple devices.

Figure 19: Components of IoT

Connectivity

Next, that collected data is sent to a cloud infrastructure but it needs a medium for transport. The sensors can be connected to the cloud through various mediums of communication and transports such as cellular networks, satellite networks, Wi-Fi, Bluetooth, wide-area networks (WAN), low power wide area network and many more. Every option we choose has some specifications and trade-offs between power consumption, range, and bandwidth. So, choosing the best connectivity option in the IOT system is important. There can be multiple connectivity options such as:
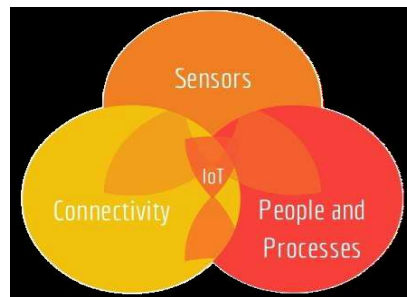
Figure 19: Building Blocks of IoT

o Applications: The applications form another end of an IoT system. They are essential for proper utilization of all the data collected. These can be any cloud-based applications which are responsible for rendering effective meaning to the data collected. The applications are controlled by users and are delivery point of particular services. Examples: Home automation apps, security systems, industrial control hub, etc.

o Gateways: Gateways are responsible for routing the processed data and send it to proper locations for its (data) proper utilization. They help in to and fro communication of the data and provide network connectivity to the data. The network connectivity is essential for any IoT system to communicate.

Processes and People

The processors formulate the brain of the IoT system with their main function of processing the data captured by the sensors and process them so as to extract the valuable data from the enormous amount of raw data collected. They give intelligence to the data and mostly work on real-time basis and can be easily controlled by the applications. Processors are also responsible for securing the data– that is performing encryption and decryption of data. Example: Embedded hardware devices, microcontroller, etc. are the ones that process the data

Once the data is collected and it gets to the cloud, the software performs processing on the acquired data. This can range from something very simple, such as checking that the temperature reading on devices such as AC or heaters is within an acceptable range. It can sometimes also be very complex, such as identifying objects (such as intruders in your house) using computer vision on video.

13.9   Applications of IoT

IoT can help the organizations in reducing cost through improved process efficiency, asset utilization and productivity. It aids in the growth and convergence of data, processes and things on the internet would make such connections more relevant and important. IoT supports creation of more opportunities for people, businesses and industries across several sectors (Figure 20).

Corporate Aspect of IoT

- IoT is a transformational force- Any physical object can be transformed into an IoT device if it can be connected to the internet to be controlled or communicate information. A lightbulb that can be switched on using a smartphone app is an IoT device, as is a motion sensor or a smart thermostat in your office or a connected streetlight.
- Companies can improve performance through IoT analytics and IoT Security to deliver better results.
- Businesses in the utilities, oil and gas, insurance, manufacturing, transportation, infrastructure and retail sectors can reap the benefits of IoT by making more informed decisions, aided by the torrent of interactional and transactional data at their disposal.
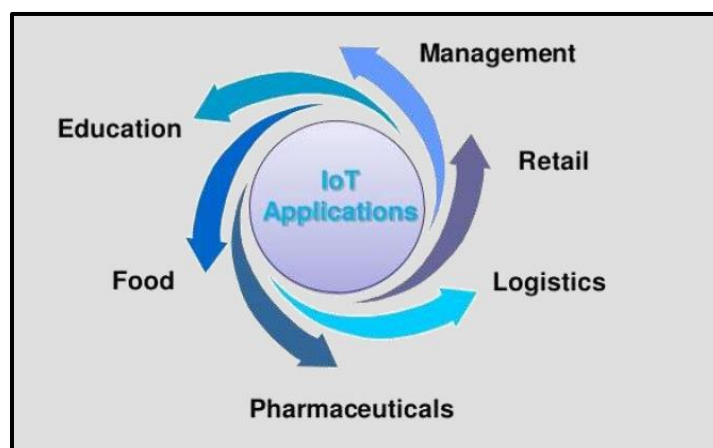

Figure 20: Different IoT Application Sectors

IoT in Food Industry

IoT is making every aspect of the food industry smarter through a combination of IoT smart connected products gathering data throughout the supply chain and intelligent algorithms, converting them into smart insights.

IoT in Education

IoT can help us make education more accessible in terms of geography, status, and ability. There are boundless opportunities to integrate IoT solutions into school environments. It serves as a solid foundation on which to build a broader understanding of IoT applications in education such as:

o Foreign Language Instruction

o Connected / Smart Classrooms

o Task-Based Learning

Other IoT Applications in Education include:

    o Special education

    o Physical education

    o School security

    o Classroom monitoring using Video-as-a-Sensor technology

    o Attendance monitoring automation

    o Student physical and mental health

    o Learning from home

    o Personalized learning

IoT in Pharmaceuticals

Pharma IoT can bring in transparency into drug production and storage environment by enabling multiple sensors to monitor in real time multiple environmental indicators, such as: temperature, humidity, light, radiation, CO_2 level.

IoT in Retail

IoT is changing numerous aspects of the retail sector—from customer experience to supply chain management. With these transformations come new challenges. It allows these devices to communicate, analyze, and share data regarding the physical surrounding world via cloud-based software platforms and other networks. Retail sector has had a complete makeover over the last decade driven by technologies such as Machine learning, Artificial Intelligence, and IoT. The major benefits of IoT in retail sector include:

o **Enhanced Supply Chain Management-** IoT solutions like RFID tags & GPS sensors can be used by retailers to get a comprehensive picture regarding movement of goods from manufacturing to when its placed in a store to when a customer buys it.

o **Better Customer Service-** IoT also helps brick and mortar retailers by generating insights into customer data while opening opportunities for leveraging that data. For example, retailer IoT applications can synthesize data from video surveillance cameras, mobile devices, & social media websites, allowing merchants better to predict customer behaviour.

o **Smarter Inventory Management** helps in automating inventory visibility otherwise inventory management can be a headache.

o Lack of accurate tracking for inventory can lead to stock-outs and overstock, costing retailers around the world billion annually.

o Smart inventory management solutions based on store shelf sensors, RFID tags, beacons, video monitoring, & digital price tags, retail businesses can enhance procurement planning.

o When product inventory is low, the system offers to re-order adequate amount based on the analytics acquired from IoT data.

IoT in Logistics

Transport and logistics isone of the first business sectors interested in IoT technologies. There are currently two systems that are already available and deployed: ConLock and Container Safe. There has been integration of light sensors, GPS and GSM. In IoT, there are things that could be an automobile with built-in sensors, that is, objects that have been assigned an IP address or a person with a heart monitor.

Other Applications Using IoT

There are several applications that are making use of IoT capabilities such as:

• **Google Traffic**

Figure 21: Jawbone UP

- **Jawbone UP:** One can link itto an iPhone application. It is not just a passive bracelet but is highly recommended to change life-style (Figure 22).
- **AutoBot:** These offer diagnostics service for cars and generate alerts relatives in case of an accident. Autobots can be used for discovery service of car position and can be easily integrated with several web services.
- **Daily Life and Domotics:** A framework has been developed for Home Automation applications: Freedom.

IoT in Construction

IoT devices are impacting the construction industry in numerous ways. The five major benefits of IoT in construction sector are listed below.

1. IoT pushes the performance of construction tools and machines.
- Heavy machine work is a common picture in the construction industry.
- Ensuring defect-free performance in such areas has been a challenge for the project managers.
- IoT sensors are involving less human involvement but allowing the machines to perform with more accuracy.

2. IoT devices ensure optimum safety measures
- Construction companies are supposed to ensure the health safety of their workforces.
- IoT, along with artificial intelligence, is likely to improve the safety parameters in the construction sector.

3. IoT devices introduce real-time insights
- Site monitoring, which is an essential part of the construction industry, is classified into two aspects, mainly for tracking of humans and machines.
- IoT helps the construction sector managers by enabling them the benefit of getting real-time insights on employee and machines.

4. IoT devices facilitate cost-cutting
- Ensuring the completion of a project within the defined budget is a challenge for a construction manager.
- IoT introduces site monitoring techniques that help the managers by keeping the projects budget-friendly.

5. IoT fleet management solutions help fleet managers
- New age construction companies use IoT in monitoring vehicles and optimizing transit routes.
- The fleet management solutions introduced by IoT help the fleet managers in dealing with unexpected weather conditions and bad road conditions.

Impact of IoT on Society

IoT has revolutionized the living and brought major changes across not just the technological sector but also the common masses. It is important to explore its impact of the society as a whole.

Positive Impact of IoT on Society

IoT has brought many benefits to us all, and has become an indispensable tool used by millions of people on a daily basis including the following:

Smart Power Grid

- IoT is helping us when we will exhaust the supply of fossil fuels.
- At some point, society will transition to renewable energy be it solar, wind, hydro, or ocean currents.
- All these sources are variable, unpredictable, and geographically distributed, meaning information exchange to match supply with demand is crucial to making them financially viable.

e-Learning

- To offset the replacement of low-skilled jobs by connected machines, humans need to move up the knowledge ladder to prepare for future where robots do most of the manual labor.
- IoT is a perfect vehicle for delivering education & training to millions of people in remote locations.

Building automation

- Similar to the smart grid, intelligent buildings that optimize energy usage, protect people from fire, and intrusion, etc., is a very positive application of the IoT.

Healthcare

- Sector where IoT is already making a very useful contribution to society.
- With populations aging around the world, ability to monitor & protect people in their homes lowers costs & increases quality of life.

Negative Impact of IoT on Society

With regards to the IoT, we are entering a critical period where major and disruptive changes in society are visible. One only has to look back at the development of the "Internet of People" to see how radically and rapidly it has changed society, access to information, and disrupted business models.

Outsourcing

- Many industries have been decimated through replacement by out-sourced online services.
- Travel agencies, print media, postal service, the music and movie business, broadcast TV, ITservices, call centers, and bank tellers are all services that have been severely impacted by the Internet.
- Many will disappear entirely.

Telecommunications

- Hasbecome commodity service which is virtually free.
- Anyone or anything with Internet connection can now communicate with each other.
- With high-bandwidth 5G revolution, however, low-cost ubiquitous video streaming may very well lead to a surveillance state where all our actions are monitored and recorded in the name of security.

Virtually free access to information and online media

- Radically changed publishing business, exponentially increasing quantity of information while often diluting the quality.
- As subscription models fail, more and more online media and news sources have turned to advertising to fund their operations, effectively turning free press into bazaar where broadcast content is sold to highest bidder.

Information Accuracy is difficult to Predict

- Although access to terabytes of information is now easily accessed from anywhere, what information is correct is becoming harder to assess.

Factory Automation

- As connected machines are becoming smarter and smarter, there may soon be no manufacturing or agricultural process left that requires a human hand.
- Result will be millions of people out of work.
- Jobs that were originally outsourced from rich countries to developing countries, decimating the middle class, would then be eliminated altogether. From a profit standpoint, this is a good thing. From a societal standpoint, it could be devastating.

Driverless Vehicles

- Rapidly developing technology promises a long list of be nets, including lower costs and increased safety and security.
- For every driverless truck, taxi, tram, or train there is one human being who is no longer required.

Loss of Privacy

- Hand-in-hand with the IoT is the growing trend of storing data in the "cloud."
- Everything from our family photos to personal financial information exists "somewhere" on remote servers.

Summary

- In an era of technological advancements, world that sees new technological trends blossoming and fading from time to time, but one new trend still promises more longevityand permanence. This trend is called cloud computing.
- Cloud computing signifies a major change in the way we run various applications andstore our information. Everything is hosted in the "cloud", a vague assemblage ofcomputers and servers accessed via the Internet, instead of the method of running programsand data on a single desktop computer.
- With cloud computing, the software programs you use are stored on servers accessed via the Internet and are not run from your personal computer. Hence, even if your computer stops working, the software is still available for use.
- The "cloud" itself is the key to the definition of cloud computing. The cloud is usually defined as a large group of interconnected computers. These computers include network servers or personal computers.
- Cloud computing has its ancestors both as client/server computing and peer-to-peerdistributed computing. It is all about how centralized storage of data and content facilitatescollaborations, associations and partnerships.
- With cloud storage, datais stored on multiple third-party servers, rather than on the dedicated servers used intraditional networked data storage.
- A Service Level Agreement (SLA) is the bond for performance negotiated between the cloud services provider and the client.
- The non-relational database is sometimes also called as NoSQL as it does not employ a table model.
- The Internet of Things (IoT) describes the network of physical objects: "things" — that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.
- Sensors are the front-end of the IoT devices and are the so-called "Things" of the IoT system. There main purpose is to collect data from its surroundings (sensors) or give out data to its surrounding (actuators).
- The processors formulate the brain of the IoT system with their main function of processing the data captured by the sensors and process them so as to extract the valuable data from the enormous amount of raw data collected.

Keywords

Cloud: The cloud is usually defined as a large group of interconnected computers. These computers include network servers or personal computers.

Distributed Computing: Distributed computing is any computing that involves multiple computers remote from each other that each have a role in a computation problem or information processing.

Group collaboration software: It provides tools for groups of people or organizations to share information and coordinate activities.

Local database: A local database is one in which all the data is stored on an individual computer.

Peer-to-Peer (P2P) computing: Peer-to-peer computing or networking is a distributed application architecture that partitions tasks or workloads between peers. Peers are equally privileged, equipotent participants in the application.

Platform as a Service: Also known as PaaS is a proven model for running applications without the hassle of maintaining the hardware and software infrastructure at your company.

Relational cloud database: The relational database is written in Structured Query Language (SQL) and is a set of interrelated tables organized into rows and columns.

Internet of things (IoT): Internet of things (IoT) describes the network of physical objects—a.k.a. "things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.

Sensors: A sensor is a device, module, machine, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. A sensor is always used with other electronics.

Self Assessment

1. _____ clients are regular computers, using a web browser like Firefox or Internet Explorer to connect to the cloud.

    (a) Thin

    (b) Thick

    (c) Modular

    (d) Hybrid

2. _____ servers are facilitating cloud services being located at geographically disparate locations

    (a) Dispersion

    (b) Facilitation

    (c) Geographical

    (d) Distributed

3. _____ allows the multiple users to make use of the same shared resources.
    (a) Outsourcing
    (b) Aliasing
    (c) Sharing
    (d) Multitenancy

4. In IoT, _____ acts as primary devices to collect data from the environment.
    (a) Sensors
    (b) RFIDs
    (c) Tracers
    (d) Mensors

5. SOA stands for
    (a) Service Oriented Architecture
    (b) Service Operation Architecture
    (c) Server Operations Aids
    (d) Server Oriented Applications

6. The other name for Virtual Machine Manager (VMM) is

    (a) Abstraction manager

    (b) Hypervisor

    (c) Operation manager

(d) VM manager

7. The full form of SLA is

(a) Service Level Applications

(b) Server Location Application

(c) Software Level Application

(d) Service Level Agreements

8. Which of the following is the responsibility of gateways in IoT?

(a) Helps in to and fro communication of the data

(b) Provides network connectivity to the data

(c) Network connectivity is essential for any IoT system to communicate

(d) All of the above

9. The Private cloud is a ....

(a) standard cloud service offered via the Internet

(b) a cloud service inaccessible to anyone but the cultural elite

(c) cloud architecture maintained within an enterprise data center.

(d) None of the above

10. Which of the following is a type of Service Models?

(a) Community-as-a-Service

(b) Public-as-a-Service

(c) Platform-as-a-Service

(d) Private -as-a-Service

11. How many cloud service models are available?

(a) 3

(b) 4

(c) 6

(d) 7

12. "Cloud" in cloud computing represents?

(a) Hard drives

(b) Floppy Disk

(c) External drive

(d) Internet

13. _____ decides how to allocate resources of a system, such as CPU cycles, memory,secondary storage space, I/O and network bandwidth, between users and tasks.

(a) Resource Utilization

(b) Resource Scheduling

(c) Resource Bandwidth

(d) Resource Latency

14. Which of the following offer online editing and storage service using cloud capabilities?

(a) Google Drive

(b) Zoho

(c) Zoom

(d) None of the above

15. NoSQL databases are also called as

(a) Relational Databases

(b) Sequel Databases

(c) Non-relational Databases

(d) Table Databases

16. In _____ communication, the devices are called "connected" or "smart" devices, if they can talk to other related devices.

(a) machine-to-device (M2D)

(b) device-to-machine (D2M)

(c) machine-to-machine (M2M)

(d) network-to-network (N2N)

17. Internet-of-Things is also called as

(a) Internet of Everything (IoE)

(b) Machine-to-Machine (M2M)

(c) Skynet

(d) All of the above

18. Which of the following is the building block for IoT?

(a) Bridges

(b) Routers

(c) Sensors

(d) Protocols

Answers for Self Assessment

1.	B	2.	B	3.	D	4.	A	5.	A
6.	B	7.	D	8.	D	9.	C	10.	C
11.	A	12.	D	13.	B	14.	A	15.	C
16.	C	17.	D	18.	C					

Review Questions

1. Explain different models for deployment in cloud computing?
2. Explain the difference between cloud and traditional storage?
3. What are different virtualization techniques?
4. What are SLAs? What are the elements of good SLA?
5. What is resource management in cloud computing?
6. Differentiate Relational and Non-relation cloud database?
7. How cloud storage works? What are different examples of cloud storage currently?
8. Explain the concept of virtualization?
9. Differentiate thin clients and thick clients?
10. What is cloud computing? Discuss its components?
11. What does Internet-of-Things (IoT) means?
12. What are the building blocks of IoT?
13. What is IoT? Discuss its characteristics

14. Indicate the different applications of IoT in various sectors?

📖 Further Readings

Cloud Computing: Concepts, Technology and Architecture by Erl, Pearson Education.

Cloud Computing Black Book by Kailash Jayaswal,Jagannath Kallakurchi, Donald J. Houde, Deven Shah, Kogent Learning Solutions, DreamTech Press.

Internet of Things by Raj Kamal, McGraw-Hill Education

Cloud Computing Overview - Tutorialspoint

Cloud Computing (w3schools.in)

What Is the Internet of Things (IoT)? (oracle.com)

Dr. Tarandeep Kaur, Lovely Professional University

Unit 14: Futuristic World of Data Analytics

Objectives

After this lecture, you will be able to

- Learn about Big Data and its characteristics
- Understand the different V's of Big Data
- Discuss Big Data Analytics and its role
- Explore different Data Analysis Techniques, data management tools and techniques
- Know about statistics and basic terminology associated with it
- Understand Statistical learning

Introduction

Big data is a field that treats ways to analyse, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software. Data with many fields (columns) offer greater statistical power, while data with higher complexity (more attributes or columns) may lead to a higher false discovery rate.Big data analysis challenges include capturing data, data storage, data analysis, search, sharing, transfer, visualization, querying, updating, information privacy, and data source. The analysis of big data presents challenges in sampling, and thus previously allowing for only observations and sampling. Therefore, big data often includes data with sizes that exceed the capacity of traditional software to process within an acceptable time and value.

Big data usually includes data sets with sizes beyond the ability of commonly used software tools to capture, curate, manage, and process data within a tolerable elapsed time. Big data philosophy encompasses unstructured, semi-structured and structured data, however the main focus is on unstructured data. Big data "size" is a constantly moving target; as of 2012 ranging from a few dozen terabytes to many zettabytes of data. Big data requires a set of techniques and technologies with new forms of integration to reveal insights from data-sets that are diverse, complex, and of a massive scale.

Big Data is a collection of data that is huge in volume, yet growing exponentially with time. It is a data with so large size and complexity that none of traditional data management tools can store it or process it efficiently. Big data is also a data but with huge size.

Big data manages the ccollections of data sets so large and complex that it becomes difficult to process using on-hand database management tools or traditional data processing applications. Data whose scale, diversity, and complexity require new architecture, techniques, algorithms, and analytics to manage it and extract value and hidden knowledge from it. There can be several correlations within data such as spotting business trends, determining quality of research, preventing diseases, linking legal citations, combating crime, and determining real-time roadway traffic conditions.

Big data forms an important aspect of data science. Data science is the study of data analyzing by advance technology (Machine Learning, Artificial Intelligence, Big data). It processes a huge amount of structured, semi-structured, unstructured data to extract insight meaning, from which one pattern can be designed that will be useful to take a decision for grabbing the new business opportunity, the betterment of product/service, ultimately business growth.Data science process to make sense of Big data/huge amount of data that is used in business. The workflow of Data science is as below:

Facts and Figures Pertaining to Big Data

Big data is becoming extensively important owing to the large amounts of data generated. Walmart handles 1 million customer transactions/hour. Facebook handles 40 billion photos from its user base and inserts 500 terabytes of new data every day. Facebook stores, accesses, and analyses 30+ petabytes of generated data. Even a flight generates 240 terabytes of flight data in 6-8 hours of flight. Not only this, more than 5 billion people are calling, texting, tweeting & browsing on mobile phones worldwide. The decoding of human genome originally took 10 years to process; now it can be achieved in one week. The largest AT&T database boasts titles including largest volume of data in one unique database (312 terabytes) and the second largest number of rows in a unique database (1.9 trillion), which comprises AT&T's extensive calling records.
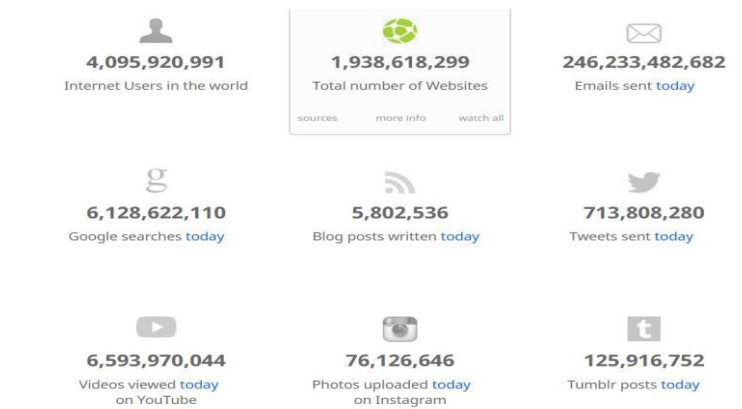
From Where Does So Much Data Come Up

There are several sources of big data such as people, machine, organization, ubiquitous computing. Currently, there are morepeople carrying data-generating devices (such as mobile phones running Facebook, GPS, Cameras etc.).

Traditional Database Methods vs Big Data

There are certain drawbacks associated with traditional RDBMS in processing the big data. The traditional RDBMS queries aren't sufficient to get useful information out of the huge volumes of data. The traditional tools are used to search it. However, in order to find out if a particular topic was trending would take so long that the result would be meaningless by the time it was computed.Big data offers solution to store this data in novel ways in order to make it more

accessible, and also to come up with the methods of performing analysis on it. It involves capturing, storing, searching, sharing, analyzing and visualization of data. The traditional model pertains to data processing where few companies are generating data, all others are consuming data (Figure 1) whilst the novel data model involves all are generating as well as consuming data (Figure 2).

Figure 1: Traditional Model

Figure 2: Novel Model

14.1 History of Big Data

Although the concept of big data itself is relatively new, the origins of large data sets go back to the 1960s and '70s when the world of data was just getting started with the first data centers and the development of the relational database.

Around 2005, people began to realize just how much data users generated through Facebook, YouTube, and other online services. Hadoop (an open-source framework created specifically to store and analyze big data sets) was developed that same year. NoSQL also began to gain popularity during this time.

The development of open-source frameworks, such as Hadoop (and more recently, Spark) was essential for the growth of big data because they make big data easier to work with and cheaper to store. In the years since then, the volume of big data has skyrocketed. Users are still generating huge amounts of data—but it's not just humans who are doing it.

With the advent of the Internet of Things (IoT), more objects and devices are connected to the internet, gathering data on customer usage patterns and product performance. The emergence of machine learning has produced still more data.

While big data has come far, its usefulness is only just beginning. Cloud computing has expanded big data possibilities even further. The cloud offers truly elastic scalability, where developers can simply spin up ad hoc clusters to test a subset of data. And graph databases are becoming increasingly important as well, with their ability to display massive amounts of data in a way that makes analytics fast and comprehensive.

Benefits of Big Data Processing

The ability to process big data brings in multiple benefits, such as-

- Businesses can utilize outside intelligence while taking decisions
- Access to social data from search engines and sites like Facebook, Twitter etc. are enabling organizations to fine tune their business strategies.
- Improved customer service

- Traditional customer feedback systems are getting replaced by new systems designed with Big Data technologies. In these new systems, Big Data and natural language processing technologies are being used to read and evaluate consumer responses.
- Early identification of risk to the product/services, if any
- Better operational efficiency

Big data technologies can be used for creating a staging area or landing zone for new data before identifying what data should be moved to the data warehouse. In addition, such integration of Big Data technologies and data warehouse helps an organization to offload infrequently accessed data.
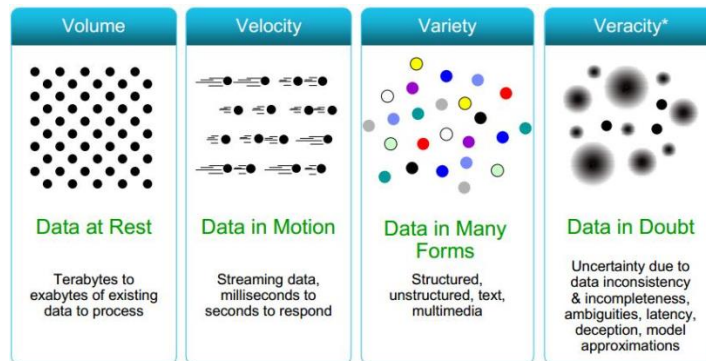
14.2 Characteristics of Big Data

Figure 3: Big Data Characteristics

Big data can be described by the following characteristics (Figure 3):

- **Volume–** The name big data itself is related to a size which is enormous. Size of data plays a very crucial role in determining value out of data. Also, whether a particular data can actually be considered as a Big Data or not, is dependent upon the volume of data. Hence, 'volume' is one characteristic which needs to be considered while dealing with big data.

  The amount of data matters. With big data, you'll have to process high volumes of low-density, unstructured data. This can be data of unknown value, such as Twitter data feeds, clickstreams on a web page or a mobile app, or sensor-enabled equipment. For some organizations, this might be tens of terabytes of data. For others, it may be hundreds of petabytes.

- **Variety–** The next aspect of big data is its variety.Variety refers to heterogeneous sources and the nature of data, both structured and unstructured. During earlier days, spreadsheets and databases were the only sources of data considered by most of the applications. Nowadays, data in the form of emails, photos, videos, monitoring devices, PDFs, audio, etc. are also being considered in the analysis applications. This variety of unstructured data poses certain issues for storage, mining and analyzing data.

  Big data can handle any type of data– Structured data (example: tabular data); Unstructured data: Text, sensor data, audio, video; Semi-Structured: Web data, log files.

- **Velocity–** The term 'velocity' refers to the speed of generation of data. How fast the data is generated and processed to meet the demands, determines real potential in the data.Big data velocity deals with the speed at which data flows in from sources like business processes, application logs, networks, and social media sites, sensors, Mobile devices, etc. The flow of data is massive and continuous.

  Sometimes 2 minutes is too late. For time-sensitive processes such as catching fraud, big data must be used as it streams into an enterprise in order to maximize its value. It scrutinizes 5 million trade events created each day to identify potential fraud. It analyzes 500 million daily call detail records in real- time to predict customer churn faster. Data is begin generated fast and

needs to be processed fast. Velocity plays an important role in Online Data Analytics such as e-promotions that are based on user's current location and purchase history, what you like will send promotions right now for store next to you; healthcare monitoring where the sensors monitoring your activities and body measuring any abnormal measurements require immediate reaction.

- **Variability–** This refers to the inconsistencywhich can be shown by the data at times, thus hampering the process of being able to handle and manage the data effectively.
- **Value-** This attribute pertains to the integration of data while reducing data complexity; increasing data availability. It helps to unify the data systems.
- **Veracity:**Refers to the biases,noise & abnormality in data, trustworthiness of data.1 in 3 business leaders don't trust the information they use to make decisions.How can you act upon information if you don't trust it?Establishing trust in big data presents a huge challenge as the variety and number of sources grows.
- **Valence:** This refers to the connectedness of big data such as in graph networks.
- **Validity:** It pertains to the accuracy and correctness of the data relative to a particular use. Example: Gauging storm intensity.
- **Viscosity and Volatility:** Both are related to the velocity. Viscosity pertains to the data velocity relative to timescale of event being studied. Volatility refers to the rate of data loss and stable lifetime of data. The scientific data often has practically unlimited lifespan, but social / business data may evaporate in finite time.
-
- **Visualization:** Another characteristic of big data is how challenging it is to visualize. The current big data visualization tools face technical challenges due to limitations of in-memory technology and poor scalability, functionality, and response time. You can't rely on traditional graphs when trying to plot a billion data points, so you need different ways of representing data such as data clustering or using tree maps, sunbursts, parallel coordinates, circular network diagrams, or cone trees.

Figure 4: Additional V's in Big Data

- **Viability:** Which data has meaningful relations to the questions of interest?
- **Venue:** Where does the data live and how do you get it?Various types of data arrived from different sources via different platforms like personnel system and private & public cloud
- **Vocabulary:**This pertains to the metadata describing structure, content, and provenance. It includes schemas, semantics, ontologies, taxonomies, vocabularies.
- **Vagueness:**Vagueness concern the reality in information that suggested little or no thought about what each might convey.

14.3   Types of Big Data

Following are the different types of big data:

1. Structured
2. Unstructured
3. Semi-structured

Structured Data: Any data that can be stored, accessed and processed in the form of fixed format is termed as a 'structured' data. Over the period of time, talent in computer science has achieved greater success in developing techniques for working with such kind of data (where the format is well known in advance) and also deriving value out of it. However, nowadays, we are foreseeing issues when a size of such data grows to a huge extent, typical sizes are being in the rage of multiple zettabytes.

Unstructured Data: Any data with unknown form or the structure is classified as unstructured data. In addition to the size being huge, un-structured data poses multiple challenges in terms of its processing for deriving value out of it. A typical example of unstructured data is a heterogeneous data source containing a combination of simple text files, images, videos etc. Now day organizations have wealth of data available with them but unfortunately, they don't know how to derive value out of it since this data is in its raw form or unstructured format. The example of Un-structured data is the output returned by 'Google Search'.

Semi-structured Data: Semi-structured data can contain both the forms of data. We can see semi-structured data as a structured in form but it is actually not defined with e.g. a table definition in relational DBMS. Example of semi-structured data is a data represented in an XML file.

14.4   How Big Data Works

Big data gives you new insights that open up new opportunities and business models. Getting started involves three key actions:

Integrate: Big data brings together data from many disparate sources and applications. Traditional data integration mechanisms, such as extract, transform, and load (ETL) generally aren't up to the task. It requires new strategies and technologies to analyze big data sets at terabyte, or even petabyte, scale. During integration, you need to bring in the data, process it, and make sure it's formatted and available in a form that your business analysts can get started with.

Manage: Big data requires storage. Your storage solution can be in the cloud, on premises, or both. You can store your data in any form you want and bring your desired processing requirements and necessary process engines to those data sets on an on-demand basis. Many people choose their storage solution according to where their data is currently residing. The cloud is gradually gaining popularity because it supports your current compute requirements and enables you to spin up resources as needed.

Analyze: Your investment in big data pays off when you analyze and act on your data. Get new clarity with a visual analysis of your varied data sets. Explore the data further to make new discoveries. Share your findings with others. Build data models with machine learning and artificial intelligence. Put your data to work.

A step-by-step and detailed description for the same is:

- Stage 1: Business case evaluation- Big Data analytics lifecycle begins with business case, which defines reason & goal behind the analysis.

- Stage 2: Identification of data- Here, the broad variety of data sources is identified.

- Stage 3: Data filtering- All of the identified data from the previous stage is filtered here to remove corrupt data.

- Stage 4: Data extraction- Data that is not compatible with the tool is extracted & then transformed into a compatible form.

- Stage 5: Data aggregation- In this stage, data with the same fields across different datasets is integrated.

- Stage 6: Data analysis- Data is evaluated using analytical and statistical tools to discover useful information.

- Stage 7: Visualization of data- With tools like Tableau, Power BI, & QlikView, Big Data analysts can produce graphic visualizations of the analysis.

- Stage 8: Final analysis result- Last step of Big Data analytics lifecycle, where the final results of analysis are made available to business stakeholders who will take action.

14.5   Big Data Analytics

The global big data market revenues for software and services are expected to increase from $42 billion to $103 billion by year 2027.Every day, 2.5 quintillion bytes of data are created, and it's only in the last two years that 90% of the world's data has been generated.In fact, if we predict correctly, there's likely much more to come.World is driven by data, and it's being analyzed every second, whether it's through a phone's Google Maps, Netflix browsing habits, or someone's reserved items in online shopping cart.Data is unavoidable and disrupting almost every known market. The business world looks to data for market insights and ultimately, to generate growth and revenue.Data is becoming a game changer within the business arena, it's important to note that data is also being utilized by small businesses, corporate and creative alike. Big data analytics is expanding in such scenarios.

Big data analytics is the use of advanced analytic techniques against very large, diverse data sets that include structured, semi-structured and unstructured data, from different sources, and in different sizes from terabytes to zettabytes.

The analysis of big data allows the analysts, researchers and business users to make better and faster decisions using data that was previously inaccessible or unusable. Businesses can use advanced analytics techniques such as text analytics, machine learning, predictive analytics, data mining, statistics and natural language processing to gain new insights from previously untapped data sources independently or together with an existing enterprise data.

Where Role of Big Data Analytics Comes into Play

The volume of data that one has to deal has exploded to unimaginable levels in the past decade, and at the same time, price of data storage has systematically reduced. Private companies and research institutions capture terabytes of data about their users' interactions, business, social media, and also sensors from devices such as mobile phones and automobiles. This is where big data analytics comes into picture.

Data analytics is the process of examining data sets (within the form of text, audio and video), & drawing conclusions about the information they contain, more commonly through specific systems, software, and methods. It is the process of converting large amounts of unstructured raw data, retrieved from different sources to a data product useful for organizations. Several data analytics technologies are used on an industrial scale, across commercial business industries, as they enable organizations to make calculated, informed business decisions.Globally, enterprises are harnessing the power of various different data analysis techniques & using it to reshape their business models.As technology develops, new analysis software emerges, and as the Internet of Things (IoT) grows, the amount of data increases. Big data has evolved as a product of our increasing expansion and connection, and with it, new forms of extracting, or rather "mining", data.

| Business Problem Definition |
| Research |
| Human Resources Assessment |
| Data Acquisition |
| Data Munging |
| Data Storage |
| Exploratory Data Analysis |
| Data Preparation for Modeling and Assessment |
| Modeling |
| Implementation |

Figure 4: Big Data Analytics Cycle

Big Data Analytics largely involves collecting data from different sources, munge it in a way that it becomes available to be consumed by analysts and finally deliver data products useful to the organization business. The global survey from McKinsey revealed that when organizations use data, it benefits the customer and the business by generating new data-driven services, developing new business models and strategies, and selling data-based products and utilities. The incentive for investing and implementing data analysis tools and techniques is huge, and businesses will need to adapt, innovate, and strategize for evolving digital marketplace.

Big Data Analytics Cycle

It consists of following phases and their key features:

1. Business Problem Definition
This phase is the common point in traditional Business Intelligence (BI)and big data analytics life cycle. A non-trivial stage of a big data project to define the problem & evaluate correctly how much potential gain it may have for an organization. It evaluates what are expected gains and costs of the project.

2. Research
This phase analyzes what other companies have done in the same situation. It involves looking for solutions that are reasonable for your company, even though it involves adapting other solutions to resources and requirements that your company has. In this stage, a methodology for the future stages should be defined.

3. Human Resources Assessment
Once the problem is defined, it's reasonable to continue analyzing if the current staff is able to complete the project successfully. Traditional BI teams might not be capable to deliver an optimal solution to all the stages, so it should be considered before starting the project if there is a need to outsource a part of the project or hire more people.

4. Data Acquisition
Data acquisition is a key stage in big data cycle and defines which type of profiles would be needed to deliver resultant data product. Data gathering is a non-trivial step of the process; it normally involves gathering unstructured data from different sources.Example: Writing a crawler to retrieve reviews from a website. It involves dealing with text, perhaps in different languages normally requiring a significant amount of time to be completed.

5. Data Munging

Once the data is retrieved, say, from the web, it needs to be stored in an easy-to-use format.Example: Let's assume data is retrieved from different sites where each has a different display of the data.Suppose one data source gives reviews in terms of rating in stars, therefore it is possible to read this as a mapping for the response variable y ∈ {1, 2, 3, 4, 5}. Another data source gives reviews using two arrows system, one for up voting and the other for down voting. This would imply a response variable of the form y ∈ {positive, negative}.In order to combine both the data sources, a decision has to be made in order to make these two response representations equivalent. This can involve converting first data source response representation to the second form, considering one star as negative and five stars as positive. This process often requires a large time allocation to be delivered with good quality.

6. Data Storage

Once the data is processed, it sometimes needs to be stored in a database. Big data technologies offer plenty of alternatives such as using Hadoop File System for storage that provides users a limited version of SQL, known as HIVE Query Language. From the user perspective, data analytics allows most analytics task to be done in similar ways as in traditional BI data warehouses. The other storage options can be MongoDB, Redis, and SPARK. The modified versions of traditional data warehouses are still being used in large scale applications. Example: Teradata and IBM offer SQL databases that can handle terabytes of data; open source solutions such as postgreSQLand MySQL are still being used for large scale applications.It is important to implement a big data solution that would be working with real-time data, so in this case, we only need to gather data to develop the model & then implement it in real time. So, there would not be a need to formally store the data at all.

7. Exploratory Data Analysis

Once the data has been cleaned and stored in a way that insights can be retrieved from it, the data exploration phase is mandatory. The objective of this stage is to understand the data, this is normally done with statistical techniques and also plotting the data. It is a good stage to evaluate whether the problem definition makes sense or is feasible.

8. Data Preparation for Modeling and Assessment

Data preparation stage involves reshaping the cleaned data retrieved previously and using statistical pre-processing for missing values imputation, outlier detection, normalization, feature extraction and feature selection.

9. Modelling

The prior stage in analytics cycle produces several datasets for training and testing, example, a predictive model. It involves trying different models and looking forward to solving the business problem at hand. The expectation is the model would give some insight into business. Finally, best model or combination of models is selected evaluating its performance on a left-out dataset.

10. Implementation

In this stage, the data product developed is implemented in the data pipeline of the company. It involves setting up a validation scheme while data product is working, in order to track its performance.Example: Implementing a predictive model. It involves applying the model to new data and once the response is available, evaluate the model.

Big Data Analysis Techniques

Big data is characterized by 3 V's: major volume of data, the velocity at which it's processed, and the wide variety of data.Velocity pertains that data analytics has expanded into technological fields of machine learning and AI.Alongside evolving computer-based analysis techniques & data harnesses, analysis also relies on the traditional statistical methods.Ultimately, how data analysis techniques function within an organization is twofold; big data analysis is processed through streaming of data as it emerges, and then performing batch analyses of data as it builds– to look for

behavioral patterns and trends.As generation of data increases, so various techniques managing it. As data becomes more insightful in its speed, scale, and depth, more it fuels innovation. There are 6 big data analysis techniques:

1. A/B Testing

- Involves comparing a control group with a variety of test groups, in order to discern what treatments or changes will improve a given objective variable.
- McKinsey gives example of analysing what copy, text, images, or layout will improve conversion rates on an e-commerce site.
- Big data once again fits into this model as it can test huge numbers; however, it can only be achieved if the groups are of a big enough size to gain meaningful differences.

2. Data Fusion and Data Integration

By combining a set of techniques that analyze and integrate data from multiple sources and solutions, the insights are more efficient and potentially more accurate than if developed through a single source of data.

3. Data Mining

Data mining is a common tool used within big data analytics.Data mining extracts patterns from large data sets by combining methods from statistics & machine learning, within databasemanagement. Example: When customer data is mined to determine which segments are most likely to react to an offer.

4. Machine Learning

Machine learning is a well-known within the field of artificial intelligence and is also used for data analysis. Emerging from computer science, it works with computer algorithms to produce assumptions based on data. It provides predictions that would be impossible for human analysts.

5. Natural Language Processing (NLP)

NLP is known as a subspecialty of computer science, artificial intelligence, and linguistics, this data analysis tool uses algorithms to analyze human (natural) language.

6. Statistics

This technique works to collect, organize, and interpret data, within surveys and experiments.

Other data analysis techniques include spatial analysis, predictive modelling, association rule learning, network analysis and many, many more.

Big Data Analytics- Data Analysis Tools

R Programming Language: R is an open source programming language with a focus on statistical analysis. It is competitive with commercial tools such as SAS, SPSS in terms of statistical capabilities and is thought to be an interface to other programming languages such as C, C++ or Fortran.Another advantage of R is the large number of open source libraries that are available.In CRAN, there are more than 6000 packages that can be downloaded for free and in Github there are wide variety of R packages available.

Python for Data Analysis: Python is a general-purpose programming language. It contains significant number of libraries devoted to data analysis (pandas, scikit-learn, theano, numpy and scipy).Python can be used quite effectively to clean and process the data line by line. For machine learning, scikit-learn is a nice environment that has large number of algorithms that can handle medium-sized datasets without a problem.

Julia: It is ahigh-level, high-performance dynamic programming language for technical computing. The syntax is quite similar to R or Python, so if you are already working with R or Python it should be quite simple to write the same code in Julia.

SAS: It is a commercial language that is still being used for business intelligence. It has a base language that allows the user to program a wide variety of applications and contains quite a few commercial products that give non-experts users the ability to use complex tools such as a neural network library without the need of programming.

SPSS: SPSS, is currently a product of IBM for statistical analysis and is used to analyze survey data and for users that are not able to program, it is a decent alternative. It provides a SQL code to score a model. This code is normally not efficient, but it's a start whereas SAS sells the product that scores models for each database separately. For small data and an unexperienced team, SPSS is an option as good as SAS is.

Matlab, Octave: Matlab or its open source version (Octave) are mostly used for research.R or Python can do all that's available in Matlab or Octave.

14.6   Statistics

Statistics is the science of collecting, describing, and interpreting data. It enables using the information in the sample to draw a conclusion about the population. There are prominently 2 areas of statistics:

- **Descriptive Statistics:**Concerned with the collection, presentation, and description of sample data.

- **Inferential Statistics:**Concerned with making decisions and drawing conclusions about the populations.Example:A handful of 10 M&M's is selected from a jar containing 1000 candy pieces.Three M&M's in the handful are red. Here the statistics question lies: What is the proportion of red M&M's in the entire jar?

Basic Terms in Statistics

- Population: Collection, or set, of individuals or objects or events whose properties are to be analyzed. There are two kinds of populations: finite or infinite.
- Sample: Subset of the population.
- Variable: Characteristic about each individual element of a population or sample.
- Experiment: Planned activity whose results yield a set of data.
- Data (singular): Value of the variable associated with one element of a population or sample. It may be a number, a word, or a symbol.
- Data (plural): Set of values collected for the variable from each of the elements belonging to the sample.
- Parameter: Numerical value summarizing all the data of an entire population.
- Statistic: Numerical value summarizing the sample data.

Example in Statistics: A college dean is interested in learning about the average age of faculty. In this case:

- Population is the age of all faculty members at the college.
- Sample is any subset of that population. For example, we might select 10 faculty members and determine their age.
- Variable is "age" of each faculty member.
- Data would be the age of a specific faculty member.
- Data would be the set of values in the sample.
- Experiment would be the method used to select the ages forming the sample and determining the actual age of each faculty member in the sample.
- Parameter of interest is "average" age of all faculty at the college.
- Statistic is "average" age for all faculty in the sample.

Variables in Statistics

There are two kinds of variables in statistics- Qualitative (or Attributeor Categorical) and Quantitative (or Numerical) variable.The qualitative variable categorizes or describes an element of a population. It is also called categorical (discrete, often binary).Example: cancer/no cancer. The quantitative or numerical Variable is a variable that quantifies an element of a population.Example: stock price. The qualitative and quantitative variables may be further subdivided:
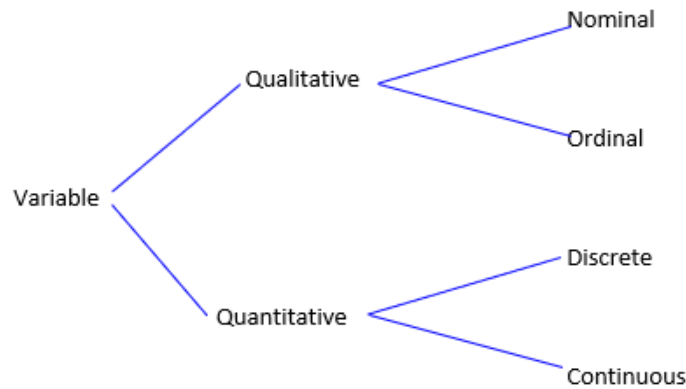
- **Nominal Variable:** Qualitative variable that categorizes (or describes, or names) an element of a population.

- **Ordinal Variable:** Qualitative variable that incorporates an ordered position, or ranking.

- **Discrete Variable:** Quantitative variable that can assume a countable number of values. Discrete variable can assume values corresponding to isolated points along a line interval. That is, there is a gap between any two values.

- **Continuous Variable:** Quantitative variable that can assume an uncountable number of values.Continuous variable can assume any value along a line interval, including every possible value between any two values.

Statistics and Technology

The electronic technology has had a tremendous effect on the field of statistics.Many statistical techniques are repetitive in nature: computers and calculators are good at this. There are lots of statistical software packages: MINITAB, SYSTAT, STATA, SAS, Statgraphics, SPSS, and calculators.

What is Statistical Learning?

Suppose we have an observation,

Yi for $X_i = (X_{i_1}, \ldots \ldots X_{i_p})$ for i=1,2,3,…..n.

We believe that there is a relationship between Y and at least one of the X's.We can model the relationship as

$$Y_i = f(X_i) + \varepsilon_i$$

where f is an unknown function and ε is a random error with mean zero.

Why Do We Estimate f?

Statistical Learning, here, is all about how to estimate f.The term statistical learning refers to using the data to "learn" f.Why do we care about estimating f?Two reasons for estimating f are:

- Prediction
- Inference

- **Prediction**: If we can produce a good estimate for f (and the variance of ε is not too large) we can make accurate predictions for the response, Y, based on a new value of X.
- **Inference**:Alternatively, we may also be interested in the type of relationship between Y and the X's.For example, Which particular predictors actually affect the response?; Is the relationship positive or negative?; Is the relationship a simple linear one or is it more complicated etc.?

How Do We Estimate f?

We will assume we have observed a set of training data

$$\{(\mathbf{X}_1, Y_1), (\mathbf{X}_2, Y_2), \ldots, (\mathbf{X}_n, Y_n)\}$$

We must then use the training data and a statistical method to estimate f.There are 2 statistical learning methods:

• **Parametric Methods:** Such methods reduces the problem of estimating f down to one of estimatinga set of parameters and involves a 2-step model based approach. The following steps are involved:

Step 1:Make some assumption about functional form of *f*, that is, come up with a model. The most common example is a linear model, that is,

$$f(\mathbf{X}_i) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_p X_{ip}$$

Step 2:Use the training data to fit the model, that is, estimate *f* or equivalently unknownparameters such as $\beta_0, \beta_1, \beta_2, \ldots, \beta_p$. The most common approach for estimating parameters in a linear model is ordinary least squares (OLS).

• **Non-Parametric Methods:** These methods do not make explicit assumptions about the functional form of f. The major advantage is they accurately fit a wider range of possible shapes of'f;. But, the problem with this method is that these methods require large number of observations to obtain an accurate estimate of 'f'. These include:

o **Data Predictions:** In such methods, data are predicted on the basis of a set of features (example, diet or clinical measurements); from a set of (observed) training data on these features; for a set of objects (example, people); inputs for problems are also called predictors or independent variables and outputs are also called responses or dependent variables.The prediction model is called a learner or estimator where we have supervised learning (Learn on outcomes for observed features) or unsupervised learning (No feature values are available).

In supervised learning, both the predictors, $\mathbf{X}_i$, and the response, Y_i, are observed.This is the situation you deal with in Linear Regression classes (example: GSBA 524) whereas in the unsupervised learning, only the $\mathbf{X}_i$'s are observed. We need to use the $\mathbf{X}_i$'s to guess what Y would have been and build a model from there. The common example is market segmentation where we try to divide potential customers into groups based on their characteristics. The most common approach used is clustering. The *cluster analysis*, in statistics includes the set of tools and algorithms that is used to classify different objects into groups in such a way that the similarity between two objects is maximal if they belong to the same group and minimal otherwise.

The supervised learning problems can be further divided into *regression and classification* problems.*Regression* covers situations where Y is continuous/numerical, example, predicting the value of a given house based on various inputs.*Classification* covers situations where Y is categorical, example:Is this email a SPAM or not? Some methods work well on both types of problems such as, *Neural Networks*. The other methods that work best on Regression, such as, linear regression, or on classification, such as, k-Nearest Neighbors.

Applications of Statistical Learning

There are several sectors where statistical learning is used. These include:

• Medical: Statistical learning helps in predicting whether a patient who has been hospitalized due to a heart attack, will have a second heart attack. This includes data such as demographic, diet, clinical measurements of a patient.

• Business/Economics: Statistical learning helps in predicting the price of stock 6 months from now. The data considered here includes company performance and economic data.

• Vision: Statistical learning helps in identifying the hand-written ZIP codes. The data here can include model for hand-written digits.

• Medical: Statistical learning can help in determining the amount of glucose in the blood of a diabetic. The data includes infrared absorption spectrum of blood sample of a patient.

• Medical: Different statistical methods are used to explore the risk factors for prostate cancer. The data includes clinical and demographic details of a patient.

Summary

- Big data is a great quantity of diverse information that arrives in increasing volumes and with ever-higher velocity.
- Big data is related to extracting meaningful data by analyzing the huge amount of complex, variously formatted data generated at high speed, that cannot be handled, processed by the traditional system.
- Big data can be structured (often numeric, easily formatted and stored) or unstructured (more free-form, less quantifiable).
- Any data that can be stored, accessed and processed in the form of fixed format is termed as a 'structured' data.
- Any data with unknown form or the structure is classified as unstructured data. In addition to the size being huge, un-structured data poses multiple challenges in terms of its processing for deriving value out of it.
- Big data can be collected from publicly shared comments on social networks and websites, voluntarily gathered from personal electronics and apps, through questionnaires, product purchases, and electronic check-ins.
- Big data is most often stored in computer databases and is analyzed using software specifically designed to handle large, complex data sets.
- R is an open source programming language with a focus on statistical analysis. It is competitive with commercial tools such as SAS, SPSS in terms of statistical capabilities and is thought to be an interface to other programming languages such as C, C++ or Fortran.
- Python is a general-purpose programming language. It contains significant number of libraries devoted to data analysis.
- Big data analytics largely involves collecting data from different sources, munge it in a way that it becomes available to be consumed by analysts and finally deliver data products useful to the organization business.

Keywords

Data Mining: It is a process of extracting insight meaning, hidden pattern from collected data that is useful to take a business decision in the purpose of decreasing expenditure and increasing revenue.

Big Data: This is a term related to extracting meaningful data by analyzing the huge amount of complex, variously formatted data generated at high speed, that cannot be handled, processed by the traditional system.

Unstructured Data: The data for which structure can't be defined is known as unstructured data. It becomes difficult to process and manage unstructured data. The common examples of unstructured data are the text entered in email messages and data sources with texts, images, and videos.

Value: This big data term basically defines the value of the available data. The collected and stored data may be valuable for the societies, customers, and organizations. It is one of the important big data terms as big data is meant for big businesses and the businesses will get some value i.e. benefits from the big data.

Volume: This big data term is related to the total available amount of the data. The data may range from megabytes to brontobytes.

Semi-Structured Data: The data, not represented in the traditional manner with the application of regular methods is known as semi-structured data. This data is neither totally structured nor unstructured but contains some tags, data tables, and structural elements. Few examples of semi-structured data are XML documents, emails, tables, and graphs.

Map Reduce: Map Reduce is a processing technique to process large datasets with the parallel distributed algorithm on the cluster. MapReduce jobs are of two types. "Map" function is used to

divide the query into multiple parts and then process the data at the node level. "Reduce' function collects the result of "Map" function and then find the answer to the query. MapReduce is used to handle big data when coupled with HDFS. This coupling of HDFS and MapReduce is referred to as Hadoop.

Cluster Analysis: The cluster analysis, in statistics includes the set of tools and algorithms that is used to classify different objects into groups in such a way that the similarity between two objects is maximal if they belong to the same group and minimal otherwise.

Statistics: Statistics is the practice or science of collecting and analyzing numerical data in large quantities, especially for the purpose of inferring proportions in a whole from those in a representative sample.

Self-Assessment

1. Which is the process of examining large and varied data sets?

A. Big data analytics

B. Cloud computing

C. Machine learning

D. None of the above

2. Big Data is use to uncover?

A. Hidden patterns and unknown correlations

B. Market trends and customer preferences

C. Other useful information

D. All of the above

3. The composition of data deals with?

A. Structure of data

B. State of data

C. Sensitivity of data

D. None

4. The important 3V's in big data are?

A. Volume, Vulnerability, Variety

B. Volume, Velocity, Variety

C. Velocity, Vulnerability, Variety

D. Volume, Vulnerability, Velocity

5. Big data is an evolving term that describes any voluminous amount of data that has the potential to be mined for information?

A. Structured

B. Unstructured

C. Semi- Structured

D. All of the above

6. Any data that can be stored, accessed and processed in the form of fixed format is termed as a?

A. Structured

B. Unstructured

C. Semi- Structured

D. All of the above

7. What does velocity in big data means?

A. Speed of input data generation

B. Speed of individual machine processors

C. Speed of only storing data.

D. Speed of storing and processing of data

8. Which one is false about big data analytics?

A. It collects data

B. It looks for pattern

C. It analyzes data

D. It does not organize data

9. A _____ is a variable that categorizes or describes an element of a population.

A. description variable

B. numerical variable

C. categorical variable

D. quantitative variable

10. Data prediction in statical methods can be based on

A. a set of features

B. a set of observed training data

C. set of objects

D. All of the above

11. _____ facilitates ability to manage, analyze, summarize, visualize & discover knowledge from the collected data in a timely manner & in a scalable fashion at a faster pace.

A. Big Data

B. Data Summarization

C. Text Summarization

D. Knowledge Summarization

12. Which of the following is/are example(s) of unstructured data?

A. Sensor data

B. Log file

C. Web data

D. None of the above

13. Veracity in big data is concerned with:

A. Accuracy and correctness of the data relative to a particular use

B. Schemas, semantics, ontologies, taxonomies, vocabularies

C. Data has meaningful relations to questions of interest

D. Biases, noise and abnormality in data, trustworthiness of data

14. _____ refers to the connectedness of big data.

A. Variety

B. Valence

C. Velocity

D. Volume

15. Which of the following stage in in big data cycle defines which type of profiles would be needed to deliver resultant data product?

A. Data Munging

B. Data Acquisition

C. Data Operations

D. Resource Assessments

Answer for Self Assessment

1.	A	2.	D	3.	A	4.	B	5.	D
6.	A	7.	D	8.	C	9.	C	10.	D
11.	A	12.	A	13.	D	14.	B	15.	B

Review Questions

1. Explain the data analysis techniques in Big data?
2. What are the different data analysis tools in Big data?
3. What are variables in Big data?
4. Differentiate Quantitative and Qualitative variables?
5. Explore the different phases in the Big data analytics cycle?
6. Explain different terms in statistics along with an example?
7. What is Big data? Explain its characteristics?
8. Discuss the different V's in Big data?
9. How big data differs from the traditional database methods?
10. Distinguish between Structured, Unstructured and Semi-structured data?
11. What are the different applications of Statistical Learning?
12. What are Statistics? What are the different methods involved in it?

Further Readings

Big Data and Analytics, Subhashini Chellappan Seema Acharya, Wiley Publications

Big Data: A Revolution That Will Transform How We Live, Work, and Think by Viktor Mayer-Schonberger and Kenneth Cukier. ISBN-10: 9780544002692

What is BIG DATA? Introduction, Types, Characteristics, Example (guru99.com)

Big Data Definition (investopedia.com)

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